



# WITS UNIVERSITY

**Critiquing existing criteria for financial provisioning for rehabilitation and closure of coal mines in South Africa.**

*Dissertation in partial fulfilment for the degree of Master of Environmental Science of the University of Witwatersrand, South Africa*

*By*

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## **Abstract**

It's vital for mining companies to allocate sufficient funds for environmental restoration after mining activities. This research explores the adequacy of financial provisions for the rehabilitation and closure of coal mines in South Africa, a critical issue given the country's heavy reliance on coal for energy and the significant environmental impacts associated with mining activities. The purpose of this research is important as it aims to ensure that financial provisions accurately reflect the true costs of environmental rehabilitation, thereby safeguarding ecological integrity and promoting sustainable mining practices. This is especially important in the context of South Africa's transitioning energy landscape and the global shift towards more sustainable energy sources.

Employing a mixed-methods approach, the study combines an extensive literature review, analysis of South African mining legislation, and comparison with international standards and best practices. The methodology is further augmented by the researcher's direct engagement with the industry, providing an insider's perspective on the challenges faced in financial provisioning for mine closure. Through interviews with industry the research offers an examination of the current state of financial provisions in the coal mining sector.

Key findings reveal gaps in the existing framework for calculating financial provisions in South Africa, including underestimation of costs, lack of comprehensive criteria covering all aspects of mine closure, and the misalignment of legal requirements with actual rehabilitation needs. The study also highlights the disparity between South African regulations and international best practices, underscoring the need for a more robust, transparent, and inclusive approach to financial provisioning.

The research proposes a set of detailed themes and criteria to enhance the accuracy and efficacy of financial provisions, advocating for a just transition that balances economic, environmental, and social considerations. However the over-reliance on specialist studies when calculating financial provisions for mine closure poses significant risks and challenges that can compromise the effectiveness and sustainability of closure efforts. The significant costs associated with conducting comprehensive specialist studies can pose a barrier to smaller mining operations, potentially exacerbating the issue of mine abandonment.

## **Declaration**

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\_\_\_\_\_

**Keith Ian Raine**

**Date:** 27/8/2024\_\_\_\_\_

## **List of Acronyms and Abbreviations**

AMD: Acid Mine Drainage

BoQ: Bill of Quantities

CEP: Closure Execution Plan

CPI: Consumer Price Index

DEA: Department of Environmental Affairs

DME: Department of Mineral and Energy

DMP: Department of Mines and Petroleum

DMRE: Department of Mineral Resources and Energy

EIA: Environmental Impact Assessment

EMP: Environmental Management Plan

EPA: Environmental Protection Authority

EPCM: Engineering, Procurement, and Construction Management

GNR: Government Notice Regulation

ICMM: International Council on Mining and Metals

IFC: International Finance Corporation

LaRSSA: Land Rehabilitation Society of Southern Africa

MPRDA: Mineral and Petroleum Resources Development Act 28 of 2002

MRF: Mining Rehabilitation Fund

NEMA: National Environmental Management Act 107 of 1998

QA/QC: Quality Assurance and Quality Control

RSA: Republic of South Africa

SRCE: Standard Reclamation Cost Estimator

USA: United States of America

WA: Western Australia

WWF: World Wide Fund for Nature Inc

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# 1 Introduction

Mining stands as a cornerstone of human civilisation, fuelling the development of modern society through the extraction of vital resources. These resources are indispensable across a wide range of industries, including construction, power generation, and the crafting of jewellery, showcasing the sector's versatility and its critical role in driving economic growth (International Finance Corporation) (IFC, 2002). Beyond its direct contributions to industry, mining plays a significant role in job creation, supporting livelihoods and bolstering local and global economies. This dual nature of mining, as both an economic catalyst and a provider of essential materials, underscores its significance in our daily lives and the broader economic landscape.

Though, the advantages of mining happen at a considerable environmental cost. The process of extracting resources from the earth entails significant alterations to the landscape, disrupting ecosystems and contributing to a spectrum of environmental issues. These involve, but are not limited to, the physical degradation of land, contamination of water bodies, and the emission of greenhouse gases (Lloyd, 2002). Such environmental impacts not only threaten biodiversity and ecosystem services but also pose long-term challenges to human health and wellbeing.

In response to these challenges, regulatory bodies across jurisdictions have instituted measures to mitigate the environmental footprint of mining activities. A crucial process involves obliging mining corporations to obtain financial guarantees for restoring mines before they are granted mining licenses (Alberts et al., 2017; ICMM, 2019; Sturdy & Cronje, 2017)

Financial provisions for mine rehabilitation are crucial mechanisms designed to safeguard that mining houses allocate sufficient funds to the environmental restoration of sites post-mining, as emphasised in guidelines by the International Council on Mining and Metals (ICMM, 2019). These measures, underscored by the ICMM's "Integrated Mine Closure: Good Practice Guide," are fundamental components of regulatory frameworks in many countries, aimed at mitigating environmental impacts like soil erosion, water contamination, and habitat destruction (ICMM, 2019). The goal is to rehabilitate mined areas to conditions safe for humans and wildlife, potentially restored to their natural state or repurposed for sustainable land uses.

Regulations demand that mining firms set aside funds for restoration efforts prior to starting their operations. This ensures resources are available for environmental restoration, safeguarding against the company's operational cessation or insolvency. The methods of

financial provisions include cash deposits, bank guarantees, surety bonds, and insurance products, with specifics often guided by regulatory bodies based on operation size, type, and potential environmental impact, as noted in the World Bank's "Environmental and Social Framework" (World Bank, 2017).

The amount set aside for rehabilitation is determined by a comprehensive plan that estimates restoration costs, including themes such as infrastructure removal, water treatment, soil rehabilitation, and re-vegetation (ICMM, 2019). These provisions aim to guarantee the allocation of sufficient resources for returning mining sites to their original condition, or as nearly as achievable, in cases where the mining entity cannot undertake the rehabilitation independently. These funds are then used by government to do the rehabilitation on their behalf. However, if the mine can and do rehabilitate the mine, they then get these funds back. The aim is to prevent the abandonment of degraded sites and to promote the responsible closure and rehabilitation of mines.

Despite these regulatory efforts, the framework for calculating financial provisions has been criticised for its inadequacies. Often, the estimated costs for environmental rehabilitation are significantly underestimated, resulting from flawed methodologies that fail to capture the full extent of environmental liabilities (World Wide Fund for Nature Inc) (WWF, 2012). This shortfall in financial provisioning leads to insufficient funds being set aside for rehabilitation, exacerbating the environmental impacts of mining, and hindering effective restoration efforts.

In South Africa, the Department of Mineral Resources and Energy (DMRE) issued a guidance document titled "Guideline Document For The Evaluation Of The Quantum Of Closure-Related Financial Provision Provided By A Mine" (DME, 2005). This Guideline has frequently been applied incorrectly in practice (Hewitson, 2012), and its use has been overtaken by the Department of Environmental Affairs releasing new Regulations on the Financial Provision for Prospecting, Exploration, Mining, or Production Operations in 2020 (GNR.1147) (DEA, 2020). The GNR.1147 regulations signify a more robust framework designed to ensure that mining companies are financially accountable for the full extent of environmental restoration and management required upon the cessation of mining activities. This includes addressing not only the immediate impacts of closure but also the management of residual and latent environmental effects. However, the new regulations have allowed for mining operations which were established prior to the implementation of the GNR.1147 regulations a transitioning period and, the Mineral and Petroleum Resources Development Act 28 of 2002

(MPRDA) continues to regulate the mining houses until March 2024. Which means the guideline can still to be used as an option for calculating the financial provision for closing a mine until March 2024 for certain mines.

The case of coal mining in South Africa's Highveld is a stark illustration of the broader environmental impacts associated with mining activities. Over more than a century, the environmental degradation caused by coal mining has been profound, affecting air, water, and soil quality across vast areas. This degradation is not unique to the Highveld but reflects a global concern correlated with the extraction of natural resources.

The extensive impact of coal mining over a period exceeding 120 years in South Africa's Highveld has led to significant landscape alterations and environmental degradation. Research by (Hallowes & Munnik, 2016) underscores the extensive damage inflicted on the landscape, highlighting the disruption of natural habitats, loss of biodiversity, and soil degradation. This degradation is exacerbated by the mining sector's practices, which have historically prioritised extraction over environmental stewardship.

The environmental repercussions of coal mining are notably severe in terms of air and water pollution. Studies by Bian et al., (2010) and Goswami, (2015) detail how emissions from coal mining activities contribute to deteriorating air quality, with significant implications for human health and the natural environment. Additionally, the generation of Acid Mine Drainage (AMD) and its role in contaminating water resources have been well-documented (Dontala et al., 2015; Hallowes & Munnik, 2016; Munnik, 2016). AMD, the exposure of sulphide minerals in mine waste to air and water triggers the leaching of heavy metals, posing significant threats to aquatic ecosystems and human water sources (Hallowes & Munnik, 2016).

The pressing need for improved mine closure and rehabilitation practices is a central theme in the discourse on mining's environmental impacts. (Hallowes & Munnik, 2016) and Munnik, (2016) argue for the adoption of comprehensive rehabilitation strategies that address the multifaceted nature of mining's environmental footprint. Such strategies should aim to restore ecological integrity, treat contaminated water, and ensure sustainable land use post-mining, thereby mitigating the long-term environmental consequences.

Given the scale and complexity of the environmental challenges posed by mining, a re-evaluation of the current approaches to financial provisioning and mine rehabilitation is imperative. There is a pressing need for more accurate and comprehensive methodologies for

assessing environmental liabilities, alongside stronger regulatory oversight to ensure compliance and accountability (DEA, 2020). Ultimately, advancing towards more sustainable mining practices requires a concerted effort to balance economic development with environmental stewardship and social responsibility.

## **1.1 Problem Statement**

The global shift towards renewable energy sources represents a critical effort to mitigate the impacts of climate change, with a particular focus on reducing reliance on fossil fuels, notably coal, which is a significant contributor to carbon dioxide emissions and environmental degradation (WWF, 2020). This transition is not only imperative for environmental sustainability but also signals a profound transformation in energy production paradigms, necessitating the closure of numerous coal mines. Such closures are anticipated to increase in the coming years, highlighting an urgent need for effective strategies to rehabilitate former mining lands to levels that not only meet environmental standards but also continue to support and provide livelihoods for local communities (Munnik, 2016).

In South Africa, a country historically reliant on coal mining for its power needs and economic stability, the process of transitioning away from coal mining presents unique challenges and opportunities. The current legislative framework governing financial provisions for mine closure is subject to broad interpretation, allowing considerable discretion in assessing the financial provisions required for mine rehabilitation (McHenry et al., 2015). This flexibility, while intended to accommodate the specificities of each mining operation, often results in the underestimation of the true costs associated with environmental rehabilitation and the safeguarding of community livelihoods post-closure (Botham et al., 2011). Such underestimations pose significant risks to the environment and local communities, potentially leaving them without adequate resources for economic transition and environmental restoration.

The inadequacy of financial provisions for mine closure and rehabilitation in South Africa underscores a broader issue faced by many countries: the need for robust, transparent, and enforceable regulatory frameworks that accurately reflect the environmental and social costs of mining. As the world moves towards a more sustainable and renewable energy-centric future, the mining sector, particularly coal mining, must adapt to these changing paradigms. This includes not only the physical act of closing mines and rehabilitating land but also

ensuring that such processes are conducted in a manner that respects environmental integrity and promotes the socio-economic well-being of affected communities.

Enhancing the legislative requirements for financial provision for closure in South Africa and elsewhere is essential. This involves developing more precise and comprehensive methodologies for assessing the financial obligations of mining companies, taking into account the long-term environmental impacts and the necessity of supporting sustainable community development post-mining. Furthermore, increased transparency and stakeholder engagement in the financial provision process can help ensure that the interests of local communities, environmental conservation, and economic development are balanced and protected.

As the global community continues to confront the challenges of climate change and transitions towards a more sustainable future, the mining industry's role in this transformation must be carefully managed. By adopting more stringent and effective regulatory frameworks for mine closure and rehabilitation, countries can not only mitigate the environmental impacts of mining but also harness these opportunities to foster resilient and sustainable communities in post-mining landscapes.

## **1.2 Aim**

The aim of this research is to identify and develop a detailed list of themes annotated with a minimum criterion to be incorporated into the calculation of the financial provisions for environmental closure of coal mines in South Africa. Estimating financial provisions involves predicting the future costs of rehabilitation, covering potential environmental, social, and infrastructural requirements, which can also be described as themes.

## **1.3 Research Objectives**

1. To Analyse the Current Practice for Calculating Financial Provision for the Closure of Coal Mines in South Africa and Compare with Current Legal Requirements.
2. To Evaluate International Best Practice on the Calculation of Financial Provision for Closure in Order to Identify Detailed Criteria Categorised into Themes.
3. To Develop Detailed Criteria for the Calculation of Financial Provision for Closure of Coal Mines in South Africa.

## 1.4 Structure of the Report

This research report is structured over the following six chapters:

- **Chapter 1:** is an introduction to the report with background to the problem, the problem statement and the aims and objectives;
- **Chapter 2:** is the literature review where mine closure and the financial provisions for mine closure are addressed, looking specifically at the South African coal sector and what the current legal requirements in South Africa are;
- **Chapter 3:** describes the methods used to address the objectives stated above;
- **Chapter 4:** presents the results of this research and has a validity test to see the actual significance;
- **Chapter 5:** is the discussion of the findings and what do they mean in context to the literature; and
- **Chapter 6:** is the conclusion and it summarises the findings and what this means for the coal mining sector.

## 2 Literature Review

At some point, all mines will have to close their doors, regardless of what they are doing (Degregori, 2020). Mine closure processes in South Africa, which externalise environmental risks and result in substantial financial burdens, have a long and negative history, as do the environmental impacts on mining in South Africa (Mpanza et al., 2021). Modern mining companies must provide certain forms of surety, bond, or financial provision as a condition to mining or applying for a mining right in most mining jurisdictions (Sassoon, 2009). In this way, governments are not solely responsible for the risks associated with a mining venture failing and, therefore, ignoring or disregarding the environmental impact and legacy of that venture.

A performance audit was conducted by the Auditor-General of South Africa with regard to the rehabilitation of abandoned mines at the Department of Mineral Resources and Energy (DMRE) and a report was submitted to Parliament in 31 March 2022 (Auditor-General of the Republic of South Africa, 2022). According to the audit, abandoned mines that were unrehabilitated “pose serious health, safety and environmental hazards for nearby communities”. The Auditor General also acknowledged the department's progress since the initial performance audit in 2009, but emphasized the urgent need for the government to enhance its rehabilitation efforts due to their negative impact on local communities and the environment (Auditor-General of the Republic of South Africa, 2022)

The heightened focus on post-mining transition over the last 10 years stems from a global uptick in mine closures, exacerbated by a history of inadequate mine closure and relinquishment practices (Everingham et al., 2022). Numerous mines are left in a state of 'care and maintenance' due to the intricate challenges associated with closing mines and worries over the transfer of remaining liabilities for these sites (Measham et al., 2024). This highlights the importance of a proactive approach to mine closure, emphasizing the shift towards new industries and a knowledge-based economy in mining areas, informed by lessons learned from transitions like Germany's move away from coal (Brauers et al., 2018). The goal of the transition is to ensure a fair shift for workers affected by mine closures and marginalised rural communities. This involves decentralized decision-making, engaging the public in regional planning, planning over several decades, and significant investments to attract new industries and build infrastructure (Measham et al., 2024).

The agenda for research and policy to enhance mine closure and post-mining transitions encompasses the necessity for investigating and discussing the varied meanings of post-mining across different settings. It also includes broadening planning considerations to encompass a diverse array of values and viewpoints, merging biophysical studies with social and economic aspects, and expanding the scope of planning for mine closure and transitions from individual sites to regional levels and further (Measham et al., 2024). This approach emphasises the necessity of building enduring relationships with Indigenous Peoples and ensuring their rights, values, and needs are addressed in post-mining outcomes (Measham et al., 2024).

The literature increasingly recognises that closure and post-mining transitions present a unique opportunity to reimagine and repurpose mining sites for future economic, environmental, and social benefits (Measham et al., 2024). The closure of mines is not merely an endpoint but a transition phase towards new beginnings, where the focus shifts from simply returning sites to their pre-mining state to exploring potential for innovative post-mining land uses (Boggs et al., 2023). This shift necessitates a broader and more integrated approach to mine closure that encompasses not just environmental remediation but also social and economic redevelopment, aligning with the principles of just transition and sustainable regional development. The transition from mining operations to sustainable post-mine land use and community development represents a critical yet complex challenge. Boggs et al., (2023) present a comprehensive exploration of this issue, emphasising the need for a paradigm shift in how mine closure is conceptualised and implemented. They argue that successful mine closure should not only address environmental remediation but also facilitate economic, social, and cultural transitions that benefit regional communities and stakeholders.

## **2.1 Mine Closure**

Mines close for a multitude of reasons that span across economic, environmental, safety, and political dimensions. One primary cause is the depletion of resources. When the mineral or resource being extracted becomes economically infeasible due to physical exhaustion or the costliness of extraction methods, mines are often shuttered (ICMM, 2019). Economic factors also play a critical role; fluctuations in global commodity prices can render a mine unprofitable if the market value falls below the cost of extraction. Increased operational costs, such as labour, energy, and equipment, further exacerbate this issue, leading to potential closures (Humphreys, 2019).

Environmental concerns and regulations have become increasingly significant in recent years. Stricter environmental regulations aimed at mitigating damage such as water pollution, deforestation, or habitat destruction can lead to mine closures. Mines that fail to comply with environmental standards or that cannot afford compliance costs might be shut down by regulatory bodies or choose to close voluntarily (Holden & Jacobson, 2012). Additionally, safety issues are a paramount concern; mines with poor safety records, frequent accidents, or catastrophic events may be closed to protect workers. Regulatory bodies closely monitor compliance with safety standards, and failure to adhere to these can result in enforced closures (Dashwood & Pupilampu, 2010).

The exhaustion of economically viable material is another reason mines close (ICMM, 2019). As the easily accessible materials are depleted, the remaining deposits may not justify the cost of continued extraction. Furthermore, community opposition and the social licence to operate significantly affect mine operations. Opposition from local communities and indigenous groups over concerns of environmental degradation, health impacts, and disruption of local economies can lead to protests, legal challenges, and ultimately, mine closures (World Bank, 2017). Lastly, political and legal issues, such as changes in government policies, legal disputes, or the nationalisation of resources, can force mines to close. Additionally, technological changes that render certain mining methods obsolete or uneconomical can lead to closures as operations that cannot adapt or upgrade become unviable (Calvo et al., 2016).

In addressing the impacts of mine closures, it is crucial to consider environmental restoration and support for affected workers and communities as part of sustainable mining practices. The closure of a mine involves a complex interplay of factors, highlighting the need for comprehensive strategies to manage the economic, environmental, and social implications (Buxton, 2012). When mines close, they are required by law in most countries to undergo rehabilitation, a process aimed at restoring the site to a state that is environmentally stable and safe for future use (ICMM, 2019). Mine rehabilitation can involve a variety of activities, including the removal of hazardous materials, contouring land to prevent erosion, replanting vegetation to restore ecosystems, and ensuring that water bodies are clean and safe (IM4DC, 2012). The objective is to mitigate the environmental impact of mining activities, address public health and safety concerns, and in many cases, return the land to a condition that supports its prior use or prepares it for a new purpose (World Bank, 2017).

The legal requirement for mine rehabilitation is often embedded in a country's mining regulations and environmental protection laws (IUCN, 2019). These laws typically mandate that mining companies develop and submit a closure plan before the commencement of mining operations, outlining how they intend to rehabilitate the site post-mining. The plan must comply with national and sometimes regional environmental standards (ICMM, 2019). Moreover, companies are frequently required to provide financial assurance in the form of bonds or guarantees to ensure that funds are available for rehabilitation, even if the company fails or abandons the site (World Bank, 2017).

For example, in South Africa, like many other countries, mine closure is governed by specific legislation and regulations aimed at ensuring the responsible management of environmental impacts and the rehabilitation of mining sites. The legal framework for mine closure in South Africa is primarily guided by the National Environmental Management Act (NEMA) of 1998 (RSA, 1998) and its associated regulations. In Australia, the mining rehabilitation requirements are stipulated under various state and territory laws, such as Western Australian Department of Mines and Petroleum and the Environmental Protection Authority in May 2015 (DMP/EPA, 2011).

These regulatory frameworks ensure that mining companies are accountable for the environmental impacts of their operations, promoting sustainable practices and the responsible closure and rehabilitation of mine sites. The specifics of the legal requirements, including the standards for rehabilitation and the mechanisms for enforcement, can vary significantly from one jurisdiction to another, reflecting the local environmental priorities, social considerations, and economic conditions. The regulatory framework around mine closure is evolving to better integrate considerations of post-mining transitions into closure planning and governance. This includes acknowledging the roles of various stakeholders in shaping post-mining futures and the importance of early and inclusive planning processes that consider the long-term social, economic, and environmental outcomes of mine closure (ICMM, 2019). Such regulatory evolutions are crucial for facilitating transitions that align with community needs and regional development goals, moving beyond compliance to achieve positive legacies.

The extent of rehabilitation required for a mine site can vary depending on several factors, including the duration of mining operations, the type of mine, and the effectiveness of management practices throughout the operation (DMIRS, 2020). These factors influence the

degree of environmental disturbance and the specific rehabilitation measures needed to restore the site (IM4DC, 2012).

**Duration of Mining Operations:** The longer a mine has been in operation, the greater the potential environmental impacts, including land disturbance, soil erosion, and water contamination. Mines that have been operational for extended periods may require more extensive rehabilitation efforts to address cumulative impacts and restore ecosystem functions. (UNEP, 2019).

**Type of Mine:** Different types of mines, such as open-cast or underground mines, can have varying environmental footprints and rehabilitation requirements. For example, open-cut mines typically result in large-scale land disturbance and alteration of surface topography, necessitating significant recontouring and revegetation efforts. In contrast, underground mines may have less surface disturbance but can pose challenges related to subsidence and groundwater impacts that require specialised rehabilitation techniques (DMRE, 2020).

**Management Practices:** The effectiveness of environmental management practices implemented during mining operations can significantly influence the extent of rehabilitation required. Proactive measures, such as proper waste management, erosion control, and water treatment, can mitigate environmental impacts and reduce the scope of rehabilitation needed post-mining. Conversely, inadequate management practices may exacerbate environmental degradation, leading to more extensive rehabilitation efforts (ICMM, 2019).

**Regulatory Requirements:** The specific regulatory requirements and standards for mine rehabilitation established by government authorities also play a crucial role in determining the extent of rehabilitation. Regulatory frameworks prescribe minimum rehabilitation standards and timelines that mining companies must adhere to, ensuring that mine closure and rehabilitation are conducted in accordance with environmental laws and regulations (DMIRS, 2020).

Overall, the extent of mine rehabilitation is contingent upon a combination of factors, including the duration and nature of mining operations, the effectiveness of management practices, and compliance with regulatory requirements. Tailored rehabilitation plans that consider these factors are essential for restoring mine sites to a condition that is environmentally stable and suitable for future land use.

The primary aim of rehabilitation is to address environmental impacts, yet it is crucial to acknowledge the substantial social concerns accompanying the process. These social issues primarily revolve around job losses, the sustainability of livelihoods after mining, and the environmental damages affecting community health and well-being (ICMM, 2019).

From an environmental perspective, rehabilitation involves a multifaceted approach aimed at restoring and mitigating the impacts of mining activities on the ecosystem (DEFRA, 2011). Key components of environmental rehabilitation include landform design, which entails reshaping the land to resemble its pre-mining contours and landforms, minimising erosion, promoting stability, and restoring the natural landscape (DEA, 2015). Another crucial aspect is the establishment of vegetation, aiming to restore vegetation cover by planting native species adapted to the local climate and soil conditions, thereby stabilising soils, preventing erosion, and enhancing habitat quality (DAWEA, 2013). Water management is also critical, involving the construction of drainage systems, erosion control structures, and sediment traps to prevent run-off and contamination of waterways, as well as restoring natural watercourses and wetlands to improve water quality and aquatic habitat (LaRSSA, 2019). Additionally, soil remediation techniques such as soil amelioration and revegetation aim to restore soil fertility, structure, and biological activity, supporting vegetation establishment and ecosystem recovery (UNEP, 2019). Habitat restoration efforts focus on rehabilitating disturbed habitats and ecosystems by reintroducing native flora and fauna species, creating habitat features, and protecting sensitive habitats, enhancing ecological resilience and promoting biodiversity recovery (UNEP, 2019). Overall, environmental rehabilitation encompasses a comprehensive strategy to minimise the long-term environmental footprint of mining activities and support the recovery of natural ecosystems.

The costs associated with mine rehabilitation arise when the mine is no longer generating income (ICMM, 2019). Hence, there is a critical need for financial provision throughout the mine's lifespan. This is often mandated by legislation, although these requirements are relatively new (MCSA, 2019). Historically, mines closed without adequate rehabilitation, leading to a legacy of abandoned mines globally and in South Africa (World Bank, 2019). In South Africa, this issue is particularly prominent, prompting the establishment of dedicated programmes and budgets for remediation (DMRE, 2020). Consequently, there is a concerted focus on avoiding new abandoned mines, underscoring the importance of making financial provisions.

## 2.2 Financial Provision

Globally, financial provisions serve as a crucial tool to ensure that mines fulfil their obligation to rehabilitate the area once mining operations cease (Fraser Institute, 2012; Laurence, 2011; Peck & Sinding, 2009; WWF, 2012). The reliability of mine closure costs hinges on the accuracy and implementation of the closure plan throughout the mine's operational lifespan (ICMM, 2019). Mines must evaluate their liability for rehabilitation in scenarios where closure occurs prematurely or at the end of the mine's productive life, commonly referred to as the Life of Mine (LoM). Estimating financial provisions involves predicting the future costs of rehabilitation, covering potential environmental, social, and infrastructural requirements which can also be described as themes. These provisions are designed to ensure that adequate funds are available for rehabilitation, with the understanding that if the mine cannot fulfil its obligation, the government will step in to rehabilitate the site using these funds. Importantly, mines cannot utilise these provisions for their own rehabilitation purposes. However, by implementing concurrent rehabilitation efforts, mines can mitigate the amount of financial provision required.

The complexity and unpredictability of mine closure costs are highlighted, with calls for a more accurate and holistic incorporation of these costs throughout the mine lifecycle. Failure to adequately plan for and address closure costs can lead to underestimation and insufficient financial provisions, exacerbating challenges in achieving successful closure and transition (Claessens & Kodres, 2014). This underlines the importance of developing more robust financial assurance models that adequately capture the full spectrum of closure and post-mining transition costs, ensuring that mines are prepared for responsible closure that benefits both the environment and surrounding communities.

The approach to calculating closure costs vary greatly between countries (Sheldon et al., 2002). It is possible for closure costs to vary depending on the location and age of a mine, as well as the type of mineral that was extracted and whether the mine had been developed or not (Sheldon et al., 2002). Other factors that affect the final closure cost include themes such the size and infrastructure of the mine, the history of ongoing rehabilitation (or not), and the volume of waste on surface (Sheldon et al., 2002). The approach to financial provision changes in different jurisdictions, but there are largely two models, one being individualised bonding which entails refundable security payments covering a set amount, this is the more common approach; and the other non-refundable contributions on a regular basis to a central or pooled

fund (DMP/EPA, 2011). Legislation generally prescribes the form and quantum of financial assurance, with cash, bank guarantee and bonds being the most common forms. Most jurisdictions require the security to cover 100% of the assessed rehabilitation liability at an individual site level, at a particular time, with a number of jurisdictions allowing for the financial assurance to increase in a graduated way over the Life of the Mine (Jones, 2012).

In Australia, the calculation of bond values for mining projects varies across different territories.<sup>1</sup>For some projects, bond values are determined on a project-specific basis, taking into consideration the overall cost of remediation rather than the complete reclamation cost. In contrast, for other projects, a fixed rate per area disturbed is utilised to calculate bond values. This diversity in approach reflects the complexity of assessing the potential liabilities associated with mine closure and rehabilitation efforts. Australia faces a significant challenge with a substantial number of abandoned mines, estimated to be around 60,000. However, there are a few instances of successful rehabilitation of these sites, particularly concerning small mines. Notably, despite the advancements in mining practices, the Australian mining industry has yet to achieve successful rehabilitation of a large-scale, open pit mine (Degregori, 2020). This underscores the ongoing need for improvements in mine closure planning and implementation to address the environmental and socio-economic impacts of mining activities effectively.

In Canada, a diverse range of financial assurance mechanisms is utilised to guarantee the availability of funds for mine closure. These mechanisms include surety bonds, letters of credit, and trust funds, among others (World Bank, 2017). The selection and implementation of these mechanisms are governed by provincial or territorial regulations, highlighting Canada's decentralised approach to mine management (Degregori, 2020).

The specific requirements and amounts for financial assurance vary depending on the jurisdiction and the nature of the mining operation. Provincial and territorial regulations outline the obligations of mining companies regarding financial provision for mine closure, ensuring that adequate funds are set aside to cover the costs of reclamation and rehabilitation activities (Degregori, 2020). Canada's approach to financial assurance reflects a commitment to responsible mine closure and environmental stewardship, aiming to mitigate the long-term

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<sup>1</sup> Reclamation: the process of reconvertng disturbed land to its former or other productive uses. Remediation: the removal, reduction, or neutralisation of substances, wastes or hazardous material from a site to prevent or minimize any adverse effects on the environment now or in the future.

impacts of mining activities on the environment and surrounding communities (World Bank, 2017). By employing a mix of financial mechanisms tailored to the specific needs of each jurisdiction, Canada seeks to ensure the sustainable management of its mining resources while safeguarding environmental integrity (Degregori, 2020).

In the United States of America, financial provisions for mine closure are governed by a regulatory framework established at both federal and state levels. Various mechanisms, including surety bonds, letters of credit, and trust funds, are commonly utilised to ensure the availability of funds for mine closure (Degregori, 2020). The specific amount of financial assurance required is determined based on the estimated cost of fulfilling reclamation obligations as defined by the relevant regulatory authorities. This diverse range of financial assurance mechanisms aims to guarantee sufficient funds for mine closure and environmental rehabilitation, thereby mitigating the potential environmental and financial risks associated with mining operations in the United States.

In South Africa, the history of financial provision starts with the introduction of Regulation 5.16 under the Minerals Act of 1991 and it was a pivotal moment in the country's approach to mining and environmental management (Dixon, 2003). This regulation mandated mines to not only plan for potential premature or unplanned closures, but also to ensure financial provisions were in place for mine rehabilitation. This legislative move was reflective of a growing global and national consciousness towards environmental responsibility and the first World Summit on Sustainable Development also followed this, signalling a shift in how businesses, particularly in the mining sector, were expected to consider their environmental impact.

In South Africa, the MPRDA of 2002 (RSA, 2002) mandates mining companies to make financial provisions for the closure and rehabilitation of mining operations, aiming to hold them accountable for environmental impacts and ensure sufficient funds for land rehabilitation post-mining. As part of their mining rights application, companies are required to submit closure plans to the DMRE, detailing measures for land rehabilitation and environmental mitigation, with financial provision being a critical aspect (RSA, 2015). These provisions can take various forms, such as financial guarantees, including cash deposits or bank guarantees, held by the DMRE to cover closure costs in case of company default, or through mechanisms like trust funds or rehabilitation funds. Some companies opt for progressive rehabilitation, spreading closure costs over the mine's lifespan. Estimation of closure costs is essential, encompassing site rehabilitation, environmental remediation, infrastructure removal, and ongoing monitoring.

Compliance with closure regulations is monitored by the DMRE, with penalties for non-compliance.

Regulation 5.16, therefore, represents an early but critical step in South Africa's journey towards integrating environmental responsibility into the mining sector. It laid the groundwork for future legislation and set a precedent for the importance of planning and financial readiness in the face of mine closure. This regulation and the subsequent scholarly discourse around mine rehabilitation costs and practices underscore the evolving nature of mine closure planning, highlighting the need for ongoing research, adaptive management strategies, and robust financial planning to address the complex legacy of mining activities on the environment and communities.

When it comes to calculating how much money is needed to clean up old mine sites, there are several key pieces of information and considerations to keep in mind, each critical for a comprehensive estimate. Firstly, understanding the costs associated with the equipment is essential; this includes not just the initial purchase price but also expenses related to operation and ongoing maintenance (SRCE, 2019). Another significant factor is the compensation for workers, which goes beyond their base salary to include benefits, taxes, insurance, and any other associated costs (SRCE, 2019). Materials like seeds for replanting vegetation and mulch for soil stabilisation are also part of the equation (Boggs et al., 2023). The prices of these materials can fluctuate, so it is important to account for potential variability in costs. In addition, if mines are hiring outside companies to help with parts of the clean-up, their estimates need to be accurate and reflect the full scope of their services (Boggs et al., 2023). For a successful reclamation project, detailed information about the mine itself is crucial. This includes maps that depict the current state of the site and what it will look like after reclamation efforts are complete. Detailed drawings or data from mine planning software can provide the necessary dimensions, volumes, and other specifics to guide the clean-up process developing a national mine closure risk and opportunity (Esau et al., 2023). Understanding the intended methods and design criteria for reclamation is also key, ensuring that efforts comply with regulatory requirements and effectively restore the site.

Environmental considerations are paramount, requiring a thorough understanding of the site's soil, hydrology, and climate. This information guides decisions on how to best restore the land in a way that is sustainable and minimises further environmental impact. The presence of any infrastructure, such as roads and buildings, also influences the clean-up strategy and costs.

Legal and regulatory frameworks dictate specific standards for mine reclamation, including financial assurances and bonding requirements to ensure that funds are available for the clean-up efforts. These legal obligations underscore the importance of a well-thought-out reclamation plan that adheres to all applicable laws and standards. Considering the environmental impact and implementing measures to mitigate any negative effects are critical for protecting the surrounding ecosystem. Worker safety is another non-negotiable aspect, with plans needing to encompass all necessary precautions and safety measures to protect those on the ground.

Different reclamation strategies may have varying costs and effectiveness, requiring a careful evaluation of all available options. Themes such as the future use of the land post-reclamation is an important consideration, influencing the specific restoration activities and goals. Engaging with the local community and understanding any land ownership issues or agreements with local governments or communities are also crucial for a smooth and successful reclamation process.

In summary, estimating the costs associated with mine site reclamation is a multifaceted process that requires careful consideration of themes that incorporate equipment and labour costs, material prices, legal and regulatory requirements, environmental and safety considerations, and community engagement. A thorough and well-informed approach ensures that the reclamation efforts are both effective and compliant with all necessary standards.

Some of these approaches to calculating the above have emerged as international best practice, such as the ICMM, 2019, the Standardized Reclamation Cost Estimator (SRCE, 2019) and the guidelines established by the Department of Mines and Petroleum (DMP) and the Environmental Protection Authority (EPA) of Western Australia (WA) (DMP/EPA, 2011).

The ICMM believes in integrated mine closure which must be included in the overall planning of the mine from the start and should include not only environmental but also health, safety, social, legal, governance and human resource considerations (Brock et al., 2019). At the onset of mine development, the ICMM highlights the importance of integrating mine closure planning, which takes into account environmental, social, and economic factors. This comprehensive approach mandates that mine operations must view closure as an integral part of their core business activities. The ICMM's 2019 guidelines delineate several key components essential for a thorough mine closure plan and its effective implementation:

- **Mine Planning:** Incorporating closure into the mine's short-, medium-, and long-term planning is crucial. Proactive integration of closure into the LoM planning facilitates better outcomes for both the mining company and stakeholders.
- **Closure Vision, Principles and Objectives:** Developing these aspects early in the planning process, with input from stakeholders and knowledge base, ensures that the closure vision aligns with regulatory requirements and includes considerations for post-closure land use.
- **Post-Closure Land Use:** Identifying and defining the land's use after mining is pivotal for closure planning, influencing all aspects of the closure plan.
- **Stakeholders:** Engaging with stakeholders shapes key elements of the closure plan, leveraging insights to refine planning and implementation strategies.
- **Identifying and Assessing Risks and Opportunities:** Evaluating physical, social, economic, and ecological risks and opportunities is essential for selecting appropriate closure activities.
- **Closure Activities:** Implementing specific closure actions, such as installing tailings covers or removing contaminated land, is critical during the final closure and progressively throughout.
- **Success Criteria:** These indicators help assess the effectiveness of closure activities, determining when a mine or part of a mine can conclude its post-closure period.
- **Progressive Closure:** Implementing closure activities during the operational LoM offers numerous benefits, allowing for the incorporation of learnings into the knowledge base.
- **Social Transition:** Addressing the transition of the community and workforce is an integral part of closure, impacting the LoM and closure process.
- **Closure Costs:** Estimating the costs associated with all aspects of closure is a vital component of closure planning, evolving as more information becomes available.
- **Closure Execution Plan (CEP):** The development and regular updating of a CEP outline specific actions to be undertaken to support both closure planning and implementation.
- **Monitoring, Maintenance, and Management:** Post-closure activity monitoring is necessary to assess success criteria achievement and to evaluate the effectiveness of closure activities, identifying any maintenance needs.

- **Annual Review:** A site-specific closure plan should incorporate environmental and socio-economic conditions, operational data, commitments, compliance requirements, waste characterisation, and environmental baseline data. (ICMM, 2019).

These components underscore the ICMM's advocacy for an integrated approach to mine closure, emphasising the need for early and continuous planning, stakeholder engagement, and adaptive management to achieve sustainable closure outcomes.

The Standardised Reclamation Cost Estimator (SRCE) from the United States of America (USA), established in 2006 (SRCE, 2019), serves as a comprehensive tool for estimating the costs associated with mine reclamation and closure. The model is designed with the flexibility to accommodate a wide range of methods for cost estimation, emphasising the importance of adaptability to specific project needs. However, the accuracy of the cost assessments generated by the SRCE is heavily dependent on the availability and quality of project data and maps. For effective usage, it necessitates that users have access to precise topographic maps that detail all project facilities both at the time of closure and after the completion of reclamation efforts.

The SRCE underscores the necessity for users to not only comprehend the model itself but also the real-world system it aims to simulate to yield beneficial outcomes. It points out that mine closure professionals, with a deep understanding of closure planning, mine reclamation construction techniques, and standard cost estimating practices, will be able to leverage the model most effectively. Recognising the diverse range of skills and experience levels of potential users, the SRCE is designed to be user-friendly, thereby ensuring its utility across a broad spectrum of users, from the highly experienced to those with less expertise in the field. This approach enhances the accessibility of the model, making it a valuable asset for professionals involved in the complex process of mine closure and reclamation.

The SRCE uses methods of calculation based on first-principal approaches for volume and distance calculations, and productivity estimation, with productivity calculations largely derived from published sources and closely mirror good international best practice (Getty et al., 2019). The SRCE meets the International Financial Reporting Standards International Accounting Standard 37 for Provisions, Contingent Liabilities and Contingent Assets (Getty et al., 2019).

The DMP, alongside the Environmental Protection Authority (EPA), advocates that mine closure plans should be viewed as evolving documents that require ongoing revision, development, and enhancement throughout the life span of a mine (DMP/EPA, 2011). This approach underscores the conviction that for a mine to be adequately covered, especially when calculating the financial provision needed for rehabilitation liabilities, the mine closure plan must be treated as a living document.

Guidelines issued by the DMP and EPA outline several essential principles and approaches crucial during the preparation of a mine closure plan. Central to these is the necessity to demonstrate, throughout the mine's lifecycle, the feasibility of achieving ecologically sustainable mine closure, taking into account post-mining outcomes and land use without resulting in undue liabilities for the State (DMP/EPA, 2011).

The integration of closure planning within the mine planning process from the outset is recommended, with a focus on this planning continuing until the mine's full closure and relinquishment. Plans should also be site-specific and consider post-mining land uses from the project's feasibility stage (DMP/EPA, 2011). The identification and agreement on post-mining land uses prior to the approval of new projects are deemed crucial. Moreover, closure plans should be risk-based, reflecting the results of material characterisation, environmental data, climate conditions, and potential environmental impacts from contaminants (DMP/EPA, 2011).

Consultation processes should address stakeholders' concerns, incorporating considerations of the project's operational lifecycle, opportunities for improving environmental outcomes, and landscape management for multiple land uses. For mines lacking an initial closure plan, establishing and working towards agreed post-mining land uses is important (DMP/EPA, 2011). Material characterisation, vital for planning a successful closure, must be completed before project approval. This includes identifying materials that may produce acidic, metalliferous, or saline drainage, among others. Determining the most appropriate materials for rehabilitation is also a part of the rehabilitation process (DMP/EPA, 2011).

Adaptive management is encouraged in closure planning, including how insights from other mine sites and research can be integrated into the closure plan. Effective record-keeping and management systems for monitoring and sustaining closure performance are critical elements of a closure plan (DMP/EPA, 2011). This comprehensive and flexible approach ensures that

mine closure plans are robust, adaptable, and aimed at securing sustainable outcomes for the environment and the community alike.

The Western Australian Government's Guidelines for Preparing Mine Closure, the Integrated Mine Closure: Good Practice Guide from the ICMM, and the SRCE from the USA are recognised as best practices in mine closure due to their comprehensive and strategic approaches. These guidelines and tools embody principles of environmental stewardship, stakeholder engagement, financial responsibility, and adaptive management. The Western Australian guidelines provide a robust regulatory framework emphasising early and continuous stakeholder engagement and flexible management approaches. The ICMM guide draws on global best practices, advocating for a lifecycle approach to mine closure that integrates closure planning with operational and financial planning from the outset, highlighting risk management and continuous improvement. Meanwhile, the SRCE standardises cost estimation for mine closure and reclamation, ensuring transparency, sufficient financial provisioning, and environmental protection. Collectively, these frameworks ensure that mine closure is conducted responsibly, minimising environmental impacts, and ensuring land can be repurposed post-mining, thereby upholding principles of sustainability and responsible mining.

### **2.3 Mine Closure in South Africa - Coal Sector**

The coal sector in South Africa is a foundational element of the nation's economy and energy framework, with its roots extending over a century deep into the country's industrial evolution (Jeffrey et al., 2015). This sector's journey began primarily in Mpumalanga, a region rich in coal deposits, but over time it has expanded into Limpopo, KwaZulu Natal and Gauteng, therefore broadening the coal mining landscape (Laisani & Jegede, 2019). Today, South Africa boasts 127 coal mines, operated by both large multinational firms and smaller, local companies (Carmen, 2022). This industry is a significant employment source, especially in Mpumalanga, where it sustains tens of thousands of jobs, directly and indirectly, underscoring its vital role in regional economic stability and growth (Bohlmann et al., 2019).

South Africa's coal sector serves a dual purpose: it is a major player on the global export market and as an essential supplier for domestic energy needs (Jeffrey et al., 2015). As one of the top coal exporters in the world, South Africa capitalises on its advanced port infrastructure, particularly the Richards Bay Coal Terminal, to ship substantial coal quantities overseas. Domestically, coal is pivotal in electricity generation, with over 75% of the country's power

supplied by coal-fired plants, highlighting the critical dependence of the state-owned power utility, Eskom, on this resource (Hanto et al., 2022).

The industry has seen a significant shift from traditional underground mining to open-cast mining, also known as strip mining (Fraser Institute, 2012). This transition is driven by the cost-effectiveness and efficiency of open-cast operations, which involve removing topsoil and subsoil and overlying rock strata to access coal seams, extracting high-grade coal with large machinery, and then rehabilitating the land by replacing the overburden and soils and then replanting vegetation. While this method allows for a larger percentage of the coal deposit to be recovered, it raises considerable environmental and social concerns, including land alteration, community displacement, and habitat destruction (Akinlabi et al., 2019).

The coal sector's environmental and social implications, particularly with the advent of open-cast mining, have sparked a complex debate about balancing economic benefits with the need for environmental stewardship and social responsibility (Munnik, 2010). As global shifts towards renewable energy and domestic pressures to address climate change mount, the future of South Africa's coal sector appears to be at a crossroads. Despite these challenges, coal continues to be a central element of the country's energy and economic strategies, albeit with an anticipated gradual transition towards cleaner energy sources. Hanto et al., (2022) detailed look into South Africa's coal industry underscores its historical significance, economic impact, and the evolving mining practices amidst growing concerns over environmental sustainability and social equity (Hanto et al., 2022).

In Mpumalanga, South Africa, the environmental impacts of coal mining have gained significant attention due to the critical challenges they pose to the region's ecology, water resources, agricultural land, and public health (WRC, 2016). Among these, AMD stands out as a particularly severe issue, resulting from the exposure of sulphide minerals in mined rocks to air and water, creating sulphuric acid that leaches heavy metals into waterways (WRC, 2016). This process not only degrades water quality but also threatens aquatic life and human health. Another pressing concern is the loss of high potential agricultural land to mining operations, which compromises food security and the economic stability of local communities reliant on agriculture (Delpont et al., 2016). Additionally, the region's wetlands, vital for water purification, flood control, and biodiversity, are under threat from mining activities, impacting water quality and availability downstream (WRC, 2016).

Dust pollution from coal mining and associated operations presents a significant health hazard in Mpumalanga, with particles carrying potentially harmful substances, including heavy metals, contributing to respiratory issues among local populations (Laisani & Jegede, 2019). The coal industry, alongside regulatory bodies, acknowledges these environmental and health challenges, prompting efforts towards stricter environmental regulation, investment in AMD treatment, land rehabilitation, and improved dust management practices (Hobbs et al., 2008). The drive towards sustainable energy sources also reflects a growing commitment to reducing the environmental footprint of energy production in South Africa (Mirzania et al., 2023). This collaborative approach, involving government, industry, communities, and environmental organisations, is crucial in developing strategies that balance economic development with environmental stewardship and public health.

In South Africa, the coal mining industry has increasingly acknowledged the significant environmental impacts of its operations, particularly in regions like Mpumalanga (Laisani & Jegede, 2019). To address these concerns, the industry has developed comprehensive rehabilitation guidelines over the years. The initiative began with the Chamber of Mines, now known as the Minerals Council South Africa, which introduced the first set of guidelines in 2007 (MCSA, 2022). These guidelines served as an early framework for responsible environmental management and rehabilitation practices within the mining sector. Building on this foundation, the Land Rehabilitation Society of Southern Africa (LaRSSA) (LaRSSA, 2019) released a more updated set of guidelines in 2019, reflecting the sector's ongoing commitment to enhancing rehabilitation methods and outcomes.

Rehabilitation in mining is a complex process that involves several critical steps designed to restore land affected by mining activities to a state that is both environmentally stable and beneficial for future use (LaRSSA, 2019). This process begins with thorough planning and assessment before mining starts, ensuring a clear plan for post-mining land use is established. As mining operations wind down, the decommissioning phase involves dismantling or repurposing infrastructure and managing waste. The physical landscape often requires contouring and reshaping to stabilise slopes and re-establish natural drainage patterns. Soil management is another crucial aspect, involving the careful handling of topsoil and subsoil to support future vegetation and, potentially, agriculture (LaRSSA, 2019).

Revegetation with native plants or suitable crops helps to stabilise the soil, restore ecological functions, and reintegrate the area with the surrounding environment (LaRSSA, 2019).

Monitoring and maintenance are essential post-rehabilitation to ensure the success of these efforts, with additional work carried out as necessary (LaRSSA, 2019). Before a mine can close officially, it must obtain a closure certificate from the government, affirming that all rehabilitation work complies with approved plans and regulatory requirements (Hanto et al., 2022). This certification process ensures that mines are responsibly managed up to and beyond their operational lifespan, safeguarding communities, and ecosystems from potential long-term damage. The development and refinement of rehabilitation guidelines, from the early efforts by the Chamber of Mines to the comprehensive approach taken by LaRSSA, underscore the mining industry's recognition of its environmental obligations. These evolving guidelines are critical for reducing mining's environmental footprint and ensuring that post-mining landscapes are left in a condition that supports safe, stable, and sustainable future land uses.

As the global community increasingly shifts away from coal in response to environmental imperatives and the push to mitigate climate change, regions like Mpumalanga in South Africa, with its rich coal deposits, are poised to face a significant transition with the expected closure of numerous coal mines (Bohlmann et al., 2019). The concept of a just transition is particularly relevant to the coal sector in South Africa and other regions facing the need to move away from coal-based energy production. The transition away from coal presents significant socio-economic challenges that require thoughtful policy interventions and investment in new industries and infrastructure to support affected communities and workers. The importance of a just transition underscores the need to consider not only the environmental aspects of mine closure but also the broader socio-economic implications, ensuring a holistic approach to post-mining transitions that are equitable and sustainable (Measham et al., 2024).

This move, while essential for environmental sustainability, brings to light the critical need for proper mine closure practices, especially given the area's environmental sensitivity, the substantial impacts of coal mining, and South Africa's historical challenges with abandoned mines. Proper mine closure is imperative not just for regulatory adherence but as a fundamental responsibility to both the environment and future generations, aiming to minimise long-term ecological impacts, restore ecosystems, and repurpose former mining lands for sustainable uses.

The adequacy of financial provisions by mining companies throughout a mine's operational life is crucial to covering the extensive costs associated with closure, including environmental rehabilitation and ongoing monitoring (WWF, 2012). South Africa's experiences with

abandoned mines have highlighted the severe environmental and health risks they pose, underscoring the necessity for sufficient financial set-asides to prevent such outcomes (Mpanza et al., 2021). Regulatory frameworks in South Africa seek to ensure compliance and the adequacy of these financial provisions, yet the challenge of enforcement remains, necessitating continuous oversight and active engagement from government, civil society, and the mining sector.

The collaborative effort of all stakeholders, government, mining companies, local communities, environmental organisations, and academia is essential in navigating the complexities of mine closure (Fraser, 2021). This collective approach can foster innovative solutions for land rehabilitation and repurposing, turning former mining sites into assets for renewable energy projects, conservation efforts, or sustainable agricultural ventures, thereby offering new socio-economic pathways for communities transitioning away from coal dependence. In essence, as South Africa, along with the rest of the world, progresses towards a less coal-dependent future, the meticulous planning and execution of mine closures in sensitive regions like Mpumalanga become not just a matter of complying with regulations but a pivotal component of the country's journey towards sustainable development and environmental restoration.

#### **2.4 South African Legislation Regulating Mine Closure**

Mining in South Africa has a rich history that spans over a century. Initially, mining regulations, such as those introduced under the Minerals Act of 1991 (Act 50 of 1991) (RSA, 1991), were primarily focused on basic surface rehabilitation. This early legislation laid the groundwork for environmental management within the mining sector, but it was relatively limited in scope, concentrating on surface impacts without addressing the broader environmental consequences of mining activities (Alberts et al., 2017; Crous et al., 2020; Swart, 2003).

The landscape of environmental legislation in South Africa underwent a significant transformation with the adoption of the South African Constitution in 1996. One of the key provisions relevant to the mining industry is found in Section 24(a), which asserts that everyone has the right to an environment that is not harmful to their health and well-being. This constitutional mandate set a new standard for environmental protection, requiring that mining

operations consider the wider implications of their activities on human health and the environment (Crous et al., 2020; Swart, 2003).

However, it is important to note that while mines are expected to respect the principles laid out in the Constitution, they are directly regulated by specific legislation that operationalises these principles. In response to the constitutional mandate, the NEMA (Act No. 107 of 1998) was promulgated (RSA, 1998). NEMA established a comprehensive framework for environmental management across all industries, including mining. One of the act's key sections, Section 28, introduces a 'duty of care' principle, placing the responsibility for remediating environmental damage squarely on the shoulders of the entity that caused the damage or pollution. This marked a significant shift towards more stringent environmental governance in the mining sector, ensuring that mining operations are held accountable for their environmental impacts (Alberts et al., 2017; Crous et al., 2020; Swart, 2003).

Over the years, South Africa's environmental legislation has evolved to become increasingly stringent, reflecting a growing awareness of the need for sustainable mining practices that safeguard the environment and public health. This evolution demonstrates the country's commitment to enforcing rigorous environmental standards and the mining industry's ongoing responsibility to adapt and comply with these regulatory frameworks.

The promulgation of the MPRDA in 2002 (RSA, 2002) represented a significant turning point for the transformation of the mining industry in South Africa, as noted by Alberts et al., (2017). This legislation was instrumental in setting the stage for a more inclusive and environmentally responsible mining sector. Specifically, Section 41 of the MPRDA, alongside Regulations 53 and 54 of R527 of the MPRDA (RSA, 2002), laid down the framework for assessing the quantum of closure liability for mining operations, ensuring that mining companies adequately plan and account for the environmental impact of their activities from the outset.

Building upon this foundation, in November 2015, the South African government introduced the new Regulations Pertaining to the Financial Provision for Prospecting, Exploration, Mining or Production Operations (Financial Provision Regulations) under the NEMA (RSA, 1998). The essence of these new regulations was to further regulate and mandate the determination and making of financial provisions by mining companies. This was aimed at covering the costs associated with the management, rehabilitation, and remediation of environmental impacts stemming from prospecting, exploration, mining, or production operations throughout the

operational life of such activities, as well as addressing latent or residual environmental impacts that may become apparent in the future.

These developments underscored the South African government's commitment to ensuring that the mining sector operates in an environmentally sustainable manner. By requiring detailed financial provisions for environmental management and rehabilitation, the MPRDA and subsequent NEMA regulations seek to prevent the adverse effects of mining activities on the environment and communities, ensuring that mining companies are fully accountable for their environmental impacts. This legislative framework not only promotes responsible mining practices but also aligns with global standards for environmental protection and sustainability in the mining industry.

The original "DME Guideline," formally titled the Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine, was issued in 2005 by the Department of Minerals and Energy (DME, 2005). This guideline offered a general model for calculating an estimated figure for mine closure costs, suggesting the use of specified rates as a foundation for these estimates. As detailed in Table 1, it encompasses a wide range of closure components applicable to different types of mines, including open-cast, underground, and combination mines. These components cover activities from the dismantling of processing plants and associated structures to the rehabilitation of access roads, sealing of shafts, and water management, indicating a thorough approach to mine closure tasks.

**Table 1: Closure Components Applicable for Type of Mine**

Component Number	Main Description	Applicable Closure Components for Mine Type		
		Open-Cast	Underground	Combination
1	Dismantling of processing plant and related structures (including over-land conveyors and power lines)	Yes	Yes	Yes
2(A)	Demolition of steel buildings and structures	Yes	Yes	Yes
2(B)	Demolition of reinforced concrete buildings and structures	Yes	Yes	Yes
3	Rehabilitation of access roads	Yes	Yes	Yes
4(A)	Demolition and rehabilitation of electrified railway lines	Yes	Yes	Yes

Component Number	Main Description	Applicable Closure Components for Mine Type		
		Open-Cast	Underground	Combination
4(B)	Demolition and rehabilitation of non-electrified railway lines	Yes	Yes	Yes
5	Demolition of housing and facilities	Yes	Yes	Yes
6	Open-cast rehabilitation including final voids and ramps	Yes	No	Yes
7	Sealing of shafts, adits and inclines	No	Yes	Yes
8(A)	Rehabilitation of overburden and spoils	Yes	Yes	Yes
8(B)	Rehabilitation of processing waste deposits and evaporation ponds (basic, salt-producing waste)	Yes	Yes	Yes
8(C)	Rehabilitation of processing waste deposits and evaporation ponds (acidic, metal-rich waste)	Yes	Yes	Yes
9	Rehabilitation of subsided areas	Yes	Yes	Yes
10	General surface rehabilitation, including grassing of all denuded areas	Yes	Yes	Yes
11	River diversions	Yes	Yes	Yes
12	Fencing	Yes	Yes	Yes
13	Water management (separating clean and dirty water, managing polluted water and managing the impact on groundwater, including treatment, when required)	Yes	Yes	Yes
14	2 to 3 years of maintenance and aftercare	Yes	Yes	Yes

Source: Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine - 2005(DME, 2005)

Upon its initial publication, it was intended that the rates provided would be annually updated to reflect current costs more accurately. Nevertheless, despite the passage of time, this guideline continues to be employed by the industry for the calculation of mine closure liabilities, highlighting its ongoing significance and its foundational role in the financial provision calculations for mine closure (DME, 2005). This method of calculating the mine closure provision has been in a transitional period, with mines which were established prior to

the implementation of the GNR.1147 (20 November 2015) regulations being allowed to use it until March 2024 (RSA, 2015).

The WWF report highlights the general failure of mining companies to adjust the DME's master guidelines rates for inflation and the resultant underestimation of potential closure cost (WWF, 2020). Numerous papers, such as those by (Badakhshan et al., 2023; Bainton & Holcombe, 2018; Mendes et al., 2013), have looked at the actual costs of mine rehabilitation activities and the shortcomings in calculating these costs. These studies provide valuable insights into the financial and practical challenges associated with mine closure, shedding light on the complexity of estimating financial provisions for mine closure, which must consider numerous factors including environmental rehabilitation, socio-economic transitions, and infrastructure development (Esau et al., 2023).

Moreover, the 2015 NEMA Regulations (GNR.1147) pertaining to the Financial Provision for Prospecting, Exploration, Mining, or Production Operations introduced a methodology for determining financial provision through a detailed itemisation of all activities and costs (RSA, 2015). This methodology is based on the actual costs of implementing measures required for annual rehabilitation (as shown in an annual rehabilitation plan), final rehabilitation, decommissioning, and closure at the end of the operations' lifespan (as shown in a final rehabilitation, decommissioning, and mine closure plan), and the remediation of latent or residual environmental impacts that may become apparent in the future. This includes measures such as the pumping and treatment of polluted or extraneous water, as outlined in an environmental risk assessment report (RSA, 1998).

This evolution towards a more detailed itemisation method under the 2015 NEMA Regulations marks a significant advancement in how financial provisions for mine closure are calculated. It transitions from a generalised model to one demanding specificity and accountability for the actual costs associated with extensive rehabilitation and closure activities. This shift ensures a more accurate and responsible approach to environmental management and financial provisioning within the mining sector, aligning with sustainable practices and the reduction of long-term environmental impacts.

In the current regulatory framework within South Africa, the responsibility for determining the total cost associated with the closure and remediation of a mine rests with the mining right holder. This cost estimation is subject to independent verification to ensure accuracy and

compliance with regulatory standards. If the Minister of the DMRE finds the initial cost assessment unsatisfactory, the mining right holder is then required to engage and finance a second independent assessment. Further to this, to validate that the cost provided has been accurately calculated, the holder must also cover the expenses of a third-party auditor appointed by the State.

While South African legislation concerning the decommissioning and closing of mines, along with the associated financial provisions, is indeed comprehensive, it has been critiqued for its susceptibility to varied interpretations. A significant concern highlighted by (Sturdy & Cronje, 2017) is that the current regulatory mechanisms do not effectively mandate the level of transparency and accountability necessary in the disclosure of mine closure liabilities by companies. This sentiment is echoed by (McHenry et al., 2015), who observed that disclosures related to mine closure in South Africa tend to be selective and lack transparency.

This situation points to a need for tighter regulations and clearer guidelines to ensure that mining companies provide thorough and transparent accounts of their financial provisions for mine closure. Ensuring transparency and accountability in this area is crucial for mitigating environmental impacts, safeguarding community interests, and promoting sustainable mining practices. Without such measures, the effectiveness of the legislative framework in protecting environmental and public interests remains compromised, underscoring the importance of revising current policies to address these shortcomings.

There has been a lot written about mine closure in South Africa, and there appears to be robust legislation and regulatory mechanisms regarding mine closure, but sustainable mine closure has yet to be achieved (Milaras et al., 2014). This suggests that there is disconnect between policy and practice in South Africa (Milaras et al., 2014).

## **2.5 Just Transition**

The transition towards a lower carbon future and away from coal, imperative for mitigating climate change, poses significant socio-economic challenges, particularly in regions heavily dependent on coal mining like South Africa, the world's 14th biggest CO<sub>2</sub> emitter (Cole et al., 2023). This shift necessitates a just transition that not only addresses environmental concerns but also ensures that the socio-economic implications for communities and workers are carefully managed. South Africa's coal sector, responsible for a considerable portion of the national economy and employment, faces inevitable closure for several mines and power plants

by 2030 and 2040, impacting approximately 2.5 million residents of host communities who already endure low levels of income, employment, and education (Ryan, 2024).

The concept of a just transition in South Africa encompasses broader considerations than merely environmental sustainability; it includes the imperative of ensuring energy security and economic growth while navigating the socio-economic ramifications of transitioning from coal-dependent industries (Esau et al., 2023). Such a transition requires thoughtful policy interventions to mitigate temporal, spatial, educational, and sectoral misalignments, ensuring that new job opportunities align with the emerging needs and capabilities of the affected workforce and communities.

Moreover, the integration of sustainable mining and mine closure practices highlights the urgent need for enhanced governance and financial assurance mechanisms that align with the long-term environmental and social objectives. This includes ensuring adequate financial provisions for mine rehabilitation, addressing the legacy of environmental degradation, and supporting the development of alternative economic activities in mining regions.

Environmentally conscious mining and mine closure are critical components of the broader efforts to achieve a just transition in coal-dependent economies like South Africa (Carneiro & Fourie, 2020; Cole et al., 2023; ICMM, 2019). As the country embarks on this transition, the challenges of environmental rehabilitation, socio-economic implications for mining communities, and the need for robust policy frameworks become increasingly apparent. The research by Cole et al., (2023) underscores the complexity of managing coal mine closures within the context of South Africa's national and regional energy and economic policies. Their findings emphasise the importance of inclusive and well-coordinated approaches that balance environmental sustainability with the socio-economic well-being of communities transitioning away from coal. This updated perspective enriches the existing literature on mine closure and highlights the critical role of governance, financial assurance, and the alignment of mine closure practices with the principles of a just transition.

The just transition framework is gaining traction as a crucial component of mine closure and post-mining planning, emphasising the need to balance environmental sustainability with socio-economic equity. The framework advocates for a comprehensive approach to transitions that safeguards the livelihoods of those impacted by mine closures, particularly in coal-dependent regions. By incorporating just transition principles into mine closure strategies, there

is an opportunity to ensure that post-mining transitions support not only environmental rehabilitation but also economic diversification and social inclusion, therefore contributing to broader sustainable development goals (Measham et al., 2024).

The future of the decommissioning and closure guidelines will need to be guided by just transition, climate change, food and water security. The International Trade Union Confederation defines a “Just Transition” as: “A Just Transition secures the future and livelihoods of workers and their communities in the transition to a low-carbon economy. It is based on social dialogue between workers and their unions, employers, government, and communities. A plan for Just Transition provides and guarantees better and decent jobs, social protection, more training opportunities and greater job security for all workers affected by global warming and climate change policies” (ITUC, 2022, para. 2).

A lack of sufficient funding is the most significant hindrance to the successful closure of mines and reclamation of lands in a timely and satisfactory manner. It is essential to include a financial assurance mechanism in a mine closure plan from the outset. In the event of a default on the mine owner's closure plan, the mechanism would protect the government from incurring any additional costs. Using a fair market value estimate of closure costs, a site-specific calculation should be used to determine the amount of financial assurance needed to implement the closure plan. A government review and approval must be required for methods and final estimates (World Bank Group, 2018).

### **3 Methodology**

Research methodologies refer to the systematic procedures, techniques, and approaches employed by researchers to conduct investigations, gather data, and analyse information in a structured and organised manner (Denzin & Lincoln, 2018). These methodologies provide a framework for designing, implementing, and interpreting research studies (Creswell & Creswell, 2017). There are various research methodologies, each with its own set of principles and techniques, catering to different research objectives and types of data (Miles et al., 2014).

Choosing the most suitable research methodology depends on the research questions, objectives, and the nature of the phenomenon under investigation. Researchers often select and combine methodologies based on the complexity of the research and the depth of understanding required (Sandelowski, 2000).

This research report uses mixed methods qualitative research as well as surveys and questionnaires to achieve the objectives. Furthermore, the researcher is involved in the sector, having worked in the sector for over three years mainly focusing on the adequacy of closure cost reports, and is hence a participant observer.

Qualitative research, while offering valuable insights, is not without its limitations. One significant challenge lies in the subjectivity and potential bias introduced by the researcher's interpretation, leading to varying analyses (Denzin & Lincoln, 2018). The validity poses another concern, as qualitative findings are often context-specific and may not extend to broader populations, particularly with small and non-random sample sizes (Creswell & Creswell, 2017). Data analysis in qualitative research can be time-consuming and subjective, lacking the same level of reproducibility as quantitative studies (Miles et al., 2014). The absence of numerical data and challenges in measurement further restrict the ability to quantify results. Conducting qualitative research is resource-intensive, demanding skilled researchers and extensive time commitments (Merriam & Tisdell, 2015). Ethical dilemmas, such as ensuring informed consent and managing power dynamics, add complexity (Guest et al., 2006). Qualitative findings may also face difficulties in comparison across studies or integration with quantitative data (Sandelowski, 2000). Despite these challenges, researchers often mitigate limitations through rigorous methodologies, triangulation, and transparent reporting, recognising that qualitative research complements and enriches the overall research landscape.

Surveys and questionnaires are popular research methods, but they come with certain limitations and pitfalls. One notable shortcoming is the potential for response bias, where participants may provide inaccurate or socially desirable responses, leading to skewed data (Groves et al., 2009). Sampling bias is another concern, as the sample may not represent the broader population accurately, impacting the generalisability of findings (Dillman et al., 2014). The reliance on self-reporting introduces the risk of measurement error, as participants might misinterpret questions or respond inconsistently (Tourangeau et al., 2000). Additionally, the fixed-response format of surveys may limit the depth of participant responses, overlooking nuanced perspectives or unanticipated insights (Conrad et al., 2011). Finally, low response rates can threaten the survey's validity, as non-response bias may affect the reliability of the results (Groves et al., 2009). Researchers must carefully consider these limitations when employing surveys and questionnaires, employing strategies to mitigate potential biases and enhance the overall robustness of their findings.

The approach to address each of the objectives is described below.

### **3.1 Objective 1 - To Analyse the Current Practice for Calculating Financial Provision for the Closure of Coal Mines in South Africa and Compare with Current Legal Requirements**

There were two components to establishing the current practice. Firstly, the legal requirements were reviewed in order to understand what is required. Once these were understood and documented, interviews with experienced practitioners were conducted.

#### **3.1.1 Legal Review**

In South Africa, mine closure and financial provision are currently regulated in terms of Section 24P and 24PA of NEMA and until March 2024 the repealed Regulations 53 and 54 of the MPRDA Regulations, 2004 due to transitional arrangements set out in Regulation GNR.1147. The specific requirements are detailed in the regulations, NEMA GNR.1147 of 20 November 2015: Regulations pertaining to the Financial Provision for Prospecting, Exploration, Mining or Production Operations (RSA, 2015) and the DME Guideline formally titled the Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine (RSA, 2002).

Regulation GNR.1147 and the DME Guideline, were examined in detail and the requirement for making financial provision is summarised, the key requirements, processes and documentation that needs to be developed was identified for each and this was presented in the process flow diagrams annotated with key deliverables and requirements. Specific criteria and line items used to calculate the financial provisions are noted and then categorised into themes to be able to compare them across the other objectives.

The themes used are:

- **Specialist Studies:** Cost of specialist to create detailed reports of all the impacts the mine has created.
- **Pollution:** Area of pollution identified by the specialist studies e.g., contaminated soil, tailing storage facilities, pollution control dams etc.
- **Post-closure Land Use:** What is the documented post closure land use, as depending on what this is, it could have a huge cost impact on how to achieve it. For example, if the post closure land use requires a mine's open pit to be back filled it would cost a great deal more than a post-closure land use where the open pit is incorporated into the land use.
- **Infrastructure:** This is the demolishing and removal of all identified infrastructure that will not be left behind.
- **Earthworks:** This theme is very broad as it incorporates any activities where earthmoving machines are required e.g., landscaping, back filling, ripping and topsoiling.
- **Ground Rehabilitation:** This is the physical landscaping of the areas identified installing ecological mitigation areas with biodiversity scores that compensate for what is lost. All which would have been identified in the specialist studies.
- **Surface Water Management:** The management of surface water that the specialist studies will have quantified the impact and remediation thereof.
- **Ground Water Management:** The management of ground water that the specialist studies will have quantified the impact and remediation thereof e.g., AMD.
- **Monitoring and Maintenance:** This is the costs associated with post closure monitoring programmes which will have been identified in the specialist studies, and the maintenance of the rehabilitated areas.

- **Support Services:** This is the cost of mobilisation of contractors to coming in and remediate the sites, and any service that has an overhead.
- **Socio-Economic:** This is the cost of ensuring the work force is demobilised in accordance with the laws and social licence to operate.
- **Security:** This is items such as fencing and personnel to ensure the site is safe.
- **Safety:** Health and safety plans, construction monitoring and Quality Assurance and Quality Control (QA/QC).
- **Delays:** Cost provision for potential delays due to extreme events or other external factors relevant to closure.

### 3.1.2 Interview Process

To understand the practice of environmental closure financial provisions in South Africa, consultants with extensive experience working with mining companies to quantify funds for mine closure were interviewed.

Consultants with at least five years extensive experience and expertise in the area of mine closure and financial provision were identified and requested to participate in this research. Initially three consultants were selected based on their experience and expertise in this area however one of the participants passed away and therefore started with two. From these two participants, an additional two participants accepted the invitation to be part of this study, however, no further consultants that were contacted out of the countless attempts chose to take part, therefore only four consultants took part. The details of the participants, their qualifications and experience are listed in Table 2.

The purpose of the interviews was as follows:

- to find out how the industry consultants address the requirements in the legislation;
- to see what approach, they use to calculate the financial provisions needed for mine closure;
- to determine what specific closure criteria and line items are used for example, Water Management, Decommissioning, Rehabilitation;
- to identify which criteria are particularly relevant to the calculation of financial provision for the closure of coal mines;

- their opinion on bigger global issues such as just transition, climate change, food and water security; and
- any gaps that the consultants have noted in the legislation will be noted.

A standard questionnaire that incorporates the above aims was drafted and used during the interview process. The outcome is a detailed examination of each of the consultants' responses in the interview how the categories they use align with the Regulations and other approaches used, and which criteria/themes are unique and/or of relevance to coal mining. Key themes, and gaps that the consultants have identified, were noted.

**Table 2: Interviewee Information**

<b>Interviewee</b>	<b>Academic Qualification</b>	<b>At least 5 Years' Experience</b>	<b>Role</b>
Person 1	Relevant tertiary qualification	Yes	Mine closure specialist
Person 2	Relevant tertiary qualification	Yes	Mine closure specialist
Person 3	Relevant tertiary qualification	Yes	Mine closure specialist
Person 4	Relevant tertiary qualification	Yes	Mine closure specialist

### **3.1.3 Ethics**

In compliance with the University of Witwatersrand's regulations, the researcher applied for ethics clearance before initiating the data collection process, and the clearance was duly approved under Clearance Number: HA2205 (Appendix A). Given that the study endeavours to capture the viewpoints and experiences of mining consultants and rehabilitation specialists/practitioners, potential ethical considerations arise. To address these concerns, participation in the study is entirely voluntary, and explicit consent is obtained from all participants. Furthermore, stringent measures are implemented to ensure the confidentiality of both the interviewees and the respective mining companies they represent. The use of gender-specific pronouns is avoided; instead, participants are assigned numerical identifiers, which are utilised in the results section of this dissertation to safeguard their anonymity.

## **3.2 Objective 2 - To Evaluate International Best Practice on the Calculation of Financial Provision for Closure in Order to Identify Detailed Criteria Categorised into Themes**

The following international best practices for environmental closure financial provision were examined:

- Western Australian Government requirements - Guidelines for Preparing Mine Closure (May 2015)(DMP/EPA, 2011);
- Integrated Mine closure Good Practice from the ICMM (2<sup>nd</sup> edition 2019)(ICMM, 2019); and
- The Standardized Reclamation Cost Estimator (SRCE) from the United States of America (16 May 2019)(SRCE, 2019).

These standards/requirements were selected because they considered to best practice globally and due to their comprehensive coverage of critical aspects of mine closure, their adaptability across various regulatory and operational contexts, and their endorsement by leading industry bodies and regulatory agencies. These guidelines and tools were chosen based on their:

- **Comprehensive Approach:** Each framework addresses a broad range of considerations essential to mine closure, encompassing environmental, social, financial, and operational aspects. This ensures a holistic approach to mine closure planning and execution.
- **Global and Regional Relevance:** They provide both global best practices (as in the case of the ICMM guide) and region-specific guidelines (such as those from Western Australia), offering valuable insights applicable across different jurisdictions and environmental settings.
- **Flexibility and Adaptability:** These frameworks allow for adaptation to specific project needs and local conditions, making them relevant for a wide variety of mining operations, from small-scale projects to large, complex operations.
- **Stakeholder Engagement:** They emphasise the importance of engaging with stakeholders throughout the mine closure process, ensuring that the interests and concerns of affected communities, governments, and other stakeholders are considered.
- **Financial Responsibility:** By advocating for accurate cost estimation and financial provisioning, these guidelines help ensure that sufficient resources are allocated for closure activities, reducing the risk of unforeseen environmental and social impacts post-closure.
- **Endorsement by Authorities and Industry Bodies:** These frameworks are recognised and recommended by authoritative bodies in the mining industry, contributing to their credibility and widespread adoption.

For this report, a decision was made to focus on the May 2015 edition of the Western Australian Government's Guidelines for Preparing Mine Closure (DMP/EPA, 2011). This edition was selected for review based on its comprehensive and in-depth coverage of the topic. Although the guidelines were subsequently updated in 2020 and again in 2023, these later versions primarily aimed at streamlining the submission process by dividing the content into distinct sections. Despite these structural changes, the core information and principles guiding mine closure remained substantially unchanged across the different editions. This continuity underscores the enduring relevance of the 2015 guidelines as a foundational document for understanding the expectations and requirements surrounding mine closure within Western Australia.

There are numerous guidelines and tools developed by various countries, industry associations, and international organisations. The number of these can vary widely depending on the specific focus areas (such as environmental protection, community engagement, or financial assurance) and the geographic and regulatory context they are designed for. The choice among these various guidelines and tools typically depends on the location of the mining project, the specific requirements of the regulatory environment in which the mine operates, and the priorities and policies of the mining company itself. While the three frameworks mentioned above are among the most widely recognised and implemented, mining companies and regulatory bodies may also draw upon additional guidelines and methodologies to suit their specific needs and contexts.

These industry leading guidelines and tools were examined in detail and the requirement for making financial provision is summarised, the key requirements, processes and documentation that needs to be developed were identified and this was presented in a process flow diagram annotated with key deliverables and requirements. Specific criteria and line items used to calculate the financial provisions are noted and then categorised into themes to be able to compare them across the other objectives.

These themes are compared between the three best practices. From this comparison, how they differ is discussed as to which areas they focus their importance on, for example, is the removal and rehabilitation of infrastructure a focal point or are water issues a focal point etc. The themes identified are also discussed in relation to coal mining and if they are material or not. The themes are also compared to those identified in objective one and any gaps between the two questions will be identified.

### **3.3 Objective 3 - To Develop Detailed Criteria for the Calculation of Financial Provision for Closure of Coal Mines in South Africa**

From the outcomes of objective one and two, a detailed list of themes was developed by taking the outcomes and combining them. The list covers the important themes with a list of minimum criteria under each, any material gaps identified which should be costed for when calculating the financial provision of closing a coal mine in South Africa. These are included in the results and further elaborated in the discussion.

### **3.4 Research Limitations**

The research encountered a limitation in the form of fewer conducted interviews than initially targeted; with an aim of eight interviews, only four were completed. This reduction in participant engagement may have constrained the study's capacity to comprehensively capture the varied perspectives and practices prevalent within the industry. Despite this limitation, it is important to note that, given the specific context of South African legislation and the limited range of operational practices therein, the likelihood of additional interviews significantly altering the study's outcomes is considered low. This suggests that, while the breadth of industry insight might have been affected, the core conclusions drawn from the conducted interviews remain relevant and insightful within the defined legislative and operational parameters.

During the development of this dissertation, it became necessary to adjust the research objectives from a detailed comparison of specific cost line items to a broader thematic analysis of cost management practices. This change was prompted by the discovery that a direct comparison of line items across different projects or entities was impractical, due to significant variations in how best practices were implemented and accounted for. Such disparities made it impossible to conduct a meaningful comparison of exact costs, leading to a methodological shift towards identifying general themes related to cost efficiency and allocation. While this approach yielded valuable insights into overarching cost management strategies, it also introduced limitations regarding the depth of specific cost-saving measures or inefficiencies that could be identified, suggesting a potential direction for future research to develop more standardised frameworks for cost comparison.

## **4 Chapter 4. Results**

### **4.1 Legal Requirements for Financial Provision in South Africa**

Prior to the Minister responsible for mineral resources issuing an environmental authorisation for prospecting, exploration, mining or production, the applicant must ensure they have provided sufficient funding for rehabilitation, closure and ongoing post-decommissioning management (RSA, 1998).

The NEMA defines financial provision as the amount which is to be provided by a mining right holder, holder of an old order right or applicant, guaranteeing the availability of funds to fulfil the obligation to undertake progressive rehabilitation, decommissioning, closure and post-closure activities including the pumping and treatment of polluted or extraneous water to ensure that the State does not become liable for those costs which should be covered by a holder, holder of an old order right or applicant;

[Definition of 'financial provision' inserted by s. 1 (f) of Act 25 of 2014 (wef 2 September 2014) and substituted by s. 1 (f) of Act 2 of 2022 (wef 30 June 2023)]” (RSA 1998). Section 24P and 24PA in NEMA deal with financial provision for mining, discussing the form it should take, and how often it should be reviewed and audited (RSA, 1998).

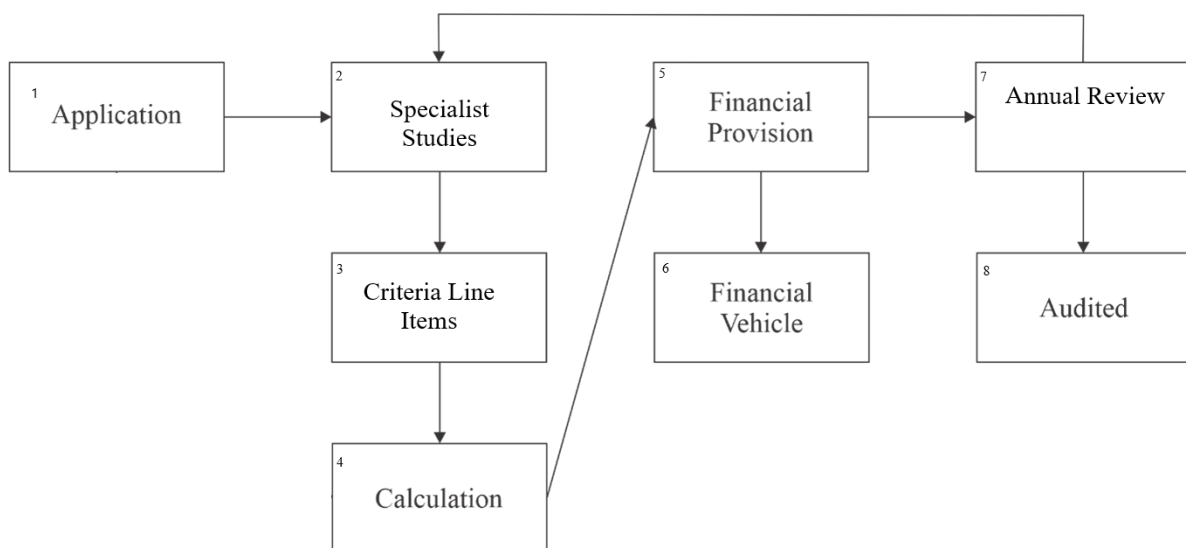
#### **NEMA GNR.1147 of 20 November 2015: Regulations pertaining to the Financial Provision for Prospecting, Exploration, Mining or Production Operations (RSA, 2015)**

The GNR.1147 Regulations provide a comprehensive framework for calculating mine closure costs, focusing on ensuring that financial provisions are adequately made for the rehabilitation, decommissioning, and closure of mining operations. A detailed examination of the document regarding its applicability for calculating mine closure costs reveals several strengths and areas for improvement.

The strengths of the regulations cover a wide range of aspects necessary for mine closure, including annual rehabilitation, final rehabilitation, decommissioning, and post-closure management of environmental impacts. This broad scope ensures that all potential costs associated with mine closure are considered. The regulations provide guidelines on how to calculate costs related to various activities and infrastructures, incorporating auditable calculations, cost assumptions, and the inclusion of monitoring and maintenance costs. This approach helps in creating a transparent and verifiable cost estimation process.

The regulations specify different levels of accuracy for cost estimates depending on the time frame to closure, which helps in managing the uncertainty inherent in long-term cost forecasting. This tiered approach to accuracy acknowledges the variability and increases in certainty as the project nears closure. The requirement for annual updates and reviews of the closure cost estimates ensures that the financial provision remains relevant and accurate over time, reflecting any changes in the operation, regulatory requirements, or other material developments.

**Regulation GNR.1147 of 20 November 2015:** Regulations pertaining to the Financial Provision for Prospecting, Exploration, Mining or Production Operations (RSA, 2015) have been reviewed and the below process flow diagram (Figure 1) represents the process of calculating the financial provision using Regulation GNR.1147 of 20 November 2015.



**Figure 1: Process Flow Diagram for Calculation the Financial Provision for Closure of a Mine using Regulation GNR.1147 of 20 November 2015**

Table 3 below explains each step in the process flow above (Figure 1).

**Table 3: Requirements to Calculate a Mine’s Financial Provision**

<b>Requirements</b>	<b>Processes</b>	<b>Documentation</b>
<b>1. Application</b>	When prospecting or mining, an applicant or holder must provide funds for rehabilitation, remediation, decommissioning and closure activities. Managing latent and residual environmental impacts that may become apparent in the future, including pumping and treating polluted or extraneous water (RSA, 2015).	Application submission.
<b>2. Specialists</b>	In order to determine, review, and assess the situation of the impacts or potential impacts of the mine, an expert and specialists must be consulted.	Specialist reports detailing the findings.
<b>3. Criteria Line Items - for Calculating Financial Provision</b>	In order to calculate the financial provision, an applicant must provide a detailed itemisation of all activities and impacts identified by the specialists in the previous step. The calculations costs must be based on the actual costs of implementing measures needed for final rehabilitation, decommissioning, and closing prospecting and mining, at the end of their lives. An environmental risk assessment report, as well as the final rehabilitation, decommissioning, and mine closure plan, must include the remediation of latent or residual environmental impacts that could become known in the future, such as pumping and treating polluted or extraneous water (RSA, 2015).	Detailed itemisation of activities and costs. Environmental risk assessment report. Final rehabilitation, decommissioning, and mine closure plan.
<b>4. Calculation</b>	An applicant is required to calculate the financial provision by meticulously itemising all activities and costs. This calculation should be based on the real costs associated with implementing the specified measures.  Assets at mine closure or mine infrastructure salvage value cannot be used to defer financial provision liabilities related to annual rehabilitation, final closure, or latent or residual environmental impacts.	Sum of financial provision.  Documentation of how the sum was determined.

<b>Requirements</b>	<b>Processes</b>	<b>Documentation</b>
<b>5. Financial Provision</b>	It is the applicant's or holder's responsibility to ensure that the financial provision is equal to the actual costs of implementing the plans and reports calculated and for a period of at least 10 years at any given time (RSA, 2015).	Final calculated amount and supporting documentation.
<b>6. Financial Vehicles used for Financial Provision</b>	An applicant or holder of a right or permit must make financial provision by one or a combination of a financial guarantee from a bank registered in terms of the Banks Act, 1990 (Act No. 94 of 1990) or from a financial institution registered by the Financial Services Board as an insurer or underwriter, deposit into an account administered by the Minister responsible for mineral resources; or a contribution to a trust fund established in terms of applicable legislation, on condition that this may not be used for the financial provision and this may not be used by an applicant for, or holder of, a mining permit in terms of the MPRDA (RSA, 2015).	Proof of Financial guarantee from a bank or financial institution. Proof of payment into an account administered by the Minister. Proof of Contribution to a trust fund.
<b>7. Annual Review</b>	The holder of a right or permit must annually re-evaluate their closure liabilities and ensure the updated amount is then guaranteed. This could require additional or updates specialist studies to ensure the up-to-date liabilities.	Annual evaluation closure cost report.
<b>8. Audited</b>	An independent auditor must verify the adequacy of the financial provision, including proof of payment. Plans and reports along with an auditor's report must be submitted to the Minister responsible for mineral resources by the holder of a right or permit for approval (RSA, 2015).	Independent auditor verification. Proof of payment verification. Submission of plans and reports with auditor's report for approval.

The calculation of the financial provision is based on criteria line items (Figure 1 and Table 3). These line items are determined through specialist studies which endeavour to fulfil the requirements set out in the GNR.1147 regulations which state:

An applicant is required to accurately calculate the financial provision by conducting a comprehensive listing of all necessary activities and their associated costs. This estimation must be based on the genuine costs needed to carry out the required measures. These measures include:

- (a) annual rehabilitation efforts as outlined in the annual rehabilitation plan;
- (b) the final rehabilitation, decommissioning, and closure activities related to the prospecting, exploration, mining, or production operations upon their conclusion, as detailed in a final rehabilitation, decommissioning, and mine closure plan; and
- (c) the remediation of any latent or residual environmental impacts that might emerge in the future, such as the pumping and treatment of polluted or extraneous water, as documented in an environmental risk assessment report (RSA, 2015).

Table 4 list the criteria mentioned above, these criteria are linked to rehabilitation themes that should be costed for.

**Table 4: List of Criteria and Themes for GNR.1147**

<b>Criteria</b>	<b>Themes</b>
Final Rehabilitation Plan	<ul style="list-style-type: none"> <li>• Post-closure Land Use</li> <li>• Earthworks</li> <li>• Ground Rehabilitation</li> <li>• Specialist Studies</li> </ul>
Decommissioning and Closure Activities	<ul style="list-style-type: none"> <li>• Infrastructure</li> <li>• Support Services</li> </ul>
Mine Closure Plan	<ul style="list-style-type: none"> <li>• Infrastructure</li> <li>• Pollution</li> <li>• Earthworks</li> <li>• Ground Rehabilitation</li> <li>• Water Management</li> <li>• Socio-Economic</li> </ul>

<b>Criteria</b>	<b>Themes</b>
The remediation of any latent or residual environmental impacts that might emerge in the future, such as the pumping and treatment of polluted or extraneous water	<ul style="list-style-type: none"> <li>• Specialist Studies</li> <li>• Pollution</li> <li>• Surface Water Management</li> <li>• Ground Water Management</li> </ul>
Environmental Risk Assessment Report	<ul style="list-style-type: none"> <li>• Specialist Studies</li> <li>• Pollution</li> <li>• Surface Water Management</li> <li>• Ground Water Management</li> </ul>

These criteria are designed to ensure that mine closure is conducted responsibly, with adequate financial resources allocated to address the environmental and social impacts of mining activities, thereby safeguarding communities and ecosystems.

Having reviewed the legal requirements for closure and financial provision the following areas for improvement are noted. The detailed and technical nature of the regulations might be challenging for smaller mining operations or those without significant expertise in environmental management and financial planning. Simplifying some aspects or providing more guidance could improve accessibility and compliance. While the regulations provide a structured approach to cost estimation, they might benefit from allowing more flexibility to accommodate diverse mining operations and their unique environmental and operational contexts. Tailoring the cost estimation process more closely to specific site conditions could improve the accuracy and relevance of the financial provisions.

The regulations could emphasise more on the involvement of stakeholders, including local communities and environmental organisations, in the mine closure planning process. Engaging stakeholders early and throughout the process can enhance transparency, address concerns proactively, and improve the social acceptability of closure plans. As technology and approaches to mine closure evolve, the regulations could include provisions for updating guidance on innovative rehabilitation and closure techniques. Encouraging the adoption of best practices and new technologies can improve environmental outcomes and potentially reduce closure costs. The regulations focus primarily on environmental and technical aspects of mine closure without explicitly addressing the economic sustainability of closure plans. Integrating economic viability assessments could help ensure that closure plans are not only

environmentally sound but also economically feasible, reducing the risk of inadequate financial provision.

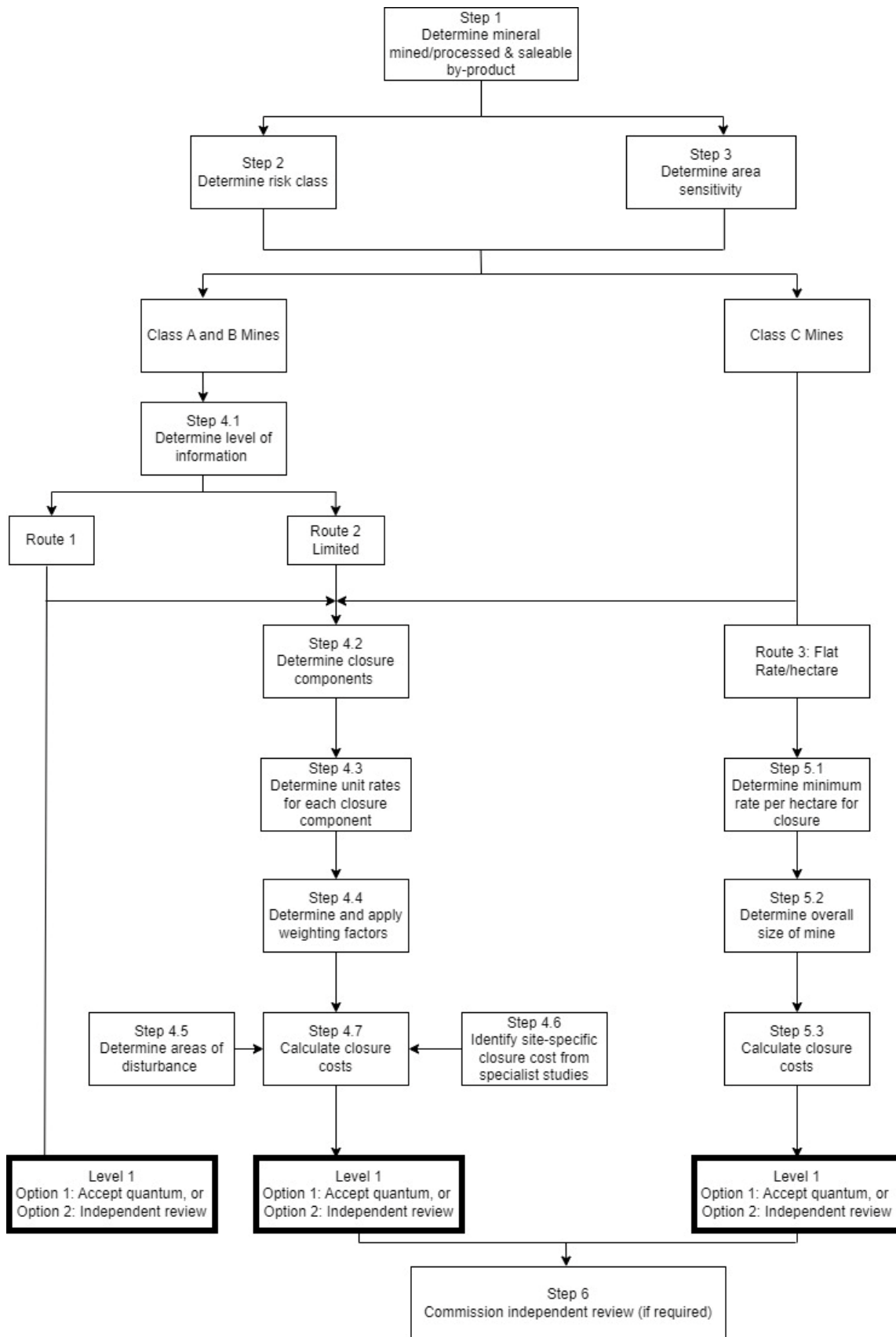
In conclusion, while the GNR.1147 Regulations provide a robust framework for calculating mine closure costs, addressing these areas for improvement could enhance their effectiveness, applicability, and sustainability. Ensuring that mine closure plans are both environmentally responsible and economically viable is essential for the long-term sustainability of mining operations and the protection of the environment and local communities.

### **Minerals and Petroleum Resources Development Act 28 of 2002 (MPRDA) as amended 7 December 2014 (RSA, 2002)**

The critical analysis of the MPRDA guideline for evaluating the quantum of closure-related financial provision by mines reveals a comprehensive framework aimed at ensuring mines adequately provide for environmental rehabilitation and closure, as stipulated under the MPRDA of 2002 (RSA, 2002). The document's executive summary and objectives articulate its purpose to improve understanding among stakeholders about the financial and legal aspects of environmental remediation, enable adequate evaluation and review of financial provisions by the Department of Minerals and Energy (DME), and offer detailed guidance on closure methodologies. The principles adopted within the guideline highlight its legal standing, generic approach, and the intent to standardise the determination of financial provision across the mining industry, while acknowledging the necessity for site-specific considerations and specialist input in comprehensive closure planning.

The guideline outlines specific requirements for making financial provision, which include conducting risk assessments, determining environmental sensitivity, identifying closure components, and calculating closure costs with precision. It mandates mines to assess the primary mineral extracted, classify the operation's risk level, and evaluate the environmental sensitivity of the mine area. Detailed identification of closure components, application of unit rates, and the use of weighting factors are required to accurately estimate the financial provision needed for mine closure. Moreover, the guideline prescribes the calculation of closure costs through specialist studies and established tables, ensuring that mines can accurately determine the quantum of financial provision required. In instances of disagreement on the financial provision's quantum, the guideline advocates for an independent review by a competent person, underscoring the commitment to accuracy and reliability in financial provision calculations.

This analysis reflects the guideline's thorough approach to preparing mines for closure, addressing environmental liabilities, and ensuring financial accountability. It also points out the guideline's reliance on standardisation and comprehensive closure components as strengths, while noting the potential for oversimplification in its generic nature and assumptions regarding salvage value. The emphasis on independent reviews highlights the guideline's dedication to ensuring that financial provisions are accurately calculated, yet it also indicates potential areas of contention between mining operations and regulatory authorities. Overall, the MPRDA guideline serves as a crucial tool for navigating the complex interplay between environmental stewardship and financial planning in the mining sector, advocating for a balanced and detailed approach to mine closure preparations.



**Figure 2: Process Flow Diagram for Calculation the Financial Provision for Closure of a Mine using Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine (DME, 2005)**

Source: Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine (DME, 2005)

The process flow diagram depicted in Figure 2 illustrates the structured approach required for assessing the financial provision for mine closure. Initially, the process requires determining the mineral mined and any saleable by-products (Step 1), as this will influence the environmental impact and the subsequent financial provision. The risk class of the mine is then assessed (Step 2), classifying it into Class A, B, or C, with Class A and B being higher risk and requiring a more detailed assessment process. The risk is calculated by combining what mineral is mined and the size of the mine, therefore an example of a class A mine is a coal mine as the mine and mine waste is classified as large mine and the mineral is being coal is high risk.

For Class A and B mines, the process splits based on the extent of information available; extensive information leads to a detailed, rules-based approach (Route 1, Step 4.1) or an independent review if necessary. Under limited information, a more streamlined rules-based approach is followed (Route 2). This entails identifying closure components (Step 4.2), determining unit rates for each component (Step 4.3), applying weighting and determining factors (Step 4.4), measuring areas of disturbance (Step 4.5), and ultimately calculating closure costs (Step 4.7). Class C mines, which are of lower risk, undergo a less complex process where a flat rate per hectare for closure is applied (Route 3, Steps 5.1 to 5.3), simplifying the calculation of closure costs based on the overall size of the mine.

At two critical junctures, Level 1 the process allows for the acceptance of the calculated quantum or the decision to conduct an independent review, especially in cases where the calculated provision is contested or does not meet regulatory requirements.

Finally, if discrepancies persist or if mandated by the guidelines, an independent review is commissioned (Step 6) to verify the accuracy and sufficiency of the financial provision for closure, ensuring that all potential environmental impacts are adequately funded for the rehabilitation and closure phase. This structured and rigorous process aims to ensure environmental responsibility and financial accountability in mine closure planning.

The process flow diagram ensures a systematic approach to calculating the financial provision for mine closure, considering the variety of factors that can affect the environmental impact and the cost of rehabilitation, and providing avenues for verification and review to ensure accuracy and adequacy of the financial provisions made.

**Table 5: Structured Overview of the MPRDA Guidelines**

<b>Category</b>	<b>Key Requirements</b>	<b>Processes</b>	<b>Documentation Needed</b>
<b>Risk Assessment</b>	Determine mineral mined and saleable by-products. Determine primary risk class (High, Medium, Low) based on environmental sensitivity and type of operation.	In the guideline there are risk tables that one uses for classifying the risk.	Risk assessment documentation.
<b>Environmental Sensitivity</b>	Assess the environmental sensitivity of the mine area (Low, Medium, High).	Depending on the biophysical, social and economic situation of the area a risk table is used to identify the sensitivity.	Sensitivity assessment report.
<b>Financial Provision Calculation</b>	Calculate costs covering rehabilitation, decommissioning, and closure activities. Identify closure costs from specialist studies for high-risk operations. Calculate closure costs using a rules-based approach or detailed assessment.	Estimate direct, indirect, and contingency costs; adjust for inflation. Compile costs for all identified components, applying unit rates and weighting factors.	Cost calculation documentation including breakdown of all anticipated expenses.
<b>Approval and Review</b>	Submission of financial provision to authorities for approval; annual reviews.	Submit initial financial provision for approval; conduct annual reviews and adjust as necessary.	Initial financial provision document, annual review reports, adjustment documentation.
<b>Financial Instruments</b>	Secure financial provision through approved financial instruments.	Select and set up appropriate financial instruments (e.g., bonds, trusts).	Proof of financial instruments (bank guarantees, insurance policies, trust fund agreements).
<b>Documentation and Transparency</b>	Comprehensive documentation of plans and financial provision; transparency with stakeholders.	Develop, submit, and update documentation as required; engage with stakeholders.	Rehabilitation and closure plans, financial provision calculation reports, stakeholder engagement records.

Table 5 offers a structured overview of the MPRDA guideline's requirements for calculating financial provisions for mine closure, categorising the information into categories: Risk Assessment, Environmental Sensitivity, Closure Planning and Cost Calculation, and Validation and Review. Each category summarises a series of steps critical to the comprehensive evaluation of the financial provision needed for mine rehabilitation and closure. The Risk Assessment category involves determining the mineral mined and any saleable by-products, assessing the primary risk class of the mining operation, and revising this risk class, if necessary, based on additional factors. Environmental Sensitivity requires evaluating the mine area's impact on the surrounding environment and adjusting the financial provision accordingly. The Closure Planning and Cost Calculation theme details the identification of specific closure activities, the calculation of their costs, and the adjustment of these costs based on weighting factors for environment and proximity to urban areas. Finally, the Validation and Review theme emphasises the importance of independent review by a competent person to ensure the accuracy and adequacy of the financial provision calculated.

**Table 6: List of Criteria and Themes in the MPRDA/DME Guidelines**

<b>Criteria</b>	<b>Themes</b>
Dismantling of processing plant and related structures (including over- land conveyors and power lines)	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Demolition of steel buildings and structures	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Demolition of reinforced concrete buildings and structures	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Rehabilitation of access roads	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Demolition and rehabilitation of electrified railway lines	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Demolition and rehabilitation of non-electrified railway lines	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Demolition of housing and facilities	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Opencast rehabilitation including final voids and ramps	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Sealing of shafts, adits and inclines	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Rehabilitation of overburden and spoils	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Rehabilitation of processing waste deposits and evaporation ponds (basic, salt-producing waste)	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Rehabilitation of processing waste deposits and evaporation ponds (acidic, metal-rich waste)	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Rehabilitation of subsided areas	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
General surface rehabilitation, including grassing of all denuded areas	<ul style="list-style-type: none"> <li>• Ground Rehabilitation</li> </ul>

<b>Criteria</b>	<b>Themes</b>
River diversions	<ul style="list-style-type: none"> <li>• Surface Water Management</li> </ul>
Fencing	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Water management (Separating clean and dirty water, managing polluted water, and managing the impact on groundwater, including treatment, when required)	<ul style="list-style-type: none"> <li>• Surface Water Management</li> <li>• Ground Water Management</li> <li>• Specialist Studies</li> </ul>
2 to 3 years of monitoring and maintenance	<ul style="list-style-type: none"> <li>• Monitoring and Maintenance</li> </ul>

Table 6 is the criteria used by the DME guideline and it focuses a lot on infrastructure and earthworks. The MPRDA/DME guidelines do not cover the socio-economic financial responsibilities that a mine will have when it closes, and this is a short fall of using this regulation. The regulation states that specialist studies should be used on high-risk operations, therefore depending on how the mine is risk assessed, it could potentially be classified incorrectly. The above criteria along with a Bill of Quantity (BoQ) is used to calculate the financial provision and this potentially has a lot of gaps and areas that are not quantified.

#### **4.2 Perspective from Mine Closure Professionals**

The interviews took place and the data collected was tabled and analysed below. The industry experts all have over five years' experience and have specialised in mine closure assessment. The experts that were interviewed all preferred to use Regulation GNR.1147 of 20 November 2015, as addressed in objective 1.1, if this regulation is used accurately and honestly, it is the most accurate of the allowed regulations in South Africa. However, the experts mentioned that if their clients requested, they would use the DME guidelines as it is a quicker, easier and cheaper option for the mines however the experts say the DME guidelines are flawed and they result in lower calculated financial provisions., due to transitional arrangements, mines who were established before the implementation of the GNR.1147 regulations were allowed to continue to use the DME guidelines until March 2024.

When the experts were asked what specific criteria they used to calculate the financial provisions for their clients' mines, they could not give the exact full criteria that they use (Table 7). This is because each mine and its impacts are different, and they rely on the specialist studies and closure documentation to populate their criteria line items which they use for their calculations. However, when asked which area they focus on, they differed (Table 7). Depending on what area the expert prefers to focus on, this will impact the criteria line items chosen. This represents how open to interpretation the legislation is, even though the experts use specialist studies, due to their experience focus on different areas which intern affects the criteria they use, however they would still be legal in their results.

Once again to be able to compare criteria between objectives, the general criteria that the experts use has been linked to the common themes which were identified in the methodology section (Table 7). The criteria column relates to line items that the experts would cost for, for example: infrastructure dismantling and demolition is the cost it of successful removal of infrastructure from affected sites.

**Table 7: Criteria Used**

Interviewee	Criteria	Key Focus Areas	Themes
<b>Person 1</b>	Infrastructure dismantling and demolition, earthworks, ground rehabilitation, dumps, open pits, pollution, stormwater management, monitoring and maintenance, groundwater, post-closure land use, annual closure plan, Environmental Management Plan (EMP)	<ul style="list-style-type: none"> <li>• Post-closure Land Use</li> <li>• Monitoring</li> <li>• Pollution</li> </ul>	<ul style="list-style-type: none"> <li>• Earthworks</li> <li>• Post-closure Land Use</li> <li>• Pollution</li> <li>• Infrastructure</li> <li>• Surface Water Management</li> <li>• Ground Water Management</li> <li>• Ground Rehabilitation</li> <li>• Monitoring and Maintenance</li> </ul>
<b>Person 2</b>	Infrastructure dismantling and demolition, earthworks, EMP, BoQ	<ul style="list-style-type: none"> <li>• Earthworks</li> <li>• Bulk Commodities</li> <li>• Open Pit Rehabilitation</li> </ul>	<ul style="list-style-type: none"> <li>• Infrastructure (BoQ)</li> <li>• Earthworks</li> <li>• Pollution</li> </ul>

Interviewee	Criteria	Key Focus Areas	Themes
<b>Person 3</b>	Site-specific BoQ criteria, infrastructure dismantling, demolition, earthworks, water management, maintenance, rehabilitation, fencing, river diversions, open-pit safety measures,	<ul style="list-style-type: none"> <li>• Site-specific Criteria</li> <li>• Water Management</li> <li>• Community</li> <li>• Workforce Considerations</li> </ul>	<ul style="list-style-type: none"> <li>• Surface Water Management</li> <li>• Ground water Management</li> <li>• Earthworks</li> <li>• Infrastructure (BoQ)</li> <li>• Socio-Economic</li> <li>• Ground Rehabilitation,</li> <li>• Monitoring and Maintenance</li> <li>• Security</li> </ul>
<b>Person 4</b>	Infrastructure dismantling and demolition, ground rehabilitation, water management, socio-economic, surrounding stakeholders, monitoring and maintenance, transitional (mobilisation/ demobilisation of contractors, consultants and other support services)	<ul style="list-style-type: none"> <li>• Social Aspects</li> <li>• Water Management</li> <li>• Affordability</li> </ul>	<ul style="list-style-type: none"> <li>• Infrastructure</li> <li>• Socio-Economic</li> <li>• Earthworks</li> <li>• Ground Rehabilitation,</li> <li>• Surface Water Management</li> <li>• Ground Water Management</li> <li>• Monitoring and Maintenance</li> <li>• Support Services</li> </ul>

When inquiring about criteria unique to coal mining, a prevalent theme among the experts was the management of both ground and surface water. Coal mines are considered high-risk operations for water source pollution, highlighting the significance of water management in these settings. Consequently, the efforts to mitigate and remediate the impact of such pollution are often associated with substantial costs. This emphasis on water management underscores the environmental challenges coal mines face, particularly regarding their potential to adversely affect water quality, and points to the critical need for effective strategies to address

these risks. Earthworks emerged as another frequently mentioned theme unique to coal mining, particularly due to the prevalence of open-pit mining methods in South Africa. This approach to mining leaves a significant mark on the landscape, resulting in large scars on the earth. Consequently, the volume of earthworks necessary to rehabilitate these areas is substantial, entailing significant effort and expense. The emphasis on earthworks highlights the extensive environmental and physical impact of coal mining, underscoring the challenges and costs associated with restoring the land post-mining to mitigate these effects.

Among the experts consulted, only one expert pinpointed social aspects as a criterion unique to coal mining. This observation is particularly intriguing as the concept of a 'just transition' gains increasing relevance in the context of coal mines. Despite the growing importance of this concept, which emphasises the need for equitable solutions during the transition away from coal to sustainable energy sources, it appears that industry experts are not focusing specifically on these social considerations. This oversight suggests a potential gap in addressing the full spectrum of impacts associated with coal mining, underscoring the necessity for a broader, more inclusive approach to evaluating and mitigating the industry's effects on communities and workers.

**Table 8: Key Gaps captured as Themes**

<b>Key Gaps</b>	<b>Key Themes</b>	<b>Identified by Interviewees</b>
<ul style="list-style-type: none"> <li>• Water management after closure;</li> <li>• Social aspects needing more focus;</li> <li>• Legislative clarification needed; and</li> <li>• Climate change assessment.</li> </ul>	<ul style="list-style-type: none"> <li>• Surface water management</li> <li>• Ground water management</li> <li>• Socio-Economic</li> <li>• Specialist studies</li> </ul>	Person 1
<ul style="list-style-type: none"> <li>• Challenges in obtaining quotes for specific work;</li> <li>• Accuracy issues in long-term pricing; and</li> <li>• Shortcomings in scheduled versus unscheduled calculations.</li> </ul>	<ul style="list-style-type: none"> <li>• Specialist studies</li> </ul>	Person 2
<ul style="list-style-type: none"> <li>• Poor quality of closure reports;</li> <li>• Lack of closure certificates;</li> <li>• Managing of polluted water;</li> </ul>	<ul style="list-style-type: none"> <li>• Specialist studies</li> <li>• Socio-Economic</li> </ul>	Person 3

<ul style="list-style-type: none"> <li>• Lack of community and workforce considerations; and</li> <li>• Climate change assessment.</li> </ul>		
<ul style="list-style-type: none"> <li>• Water and social aspects gaps in legislation;</li> <li>• Inaccuracies in measuring and pricing quantities;</li> <li>• Inadequate consideration of affordability; and</li> <li>• The DME Guideline 2005 (DME, 2005) the increase in the costing is only required by inflating the costs by Consumer Price Index (CPI) where in actual fact, the price increases at a much higher rate.</li> </ul>	<ul style="list-style-type: none"> <li>• Ground water management</li> <li>• Surface water management</li> <li>• Specialist studies</li> </ul>	Person 4

The discourse on mine closure, especially within the realm of coal mining, highlights pronounced gaps in both legislative frameworks and practical implementations (Table 8). These deficiencies point to the multifaceted challenges that need to be addressed to ensure environmentally responsible and socially sustainable closure processes (Table 8).

Legislatively, there is a stark absence of detailed and enforceable regulations specifically targeting the environmental and social impacts of mine closure. This includes a notable lack of stringent requirements for post-closure water management and the mitigation of socio-economic impacts on local communities and workers. Furthermore, legislation falls short in mandating climate change assessments within mine closure plans, overlooking potential risks and failing to integrate forward-looking environmental considerations. Another critical legislative gap is the outdated financial models, such as those relying solely on the CPI for adjusting closure costs as outlined in the DME Guideline 2005, which do not accurately reflect the real cost escalations associated with closure activities.

On the practical side, the implementation of existing guidelines, particularly those related to water management and social impact strategies, often proves inadequate. This indicates a disconnection between the intentions of the law and its practical execution, leading to environmental degradation and social unrest. Moreover, the preparation of closure reports

frequently exhibits deficiencies in quality and completeness, lacking essential assessments and detailed plans for addressing environmental concerns. The engagement of local communities and workforces in the closure process also remains insufficient, resulting in overlooked socio-economic repercussions and missed opportunities for inclusive and ‘just transition’ planning. Additionally, the financial planning and cost estimation practices for closure activities are plagued by inaccuracies and an over-reliance on simplistic financial adjustments, further compounded by a sluggish adaptation to legislative updates and best practices.

To bridge these gaps, a concerted effort from regulatory bodies, mining companies, and environmental advocates is imperative. Legislative reforms should strive for specificity, comprehensiveness, and enforceability, with a keen focus on the nuanced aspects of mine closure. Simultaneously, practical approaches need to evolve to not only meet legislative requirements, but also to embody the principles of environmental care, social equity, and financial prudence. This holistic strategy is crucial for moving towards more responsible mining and closure practices that are attuned to both environmental sustainability and social justice.

The experts have identified common concerns and gaps in mine closure procedures and regulations. Firstly, there is a shared concern about the lack of clarity in defining terms like residual and related risks, posing challenges in understanding, and implementing legislative requirements. The infrequent issuance of closure certificates raises questions about the adequacy of personnel authorised to issue them. Additionally, the experts point to shortcomings in obtaining accurate quotes for specific work, particularly in the context of limited options among demolition companies. The accuracy of pricing for long-term closure activities is questioned, and the estimation for unscheduled events is deemed impractical.

Environmental impact and land usage are recurring themes, with suggestions to collaborate between mines by using neighbouring open pits for overburden disposal. Concerns about water management, especially the difficulty in accurately calculating water impact, are highlighted across the different experts. Social aspects, including community and workforce considerations, are noted as ‘falling through the cracks’, particularly for small mines lacking specific standards.

Moreover, there is consensus on the need for a more comprehensive approach, involving financial specialists alongside environmentalists. Criticisms of the reliance on CPI for cost

inflation and generic EMPs without site-specific closure strategies are echoed by multiple stakeholders. Overall, the identified gaps and concerns underline the complexity and interdisciplinary nature of mine closure, suggesting the need for a more cohesive and adaptable regulatory framework.

The interviews and analysis reveal critical insights into the mine closure process, particularly in the context of coal mining, and identify significant gaps in both legislation and practice. The experts showed a preference for Regulation GNR.1147 of 20 November 2015, citing its accuracy when applied correctly and honestly, compared to the quicker, easier, and cheaper but flawed DME guidelines, which tend to result in lower financial provisions for mine closure. Despite the availability of these regulations, experts face challenges in defining a uniform set of criteria for calculating financial provisions due to the unique nature of each mine and its impacts, relying instead on specialist studies and closure documentation.

The primary concerns identified include the management of ground and surface water, highlighting the environmental challenges of coal mining and the substantial costs associated with mitigating water pollution. Interestingly, social aspects, critical for a 'just transition' away from coal, were notably underemphasised by the experts, suggesting a gap in integrating social considerations into closure planning. The interviews further disclosed concerns over the legislative clarity, accuracy in long-term pricing, and the practical challenges in obtaining quotes for closure activities.

To address these gaps, a coordinated effort from all stakeholders is essential for developing more specific, comprehensive, and enforceable regulations that cover the nuanced aspects of mine closure. This includes a need for legislative reforms that accurately reflect environmental sustainability and social justice principles and practical approaches that align with these updated legislative requirements, ensuring environmentally responsible and socially sustainable closure processes.

### **4.3 International Best Practice**

#### **4.3.1 Western Australian Government requirements - Guidelines for Preparing Mine Closure.**

The Guidelines for Preparing Mine Closure Plans issued by the Western Australian Department of Mines and Petroleum and the Environmental Protection Authority in May 2015 (DMP/EPA,

2011), emphasise the importance of integrating mine closure planning from the inception of mining projects. They define financial provision as: financial provisioning for closure is to guarantee the availability of sufficient funds when the time comes to close the operation, ensuring that the community does not bear any unacceptable financial burdens (DMP/EPA, 2011).

These guidelines advocate for a risk-based approach to address environmental and socio-economic considerations effectively. They are designed to ensure that mines are closed, decommissioned, and rehabilitated to meet regulatory objectives, promoting sustainability, and minimising environmental impacts.

Planning for mine closure and ensuring adequate financial provisions are obtained, incorporates comprehensive strategies and principles that should be adopted by mining operations in Western Australia to ensure ecologically sustainable mine closures. This highlights several key aspects:

**Integration of Closure Planning:** The guidelines underscore the importance of integrating closure planning into the life cycle of the mine, starting as early as the project feasibility stage. This proactive approach is aimed at ensuring that closure considerations are embedded into the operational decisions and planning processes, facilitating a smoother transition to closure. This in turn, helps identify what needs to be costed for with regards to mine closure.

**Risk-Based Approach:** A central theme is the adoption of a risk-based approach to closure planning. This involves identifying potential environmental and socio-economic risks associated with mine closure and developing strategies to mitigate these risks effectively. The risk-based approach is intended to minimise unforeseen challenges during closure and to ensure that closure activities are aligned with environmental sustainability goals and reduce uncertainty in closure costs.

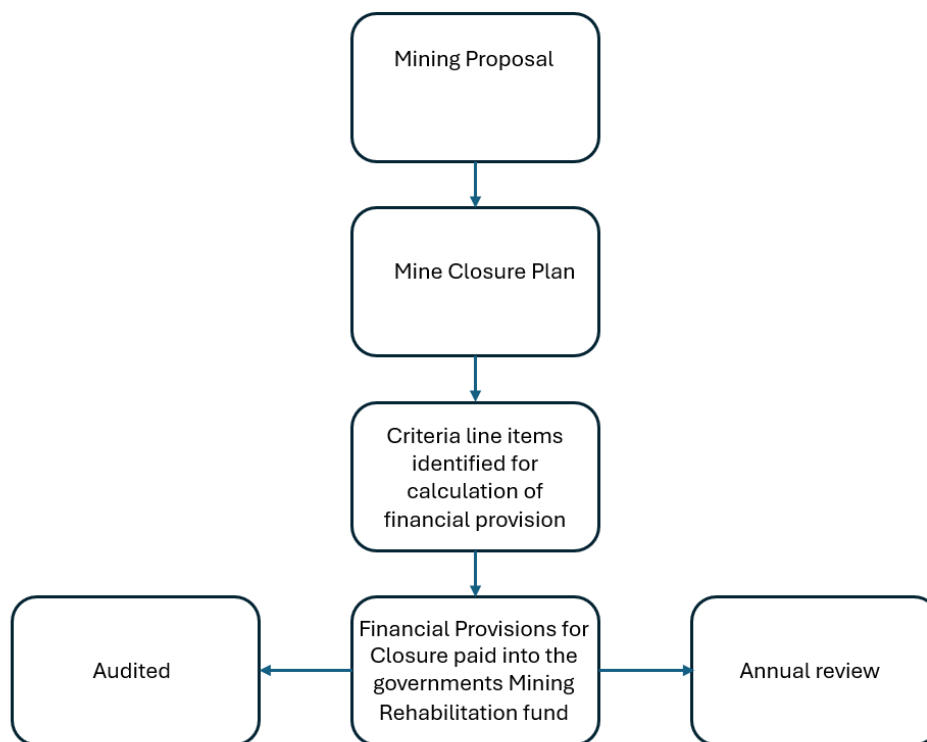
**Stakeholder Engagement:** The guidelines highlight the importance of stakeholder engagement in the mine closure planning process. Engaging with local communities, Indigenous groups, regulatory authorities, and other stakeholders is crucial for identifying concerns, setting post-mining land use objectives, and ensuring that the closure plan is responsive to the needs and expectations of all interested parties. Which in turn, has an impact on what the financial provisions need to account for.

**Dynamic and Progressive Planning:** Mine closure plans are described as ‘living documents’ that should be regularly reviewed and updated throughout the mine's life. This dynamic approach acknowledges that changes in the operational, environmental, and regulatory context can impact closure strategies and necessitates periodic adjustments to the closure plan. It will also alter the financial provision each time.

**Specific Closure Considerations:** The section also addresses specific closure considerations, such as post-mining land use planning, development of completion criteria, and management of closure issues (e.g., acid and metalliferous drainage, hazardous materials, and contaminated sites). These considerations are critical for ensuring that the mine site can be safely and sustainably managed post-closure.

Critically, while the guidelines provide a robust framework for planning mine closure, the effectiveness of these strategies depends on their implementation by mining companies and the oversight of regulatory authorities. Challenges may arise in balancing economic considerations with environmental sustainability goals, particularly in the context of fluctuating commodity prices and operational constraints. Additionally, the specificity of guidance on certain closure issues, such as management of pit lakes or dealing with legacy contamination, may require further detail or technical guidance to assist mine operators in developing effective closure strategies.

The guidelines for calculating the financial provisions using the Guidelines for Preparing Mine Closure Plans issued by the Western Australian Department of Mines and Petroleum and the Environmental Protection Authority in May 2015 (DMP/EPA, 2011) is summarised into the following process flow diagram (Figure 3).



**Figure 3: Process Flow Diagram for Calculation the Financial Provision for Closure of a Mine using the Guidelines for Preparing Mine Closure Plans issued by the Western Australian Department of Mines and Petroleum and the Environmental Protection Authority in May 2015 (DMP/EPA, 2011)**

Figure 3 delineates a critical aspect of the financial provision process, emphasising the necessity of a comprehensive mine closure plan right from the inception phase of a mining project. This plan serves as a blueprint, outlining specific rehabilitation actions and interventions needed to mitigate the environmental impact once the mine ceases operations. It meticulously lists criteria and line items, such as infrastructure dismantlement, land rehabilitation, water treatment, and the restoration of flora and fauna, among others, that are crucial for restoring the mining site to a state that is safe and environmentally stable.

The financial aspect of this plan is a focal point, requiring a detailed cost estimation for each rehabilitation activity. This estimation forms the basis of the financial provision where a set monetary amount must be allocated to cover the costs of these activities in the event of an unplanned or premature closure. The rationale behind this provision is to ensure that sufficient funds are readily available, without imposing any financial liability on the local community or the government, should the mining company fail to fulfil its rehabilitation responsibilities.

To safeguard these funds and ensure they are used for their intended purpose, the financial provision is deposited into the government's Mining Rehabilitation Fund (MRF). This fund acts as a financial safety net, providing the necessary resources for rehabilitation in cases where a mining company cannot or does not address the environmental aftermath of its operations. The integrity and adequacy of this financial provision are maintained through an annual audit and review process. This rigorous scrutiny evaluates the sufficiency of the allocated funds in light of evolving rehabilitation needs, cost fluctuations, and any changes in mining operations or environmental regulations. This continuous evaluation process ensures that the financial provision remains responsive to the actual costs of implementing the mine closure plan, thereby upholding environmental protection standards and safeguarding community interests.

The Identification and Management of Closure Issues addresses the necessity for mine operators to comprehensively identify and effectively manage various closure-related challenges to ensure environmentally sustainable mine closure and rehabilitation. This section delineates a broad spectrum of closure issues, including hazardous materials, unsafe facilities, contaminated sites, acid and metalliferous drainage, radioactive materials, and impacts on water quality and biodiversity. Additionally, it highlights the significance of addressing dispersive and sodic materials, managing pit lakes, and mitigating dust emissions and visual impacts.

However, the successful application of these guidelines depends on several factors, including the availability of accurate and comprehensive data, the effectiveness of stakeholder engagement, and the adaptability of management strategies to evolving site conditions and regulatory requirements. The challenges of accurately predicting long-term environmental impacts and ensuring the availability of adequate financial and technical resources for closure activities are also significant considerations.

Table 9 outlines the required criteria for financial provisioning for mine closure in Western Australia, capturing a broad array of activities. This set of criteria is thorough, potentially covering all facets of the closure process, though its comprehensiveness and effectiveness ultimately rely on the precision of specialist studies. The criteria are connected to the themes discussed in the methodology section, allowing for their comparison with other identified international best practices. This structured approach ensures that the financial provisions are not only grounded in detailed, expert analyses but are also aligned with industry standards, facilitating a comprehensive framework for adequately addressing and funding the various

components of mine closure. This alignment aims to ensure that all necessary environmental and socio-economic considerations are accounted for, based on a rigorous and comparative analysis of closure strategies.

**Table 9: List of Criteria and Themes in the Western Australian Department of Mines and Petroleum and the Environmental Protection Authority in May 2015 (DMP/EPA, 2011)**

Criteria	Themes
Earthmoving and landscape forming	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Management of problematic materials	<ul style="list-style-type: none"> <li>• Pollution</li> <li>• Ground Water Management</li> </ul>
Post-closure management of surface water drainage	<ul style="list-style-type: none"> <li>• Surface Water Management</li> </ul>
Closure research and trials	<ul style="list-style-type: none"> <li>• Specialist Studies</li> </ul>
Decommissioning and removal of infrastructure	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
Remediation of contamination	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Progressive and final rehabilitation	<ul style="list-style-type: none"> <li>• Ground Rehabilitation</li> </ul>
Maintenance and monitoring, and auditing programmes Includes post-closure phase	<ul style="list-style-type: none"> <li>• Monitoring and Maintenance</li> </ul>
Ongoing stakeholder engagement process	<ul style="list-style-type: none"> <li>• Socio-Economic</li> </ul>
Closure project management costs	<ul style="list-style-type: none"> <li>• Support Service Fees</li> </ul>
Specialist and consultant fees	<ul style="list-style-type: none"> <li>• Support Service Fees</li> </ul>
Provision for installing additional infrastructure. Required for the agreed land uses	<ul style="list-style-type: none"> <li>• Post-closure Land Use</li> </ul>
Provision for potential delays, extreme events or other external factors relevant to closure	<ul style="list-style-type: none"> <li>• Delays</li> </ul>

The objective of this comprehensive financial provisioning is to ensure that closure costs are estimated as early as possible, identifying that early estimates are subject to assumptions and unforeseen events. The guidelines require these assumptions to be clearly documented with a percentage for cost variation, which should be refined during the operations and decommissioning phases.

In conclusion, the Guidelines represent a forward-thinking framework that underscores the critical importance of early, integrated, and comprehensive planning for mine closure. By advocating for a risk-based approach, stakeholder engagement, and dynamic planning, the aim is to ensure that mining operations conclude in a manner that safeguards environmental

sustainability and supports socio-economic development. The effectiveness of these guidelines' hinges on their meticulous application by mining entities and diligent oversight by regulatory bodies, emphasising the need for continuous adaptation and improvement in response to evolving challenges and opportunities in mine closure practices.

#### **4.3.2 Evaluation of the Integrated Mine closure Good Practice from the ICMM**

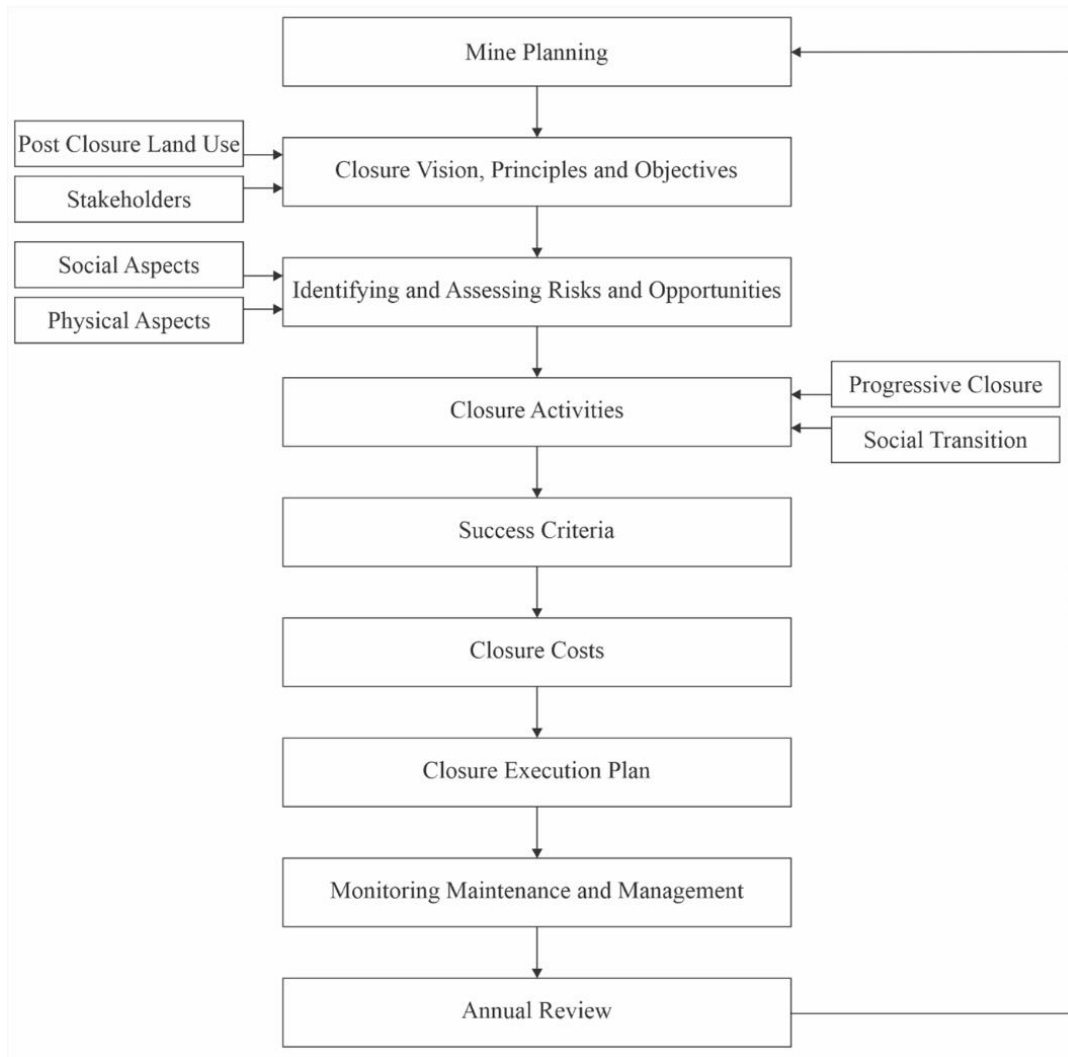
The ICMM Guidance on Integrated Mine Closure: Good Practice Guide, 2nd Edition represents a significant contribution towards fostering sustainable practices in the mining industry, with a focus on the integration of mine closure activities throughout the mining lifecycle. This guide underscores the importance of a holistic approach to mine closure, advocating for proactive planning from the onset of mining activities to ensure environmentally sustainable, socially responsible, and economically viable outcomes. A notable strength of the guide is its emphasis on stakeholder engagement, highlighting the necessity of inclusive dialogue with local communities, governments, and employees to align closure plans with broader societal expectations and covering these in the calculation of the financial provision. Additionally, the inclusion of practical tools, methodologies, and case studies offers valuable resources for mining companies, facilitating the application of best practices in real-world scenarios.

Despite these strengths, there are areas where the guide could be improved to enhance its applicability and effectiveness further. It could benefit from greater emphasis on adaptability to diverse geographical, cultural, and regulatory environments, ensuring that the guidance is relevant across the broad spectrum of contexts in which mining companies operate. Moreover, a stronger focus on innovation and technology, such as renewable energy, advanced monitoring systems, and novel rehabilitation techniques, could empower companies to address closure challenges more efficiently. Enhancing the sections on post-closure monitoring and evaluation would also be beneficial, providing detailed methodologies for assessing the long-term success of closure initiatives. Lastly, expanding the discussion on financial assurance mechanisms would provide more comprehensive support for ensuring the availability of closure funds, especially under unforeseen financial challenges.

Overall, while the guide serves as a valuable resource for promoting sustainable mine closure practices, integrating innovative approaches, and tailoring guidance to specific local contexts could significantly increase its relevance and impact. Future editions could therefore benefit

from addressing these areas for improvement, ensuring that the guide remains a cornerstone resource for responsible mine closure.

The ICMM guide process flow diagram for calculating the financial provision for closure of a mine is shown in Figure 4.



**Figure 4: Process Flow Diagram for Calculation the Financial Provision for Closure of a Mine using ICMM**

The process flow diagram is explained as follows:

**Mine Planning:** This initial phase involves strategically incorporating closure considerations into the mine design and operational plan to ensure a smoother transition to closure as well as accurate financial provisions.

**Closure Vision, Principles and Objectives:** At this stage, a comprehensive vision for the mine's closure is developed, which includes establishing key principles and setting specific objectives that reflect environmental, economic, and community values. These will be used in creating the criteria line items that will be costed for the financial provision.

**Identifying and Assessing Risks and Opportunities:** Here, a thorough analysis of potential risks and opportunities associated with the mine's closure is conducted, considering factors like regulatory requirements, environmental impacts, and social implications. These will be used in creating the criteria line items that will be costed for the financial provision.

**Closure Activities:** Detailed closure tasks are outlined, which can range from environmental remediation to infrastructure dismantling, and plans are made for their execution. These will be used in creating the criteria line items that will be costed for the financial provision.

**Progressive Closure:** This involves the ongoing implementation of closure-related activities during the mine's operational phase to reduce the burden and risks at the actual point of closure. This is important because with concurrent rehabilitation the closure liabilities of the mine reduce thus the financial provision should reduce.

**Social Transition:** Strategies are prepared to address the social impacts of closure, such as workforce redeployment and support for affected communities, to ensure a smooth transition post-mining. These will be used in creating the criteria line items that will be costed for the financial provision.

**Success Criteria:** Concrete criteria are established to measure the effectiveness and success of the closure process against the set objectives. This will be the criteria line items that will be costed for the financial provision.

**Closure Costs:** A comprehensive financial estimate is made of all the costs associated with the closure activities identified previously.

**Closure Execution Plan:** This plan operationalises the strategy by detailing the approach, schedule, responsibilities, and resources required for effective closure implementation.

**Monitoring Maintenance and Management:** Post-closure, the site is monitored to manage any ongoing environmental or social issues, ensuring the long-term stability and safety of the closure.

**Annual Review:** Regular review and revision of the closure plan are essential to adapt to any changes in the operational environment or regulatory requirements, ensuring the plan remains relevant and effective.

These steps are interconnected and cyclical, often requiring revisitation and revision as the mine progresses through its lifecycle and new information comes to light.

Based on the ICMM guide, the criteria used to calculate closure costs include a range of direct costs, which are typically considered in closure cost estimates. Table 10 is a list of criteria and themes in the ICMM guide.

**Table 10: List of Criteria and Themes in the ICMM Guide**

<b>Criteria</b>	<b>Themes</b>
Decommissioning and demolition of structures and clean-up of contaminated sites.	<ul style="list-style-type: none"> <li>• Infrastructure</li> <li>• Pollution</li> <li>• Specialist Studies</li> </ul>
Earthworks, including re-sloping, channel construction/expansion, placement of erosion protection material, relocating waste materials, cover construction, and borrow source development.	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Implementation of rehabilitation measures, such as seeding, planting, fertiliser placement, maintenance, and other related activities.	<ul style="list-style-type: none"> <li>• Ground Rehabilitation</li> </ul>
Water management, encompassing both surface and groundwater management.	<ul style="list-style-type: none"> <li>• Surface Water Management</li> <li>• Ground Water Management</li> <li>• Specialist Studies</li> </ul>
Treatment of water, which may involve the construction and operation of water treatment plants.	<ul style="list-style-type: none"> <li>• Water Management</li> </ul>
Liner installation or removal.	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Construction of seals on underground mine openings to the surface.	<ul style="list-style-type: none"> <li>• Earthworks</li> </ul>
Post-closure monitoring and maintenance.	<ul style="list-style-type: none"> <li>• Monitoring and Maintenance</li> </ul>
Access control and signage.	<ul style="list-style-type: none"> <li>• Security</li> </ul>
Disposal costs.	<ul style="list-style-type: none"> <li>• Pollution</li> </ul>

<b>Criteria</b>	<b>Themes</b>
Costs of funding the management of future or long-term activities related to residual risks.	<ul style="list-style-type: none"> <li>• Post-closure Land Use</li> <li>• Support Services</li> </ul>
Closure planning and decommissioning investigations and studies to inform and assist in development of the closure designs. Includes climate change.	<ul style="list-style-type: none"> <li>• Specialist Studies</li> </ul>
Mobilisation/demobilisation of contractors, consultants and other support services.	<ul style="list-style-type: none"> <li>• Support Services</li> </ul>
Retrenchment of staff.	<ul style="list-style-type: none"> <li>• Socio-Economic</li> </ul>
Socio-economic programmes.	<ul style="list-style-type: none"> <li>• Socio-Economic</li> </ul>
Engineering, procurement, and construction management (EPCM) costs.	<ul style="list-style-type: none"> <li>• Support Services</li> </ul>
Health and safety plans, construction monitoring and QA/QC.	<ul style="list-style-type: none"> <li>• Safety</li> </ul>
Costs for management of closure activities, including management and supervision, power, water and sewage services, fuel and supplies.	<ul style="list-style-type: none"> <li>• Support Services</li> </ul>
Closure planning activities.	<ul style="list-style-type: none"> <li>• Specialist Studies</li> </ul>
Interim care and maintenance costs (sometimes required while closure designs are being finalised).	<ul style="list-style-type: none"> <li>• Monitoring and Maintenance</li> </ul>
Ongoing dam safety inspections and reviews.	<ul style="list-style-type: none"> <li>• Security</li> </ul>

The criteria outlined in the ICMM guideline for mine closure are notably comprehensive, addressing a wide spectrum of considerations, including the assessment of climate change impacts within the closure planning process. This thoroughness in defining criteria and line items contributes significantly to enabling the most accurate calculation of financial provisions necessary for mine closure. Such detailed and inclusive criteria ensure that financial planning encompasses all potential environmental, social, and economic impacts, allowing for a well-rounded approach to closure that anticipates future challenges and mitigates adverse effects.

However, the effectiveness and accuracy of these comprehensive criteria are contingent upon the quality of specialist studies conducted in preparation for mine closure. The depth and detail of these studies play a crucial role in informing the criteria and, by extension, the financial provisioning. If the specialist studies lack precision or fail to cover all necessary aspects, the financial estimation based on these criteria may not fully account for all potential closure costs.

Therefore, while the ICMM guideline offers a robust framework for closure planning, its successful implementation and the accuracy of the resulting financial provisions heavily depend on the thoroughness and accuracy of the specialist studies underpinning the closure plan.

In summary, the integrated mine closure approach advocated by ICMM requires meticulous planning, stakeholder engagement, and continuous evaluation to ensure that mine closure is responsible and beneficial for all stakeholders. This comprehensive strategy not only addresses environmental and social concerns but also aligns with economic objectives, contributing to sustainable development in the post-mining landscape.

### **4.3.3 The Standardized Reclamation Cost Estimator (SRCE) from the United States of America.**

The SRCE is a software tool designed to assist in the calculation of reclamation costs for mining operations. This tool is typically used by engineers, environmental scientists, and financial analysts to estimate the cost of restoring a mine site to a condition that meets regulatory requirements and other stakeholder expectations after mining operations have ceased.

The software facilitates detailed scheduling at the activity level, allowing users to delineate and plan reclamation tasks with precision. Enhancements in productivity calculations give users more control, including the ability to input specific data. Additional modules have been introduced for calculating equipment hours and for managing mobilisation/demobilisation costs. The software also allows for the scheduling of various categories of environmental sampling and includes several presentation-ready graphs. These graphical representations help users convey cost estimates to stakeholders effectively.

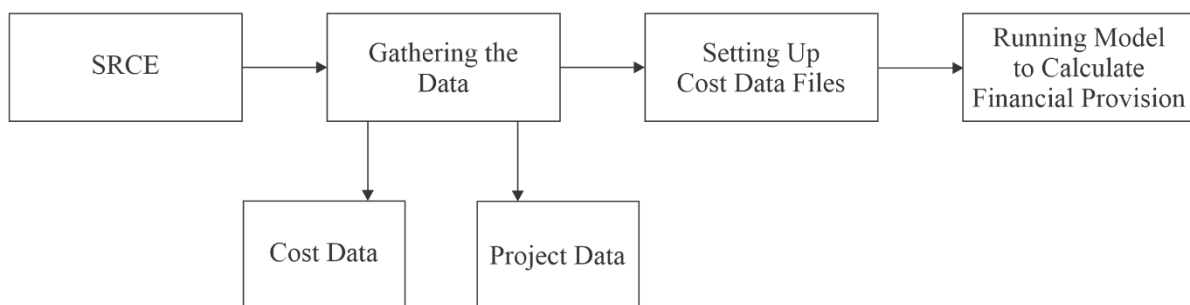
The SRCE 2.0 is equipped with a suite of features designed to aid in the detailed estimation of mine closure costs. Its ability to account for various cost data and project data is essential for creating a comprehensive financial provision for mine closure. Users can input a wide range of data, which the SRCE model processes to provide an estimate. The depth and breadth of its features, such as the inclusion of mobilisation/demobilisation costs and environmental sampling schedules, suggest a thorough understanding of the reclamation process.

While the model provides a framework for cost estimation, the reliability of its output heavily depends on the accuracy of the input data. This means that the quality of the results is

contingent on the user's ability to gather precise and detailed data. Additionally, the software is input-heavy relative to other calculators and depends on rates and quantities which are often difficult to obtain.

The adaptability of the SRCE 2.0 to different mining scenarios and regulatory environments is important to the strength of using this method in mine closure calculations. Mine closure requirements can vary significantly based on geographical location, the scale of operations, and local regulations. The SRCE must offer enough flexibility to adjust to these conditions, allowing users to create estimates that are not only accurate but also compliant with all necessary legal standards.

In conclusion, while the SRCE 2.0 appears to be a comprehensive tool for estimating mine closure costs, its effectiveness is largely dependent on the user's expertise and the quality of the input data. As with any modelling software, it is a tool to assist professionals but not a substitute for expert judgment and experience in mine closure planning.



**Figure 5: SRCE 2.0 Process Flow Diagram of How to Calculate Financial Provisions for Mine Closure**

The process flow diagram above (Figure 5) illustrates the sequence of steps involved when using the SRCE Version 2.0 to calculate financial provisions for mine site reclamation. Below is an explanation of each step in the process:

**SRCE:** This represents the starting point where the SRCE software is initialised. It is the platform that will be used to carry out the subsequent steps.

**Gathering the Data:** In this critical step, the user must collect all necessary data that will be used to inform the cost estimation process. This data is bifurcated into two streams:

**Cost Data:** This includes all financial information relevant to the reclamation activities. It would typically encompass equipment rental or purchase costs, labour rates, material costs, and any other direct or indirect expenses that would be incurred during the reclamation process.

**Project Data:** This stream involves gathering all physical and logistical data about the mine site that might affect the reclamation process and associated costs. This could include geographical data, site infrastructure, environmental studies, and any other site-specific information required to build an accurate cost model.

**Setting Up Cost Data Files:** Once the data has been collected, the user must input or import this information into the SRCE to create cost data files. This set-up process is crucial as it organises the data in a way that the SRCE can use to generate accurate cost estimates.

**Running Model to Calculate Financial Provision:** With the cost data files configured, the SRCE model is run. At this stage, the software processes the input data using its built-in algorithms and produces an estimate of the financial provision required for the reclamation of the mine site. This financial provision is an estimate of the total expected cost to return the disturbed land to a safe and stable state after mining operations have ceased.

The flow diagram indicates a linear progression from initialising the SRCE software, through data collection and organisation, to finally running the model to obtain financial estimates. Each step is dependent on the successful completion of the previous one, highlighting the importance of meticulous data collection and input to ensure the accuracy of the cost estimation output.

Based on the SRCE Version 2.0 User Manual, the criteria needed to estimate the costs associated with the reclamation of mine sites are extensive and detailed. Table 11 is a summarised list of the key criteria and data required and the themes in the SRCE.

**Table 11: List of the Key Criteria and Data Required and the Themes in the SRCE**

Criteria	Themes
<p><b>Cost Data:</b></p> <ul style="list-style-type: none"> <li>• Equipment rates, including purchase, operation and maintenance costs.</li> </ul>	<ul style="list-style-type: none"> <li>• Support Services</li> <li>• Earthworks</li> </ul>

Criteria	Themes
<ul style="list-style-type: none"> <li>• Labour rates, which may vary based on unionised or non-unionised workforce, including all fringe benefits, taxes, insurance, and contractor’s profit.</li> <li>• Material rates for items necessary for reclamation, like seeds, mulch, and fertilisers, which should include long-term averages to account for price volatility.</li> <li>• Third-party contractor estimates, which are often used for financial reporting and may need to be verified for accuracy and completeness.</li> <li>• Mine-specific data, particularly for planning and budgeting purposes, which should reflect all indirect costs related to the project.</li> </ul>	
<p><b>Project Data:</b></p> <ul style="list-style-type: none"> <li>• Precise topographical maps displaying all project facilities at closure time and following the completion of reclamation.</li> <li>• Measurements from CAD drawings or mine planning software to collect dimensions, volumes, and other physical data.</li> <li>• Techniques and design standards employed to outline the closure plan for the facilities, including regulatory compliance requirements.</li> <li>• Environmental data such as soil type, hydrology, and climate conditions.</li> <li>• Infrastructure details like roads, buildings, and service utilities.</li> </ul>	<ul style="list-style-type: none"> <li>• Infrastructure</li> </ul>
<p><b>Regulatory and Compliance Data:</b></p> <ul style="list-style-type: none"> <li>• Any jurisdiction-specific requirements for the reclamation process and cost estimation.</li> <li>• Financial assurance and bonding requirements.</li> <li>• Legal obligations and standards for closure.</li> </ul>	<ul style="list-style-type: none"> <li>• Support Services</li> </ul>
<p><b>Environmental and Safety Considerations:</b></p> <ul style="list-style-type: none"> <li>• Potential environmental impacts and measures to mitigate them.</li> <li>• Health and safety considerations for the workforce during reclamation activities.</li> </ul>	<ul style="list-style-type: none"> <li>• Pollution, Specialist Studies</li> </ul>
<p><b>Operational Scenarios:</b></p> <ul style="list-style-type: none"> <li>• Different reclamation strategies and their associated costs.</li> <li>• Post-closure land use objectives and maintenance plans.</li> </ul>	<ul style="list-style-type: none"> <li>• Monitoring and Maintenance</li> </ul>

Criteria	Themes
	<ul style="list-style-type: none"> <li>• Post-closure Land Use</li> </ul>
<b>Stakeholder and Community Involvement:</b> <ul style="list-style-type: none"> <li>• Community impact assessments and engagement records.</li> <li>• Land ownership and any agreements with local communities or governments.</li> </ul>	<ul style="list-style-type: none"> <li>• Socio-Economic</li> </ul>

These criteria are critical for creating a detailed and accurate cost estimate for mine reclamation, which ensures that all aspects of the closure process are financially accounted for and planned effectively. The SRCE 2.0 model allows for flexibility in inputting this data, enabling it to accommodate a range of site-specific conditions and reclamation methods.

The SRCE was designed for a variety of input methods, basically the SCRE can be used in conjunction with any of the previous methods discussed above, where it is powerful, is that it is more accurate in measuring the quantities and ensuring more accurate costs A reclamation and closure plan that is incomplete cannot be made up for by the model. While this tool may assist in uncovering gaps in the closure planning process, it may also highlight data errors in certain circumstances when used properly (SRCE, 2019)

#### 4.3.4 Comparing Objective 2 Criteria.

Table 12 compares the criteria themes that each of the international best practices requires for calculating the financial provision for mine closure.

**Table 12: Comparison of the Minimum Criteria of each International Best Practice required for Calculating the Financial Provision for Mine Closure**

Western Australian Government requirements - Guidelines for Preparing Mine Closure (May 2015) (DMP/EPA, 2011)	Integrated Mine Closure Good Practice from the ICMM (2nd edition 2019) (ICMM, 2019)	Standardized Reclamation Cost Estimator (SRCE) from the United States of America (16 May 2019) (SRCE, 2019)
Infrastructure	Infrastructure	Infrastructure
Pollution	Pollution	Pollution
Earthworks	Earthworks	Earthworks
Ground Rehabilitation	Ground Rehabilitation	Ground Rehabilitation
Surface Water Management	Surface Water Management	
Ground Water Management	Ground Water Management	

	Security	
Post-closure Land Use	Post-closure Land Use	Post-closure Land Use
Monitoring and Maintenance	Monitoring and Maintenance	Monitoring and Maintenance
Support Services	Support Services	Support Services
Socio-Economic	Socio-Economic	Socio-Economic
Specialist Studies	Specialist Studies	
Delays		
	Safety	

Source: Western Australian Government requirements - Guidelines for Preparing Mine Closure (May 2015) (DMP/EPA, 2011); Integrated Mine closure Good Practice from the ICMM (2nd edition 2019) (ICMM, 2019); The Standardized Reclamation Cost Estimator (SRCE) from the United States of America (16 May 2019) (SRCE, 2019)

The Integrated Mine Closure Good Practice guide from ICMM (2nd edition, 2019) emerges as the most thorough framework for identifying comprehensive criteria line items for calculating financial provisions for mine closure, closely followed by the Western Australian Government's Guidelines for Preparing Mine Closure (May 2015). In contrast, the SRCE from the USA (16 May 2019) is not a guideline but rather a tool that depending on the input data can be as comprehensive as the ICMM guidelines. However, it ranks as less comprehensive, covering fewer theme as a bases as it requires the user to input what they deem necessary over and above the minimum. Despite this, it is recognised as part of the international best practices due to its accuracy and effectiveness in cost calculation, contingent on the quality of input data.

All three methodologies underscore the necessity of including decommissioning and removal of infrastructure in their thematic considerations. However, given that coal mining operations often feature basic infrastructure due to minimal processing requirements, these expenses are not as significant as others. Conversely, the extensive linear infrastructure typical of coal mines, such as power lines and access roads, demands substantial financial provisioning for rehabilitation due to the substantial footprint of these operations.

Earthworks represent one of the costliest facets of mine rehabilitation, especially for coal mines with their characteristically large open pits (Menegaki & Kaliampakos, 2011). Proper earthworks are essential, not only for legal closure, but also for mitigating safety hazards associated with leaving pits open. Both earthworks and ground rehabilitation are pivotal for managing post-closure land use and minimising environmental impacts like soil erosion and water contamination. The planned post-closure land use plays a critical role in determining the scope and cost of these activities, affecting whether a site is returned to natural vegetation or repurposed for recreational or agricultural use.

Water management is a significant concern for coal mines, with the ICMM and DMP guidelines addressing the financial implications of surface and groundwater management and treatment. The accuracy of these cost estimates heavily relies on detailed specialist studies in water management. Similarly, pollution control is a universal theme across all methodologies, highlighting the importance of addressing waste management facilities' rehabilitation costs. Post-closure monitoring and maintenance are acknowledged by all three approaches, with the precision of these cost estimates depending on the identification of residual and latent effects through specialist studies.

The inclusion of support services captures the administrative and operational costs essential for the closure process, emphasising the need for skilled professionals to manage the multifaceted tasks associated with mine rehabilitation. Furthermore, all methods consider the socio-economic impacts on the workforce and nearby communities, emphasising the necessity of stakeholder engagement and the development of socio-economic programmes to support the transition of employees and the integration of mine closure into local development plans.

Specialist studies are highlighted by the ICMM and DMP guidelines as crucial for accurately assessing and modelling environmental risks, such as water management and soil chemistry, to inform effective closure strategies. These studies ensure that rehabilitation plans are scientifically sound and adapted to the specific conditions of the mine site, facilitating a responsible and sustainable mine closure process.

#### **4.3.5 Comparing Criteria Objective 1 vs Objective 2.**

Table 13 demonstrates a side-by-side comparison of themes identified through Objectives 1 and 2, revealing a notable consistency between them, with security considerations emerging as the sole differentiator in the themes consolidated from Objective 2. This similarity prompts a critical reflection on the underestimation of mine closure provisions in South Africa, despite the apparent alignment of identified themes. This report points to the crucial roles played by specialised reports, the exploration of residual and latent effects, and mandated risk assessments in creating gaps between projected and actual costs required for mine closure. Such variations are predominantly linked to the depth of analysis and the accuracy applied in these critical assessments.

**Table 13: Side-by-Side Comparison of Themes Identified through Objectives 1 and 2**

<b>Objective 1: Combined Themes</b>	<b>Objective 2: Combined Themes</b>
Infrastructure	Infrastructure
Pollution	Pollution
Earthworks	Earthworks
Ground Rehabilitation	Ground Rehabilitation
Water Management	Water Management
	Security
Post-closure Land Use	Post-closure Land Use
Monitoring and Maintenance	Monitoring and Maintenance
Support Services	Support Services
Socio-Economic	Socio-Economic
Specialist Studies	Specialist Studies
	Safety

#### **4.4 Detailed Criteria for the Calculation of Financial Provision for Closure of Coal Mines in South Africa**

Table 14 presents a detailed compilation of themes critical for the calculation of financial provisions for coal mine closure in South Africa. This list joins the insights from Objectives 1 and 2, offering a robust framework for understanding the financial requirements of mine closure. Each item is accompanied by a rationale, interpreting its significance in accurately determining the costs associated with the closure of a coal mine in South Africa.

**Table 14: Proposed Closure Criteria required for calculating the Financial Provision for Mine Closure**

<b>Proposed Closure Themes</b>	<b>Comments</b>
<p><b>Infrastructure</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>Demolishing and decommissioning of buildings and clean-up of contaminated sites; and</li> <li>putting up and pulling down powerlines</li> </ul>	<p>The decommissioning and demolition process requires identifying all structures within the coal mine, for which a BoQ must be either provided or developed. Additionally, any off-site infrastructure constructed by the mine should be incorporated into both the rehabilitation plan and its associated costs.</p>
<p><b>Pollution</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>contaminated land;</li> </ul>	<p>For decommissioning and demolition, including site decontamination, it is essential to catalogue all structures within the coal mine. The process</p>

Proposed Closure Themes	Comments
<ul style="list-style-type: none"> <li>• pollution control dams;</li> <li>• waste; and</li> <li>• tailing storage facilities</li> </ul>	<p>must also encompass the financial assessment of waste disposal, notably for hazardous materials, which represents a significant expenditure. Additionally, the management of contaminated water and tailings dams, including the cost implications of liner removal or maintenance and the potential construction of new dams, must be thoroughly evaluated, and incorporated into the overall budgeting.</p>
<p><b>Earthworks</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• landscaping;</li> <li>• removal of linear infrastructure such as roads and pipelines;</li> <li>• back filling;</li> <li>• ripping; and</li> <li>• topsoiling</li> </ul>	<p>In coal mining, significant financial resources must be allocated for earthworks due to substantial landscape modifications, such as reshaping and capping extensive areas. The cost of rehabilitating open pits and voids is particularly notable for coal mines, which are usually open pit. These expenses vary widely, depending on the future use of the land post-closure, be it for agricultural, grazing, or recreational activities. Therefore, precise budgeting is essential and must account for the varied cost implications of different land uses and the necessary restoration of access roads.</p>
<p><b>Ground Rehabilitation</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• grass seed mixes; and</li> <li>• trees</li> </ul>	<p>The substantial area impacted by coal mines necessitates considerable investment in topsoiling and revegetation, with costs significantly influenced by the planned use of the land after mine closure, which determines the choice of vegetation. Additionally, climate change considerations are crucial in selecting appropriate plant species. The challenge of topsoil being either lost or contaminated requires an assessment of both the quantity of topsoil needed for rehabilitation and what is available, with topsoil replacement representing a major expense in the financial planning for</p>

Proposed Closure Themes	Comments
	mine closure. This expense underlines the importance of mines taking greater care in preserving their topsoil.
<p><b>Surface Water Management</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• storm water drainage; and</li> <li>• settlement ponds.</li> </ul>	<p>Identifying and addressing issues like leaking tailings dams, accumulation of contaminated water, and highly polluted zones is crucial. These challenges necessitate detailed investigations and accurate cost assessments for their treatment, closure, and rehabilitation. Water management is particularly critical for coal mines, as treating and managing contaminated water, identified through specialist studies, incurs significant expenses. These costs extend to post-closure water management, highlighting the importance of thorough planning and financial provision for addressing such environmental concerns.</p>
<p><b>Ground Water Management</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• AMD; and</li> <li>• contaminated ground water.</li> </ul>	<p>Identifying and addressing issues like AMD and contaminated ground water. These challenges necessitate detailed investigations and accurate cost assessments for their treatment, closure, and rehabilitation. Ground water management is particularly critical for coal mines, as treating and managing contaminated water, identified through specialist studies, incurs significant expenses. These costs extend to post-closure water management, highlighting the importance of thorough planning and financial provision for addressing such environmental concerns.</p>
<p><b>Security</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• fencing;</li> <li>• security guards; and</li> <li>• dam safety measures.</li> </ul>	<p>Coal mines feature several areas with high safety risks and zones undergoing rehabilitation, which must be clearly marked to restrict access. Therefore, significant investment in signage and access control measures is necessary to ensure safety and</p>

Proposed Closure Themes	Comments
	compliance. This constitutes a substantial cost that must be factored into the overall budget for mine closure and post-closure.
<p><b>Post-closure Land Use</b></p> <p>Example:</p> <ul style="list-style-type: none"> <li>• expenses associated with financing the management of future or long-term activities tied to lingering risks .</li> </ul>	Determining the future use of land post-mining should occur early, ideally during the mining rights application phase. This decision should consider a just transition, climate change impacts, and the needs of surrounding communities. Such considerations will significantly influence the scope and cost of required earthworks, a critical component of the mine closure budget.
<p><b>Monitoring and Maintenance</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• water testing; and</li> <li>• vegetation surveys.</li> </ul>	Monitoring after mine closure is crucial for coal mines due to the potential for ongoing environmental impacts. Specialist studies are essential for accurately determining the financial provisions needed to address these latent and residual effects, ensuring that post-closure responsibilities are met comprehensively.
<p><b>Support Services</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• EPCM;</li> <li>• mobilisation of contractors; and</li> <li>• services (fuel, water, electricity).</li> </ul>	Costs associated with engineering, procurement, and construction management (EPCM), alongside QA/QC, are critical to ensure that rehabilitation meets high standards and prevents failure. These expenses are frequently overlooked in the current South African mining sector, yet they represent substantial costs that should be incorporated into financial provisions for mine closure.
<p><b>Socio-Economic</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• retrenchment of staff; and</li> <li>• socio-economic programmes.</li> </ul>	Addressing just transition by considering the futures of local communities and the workforce facing retrenchment is a crucial aspect of planning. It is essential to ensure that these groups are accounted for, making this a significant item in the planning process.

Proposed Closure Themes	Comments
	Additionally, the impact on surrounding stakeholders must be carefully considered to prevent any negative consequences from latent or residual effects of the mine's operations.
<p><b>Specialist Studies</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• water specialist;</li> <li>• ground water specialists;</li> <li>• vegetation and ecology specialists;</li> <li>• mine closure experts;</li> <li>• social experts; and</li> <li>• climate change experts.</li> </ul>	<p>Budgeting for specialist studies is critically important due to their potential for revealing issues that could significantly impact costs. For instance, investigating water management in coal mining is essential, as treating and managing contaminated water identified through these studies can be costly.</p> <p>Additionally, these expenses will extend into managing water post-closure, underscoring the importance of incorporating these studies into the budget for comprehensive financial planning.</p>
<p><b>Safety</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• health and safety plans;</li> <li>• construction monitoring; and</li> <li>• QA/QC.</li> </ul>	<p>In the mine closure process, safety is of utmost importance, covering health and safety strategies, construction oversight, and Quality Assurance/Quality Control. These elements ensure that all closure activities are conducted in a manner that prioritises the health and safety of workers and the surrounding community.</p>
<p><b>Delays</b></p> <p>Examples:</p> <ul style="list-style-type: none"> <li>• extreme weather events due to climate change</li> <li>• force majeure.</li> </ul>	<p>Allocating funds for potential setbacks caused by extreme occurrences or other external factors related to closure .</p>

The comprehensive coverage of these themes, if fully addressed, captures most of what is required to develop the most precise closure cost estimate for a coal mine in South Africa. This entails conducting thorough and accurate specialist studies, risk assessments, cost analyses, and planning. Attaining precision in these areas is crucial for accurately estimating the financial requirements necessary for the responsible closure and rehabilitation of coal mining operations,

ensuring that environmental, social, and economic impacts are comprehensively considered and mitigated.

## **5 Chapter 5. Discussion**

The comparison of South African practices against international standards reveals critical insights into the financial provisioning for mine closure, emphasising the need for a comprehensive approach that aligns with global best practices.

The guidelines issued by the Western Australian Department of Mines and Petroleum and the Environmental Protection Authority stress the importance of integrating mine closure planning from the inception of mining projects, advocating for a risk-based approach to address both environmental and socio-economic considerations effectively. This contrasts with South African practices, which, while detailed, sometimes lack the proactive and integrated approach seen in Western Australia. The Western Australian guidelines underscore stakeholder engagement, dynamic planning, and specific closure considerations, highlighting a holistic approach to sustainable mine closures.

The ICMM Guidance on Integrated Mine Closure provides a robust framework for sustainable mine closure, focusing on stakeholder engagement and the holistic integration of closure activities throughout the mining lifecycle. This guide emphasises the necessity of inclusive dialogue and the alignment of closure plans with social expectations, showcasing a strong emphasis on socio-economic sustainability alongside environmental considerations.

The SRCE from the USA offers a detailed methodology for calculating mine closure costs, emphasising the adaptability of the tool to various mining scenarios and regulatory environments. Although it presents a powerful and accurate means for closure cost estimation, its effectiveness is contingent upon the accuracy of input data and the expertise of the user, highlighting the importance of detailed and comprehensive planning.

The comparison reveals that while South Africa's approach to financial provisioning for mine closure is comprehensive, it could benefit from incorporating elements of these international standards, such as a more integrated planning process, enhanced stakeholder engagement, and the adoption of a risk-based approach to closure planning. Specifically, the emphasis on dynamic and progressive planning, as well as the focus on socio-economic sustainability in international guidelines, could enhance the effectiveness of South African practices in achieving ecologically sustainable and socially responsible mine closures.

Moreover, the need for detailed specialist studies and accurate cost estimations is echoed across all practices, underscoring the importance of rigorous and transparent financial provisioning. By integrating these international best practices, South Africa can improve its mine closure strategies, ensuring that they not only meet but exceed global standards for environmental protection and social responsibility.

The exploration of financial provisioning for coal mine closure in South Africa uncovers several emerging themes, underlining the multifaceted challenges and necessities in ensuring effective and sustainable mine rehabilitation. These themes, gathered from the research findings and expert interviews, highlight areas requiring attention and improvement within the current regulatory and operational framework.

**Water Management Post-Closure:** A recurring theme is the vital concern of water management following mine closure, which includes the treatment and handling of groundwater, surface water, and stormwater. This theme underscores the environmental and financial challenges of addressing water contamination, including acid mine drainage, which poses significant risks to local ecosystems and communities.

**Social Considerations:** The study underscores the necessity for increased attention to social dimensions, indicating that present practices and laws fail to adequately address the socio-economic effects of mine closure on communities. This includes job losses, socio-economic transitions, and the need for community development initiatives to support affected populations.

**Legislative Clarity and Enforcement:** A consensus among experts points to the necessity for clearer legislation and stronger enforcement mechanisms. This encompasses the need for detailed guidelines on financial provisioning and mine closure practices, ensuring that mines adequately prepare for closure from an environmental and social standpoint.

**Climate Change Considerations:** The importance of integrating climate change assessments into mine closure planning is highlighted, reflecting a growing awareness of the need to consider long-term environmental changes and their impacts on closure strategies. The integration of climate change considerations into mine closure plans is insufficient. Assessing and mitigating the long-term environmental impacts of coal mining, including the contribution to climate change, should be a priority in mine closure strategies. This includes the selection

of appropriate plant species for rehabilitation and the management of water resources in a changing climate (The World Bank, 2020).

**Accuracy in Financial Provisions:** Challenges related to accurately estimating the costs associated with mine closure, including long-term environmental monitoring and rehabilitation, are identified. This theme stresses the importance of developing more precise cost estimation methods that reflect the true scope of closure activities.

**Need for Specialist Studies:** The necessity for comprehensive specialist studies to inform closure planning and financial provisioning is another key theme. This includes studies on water management, soil rehabilitation, and the socio-economic impacts of closure, ensuring that all potential risks and requirements are adequately addressed.

**Global Best Practices:** The research draws comparisons with international standards, indicating a need to align South African practices with global best practices for mine closure. This theme suggests that South Africa can benefit from adopting more integrated, proactive, and stakeholder-inclusive approaches to mine closure.

**Post-Closure Land Use Planning:** The significance of planning for post-closure land use emerges as a crucial consideration. This involves determining the future use of mine land early in the mine life cycle, with considerations for environmental sustainability, community needs, and economic viability.

These themes reflect a comprehensive understanding of the complexities involved in mine closure, pointing to the need for a holistic approach that addresses environmental, social, and legislative aspects. By addressing these themes, South Africa can improve its mine closure practices, ensuring more sustainable outcomes for the environment and affected communities.

However, the over-reliance on specialist studies when calculating financial provisions for mine closure poses significant risks and challenges that can compromise the effectiveness and sustainability of closure efforts (Haymont, 2012; Kragt & Manero, 2021; Streit et al., 2023). While specialist studies are undoubtedly valuable tools for assessing technical aspects of closure, such as Environmental Impact Assessments (EIAs), geotechnical analyses, and engineering designs, they inherently have limitations that need to be recognised and addressed.

One of the primary concerns is the potential for these studies to overlook or underestimate the complexity and variability of conditions at mine sites. Specialist studies often focus narrowly on specific technical aspects, such as soil composition or groundwater contamination, without fully considering the broader context in which closure activities will occur (Kragt & Manero, 2021). As a result, critical factors that could significantly impact closure costs, such as the presence of undiscovered contaminants or the need for extensive remediation measures, may be overlooked or inadequately assessed.

Furthermore, specialist studies may be conducted by consultants or experts with limited understanding of the broader socio-economic and regulatory frameworks in which mine closure operates (Haymont, 2012; Kragt & Manero, 2021). This narrow focus can lead to a lack of consideration for the socio-economic impacts of closure on local communities, including potential job losses, disruptions to livelihoods, and socio-economic inequalities. Failure to address these socio-economic factors adequately can undermine the effectiveness of closure efforts and lead to long-term social and economic challenges for affected communities.

Another concern is the potential for bias or conflicts of interest in specialist studies. Consultants or experts hired to conduct these studies may have financial incentives to produce results that align with the interests of their clients, such as mining companies or regulatory agencies (Haymont, 2012; WWF, 2012). This bias can lead to overly optimistic projections of closure costs or downplaying of potential risks and liabilities, resulting in inadequate financial provisions and leaving mine sites vulnerable to environmental degradation and regulatory non-compliance.

The significant costs associated with conducting comprehensive specialist studies can pose a barrier to smaller mining operations, potentially exacerbating the issue of mine abandonment (Mishra et al., 2012). Smaller mines often have limited financial resources and may struggle to afford the expenses involved in commissioning detailed studies to meet regulatory requirements for closure planning (Streit et al., 2023).

There are several reasons why the costs of specialist studies can be prohibitive for smaller mines. Firstly, specialist studies often require a multidisciplinary approach, involving experts in fields such as environmental science, geology, hydrology, and engineering. Coordinating and funding these diverse expertise areas can be challenging and costly for smaller mining operations with limited internal capacity (Streit et al., 2023).

Secondly, regulatory requirements for mine closure planning vary widely and may necessitate extensive specialist studies to assess environmental impacts, develop closure plans, and estimate financial provisions. Meeting these regulatory standards can be particularly burdensome for smaller mines, which may lack the resources and expertise to navigate complex regulatory frameworks (Streit et al., 2023).

Moreover, smaller mines typically operate on a smaller scale and may not benefit from the economies of scale enjoyed by larger mining operations. The fixed costs associated with conducting specialist studies, such as hiring consultants or purchasing equipment, may represent a more significant financial burden for smaller mines relative to their revenue. Lastly, the inability of smaller mines to afford the costs of specialist studies can have serious implications for mine closure and environmental management. Without adequate planning and financial provisions in place, there is a higher risk of environmental contamination, safety hazards, and long-term liabilities associated with abandoned mines.

The notion of mine closure, particularly in coal mining, often presents an illusion of finality, suggesting that ceasing operations and undertaking closure procedures can effectively neutralise all associated environmental and social risks. This perception is misleading, as coal mining leaves behind both residual and latent risks that can persist well beyond the official cessation of mine operations (Dontala et al., 2015; Hallowes & Munnik, 2016; WRC, 2016). These enduring risks challenge the idea that mine closure equates to the comprehensive resolution of environmental and social concerns.

Residual risks persist even after mining operations have stopped (Dontala et al., 2015; Hallowes & Munnik, 2016; WRC, 2016). Abandoned mine structures and open pits can pose significant physical safety hazards, while pollution from heavy metals and other contaminants can continue to affect soil and water quality, posing ongoing risks to ecosystems and human health (Favas et al., 2018). Specifically, improperly managed coal mine waste can contaminate water sources and soil, adversely affecting agriculture and compromising the quality of drinking water for surrounding communities.

Latent risks are those that may not emerge until long after the mine has been closed. AMD represents one of the most significant latent risks, with the potential to pollute water sources for decades after mining has ended (Dontala et al., 2015; Hallowes & Munnik, 2016; WRC, 2016). This process, which involves the reaction of sulphide minerals in exposed rock with air

and water to create sulphuric acid, leaches heavy metals into waterways, devastating aquatic ecosystems and making water unsafe for consumption and agricultural use (Dontala et al., 2015; Hallowes & Munnik, 2016; WRC, 2016). Additionally, the risk of subsidence (where the ground above underground mines collapses) poses a threat to infrastructure and homes, potentially leading to damage or destruction years after mining activities have ceased (Favas et al., 2018).

The concept of "closure" in the context of coal mining inaccurately implies a tidy conclusion to the myriad operations and their impacts. In reality, the illusion of closure overlooks the enduring nature of many mining-related risks, underscoring that effective mine closure and rehabilitation is a complex, ongoing process that demands continuous management, monitoring, and maintenance to mitigate these persistent challenges.

## **6 Chapter 6: Conclusion**

The comparative analysis of mine closure practices, particularly the Integrated Mine Closure Good Practice by ICMM, Western Australian Government guidelines, and the SRCE, sheds light on the comprehensive requirements of financial provisioning and strategic planning for coal mine closures. South Africa's approach to financial provisioning for mine closure is comprehensive, it could be strengthened by incorporating aspects of international standards, including a more integrated planning process, improved stakeholder engagement, and the adoption of a risk-based approach to closure planning. The ICMM guidelines stand out for their comprehensive approach, highlighting a detailed assessment across various rehabilitation activities, from infrastructure decommissioning to water management and socio-economic impact mitigation. Despite the generally basic infrastructure of coal mines, the significant financial provisions necessary for the rehabilitation of extensive linear infrastructure and the execution of costly earthworks and ground rehabilitation underscore the scale of planning and resources required for responsible mine closure.

The findings highlight a critical need within the coal mining sector for enhanced accuracy in financial provisioning, driven by detailed specialist studies and robust environmental and socio-economic assessments. This need reflects a broader movement towards sustainability and accountability in mining operations, urging coal mining companies to adopt more integrated, transparent, and stakeholder-inclusive closure strategies. As the sector grapples with the environmental legacy of coal mining and the global transition towards cleaner energy sources, these insights call for a proactive approach to mine closure. By aligning with best practices and international standards, the coal mining sector can mitigate environmental impacts, support community transition, and navigate the complexities of mine closure with greater efficacy and foresight. This shift not only addresses regulatory and social expectations, but also positions the sector towards a more sustainable and responsible future, stressing the critical role of thorough planning and financial provisioning in achieving successful mine closures.

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## 8 Appendix A

### Ethics Clearance Certificate



**SCHOOL OF ANIMAL, PLANT AND ENVIRONMENTAL SCIENCES ETHICS COMMITTEE**  
**CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)**

**CLEARANCE CERTIFICATE**

**PROTOCOL NUMBER: HA2205**

**PROJECT TITLE**

Critiquing existing criteria for financial provisioning for rehabilitation and closure of coal mines in South Africa

**INVESTIGATOR**

Mr Keith Raine

**SCHOOL/DEPARTMENT OF INVESTIGATOR**

School of Animal, Plant and Environmental Sciences

**DATE CONSIDERED**

16 September 2022

**DECISION OF THE COMMITTEE**

Approved unconditionally

**RISK LEVEL**

MINIMAL RISK

**EXPIRY DATE**

Date of submission of the project Research Report

**ISSUE DATE OF CERTIFICATE**

06 October 2022

**CHAIRPERSON**

  
(Dr Shalini Dukhan)

cc: Supervisor: Dr Ingrid Watson and Dr Ute Schwabold

**DECLARATION OF INVESTIGATOR**

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

  
Signature

Date 10 / 10 / 2022

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES