

# Investigating the challenges of sustainable rehabilitation by selected mining companies in South Africa

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# ABSTRACT

This study determined the most important environmental rehabilitation challenges that mining houses and mining contractors are faced with today in order to maintain positive production results for stake - and shareholders and, at the same time, rehabilitate and save the environment.

Thus, the main objective of the study was to investigate the challenges of sustainable rehabilitation by mining companies in South Africa. The secondary objectives were to conceptualise the effect and processes of mining on the environment and mankind, clarify sustainable rehabilitation and investigate the challenges faced by mining companies.

The study was conducted within the subject discipline of environmental rehabilitation and the management thereof. The targeted population of the study is aimed at mining houses and mining contractors in South Africa. Questionnaires were sent to 42 respondents via email.

Studies obtained were legislative adherence; environmental planning and financial provision which are some of the essential elements for an environmental rehabilitation plan to succeed.

It was obtained that the most prominent method of operation today is underground mining. It is quite evident that the DMR's requirements are outsourced by the mining houses and contractors which apply to the EMP. The most challenging objectives within the EMP were the elimination of the environmental damages and the least interest shown was in the socio-economic goals.

The three most challenging regulations identified was the National Water Act, NEMA - Environmental Authorisation and NEMA – Waste Act. The mining houses regularly submitted their auditing to the DMR.

Mining companies and contractors considered collapsed mining areas to be the biggest challenge in their daily operations and that water pollution was the most challenging ecosystem element to maintain and to resolve once day-to-day mining operations commenced.

The biggest challenging objective that had to be met within the Environmental Rehabilitation plan was the elimination of the Environmental Damages, which received a 64.7% response.

**Keywords:** Sustainability, Mine Rehabilitation, Green, Water, Mining House, Contractor, MHSA, Guarantee, Soil, Environmental, Ecosystem, Legislation, Financial Provision, Environmental Plans, Inflation.

## ACRONYMS

<b>CPI</b>	Consumer Price Index
<b>DMR</b>	Department of Mineral Resources
<b>DWA</b>	National Water Act 36 of 1998
<b>EIA</b>	Environmental Impact Assessment
<b>EMP</b>	Environmental Management Plan
<b>EMPr</b>	Environmental Management Programme
<b>EPA</b>	Environmental Protection Agency
<b>ESD</b>	Ecologically Sustainable Development
<b>GRI</b>	Global Reporting Initiative
<b>IABS</b>	International Accounting Standard Board
<b>ICMM</b>	International Council on Mining and Metals
<b>IUCN</b>	International Union for Conservation of Nature
<b>MCM</b>	Mine Closure Model
<b>Minerals Act</b>	Minerals Act 50 of 1991
<b>MPRDA</b>	Minerals and Petroleum Resources Development Act 28 of 2002
<b>NEMA</b>	National Environmental Management Act 107 of 1998
<b>PMBOK</b>	Project Management Body of Knowledge
<b>PWC</b>	Price Waterhouse Cooper
<b>SAMREC</b>	South African Mineral Resource Committee
<b>SHEQ</b>	Safety, Health, Environment and Quality
<b>Waste Act</b>	National Environmental Management: Waste Act 59 of 2008
<b>ZAR</b>	Zuid-Afrikaanse Rand (South African Rand)

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# CHAPTER 1

## NATURE AND SCOPE OF THE STUDY

### 1.1 INTRODUCTION

The need for improved environmental maintenance and rehabilitation in the mining sector have been highlighted by the growing concern of the state of mining areas and the environmental degradation caused by mines (Van Zyl, Bon-Smith, Minter, Botha and Leiman, 2012). According to Gilchrist and Holtzhausen (2015), the mining industry has been the backbone of social economic growth but, recently, in a short period of time, the environmental rehabilitation of the closure of mining shafts has become a major issue which is mainly due to the need for ensuring sustainability of the environment and the regeneration of the habitat.

Environmental rehabilitation is a complex system involving a lengthy and costly process. An increasing number of mining shafts have been sold before closure due to low grade mines and the liquidation of mining houses, which has led to the implementation and enforcement of the National Environmental Management Act.

Mine rehabilitation and closure plans must be implemented from day one on all mining projects. All stakeholders must be involved and committed to promote successful mining rehabilitation and sustainable development to ensure social development throughout the process. Proper closure can enable mines to become the engines for development beyond their own life through a process that decreases hostile impacts and maximises after-use benefits in the long-term (Stacey, Naudé, Hermanus and Frankel, 2010).

Stacey *et al.* (2010) express that due to different external factors required for each unique mining project, planned and unplanned closure can accrue; such closures require different applications of the closure processes. Effective mine closure involves multiple interrelated concepts, across the social, environmental and economic scopes of development that are necessary for the successful implementation of rehabilitation.

Mine rehabilitation is essential to environmental sustainability, restoring the land to its original state during and after mining closure through firm, well studied strategies and processes.

Rehabilitation of disturbed areas is carried out concurrently with mining processes as part of the mine's environmental commitment, which includes the progressive rehabilitation of its mining operations. According to Whitehaven coal (s.a.:5-21) the main objective of mine rehabilitation is to recreate land reform after mining closure for future use and, thus, incorporates the comprehensive process of categorising overburden material, land recontouring, planting and renewal, all of which are detailed below.

### **1.1.1 Overburden material categorising**

This process is categorised as having the ability to generate geochemical impacts, such as acid rock drainage, on the environment (Whitehaven coal, s.a.:5-21).

### **1.1.2 Land regeneration**

After closure when the landforms are no longer needed for mining or dumping purposes, the slopes are recontoured to around 10 degrees to control surface run-off and to ensure a stable slope. Topsoil is then spread to a depth of 150 millimetres before the area is contour ripped, fertilised and seeded with local native floral species (Whitehaven coal, s.a.:5-21).

### **1.1.3 Seeding**

Some rehabilitation areas are seeded at the break of the winter rainy season, and initially are vulnerable to erosion damage until germination and root development have occurred. Historically dumps were rehabilitated to pasture species, this approach was chosen to stabilise the dump slope quickly to prevent erosion. More recently efforts have been directed to the re-establishment of native flora (Whitehaven coal, s.a.:5-21).

### **1.1.4 Regeneration**

Native species do not germinate and develop until the following spring, therefore, the potential for massive erosion is present during the winter. A strategy has been developed whereby native bush species, comprising grasses, groundcovers, shrubs and trees, are sown together with a "nurse" crop of cereal rye (Whitehaven coal, s.a.:5-21).

A range of mining methods are being exercised, which all have a negative and devastating effect on the environment. Open-cast mines not only require a large area to be regenerated, but while construction is in progress, extensive waste is also dumped on potential vegetation areas.

As is the case with open-cast mining, underground mining, especially the ground infrastructure, involves displacement of waste rock and vegetation. The use of hydraulic pumps and suction dredges in underground mining operations can result in an increase of sedimentation in nearby rivers. The removal of ecologically valuable topsoil during mine development makes it very hard for vegetation to recover to its previous state. This type of mining also leads to the deforestation and disintegration of biomes, resulting in mass erosion zones (Miranda, Blanco-Uribe, Hernandez, Ochoa, Yerena, 1998).

The dust released when mining companies break up materials can lead to a variety of health problems due to the dust's heavy metal content. Chemicals and explosives used to blast rock eventually find their way to a water source because mining operations are extremely dependent on water. If these water sources (e.g. tailing dams) are not constructed properly, mining operations can pollute the underground water sources which then spread over vast distances.

Table 1.1 illustrates some of the environmental hazards associated with mining operations (Anon. 2016?).

**Table 1.1: Environmental hazards**

<b>Risk</b>	<b>Affected compartments</b>	<b>Relevant toxic compounds</b>
Overtopping of tailings dam	Groundwater, surface water and soil	<b>Water emissions:</b>  In most cases; radionuclides, mainly thorium and uranium; Heavy metals;
Collapse of tailings dam by poor construction	Groundwater, surface water and soil	
Collapse of tailings dam by seismic event	Groundwater, surface water and soil	
Pipe leakage	Groundwater, surface water and soil	

Ground of tailing dam not leak proof	Groundwater	Acids; and Fluorides.  <b>Air emissions:</b>  In most cases radionuclides, mainly thorium and uranium; Heavy metals; and HF, HCl, SO <sub>2</sub> etc.
Waste rock stockpiles exposed to rainwater	Groundwater, surface water and soil	
Dusts from waste rock and tailings	Air, soil	
No site-rehabilitation after cease of mining operations	Land-use, long term contaminated land	
Processing without flue gas filters	Air, soil	
Processing without waste water treatment	Surface water	

**Source:** (Anon. 2016?)

One might question the availability of funds and provisional budget allowance for the rehabilitation of mines considering the growing concern for the future sustainability of mined areas. Previous research suggests that older and abandoned mines are the cause of current negative environmental impact and degradation; therefore, it is imperative to ensure that all current and future mining operations learn from costly lessons and do not make the same mistakes as in the past, in order to promote a sustainable future (Van Zyl *et al.*, 2012).

South Africa is a country rich in natural resources and minerals in which the mining sector contributes significantly to the economy, as well as providing employment opportunities for thousands of people. However, almost all mining activities affect the environment and natural state of the surrounding areas and the communities' heirs (Liebenberg, Claasens, Van Rensburg, 2013).

The Mining Industry has been in existence for hundreds of years and, since its inception, mining companies have been extracting minerals and precious metals in various countries without the rehabilitation of mined and polluted areas, leaving behind hazardous and improperly closed mines. Due to the non-binding/non-perspective regulations of the past,

these companies could have conducted their mining operation with its destructive impact on the environment without accepting any responsibility to restore the mined area to its previous state through rehabilitation and land restoration (Nzimande & Chauke, 2012). Authors Nzimande and Chauke (2012) argue that sustainable development should be at the heart of the economic activities of a country, thus ensuring the social wellbeing of its communities and the environment. The synergies between these three pillars must be well aligned for the realisation of sustainable development.

## **1.2 PROBLEM STATEMENT**

Mining operations in South Africa are subject to operational requirements such as the Environmental Impact Assessment (EIA). The EIA assesses the environmental impact of new projects or developments, considering socio-economic, cultural and human health impacts, both valuable and hostile. Although EIA and many other regulations or impact studies must be followed to ensure the sustainability of the natural environment, visible signs show that these processes are not adhered to. All the above elements need be considered and addressed from the beginning to the end of a project. It is only through such a procedure that mining operations can ensure that the environment is restored to its original state.

To return a site disturbed by mining activities to a sustainable usable condition or to its previous state is the ultimate goal of the rehabilitation of mining sites. However, it is noted that the rehabilitated site might not have been restored to its former condition prior to the commencement of mining operations (Liebenberg, *et al.*, 2013). The end costs for governments and communities will be devastating if modern mining operations do not adapt and eradicate their many environmental problems and hazards (Anon. 2016?).

Mining sites and facilities are closed and reclaimed after active mining operations stop. To resemble the site's pre-mining conditions should always be the focus and goal of the mine site reclamation and closure procedure. The period when mines are closing their operations is the stage when many mines make their biggest environmental impact and these impacts can last for decades. Therefore, the mining companies involved in proposed mining projects are required to include a detailed discussion of mine closure and rehabilitation planning in their Evaluating Mining Project Environmental Impact Assessment (EIA) (Environmental Law Alliance Worldwide, 2015). The Guidebook for Evaluating Mining Project EIAs states that,

“Mine reclamation and closure plans must describe in sufficient detail how the mining company will restore the site to a condition that most resembles pre-mining environmental quality”. Basically, this involves describing how funds will be set aside to prevent the release of toxic contaminants and ensure that the cost of the full reclamation and closure of the mine is provided for (Environmental Law Alliance Worldwide, 2015).

### **1.3 OBJECTIVES**

#### **1.3.1 Main objective**

The main objective of the study was to investigate the challenges of sustainable rehabilitation by mining companies in South Africa.

#### **1.3.2 Secondary objectives**

The secondary objectives of the study were as follows:

- To conceptualise the effect of mining processes on the environment and mankind.
- To clarify sustainable rehabilitation.
- To undertake a literature review to investigate the challenges faced by mining companies, namely Laws and Regulations, Financial Provision, Day-to-Day Mining Operations, Eco Systems and Social and Sustainable Development.
- To implement an empirical study in which the secondary objectives could be investigated through the development and dissemination of a questionnaire to identify the rehabilitation challenges facing mining companies.
- To analyse the data to draw meaningful conclusions and make recommendations.

### **1.4 SCOPE OF STUDY**

The rehabilitation of mines, the businesses and other role players involved in the sustainable rehabilitation of mines.

#### **1.4.1 Field of study**

The field of this study falls within the subject discipline of environmental rehabilitation and the management thereof. The targeted population of the study is aimed at mining houses and mining contractors in South Africa. Even though mining houses are themselves involved in mining, contractors can provide more specialised mining services which are often utilised by mining houses.

Today many mining techniques exist for extracting minerals from underground and different rock types can be divided into two categories namely: hard and soft rock mining. Hard rock mining involves excavation of hard minerals that mainly contain gold, silver, iron and tin. Soft rock mining refers to the excavation of softer minerals such as coal, oil, sands and salt.

#### **1.4.2 Research method**

In order to reach the objectives stated in paragraph 1.3 above, a literature review and an empirical study were performed.

#### **1.4.3 Literature review**

A literature review investigated the information gathered regarding mining activities and their role in ensuring sustainable rehabilitation. This research focused on the mine's daily operations and their impact on the environment.

The literature review covered the following aspects:

- Conceptualising the effect of mining processes on the environment and mankind.
- Clarifying sustainable rehabilitation.
- Investigating the challenges faced by mining companies in the following areas:
  - Laws and Regulations
  - Financial Provision
  - Daily Mining Operations
  - Social and Sustainable Development
  - Eco Systems

The following sources were used:

- NWU databases e.g. LexisNexis, EbscoHost, GoogleScholar
- Internet sources
- Published articles
- Academic journals

#### **1.4.4 Empirical research**

The research method was quantitative and descriptive. Questionnaires were used to collect all data. Introductory letters were sent to mining houses and mining contractors explaining the purpose of the investigation and the information required and requesting their participation in the research project.

#### **1.4.5 Research participants**

The researcher made use of non-profitability and convenient sampling, focusing on the health, safety and finance departments applicable to various mining houses and mining contractors. Elements such as laws and regulations (listed below) were addressed in the questionnaire.

#### **1.4.6 Measuring instrument**

A structured questionnaire was developed as a measuring instrument for the target sample. Non-probability sampling was used as the sampling method, together with convenience and purposive sampling. The purposive sampling in this study serves the purpose of engaging directly with survey respondents whose daily operations focus on environmental rehabilitation. A structured questionnaire was used to assess the differences in terms of how mining companies and contractors evaluate and understand the process of rehabilitation. It also addressed the impact of mining on the environment and the economy, in conjunction with the elements of law, regulations and finances.

The questionnaire is specifically formulated for this research project and takes cognisance of the guidelines provided by Maree (2007) for the formulation of effective research questions.

The research questions must:

- stipulate and focus on the study;
- direct the reader to definite literary resources;
- focus on a certain category of data;
- point out the emphasis area;
- give the reader a clear perception of the proposed reading;
- be couched in straight forward language that is also capable of expressing rich meaning;
- provide straight answers;
- ensure the study can easily be executed;
- ensure the research project can escalate into further studies in the same field.

### Statistical analysis

Data was analysed by the Statistical Consultation Services of the North-West University. The statistical techniques that were performed included:

- demographics;
- the most frequent opinions with regard to legislative, financials, sustainable development and eco systems within Environmental Rehabilitation.

The study aimed to investigate the challenges of sustainable rehabilitation facing mining companies in South Africa.

### **1.5 LIMITATIONS OF THE STUDY**

- Non-probability sampling method – convenience and purposive sampling: this method may cause selection bias and, therefore, may not be generalised to mining activities throughout the world. The results for the convenience sampling were limited to South African Mines.
- Geographically: respondents were limited to mining houses and mining contractors within South Africa.
- The scope of the study is restricted to the safety, finance, health and environmental departments of South African Mines.
- The literature review's aim is to illustrate the importance of implementing the environmental rehabilitation plan given to a mine during the application stage.

- Sample size: the proposed sample consists of  $\pm 20$  mining houses and or mining contractor's respondents, which is a relatively small sample and does not allow for generalisation.

## **1.6 LAYOUT OF THE STUDY**

### **Chapter 1: Nature and scope of the study**

This chapter serves as a summary of the study and includes an introduction, problem statement, objectives and scope, research methodology and the limitations of the study. The study outlines the risk, potential and necessity for the practice and application of environmental rehabilitation by mining houses and mining contractors.

### **Chapter 2: Literature review**

This chapter provides an overview of South African mining. Mining today has a major impact on investments, mineral sales, commodity import and exports, employment and exchange rates. All the above can only be sustained by regular mining activities but will only continue as long as the good practice of environmental rehabilitation applies. Environmental rehabilitation has been set out and driven by the Chamber of Mines (Department of Environmental Affairs, 2011).

This section examines the key concepts outlined in the literature study to illustrate the importance of environmental rehabilitation. Rehabilitation involves application, budgeting, operations and care of mining sites at the end of a mining project. Such information was divided into three categories, namely: conceptualising the effect and process of mining on the environment and mankind; clarifying sustainable rehabilitation and investigating the challenges faced by mining companies in terms of mining rehabilitation.

### **Chapter 3: Findings and discussions**

This chapter presents the research methodology and elaborate on the procedures used to conduct the study. It consists of an analysis of the data and findings of the study, including a

demographic profile of the sample, the discussion of the consequences on mining activities on the environment, as well as the clarification of the statistical methods and results used in the analytical process. Sample outlines, tables and figures are provided to summarise the findings. The data also includes different government Acts that relate to the treatment of the environment.

#### **Chapter 4: Conclusions and recommendations**

Chapter 4 provides a summary of the study, together with a discussion of the conclusions and recommendations with regard to the results obtained. The recommended suggestions for future research are also presented in this chapter. Mining houses and mining contractors may utilise the results of this study as a means of improving the environmental impact of their activities.

# **CHAPTER 2**

## **LITERATURE REVIEW**

### **2.1 INTRODUCTION**

#### **2.1.1 Mining operations and rehabilitation**

Environmental rehabilitation is a lengthy process which must start in conjunction with the commencement of a new mining project and the rehabilitation process thereof.

#### **2.1.2 Mine rehabilitation: closure regulations and requirements**

Mine closure planning is a relatively new concept in the mining industry due to an increase in mining activities which has led to a greater awareness of the social factors resulting from the impact of mining on the environment having become more and more visible. Even though this concept has been legally enforced, it is still in its developmental stages currently. Mining companies are financially liable for the rehabilitation of mined sites (Miningfacts.org, 2012).

Prior to the enforcement of rehabilitation processes and the consequences for not complying, mining companies abandoned mining sites without adequately decommissioning or rehabilitating sites to proposed standards Miningfacts.org (2012). According to Miningfacts.org (2012) abandoned mines have the potential to be environmental and social hazards when open mine shafts exist and contamination from acid rock drainage is not addressed. The environmental concerns over abandoned mines and the cost of rehabilitating the area to its natural state have led governments to tighten regulatory controls on mine closure.

Mine land reclamation and closure plans to ensure certain standards are now required by regulatory and government agencies around the world and are often a component of the environmental impact assessment processes (Miningfacts.org, 2012).

#### **2.1.3 Mine closure plans**

All mine closure plans are specific to each mining operation, and include action plans regarding the closure of the mining site, how environmental standards will be maintained, and how the site will be returned to a satisfactory state for a pre-arranged land use. The terms reclamation, remediation, rehabilitation and restoration are all used to describe mine closure activities that incorporate the modification of the organic and physical state of a site. The terms are sometimes used interchangeably, and are closely linked, but refer to different steps in the preparation of the site for other processes namely: reclamation, remediation, rehabilitation and restoration (Blommerde, Taplin, Simitkumar, 2015).

In the lead-up to mine closure, closure criteria are needed to demonstrate the success of rehabilitation. Both regulators and the local community can play an important role in the establishment of these criteria, together with the monitoring methods chosen to assess performance. This is particularly important if components of the closed mining site are to be utilised by the local community. There may also be a role for the local community to play in the long-term monitoring of the success of the rehabilitation process. Some ecosystems may take decades to re-establish and early warning of potential problems may prevent costly maintenance programmes (Blommerde *et al.*, 2015).

Rehabilitation plans' primary purpose, according to Butterworth and Grant (2012), is to:

- Outline the processes for post-closure landforms and land uses.
- Establish parameters that will measure successful closure and rehabilitation.
- Shape the comparison between the engineering and planning of closure costs and financial rehabilitation provision.
- Reveal risk-based closure planning.

Mine sites are usually returned to their pre-mine uses, however, the new concept of economic sustainability and its growing inclusion in mine closure plans has resulted in the partnership of mining companies, regulators, land-use planners, investors and citizens to identify the most beneficial use of a mine site, leading to the creative and successful re-use of a number of decommissioned mines sites around the world (Miningfacts.org, 2012).

The Department of Environment and Heritage Protection (2016) encourages mining companies to ensure comprehensive environmental practice during the life cycle of a mine (current project) to achieve the following objectives:

- On-going maintenance and rehabilitation in order to deliver a rehabilitated mining site that will equal an un-mined land.
- Day-to-day rehabilitation requirements that is open to public inspection.
- Treating mine closure and rehabilitation as an essential part of mining operations.

According to the Mine Rehabilitation and Closure Act (2016), the rehabilitation plans must strive to meet the following objectives listed in Table 2.1 below with the applicable principles.

**Table 2.1: General rehabilitation objectives**

Objective	Guiding Principles
Safe for humans and wildlife	<p>Mine voids will be backfilled to the most practicable and cost effective extent during operations.</p> <p>Areas of unstable ground will be stabilised as appropriate to ensure that there is no risk to humans or animals.</p> <p>Hazardous materials will be removed or treated</p>
Non-polluting	<p>Leachate will be managed to prevent mobilisation from sources of potential contaminants such as tailings.</p> <p>Contaminated land will be remediated to prevent runoff and seepage.</p>
Stable	<p>All residual slopes will be made stable, when possible. Slopes will have vegetative cover preventing erosion</p>
Able to sustain an agreed post-mining land-use	<p>Post mining landform will be reseeded with local native tree and shrub species.</p>

**Source:** Mine Rehabilitation and Closure Act (2016)

According to Butterworth and Grant (2012) detailed closure care and maintenance plans must be developed to ensure that closure planning can achieve:

- Sufficient monitoring to track and demonstrate achievements of closure performance.
- Management plans and assessments to model post closure performance.
- Allocation of sufficient resources.
- Financial provision for carrying out all the envisaged activities.

#### **2.1.4 Consultation during rehabilitation mine planning**

During the initial planning of mine rehabilitation, the focus should be on identifying existing groups and organisations within the community who are already engaged in similar activities. Much of the early phase in rehabilitation planning is about establishing where there are gaps in knowledge and identifying research programmes or site-specific trials to provide critical information. Consultation with key stakeholder groups at this stage can result in better targeted research and trial programmes and enhance the potential transfer of knowledge into community projects. In areas where extensive clearing has taken place, such as agricultural regions, this may result in rehabilitation programmes being integrated into broader regional land management projects (Food and Agriculture Organization of the United Nations, 1998).

Plans and procures used for rehabilitation work have in the past tended to be relatively fixed, applying specific land reform designs and construction practices virtually irrespective of location or material properties. There is now increasing interest in developing personalised rehabilitation plans to correctly handle and position each type of project and the materials needed to ensure environmental sustainability that take the required final land use into consideration (Food and Agriculture Organization of the United Nations, 1998).

#### **2.1.5 Planning the rehabilitation programme**

If the initial site assessment indicates significant risks or issues for rehabilitation, then research needs to be undertaken to develop and validate methods (controls) for managing those risks and for monitoring the success of the techniques adopted. This process should not delay the development of a comprehensive rehabilitation plan for the mine site. Results

from research and on-site rehabilitation trials are used to modify the plan throughout the life of the mine in a process of continual improvement (Whitehaven coal, s.a.:5-21).

The following factors will be included into the rehabilitation programme:

- Landform design:
  - Mine waste water balances
  - Landform reconstruction
  - Waste storage outer slopes
  - Topsoil management
  - Establishing vegetation communities
  - Functional ecosystem
  - Vegetation establishment
  - Fauna communities
- Monitoring and maintenance of rehabilitation planning.
- Development of a rehabilitation monitoring programme.
- Development of rehabilitation success criteria.

#### **2.1.6 Mine activities after mine rehabilitation**

Mining is a man-made mineral recovery process with a lifespan of between a few months and a number of decades. Mine closure occurs once the mineral resources at a working mine are detected, operations are no longer profitable or ground conditions no longer effectively accommodate mining activities Miningfacts.org (2012). Before a mining permit is granted, regulatory agencies worldwide require mine rehabilitation plans and processes which validate that the mining site will not pose a threat to the health of the environment or society in the future Miningfacts.org (2012). Mining sites may be repurposed for other human uses or restored to its pre-mining use following closure. Financial assurance is required by regulators as a guarantee that the funds required for mine closure will be available should the responsible company be unable to complete the closure as planned (Miningfacts.org, 2012).

Mine closure is the process of stopping all mining activities on a temporary or permanent basis. The life of a mine is determined through mineral extraction. Mines are closed when the supply of minerals runs out or the commodity prices drop, making the mine uneconomical

to operate. Rehabilitation for closure, on average, can take from two to ten years, depending on whether water treatment is part of the closure process. Mine closure processes mainly consist of the following: shut-down, decommissioning, remediation/reclamation and post-closure (Miningfacts.org, 2012).

According to Miningfacts.org (2012) examples of the uses of former mine sites include:

- Museums or education centres
- Visitor attractions
- Scientific centres
- Recreational areas
- Gardens or parks
- Fish farms.

### **2.1.7 Sustainable Rehabilitation**

Sustainable Rehabilitation is the process used to repair and mitigate the impact of mining on the environment. The long-term objectives of rehabilitation can vary from simply converting an area to a safe and stable condition, to restoring the pre-mining conditions as closely as possible to support the future sustainability of the site. Rehabilitation normally comprises developing designs for appropriate landforms for mining sites, creating landforms that will behave and evolve in a predictable manner according to the design principles established, and creating appropriate sustainable ecosystems (PricewaterhouseCoopers, 2012).

Landform, according to PricewaterhouseCoopers (2012), involves a design for rehabilitation and requires a complete review of mining operations, in which each operational stage and component of the mine is part of a plan that considers the full life cycle of a mine, such as planning operations and final end use of the site. This plan needs to be flexible to accommodate changes in method and technology. Maximising planning reduces site disturbance and ensures that material, such as waste rock, is close to its final location. The emphasis is on gaining and analysing maximum information about the site. Such research has two main uses; it provides baseline data for mine planning and essential information for the rehabilitation and closure phase when the site is being restored to an agreed post mining use (PricewaterhouseCoopers, 2012).

Key factors that need to be considered in pre-mining studies include legal requirements, climate, topography, soils and community views. Community views are clearly most important in deciding the final land use because community members are the most likely future site users. Their knowledge and expertise can also be invaluable in understanding aspects of the site. Poorly rehabilitated mines provide a difficult legacy issue for governments, communities and companies, and ultimately tarnish the reputation of the entire mining industry. Increasingly, as access to resources become tied to the industry's reputation, effective closure processes and satisfactory mine rehabilitation become critical to a company's ability to develop new projects. Poor planning invariably increases the costs of rehabilitation and mine closure and decreases overall profitability. Taking a more integrated approach to mine rehabilitation, and implementing it progressively, can achieve effective mine rehabilitation. A range of sustainable development policy frameworks have been developed by the mining industry and other organisations that are now driving improved practice (PWC, 2012).

To allow a productive and sustainable post-mining use of the site which is acceptable to all concerned parties, the rehabilitation plan must include the following aims:

- To protect the health and safety of future site users.
- To alleviate environmental damage and encourage environmental sustainability.
- To conserve valuable attributes.
- To minimise adverse social-economic impacts.

## **2.1.8 Sustainable rehabilitation: the process**

### **2.1.8.1 *Sustainable rehabilitation: environmental aspects***

It should not be assumed that the objective of all rehabilitation processes is some form of natural ecosystem approximating what existed prior to mining. If successful, this will provide a low-maintenance final land use, which seeks to control the release of potential pollution from the site. Where components of the mine site have the potential to be used for agriculture or community-based activities, there will be a need for on-going management. It is important, at an early stage, to establish the long-term capacity of the local community, its local council and community groups to undertake such activities. Without a long-term commitment and

adequate resources, managed rehabilitation programmes may ultimately fail (Blommerde *et al.*, 2015).

#### **1.6.1.1 Sustainable rehabilitation: social aspects**

Mining companies in Africa have made a commitment to the social and economic development of the communities in which they operate. This entails a commitment to minimise the adverse impacts of mining on neighbouring communities and also raises the issue of how to maintain or improve the wellbeing and social sustainability of affected communities (Blommerde *et al.*, 2015).

#### **1.6.1.2 Sustainable rehabilitation: business aspects**

The business case for approaching mine rehabilitation within a sustainable development framework in a planned, structured and systemic manner that is progressively implemented over the whole project cycle and, according to Blommerde *et al.* (2015), includes:

- Improved Mine Management
- Improved stakeholder engagement in planning and decision-making

## **2.2 MAJOR REHABILITATION CHALLENGES DURING ENVIRONMENTAL REHABILITATION**

The major rehabilitation challenges that mining companies face in achieving success during Environmental Rehabilitation programmes consist of:

- Laws and Regulations.
- Financial Provision.
- Day-to-Day Mining Operations.
- Sustainable and Social Development.
- Eco systems.

### **2.2.1 Laws and regulations underpinning the rehabilitation process**

Principals are set out in National Environmental Management Acts (NEMA) and Mineral and Petroleum Resources Development Act (MPRDA) and are applicable to all mining operations. In terms of the MPDRA an applicant for a mining prospect, mining right and/or mining permit, must provide sufficient financial provision for the rehabilitation of the project and/or for negligence of environmental impacts (Van Zyl *et al.*, 2012).

In terms of the Section 89 of the MPRDA no mining right or operation may be exercised without financial provision that is accurate and acceptable to the strategy and day-to-day working of the project.

When applying for mining rights, all standards must be adhered to, including financials. Mines must operate in conjunction with the following acts (Van Zyl *et al.*, 2012):

- National Water Act.
- National Environmental Management Act.
- Information Act.

Specific actions from mining companies are required in terms of the Environment Conservation Act which implements and guards natural environmental issues and the regulation of any pollution. Since 2009 financial provisions for ensuring rehabilitation of the environment have been dictated by the National Environmental Management Act and enforced by the DMR (Sanlam, 2016).

The Waste Act (2008) ensures that mining companies treat and re-use waste to its full potential, this Act provides guidelines to reduce multiple pollution (Sanlam, 2016).

The following Acts regulate the impact of mining operations conducted in South Africa on the environment, statutory duties in respect of the environmental standards, the mitigation of environmental impacts and rehabilitation of the affected environment (Chamber of Mines, 2007).

- The Mineral and Petroleum Resources Development Act (28 of 2005 the MPRDA).
- The National Environmental Management Act (107 of 1998).
- The National Water Act (36 of 1998).

Financial provision, according to the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002), is required to adhere to:

- Section 41(1), which requires that an applicant for a prospecting right, mining right or mining permit must, provide for sufficient financial provision before any approval of the environmental management plan or environmental management programme (EMP) in terms of Section 39(4), can be taken into consideration.
- Section 41(2) which provides that, if the mining house and/or holder of the mining operations, do not rehabilitate the mining site to its previous state, the minister shall submit a notice to the mining house and uplift the provision to rehabilitate the environment by itself.
- Section 41(3) which require that the mining house or holder assess his mining permit and the current state of operations in order to increase his financial provision.
- Section 45, which allows the Minister to recover any rehabilitation costs in the event of crucial remedial events.

Regulations announced in terms of the MPRDA (Act 28 of 2002) stipulate that:

Financial provision is required to achieve success with rehabilitation regarding the environmental impacts and related harm, including the aftercare after closure which will be in the form of the following methods:

- A Trust Fund as provided for in terms of Section 10(1)(cH) of the Income Tax Act, 1962;
- A financial guarantee;
- A deposit into a specified account.

Further requirements prescribed by this legislation are as follows:

The MPRDA and NEMA require that mining and its related activities should be conducted in an environmentally maintainable manner while the NWA regulates the sustainable use of water resources. These statutes could lead to penalties to counter any harm caused by non-compliance.

When an application for a mining right in terms of section 22 of the MPRDA, is accepted by the Regional Manager, applicants, within 180 days of the date on which they received

notification from the Regional Manager, must adhere to the following regulations (Chamber of Mines, 2007):

- Conduct an environmental impact assessment (EIA), this is the process by which the anticipated effects on the environment of a proposed development or project are measured; and
- Submit an environmental management programme (EMPr), which can be defined as “an environmental management tool used to ensure that reasonably preventable adverse impacts of the construction, operation and decommissioning of a project are prevented; and that the positive benefits of the projects are enhanced” (Chamber of Mines, 2007).

Any organisation or person who applies for a reconnaissance permission, prospecting right or mining permit, and whose application is accepted by the Regional Manager, must submit an environmental management plan (EMP).

Section 37 of the MPRDA prescribes environmental management principles and incorporates the NEMA principles which are aimed at ensuring sustainable development (Chamber of Mines, 2007). These principles are helpful in making environmental decisions and consist of the following:

- Polluter Pays Principle (PPP)
- User Pays Principle (UPP)
- Precautionary Principle (PP)
- Principle of Effectiveness and Efficiency
- Principle of Responsibility
- Principle of Participation
- Principle of Proportionality.

### **2.2.2 Penalties for non-compliance within the process of rehabilitation**

The directors of a company or members of a close corporation are jointly and severally liable for any unacceptable negative impact on the environment. This includes damage, degradation or pollution advertently or inadvertently caused by the company or close corporation which they represent or represented. Upon conviction, a director may be sentenced to a fine or imprisonment not exceeding six months or any magisterially imposed penalty (Chamber of Mines, 2007).

In terms of section 43 of the MPRDA, the holder's liability in respect of rehabilitation ceases only upon the issuance of a closure certificate (Chamber of Mines, 2007).

The failure to rehabilitate exposes the holder of a prospecting right, mining right or mining permit to criminal liability for not complying with the requirements of the EMP or EMPr which may attract a fine not exceeding ZAR 100 000 or two years' imprisonment or both. The holder's failure to manage adverse impacts in accordance with an EMP or EMPr also attracts liability in the form of a fine not exceeding ZAR 5 million or ten years' imprisonment or both (Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum & South African National Biodiversity Institute, 2013).

When the mining activities include associated activities (which are listed in terms of NEMA), such activities require prior environmental authorisation by the relevant environmental authority. Failure to obtain such authorisation prior to commencement of the listed activities is an offence in terms of section 24F of NEMA and the offending party is liable, upon conviction, to a fine not exceeding ZAR 5 million or ten years' imprisonment or both (Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum & South African National Biodiversity Institute, 2013).

When the holder of an environmental authorisation fails to comply with a condition of approval, which may include the submission of an EMP which makes provision for rehabilitation and compliance with such an EMP, the environmental authority may issue a compliance notice in terms of section 31L of NEMA. Failure to comply with a compliance notice is also an offence and the offender is liable on conviction to a fine not exceeding ZAR 1 million or five years' imprisonment or both (Chamber of Mines, 2007).

Further, section 28(1) of NEMA prescribes an environmental duty of care and provides that, when any person causes, has caused or may cause significant pollution or environmental degradation, he or she has a duty to prevent such pollution or degradation from occurring or recurring, or (when it cannot be prevented) to take reasonable steps to mitigate such damage (Chamber of Mines, 2007).

The above described duty creates retrospective liability. When there has been a failure to comply with this duty, the Minister, or a Provincial Head of Department, can issue a directive instructing certain steps to be taken, including rehabilitation measures. Failure to comply with such a directive is an offence and the offender is liable on conviction to a fine not exceeding ZAR 1 million or five years' imprisonment or both.

Section 151(2) of the NWA (National Water Act 36 of 1998) creates criminal liability in respect of various offences in relation to water resources and creates criminal liability on the first conviction to a fine or imprisonment for a period not exceeding five years, or to both a fine and such imprisonment and, in the case of a second or subsequent conviction, to a fine or imprisonment for a period not exceeding ten years or to both a fine and such imprisonment (Chamber of Mines, 2007).

### **2.2.3 Financial impact on the environmental rehabilitation**

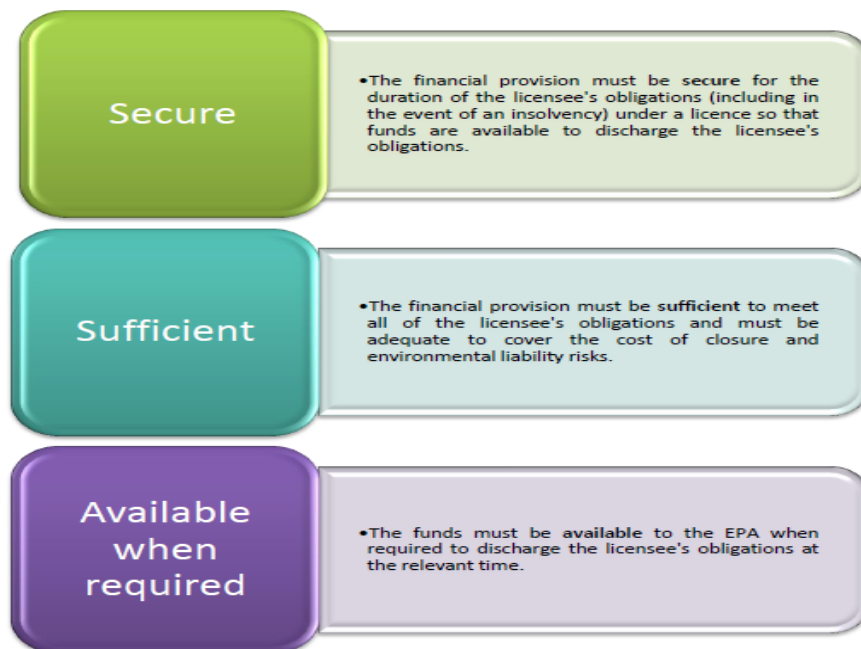
The mining sector has been highlighted for its ownerless and abandoned mines and, therefore, the question arises as to (a) why has mining rehabilitation in various sites not been carried out and (b) is there adequate financial provision made by mining companies for such rehabilitation?

Butterworth and Grant (2012) advise that all mining companies must be able to undertake any necessary financial form of closure by providing for planned and unplanned closure, and be fully aware of its obligations and costs for the closure and rehabilitation of the mining site. Different financial scenarios of closure will include: planned closure, unplanned or sudden closure or temporary closure.

Financial provisions are required to cover environmental liabilities whenever they might occur during the life time of any mining project and at closure. It is essential, therefore, that financial

provision must be secure, sufficient and available when required (Environmental Protection Agency, 2015).

**Figure 2.1: Financial Instruments accepted by the EPA**



**Source:** Environmental Protection Agency (2015)

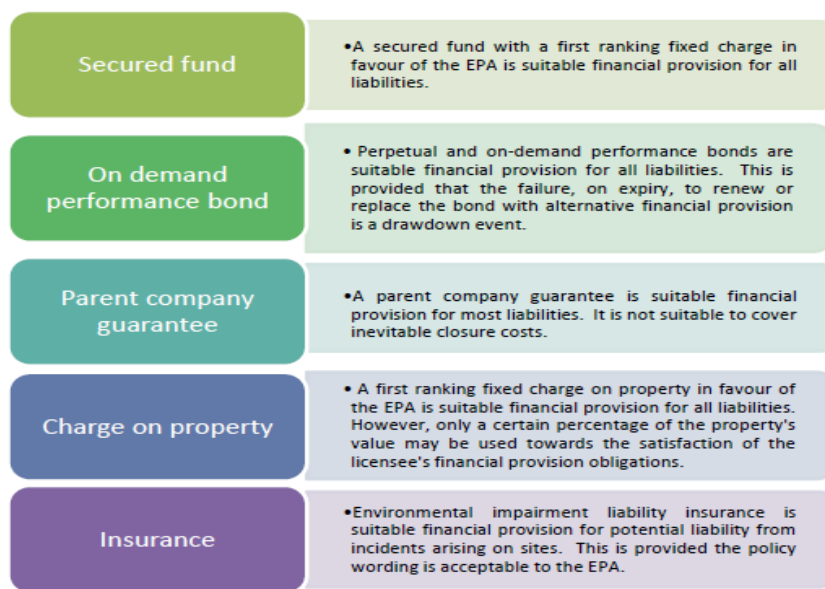
Van Zyl *et al.* (2012), suggests that frequently updated guidelines can ensure that the industry, stakeholders and experts remain clear and willing to adapt to emerging environment. Continuous change and improvement between the EMP guidelines and the DMA financial provisions will ensure broad and available rehabilitation plans within the EMP. The implementation of rebates and incentives for mining companies that rehabilitate a mining site to its primary state should be enforced by the DMR. Clarity on environmental liability costs accounted for by mines is provided by the South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves (SAMREC Code) along with the inclusion of the DMR guidelines on environmental rehabilitation regulations (Van Zyl *et al.*, 2012).

In terms of Section 41 of the Mineral and Petroleum Resources Development Act financial rehabilitation security can be given in the following ways:

- Cash
- Deposits
- Insurance/ Bank Guarantees
- Trust funds.

According to the Environmental Protection Agency all the mediums listed below are accepted and comply with the legislative requirements:

**Figure 2.2: Mediums accepted by the DMR**



**Source:** Environmental Protection Agency (2015)

#### 2.2.4 Financial Provision, processes and reporting

The Environmental Management Plan (EMP) must be drawn up in conjunction with the requirements from the MPRDA and approved by the DMR. The EMP must be descriptive as to how the impact will be dealt with and the environmental costs provided for and distributed, as well as the implementation of the rehabilitation closure plan. The EMP would provide the necessary guidance to ensure that all the requisite closure processes have been adhered too.

Clyde & Co. (2016) explains that prior to any feasibility study or mining activities taking place, mining applicants or shareholders must secure financial provision for:

- Environmental rehabilitation and remediation (on an on-going basis annually, and upon closure of a mine);
- Decommissioning and closure activities at the end of a mining project or operation.
- Rehabilitation of hidden or residual environmental impacts which can become known and problematic in the future. This latent financial provision is often used for the pumping and treatment of polluted water.

Anon. (s.a.) reiterates the claims of Clyde & Co. (2016) that financial provision must include cost provision for premature closure, decommissioning of a project, and final shaft closure and post-closure management of the remaining and latent environmental effects.

Regulation 37(1) under the MPRDA requires that the financial provision must be constructed on the requirements of the approved EMP and shall include a detailed breakdown of all actual costs required for:

- Rehabilitation of surface area.
- Rehabilitation of pollution to the atmosphere, water and soil.
- Decommissioning and final closure of the mining project or operation.
- Post-closure management of residual and latent environmental impacts.

Calculations for financial provision must provide guidance of rehabilitation action plans together with an approved budget. According to van Zyl *et al.* (2012), the existence of rehabilitation costs models a reality developed by mining companies involved in rehabilitation, as well as providing a guideline document for the evaluation of the closure provision provided by the DMR.

Values which have formed part of the guidelines overtime include the legal standing of environmental liability. The fact that not all questions relating to financial provision can be answered within the submitted documentation, has resulted in this study being deemed generic and, thus, it includes a standardised approach that aims to overview the complete picture (Van Zyl *et al.*, 2012).

Major changes within mining companies are necessary according to Kate Swart, an Associate at Clyde and Co., in terms of the calculation and the reporting of mining rehabilitation liabilities. With the new deadline to be implemented in February 2017, a new amendment to the Act will require that the focus shifts to paying more attention to the rehabilitation costs. Further, each mine needs to be completely compliant before the implementation date in February 2017. Sanlam (2016) list the three stages to the closure plan as follows:

- On-going rehabilitation plan – which consists of the day-to-day operations.
- Final rehabilitation plan – this entails a description of the operations and the final version of the rehabilitation plan.
- Post-closure plan – the mine’s liability continues after closures, especially when water treatment is involved.

According to Van Zyl *et al.* (2012), the following processes and reporting elements within the financial provision required by legislation are set out in the figure below:

**Table 2.2: Elements in the legislated financial provisions, process and reporting**

<b>Elements in the legislated financial provisions, process and reporting.</b>	
Financial provision is determined and issued by the mine in the specific financial method for closure, which forms part of the EMP in terms of the DMR guidelines.	
Approval of provisions for financial closure is completed by the DMR.	
Mining/projects can only start once financial provision is agreed to and implemented.	
The EMP and financial provision are revised annually by the DMR. Rehabilitation is undertaken to minimise risk and to shorten the rehabilitation process at closure.	
Mining stops and closure rehabilitation is implemented in accordance with the EMP.	
Closure certificates are issued by the DMR after the environmental rehabilitation requirements have been audited.	
	<p>Financial instruments maintained. On-going financial reporting of Rehabilitation and DMR closure requirements by mining houses.</p>

**Source:** Van Zyl *et al.* (2012).

### **2.2.5 Elements to be addressed in the assessment for financial provision are:**

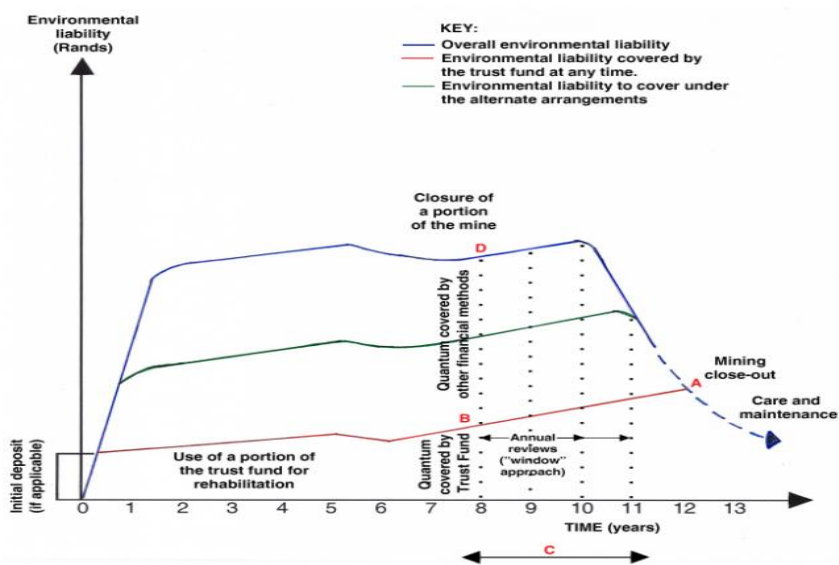
- Mine type risk ranking
- Environmental sensitivity
- Amount of project and client information available to DMR
- Type of mining activities
- Geographic location of mine
- Disturbance areas for class A and B mines
- Closure cost
- Overall size of mine: class C mine
- Cost factors: inflation as part of the financial provision, demolition and rehabilitation of railways, roads, water systems, fencing, housing, sealing of shafts and maintenance and aftercare of operated areas.

Standard cost factors are supplied for application in the case of each component with the risk class being considered. Cost factors are subjected to annual adjustment to inflation based on CPIX (Van Zyl *et al.*, 2012).

The formula used to calculate the annual contributions to planned closure is  $(A-B/C)$ . “A” will commonly be the amount incurred at the time that operations of the mine are stopped in order to discharge the obligations imposed in terms of any law in relation to operations. “B” is the market value of the assets held by the project company. In respect of the mine, the date of termination of the estimated costs is indicated in symbol “A”. “C” is the number of years that the project would still be in operation (Van Zyl *et al.*, 2012).

The process below serves the purpose to ensure that sufficient funds are available at the time of closure. This must be in accordance of the MPRDA and the DMR (Van Zyl *et al.*, 2012).

**Figure 2.3: Annual contribution**



**Source:** Van Zyl *et al.* (2012)

The rehabilitation action plans (Sanlam, 2016) encourage mining companies to dig deeper into their environmental risk control practices, reminding them that not only do day to day operations need attention and assessment but environmental regulations and requirements must be adhered to and prepared for. Environmental insurance, also referred to as environmental impairment liability or pollution legal liability, will add value and ensure protection against the new environmental regulatory system in South Africa (Sanlam, 2016).

Sanlam, (2016) reasons that insurance is an undertaking by a third party (“insurer”) to compensate the licensee for environmental damage. Insurance is not a suitable financial provision for known liabilities such as closure. Insurance is potentially acceptable as a financial provision for unknown liabilities. However, general third party liability policies will not be acceptable as financial provision.

Mining Companies must ensure that their environmental impairment liability policy can be relied on in the following scenarios (Environmental Protection Agency, 2015):

- Environmental and pollution loss and damage.
- Response to the release of chemicals.

- The need for extended coverage to the mining company insured under the policy in the event that:
  - the mining company becomes insolvent or bankrupt
  - the mining company licensee policyholder is deceased.

According to Van Zyl *et al.* (2012), proper financial provision cannot be conducted in a suitable manner because of the following problems:

- Environmental Management Plans (EMP) with no or poor rehabilitation plans that should direct the way for future/similar mining projects.
- Guidelines provided by the Department of Mineral Resources Guidelines (2005 DMR Guidelines) does not make provision for inflation that results in under estimation of financial requirements.
- Satisfactory rehabilitation financial estimations are lacking certainty because of the unavailability of independent financials that can be utilized for rehabilitation planning.

Common areas of concern within the review of the financial revision process, according to PWC (2012), are:

- Insufficient EMP and rehabilitation plans with no correlation between the rehabilitation plans and financial provisions.
- Non-inflation of cost factors.
- Inadequate financial provisions for the closure.
- Lack of simultaneous rehabilitation.

#### *Insufficient Environmental Management Planning and Rehabilitation*

EMPs must be presented in such a way that actions required and dead-lines to be met are clear and mitigate environmental impacts and achieve an acceptable closure (van Zyl *et al.*, 2012).

Known problematic areas are as follows:

- EMPs do not contain rehabilitation plans or make it possible to trace the links between the plans and calculations of the financial provisions (termed the “black box” due to lack of information).
- There is no clear distinction between concurrent rehabilitation measures and rehabilitation at closure on terms of:
  - non-inflation of cost factors;
  - inadequate financial provisions for the closure;
  - lack of simultaneous rehabilitation.

### **2.2.6 Compatibility of Environmental regulations with the International Accounting Standard Board (IABS)**

The conceptual framework for financial reporting (adopted in December 2010) illustrates some of the conceptual compatibility problems experienced in convincing mining institutions of environmental risks and liabilities. According to the Chamber of Mines (2007) these include the following problematic issues:

- Compliance with environmental laws cannot be detected through financial results.
- The cost of obligatory rehabilitation cannot be measured with sufficient reliability.
- The ambiguous nature of the “forward looking statements” in the Integrated Report which include the “safe harbour provisions” that mining institutions and personnel cannot be held accountable for misrepresentation or inaccuracies.
- Non-consistency in financial statements and integrated reports.

### **2.2.7 Role of International Council on Mining and Metals (ICMM)**

This council was established to improve the developmental performance of the mining and metal industry. The key concern of this body is measuring the extent to which the membership contributes to environmental compliances and Section 41 of the MPRDA (Van Zyl *et al.*, 2012).

### **2.2.8 Role of Global Reporting Initiative (GRI)**

The aim of the GRI is to identify present and future risks. Not all mining related reports disclose all the relevant government Acts tasked with ensuring stakeholders' enforcement of environmental legislation. Water pollution and environmental degradation are not identified by all mines and the integrated and sustainability reports in their current form cannot be used as tool for assessing environmental compliances. Non-standardised information reported between various entities within the mining industry are not disclosed to all relevant parties with regard to environmental rehabilitation provision, guarantees to DMR, the life of a mine, water use, total land affected by mining, waste produced verses recycled and total land rehabilitated (Van Zyl *et al.*, 2012).

### **2.2.9 Consequence of mining operations**

Mining is one of the world's most valuable mineral operations and job creators but whilst mining operations remain competitive and stimulate the economy, they face many rehabilitation challenges (Gilchrist & Holtzhausen, 2015).

Mining operations have substantial environmental, economic inheritance and sustainable development difficulties that make the existence and profitability of mining operations vulnerable. These difficulties are the result of issues such as tax legislation, enforcement regimes, environmental issues, non-compliance with mine practices, government involvement and outside factors beyond the control of mines (referred to as 'Acts of God') (Coaltech, 2010).

Land allocated and approved for mining operations may have constructions, landscape elements and vegetation of heritage significance that could contain chemical substances or waste, or are located above soils or groundwater that may be contaminated. Excavation or earthmoving activities may expose artefacts of cultural or historical significance. Such artefacts may have significant heritage value and should be protected (Environment Protection Authority, 2006). The Environmental Protection Authority explains that mining companies must consider all the following factors that impact on heritage issues:

- The heritage significance of structures, landscape elements, archaeological deposits, vegetation or artefacts that may be present.
- The procedures to be taken following discovery of any heritage item.
- The training and awareness of workers in relation to heritage issues.
- The presence of site contamination within the fabric of the heritage structures/artefacts, or in the land supporting or surrounding them.
- The assessment of the health risks posed by site contamination at a heritage site.
- The type of remediation activities to be undertaken.

The Environmental Protection Authority, (2006) further advises that mining companies must engage in and solve potential heritage issues that may be contaminated, by implementing the following guidelines:

- Evaluation of the heritage significance of a construction site.
- Decontamination of all concerned areas within the construction site.
- Controlled access must be enforced and the rehabilitation of contaminated materials must take effect immediately in accordance with relevant reporting guidelines.
- If, and when, significant artefacts are discovered, appropriate studies must take preference over the commencement of any other mining activity (Environment Protection Authority, 2006).

Heritage issues will mainly consist of:

- Trans-national hazards for human safety, especially air and water pollution associated with acid drainage water. Acid drainage water is produced when mining activities continually operate on a daily basis. This emission is not created by man but by chemical reactions during the process of mining, (Coaltech, 2010).
- Local environmental impacts which can affect the quality of life and livelihoods of local communities (Coaltech, 2010).
- Unemployment, loss of social services, pollution, disturbance of the landscape, the loss of land utility and increased risks to health and safety amongst the local communities (Laurence, 2002; Azapagic, 2004).

Today one of mining's major difficulties involves implementing successful restoration programmes when applying current rehabilitation principles to historical conditions. The costs of rehabilitating abandoned closed mines often results in massive financial liabilities and, therefore, not all planned post-closure projects are started or completed. Neither governments, nor current mining companies, wish to pay for avoiding and/or solving problems relating to the implementation of historical laws that now prove inadequate in relation to current performance expectations (Coaltech, 2010).

Figure 2.4 is a visual illustration of how mining activities actually affect the daily lives of members of surrounding communities. These effects may not be visible from the outset but as the life of the mine continues with its day-to-day operations the effects will surface eventually.

**Figure 2.4: Elements affected and created by mining activities**



**Source:** Gilchrist & Holtzhausen, (2015)

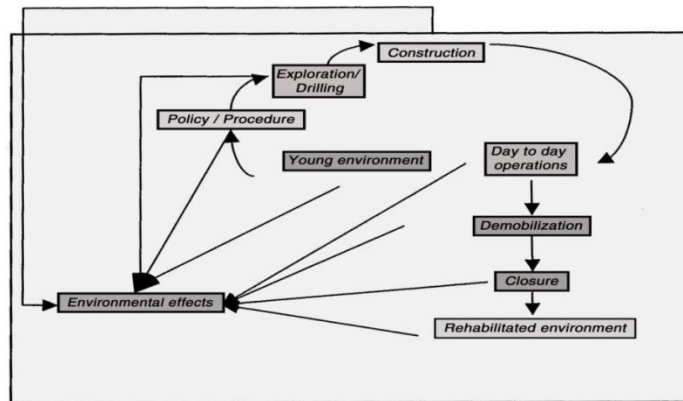
### 2.2.10 Life cycle of mine rehabilitation

Mining Operations are known for their various impacts on the environment throughout the mine cycle. The life cycle and table below summarises each mining activity associated with each environmental impact and grows public awareness of these issues. Serious environmental threats necessitated an immediate reaction to current mining regulations and

mining practices which resulted in changes to the laws governing the day-to-day procedures of mining activities, (Fourie & Brent, 2006).

Figure 2.5 illustrates the Life Cycle of the Mine Rehabilitation Process. This life cycle may vary from project to project and from mine to mine (Fourie & Brent 2006).

**Figure 2.5: Life Cycle of Mine Rehabilitation Process**



**Source:** Fourie & Brent (2006)

All mining activities/processes are affiliated with certain Development and Environmental phases; the Life Cycle's activities are shown in Table 3 below; such phases explain the process of how various environmental issues develop.

The Fundamental Principles for the Mining Sector according to the day-to-day operations of Commonwealth of Australia (2002) are:

- Identify environmental rehabilitation management as a high priority. These management plans should include early and complete environmental impact calculations, control and any other preventative and mitigated measures, monitoring and auditing activities, and should include unplanned closure procedures.
- Plan for preventing and/or dealing with possible social economic impacts from the start of any project.
- Establish environmental accountability in all aspects of the mining industry.
- Ensure all staff and management personnel are trained in every aspect of the implementation of environmental plans.

- Approve and adopt best practices to minimise environmental issues.
- Provide additional financial funds for continuous environmental rehabilitation.

Encourage and support long term investment in the South African Mining Industry by enforcing the implementation of environmental standards with stable and expected environmental principles and measures.

**Table 2.3: Mining Activities versus Environmental Issues**

Activity	Development potential phase	Environmental issue phase
<b>Exploration / Drilling:</b>	Geo-chemical and geophysical surveys, prospecting, claim staking, line cutting, stripping, drilling and trenching, road/trail building and bulk sampling.	Land disaffection from protection options, camp garbage, trail/road and trenching erosion, access-related over harvesting and fishing, habitat disruption, noise pollution, acid mine drainage.
<b>Construction and mining:</b>	Environmental impact assessment, mine design and construction, stripping/storing of “overburden” of soil and vegetation, ore extraction, crushing/grinding of ore, flotation or chemical, storage of waste rock and tailings.	Wildlife and fisheries habitat loss, changes in local water balance, sedimentation, containment of toxins in tailings ponds or leaching pads, stability failure, potential acid generation from waste rock and pit walls, heavy metal leaching from acid mine drainage, cyanide solution containment at heap leach operations, wind borne dust.
<b>Process plant:</b>	Processing of minerals	Sulphur dioxide emissions contribute to acid rain, toxic chemical use for processing.

<p><b>osure / Rehabilitation:</b></p>	<p>Re-contouring of pit walls, and waste dumps, covering of reactive tailings dumps, de-commissioning of roads, dismantling of buildings, re-seeding/planting of disturbed areas, ongoing monitoring and possible water quality treatment.</p>	<p>Seepage of toxic solutions into ground and surface water contamination from acid mine drainage, wildlife and fisheries habitat loss, re-vegetation failure, wind borne dust, slope and tailings impoundment failure.</p>
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**Source:** Fourie and Brent (2006)

The major rehabilitation factors that need to be considered within financial provision, planning and management of the EMP and which form part of the “Life Cycle” activities, in accordance with the mine rehabilitation process, according to Fourie and Brent (2006) include:

- The reliability of the physical and chemical qualities of mine waste;
- Water quality and safety;
- Safety of infrastructure;
- Sustainable habitat;
- Social and sustainable development.

Butterworth and Grant (2012) describe list other mine rehabilitation factors that need to be considered as follows:

- Post closure land use
- Radiological
- Surface and underground water
- Seismicity
- Erosion

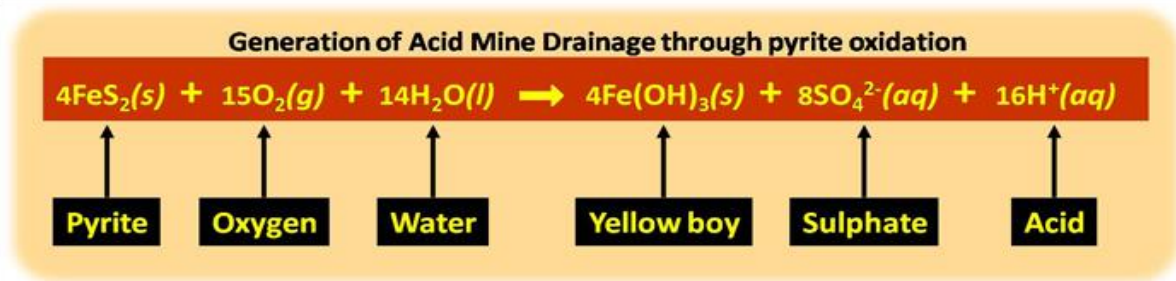
### **2.2.11 Water**

Acid mine water drainage is generated when sulphide bearing minerals, often in the form of pyrite found in the reefs of mined areas, are exposed to both oxygen and water during the day-to-day operations of the mine. This method of pyrite oxidation, produces sulphuric acid and dissolved iron (Department Water and Sanitation, 2016). The most serious threat to

water is acid mine drainage that can exist for thousands of years and which affects rivers, streams and aquatic life (Septoff, 2005).

Acid Mine water is created when chemical reactions occur, the reactional processes amongst the elements are displayed in Figure 2.6.

**Figure 2.6: Illustrates the chemical reaction forming acid mine water**



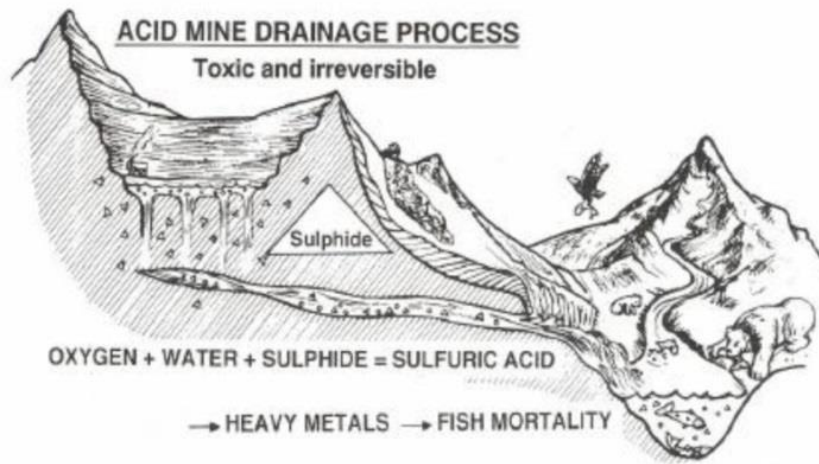
**Source:** Department of water and sanitation (2016)

Acid mine drainage originates from waste rock piles, tailings, open pits and underground tunnels and basically anywhere sulphides are exposed to air and water. Therefore, acid mine drainage impacts fish, animals and plants, so has an enormous influence on the environment and the social life of surrounding communities (earthworksanctions, 2016).

According to McCarthy (2011), acid mine drainage is a worldwide challenge for all mining services, underground and surface. The overall impact is dependent on its area's conditions and varies widely, depending on external factors, namely climate and geomorphology. An interesting fact is that acid mine drainage has different methods of generation within the gold and coal mining industries (McCarthy, 2011).

Figure 2.7 illustrates which natural elements of the environment acid mine drainages affects.

**Figure 2.7: The process of acid mine drainages**



**Source:** Septoff (2005)

### **2.2.12 The importance of water conservation especially for mining operations**

Agriculture, fishery, mining and forestry are all economic sectors that cannot exist nor operate without water and without fresh water no human being will survive. Thus, it is no secret that water equals life. Water protects the natural eco-systems, the oceans, streams and lakes that are the lifeblood of so many local eco-systems that are all dependent on water. It is with this fact in mind that the legislative bodies and the EMP, who enforce environmental rehabilitation on various elements, place great emphasis on the rehabilitation of water during day-to-day mining operations.

### **2.2.13 Sustainable development**

The concept of sustainable development within the mining industry aims to conserve and enhance communities. Social development involves the use of natural resources and ecological processes which, in turn, enhance or deplete the quality of life (Coaltech, 2010).

A major deficit within the literature and legislation of the mine closure plans is a reference to the lack of success of sustainable development closure plans because the requirements are not specified with sufficient detail or means for enforcement. Although the aspects of a closure plan are itemised and clearly set out (including sustainable development) little information and/or guidelines are provided on how to achieve these requirements and why specific approaches must be favoured over others (Coaltech, 2010).

In comparison to the ample research undertaken on environmental rehabilitation within the closure programme, is the rareness of research conducted on the management of social development risk and success. Social development and the sustainability thereof, after the closure of a mine are now more than ever enforced legislative requirements. Mine rehabilitation policies must make provision for the planning and implementation of a sustainable infrastructure to enhance economic factors after decommission. Rehabilitated mining sites may not curtail the daily functions of communities (Coaltech, 2010).

Mine Rehabilitation Closure can have major consequences for social development within communities, as well as the local and regional environment. Rehabilitation closure results are dependent on a mine’s investment in time, financial funds and how management deals with interrupted mining sites in collaboration with the local communities (Coaltech, 2010).

Three hypotheses of closure have been established from the variable combinations of these factors, namely minimalist, compliance and sustainable closure. The latter is the understood and stated aim within this guideline for all closure processes, in order to finally achieve Sustainable Rehabilitation (Coaltech, 2010).

Table 2.4 shows the minimum closure requirements for mining houses and the compliance Acts within which they operate.

**Table 2.4: Variable Combinations**

<b>Minimalist closure</b>	<b>Compliance closure</b>
<p>The minimum requirements that must be in place after closure:</p> <p>Sustainable job opportunities have been created.</p> <p>Skills development programmes have equipped people to participate in economic activity on a sustainable basis.</p> <p>Local infrastructure has been developed to service sustainably social and economic needs.</p>	<p>The mining company complies with the regulatory regime, whether or not the regulatory framework facilitates optimal social closure and sustainable development.</p> <p>In South Africa (the most explicit of all Southern African countries in articulating policies and targets for social and community development), this practice includes compliance with:</p>

<p>Social investment projects and employee welfare programmes cater effectively to human needs into the indefinite future.</p>	<p>The Mining and Petroleum Resources Act (2002);  The Mineral and Petroleum Resources Development Regulations (2004);  Various supportive legislation and regulatory provisions relating to, inter alia, procurement of services, employment equity, skills development and training, local and regional developmental regulations.</p>
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**Source:** Septoff (2005)

Sustainable Development forms part of the rehabilitation process, this element of closure can be validated by pursuing the following elements that are incorporated into the legislation relating to the setting up, running and closing of mining operations in South Africa:

- Principled business practices;
- Essential human rights and respect for different values, cultures and customs;
- Binding data and complete science;
- Continual development in health, safety and environmental performance;
- Biodiversity and integrated land-use planning;
- The social, economic and institutional development and long-term viability of communities.

Coaltech (2010) reassures mining houses that sustainable closure can be achieved if processes are managed optimally and are not seen as additional elements to the project but as essential parts of the rehabilitation 'puzzle'. These processes include the following (Coaltech, 2010):

- A Sustainable Development Plan, as part of the rehabilitation plan, which displays clear principles.

- Closure is not seen “simply” skilling people or providing jobs, but must provide for long term economic diversification.
- Social realities should be reliable and solid rather than unclear and standard prescriptions.
- South African social conditions should be brought in line with international best-practice.
- Site specific agendas and policies, derived from systematic developmental research, that are usable on a micro-managerial, step-by-step sequential or concurrent basis, and are deployable on a rehabilitative basis, in cases where effective closure measures prove unsustainable.

#### **2.2.14 Eco systems**

Where the aim of rehabilitation is to establish a sustainable native ecosystem, fauna habitat requirements should be considered. Recolonisation of fauna species to rehabilitated areas can be encouraged by the provision of a suitable habitat. Establishment of vegetation communities similar to those that existed prior to mining should ensure that most species will recolonise in time. Natural fauna recolonisation is almost always preferable to physically reintroducing animals because there is no cost involved and fauna will return when the habitat meets their requirements (Mattiske, 2016).

According to Montana State University’s Bozeman (2004), the following elements can occur due to mining activities and must be well scheduled, well controlled and well achieved to ensure minimal negative impact on the environment:

##### ***Erosion and sedimentation***

Erosion and sedimentation occurs when solution and sedimentation come into contact with water and are then transported to various areas. The extent of the erosion and sedimentation depends on the degree to which the surface that has been disturbed, the type of ground conditions, the slope length and the number of nutrients the land contains (Whitehaven coal, s.a.:5-21).

##### ***Cyanide and chemical releases***

Cyanide is used in mining's refining processes. During this process, valuable minerals are separated from unwanted minerals. Oil, petroleum products and various acids used to facilitate the process are released into the environment and can affect the water, soil, aquatic organisms, wildlife, waterfowl and humans within the mining area. The solutions remaining after the valuable metals have been removed can result in the acute or chronic poisoning of all living creatures coming into contact with them (Ritter, 2012).

### ***Dust pollution***

Dust pollution is an inevitable problem because it occurs as a result of the large-scale earthwork processes that are carried out every day on open cast mines. Dust pollution originates from sources such as ore crushing, loading bins, blasting, traffic, tailings, disturbed areas and waste rock piles (Ritter, 2012).

### ***Habitat modification***

Mining activities can disturb the following locals: aquatic habitats – lakes, ponds and streams; terrestrial habitats – deserts, grass lands and forests; resulting in the disruption of hydrology, the manipulation of topography and release of toxic chemicals (Whitehaven coal, s.a.:5-21).

### ***Vegetation on erosion***

In general, the establishment of vegetation on sloping areas is expected to reduce erosion due to reductions in run-off and in sediment detachment. The extent to which vegetation meets that expectation, however, is a function of various factors, including climate, vegetation type and soil properties (Ritter, 2012).

- Successful establishment of vegetation can provide large increases in infiltration through surface protection from raindrop impact, through reductions in soil water content, improvements in soil structure and structural stability. Surface protection is largely associated with 'contact cover' with the 'canopy cover' becoming less effective as canopy height increases. Vegetation communities, typically those with a significant component of grass, produce high rates of contact cover. In comparison, vegetation communities dominated by trees or shrubs tend to have much lower levels of contact

cover and are particularly susceptible to erosion during initial establishment (Ritter, 2012).

- In planning rehabilitation, it is important to identify whether vegetation is a major factor in erosion control and, if so, to determine what aspects of vegetation are critical for slope stabilisation and at what stage in the rehabilitation process. If rehabilitation relies on vegetation for erosion control, then there is typically an initial 'window of risk' that should be closed as quickly as possible. In that case species, such as grasses that give rapid initial cover, can be crucial and may also be important for site stabilisation following disturbances such as fire (Ritter, 2012).
- Vigorous grass growth can hinder establishment of trees, but this is routinely managed by forestry organisations using a combination of knockdown and pre-emergent herbicides. There may also be the potential to selectively place materials that favour either grass or trees to achieve the desired balance (Ritter, 2012).
- In general, a balanced ecosystem will contain all the species required to provide a range of ecosystem services. Trees and shrubs are crucial components of most native ecosystems, but their contribution to erosion control, particularly at some stages of the rehabilitation process, may be minimal (Ritter, 2012).

### **2.2.15 Climate**

Climate has an enormous impact on landform stability and site rehabilitation. Consequently, prior evaluation of site climate is essential to ensure that (Lonmin Platinum, 2005):

- Goals for rehabilitation and final land use are realistic
- Plant species used are appropriate
- Soil profiles are developed that are suitable for plant growth
- Landforms are designed to be stable under the prevailing conditions
- Cover systems are designed appropriately

Climate data tend to average out extreme weather conditions. Therefore, planning should consider not only long-term average conditions, but also shorter-term extremes of drought, wind and rainfall. Seasonal rainfall can have considerable impact on landform and vegetation

performance. Where there are distinct wet and dry seasons, the timing of rehabilitation can be critical to its success (Lonmin Platinum, 2005).

# **CHAPTER 3**

## **EMPIRICAL RESEARCH**

### **3.1 INTRODUCTION**

The primary objective of this empirical research is to investigate the challenges of achieving sustainable rehabilitation by mining companies in South Africa: the survey sought to determine the current laws and regulations, which were the most challenging requirements to fulfil in order to successfully achieve 100% closure.

Chapter 3 outlines the instruments used and the procedures followed to collect the research data. The researcher directed the survey and administered a questionnaire to a convenience sample, consisting of representatives from different mining houses and contractors within South Africa.

Descriptive statistics are presented and followed by an analysis of the results, which are presented in the form of tables and figures that summarise the findings. The research results are followed by a discussion on the analysis of the findings. Lastly, the chapter concludes with the key research findings in relation to the literature study.

### **3.2 TARGET AND STUDY POPULATION**

The target population was the SHEQ and Environmental Managers within the Safety and Environmental Departments of mining houses and mining contractors. A total of 42 mining shafts, mining houses and mining contractors in geographical areas throughout South-Africa were identified and requested to participate in the study.

#### ***Questionnaire used in the study***

In order to confirm and substantiate the results of the study a structured questionnaire was used to investigate current rehabilitation challenges of sustainable rehabilitation faced by mining companies in South Africa.

The empirical study was conducted by means of a questionnaire administered to SHEQ and environmental managers. The questionnaire was constructed, face validity was established

and the reliability, thereof, was formulated in conjunction of the North-West University Statistical consultation services.

The questionnaire assessed five aspects through a process of requesting respondents to tick the relevant option(s) in each of the five sections outlined below:

### **3.2.1 Section A: Demographical and background overview**

Background statements of current mining projects, statistics and 'life of mine' were presented. Respondents were asked to tick or rank the relevance of statement(s) or answer(s) in relation to their specific project requirements.

### **3.2.2 Section B: Legislative overview**

Respondents were asked to recognise the specific law(s) that their mining operation practised within the rehabilitation process and to tick or rank the relevant statement(s) or answer(s) relating to their mining house principles and in-house practices.

### **3.2.3 Section C: Financial overview**

Respondents were asked to tick or rank the relevant statement(s) or answer(s) relating to their specific project and mining house requirements in relation to their financial provisions. In addition, they were asked to indicate their knowledge and expertise of the successful financial closure of the specific mining project.

### **3.2.4 Section D: Day-to-day mining activities**

Respondents were requested to identify the challenges which developed within the rehabilitation programme as a result of their day-to-day mining operations; these responses are relevant to each mining house or contractor's projects and expertise. Respondents were asked to tick or rank the relevant statement(s) or answer(s) relating to their mining house principles and in-house practices.

### **3.2.5 Section E: Environmental and sustainable development overview**

In this section respondents had to identify the day-to-day mining activities which resulted in the deterioration of the environment. Respondents were also asked how efficiently sustainable development was implemented and driven within their mining house.

### **3.3 GATHERING OF DATA**

Permission was obtained from various mining houses and contracting companies currently participating in environmental rehabilitation projects and a confidentiality agreement. The agreement stipulated that the mining house and/or mining contractor's identity may not be disclosed and participants should be referred to merely as "mining house" or "mining contractor".

The questionnaires were e-mailed to the selected mining shaft representatives. A cover letter was attached to the e-mail clarifying the purpose of the study, and stating that responses to the questionnaires would be anonymous and the information supplied would be treated as confidential. A total of thirty-four respondents successfully completed the survey.

The respondents who completed the questionnaire had to follow the instructions and complete the survey by ticking the appropriate statement/answer on the list. The completed questionnaires were returned to the sender via e-mail in pdf format.

### **3.4 STATISTICAL ANALYSIS OF DATA**

The completed questionnaires were captured and processed by the Statistical Consultation Services of the North-West University (Potchefstroom Campus) and analysed using SPSS Statistics version 23 (SPSS Inc., 2016). Descriptive statistical methods were employed and interpreted to make conclusions and future recommendations. Some of the questions were asked in such a manner that the respondents could select more than one answer, thus these answers are represented in a table format and discussed individually. Due to the nature and the formulation of the questionnaire no inferential statistics were utilised or interpreted.

### **3.5 RESULTS OF SECTION A: DEMOGRAPHICAL AND BACKGROUND OVERVIEW**

The purpose of Section A of the questionnaire (see Annexure A) is to provide a biographical profile of each survey participant's' current mining project and the rehabilitation history and their experience of day-to-day procedures.

The respondents indicated their mining projects' life span, type of commodity in which it was trading, demographical design of the mining operations, the existence of a Health and Safety Department and the outsourcing of environmental rehabilitation required by the DMR.

The results for Section A are illustrated by means of the frequency and percentage distribution displayed within the tables presented below.

### 3.5.1 New or expansion of the mining development

The objective of question A1 was to obtain an overview of the operations that respondents are currently working on. Respondents were given the option of "new" and "expansion" of a mining operation which would determine in a subsequent section of the questionnaire if "new" or "expansion" operations follows the processes of environmental rehabilitation. The results are presented in Table 3.1 below:

**Table 3.1: New or Expansion mining development**

Question A1	Frequency	Percentage
New	12	35.3
Expansion	22	64.7

From the table above, 35.3% of the respondents indicated that they worked on new mining projects compared to the 64.7% who worked on existing mining projects that had been expanded.

### 3.5.2 Expected life span of new mining operations

The objective of questions A2 - 1 and A2 - 2 was to determine what the expected life spans of new and expanded mining operations were. This information indicated the estimated mine

life for operations and the period of environmental rehabilitation. The results are presented in Table 3.2 (A2-1) and Table 3.3 (A2-2) below:

**Table 3.2: Expected life span of new mining operations**

Question A 2 -1	Frequency	Percentage
Life of Mine > 25	17	50.0
Life of Mine < 25	17	50.0

From the sample, it is evident that 50% of respondents were of the opinion that the life span of their mine’s new project was more than 25 years, and 50% believed that their current new project would not exist for another 25 years.

**Table 3.3: Expected life span of expanded mining operations**

Question A2 -2	Frequency	Percentage
Life of Mine > 25	10	29.4
Life of Mine < 25	24	70.6

Responses indicated that 29.4% of participants believed their existing operation would continue for more than 25 years whilst the other 70.6% did not feel that the expanded operation would continue for a further 25 years.

### 3.5.3 Commodities trade in

The objective of question A3 -1 was to determine the commodity or commodities our respondents traded in, and if there were mining operations that traded in more than one commodity. The results are presented in Table 3.4 below. In this section, respondents/participants could select more than one option, and thus the results have been split to accommodate either answer.

**Table 3.4: Commodities trade in**

Question A3 -1	Frequency	Percentage
Platinum	25	73.5
Gold	14	41.2
Other	3	8.8
Coal	2	5.9
Uranium	1	2.9

From the list of commodities that was supplied in the questionnaire, platinum at 73.5% proved to be the most traded commodity amongst the respondents and with 41.2% of respondents indicated that they traded in gold. As the results indicated a total of more than 34 responses, it is obvious that some of the participating mining operations traded in more than one commodity.

### 3.5.4 Mine Demographical design

The objective of question A4 -1 was to determine the demographical design of the mining operations that respondents were working on at the time of the study and if this design would affect the implementation of environmental rehabilitation. The results are presented in Table 3.5 below. In this section, respondents once again could select more than one option and, thus, the total frequency of responses is higher than the number of participants.

**Table 3.5: Mine Demographical Design**

Question A4 -1	Frequency	Percentage
Underground Mining	30	88.2
Open Cast Mine	4	11.8
Open Cut Mine	2	5.9

The demographical design of open cast mine was indicated by 11.8% and the open cut mine design by 2 mines. Underground mining at 88.2% was the most prominent method of operation.

### 3.5.5 Risk and environmental departments

The objective of question A5 -1 was to determine if the respondents' companies have a Risk and Environmental Department which is regarded as an essential component for successful environmental rehabilitation. The results are presented in Table 3.6 below.

**Table 3.6: Risk and environmental departments**

Question A5 -1	Frequency	Percentage
Yes	34	100.0

One hundred percent of the respondents indicated that their companies had a Risk and Environmental Department.

### 3.5.6 Environmental policies

The objective of question A6 -1 was to determine if respondents' companies had policies for environmental rehabilitation. The results are presented in Table 3.7 below.

**Table 3.7: Environmental policies**

Question A6 -1	Frequency	Percentage
Yes	26	76.5
No	8	23.5

The table above reveals that 76.5% of the respondents were aware of the environmental policies in their companies.

### 3.5.7 Submit and manage DMR requirement

The objective of question A7 -1 was to determine if the respondents' companies managed and submitted their DMR requirements for the Environmental Rehabilitation plan "in-house", or if the requirements were outsourced. The results are presented in Table 3.8 below.

**Table 3.8: Submit and manage DMR requirement**

Question A7 -1	Frequency	Percentage
Yes – outsourced	29	85.3
No – in house	5	14.7

The above result of 85.3% indicates that the majority of respondents outsourced their environmental rehabilitation requirements.

### 3.5.8 Objectives of environmental rehabilitation

The objective of question A8 -1 was to determine which of the listed objectives were the most demanding for companies to achieve in order to reach their Environmental Rehabilitation Plan’s goal. The results are presented in Table 3.9 below. Respondents could select more than one option in this section and thus the recorded total frequency is higher than the number of participants.

**Table 3.9: Objectives of environmental rehabilitation**

Question A8 -1	Frequency	Percentage
Eliminate Environmental Damages	22	64.7
Productive land use	14	58.8
Water Quality	18	52.9
Financial Provision for Rehabilitation Processes	16	47.1
Restore aesthetic values	10	29.4
Rehabilitation Legislation	10	29.4
Socio-economic outcomes	6	17.6

From the list provided, the most challenging objective to meet within the Environmental Rehabilitation plan was the elimination of the Environmental Damages which received a 64.7% response. The least effort required for implementation is for the socio-economic goals.

## 3.6 RESULTS OF SECTION B: LEGISLATIVE OVERVIEW

The objective of section B of the questionnaire (see Annexure A) was to determine which of the following Legislative Regulations were the most challenging for mining companies and mining contractors to implement successfully as part of the requirements for the EMP.

The DMR has set out a framework of required Legislative Regulations that mining houses and contractors must respect to ensure the survival and sustainability of the mining project and the rehabilitation of natural land to its previous state for the future existence of humankind.

The respondents indicated which elements in their EMP they took special interest in when making financial provision and marked the three most challenging regulations to implement as described by the DMR.

The results for section B are illustrated in the tables below by means of frequency and percentage distribution.

### 3.6.1 Regulations prescribed by DMR

The objective of question B1 -1 was to determine, from the regulations prescribed by the DMR, the 3 regulations respondents found the most challenging to implement as part of their EMP. The results are presented in Table 3.10 below and, due to the fact that the respondents could select more than one option, the total frequency recorded is more than number of participating respondents.

**Table 3.10: Regulations**

Question B1 -1	Frequency	Percentage
National Water Act - Water Licence	17	50
NEMA - Environmental Authorisation	16	47.1
NEMA - Waste Act - Waste Management Licence	14	41.2
MPRDA - Prospecting right or mining right	11	32.4
MPRDA - Approved Social and Labour Plan	10	29.4
National Heritage Act	10	29.4
NEMA - Air Quality Act - Air Emissions Licence	8	23.5
MPRDA – Mine Works Programme	5	14.7
NEMA – Biodiversity	5	14.7
Land use Zoning	4	11.8

From the table above, the three most challenging regulations are as follows: the National Water Act with 50%; NEMA - Environmental Authorisation with 47.1% and NEMA – Waste Act with 41.2%.

### 3.6.2 Environmental management plan

The objective of question B2 -1 was to conclude if the respondents' Environmental Management Plans were regularly submitted for auditing by the DMR, whereby the DMR could direct the companies in terms of the way forward with certain aspects as a guide to achieving successful implementation. The results are presented in Table 3.11 below.

**Table 3.11: Environmental management plan**

Question B2 -1	Frequency	Percentage
Yes	31	91.2
No	3	8.8

The overpowering figure of 91.2% confirms that the respondents were submitting their EMP on a regular basis to the DMR.

## 3.7 RESULTS OF SECTION C: FINANCIAL OVERVIEW

Financial Provision today is almost the greatest common reason why mine owners fail to comply and rehabilitate the working mining sites. Financial regulations within the rehabilitation process create obstacles (which take time and money to resolve) thus lessening the possibility of environmental rehabilitation being achieved by the closure of a project.

The objective of section C was to identify which elements the respondents considered when making their financial provision, what type of provision was required at their financial institutions and if they made use of planned and unplanned provision plans.

The most important element to identify was which factor most frequently influenced a mining company or contractors' financial provisions.

The results for section C is illustrated in the tables below by means of frequency and percentage distribution.

### 3.7.1 Financial provision elements

The objective of question C1 -1 was to determine which of the following elements from the list below respondent companies took special interest in when making financial provision. The results are presented in Table 3.12 below.

**Table 3.12: Financial provision elements**

Question C1 -1	Frequency	Percentage
Cost Factors	21	61.8
Type of Mine Activities	13	38.2
Environmental Risk Ranking	11	32.4
Mine Type Risk Ranking	10	29.4
Location of Mine	5	14.7

The table above shows that according to the respondents, cost factors with 61.8% were the element that most companies focused on when planning for Financial Provision followed by the provision for the type of mining activities and environmental risk ranking.

### 3.7.2 Types of financial provisions

The objective of question C2 -1 was to conclude which medium of financial provision the respondents' companies gave preference to when supplying financial security as part of their Environmental Rehabilitation requirements. The results are presented in Table 3.13 below.

**Table 3.13: Types of financial provisions**

Question C2 -1	Frequency	Percentage
Bank Guarantees	19	55.9
Trust	10	29.4
Bonds	7	20.6
Cash	2	5.9

The table above shows that the majority of respondents' companies chose to supply Bank Guarantees as a financial security medium.

### 3.7.3 Closure scenarios

The objective of question C3 -1 was to establish if the respondent companies procured funds for planned, unplanned and temporary closure within their financial provision for closure. The results are presented in Table 3.14 below.

**Table 3.14: Closure scenarios**

Question C3 -1	Frequency	Percentage
Planned Closure	25	73.5
Unplanned Closure	4	11.8
Temporary Closure	4	11.8

The results above show that 73.5% of respondents' companies made financial provision for planned closure, but not for unplanned or temporary closure.

### 3.7.4 Completed rehabilitation projects

The objective of question C4 -1 was to determine if the respondent companies had successfully rehabilitated past mining projects. The results are presented in Table 3.15 below.

**Table 3.15: Completed rehabilitation projects**

Question C4-1	Frequency	Percentage
Yes	21	61.8
No	13	38.2

As shown in the table above, 61.8% of the participating respondents' companies had completed at least one or more rehabilitation project successfully, where 38.2% had not yet completed rehabilitation closure for certain projects or that rehabilitation closure is outsourced by the companies.

### 3.7.5 Successful rehabilitation

The objective of question C5 -1 was to conclude how many of the respondent companies had successfully rehabilitated past mining projects. The results are presented in Table 3.16 below.

**Table 3.16: Successful rehabilitation**

Question C5-1	Frequency	Percentage
>5	16	47.1
<5	18	52.9

The above table shows that only 47.1% of the participating respondents had successfully completed more than 5 rehabilitation projects and the majority of 52.9% had completed less than 5 rehabilitation projects.

### **3.7.6 Successful rehabilitation in terms of financial provision**

The objective of question C6 -1 was to conclude if the respondent's companies had successfully rehabilitated past mining projects in terms of the financial provision made before and during the feasibility and revisions of the EMP. The results are presented in Table 3.17 below.

**Table 3.17: Successful Rehabilitation in terms of financial provision**

Question C6-1	Frequency	Percentage
Yes	20	58.8
No	14	41.2

From the above table, it can be seen that 58.8% of the respondents had completed rehabilitation projects within the estimated financial provisions.

### **3.7.7 Revised financial provisions**

The objective of question C7 -1 was to determine whether the respondents' companies revised their financial provision on a regular basis when regulations changed and requirements differed. The results are presented in Table 3.18 below.

**Table 3.18: Revised financial provisions**

Question C7-1	Frequency	Percentage
Yes	29	85.3
No	5	14.7

The table above shows that the majority of the respondents' Financial Provision for rehabilitation was revised on a regular basis.

### 3.7.8 Financial provision factors

The objective of question C8 -1 was to confirm which of the factors provided in the list below influenced the financial provision for environmental rehabilitation outcomes the most. The results are presented in Table 3.19 below. Due to the fact that the respondents could select more than one option, the total frequency of responses is greater than the number of participating respondents.

**Table 3.19: Financial provision factors**

Question C8-1	Frequency	Percentage
Inflation Provision	25	73.5
Simultaneous Rehabilitation	14	41.2
Poor guidelines provided by DMR	11	32.4
Poor Rehabilitation Plan	7	20.6

From the table above it is evident that Inflation Provision shown with 73.5% was the most common factor influencing financial provision.

## 3.8 RESULTS OF SECTION D: DAY-TO-DAY MINING ACTIVITIES

The objective of section D was to determine which day-to-day activities that form part of mining operations, lead to the development of harmful environmental factors. In addition, it sought to establish which environmental hazard the mining industry regards as its greatest challenge in the course of daily operations.

### 3.8.1 Factors of day-to-day mining operations

The objective of question D1 -1 was to verify which of the factors provided in the list below were the greatest challenges in their day-to-day operation to maintain and rehabilitate. The results are presented in Table 3.20 below. Due to the fact that the respondents could select more than one option the total frequency of responses is more than the number of participating respondents.

**Table 3.20: Factors of day-to-day mining operations (environmental elements)**

Question D1-1	Frequency	Percentage
Collapsed Mining Areas	14	41.2
Post Closure Activities	10	29.4
Surface Damage	9	26.5
Acid Mine Drainages	7	20.6
Flooded Land	5	14.7

According to the above table, 41.2% of participating respondents considered Collapsed Mining Areas to be the biggest challenge in their daily operations.

### 3.8.2 Most harmful elements to the environment

The objective of question D2 -1 was to confirm which of the elements provided in the list below was the most harmful to the environment that had its existence from the mining activities. The results are presented in Table 3.21 below. Because the respondents could select more than one option, the total frequency of responses is higher than the number of participating respondents.

**Table 3.21: Most harmful elements to the environment**

Question D2-1	Frequency	Percentage
Chemical Mine waste	16	47.1
Water Quality	16	47.1
Sustainable Habitat	7	20.6
Radiology	7	20.6
Seismicity	7	20.6
Infrastructure Safety	6	17.6
Erosion	4	11.8
Social Development	3	8.8
Post closure land use	1	2.9

Both Water Quality and Chemical Mine Waste were considered by 47.1% of the respondents as the elements most harmful to the environment.

### **3.9 RESULTS OF SECTION E: ENVIRONMENTAL AND SUSTAINABLE DEVELOPMENT OVERVIEW**

The objective of section E was to determine which challenges mining companies and mining contractors experienced with regard to the eco-system, social development and the EMP.

The regulations governing environmental rehabilitation and sustainable development require all environmental regulations and elements to work together in order to succeed in not disturbing local eco-systems whilst mining and achieving and maintaining sustainable development.

#### **3.9.1 Eco system challenges due to mining operations**

The objective of question E1 -1 was to verify which of the elements of the Eco system were the most challenging due to the mining operations, while implementing and managing environmental rehabilitation. The results are presented in Table 3.22 below. Due to the fact that the participants could select more than one option, the total frequency of responses is more than the number of participating respondents.

**Table 3.22: Eco system challenges due to mining operations**

Question E1-1	Frequency	Percentage
Water Pollution	19	55.9
Dust Pollution	10	29.4
Habitat Modifications	10	29.4
Chemical Release	6	17.6
Erosion	4	11.8

As can be seen in the table above, most of the respondents were of the opinion that water pollution with 55.9% was the most challenging eco system element to maintain and to resolve once day-to-day mining operations commenced. This was also stated and earmarked in the literature study under the law and regulation, day-to-day operations and the eco system section.

### 3.9.2 Implementation of Sustainable Development

The objective of question E2 -1 was to verify which of the sustainable development elements provided in the list below were the most challenging for mining companies and contractors. The results are presented in Table 3.23 below. Because the respondents could select more than one option, the total frequency of responses is more than the total number of participating respondents.

**Table 3.23: Implementation of Sustainable Development**

Question E2-1	Frequency	Percentage
Risks and Opportunities	14	41.2
Stakeholder Engagement, Consultation Empowerment	13	38.2
Human Rights	6	17.6
Building Closure into the Rehabilitation Mine Life	5	14.7
Setting Clear Social Goals	5	14.7

The above table shows that 41.2% of the respondents recognised that the element of risk and opportunities as the most challenging element when seeking sustainable development together with the 38.2% of Stakeholder Engagement and Consultation Empowerment.

The table also depicts that 14.7% of the respondents believed that Building Closure for Sustainable Development into the Rehabilitation Plan and Setting Clear Social Goals were two of the challenges facing mining companies and contractors.

### **3.10 SUMMARY**

Chapter 3 revealed the empirical study's results and discussion. The questionnaire (Annexure A) was used in the empirical study to investigate the challenges that mining companies and contractors are currently faced with during their implementation of the EMP. The data samples entailed of SHEQ and Environmental Managers within the Safety and Environmental Departments of mining houses and mining contractors. The results indicated that mining houses trade in more than one commodity per project and that Platinum is the most common commodity traded with.

Underground mining was the most prominent method of operation and a 100% of the respondents indicated that their companies had a Risk and Environmental Department. The greater part of respondents indicated that their DMR requirements for the implementation of the EMP is outsourced by the mining houses and contractors. The respondents indicated that within the EMP elimination of the environmental damages was the most challenging objective to achieve and the least effort required for implementation was for the socio-economic goals.

In the legislative section the three most challenging regulations was identified namely the National Water Act, NEMA - Environmental Authorisation and NEMA – Waste Act. Successful financial rehabilitation of mining projects was indicated with a 61.8% versus the 38.2% of either mining projects not yet rehabilitated or unsuccessful rehabilitated because of inadequate financial rehabilitation.

Cost factors was the element that most companies focused on while planning for Financial Provision of mining projects that needed to be rehabilitated with closure, where the most common cost factor was inflation provision which influenced the financial provision.

Water Quality and Chemical Mine Waste were considered by 47.1% of the respondents as the elements most harmful to the environment. According to 41.2% of participating respondents considered collapsed mining areas to be the biggest challenge in their daily

operations and that water pollution was the most challenging eco system element to maintain and to resolve once day-to-day mining operations.

The final chapter of the study utilised the results recorded in Chapter 3 to draw conclusions, highlight limitations and make recommendations for future studies.

# **CHAPTER 4**

## **CONCLUSIONS AND RECOMMENDATIONS**

### **4.1 INTRODUCTION**

Chapter 4 serves to conclude and deliberate on the findings of the empirical study depicted in Chapter 3. Practical recommendations are made for achieving more success with the environmental rehabilitation within all departments which form part of the mining life cycle.

### **4.2 ACHIEVEMENT OF OBJECTIVES**

The evaluation of the success of this study is based on the achievement of the objectives set out in Chapter 1, paragraph 1.3.

#### **4.2.1 Primary objectives**

The primary objective of this study was to investigate the challenges of sustainable rehabilitation by mining companies in South Africa. The primary objective was achieved by recognising the secondary objectives of this study.

#### **4.2.2 Secondary objectives**

In order to achieve the primary objective, the following secondary objectives were formulated:

- Conceptualise the effect and processes of mining on the environment and mankind.
- Clarify sustainable rehabilitation.
- Investigate in literature the challenges faced by mining companies namely Laws and Regulations, Financial Provision, Day-to-Day Mining Operations, Eco Systems and Social and Sustainable Development.
- In the empirical part of the study, the secondary objectives were investigated through the development and dissemination of a questionnaire to identify the challenges faced by mining companies during the rehabilitation process.
- Analysis of the data collected to draw meaningful conclusions and make recommendations.

In the literature study:

- The theory of conceptualising effects and processes of mining on the environment and mankind was defined and discussed in paragraph 2.1.1
- The clarification of sustainable rehabilitation was discussed in paragraph 2.1.7
- The investigation of current challenges faced by mining companies was discussed in the following sections:
  - Laws and Regulations in paragraph 2.2.1;
  - Financial Provision in paragraph 2.2.3;
  - Day-to-Day Mining Operations in paragraph 2.2.10;
  - Sustainable Development in paragraph 2.2.13;
  - Eco systems in paragraph 2.2.14.

In the empirical study:

- The questionnaire compiled to identify the challenges faced by mining companies during the rehabilitation process comprised the following sections:
  - Demographical and background overview in paragraphs 3.5.1 – 3.5.8
  - Laws and Regulations in paragraphs 3.6.1 – 3.6.2
  - Financial Provision in paragraphs 3.7.1- 3.7.8
  - Day-to-Day Mining Operations in paragraphs 3.8.1- 3.8.2
  - Environmental and Sustainable Development in paragraphs 3.9.1 – 3.9.2
- Conclusions from the empirical study and subsequent recommendations are provided in Chapter 4.

Chapter 4 consists of 2 sections. The first section focuses on the conclusions drawn from the literature study and the findings of the empirical study. The conclusions are based on how the study contributes to the body of empirical research on the most common challenges facing the mining industry in South Africa. The section also provides the limitations to the study. The second section includes recommendations based on the conclusions drawn, evaluates the objectives set out in Chapter 1 and offers recommendations for future research.

### **4.3 CONCLUSIONS REGARDING THE EMPIRICAL STUDY**

This section consists of drawing conclusions from the results obtained in Chapter 3. Firstly, the conclusions are based on the responses to the questionnaire and the demographical and background, legislative, financial, day-to-day mining activities and environmental and social and sustainable development overview information received from the respondents. The information was obtained, examined and statistically summarised and presented in Tables 3.1 to 3.23 for ease of reference.

#### **4.3.1 Section A: survey participants and their demographical and background overview**

The following conclusions were drawn with regard to the participants' responses to the questionnaire and the demographic information they provided:

- The researcher used a convenience sample of 42 participants for the study. Only 34 of the participants completed the survey successfully. All 34 completed questionnaires were used for the study, which represents a response rate of 81%.
- All respondents were involved physically in day-to-day mining operations, and thus faced the challenges of environmental rehabilitation.

The empirical demographical and background overview revealed that 35.3% of the respondents worked on new mining projects compared to the 64.7% currently working on existing mining projects that have been expanded.

The expected life span of new mining projects is 50% versus the expected life span of existing mining projects of 29.6%. Mining houses are trading in more than one commodity per mining project and Platinum are the most traded commodity. Underground operations with an 88.2% frequency are the most prominent method of mining operations.

With regard to the SHEQ department, 100% of the mining houses and contractor have Risk and Environmental Departments, together with 76.5% of Environmental policies in place. The required EMP by the DMR is 85.3% outsourced by mining houses and contractors which

confirms that these requirements are a challenge to be regulated, managed and implemented.

The most challenging objective to meet within the Environmental Rehabilitation plan was the elimination of the Environmental Damages which received a 64.7% response. The least effort required with 17.6% for implementation according to the respondents for socio-economic goals. The literature study highlights all of the objectives as equal important to succeed with Environmental Rehabilitation within the EMP. It is noticeable with reference to the SHEQ Department that the mining sector's Safety Department mainly concentrate on the Health and Safety aspects rather than on the environmental and social aspects and visible damages which deteriorate over time because of mining operations.

#### **4.3.2 Section B: Legislative overview**

The EMP and its required legislative in particularly with regard to all of the mentioned Acts related to environmental stability and re-use of land after mining operations must be encouraged and enforced.

The three most challenging regulations are as follows, the National Water Act with 50%; NEMA - Environmental Authorisation with 47.1% and NEMA – Waste Act with 41.2%. These frequency percentages of the above-mentioned acts confirm the relationship between the some of the challenges experienced in the literature study and now in the empirical section.

According to Van Zyl *et al.* (2012), the most important acts to implement and maintain within the mining operations is the National Water act, the National Environmental Management act, Information act and the Waste act.

It is evident that Environmental Management Plans are regularly submitted for auditing by the DMR with an overpowering 91.2% that confirms that mining houses and contractors do submit their revised EMP and achievements to date to the DMR. The DMR can with regular submissions direct mining houses and contractors in their challenge to achieving successful implementation of Environmental Rehabilitation.

#### **4.3.3 Section C: Financial overview**

The most important component to identify was which element most frequently influences a mining company or contractors' financial provisions. The following elements were mentioned: Cost factors with 61.8%, the type of mine activities with 38.2% and Environmental Risk with 32.4%. The cost factors which was identified was Inflation Provision 73.5%, Simultaneous Rehabilitation 41.2% and poor guidelines provided by the DMR 32.4%. All of these above-mentioned factors influence the financial provision that must be sufficient to maintain and conclude closure at the end of a mining project.

A 58.8% frequency for successful mining project rehabilitation in terms of financial provision shows that cost factors as mentioned above plays a big role when planning for closure.

According to Butterworth and Grant (2012) all mining companies must be able to undertake any necessary financial form of closure by providing for planned, unplanned and temporary closure. From the results, it is noticeable that mining houses and contracts provide for planned closure with a 73.5% frequency only. Unplanned and temporary closure was reported with an 11.8% for both which indicates that little to non-time and effort is spend on unplanned and temporary closure.

#### **4.3.4 Section D: Day-to-day mining activities**

Mining houses and contractors see collapsed mining areas 41.2%, post closure activities 29.4% and surface damages 26.5% are there greatest challenges within the daily activities of mining operations.

The most harmful elements to the environment highlighted from the research results was chemical mine waste 47.1%, water quality 47.1% and sustainable Habitat 20.6% which has its existence from the day to day activities of mining.

#### **4.3.5 Section E: Environmental, social and sustainable development overview**

Water pollution with 55.9% is the most challenging eco system elements, followed by dust Pollution 29.4% and Habitat Modification 29.4% to maintain and resolve once day-to-day mining operations commence.

The two most challenging factor within the sustainable development sector is the risk and opportunities 41.2% and the stakeholder engagement 38.2%.

According to Coaltech (2010), it is essential for mining houses and contractors to include and maintain all of the principles below:

- Building closure into the Rehabilitation Mine Life Cycle.
- Setting clear sustainable Social Goals.
- Improved Stakeholder Engagement.
- Ensuring the protection of Human Rights.
- Taking note of Risks and Opportunities for social development.
- Ensuring Resource Provision from the mining house and contractor.

#### **4.4 RECOMMENDATIONS**

From the above findings, it is evident that the driving force behind rehabilitation plans has not been effectively introduced, implemented and managed within the mining organisations studied. For successful implementation, greater attention must be given to the pre-planning, implementation and management of the EMP. The EMP covers critical elements that need to be driven successfully in an attempt to achieve a desirable outcome for the rehabilitation of mine shafts or project closures.

In order to address these concerns and assure proper legislative adherence; financial provision and management of environmental rehabilitation processes within mining activities must be undertaken in accordance with the Mining Industry's administration systems which include the planning and processes of environmental rehabilitation.

The Mine Closure Model is suggested for the successful implementation of the EMP and all its requirements of each section as mentioned above:

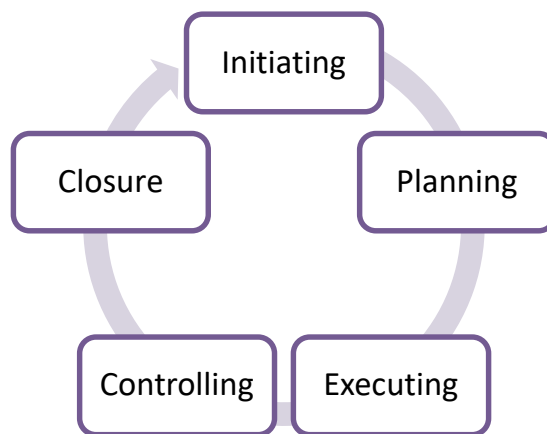
##### **4.4.1 Mine Closure Model**

The MCM is known for its measured success within the mining industry and can be seen as a generic but rudimentary model that provides a structured approach for achieving environmental rehabilitation. This structured approach can be implemented within the guidelines provided by the DMR and the requirements for the EMP.

The MCM provides a collection of processes and knowledge areas within any mining project management discipline with visible outcomes and goals. The goals and outcomes of the EMP and the DMR can be integrated with the proposed actions by the MCM as seen as the most suitable option by management to implement environmental rehabilitation.

The MCM model recognises five basic processes or concepts that are applicable to mining projects. These five processes are set out in the diagram below.

**Figure 4.1: MCM management process**



The MCM management process, thereby, presents formal steps and phases that direct resources towards the required end-state. This method implies that there is no iteration procedure that will ensure a better end result and that the original design shall be achieved at the first attempt. This initial success, according Fourie and Brent (2008), is predominantly required with rehabilitation. The required end state after the completion of mining activities is a stable environment that can be used for an unlimited period for productive, recreational or natural purposes.

**Table 4.1: Mine Closure Model (MCM) showing all management phases of the Environmental Rehabilitation Plan**

Project phases	Related mine rehabilitation		
<b>Feasibility</b>			
<b>Project Formulation</b>	Legislation, EMP, Customer requirements	EMPR	Steps to comply with applicable air and water quality laws and regulations and any applicable health and safety standards
<b>Feasibility studies</b>		Pre-mining site	The identification of the lands subject to mining operations over the estimated life of those operations and size, sequence, and timing of the sub-areas for which it is anticipated
<b>Strategy design and approval</b>	Concepts of rehabilitation (backfill, type of vegetation strategy, etc.)	Characteristics: Base line, Climate, Topography, Soils, Vegetation	The condition of the land to be covered by the permit and the capability of the land prior to any mining to support a variety of uses, considering soil and foundation characteristics, topography, and, if applicable, a soil survey.
			Consideration which has been given to developing the reclamation plan in a manner consistent with local physical environmental, and climatological conditions
			Results of test boring which the applicant has made at the area to be covered by the permit, or other equivalent information and data in a form satisfactory to the regulatory authority, including the location of subsurface water, and an analysis of the chemical properties, including acid forming properties of the mineral and overburden; provided that information which pertains only to the analysis of the chemical and physical properties of the commodity (excepting information regarding such mineral or elemental contents which are potentially toxic in the environment) shall be kept confidential and not made a matter of public record.

<b>Planning and design</b>			
<b>Base design</b>	Rehabilitative plan	Restoration plan	The use which is proposed to be made of the land following rehabilitation, including a discussion of the utility and capacity of the reclaimed land to support a variety of alternative uses and the relationship of such use to existing land use policies and plans
<b>Cost of schedule</b>	Tenders and costing	Restoration cost, Post mining land use, Soil and soil handling, and Water handling, Erosion, Landscape design and Re-vegetation	A detailed description of how the proposed post-mining land use is to be achieved and the necessary support activities which may be needed to achieve the proposed land use.
<b>Contract terms and conditions</b>	Awarding rehabilitation contracts		The consideration which has been given to making the surface mining and reclamation operations consistent with surface owner plans, and applicable State and local land use plans and programmes
<b>Detail planning</b>	Vegetation, water seepage design		The mining techniques proposed to be used, mining and reclamation and a description of the major equipment; a plan for the control of surface water drainage and of water accumulation; a plan, where appropriate, for backfilling, soil stabilisation and compacting, grading, and appropriate re-vegetation; a plan for soil reconstruction, replacement, and stabilisation
<b>Production/Operation</b>			
<b>Manufacturing</b>	Physical earthmoving, work and planting of vegetation		
<b>Delivery</b>	Commissioning of part completion		
<b>Civil Works</b>	See above		
<b>Installation</b>	See above		

<b>Testing</b>	Inspection by government (DMR)	Plan	Measures to be taken during the mining and reclamation process to assure the protection of: (1) the quality of surface and ground water systems, both on-and off-site, from adverse effects of the mining and reclamation process; (2) the quantity of surface and ground water systems, both on-and off-site, from adverse effects of the mining and reclamation process, or to provide alternative sources of water where such protection of quantity cannot be assured. (3) the rights of present users to such water.
<b>Turnover and start up</b>			
<b>Final testing</b>	Closure certification		
<b>Maintenance</b>	Sustainable remote monitoring of environment		

**Source:** Fourie and Brent (2008)

All different mining operations, EMP requirements, can be integrated within the Mine Closure Model (“MCM”). The challenges faced can be once again integrated within the appropriate sections and further assist with possible outcomes of the required environmental rehabilitation.

#### **4.4.2 Contributions of the study**

The study investigated the challenges mining companies face while implementing and managing final closure of environmental rehabilitation in their day to day operations. These environmental rehabilitation requirements include different elements such as adherence to law and regulations, financial provision, social and sustainable development of the mining project and not just the operations as such. The challenges were identified within the empirical study, reviewed within the literature review and methods attained. The MCM is recommended for providing possible solutions to environmental requirements. Further, the MCM has a wide range of fundamental principles wherein it can take on any form/project/requirements and set out possible solutions and achieve a successful closure.

## **4.5 SUGGESTIONS FOR FUTURE RESEARCH**

In the mining and environmental milieu requirements and changes are being experienced daily. Based upon the limitations, conclusions and recommendations expressed in this study, numerous proposals can be suggested regarding future research which includes the following:

- The findings might not allow for generalisation to all mining houses and contractors operating throughout South Africa, therefore, it is recommended that the study be replicated within these organisations.
- The study can also be performed among private and public organisations.
- The study should be duplicated in other countries to determine if similar results are obtained.
- More participants need to be included in the target population used as a research sample. The current study consisted of 34 participants which is a relatively small sample and does not allow for generalisation.

Convenience sampling was used to obtain the participants; thus, it is suggested that the random sampling method be used in future. This latter method can offer a more representative sample of employees.

## **4.6 SUMMARY**

The final chapter presented the researcher's conclusions and recommendations drawn from the results in Chapter 3. Conclusions were made with regard to the challenges faced by mining companies in terms of legislation and regulations, financial provision, day-to-day mining operations, sustainable development and the rehabilitation of eco systems.

Even though 42 respondents were selected to participate in the study, only 34 successfully completed the survey. The sample consisted mainly of Safety Officers and Environmental Managers.

From the Conclusions, recommendations were formulated on how best to ensure successful mining closure and rehabilitation. Environmental rehabilitation within the EMP can lead to

success if proper feasibility, implementation and rehabilitation plans are managed and finalised, together with sufficient financial provision and project specific guidelines.

Chapter 4 concluded by addressing the achievement of all the objectives of the study and recommending possible future research that can be conducted.

## BIBLIOGRAPHY

Anon. s.a. Gamsberg Esia Report: Closure, rehabilitation and post mining land use.  
<http://www.erm.com/contentassets/34e202e6c03e4c5f9f0c4338134b71e7/final-esia/chapter-12---closure-and-post-mining-landuse.pdf> Date of access: 20 October 2016.

Anon. 2016? Mission 2016: Strategic mineral management.  
<http://web.mit.edu/12.000/www/m2016/finalwebsite/> Date of access: 16 October 2016

Blommerde, M., Taplin, R. & Simitkumar, R. 2015. Assessment of Rehabilitation Completion Criteria for Mine Closure Evaluation. Paper presented by the Sustainable Development in the Minerals Industry 2015.  
[https://www.researchgate.net/publication/280628151\\_Assessment\\_of\\_Rehabilitation\\_Completion\\_Criteria\\_for\\_Mine\\_Closure\\_Evaluation](https://www.researchgate.net/publication/280628151_Assessment_of_Rehabilitation_Completion_Criteria_for_Mine_Closure_Evaluation) Date of access: 15 September 2016

Butterworth, M. & Grant, D. 2012. Mine closure and rehabilitation plan 2012.  
[http://www.bhpbilliton.com/~media/bhp/documents/society/regulatory/\\_copper/olympicdamproject/currentenvironmentalprotectionmanagementprogramsagovt/130717\\_copper\\_olympicdam\\_odmineclosureandrehabilitationplan2012.pdf?la=en](http://www.bhpbilliton.com/~media/bhp/documents/society/regulatory/_copper/olympicdamproject/currentenvironmentalprotectionmanagementprogramsagovt/130717_copper_olympicdam_odmineclosureandrehabilitationplan2012.pdf?la=en) Date of access: 14 September 2016.

Chamber of Mines of South Africa. 2007. Guidelines for the rehabilitation of mined land. Johannesburg, South Africa.

Clyde & Co. 2016. New financial provision regulations under NEMA.  
<http://www.clydeco.com/insight/article/new-financial-provision-regulations-under-nema> Date of Access: 2 October 2016.

Coaltech. 2010. The Socio Economic Aspects of Mine Closure and Sustainable Development: Literature Overview and Lessons for the Socio-Economic Aspects of Closure Report 1 of 2.  
[http://www.coaltech.co.za/chamber%20databases%5Ccoaltech%5CCom\\_DocMan.nsf/0/13C0E50053B60B8788257AF4003392EC/\\$File/Coaltech%20Mine%20Closure%20Report%201%202010.pdf](http://www.coaltech.co.za/chamber%20databases%5Ccoaltech%5CCom_DocMan.nsf/0/13C0E50053B60B8788257AF4003392EC/$File/Coaltech%20Mine%20Closure%20Report%201%202010.pdf) Date of access: 15 Augustus 2016.

Commonwealth of Australia. 2002. Best Practice Environmental Management in Mining: Overview of Best Practice Environmental Management in Mining.

Department of Environmental Affairs. 2011. National Strategy for Sustainable Development and Action Plan.

[https://www.environment.gov.za/sites/default/files/docs/sustainabledevelopment\\_actionplan\\_strategy](https://www.environment.gov.za/sites/default/files/docs/sustainabledevelopment_actionplan_strategy). Date of Access: 22 September 2016.

Department of Minerals and Energy. 2005. Guideline document for the evaluation of the quantum of closure-related financial provision provided by a mine. Date of access: 16 November 2016.

Environment Protection Authority. 2006. EPA Guidelines for Environmental management of on-site remediation. Adelaide, South Africa.

Environmental Protection Agency. 2015. Guidance on financial provision for environmental liabilities. Wexford, Ireland. Environmental Protection Agency (2015)

Fourie, A. & Brent, A.C. 2006. A project-based Mine Closure Model (MCM) for sustainable asset Life Cycle Management. *Journal of Cleaner Production*, 14(2006):1085-1095.

Fourie, A. & Brent, A.C. 2008. A project-based mine closure model (MCM) for sustainable asset life cycle management.

Gilchrist, J. & Holtzhausen, N. 2015. The challenge of mining rehabilitation.

<http://ww2.oldmutual.co.za/old-mutual-investment-group/insights/magazines/tomorrow-2015/the-challenge-of-mining-rehabilitation> Date of access: 14 September 2016.

Liebenberg, D., Claasens, S., & Van Rensburg, L., 2013. Insights and Lessons Learned from the Long-term Rehabilitation of an Iron Ore Mine. Unit for Environmental Sciences and Management, North-West University, Potchefstroom, South Africa.

Limpitlaw, D. & Hoadley, M. 2016. Mining and sustainable development: Measuring progress. <https://www.researchgate.net/publication/239539616> Date of access: 14 September 2016.

Lonmin Platinum. 2005. Lonmin Platinum Closure Plan. Report No. NSS1048/01. Lubke, R.A. & Avis, A.M. 1998. A Review of the Concepts and Application of Rehabilitation Following Heavy Mineral Dune Mining. *Marine Pollution Bulletin*, 37(8-12):546-557.

Maree, K. 2007. *First Steps in Research*. Pretoria: Van Schaick Publishers.

Mattiske, A. 2016. Mine rehabilitation in the Australian minerals industry. Minerals Council of Australia, Sydney, Australia.

Miningfacts.org. 2012. What happens to mine sites after a mine is closed?  
<http://www.miningfacts.org/environment/what-happens-to-mine-sites-after-a-mine-is-closed/>  
Date of access: 15 Augustus 2016.

Miranda, M., Blanco-Uribe, Q. A., Hernandez, L., Ochoa, G. J., & Yerena, E. 1998. All That Glitters Is Not Gold: Balancing Conservation and Development in Venezuela's Frontier Forests.

Montana State University Bozeman. 2004. Environmental impacts of mining.  
<https://mail.google.com/mail/u/0/#inbox/15b11287c022c4bb> Date of access: 19 September 2016.

National Parks Directorate Parks Canada Agency. s.a. Principles and guidelines for ecological restoration. Date of access: 16 November 2016.

Nzimande, Z., & Chauke, H., 2012. Sustainability through responsible environmental mining. *The Journal of the Southern African Institute of Mining and Metallurgy*, 12.

PWC. 2012. SA Mine: Review of trends in the South African mining industry.  
<https://www.pwc.co.za/en/assets/pdf/sa-mining-2012.pdf> Date of access: 15 Augustus 2016.

Ritter, J. 2012. Soil Erosion – Causes and Effects.  
<file:///C:/Users/Anine/Desktop/Soil%20Erosion%20%E2%80%93%20Causes%20and%20Effects.htm> Date of access: 15 Augustus 2016.

Sanlam. 2016. Finance to get involved as mining faces tough new environmental rehabilitation law. <https://www.cover.co.za/finance-to-get-involved-as-mining-faces-tough-new-environmental-rehabilitation-law/> Date of access: 14 September 2016.

Septoff, A. 2005. Hardrock mining: Acid mine drainage. [https://www.earthworksaction.org/files/publications/FS\\_AMD.pdf](https://www.earthworksaction.org/files/publications/FS_AMD.pdf) Date of access: 15 Augustus 2016.

South Africa. Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity forum & South African National Biodiversity Institute. 2013. Mining and biodiversity guideline: Mainstreaming biodiversity into the mining sector. Pretoria.

South Africa. Department of Mineral Resources. s.a. Environmental assessment report and environmental management programme report. Pretoria.

Stacey, J., Naude, A., Hermanus, M. & Frankel, P. 2010. The socio-economic aspects of mine closure and sustainable development-guideline for the socio-economic aspects of closure: Report 2. *Journal of the Southern African Institute of Mining and Metallurgy*, 110(July): 395-413.

Swart, E. (2003) – “The South African Legislative Framework for Mine Closure” The South African Institute of Mining and Metallurgy. Paper ISSN 0038-223X/3.

Van Zyl, H., Bon-Smith, M., Minter, T., Botha, M. & Leiman, A. 2012. Financial Provisions for Rehabilitation and Closure of South African Mining: Discussion Document on Challenges and Recommended Improvements: World Wide Fund for Nature, Cape Town.

Whitehaven coal. s.a. Vickery coal project. Environmental impact statement. Section 5: Rehabilitation and mine closure. <http://www.whitehavencoal.com.au/environment/docs/section-5-rehabilitation-and-mine-closure.pdf> Date of access: 22 August 2016.

# **ANNEXURE A**

## **REHABILITATION PROCESSES WITHIN MINING HOUSES**

The questionnaire was distributed through manual questioners.

Annexure A consists of:

- A cover letter
- General instructions
- Questionnaire

Dear Respondent,

Thank you for your time and participation in this survey.

This survey is conducted to determine the level of rehabilitation compliance of mining houses and contractors. This survey contributes to the dissertation as a partial completion of my MBA studies at the North-West University in Potchefstroom. The results of this study will be made available on request after the completion thereof.

This form is filled in anonymously and the information supplied on the questionnaire will be kept private and confidential. The results from this survey are purely for the purpose of the study and will have no effect on anyone's working environment.

The questionnaire is divided into five sections:

Section A: Demographical and Background overview.

Section B: Legislative Overview

Section C: Financial Overview.

Section D: Day to Day Mining Activities.

Section E: Environmental and Sustainable Development Overview

Yours sincerely,

Ida Oberholzer

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## ANNEXURE B

### DECLARATIONS OF LANGUAGE & TECHNICAL EDITING

#### **Investigate the challenges of sustainable rehabilitation by mining companies in South Africa**

The above mini-dissertation submitted by Ida Oberholzer, student number 13136593, in partial fulfilment of the requirements for the degree *Master in Business Administration* at the Potchefstroom Business School, Potchefstroom Campus of the North-West University, has undergone a language edit by

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5 December 2016

## DECLARATION

I, C Vorster (ID: 710924 0034 084), Language editor and Translator, and member of the South African Translators' Institute (SATI member number 1003172), herewith declare that I did the technical editing of the mini-dissertation of Ms I Oberholzer (student number 13136593) from the North-West University.

Title of the mini-dissertation: Investigate the challenges of sustainable rehabilitation by mining companies in South Africa



3 Jan 2017

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C Vorster

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Date