THE PRACTICAL CONSIDERATIONS REGARDING COAL MINE REHABILITATION AND CLOSURE

ABRI DE BEER

22294407

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In the faculty of Engineering, Built Environment and Information Technology

University of Pretoria

Study Leader

Mr JH Cruywagen

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Declaration by Student

I, the undersigned, hereby confirm that the attached treatise is my own work and that any sources are adequately acknowledged in the text and listed in the bibliography.

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Abri de Beer

Signature of acceptance and confirmation by student

ABSTRACT

Title of treatise: The practical considerations regarding coal mine rehabilitation and closure

Author: Abri de Beer

Study leader: Mr JH Cruywagen

Institution: Faculty of Engineering, Built Environment and Information Technology

Date: October 2009

Coal Mine closure is an important subject for the coal mining industry and the community within South Africa. The coal mine closure process begins with planning during the project feasibility assessment phase and concludes with the surrender of tenure. Where a coal mine has not developed a closure plan, early commencement of closure planning is the best insurance for achieving surrender.

Comprehensive coal mine closure plans should include rehabilitation and decommissioning strategies and provide for the allocation of financial and other resources within operational management. A consistent approach to defining, planning, implementing and evaluating successful environmental outcomes is essential to enable coal mining companies to complete environmental closure criteria agreed to by relevant stakeholders and ultimately enable government to grant surrender of tenure.

The objective of this treatise is to investigate the practical considerations regarding coal mine rehabilitation and closure as well as the financial provision for closure purposes.

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1. INTRODUCTION

1.1 Background

Coal mine closure is an important subject for the coal mining industry and the community within South Africa. The coal mine closure process begins with planning during the project feasibility assessment phase and concludes with the surrender of tenure. Where a coal mine has not developed a closure plan, early commencement of closure planning is the best insurance for achieving surrender (Schroder 2001:81).

Comprehensive coal mine closure plans should include rehabilitation and decommissioning strategies and provide for the allocation of financial and other resources within operational management. A consistent approach to defining, planning, implementing and evaluating successful environmental outcomes is essential to enable coal mining companies to complete environmental closure criteria agreed to by relevant stakeholders and ultimately enable government to grant surrender of tenure (Schroder 2001:81).

The rehabilitation of coal mine sites should ideally be planned before any mining commences using data provided by exploration. The data referred to, should include physical, chemical and geo-technical properties of the coal. Data collected through exploration should be used to develop the Environmental Management Plan (EMP). An EMP is also necessary for operational coal mines to ensure that the best result is achieved, and that the communities and regulatory authorities are satisfied (Fourie and Brent 2008:4).

The coal mining industry in South Africa has experienced uncertainty as to how to manage the associated impacts of mining closures in order to leave mine sites in successfully rehabilitated states. However, mine closure certification can now be secured from the South African National Department of Minerals and Energy (DME). By issuing a closure certificate, the government relieves a mine owner of obligations that might follow as a result of pollution and negative environmental impacts (Fourie and Brent 2008:4).

According to Fourie and Brent (2008:5) “the DME is reluctant to accept the burden of the past failures due to the inability and ignorance of mining houses to plan and manage the environmental risks associated with mining actions and make sufficient financial provision for the rehabilitation. The responsibility of all impacts remains with the mining company, with large associated financial burdens”.

1.2 Stating the problem

“The lack of financial provision and management for the rehabilitation and closure of coal mines”

Financial provision for the rehabilitation will be made in the coal mine’s existing Pollution Control Fund (PCF). This provision will be audited by the coal mine and adjusted annually. Ongoing environmental management and rehabilitation will be funded from working costs during the life of the mine.

Fourie and Brent (2008:5) states that “with specific focus on coal mine closure, it has been hypothesized that a model can be derived from past failures and successes, which can be developed as an integrated project in terms of total mine Life Cycle Management (LCM)”.

By using a Mine Closure Financial Model for specific phases in coal mine closure, the following financial objectives can be achieved:

- The coal mining industry can plan closure successfully in a formal EMP. The entire closure process can be viewed as a project on its own with probable certainties, making the planning more deterministic.
- A budget can be compiled more accurately based on scenarios generated by the project plan, including any contingency plans and impact risks.
- The government through the DME manages all unsuccessful closures. This places an obligation on the taxpayers for the cost. By achieving more successful closures, this burden to the taxpayers will be reduced (Fourie and Brent 2008:6).

The South African Revenue Service (SARS) allows annual contributions to a Trust Fund for rehabilitation and closure purposes. The SARS contributions are allowed on the basis of the following formula:

The total current cost of rehabilitation (A) **minus** the total net balance of the Trust Fund as at the date of current estimates (B) **divided** by the estimated remaining number of years life of the mining operations (C).

Thus, (A-B) **divided** by C.

The PCF should be adjusted and increased on an annual basis. This is not always the case in practice. To avoid any financial constraints and difficulties, the following two objectives should be kept in mind;

- It is of utmost importance that the dependency on the mine itself during the life of the mine should be minimized so that alternative economies are promoted before closure.
- Environmental and social costs of mining operations must be internalized during the operational life of the mine to avoid high cost mining legacies on closure.

1.3 The sub problems

a) What is the purpose of rehabilitating a coal mine?

b) What are the differences between opencast and underground rehabilitation procedures?

c) Why is there a lack of financial provision for the rehabilitation and closure of a coal mine?

d) Are the objectives of mine closure planning unambiguous?

1.4 The Hypothesis

a) What is the purpose of rehabilitating a coal mine?

It is accepted that coal mine closure requires the return of land to a viable post-mining use, such as agriculture. It is not even sufficient to simply physically reclaim mined lands anymore as the socio-economic impacts of the closure must also be assessed and managed (Limpitlaw 2004:1).

A mine is often the primary provider of income, employment and services in a local economy. The closure of the mine thus has significant impacts on the well-being of the community. This impact is more extreme in developing countries where local government lacks capacity to structure a development process that would provide alternative economic opportunities (Limpitlaw 2004:1).

Rehabilitation includes the development of management strategies to restore and maintain physical, chemical and biological ecosystem processes in degraded environments. Rehabilitation of disturbed areas has been conducted for centuries; with the ultimate success thereof being largely dependent upon the prevailing environmental conditions, the characteristics of the site, and the inclination of and resources available to those undertaking the rehabilitation process (Limpitlaw 2004:2).

b) What are the differences between opencast and underground rehabilitation procedures?

Rehabilitation procedures can be either for opencast or underground mining operations. The differences between these two mining operations are quite significant and so are the ways in which they are rehabilitated. It must be kept in mind that the two methods of rehabilitation should each be dealt with in its own right.

c) Why is there a lack of financial provision for the rehabilitation and closure of a coal mine?

Early cost estimates are critical: accurate timeous estimates are necessary to ensure that sufficient funds are available towards the end of the mine's life. The estimates should be updated systematically every five years (Limpitlaw 2004:6).

In many instances it is not always a case of not having financial provision for coal mine rehabilitation and closure, but a case of not managing the funds in an appropriate way.

d) Are the objectives of mine closure planning unambiguous?

The objectives of mine closure planning should be stated in such a way that all parties involved, should clearly identify themselves with each objective.

1.5 Delimitations

The scope of the research is limited to the rehabilitation and closure principles applied to existing coal mines with regards to coal mine closure considerations in the long term. The solution to the problem is frameworks and structures that need to be in place when designing and planning new coal mines. The information on which the investigation is based is gathered by the coal mines in the Mpumalanga province of South Africa.

Restricted time, material, confidentiality of information and the depth of the investigation are general factors pertaining to the limitations of this research report.

1.6 Definition of terms

Acid Mine Drainage: Also referred to as acid rock drainage which refers to the outflow of acidic water from (usually abandoned) metal mines or coal mines. However, other areas where the earth has been disturbed (e.g. construction sites, subdivisions, transportation corridors, etc.) may also contribute acid rock drainage to the environment. In many localities the liquid that drains from coal stocks, coal handling facilities, coal washeries, and even coal waste tips can be highly acidic, and in such cases it is treated as acid rock drainage. Acid rock drainage occurs naturally within some environments as part of the rock weathering process but is exacerbated by large-scale earth disturbances characteristic of mining and other large construction activities, usually within rocks containing an abundance of sulfide minerals.

Anthropogenic: The effects, processes or materials that are derived from human activities, as opposed to those occurring in biophysical environments without human influence. The term is often used in the context of environmental externalities in the form of chemical or biological wastes that are produced as by-products of otherwise purposeful human activities.

Defoliation: To cause the leaves of any plants or trees to fall off, especially by the use of chemicals. Coal mining is a very high chemical process.

Derelict: An item that is deserted by an owner or keeper; usually abandoned.

Desertification: The transformation of habitable land to usually a desert, as by a change in climate or destructive land use, like coal mining.

Exploration: Is the act of searching or traveling a terrain for the purpose of discovery, e.g. of unknown people, including space (space exploration), for oil, gas, coal, ores, caves, water, (Mineral exploration, botanical exploration, or prospecting), or information.

Iterative: Means the act of repeating a process usually with the aim of approaching a desired goal or target or result. Each repetition of the process is also called an "iteration", and the results of one iteration are used as the starting point for the next iteration.

Overburden: Is the term used in mining and archaeology to describe material that lies above the area of economic or scientific interest, e.g., the rock, soil and ecosystem that lies above the coal or ore seam. It is also known as 'waste'. Overburden is distinct from tailings, the material that remains after economically valuable components have been extracted from the generally finely milled ore. Overburden is removed during surface mining, but is typically not contaminated with toxic components and may be used to restore an exhausted mining site to a semblance of its appearance before mining began. Overburden may also be used as a term to describe all soil and ancillary material above the bedrock horizon in a given area.

Surrender: Giving up or giving something away. Also referred to as relenting or succumbing.

Sustainable Development: Development that meets the needs of the present without compromising that of future generations to meet their own needs.

Tenure: The act, fact, or condition of holding something in one's possession, as real estate or an office; occupation. A period during which something is held.

Topsoil: Topsoil is the upper, outermost layer of soil, usually the top 5.1 cm to 20 cm. It has the highest concentration of organic matter and microorganisms and is where most of the earth's biological soil activity occurs. Plants generally concentrate their roots in and obtain most of their nutrients from this layer. The actual depth of the topsoil layer can be measured as the depth from the surface to the first densely packed soil layer known as subsoil.

1.7 Assumptions

Rehabilitation and closure frameworks are the solution to the problem of rehabilitating existing coal mines. Such frameworks will be the solution to proper closure planning and management.

1.8 Importance of the study

When the existing coal mines in the Mpumalanga province were built and implemented a few decades ago, the environmental effects of extracting coal was not the main issue of concern during the design and planning stage, neither was the rehabilitation and closure of the mine.

The legislative bodies such as the Government and DME have implemented the environmental impact assessment requirements as well as the environmental management plan for any project undertaking. All operational coal mines have to adapt to these requirements.

Research was done and the solution to the problem is having closure planning frameworks in place, which involves the financial and strategical considerations necessary for successful coal mine rehabilitation and closure.

1.9 Research methodology

- Consulting reports compiled by Mr. RN Schroder
- Published literature in the Gazette of the Department of Minerals and Energy
- Books
- Electronic journals
- Electronic media from the following websites:

  www.google.co.za

  www.dme.gov.za

2. THE PURPOSE OF REHABILITATING A COAL MINE

Ever since the earth was formed, natural disturbances on a geological scale – ranging from meteor strikes, volcanic activity and earthquakes to floods and ice ages have been frequent and varied, resulting in ecosystem disturbances. These changes have occurred both in time and in space and their characteristics have been inferred from several types of scientific studies. Thus, an ecosystem disturbance can be defined as an event, or series of events, that result in changing the relationship between organisms and their habitats from their natural state, both temporally and spatially (Schroder 2001:1).

According to Schroder (2001:1) "presently the concern lies with disturbances that are anthropogenic and whose impact has resulted in scales that are temporarily narrow but spatially wide. Several events have created these disturbances: (1) extensive clearing of natural vegetation for agricultural and other purposes; (2) selective harvesting of desirable species to a given area; (3) soil erosion and desertification; (4) abandonment of unproductive agricultural land; (5) drainage of wetlands for agricultural or fuel usage or for the control of diseases; and (6) creation of war impacted ecosystems by bombing, defoliation, and movement of men and material. However, over the years technology and practices have been developed to rehabilitate some of the areas affected by such disturbances."

The impact of mining activities on the land and the manner in which natural resources are affected is well documented. Inadequate mining regulations, and when existing, their non –implementation has meant that coal mines are often not rehabilitated after mineral extraction has been completed. Negative mining impacts are documented to indirectly influence the lives of large numbers of people, by curtailing industrial and agricultural development, limiting housing and infrastructure development and placing ordinary people at risk on a daily basis (Tsivhandekano 2005:7, 8).

2.1 Mining activities

Mining activities result in large areas of devastated lands. The majority of this land disturbance is related to exploration activities, opens pit mining, quarrying and coal mining activities such as strip and contour mining. The waste products from these operations include overburden material, the unconsolidated surface horizons (topsoil, subsoil, parent material) and underlying geologic strata that must be removed to expose the orebody.

Surface mining drastically disturbs the environment. On the mining site, vegetation is destroyed and soil is disrupted, buried or mixed with other geologic material, resulting in surface materials that are incapable of supporting plant life. Wildlife habitats are greatly altered and the resulting landscape is aesthetically displeasing.

Rehabilitation is the process by which impacts of mining on the environment are repaired. It is an essential part of developing mineral resources in accordance with the principles of sustainable development (Ghose 2005:1). Mining is a temporary land use, which should be integrated with or followed by other forms. Rehabilitation of mines should be aimed at a clearly defined future land use for the area. The mineral extraction process must ensure return of productivity of the affected land (Ghose 2005:1).

Some of the factors that must be considered with mine rehabilitation are as follows:

- Physical and chemical stability of mine waste dumps and open-pits
- Maintenance of water quality
- Safe disposal of infrastructure
- Development of sustainable ecosystems
- Meeting community expectations (Fourie and Brent 2008:4, 5).

2.2 Management approaches for the rehabilitation of coal mines

The rehabilitation of a coal mine is of utmost importance when future planning and development strategies are being implemented. These planning and development strategies can only be implemented successfully, if the correct management approaches are carried out. Fourie and Brent (2008:6, 7) explains that "when considering coal mine rehabilitation, there are three management approaches that need to be examined:"

- **Project Managing Rehabilitation**

Projects are, by definition, “a proposal of something to be done; plan; an organized undertaking; special unit of work; research etc”. A project is a unique requirement that involves a single definable purpose, a temporary activity with a start and end date and a process of working to achieve the objectives.

With respect to rehabilitation, the main objective of a restoration and rehabilitation programme for a coal mine is to create a self-sustaining land surface which can in the long term be put to some productive use. Thereby, rehabilitation can be managed in a similar manner to normal projects in the industry. The associated phases within projects are the pre-feasibility, conceptual phase and the scope of work, followed by execution and post-project evaluation. Required work breakdown structures are generated with detailed time scheduling based on these phases. Stakeholder involvement and continuous monitoring of environmental impacts are imperative to achieve success in the rehabilitation process.

- **Risk Managing Rehabilitation**

Project risk management is about people making decisions to try to optimize the outcome, being proactive in evaluating risk and the possible responses, using this information to best affect, demonstrating the need for changes in project plans, taking the necessary actions and monitoring the effects. This technique can be used in the rehabilitation of coal mines, whereby the environmental criteria of actions relative to the safety of the surrounding environment and communities are evaluated. The technique verifies and prioritises actions on, and costs of, particular areas.

Within the normal processing of coal mining options, decisions are often based upon production and economical pressures in the short term. These actions have consequences on the original EMP that was approved by authorities, and should be addressed differently in the Rehabilitation Plan. It can be seen as a Project Contingency Plan that must be initiated. However, these plans will have long-term risks and should be evaluated formally and then be documented. The Project Risk Management approaches that are available make provision for these decisions to be taken responsibly.

- **Concurrent Engineering Rehabilitation**

Concurrent engineering includes all aspects of a defined process. For example, in a product industry, it will include sales, marketing, purchasing, finance, quality and design from the conceptual stage to de-commissioning.

With regard to the Mine Life Cycle (MLC) phases, concurrent engineering should be applied from the initial planning of the coal mine to the eventual post-closure phases as an input into the Rehabilitation Plan. This helps to ensure alignment of all operational activities to the rehabilitation process, thus ensuring minimum impacts on the environment throughout the MLC. Should operational decisions be made to change mining methods or basic processes, this information should be reviewed against the Rehabilitation Plan to consider the long-term effects, and not only the short-term effects, as is often the case due to immediate economic pressures. This can be applied to each phase of the MLC in order to ensure the whole focus remains on leaving a mined area in a stable and socially acceptable state, without having an uncontrolled environmental impact during and after the rehabilitation phase.

The way in which exploration is executed should also be incorporated into the final Rehabilitation Plan in order to evaluate all options and establish exploration practices with minimal environmental and financial burdens.

2.3 Coal mine reclamation

Having discussed the purpose of coal mine rehabilitation, the aspect of “reclamation” goes hand in hand with the process of rehabilitating a coal mine.

Typical reclamation aspects that form part of the rehabilitation process & structure, can be summarized as follows (RWTH: 2004, 4);

- **Preparation of the Reclamation Plan:** The land which is drastically disturbed due to coal mining activities should be brought back to its pre-mining conditions both economically and ecologically.

- **Base Line Study:** A Base Line Study is the evaluation of data, which is collected during the preliminary studies for reclamation of disturbed lands due to coal mining activities and determination of post mining land-use alternatives.

- **Public Relations and Exhibitions, Relations with Local Government:** Coal mining companies prepare an organization with local government to inform the public living in the vicinity of the mining district about the mining activities and their impacts and evaluate the public opinions about the activities.

- **Overburden Handling:** This aspect covers the overburden removal, storage, site preparation, removal, transportation and storage of topsoil, backfilling of the gaps generated due to stripping, production and other mining activities, smoothing the disturbed lands and spreading out the topsoil.

- **Environmental Studies:** Environmental Studies includes landscape activities, which is performed to re-establish the aesthetical values of the disturbed lands.

- **Mine Closure:** The mine closure process consists of finishing up all mining activities in accordance with rehabilitation studies, filling of gaps generated during all mining activities and bringing the topographic contour levels back to its original levels.

- **Monitoring, Maintenance and Control:** After mine closure, the reclamation studies are monitored and maintenance and controlling of reclaimed lands performed during 3-5 years of periods.

As can be derived from the above mentioned reclamation aspects, all of them form part of the complete framework pertaining to coal mine rehabilitation and the purpose thereof.

It is of utmost importance that mine closure planning should be linked in with the local economic development plans (Limpitlaw 2004:4). Linkage with the planning framework of local government as well as integrated development plans can ensure that post mining land uses are compatible with surrounding development initiatives. This broader view provides a context against which the investments of the mine in human capital and infrastructure can meet local/regional development needs and create a mechanism for economic growth post closure (Limpitlaw 2004:4).

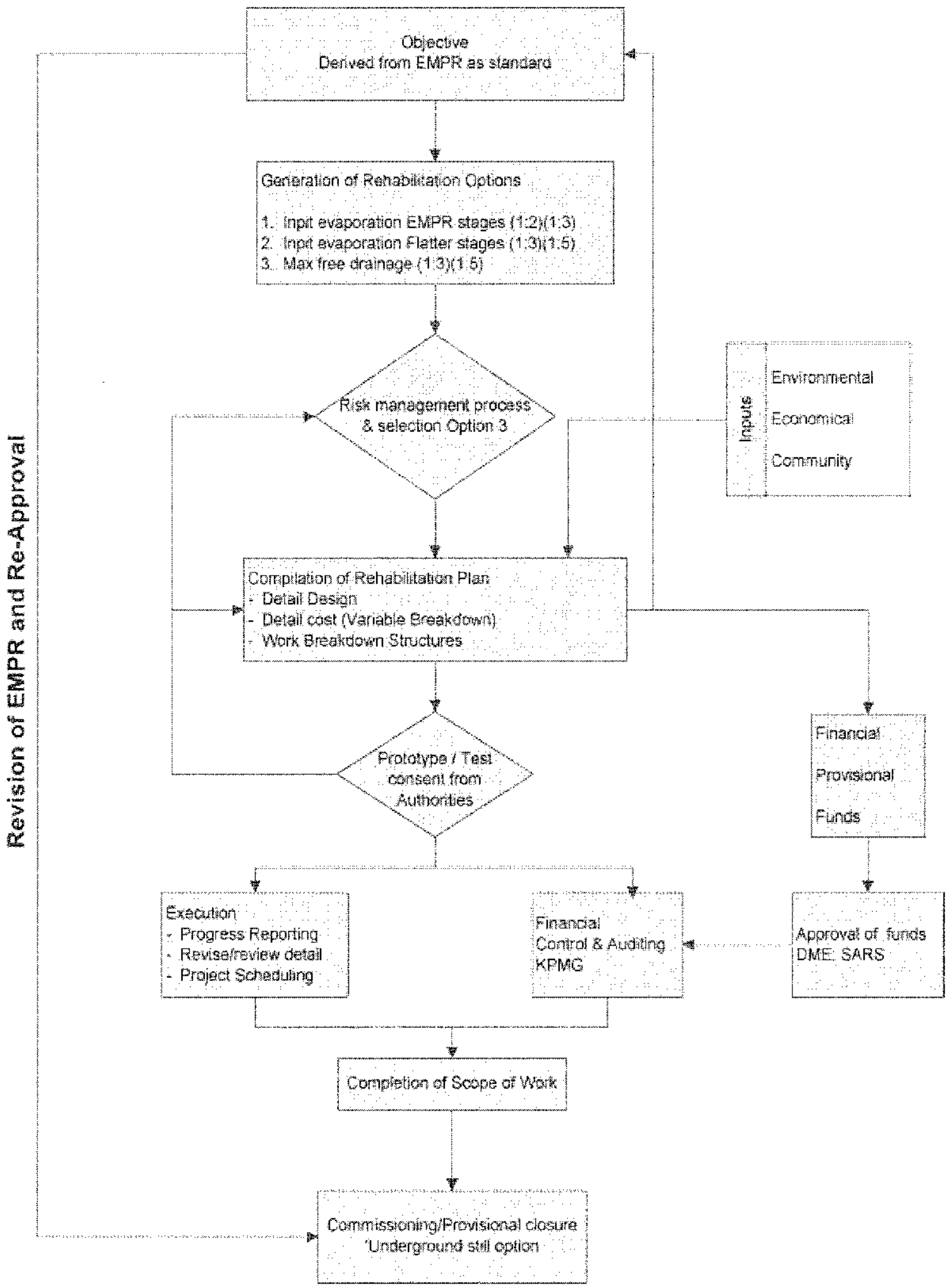

Figure 1: A Rehabilitation Process

(Fourie and Brent 2008:9)

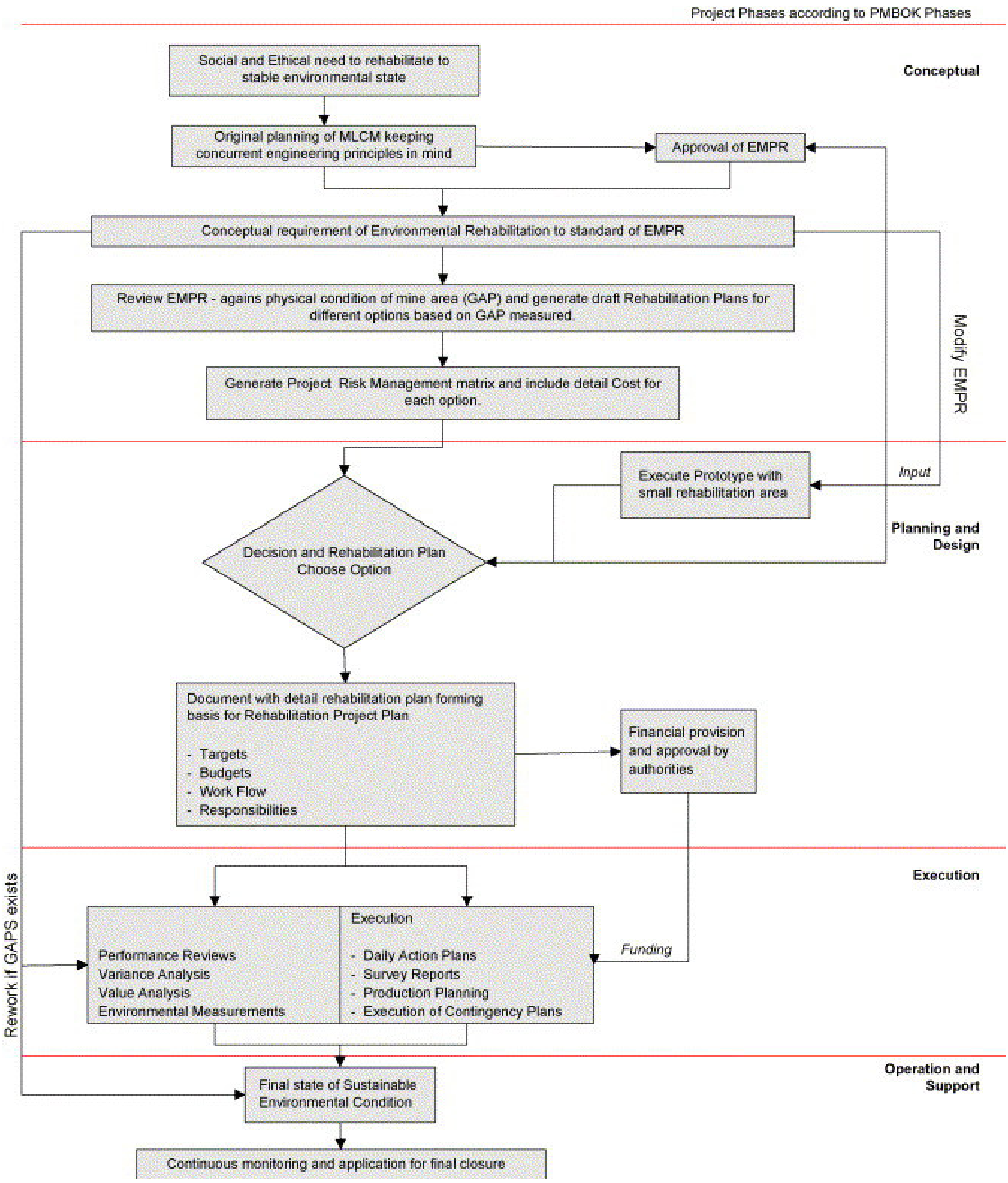

Figure 2: A Mine Closure Model

(Fourie and Brent 2008:17)

2.4 Summary

The purpose of rehabilitating a coal mine is an aspect that should be given a lot of thought and be dealt with in detail. The life cycle of a coal mine is usually between 25 -35 years, depending on the quality of the resources on the particular mine.

Historically, when an ore body was exhausted, production ceased and mines were boarded up and abandoned. Today it is accepted that mine rehabilitation and closure requires the return of land to a viable post-mining use, such as agriculture. It is not even sufficient to simply physically reclaim coal mined lands anymore as the socio-economic impacts of the closure must also be assessed and managed (Limpitlaw 2004:1).

Limpitlaw (2004:1) states that "a coal mine is often the primary provider of income, employment and services in a specific local economy. The rehabilitation and closure of the mine thus has significant impacts on the well-being of the community. This impact is more extreme in developing countries where local government lacks capacity to structure a development process that would provide alternative economic opportunities".

The safety, environmental and social risks arising from badly conducted coal mine rehabilitation and closure can result in significant liabilities for mining companies. For communities, rehabilitation and closure can cause severe distress because of the threat of economic and social collapse (Limpitlaw 2004:2).

2.5 Conclusion

There exist some major challenges with coal mine rehabilitation and closure in South Africa, therefore the mis-alignment of South African authorities and mining companies regarding rehabilitation as a phase in Mine Life Cycle Management (MLCM), should be examined. This mis-alignment results from the existing lack of structure, which is attributable to not following a formalized project management approach to mine rehabilitation.

By structuring coal mine rehabilitation into project management phases (i.e. objectives, feasibility, detail design, testing, execution, control and completion), and including additional working tools such as risk management processes to prioritize options, together with concurrent engineering principles to address each aspect of the MLC, the impacts and unexpected conditions of the MLC can be integrated with environmental requirements. Experiences in the South African coal mining industry indicate that some gaps do exist, and that best practice leans towards an integrated project management approach.

Based on these industry experiences, a Mine Closure Model (MCM) was derived (Fig. 2). Past closure failures are shown to be avoidable, as all aspects are continuously integrated and managed to a desired end state. Industry resources and financial funds can be motivated to improve the accuracy of evaluated risks, and complex negative impacts can be managed in a Project Risk Management system that generates contingency plans in alignment with environmental objectives.

The suggested MCM aligns the focus of South African authorities and mining companies towards achieving the required environmental state at the initial start of the mining activities (i.e. extraction). At present, the South African authorities emphasize that the management of mining companies should accept the long-term liabilities of their actions. On the one hand, companies overreact by investing ineffective financial resources to overcompensate. On the other hand, other side mining companies believe that a mine rehabilitation and closure will not be achieved, and thus attempt to bypass liabilities or only make provision for liability claims but neglecting the environment in the longer term.

By using the MCM as a formal and transparent process, the South African authorities can audit actions taken and provisionally state their acceptance of the suggested process towards mine rehabilitation and closure. It is possible for a mine company to accurately allocate financial funds and manage rehabilitation with an aim of achieving mine rehabilitation and closure in a responsible manner, knowing that the long-term environmental burdens were made part of each phase in the MLC.

2.6 Testing the Hypothesis

What is the purpose of rehabilitating a coal mine?

It is accepted that coal mine closure requires the return of land to a viable post-mining use, such as agriculture. It is not even sufficient to simply physically reclaim mined lands anymore as the socio-economic impacts of the closure must also be assessed and managed (Limpitlaw 2004:1).

A mine is often the primary provider of income, employment and services in a local economy. The closure of the mine thus has significant impacts on the well-being of the community. This impact is more extreme in developing countries where local government lacks capacity to structure a development process that would provide alternative economic opportunities (Limpitlaw 2004:1).

Rehabilitation includes the development of management strategies to restore and maintain physical, chemical and biological ecosystem processes in degraded environments. Rehabilitation of disturbed areas has been conducted for centuries; with the ultimate success thereof being largely dependent upon the prevailing environmental conditions, the characteristics of the site, and the inclination of and resources available to those undertaking the rehabilitation process (Limpitlaw 2004:2).

This statement is **true**. For coal mine rehabilitation and closure to be successful, adequate frameworks and structures must be implemented in the design and planning phase of each mine. Management strategies are the key for socio-economic sustainability and post environmental consideration.

3. THE DIFFERENCES BETWEEN OPENCAST AND UNDERGROUND PROCEDURES

Mine planning and design involves the compilation and integration of all relevant geological, geotechnical, mining, engineering and economic data into a single document to define and describe the exploitation strategy for a particular mineral or coal deposit within acknowledged and identified legal, financial and regulatory requirements and constraints (Fourie and van Niekerk 2001:2). Mine planning and design is an iterative and continuous process which starts at the conceptual stages of a new mining project, when the need for such a mining venture has been identified, and is only completed at the end of the mine's life when successful mine closure has been achieved (Fourie and van Niekerk 2001:2).

According to Fourie and van Niekerk (2001:2) "the primary objective of any mining plan should be the effective integration of all the activities involved in the overall mining process that will meet predetermined targets with regard to health, safety, environmental, productivity and unit cost criteria. The South African coal mining industry and its stakeholders acknowledge that effective mine planning and design forms the basis of any successful mining operation in meeting its objectives, both in terms of physical and financial performances, as well as in fulfilling its social and environmental obligations".

The goal of the ***planning & design*** for opencast and underground coal mining operations is a strategy for designing an integrated mineral exploitation system that will ensure that coal is extracted and prepared at a desired market specification, at a minimum unit cost, within acknowledged safety, health, social, legal and regulatory constraints (Fourie and van Niekerk 2001:3). A large number of specific engineering, scientific and economic disciplines contribute interactively to the overall mine planning and design process, thus making it a true multi-disciplinary activity (Fourie and van Niekerk 2001:3).

Given the complexity of the mineral excavation process, ***planning*** assumes the correct selection, co-ordinated operation and integration of all subsystems, whereas ***design*** applies to the traditionally held engineering design of subsystems (Fourie and van Niekerk 2001:3). In other words, planning in the context of this text refers to the consideration of the interrelationships that exist in the design processes and assures that the subsystems of all opencast and underground coal mining operations are in harmony with the overall mine design strategy. Planning therefore identifies key interrelationships that must be considered in the design stage. The design stage is that point where active system structures are developed and alternative options evaluated. An optimum design for any mining system is one that has considered the effects of each subsystem on all others and optimizes the objectives of the whole system (Fourie and van Niekerk 2001:3).

3.1 Coal as a resource mineral

According to Murthy and Singh (2007:2) “coal is one of the world's most plentiful energy resources, and its use is likely to quadruple by the year 2020. Coal occurs in a wide range of forms and qualities”. There are two broad categories: (a) hard coal, which includes coking coal (used to produce steel) and other bituminous and anthracite coals used for steam and power generation; and (b) brown coal (sub-bituminous and lignite), which is used mostly as on-site fuel. Coal has a wide range of moisture (2-40%), sulfur (0.2-8%), and ash content (5-40%). These can affect the value of the coal as a fuel and cause environmental problems in its use (Murthy and Singh 2007:2).

Murthy and Singh (2007:2) state that “the depth, thickness, and configuration of the coal seams determine the mode of extraction. Shallow, flat coal deposits are mined by surface processes, which are generally less costly (per ton of coal) than underground mines of similar capacity. Strip mining is one of the most economical surface processes. Here removal of overburden and coal extraction proceeds in parallel strips along the face of the coal deposit, with the spoil being deposited behind the operation in the previously mined areas. In open pit mining, thick seams (tens of meters) are mined by traditional quarrying techniques. Underground mining is used for deep seams. Underground mining methods vary according to the site conditions, but all involve the removal of seams followed by more or less controlled subsidence of the overlying strata”.

Raw coal may be sold as mined or may be processed in a beneficiation/washing plant to remove noncombustible materials (up to 45% reduction in ash content) and inorganic sulfur (up to 25% reduction). Coal beneficiation is based on wet physical processes such as gravity separation and flotation. Beneficiation produces two waste streams: fine materials that are discharged as slurry to a tailings impoundment, and coarse material (typically greater than 0.5 millimeters (mm) that is hauled away as a solid waste (Murthy and Singh 2007:2).

3.2 The mining development plan

Early planning and careful design of operations is the key to minimizing pollution associated with mining activities. Specific responsibilities should be assigned for the implementation and monitoring of environmental measures. Before mining begins, a mining development plan and a mine closure and restoration plan must be prepared and approved. These plans define the sequence and nature of extraction operations and detail the methods to be used in closure and restoration. These plans should be updated regularly as mining progresses (World Bank Group 1998:1, 2).

According to the World Bank Group (1998:2) "the mining development plan defines the sequence and nature of extraction operations and details the methods to be used in closure and restoration. At a minimum, the plan must address the following:

- Removal and proper storage of topsoil.
- Early restoration of worked-out areas and of spoil heaps to minimize the extent of open areas.
- Diversion and management of surface and groundwater to minimize water pollution problems. Simple treatment to reduce the discharge of suspended solids may also be necessary.
- Identification and management of areas with high potential for Acid Mine Drainage (AMD) generation.
- Minimize the generation of AMD by reducing disturbed areas and isolating drainage streams by avoiding contacts with sulfur bearing materials.
- A water management plan for operations and post-closure including minimization of liquid wastes by methods such as recycling water from tailings wash plant.
- Minimization of spillage losses by proper design and operation of coal transportation and transfer facilities.
- Reduction of dust by early revegetation and by good maintenance of roads and work areas. Specific dust suppression measures may be required for coal handling and loading facilities such as minimizing drop distances, covering equipment, and wetting storage piles. Release of dust from crushing and other coal processing and beneficiation operations should be controlled.

- Controlling the release of chemicals (including floatation chemicals) used in beneficiation processes.
- Minimization of the effects of subsidence by careful extraction methods in relation to surface uses.
- Development of suitable restoration and revegetation methods, appropriate to the specific site conditions.
- Proper storage and handling of fuel and chemicals used on-site to avoid spillages".

3.3 The mine reclamation plan

The World Bank Group (1998:2, 3) states that "the mine closure and restoration plan should include reclamation of open pits, waste piles, beneficiation tailings, sedimentation basins, and abandoned mine, mill, and camp sites. Mine reclamation plans should incorporate the following:

- Return of the land to conditions capable of supporting prior land use, equivalent uses, or other environmentally acceptable uses.
- Use of overburden for backfill and topsoil (or other plant growth medium) for reclamation.
- Contour slopes to minimize erosion and runoff.
- Plant native vegetation to prevent erosion and encourage self-sustaining development of a productive ecosystem on the reclaimed land.
- Management of post-closure AMD and beneficiation tailings.
- Budget and schedule for pre- and post-abandonment reclamation activities".

3.4 Opencast and underground mining techniques and rehabilitation procedures

There is quite a significant difference between opencast and underground coal mining techniques and their rehabilitation procedures.

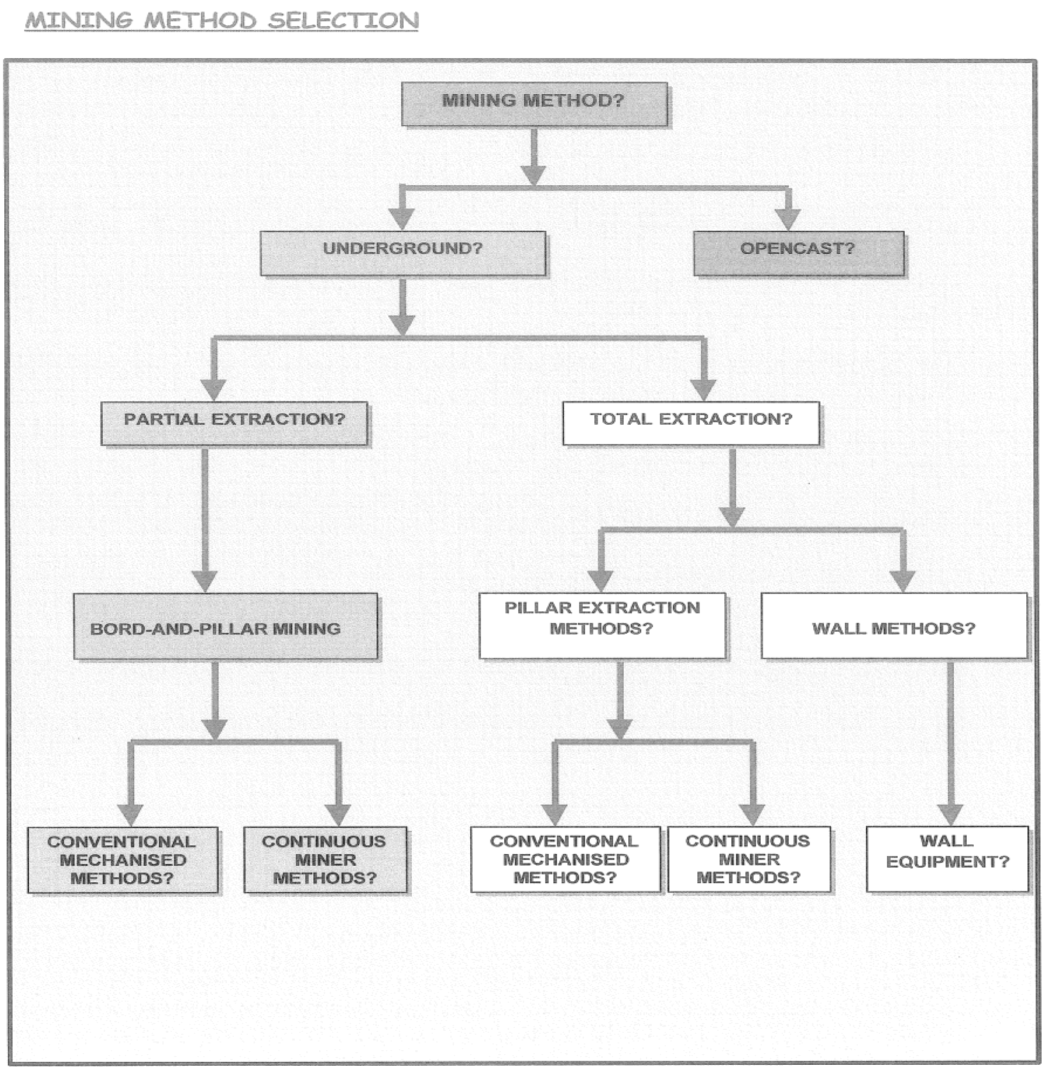

Figure 3: The coal mining method selection

Fourie and van Niekerk (2001:43)

3.4.1 Opencast coal mining techniques and rehabilitation procedures

According to Oryx Environmental (2006: i), "opencast mining can be described as a mining method that includes a combination of dragline and truck and shovel operations.
Coal is to be loaded onto trucks using a mechanical shovel, and taken to a tip adjacent to the pit where it will be crushed and loaded onto a conveyor".

The conveyor will transport the correctly sized coal to a stockyard adjacent to the power station. Haul and service roads will connect the various pits and tips. Offices, workshops, change houses and other key infrastructure are required for the maintenance of equipment and for staff (Oryx Environmental 2006: i).
The mining process will include stripping of usable soil for rehabilitation of the mining area. After removal of the soil, soft overburden will be excavated to reach the hard rock overlying the coal seam. The hard rock will be blasted and removed to expose the coal seam. The coal seam will then be blasted to fragment the coal. Blasting is usually a daily occurrence (Oryx Environmental 2006:2).

As open cast mining advances, the overburden will be tipped into the mined-out cuts. When these mined-out areas have been filled, the material will be flattened and the usable soil that was previously removed, will be replaced and leveled. Vegetation will then be re-established to rehabilitate the site.

3.4.2 Underground coal mining techniques and rehabilitation procedures

According to Bilodeau (2007:1), underground coal mining can be described as follows:

"There are two methods of mining that are typically used in underground coal mines in South Africa: room and pillar mining or longwall mining. All underground coal mines must have a Mine Safety and Health Administration (MSHA) approved roof control plan that is specific to that mine. As part of the plan, mines must include safety procedures that will be followed. For underground mining, the plan includes the use of temporary supports (timbers) or mobile roof supports to protect miners against roof falls".

In room and pillar mining, coal seams are typically mined using continuous mining equipment (continuous miner) that cuts a network of "rooms" into the seam of coal. As the rooms are cut, a series of pillars, or columns of coal, is left to help support the mine roof and control the flow of air. Generally, openings are driven 6. 10 meter wide and the pillars are generally rectangular in shape measuring 10.67 – 15.24 meter wide by 10.67 – 24.38 meter long. As mining advances, a grid-like pattern of tunnels (entries) and pillars is formed. Shuttle cars or scoops are used to transport coal to the conveyor belt for transport to the surface. The room and pillar method is often used to mine smaller coal blocks or thin seams as opposed to longwall mining, where large blocks of coal are mined. In some mines, both room and pillar and longwall mining methods may be used based on the nature of the coal seam (Bilodeau 2007:1, 2).

When room and pillar mining advances to the end of a panel, retreat mining may begin. Retreat mining is a planned and engineered method of removing all or part of the pillars. The removal of the pillars occurs in the opposite direction (retreat) from which the mining initially advanced. In retreat mining, as much coal as is feasible is mined from the pillars that were created in advancing the panel. Based on the extent of pillar removal, the roof may be engineered to cave to relieve stresses created by the removal of the coal pillars. When retreat mining is completed to the beginning (mouth) of the room and pillar panel, the mined panel is abandoned, and a new area developed using the continuous mining machine (Bilodeau 2007:2).

Mine shafts and adits (declines) must be left in a safe condition in compliance with the relevant mine safety regulations. Detailed and accurate survey plans of the workings and all entrances should be maintained at all times, including documentation of the conditions existing at the time of closure and abandonment. Such plans are required to be submitted to the DME at the time that formal notification is given of the abandonment of the mine and surrender of the tenure (Department of Minerals and Energy 1998:1).

According to the Department of Minerals and Energy (1998:1) ”potential problems and hazards associated with abandoned shafts and adits include subsidence, illegal access, fires, gas emissions, pollution of surface water or groundwater, illegal dumping of rubbish and injury to stock, native fauna and the public. Uncapped or unsealed boreholes present a potential hazard to stock, native fauna and the public, particularly where there is no readily identifiable indication of their presence, by way of a collar pipe or standpipe above the level of the natural surface. Whenever possible, information on the full extent and nature of the workings and the geological conditions should be obtained prior to closure. Where there is a high possibility of mine gas, seismic activity, or other destabilizing event, all measures and structures intended to seal the shaft should be adequately planned and designed. Advice should be sought from the local Inspector of Mines, Regional Environmental Officer or a Field Officer of the DME".

The Department of Minerals and Energy (1998:2) states that: "actions that should be taken before sealing shafts or adits include the following:

(1) The quality of mine water should be checked to determine whether the water could provide a useful water supply, or alternatively present a potential pollution hazard.
(2) All disused equipment should be removed and any waste, ore or similar material likely to cause pollution should be identified.
(3) Waste material containing hazardous substances should be disposed of safely in an approved manner and not used as fill in abandoned shafts, nor elsewhere on or off site.
(4) An accurate plan of the shaft/adit location should be prepared. The sealing/capping procedure for shafts and adits should be properly documented with scaled and dimensioned drawings".

The selection of closure and sealing methods for shafts will depend on site-specific conditions. Possible measures include:

(1) **Enclosure with safety fence or wall**. A sufficient area needs to be enclosed to allow for subsidence. The fence should be extended along the line of the excavation until rock cover is sufficient to ensure protection. The fence should be properly maintained while the adit or shaft remains unsafe. It may be necessary to negotiate a maintenance agreement with the landowner. Total reliance should not be placed on such enclosure alone to ensure safety (Schroder 2001:82).

(2) **Surface Covers and Caps**. These can be used to help prevent accidental access, illegal dumping and injury to animals or persons, usually in conjunction with enclosures, but they will not protect against subsidence nor support heavy loads. When covering or capping, concrete and/or steel plates, or other similar treatment should be used to raise the cover above ground level to avoid accidental loading. Covers should be sufficiently large to prevent burrowing around the edges.

Accordingly, it is preferred that caps (for shafts) be made of reinforced concrete supported around the periphery of the shaft by solid bedrock for at least one meter. To protect against termites and white ants with timbered shafts in weathered ground, consideration should be given to constructing the main seal in unweathered rock. The seal should be secured into the rock and the shaft then filled with rubble to above collar level.
Ventilation or breather pipes should be extended through the fill (Schroder 2001:83, 84).

(3) **Backfilling with Selected Material**. Abandoned shafts should not be used to dispose of rubbish, chemical residues or other hazardous substances. Generally, shallow shafts, (ie.those less than 100 meters in depth), should be filled to above surface level to allow for settlement. Precautions should be taken with the selection of material for filling and the procedure closely supervised to prevent material “hanging-up” and causing blockages that may later result in dangerous subsidence. It is generally not good practice to attempt to fill deep shafts due to the difficulties of ensuring total filling without hang-ups. Where flammable mine gas is present, tipping quartzite, concrete rubble with metal reinforcing, or other material liable to cause sparking should be avoided. At the commencement of filling, the base of shafts should first be stabilized with clean, hard, free draining rock to a depth at least five times the diameter of the shaft.
Materials used for filling a shaft (other than at critical points) should be stable and able to fill voids and support the shaft lining. Suitable materials include broken stone, brick and concrete rubble. A record should be kept of the type and amount of fill used and of the estimated total volume of the shaft and immediate excavations. Surface water drainage should be directed away from the filled shaft to prevent erosion or slumping of the fill material (Schroder 2001:85).

The World Bank Group (1998:3, 4) explains that “there is a need to reserve money over the life of the mine to cover the costs associated with mine closure. The amount of money and the type of financing required will depend on a number of factors such as the projected life of the mine, the nature of the operations, the complexity of environmental issues, the financial and environmental management capacity of the borrower/project sponsor, and the jurisdiction in which the mine is located. The mine reclamation and closure plan, the timing of its submission, and its financing should be discussed and agreed with the borrower/sponsor as early as possible”.

3.5 Summary

As can be derived from the above statements, it is quite clear that there are significant differences between opencast and underground coal mining techniques and rehabilitation procedures. The most important aspect regarding these rehabilitation and closure procedures is to follow the specific guidelines and methods published by the DME. Opencast and underground rehabilitation procedures should be performed in such a way that the surrounding environment will not be jeopardized for future use. The specific method used to rehabilitate opencast and underground coal mines, will serve as the basis for successful future land use and economic viability.

3.6 Conclusion

Ghose (2005:11) concludes that "rehabilitation is an essential part of developing mineral resources in accordance with the principles of ecologically sustainable development. Rehabilitation is not an operation, which should be considered only at, or just before, mine closure. Rather, it should be a part of an integrated programme of effective environmental management through all phases of resource development, from exploration to construction, operation, and closure".

3.7 Testing the Hypothesis

<u>What are the differences between opencast and underground rehabilitation procedures?</u>

Rehabilitation procedures can be either for opencast or underground mining operations. The differences between these two mining operations are quite significant and so are the ways in which they are rehabilitated. It must be kept in mind that the two methods of rehabilitation should each be dealt with in its own right.

The above statement is **true;** due to the fact that the two methods of coal extraction differ from each other, so does the methods through which they are rehabilitated. It is quite clear that the rehabilitation procedures are strictly structured for each mining operation and should be adhered to at all times.

4. The lack of financial provision for the rehabilitation and closure of a coal mine

According to the Environmental Protection Agency (2006:45) “the main objective of financial provision is to ensure that sufficient financial resources are available to cover:

- Known environmental liabilities that will arise at the time of coal mine closure
- Known environmental liabilities that are associated with the aftercare and maintenance of the coal mine until such time as the facility is considered to no longer pose a risk to the environment.
- Unknown environmental liabilities that may occur during the operating life of the coal mine”.

There are also the unknown environmental liabilities, which could occur during the aftercare phase, and post-surrender of the mining license. It is considered that the likelihood of occurrence of such liabilities should be extremely low provided that all significant environmental issues are identified and addressed during the closure, restoration and aftercare phases (Environmental Protection Agency 2006:45).

It can therefore be said that financial provision encompasses two aspects:

- Quantifying the financial amount of the environmental liabilities (known and unknown)

- Selecting appropriate financial instrument(s) to underwrite the liabilities.

Packee (2004:7) states that “there is essentially one reason that collieries are not being closed in accordance with the Minerals Act. That reason is money. Colliery closure forces two fundamentally opposing parties, namely the mine owner and the regulatory authorities, to the negotiating table”.

The imposition of the ‘polluter-pays-principle’ on industry, both formally and by unilateral consent on the part of governments, has driven a financial wedge between, what should be co-operating parties (Packee 2004:7). While the ‘polluter-pays-principle’ is the government’s single greatest tool for insuring environmental compliance, it represents the greatest threat to the bottom-line of mining companies (Packee 2004:7).

Packee (2004:7) concludes that “the ‘polluter-pays-principle’ mandates that the party, which causes environmental degradation as a result of its activities, is responsible for the costs of mitigation”.

4.1 Financial provision and associated liabilities

According to the Environmental Protection Agency (2006:45) “the amount of financial provision required for a coal mine closure should be determined using the Closure Restoration Aftercare Management Plan (CRAMP) (2006) as well as the Environmental Liability Risk Assessment (ELRA) (2006) process.

Financial provision should be clearly set out with a description of the liability, how it has been quantified, the amount of provision and the financial instrument used to underwrite the liability (Environmental Protection Agency 2006:45).

The abovementioned liabilities can clearly be provided for if structured according to the following financial provision methods set out by the Environmental Protection Agency (2006:48):

4.1.1 Known liability - closure

a) Description

Planned liabilities that will arise upon closure, of the facility (e.g. site decommissioning, residual waste disposal, landfill capping, soil and groundwater remediation programmes).

b) Method of Quantification

Preparation of a site specific Closure Plan as part of the overall CRAMP.

c) Amount of provision

Financial provision to cover all known environmental liabilities that are expected to be incurred upon closure.

d) Appropriate Financial Instrument

Cash based solutions depending on the type of activity: Cash deposits /Accumulating trust funds

e) Accessibility

Financial provision to be accessible by the regulatory authority and the operator with the approval of the regulatory authority. Provision to be maintained through the life of the activity and drawn down as the liabilities falls due.

f) Revision

CRAMP and cost estimates to be revised on a yearly basis and the financial provision updated to reflect the current level of known environmental liabilities.

4.1.2 Known liability – Restoration and Aftercare Management

a) Description

Planned liabilities that will arise upon restoration and aftercare management of the facility (e.g. land from restoration, long term soil and groundwater remediation programmes and long term environmental monitoring).

b) Method of Quantification

Preparation of detailed site specific CRAMP.

c) Amount of provision

Financial provision to cover all known environmental liabilities.

d) Appropriate Financial Instrument

Cash based solutions: Cash deposits /Accumulating trust funds.

e) Accessibility

Financial provision to be accessible by the regulatory authority and the operator with the approval of the regulatory authority. Provision to be maintained through the life of the activity and drawn down as the liabilities falls due.

f) Revision

CRAMP and cost estimates to be revised on a yearly basis and the financial provision updated to reflect the current level of known environmental liabilities.

4.1.3 Unknown liability

a) Description

Unplanned liabilities that have the potential to arise during the operational life of the facility (e.g. failure in chemical storage tank resulting in soil and groundwater contamination)

b) Method of Quantification

Undertake detailed site specific risk assessment (ELRA). Statistical (probabilistic) analysis of cost scenarios to calculate 90th percentile expected.

c) Amount of provision

Financial provision to cover the expected cost of potential environmental liabilities. Based on statistical assessment of cost scenarios.

d) Appropriate Financial Instrument

Risk-transfer instruments to reflect the uncertainty of the risk occurrence and availability of funds: Bonds/ Insurance/ Letters of Credit

e) Accessibility

Financial provision to be accessible by the regulatory authority and the operator with the approval of the regulatory authority. Financial provision to be maintained for the life of the potential environmental liability.

f) Revision

Risk assessment and cost estimates to be revised on a yearly basis and the financial provision updated to reflect the current level of unknown environmental liabilities.

4.2 Financial Constraints

In general, mine cash flow peaks during production and steadily declines as the operation approaches the end of mine life (Packee 2004:11). The mine owner is in the position of balancing decommissioning and final rehabilitation costs and the long- term liabilities imposed by regulation with declining revenues (Packee 2004:11). Furthermore, Packee (2004:11) states that “all mine assets will remain in place until a closure certificate has been granted”. For South African collieries closure is not merely a desirable situation but is an economic necessity (Packee 2004:11).

Packee (2004:14) explains: “in recent years, the national and, to a lesser but growing extent, the international operating environment of coal mining properties has been impacted significantly by environmental and other regulatory requirements. These constraints have invariably increased operating and capital cost requirements for the industry and have reduced production of mineral commodities. All these costs, whether direct or indirect, impact profit margins, ore reserves, mineral conservation, and ultimately project viability”.

Worldwide, mine rehabilitation and closure is accepted as being the last step in the active management of mines (Packee 2004:16). Thus, closure forces two parties with opposing self-interests to the negotiating table. The subject of these negotiations is the amount of the closure provision. Industry will seek to minimize the amount, while government will seek to maximize it (Packee 2004:16).

4.3 Financial instruments

According to the Environmental Protection Agency (2006:50) “there are a number of financial instruments available to underwrite environmental liabilities. The main instruments are based on the type of liability to be underwritten, along with a description of their advantages and disadvantages”.

4.3.1 Known closure, restoration and aftercare liabilities

Cash Deposits: Cash being deposited into a bank account in the sole name of the regulator. The cash can be paid in as a lump sum or being set up as an accumulating fund (Environmental Protection Agency 2006:51).

Advantages :

- Ensures that some monies are available in the event of the operator's insolvency.
- Provides long term security.
- Payment made into the account are invested rather than consumed in the form of premiums.
- Annual cost likely to be equivalent to that of bond or insurance premiums.

  (Environmental Protection Agency 2006:51)

Disadvantages:

- Monies may not be enough to cover the operator's obligations as capital is not pooled.
- Start up costs can close the market to small operators.
- Can tie up valuable working capital.
- Problems arise if a loss occurs at an early stage when the fund is not yet big enough to pay for it.

  (Environmental Protection Agency 2006:51)

Escrow accounts: The Environmental Protection Agency (2006:51) describes escrow accounts as "a property (cash or other assets) held by a third party (e.g. a lender) on behalf of two people (e.g. the licensee and the regulator) for a specified period of time until one or both parties meets the conditions set out in the escrow agreement (e.g. in the case of the licensee a successful surrender of its license with no liability having arisen)".

Advantages:

- Cannot be unilaterally released by the operator.
- Secures a definite amount of money to cover environmental liabilities.
- Suited to cover liabilities, which are quantifiable before operations commence, e.g. closure costs.

Disadvantages:

- Ties up valuable working capital.
- Potentially high transactional costs for all parties.
- Monies may not be released to cover obligations; it is meant to guarantee.
- Not suitable for unexpected liabilities such as damage to third parties.
  (Environmental Protection Agency 2006:51).

4.3.2 Short – medium term unknown liabilities

Insurance: A risk spreading mechanism for securing environmental liability. Through premiums, the overall cost for the operator of securing risks is reduced. By pooling together resources, the insurer is more likely to be able to respond to significant liabilities (Environmental Protection Agency 2006:52).

Advantages:

- Established and growing market.
- Products are available on the market.
- Current willingness by insurers and reinsurers to insure.
- Induces better environmental management.
- Cover is flexible and can be structured to include site closure costs.

Disadvantages:

- Larger operators may be able to negotiate better policies to the detriment of the smaller operator.
- Risk of insolvency of the insurer
- Attracts Insurance Premium Tax, although not VAT.
- It is possible that some sites will be uninsurable owing to site features of poor site management.
  (Environmental Protection Agency 2006:52).

The abovementioned financial instruments are only a few that can be used in the financial provision for coal mine rehabilitation and closure.

4.4 Financial Provision as set out by the DME

The Department of Minerals and Energy (2005:8) explains that "the Mineral and Petroleum Resources Development Act 28 of 2002, has relevant sections that deals with the financial provision for coal mines":

Section 41(1), requires that an applicant for a prospecting right, mining right or mining permit must, before the Minister approves the environmental management plan or EMP in terms of Section 39(4), make the prescribed "financial provision" for the rehabilitation or management of negative environmental impacts.

Section 41(2) provides that, if the holder of a prospecting right, mining right or mining permit fails to rehabilitate or manage, or is unable to undertake such rehabilitation or to manage, any negative impact on the environment, the Minister may, upon written notice to such holder, use all or part of the financial provision to rehabilitate or manage the negative environmental impact in question.

Section 41(3) requires the holder of a prospecting right, mining right or mining permit to annually assess his or her environmental liability and increase his or her financial provision to the satisfaction of the Minister.

Section 45, allows the Minister to recover costs in the event of urgent remedial measures.

4.5 Summary

As can be derived from the above statements and facts regarding the financial provision for coal mine rehabilitation and closure, it is of utmost importance to have the correct structures in place. A well co-ordinated and managed structure should form the basis of any financial planning and implementation process.

The holder of a prospecting right, mining right or mining permit is required to annually assess the total quantum of environmental liability for the mining operation and ensure that financial provision are sufficient to cover the current liability (in the event of premature closure) as well as the end-of-mine liability (Department of Minerals and Energy 2005:10).

4.6 Conclusion

Having discussed the CRAMP & ELRA processes as well as the financial instruments, the conclusion regarding coal mines' financial provision for rehabilitation and closure can be made. The coal mines do not implement the correct structures and therefore the management of funds isn't being carried out in the appropriate way.

In order for the DME to address the budgetary inadequacies within the department, it reported that it had to motivate for a budget increment. Furthermore, the department joined forces with the Department of Water Affairs and Forestry (DWAF) and the Department of Environmental Affairs and Tourism (DEAT) with regard to Pollution Control and Rehabilitation activities. Since these budgets are not adequate for the rehabilitation of these derelict ownerless mines, the DME is in the process of trying to secure some international donor funding within this regard.

4.7 Testing the Hypothesis

<u>Why is there a lack of financial provision for the rehabilitation and closure of a coal mine?</u>
Early cost estimates are critical: accurate timeous estimates are necessary to ensure that sufficient funds are available towards the end of the mine's life. The estimates should be updated systematically every five years (Limpitlaw 2004:6).
In many instances it is not always a case of not having financial provision for coal mine rehabilitation and closure, but a case of not managing the funds in an appropriate way.

The hypothesis is **partially true**; financial provision structures should be in place early enough to ensure proper planning strategies for any present and future liabilities. These structures should be monitored and updated on an annual basis and not every five years.

The statement of not managing the funds in an appropriate way is absolutely true. The funds in the Pollution Control Fund might be adequate for rehabilitation and closure purposes, but not managed properly according to legislation.

5. THE OBJECTIVES OF COAL MINE CLOSURE PLANNING

According to Laurence (2000:1) "the issues involved in mine closure are usually complex and the risks significant." Coal mines are opened with closure in mind and the post – mining phase of the operation is cautiously planned before construction. The disposal of mine waste is the greatest source of mining environmental impact in South Africa (Limpitlaw 2008:1).

The process of closing a mine successfully needs to be considered during the design stage of the project and should include the following requirements (Limpitlaw 2004:2):

- Constructive action by mining companies to make sure that the memory of mining is not one of negative environmental and social impacts.
- Pro –active involvement by local communities, to make certain that the benefits from mining are sustainable for future generations.
- Legal framework. (With early planning and support to local communities by government, this guarantees that authorities are not left to manage large environmental and social problems.)

Mine closure planning has increasingly become the focus of mining companies, governments, non-government organizations and other stakeholders and is destined to be the big mining issue of the new millennium (Laurence 2000:1).

The need to reclaim and restore derelict mining lands is now accepted in South Africa as a priority by the government and other non-governmental bodies. In certain countries e.g. Britain and Australia, investing in improving environmental performance, is viewed as providing competitive economic benefits. It is, therefore, imperative that mining operations should be designed, run and maintained to the best professional standards rather than to those ways, which appear to be the most economic in a short-term view (Tsivhandekano 2005:8).

The primary outcome of the mine closure planning report is the identification of the strategies and procedures that are required to meet all criteria as defined in the Environmental Management Programme Report (EMPR) in order to minimize the impact of mine closure on health, safety and environmental risks (Fourie and Van Niekerk 2001:37).

5.1 Coal mine closure planning

Noted by Fourie and Brent (2008:4) "the rehabilitation of mine sites should ideally be planned before any mining commences. Most coal mines that are still in operation today in South Africa are in excess of 50 years old. When opened, the mining planning and methods did not acknowledge ecological impacts and effects to the same extent as they do at present". Legislation has also changed and the EMPR's that are mandatory in South Africa are lacking the management of risks, and concurrent engineering throughout the life cycle, in order to ensure that all of the commitments to stakeholders are aligned with responsibility towards the environment (Fourie and Brent 2008:4).

Murthy and Singh (2007:6) mentions that; "as closure planning occurs some time before the actual closure decision is made, there is a high degree of uncertainty regarding the specific constraints and circumstances of closure. Therefore, to facilitate effective planning, it is necessary that certain assumptions are made on which the Closure Management Plan can be developed". These assumptions are typically generated during the early stages of planning and must be tested and refined progressively with the closure implementation and operation (Murthy and Singh 2007:6, 7). Many of these assumptions impart a degree of risk and may therefore have considerable implications if incorrect (Murthy and Singh 2007:7).

Limpitlaw (2004:4) mentions that the elements of good mine closure planning should commence in the design phase and contain the following: "times and costs; specifics about the expected final landform; risk assessment and a management plan for implementation of closure and post - closure monitoring proposals." It is of utmost importance that this plan should be integrated with annual mine plans.

5.2 Coal mine closure planning and the local community

To close a mine successfully, a trilateral consultation and problem solving process is required between mining companies, governments and communities. This process needs to commence at the design stage of the project. If conducted effectively, closure can be the mechanism by which capital generated through mineral extraction is transferred to future generations (Limpitlaw 2004:1, 2).

Mine closure planning should be linked in with local economic development plans. Linkage with the planning framework of local government can ensure that post mining land uses are compatible with surrounding development initiatives. This broader view provides a context against which the investments of the mine in human capital and infrastructure can meet local/regional development needs and create a mechanism for economic growth post closure (Limpitlaw 2004:4).

Limpitlaw (2004:4) states the following; “There are several ways in which mines can create socio-economic development opportunities for the local community. To promote sustainability these mining benefits must continue after closure. A number of mines contribute to adjacent communities by providing or subsidizing schools, clinics, hospitals, community centres or sports facilities.”

According to Laurence (2000:1) “There are three certainties in life; death, taxes and mine closures. Mineral resources are finite and even though the life of mines can be prolonged through reducing costs, mining lower grades, benefiting from higher commodity prices, and additional resource definition, eventually the mine will cease operating. The challenge for all stakeholders impacted by mining is to ensure that upon closure, costs to the community will be few and benefits will be optimized.”

Ensuring the best outcome for the community is one of the many challenges confronting a mining company and its management team as they attempt to optimize shareholder value (Laurence 2000:1).

Failing to involve the community during the mine closure process can result in numerous adverse outcomes including:

- Social ills including crime and alcoholism may escalate, an increasing problem in developing countries
- Local businesses could dramatically collapse
- Real estate values could plunge and
- Unnecessary expenditure of management and employees time (Laurence 2000:2)

5.3 Coal mine closure planning objectives

The following closure planning objectives have been identified:

- ***Identify potential post-closure uses of the land occupied by mine infrastructure in consultation with the surrounding land owners and land users. Should a suitable use for the mine infrastructure not be found, it will be removed.***

  Consultation should be a life of mine principle. If consultation is working well during the mine's operations then there will not be a problem during the closure process (Laurence 2000:10). The mining company should always be honest and transparent in its dealing with the community and should always provide it with appropriate notice of closure (Laurence 2000:10)

- ***Rehabilitate all disturbed land to a state that is suitable for its post-closure uses.***

  Identification of a viable end land-use before mining, excellent rehabilitation of the ecosystem for a specific land use together with restoring the land's ecological integrity and potential (Limpitlaw 2004:9).

- ***Rehabilitate all disturbed land to a state that facilitates compliance with applicable environmental quality objectives***

  The right to a clean environment and sustainable development is fundamental and closely connected to the right to health and well-being. It is of fundamental importance to note that there is a strong connection between the quality of the environment and the health of the people living and/or exposed to those environments (Environmental Rights 2002:1).

- ***Reduce the visual impact of the site through rehabilitation of disturbed land***

Successful rehabilitation to a low maintenance land use such as a native ecosystem, which is sustainable in the long term, requires an understanding of the basic concepts of soil development, plant succession, and species diversity. Rehabilitation aims to accelerate the natural successional processes so that the plant community develops in the desired way. The vegetation must be resilient to disturbance, especially fire, and principally, nutrient cycling and natural inputs must meet the demand for nutrients (Ghose 2005:2).

- ***Keep relevant authorities informed of the progress of the decommissioning phase***

By using the Mine Closure Model as a formal and transparent process, the South African authorities can audit actions taken and provisionally state their acceptance of the suggested process towards mine closure. It is further possible for a mine company to accurately allocate financial funds and manage rehabilitation with an aim of achieving mine closure in a responsible manner, knowing that the long-term environmental burdens were made part of each phase in the Mine Life Cycle (Fourie and Brent 2008:19).

- ***Submit monitoring data to the relevant authorities.***

After the coal mine has been rehabilitated according to the required legislative procedures, the rehabilitated area should be monitored on an on-going basis. No risks should be present at this stage, as the future use of the land might be that a new residential development will be built. The ground conditions and safety factors should be of such a nature that the development will be defect free.

Data should be submitted to the relevant authorities, indicating that the rehabilitated area is monitored on an on-going basis after the closure process was completed.

5.4 Summary

As can be derived from the above statements, it is quite clear that the objectives of mine closure planning should be understood by all parties involved in the life cycle of the mine. Mine closure planning should be taken into consideration in the design phase of the mine. This means that when a new coal mine is being designed and planned, the rehabilitation and closure planning phase should be made a top priority, although only happening in the end of the mine's life cycle.

5.5 Conclusion

A mine closure planning report should be implemented during the feasibility phase of designing a new mine and must be unambiguous. The objectives of mine closure planning should be seen as "goals" that needs to be achieved by all participating parties. This means that throughout the operating life of the mine, the mining company, government and local community should work together to fulfill the objectives at the end of the mine's life.

Geel (2008:18) explains that "sustainable development relies on people who coordinate, control, direct, plan and supervise the use and implementation of the sustainable development criteria". This means that all the relevant parties involved in the mine's operational cycle, should work towards achieving sustainable development.

5.6 Testing of hypothesis

<u>Are the objectives of mine closure planning unambiguous?</u>
The objectives of mine closure planning should be stated in such a way that all parties involved, should clearly identify themselves with each objective.

The above hypothesis is **true**. The objectives of coal mine closure planning should be clear and concise to all participating parties i.e. the mining company, the government and the local community. These objectives should be made part of the overall design plan of the mine. In other words, when planning to construct a new coal mine, the rehabilitation and closure phase should be priority number one, although only actually happening at the end of the mine's life cycle. Each closure planning objective is unambiguous and can therefore easily be understood by all the relevant parties.

6 Summary, conclusions and recommendations

6.1 Main Problem

Investigating the reasons why there is a lack of financial provision and management for the rehabilitation and closure of coal mines.

6.2 Background

Coal mine rehabilitation and closure is an important aspect for the coal mining industry and the local community within coal mining areas. The coal mine closure process begins with planning during the project feasibility phase and concludes when a closure certificate has been issued by the Department of Minerals and Energy. Where a coal mine has not developed a closure plan, early implementation of closure planning is the best insurance for achieving the required closure objectives.

Detailed coal mine closure plans should include rehabilitation and decommissioning strategies and provide for the allocation of financial and other resources within operational management. A consistent approach to defining, planning, implementing and evaluating successful environmental outcomes is essential to enable coal mining companies to complete environmental closure criteria agreed to by relevant stakeholders and ultimately enable government to issue the closure certificate.

The rehabilitation of coal mine sites should ideally be planned before any mining commences. An Environmental Management Plan is also necessary for operational coal mines to ensure that the best result is achieved, and that the communities and regulatory authorities are satisfied.

The coal mining industry in South Africa has experienced uncertainty as to how to manage the associated impacts of mining closures in order to leave mine sites in successfully rehabilitated states. Mine closure certification can now be secured from the Department of Minerals and Energy. By issuing a closure certificate, the government relieves a mine owner of obligations that might follow as a result of pollution and negative environmental impacts.

Financial provision for the rehabilitation and closure will be made in the coal mine's existing Pollution Control Fund.

By using a Mine Closure Financial Model for specific phases in coal mine closure, the following financial objectives can be achieved:

- The coal mining industry can plan closure successfully in a formal Environmental Management Programme. The entire closure process can be viewed as a project on its own with probable certainties, making the planning more deterministic.
- A budget can be compiled more accurately based on scenarios generated by the project plan, including any contingency plans and impact risks.
- The government through the Department of Minerals and Energy manages all unsuccessful closures. This places an obligation on the taxpayers for the cost. By achieving more successful closures, this burden to the taxpayers will be reduced.

6.3 Summary

The most important fact regarding coal mine rehabilitation and closure is for proper and detailed structures to be in place. Some of the structures referred to includes the following:

- Environmental Management Programme Report
- Environmental Management Plan
- Mine Closure Financial Model
- Mine Rehabilitation Process
- Coal Mine Closure Model

All these structures should be included in the feasibility stage of designing and implementing a new coal mine. Having detailed structures in place, all the objectives and outcomes required to be achieved, is much more manageable. The financial provision that must be made into the mine's Pollution Control Fund can also be managed and monitored much more effectively by having these structures in place.

On numerous occasions it is found that these structures are not implemented into the overall feasibility stage, therefore mine rehabilitation and closure are not considered from the initial planning phase. In some instances the issue of mine closure is only realized during the operational life of the mine and improper closure methods are then utilized.

One serious aspect that arises from not including such structures and frameworks in the initial feasibility stage, is that of financial concerns regarding coal mine rehabilitation and closure. The lack of financial provision and not managing such finances in an appropriate way is the biggest reason for not fulfilling mine closure according to the required legislation. In many instances the finances are inadequate, not managed correctly and in some instances, even "vanishing" due to fraudulent activities.

Having legal and structured frameworks in place will prevent these activities from taking place and ensure the proper rehabilitation and closure of coal mines.

6.4 Conclusion

Coal mining in South Africa is one of the biggest mining activities taking place with a number of mining houses actively mining. Coal is the essence behind generating electricity for the whole of South Africa. Without electricity and power, the everyday life of each citizen will be disrupted dramatically. Electricity makes it possible for us as citizens to perform our daily activities during daytime and very importantly, during night time.

The conclusion: coal is required to generate electricity which in its turn is required by us citizens to live and perform activities on a daily basis. As was derived, coal is extracted using opencast and underground mining operations. Major disruptions to the earth's vegetation and subsidence are made. These disruptions must be rehabilitated so that the specific piece of disrupted land can be rehabilitated for future use.

Financial provision and legal frameworks are the two main criteria for achieving successful coal mine rehabilitation and closure. The reason that there is a lack of financial provision and management for coal mine rehabilitation is that the closure planning frameworks and financial models are not implemented and carried out appropriately. The mining houses are so profit driven during the feasibility and the operational phases that the rehabilitation aspect is regarded as something that will be dealt with when "crossing that bridge". Rehabilitation frameworks should be implemented as early as possible in the coal mine's life cycle, to manage the finances required for successful closure.

6.5 Suggestions for further research

Research into coal mine rehabilitation and closure can be done in all types of disciplines i.e. Law, Engineering and Construction. Coal mine rehabilitation and closure involves sections such as methods of rehabilitations and closures, financial aspects, socio-economic development, sustainability and management of waste products.

Each one of these sections can be researched as a single investigation into the rehabilitation and closure of coal mines.

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8 ANNEXURE A

A few photographs indicating the various stages of a coal mine life cycle.

Figure 4: The terraces and earthworks being constructed for new buildings that will be built on the coal mine

(Rossouw 2008: Phola Coal Plant)

Figure 5: An aerial view of the new construction site

(Rossouw 2008: Phola Coal Plant)

Figure 6: A vertical shaft being constructed out of concrete (Rossouw 2008: Zondagsfontein Colliery)

Figure 7: Temporary retaining walls around the new shaft

(Rossouw 2008: Zondagsfontein Colliery)

Figure 8: A new conveyor belt being constructed

(Rossouw 2008: Phola Coal Plant)

Figure 9: New railway lines for the trains to transport the coal

(Rossouw 2008: Phola Coal Plant)

Figure 10: A coal mine in operation and actively producing coal

(Schmidt 2008: Bank Colliery)

Figure 11: The infrastructure on an active coal mine

(Schmidt 2008: Bank Colliery)

Figure 12: Infrastructure being demolished after coal mine closure

(Rooza 2008: Middelplaats Colliery)

Figure 13: Steel structures being broken down into manageable sizes

(Rooza 2008: Middelplaats Colliery)

Figure 14: Disturbed land being re-shaped for the specific rehabilitation required

(Rossouw 2008: Isibonello Colliery)

Figure 15: Some more earthworks being carried out on disturbed mining land

(Rossouw 2008: Isibonello Colliery)

Figure 16: Vegetation and new trees on the eastern part of an old coal mine dump

(Rooza 2008: Middelplaats Colliery)

Figure 17: Old coal mine dumps and slopes now covered in plant-life

(Schmidt 2008: Schoonie Dump)

Figure 18: The entire previously disturbed area , now covered in new vegetation

(Schmidt 2008: Schoonie Dump)

Figure 19: The end product of a coal mine's rehabilitation and closure process

(Schmidt 2008: Schoonie Dump)