Exploring the Linkages between Land Management Institutions, Land Degradation and Acid Mine Drainage: The Case of the West Rand Goldfield

Banze Nkulu Mulunda Frank

Research Report Submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg in partial fulfillments of the requirement for the Degree for Master of Science in Development Planning.

Johannesburg, 2013.

DECLARATION

I here declare that this research report is my own original work and that all sources have been accurately reported and acknowledged. It is submitted for the Degree for Master of Science in Development Planning at the University of Witwatersrand, Johannesburg. It has not been submitted for any degree or examination in this or any other University.

Signed **Banze Nkulu Mulunda Frank**, on this day **14**, in the Month of **May**, Year **2013**

_____

ABSTRACT

From the beginning of time, land has been an important asset to man: it provides shelter and serves as a source of livelihood for man (through farming, mining, etc.), which are important for human survival. However, these activities, if unmanaged, can contribute to the destruction of the quality of land and the environment. This study adopted a qualitative approach to understanding the dynamics of and logic behind government institutions' response(s) to the issue of AMD

The most prominent effect of mining activities that can negatively affect the quality of land is acid mine drainage, which is generated through mining activities and after mines closure. AMD formation takes longer to generate but its effects can persist even after mines have been shut down. It also results in the pollution of water, soil and air, and through these media, presents health problems to man, in this research report, a qualitative study was undertaken on the West Rand Goldfield. It explored the extent to which institutions responsible for the land and environmental management respond to the challenging issue of AMD in the West Rand Gold Field. The approach used to analyse government intervention in the study area is theoretically based. The report draws from different academic literature, policy documents, news articles related to AMD and how it been managed in the West Rand goldfield

The findings from the study were that most government interventions came into being only after AMD had started decanting from the mines in 2002. There is a lack of collaboration among different government institutions and other stakeholders for the management of the AMD problem. Furthermore, the land management policy is also not clear as to which arm of government should take the lead in AMD management, and there is a lack of enforcement of environmental laws and directives from by the Department of Environmental Affairs and Tourism (DEAT).

In order to rectify these problems, some of the measures recommended include policy reform to clarify roles and responsibilities of land management institutions, reducing the number of institutions involve in the management of AMD establishing a joint task force for land rehabilitations after mine closure.

DEDICATION

To my parents, who are no longer in this world of the living but showed me the importance of studies and hard work.

To Moshel Françoise Nkulu Mulunda: only the sky should be your limit - with faith in our God, hard work and perseverance all things are possible.

ACKNOWLEDGMENTS

While conducting this research has been pleasant and informative; the process has also been tough, frightening, burdensome and (financially, psychologically and physically) exasperating. Completion of this research would have been a next-to-impossible mission had it not been for the support from the following:

- God Almighty (through You, all things are possible)
- My supervisor Dr. Brian Boshoff, thank you for your guidance throughout the research report and my academic studies
- Professor Mfaniseni Sihlongonyane. I am grateful that you were there for me whenever I needed your input and clarification and for your making me understand planning concepts.
- Professor Aly Karam, thank you for your continuous academic and personal advice
- The lecturers/academics who continually inspire me; Nqobile Malaza (you've been inspirational from day one and Neil Klug for making planning studies enjoyable.
- The rest of my lecturers - Sarah Charlton (thank you for making me enjoy the Housing course), … and to all other lecturers Marie and Alison Todes, who in one way or another contributed to making my studies and my stay in John Moffat enjoyable, I say thank you.

LIST OF FIGURES:

LIST OF ACRONYMS

AMD: Acid Mine Drainage

ANZMEC: Australian and New Zealand Minerals and Energy Council

CEC: Committee for Environmental Coordination

CSIR: Council for Scientific and Industrial Research

DEA: department of Environmental Affairs

DEAT: Department of Environmental Affairs and Tourism

DMR: Department of Minerals Resources

DST: Department of Science and Technology

DWA: Department of Water Affairs

DME: Department of Minerals and Energy

DARDGP: Department of Agriculture and Rural Development Gauteng Province

DBSA: Development Bank of Southern Africa

FSE: Federation for a Sustainable Environment

GTT: Government Task Team

IDP: Integrated Development Plan

SDF: Spatial Development Framework

MEND: The Mine Environment Neutral Drainage

MMSD: Mining Minerals and Sustainable Development

NEMA: National Environmental Management Act

NEAF: National Environmental Advisory Forum

NNR: National Nuclear Regulator

OSMRE: Office of Surface Mining Reclamation and Enforcement

WRDM: West Rand District Municipality

TABLE OF CONTENTS

CHAPTER ONE:

GENERAL INTRODUCTION

1.1 Setting the Scene: Background

The discovery of gold in 1868 in the vicinity of Johannesburg was the tipping point for the development and expansion of the city as we know it today. However, it was the discovery of the Witwatersrand Goldfields around 1884/1885 which ultimately led to the later prominence of the gold mining sector (Reichardt, 2012). Thereafter, the mining industry expanded to other areas such as the East Rand, West Rand Welkom and Klerksdorp goldfields with the sinking of shafts (*ibid*.).

The consequence of mining expansion and the different techniques used, meant that huge quantities of ore were extracted from the ground to be crushed and sent away for the gold extraction process. Crushed materials by stump mills had been labelled as sand, which was then milled to smaller particle size, called slimes or tailings (*ibid*.). However, the production of industrial gold also generated waste which posed a disposal challenge. In this regard, Reichardt (2012) stresses that there were problems with the disposal of mine residues such as waste rock, sand and slime containing cyanide, surplus mine water and discarded solution, for lack of adequate mining legislation constraining it.

The Constitution of the Republic of South Africa Act 108 of 1996 provision(s) for the protection of the environment from harmful substances activities. Section 24 of the Constitution is the supreme authority regarding environmental sustainable development principles in South Africa. This means that the law regarding the protection of the environment involves the responsibility to give rights to environmental activities as well as that of preventing environmental disasters or repair after the disaster has occurred. Hence, the state institutions involved with land management are given the mandate to administer and take decisions that protect the environment. In this regards, the court in the case of the City of Tshwane Metropolitan Municipality vs. Grobler 2009 5 SA 563 (T) SAFLII, the high court judge stressed the need for more environmental awareness in the making of (environmental) decisions that have an impact on land, for example mining. Section 24 states that:

(a) Everyone has the right to an environment that is not harmful to their health or wellbeing; and

(b) To have the environment protected for the benefit of present and future generations through reasonable legislative and other measures that:

(i) Prevent pollution and ecological degradation

(ii) Promote conservation and

(iii) Secure ecological sustainable development and use of natural resources while promoting justifiable economic and social development.

(The Constitution of the Republic of South Africa Act 108 of 1996)

Also made emphatic by Section 24 above is the necessity for the regulation and management of activities such as mining by concerned state institutions. The emphasis on protection of the environment from mining activities due to the level of impact is also made clear by Sakoane (2005) who argues that gold mining activities in South Africa are associated with a number of negative environmental impacts - soil pollution, water resources contamination, destruction of heritage resources and agricultural land, to mention but a few. All of these occur in the form of subsidence, soil erosion, sinkholes and chemical pollution. Moreover, mining is associated with landscape changes that consequently change biological habitats, populations, communities and ecosystems (*ibid*.).

In addition to gold mining that threatens the environment with acid mine drainage in South Africa, there is also coal mine which generates AMD in some mining parts of Mpumalanga Province. As observed by the Centre for Scientific and Industrial Research (2009: 1) that, AMD from coal mining is problematic in the Highveld Coalfield in Mpumalanga, and has attracted significant media attention on the consequences of severe pollution seen in the Loskop Dam and the Olifants River Catchment. Correspondingly, Mohring *et al.* (2001) note that the number of operating coal mines in South Africa has declined by more than half from 112 in 1986, to 53 at the end of 2000, and the closure of these mines has the propensity to generate AMD and thus pollute the area. As such, through decantation, it is highly likely that AMD

will contaminate water resources, provided closure is not planned to prevent decantation from happening.

The Environment and Conservation assessment of the impact of mining activity on the environment by the Gauteng Department of Agriculture brings to light the fact that mining operations usually have a lasting impact on the quality of rock (ore) which in turn has an effect on the quality of ground water and landscape of the area after mine closure (GDAEC 2008). In addition, the stockpile of tailing that are see in mining areas contains heavy metals that seep into the ground below with the help of erosion, storm water runoff and contaminate the groundwater below (*ibid*.). This means that mining operations in South Africa contribute to environmental disasters and landscape changes (deformation).

The process of Acid Mine Drainage formation occurs due to the presence of water, where sulphide minerals are oxidized, resulting in the formation of large amounts of acidic water (Cobbing, 2008). When mines cease to operate, dewatering pumps may be turned off and water levels start to return to their natural level, a process known as 'rebound'. This water comes into contact with rock containing sulphide minerals exposed by mining (e.g. in underground shafts) and the pH of the water may drop considerably due to the resulting chemical reactions. This acidic water may then dissolve other minerals in the rock, which can lead to high concentrations of pollutants such as lead, zinc, aluminium or cadmium in the water and high salinity generally. Polluted, acidic mine water may overflow at the ground surface, sometimes in considerable quantities, and the problem is often referred to as 'Acid Mine Drainage' or AMD (Adler and Rascher, 2007 quoted in Cobbing, 2008).

AMD is the most devastating result of gold mining activities that affect soil and water resources. As such, the issue of AMD has been categorised as the second most severe threat to the South African environment after global warming (Naidoo, 2009). The closure of some mines in the Witwatersrand has led to AMD generation which is contaminating the environment, more specifically the quality of water resources in the area. According to Coetzee (Undated), void water is pumped from operational mines and floods non-operational basins, eventually leading to decant. More so, pumping shafts and decant act as point source (*ibid*). Hence, the decanting of AMD in the West Basin Randfontein, took government and mining companies by surprise,

when an abandoned shaft, flooded Tracy *et al.* (2002). In this regards, the GDACE Mining and Environmental Impact Guide (2008) note that since then, AMD has found its way into the Tweelopiestpruit and flowed northwards through the Krugersdorp Game Reserves towards the Cradle of Humankind World Heritage Site (Tracy and Liefferink, 2009). This, in essence, implies that the negative impact of closure of mine which has led to AMD generation has threatened the Randfontein area and its surrounds.

Since 2002, AMD has been a threat to the environment in the West Rand Goldfield and it has affected the wellbeing of social-economic and human health in the area by contaminating water resources (Report to the inter-ministerial committee, 2010). Moreover, the contaminated mine water which contains heavy metals substances is seeping into the ground and contaminating ground water. That having been said, the quality and quantity of water - an important commodity for human health, agriculture and industry is in danger and must be protected against harmful environmental threats such as AMD. The government has adopted the National Environmental Management Act 107 of 1998 (NEMA) as the guideline statute for environmental matters in South Africa. NEMA was enacted to give effect to Section 24 of the Constitution. It embraces the concept of sustainable development and the notion of co-operative governance: In addition, sectoral statutes have also been enacted to give effect to Section 24. These are the National Environmental Management: Protected Areas Act 57 of 2003, National Environmental Management: Biodiversity Act 10 of 2004, National Environmental Management: Air Quality Act 39 of 2004, National Environmental Management: Integrated Coastal Management Act 24 of 2008 and the National Environmental Management: Waste Act 59 of 2008.

In relation to environmental co-operative governance, NEMA has put in place on the one hand a structure (the Committee for Environmental Co-ordination), and on the other hand, a set of integrated plans (the submission of Environmental Implementation Plans (EIPs) and Environmental Management Plans (EMPs) that must be applied by specific national departments and provinces (Tracy *et al*. 2009).
The Constitution of the Republic of South Africa states that South Africa is one sovereign State; however there are different levels of government which share administrative and legislative power. Therefore environmental governance is

however shared at different level that is at national, provincial, and local sphere. Regardless of the threat posed by AMD, there appears to be a lack of consensus amongst companies, leading industry bodies, investors, international institutions, civil society organizations and governments to examine how mining waste management practices can meet the challenges of sustainable development (MMSD, 2002).

This implies that there is incoherency in the response of different institutions and role players in relation to National Environmental Management Act 107 of 1998 (Tracy and Liefferink 2009). This not only suggests that external parties and international bodies lack consensus with regard to how mining waste management can meet challenges of sustainable development, it also has negative implications for different institutions and role players concerned. Moreover, the poor management of AMD implies a huge environmental threat.

1.2 Problem Statement

According to Glazewski (2000: 12), the South African constitution is relevant for the management of the environment as it provides the framework for the administration of environmental laws. The Constitution designates 'environment' as a matter of concurrent national and provincial competence. As Glazewski (2000) notes, this institutional arrangement is causing some uncertainty about the respective rights and responsibilities of national, provincial and local government regarding environmental matters. The relevance of this is that the government response to the issue of AMD in the West Rand Goldfield seems to be lagging behind due to non-clarity on institutional roles and responsibilities regarding the matter of AMD.

The current situation of AMD was accelerated with the decline in the demand for uranium and the decline of gold mining profit; several mines in the Witwatersrand goldfield were forced to stop production and close down their operations (Winde and Stoch, 2010). Consequently, large numbers of mines in the region were left ownerless, dilapidated and riddled with mountainous piles of mine tailings which are a significant surface source of AMD (Tracy and Liefferink, 2009). This is an important turning point because closed mines stop pumping water and aggravate the acid mine drainage generation.

Muthreja and Paithankar (1994) highlight that the major sources of metal pollutants are mine drainage and water seepage through waste dumps (overburden and processing plant waste, tailings impoundments, surface runoff and groundwater interception). Thus, according to Sutton (2008), the major primary pathways by which contamination can enter the environment from mine site waste dumps (tailings) are:

- The airborne pathway, where random gas and windblown dust disperse outwards from the mine site

Figure 1.1: AMD formed owing to interaction between water and mine residue on the surface tailing reclamation operation in the Western Basin. This site drains into pit operations that are directly connected to mine void

Source: *Report to the inter-ministerial committee on AMD, 2010*

- The waterborne pathway, either via ground or surface water or due to direct access, where people are contaminated;

Figure 1.2: acid drainage flowing into streams near Krugersdorp
Source: Rachel, 2011

- Or externally irradiated after unauthorised entry to a mine site,

Figure 1.3: *Water pumped from the Eastern Basin to the treatment plant at Grootvlei Min*
Source: Report to the inter-ministerial committee on AMD, 2010

- By living in settlements directly adjacent to mines or in some cases, living in settlements on the contaminated footprints of abandoned mines.

Figure 1.4: *Tudor Shaft informal settlement, built on top of an old slimes dam. In December 2010 radiation levels here were measured at 15 times higher than normal background levels for the area. In 2011 the community was relocated, but only to an area 500m away from a mine dump containing uranium*
Source: Rachel, 2011

AMD mismanagement will result in the spills of acidic water into some of the country's water systems, such as the Vaal and Limpopo rivers that are important water resources for the country. Moreover, excessive stress is put on the country's economy and water-scarce environment, with the potential to weaken the agricultural and industrial sectors.

According to the Development Bank of Southern Africa (2009), South Africa's water resources are limited and support a dynamic growing economy and provision of services; and so there are areas in which water is already, or could soon become, a constraint to economic and social development due to acid mine drainage that is costly to manage. Therefore, it is of great importance that water resources that are in the vicinity of the West Rand Goldfield be protected against the treat posed by AMD.

The challenges of acid mine drainage management and the danger of its effects on the environment and human health is a major concern for governments, mining companies, scientists, ecologists and environmentalists to mention but a few.

The United States Environmental Protection Agency (USEPA) stresses the effects of AMD on the environment can be rated as second to global warming (Mandres *et al*.2009). It is thus a matter of urgency that the government, in collaboration with all parties concerned with and interested in the issue of AMD, establishes a working partnership for the protection of the environment against the negative effects of AMD on the West Rand Goldfield. In this regard, the National Environmental Management Act 107 of 1998 (NEMA) states that the government must prevent pollution and the National Water Act 36 of 2008 regulates the protection of water resources. Also, the Department of Water Affairs and Forestry (DWAF) proposes a holistic system approach to prevent the pollution of the environment by recovering the cost of water quality management from the polluter (Sakoane, 2005).

However, the challenge is that some of the (gold) mines that are responsible for generating AMD in the West Rand are ownerless, (thus there is no one to account for the pollution). Therefore, the current situation of AMD requires that all spheres of government unite their forces and work together and/or in conjunction with each other through 'cooperative governance' as stipulated by the South African Constitution for a better management of the situation. Surprisingly, government institutions are working in silos (Tracy *et al*. 2009). This means that there is no co-ordination of government intervention as well as effective institutional co-operation regarding the management of environmental disasters caused by mining activities. Whereas a successful AMD management will requires an efficient intergovernmental action to prevent negative impacts of AMD on the environment, social-economic and human health. This raise concerns about the ways government have responded to AMD situation in the West Rand Goldfield.

1.3 Research Question

To what extent have institutions responsible for the land and/or environmental management responded to the issue of AMD in the West Rand Goldfield?

The research sought to explore the management approach of AMD issue in the West Rand Goldfield by land management institutions and how these actions affect the quality of land and the environment.

Sub-Questions

In exploring the land management institutions approach, the research will use the following sub-questions to guide and develop depth to the investigation.

- What is the government structure in place for the management of AMD in the West Rand Goldfields?
- What are the impacts of AMD mismanagement and their implication to planning in West Rand Goldfield?
- How can planning mitigate the challenges associated with AMD in West Rand Goldfields?

1.4. Aims of the Study

Firstly, the purpose of this study was to understand the management approach of different land management or environmental institutions in relations to the environmental disasters caused by mining activities such as the case in the West Rand Goldfield. Secondly, the study sought to understand the role and responsibilities of these institutions in the process as well as how they operate and consider each other and other stakeholders such as mining companies, local community, scientific institutions and non-government organisations. Thirdly, the report also sought to understand the implications of AMD mismanagement to planning, socio-economic as well as the environment. Lastly, the study seeks to show how planning theories can be applied regarding the management of environmental disaster caused by mining activities such as AMD in the study area and across the country where simular situation is occurring like in Mpumalanga.

1.5. Importance of the Study and Relevance for Planning

Turton (2009) stressed that South Africa is a water-constrained country, with a long history of mining industry that use to be the economic drive of the country. Consequently, the mining industry is the biggest contributor to environmental

pollution. To date there are an estimated 6000 abandoned mines around the country and 400km^2 of mine tailings dams (Witwatersrand Goldfield) with the potential to generate AMD and contaminate the source of water (ibid). Moreover, according to the South African law, ownerless mines belong to the government and the government should assume all responsibility, including for environmental risk linked to mines residue hazard (Lifferink, 2009). Moreover, the West Rand District Municipality is home to the Cradle of Humankind a world heritage and source of job creation in tourism industry that needs to be protected against decanting acidic water. This also includes ground water resource that is important for human consumption and the economy.

According to the Department of Environmental Affairs report "State of the environment" 2007, South Africa faces various critical environmental challenges ranging from land degradation to the destruction of restricted resources; however it is the problem of acid mine drainage that may be its most dangerous hazard in terms of its impact on the environment. Hence this study intends to analyse the functionality of the institutions in relation to the management of acid mine drainage situation in the West Rand and their mechanism in place to prevent environmental disaster can be caused by AMD and identify the lessons that planners can learn from the institutional management of current AMD situation in the West Rand Goldfields and make suggestion for future references.

The study brings into the analysis the aspect of planning. It looks into how planning can intervene in the management of the current situation of AMD as well as mitigating it negatives effects in order to prevent the spreading over other regions. The significance of the study is highlighted by the fact that the issue of acid mine drainage in South Africa is on the rise, implication in the future are certain to affect the politics, socio-economics, environment and – most importantly – land management institutions and the making of policies and planning processes.

1.6 Research Methods

This study adopted a qualitative approach to understanding the dynamics of and logic behind government institutions' response(s) to the issue of AMD. According to Creswell (2009), the main characteristics of qualitative research method and Philip

(1998) are the use of multiple research methods and or sources of data to understand a specific event or phenomenon. The numerous sources of data for this research comprise desktop research (academic literature, policy documents, newspaper articles related to the issue of AMD, audio-visual material such as photographs, videos and recordings (ibid.).

The rationality behind qualitative procedures is for to comprehend government interventions and approaches, especially through interactions with informants who are either affected or concerned with the phenomenon of (AMD) (Philip 1998; Creswell 2009). These diverse research methods - photography, observations, case study, pieces of literature - are discussed in the section below.

1.6.1 Single Case Study: West Rand Goldfields

The research examined the case of the West Rand Goldfields, in order to explore land management and environmental management institutions' responses to environmental disasters caused by mining activities such as AMD.

Zainal (2007: 2) notes that:

> The case study method enables a researcher to closely examine the data within specific context [… because] Case studies, in their true sense, explore and investigate contemporary real-life phenomenon through detailed contextual analysis of a limited number of events or conditions, and their relationship

West Rand Goldfield has been chosen as the area of focus for this research because of its economic importance to RSA. For one, the area is home of the Cradle of Humankind, a world heritage site that is a tourist attraction and generates revenue for RSA. Also, the agricultural activities taking place in the West Rand Goldfields contribute significantly to the food security of the nation, and in the long run they – together with the surface and ground water of the area may be in threat due to the phenomenon of AMD.

While the issue of AMD is not unique to the West Rand Goldfields, it provides a context within which to explore the research question and yield useful findings and recommendations that can possibly be adopted in other (similar) contexts.

1.6.2 Literature

Diverse types of literature, ranging from academic books, journals, book chapters, newspaper articles; internet articles and policy or legislative documents, were used. Creswell (2009: 25) argues that reviewing literature in a study serves the purpose of situating the study in "the larger, ongoing dialogue in the literature, filling in the gaps and extending prior studies".

Academic literature such as journals, books, and book chapters were mainly used in chapter two in order to give the researcher a theoretical background of issues and concepts relating to the research study. This is critical because an understanding of theories relating to the matter at hand helps the researcher to understand as well as make a clear research question. As stressed by Reeves, Albert, Kuper and Hodges (2008: 631), theories "provide complex and comprehensive conceptual understandings of things that cannot be pinned down: how societies work [and] how organizations operate'. In this regard, theory provides an abstract comprehension of how government has reacted to the issue of AMD via policy. Moreover, theory helps the researcher "design a research question, guide the selection of relevant data, interpret the data, and propose explanations of causes or influences" (Reeves *et al.* 2008: 63).

Apart from the academic literature, online resources such as newspaper articles and legislation or policy documents were analysed by the qualitative researcher. The phenomenon of AMD has been in the public eye, as evidenced by the multitude of (online) newspaper articles based on the issue. Legislative documents were analysed and some were reviewed so as for the researcher to gain an understanding of the magnitude of government's responses to the phenomenon of AMD.

1.6.3 Photography

Creswell (2009: 180) observes that of audio-visual materials such as photography are creative and valuable methods of collecting data, especially in light of the fact that photography "captures attention visually". Pictures and videos have the power to immortalise the information in optical detail. The purpose of using photography in this research was to show the extent of decantation and/or AMD in the West Rand

Goldfields area. Pictures of the study area were taken and they formed an essential part of data collection. The power of the images taken by the researcher on site lies in their ability to visually show the nature and extent of damage caused by the phenomenon of AMD and/or decantation in the West Rand Goldfields area.

1.6.4 Mapping

The researcher used different maps to show areas in the West Rand Goldfields which are affected by AMD as well as areas with the potential to generate AMD. This method was helpful in such a way that it gave the researcher a clear view of mining location in relation to human settlement in the West Rand Goldfield.

1.7 Limitations of the Study

In as much as the researcher is aware of the fact that the phenomenon of AMD - as a result of mining activities and the closure of mines – is acute in the whole of RSA. However, the researcher does not intend to look beyond the boundaries of the West Rand Goldfields area to understand the extent of damage caused by AMD, as well as government's response to the issue. The aim is to use the case of the West Rand Goldfields as an encapsulation of government's reaction to the (effects of) the phenomenon of AMD

1.8 Chapter Outline

This research is comprised of five chapters, and the essence of these five chapters is summarised below.

The first chapter gives a general introduction to the topic and the phenomenon under study. It consists of the background, aims of the study, problem statement, research question, research methods, study limitations as well as the importance of the study.

The second chapter reviews literature drawn from various sources on institutional management of the issue of acid mine drainage (AMD) management in the West Rand Goldfield and RSA. . The second chapter comprises four sections. The first section describes the concept of AMD, AMD generation, environmental impact of AMD, AMD situation in South Africa and how it been managed. The second section investigates South Africa land management system in relation to AMD management

in the West Rand goldfield. The third section examines the issue of land degradation as a result of poor AMD management.

The third chapter 'formally' introduces the area of focus – the West Rand Goldfield as the case study area for the research. The chapter presents the historical background of (mining in) the West Rand District Municipality, the situation of AMD in the area, the systems and approaches put in place by the municipality to manage the issue of AMD, as well as the WRDM environmental management institutions.

The fourth chapter is based on an analysis and discussion of different issues identified by the literature review as the causes of AMD mismanagement. It discusses the nature and extent of institutional response to the AMD situation in the West Rand Goldfield. Furthermore, the chapter discusses the institutional management approach of AMD situation. Not only that, the chapter analyses the causes and effects of AMD.

Chapter Five is the study's concluding chapter which, in essence, is partially focusing on a summary of the examined and interpreted outcomes, also it comprises the researcher's recommendations on alternative institutional AMD management method using planning approach.

CHAPTER TWO:

LITERATURE REVIEW

2.1 Introduction

Since the discovery of gold in 1886 by George Harrison in what is known today as Johannesburg, mining activities have expanded dramatically because of the commercial exploitation of gold which came in 1896 in Transvaal (Harington *et al*. 2004). More so, it is the discovery of the Witwatersrand Goldfield in 1886 that has led to the development of South Africa's world-class gold mining industry for 120 years (AngloGold Ashanti, 2006). At the same time companies established in this area used different techniques to mine, but has used the natural environment to dispose waste generated from mining activities. The disposal of mining waste has led to natural environment contamination, which Weierbye *et al.* (2006) argues the long history of mining activities in South Africa has had negative impacts on the environment and led to ground water and soil contamination.

In this regard Adler *et al.* (2007) quoted in Funke *et al.* (2011) that, from an environmental standpoint, South Africa faces a number of environmental challenges that affect the ecological biodiversity as well as its socio-economic and socio-political security. One of the most well-known mining challenges to the environment is the Acid Mine Drainage (*ibid*). Nevertheless, "the disposal of mine wastes on the environment has a negative implication on the environment that include contamination of streams AMD, contamination of streams due to surface run-off from impoundment area, air and water contamination due to wind erosion of dried-out tailings, possible risk of catastrophic dam failure and release of slimes, physical and aesthetic modification to the environment and difficulty of establishing vegetation cover to permanently stabilise the tailings, due to unfavourable soil conditions in the presence of pyritic tailings" (Oelofse et al, 2007: 1).

Hence, the long negative legacy of mining activities on the environment requires an efficient management from government institutions in order to prevent pollution which destroys nature and threatens the wellbeing of future generations.

To date, the management of AMD situation in the West Rand Goldfield is a matter of great concern due to the fact that no positive result is palpable since the first decant in 2002, this situation could lead to unrest in the local community if land management institutions do not acts efficiently.

This chapter focuses on the review of the general literature on land management, environmental legislation as well as land degradation in relation to the management of acid mine drainage in the West Rand Goldfield. The chapter start by defining the concept of AMD, explaining how it forms and how it can be predicted. Furthermore, the chapter draws on examples from the South African literature on land management, as well as different institution involved in land and environmental management, especially regarding the manner in which they have responded to the issue of AMD in the West Rand Goldfield. To conclude, the chapter shows how poor land management system can lead to land degradation.

2.2 Theoretical concerns

According to Younger (2001), AMD is largely responsible for most environmental hazards in South Africa and as such it is associated with pollution from mining activities and must be prevented from contaminating the environment. The reason for this is to ensure health safety, prevent environmental pollution and encourage sustainability. For this reason, Gadsky *et al*. (1990) argues that acid mine drainage is the largest single environmental threat to date in South Africa, and it is estimated that the situation could aggravate due to closure of mines that have reached their maximum capacity.

According to the Department of Water Affairs media release (2010: 2), AMD arises when sulphate bearing minerals are exposed to oxygen. Thereafter, the process termed pyrite oxidation, is enhanced when water moves through and over the surface of acid bearing rock having been exposed because of mining activities disturbing the underlying geology. Hence, the process that leads to AMD formation is as follows:

- Exposure of ore or waste materials containing sulphide minerals to ground water seepage and oxygen resulting in acidic water, rich in heavy metals and sulphates in a mining environment;

- Most common sulphide mineral, abundant at metal and coal mines: Pyrite (FeS_2);
- Outflow of polluted water through mine voids resulting in Acid Mine Drainage (Coetzee *et al*. 2008).

2.2.1 Acid Mine Drainage Overview

The process of AMD starts in most cases when mines cease activities or are abandoned, especially when pumps that were pumping water out to the surface are turned off, the rebound of the water table can lead to contaminated ground water being discharged (Johnson and Hallberg, 2005). Water draining from abandoned mines is often highly acidic; posing a major risk to the receiving environment due to the presence of heavy metals such as iron, aluminium and manganese (ibid). In addition, disposal of mine waste affects not only the environment on the surface but also the ground water in the long run through infiltration processes of heavy metals that it contains. This contamination of ground water through AMD is putting pressure on available fresh water by contaminating it with heavy metals. Bell and Donnelly (2006) estimate that ground water represent about 90% of fresh water worldwide.

The true extent of the environmental pollution caused by AMD is difficult to establish but it was estimated that ca. 19,300 km of streams and rivers, and ca. 72, 000 ha of lakes and reservoir worldwide had been seriously damaged by mine effluents (Johnson *et al*. 2006). This means that environmental impact associated with AMD can be felt long after mines have stopped activities. Therefore, AMD remains a major concern for the South African government, mining companies and communities in relation to Section 24 of the 1996 Constitution of the Republic of South Africa (see chapter 1, Background). It is the responsibility of the government to make sure that the environment is taken care of and that mining companies comply with the constitution in this regard.

2.2.2 AMD Generation

The oxidation of sulphur-rich mine wastes interactions with water and oxygen results in the release of Acid Mining Drainage. When the ore containing high amounts of pyrite and other sulphide minerals is processed, the rock and tailings produced on

the surface are exposed to water and oxygen. Adding to that, the excavation practice exposes sulphide in the walls of opencast and underground operations, and perturbs the host rock and hydrological regime around mined-out areas, allowing the entrance of water and oxygen, (Report to the inter-ministerial committee on Acid Mine drainage, 2010).

According to Jennings et al (2008), in South Africa, the environmental impacts relating to mining activities are as follows:

1. *Soil pollution from Mining waste*: A 1991 CSIR report estimated that mining and discards (mines dumps or tailings) constitutes about 75% of the total waste generated within the country. However, at the writing of this report, there were no new data available to measure whether the situation has improved or not. The MPRDA Act 28 of 2002 defined tailing as a "product derived from or incidental to a mining operation and which is stockpiled, stored or accumulated for potential re-use, or which is disposed of, by the holder of mining rights, mining permit or production rights". The disposal of mine dumps or tailing must be done in accordance with the environmental law set forth. However, some tailing in the West Rand are disposed without following the necessary environmental protection as regulated by the law (personal observation during site visit).

2. *Atmospheric pollution from contaminated tailings*: the current regulation emphasises the fact that, uncovered mine dumps presents a danger to the air and atmosphere. Therefore, it requires that all mine dumps around the country be covered to prevent airborne pollution and to control dust and fumes released into the atmosphere. Again, the covering of mine dumps in and around the country and in the West Rand Goldfield is not applied according to the law. In the West rand, for instance, there are situations where RDP houses are built not far from uncovered mine dumps which are in total contravention of basic principles of human settlement. (Example of Tarlton in Mogale city)

3. *Water Pollution from AMD*: the presence of metals in mine dumps presents a great danger to the environment and human health as it can contaminate

ground water by seeping underground which is an important source of potable water in South Africa.

2.2.3 Prediction of AMD

During feasibility studies, substantial emphasis is placed on prediction of acid mine drainage generation before coal mines development in the Eastern United States (Pennsylvania DEP 1998; Skousen and Ziemkiewicz, 1996), and metal mining in the Western Unites States and in Canada (MEND, 2001) could be approved. The standard procedures for evaluating geologic materials for their ability to produce AMD are generally agreed upon within the scientific community, but the uncertainties makes it difficult for scientists and engineers to predict the ultimate drainage quality years in the future as many complex variables influence acid mine drainage generation and neutralization (*ibid*).

The result of this approach was that, the prediction of AMD generation proves to be an effective step in dealing with the negative impacts of AMD on the environment. Rose *et al.*(undated), on the assessment of prediction of AMD potential from coal mine, states that, the process of prediction is very complex and they are not yet able to make accurate predictions of future acid mine drainage generation at mine sites or to prevent or even ameliorate acid mine drainage at an economically acceptable cost. This shows that AMD prediction can be a very delicate operation and can vary from one type of mine to another, such as gold or coal mines. According to U.S Environmental Protection Agency (U.S.E.P.A), the focus of AMD generation prediction should therefore be:

- To determine if a discrete volume of mining waste will generate AMD and ;
- To predict the quality of the drainage based on the rate of AMD formation measured (California Mining Association, 1991).

Furthermore, the most important things to consider when evaluating the AMD generation potential of a rock material are firstly, the collection of samples from the field for analytical testing; and secondly the determination of the kind of analytical test method to use (U.S.E.P.A, 1995). Hence methods used to predict the acid

generation potential are classified as either static or kinetic (*ibid*).Below are certain steps that companies and government institutions should consider in order to be able to predict AMD generations, (British Columbia AMD Task Force, 1989; California Mining Association, 1991)

- Develop a sampling plan based on the understanding of geology (rock mass, etc.). Collect samples to represent ranges of compositional variation within a rock unit. (See also Lapakko 1988, 1990a).
- Select static or kinetic tests and evaluating potential for acid formation.
- Evaluate sampling criteria and conduct additional kinetic tests as required.
- Develop a model as appropriate.
- Based on findings, classify geologic (lithologic) units as either acid, non-acid forming, or uncertain. (Note: the potential to produce acid may vary within a given geologic unit.)

Based on the afore mentioned and the analysis of AMD prediction method and its objectives, one can conclude that there is no prediction methodology or a blue print prediction method which is universal and able to give with accuracy the future acid generation potential of a mine.

2.2.4 Environmental Impacts of AMD

According to Sakoane (2005), Acid Mine Drainage impact on the environment happens over time and depends on drainage quality, baseline environmental conditions and the natural dilution and neutralizing capacities of the environment. The dilution of the environment will depend on the magnitude of flow of the receiving water in relation to the contaminated drainage (*ibid*).Also, the rainfall seeping through the mine waste may carry the acid to nearby streams, destroying the aquatic life and contaminating surface water supplies.

Weber-far *et al.* (2001) on assessment of AMD effects, stresses that the effects are that it can lead to loss of agricultural land , water pollution, potable water quantity being reduced, tailing management, noise, dust, and land disturbance. The danger

of AMD to the environment has been documented by a number of institutions as noted by UNEP (2002) cited in Jennings *et al*. (2008). The consequence of the discharge of acidic water into streams is that, fish die resulting from the uncontrolled release of acid and metals from mine wastes into receiving streams and a number of this kind of situations have been reported worldwide in which hard rock mining, milling, and smelting activities have occurred (*ibid*).

For example, in 1998, a mine flood incident in Spain dumped some 6 million m^3 of acid water over the banks of the Guadiamar River with metal and sulphide rich sediments. In the United States of America, the EPA has described 66 cases in which environmental damages from mining activities are detailed (EPA 1995 in Jennings *et al*. 2008). Furthermore, Jennings *et al.* (2008) quoting Nordstrom and Alpers (1999) argues that millions, perhaps billions, of fish have been killed from mining activities in the U.S. during the past century.

Consequently, the negative effects of AMD can harm food security, the health and livelihood of the poor population, especially vulnerable people with little means of improving negative impacts (Weber-far *et al.* 2001). It is important to note that, the negative impact of AMD on the environment can be caused by small or large mining scales. As stated by the CSS (2002) quoted in Jennings *et al*. (2008) that AMD continues to emanate from established mines in Europe during the Roman Empire prior to 467 AD. This means that environmental management institutions should be constantly monitoring areas with a long history of mining in order to prevent AMD formation and it decanting in the environment.

Effects of AMD on Aquatic Resources

AMD is characterized by high levels of heavy metals in water, as such it is responsible for physical, chemical and biological degradation of water streams habitat (Jennings *et al.* 2008). This means that once AMD is formed and decanted into the environment, it becomes available to the biological organism of the receiving environment. Therefore, when it reaches streams of water, fish and other animals are directly exposed to different metals contained in AMD and H^+ ions and this may weaken their respiration and acute toxicity may result after consumption (*ibid*.). Hill

(1974) points out the fact that contaminated receiving water may have pH as low as 2.0 to 4.5 levels toxic to most forms of aquatic life.

Effects of AMD on Water Resources

According to Coetzee *et al.* (2006), the impact of mining activities, in particular gold mining, on South African water resources can be divided into two major groups:

- The impact on the availability of water in the areas (qualitative aspect);
- The impact on the quality of water.

As noted in chapter one, South Africa is a water scarce country; therefore efficient and sustainable planning is required to protect the country's water resources; such as streams of water and ground water (aquifer). The relevance of this statement is that AMD contains a number of chemicals such as acidity, high concentration of dissolvent metals and deposition of precipitated metals oxides like iron hydroxide that put too much stress on receiving aquatic ecosystem (Mcnight and Feder 1984; Kelly 1988 cited by Niyogi *et al.* 2001: 506).

Moreover, according to Kelly (1988) quoted in Niyogi *et al.* (2001), the high levels of concentrations of heavy metal contained in AMD can be toxic to aquatic biota. Furthermore, Abiye *et al.* (2011) cited in Bamuza *et al* (undated) states that most parts of South Africa rely on ground water resources for a number of domestic and agriculture activities. It is important to note that agricultural industry is one of the biggest consumers of groundwater after industrial and mining activities (Abiye *et al*. 2011). This means that economic growth in South Africa depends also on the provision of clean water. If the current situation of AMD in the West Rand is not solved efficiently, the country is going to face a major multi-sectoral crisis. This is due to the fact, in the West Rand District Municipality groundwater is collected from shallow aquifers composed of alleviated materials, weathered rocks and small surface water streams (Abiye *et al*. 2011). Therefore, due to the presence of these important waters sources in the study area, a proper management system must be put in place to protect these sources of water against AMD hazard. Hence, environmental management institutions must work in collaboration with one another and the mining companies to prevent AMD from entering streams of water and

sources of groundwater that are found in close proximity with areas that have the potential to generate AMD.

However, AMD is not the only thing that stresses groundwater and water resources in South Africa, as noted by Ryan *et al.* (2010) that urbanization, agricultural and industrial activities continues to affect groundwater negatively as well. More so, Witthuser and Holland (2008), argue that urban expansion, industrial development, and mining activities have put too much pressure on the dolomitic aquifers in the West Rand area.

Hobbs *et al.* (2007: IV) conclude that "the quality of groundwater in especially the karst aquifer of the Zwartkrans compartment derives from both acid mine drainage originating in the outlier and from effluent discharge originating at the Percy Stewart waste water treatment works. Whereas the former contributes elevated calcium, sulphate and heavy metal concentrations, the latter primarily contributes exceedingly high bacteriological concentrations to the Karst environment." Furthermore, Hobbs *et al.* (2007) argues that AMD from defunct and flooded underground gold mine in the West Rand presents a threat to the Cradle of Human Kind World heritage site as well as landowners and agricultural activities that are essentially or wholly dependent on groundwater for potable and economic use.

Based on the aforementioned effects of AMD, it is clear that there are many threats to water resources such as groundwater and streams of water in the West Rand due to effects of AMD. The consequences of this situation will be affecting not just West Rand District Municipality but the entire Gauteng region by contaminating the streams and ground water if government institutions fail to take responsible and effective actions to deal with the issue of AMD in the West Rand goldfield area. Therefore, cooperative planning will be appropriate because it will help all government departments to exchange their views and found a common solution to the problem of AMD.

Effects of AMD on Quality of Land

The negative effects of mining activities on quality of land have been documented by a number of Environmental scientist and environmental activist; these effects range form sinkholes, instability of landscape, water resources contamination due to AMD

and disposal of tailings which are highly airborne toxic. In this section, the focus is on AMD generate throughout mining activities and that have a potential to degrade the quality of land when it decant. Therefore, AMD affect negatively the quality of land in different ways and the most probable one is the reduction of the quality of arable land and consequently the agricultural industry and livelihood of communities living in these areas.

The other negative effect of AMD on quality of land is that it can affects the stability of infrastructure development or human settlement due to water contamination that is important for human consumption and land instability which can lead to landslide. In this regards Van Niekerk *et al.* (2005) argued that ground instability in dolomitic land occurs naturally if given sufficient time and the presence of triggering mechanism that can be caused by human activities such as:

- The ingress of water from leaking water-bearing services;
- Poor surface management drainage system (usually at urban structures); and
- Groundwater draw-down (Trollip, 2002).

Furthermore van Niekerk *et al.* (2005), note that the decrease in the water level can result to local ground instability features such as sinkholes and dolines in sensitive areas. Hence, any changes in depth of the water-table will continually influence ground instability. Therefore, the development of built form in areas that has been subject to dewatering can be dangerous due to the effect that sinkhole can caused to building or road. Towards the end of 1960, the West Driefontein mine has experienced signs of surface depression at number of shaft that were caused by dewatering, distortion of building and the reduction plant caused great concern (ibid). However, government institutions did not react effectively to this report. In Carletonville for example, some houses and street shows signs of slump (*ibid*). Examples of Gold mines Dewatering and groundwater Instability

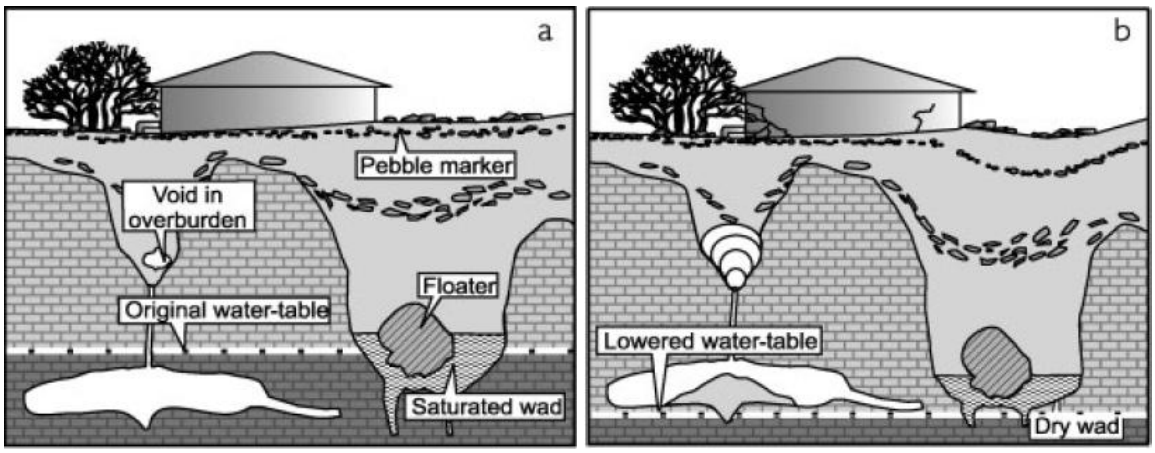


Figure 2.1(a,b&c): *Sinkhole and doline formation by dewatering.*
Source: Adapted from Council for Geoscience (2003) in Van Niekerk et al (2005)

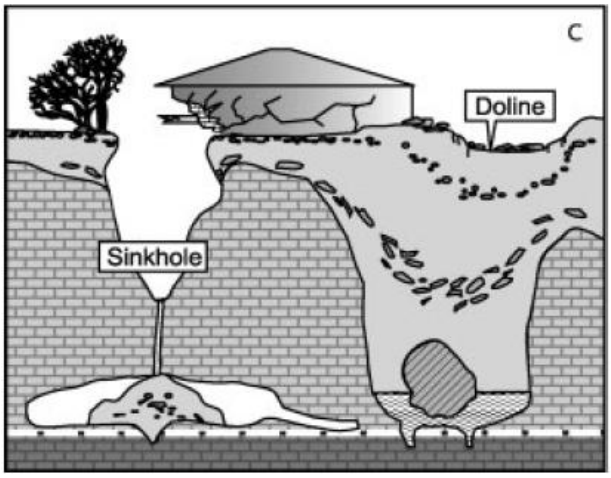


Figure 2.1(a,b&c): *Sinkhole and doline formation by dewatering.*
Source: Adapted from Council for Geoscience (2003) in Van Niekerk et al (2005)

Therefore, it is important to conduct an assessment of the potential of AMD generation in mining areas and before giving mining rights, in order to prevent land degradation that may put in danger human lives and affect the social economic environment of the affected area.

2.2.5 AMD Situation in South Africa and the West Rand Goldfield

The focus of South Africa's economy use to be on the mining industry because of their great potential to generate vast economic benefits, as well as the creation of jobs. However, many mines have stopped their activities, due to the cost of production or resource depletion, especially, in the Witwatersrand Goldfield.

The consequences of mine closure in this region have led to AMD formation, which has spilled over into the Vaal River, and is damaging the eco-systems of the surrounding environment. In addition, other mines in operation dump their waste into the surrounding environment without putting in place precautionary measures to protect the environment. As a result of this situation, communities living in close proximity to these mine dumps are likely to be exposed to serious health problems. This situation was highlighted in 2002 when acidic mine water started to flow from an abandoned shaft in Mogale City in the Randfontein area of the Western Basin into the surrounding environment (Report to the inter-ministerial committee on Acid Mine drainage, 2010). According to the report, the same situation is currently developing in the central Basin (Johannesburg area) and Eastern Basin (Spring-Nigel area).

The severity of the impact of AMD on the environment has been identified and the government has taken steps in dealing with the issue through the Department of Mineral Resources (DMR), Department of Water Affairs (DWA), Department of Environmental Affairs (DEA), and Department of Science and Technology (DST). Furthermore, the report identified the Witwatersrand area as a high priority area due to the immediate danger that the decanting mine water poses on the receiving water environment and concomitant surface areas (*ibid*). However, in relation to AMD management in the West Rand, the report reveals that few government institutions have been active on the ground and in some cases their responses have been very slow.

It is important to know that the issue of AMD is unique to the West Rand Golfieldsthe report to the inter-ministerial committee has identified areas within the country which are generating AMD, and these are Witwatersrand Goldfields, Mpumalanga and KwaZulu/Natal Coal fields and the O'kiep Copper District (IMCR, 2010: IV). However, areas such as the western, central and eastern basin have been identified as high priority areas which require urgent and immediate intervention (*ibid*). More importantly is the fact that areas identified with the potential to generate AMD are located in close proximity to densely populated locations, and for this reason, are a threat to people living in these communities (*ibid*).

During the time of writing of this research report, it emerged that tap water in some parts of Mpumalanga region (Carolina) is contaminated by acidic mine water from

the nearby mines and it has caused skin infections among members of the community (Carte blanche program, 2012). The Mpumalanga case is just an indication that areas which had mining activities and where mining activities are still taking place should also be considered as areas of priority and include in AMD management prevention plan in order to prevent the risk associated with AMD to damage the environment and destroy lives.

The following risks associated with AMD have been identified by the team of experts within the high priority areas in the country:

a) Risks due to flooding of the mines (IMCR, 2010: V):-
   - Contamination of shallow groundwater resources required for agriculture use and human consumption;
   - Geotechnical impact, such as the flooding of underground infrastructure in areas where water rises close to urban areas.
   - It increases seismic activity which could have a moderate localised effect on property and infrastructure.

b) Risks due to the decant of AMD to the environment:-
   - Serious negative ecological impact
   - Regional impacts on major river systems
   - localised flooding in low-lying areas.

Therefore, in order to protect the environment in the Witwatersrand Goldfield area, the team of experts has made some recommendations and proposed a generic plan to the government and these are to be implemented for the prevention of AMD or to serve as a strategy to deal with AMD in places where they are already decanting; areas such as the West Rand. According to the team of experts, the generic plan implementation will focus on three important aspects and they include (*ibid*):

- decant prevention and management;
- Ingress control; this approach will consist of reducing the rate of flooding and eventually the decant volume;
- Water quality management.

The success of the proposed generic plan in areas of high risk, in my view, will depend on the level of institutional co-operation and collaboration. Any failure to adopt a collaborative approach within all spheres of government and designated specialised units can result in negative outcomes. For instance, we could be faced with land degradation, which can have long lasting negative impact on food security, human health and the socio-economic environment. Therefore, in the next section, the focus will be on international experience regarding the management of AMD. The research report will delve into some of the approaches being used in other countries for addressing the problem of AMD

2.2.6 World Experience regarding AMD

AMD has been identified as the main environmental challenge facing the mining industries and causing environmental degradation worldwide. Hence, many countries that have large scale mining industries focus on dealing with these challenges, which has proven to be very costly to manage. For example, the cost of managing AMD at a mining operation in Australia has been estimated to be $60 million (Australian dollar) per year (Harries, 1997).

Therefore, the management of mining waste should be of paramount importance in order to prevent huge sums of money being channelled into the treatment of acidic water and reconditioning fauna and flora. According to Harries (1997), the cost of remediation of AMD effects on a mine which is no longer in operation in Australia has been estimated at $100 000[2] per hectare. And the cost of remediation in Canadian mine sites is estimated to be three to four times higher than their Australian counterpart, where about $2 billion to $ 5 billion is spent per hectare (Harries, 1997). This shows the gravity and the extent to which AMD issues are very costly for the government and mining companies to remediate. It is important to find long lasting solutions that will help mitigate the effects of AMD and to prevent it from contaminating the environment.

<u>Acid Mine Drainage in Australia</u>

The Australian and New Zealand mineral and Energy Council (ANZEMEC) were established in 1995. The council published a baseline environmental guideline for operating mines in Australia. In relation to AMD, the baseline set a requirement for

all mining companies to predict acid generation potentials and to incorporate it in their mine closure plans (ANZMEC, 1995). The importance of this approach is to get better understanding of the impacts of AMD in Australia and provide indispensable guidance for the assessment of long-term management options. Therefore, the office of the supervising scientists and the Australian centre for Mine site Rehabilitation Research initiated the preparation of a status report on AMD across the country as a prevention method (Harries, 1997).

Acid Mine Drainage in Canada

Acidic drainage has been identified as the largest environmental liability facing the Canadian mining industry and it is costing an estimated amount of $2 to $5 billion to the government to deal with the effects (MEND 2001). In response to the challenge presented by AMD, 200 technology-based reports were generated to evaluate the sampling, prediction, prevention, treatment and monitoring of potentially acid-generating materials and locations. A 1986 estimate for Canada suggests that acid-generating tailings cover 12,000 hectares plus an additional 350 million tons of mine waste rock were noted (MEND 2001).

The Canadian Mine Environmental Neutral Drainage (MEND) was established in 1989 by mines and provincial, territorial and federal government agencies in response to the recognition of AMD being the main environmental problem facing the Canadian mining industry. From that time on, mines in Canada were required to establish trust funds to cover the cost of the effect of AMD on the environment from mine wastes. Hence, a survey of metal-mine and industrial-mineral tailings was conducted in 1994 and the result showed that, of the 7 billion tons of tailings and 6 billion tons of waste rock, 1.9 billion tons of tailings and 750 million tons of waste rock were potentially acid generating (MEND, 1995).

Acid Mine Drainage in the USA

In the USA, the main impact of AMD on the environment was identified as being from the coal mine which polluted over 7000 km of streams (Ferguson and Erickson, 1988). According to a report published by USEPA (1995) the streams polluted by AMD is between 8000km and 16000 km (USEPA, 1995). This ecological disaster triggered the regulatory institutions to insist on the payment of performance bonds.

Also, the USA put in place an institution that deals with abandoned mine and every mine that has ceased any form of activities. The Office of Surface Mining Reclamation and Enforcement (OSMRE) has the responsibility to rehabilitate abandoned mines and its funding comes from a levy collected on active coal mines and deposited into the abandoned lands (AML).

AMD in Germany

Isolde (2009) argues that in Germany, the mining and the upgrading of brown coal has a major impact on various geo-factors. However, mining operations have negatively affected the local water balance. There is also the part where there is overlapping in the area of jurisdiction of mining, and this led the Saxon government to make brown coal planning a part of the regional land-use plan (*ibid*). This situation was motivated by the fact that several mining municipalities were concerned. Moreover, land use was similarly affected, including the utilities and roadway networks as well as social infrastructure and facilities (*ibid*). Due to the negative impacts of AMD in many sectors across different regions, the government has adopted new perspectives for land use after the decline of mining.

International Agencies' Views on AMD

The Brundtland Report of the UN World Commission on Environment and Development (1987) set the foundations for mineral industries to have a series of discussions to enable a better understanding of the relationship between resource extraction and sustainable development. Therefore, through initiatives such as the World Bank's Extractive Industry Review (2001-2004) and the International Council on Mining and Metals (2001), mineral sector plans to position itself as a positive contributor to sustainable development.

The World Business Council for Sustainable Development and the International Institutes for Environment and Development also conducted an assessment of the sustainability of mineral industries through the Mining Minerals Sustainable Development Project (MMSD). The final results were compiled in the document called Breaking New Ground, which made recommendations in relation to environmental management. It suggested a series of principles such as the promotion of responsible stewardships of natural resources, to remediate past

damage and to minimize waste and environmental impact along the supply chain for sustainable development (MMSD, 2002). It must be noted that the emphasis of this report was on responsible mining, which means that mining and mineral processing companies should be prudent where potential impacts are not known (Franks *et al,* 2011).

Mining Companies Approach to AMD

Mining companies are taking some positive initiatives in dealing with the impact of their activities on the environment. AngloGold Ashanti conducted a Social and Land Use Baseline Assessment in 2009, which it is using as a strategy for the monitoring of indicators to determine future impacts of mining activities. Also, the baseline will be used to inform the community on human health risks (*ibid*). This approach is based on the fact that AngloGold Ashanti recognizes that their operations may have unintended outcomes which may impact on stakeholders and businesses (*ibid*).

Therefore, AngloGold Ashanti is committed to communicating and consulting on their activities throughout their operations, and undertake initiatives that would contribute to sustainable partnerships with the societies in which they operate (*ibid*). However, this example is not followed by other mining companies. They abandon sites and it becomes the responsibility of the government to pay for the damages.

2.3 AMD Management Approach in South Africa

Goldfrey *et al.* (2007) suggest that there is no clarity as to the roles and responsibilities of the Department of Environmental Affairs and Tourism (DEAT), and the Department of Minerals and Energy (DME) with respect to the management of mining waste such as AMD situation in the West Rand Goldfield, and this is a problem. Both departments have placed certain requirements on mines before a closure certificate is granted, the main requirement being an environmental management plan (EMP) which is compulsory for any mine and for which DME is the lead agent (Pulles*et al*., 2005 quoted in Oelofse *et al.* (2007: 7).

Furthermore, Oelofse *et al*. (2007) states that, co-operative governance is however not very effective in protecting the environment against the negative impacts of mining waste.

In this regard, the GDARD (2011) quoted in the Department of Agriculture and Rural Development Gauteng Province (2012: 10) notes that "the delegation of power between various national, provincial and municipal government is unclear. Institutional roles and responsibilities are fragmented, overlapping or vaguely defined. The level of interaction between national government departments who administer environmental legislation is lacking, especially, between DWA, DEA, DMR and NNR. There is thus, a lack of responsibility and an attempt to place the onus on other departments or directorates.

Where overlapping work is being undertaken, the result may not be communicated widely enough, resulting in duplication of efforts and associated waste of time and resources. On the other hand, there may also be cases where mandates between various departments or directorates overlap, and where necessary work is not being undertaken due to each department believing that the other is responsible and active.

This means that in relation to environmental management and in relation to AMD in the West Rand Goldfield, environmental policies are unclear in terms of which department is to take the initiative and engage with the other departments in order to find an efficient and sustainable solution to AMD. Hence, institutional divergence created by insufficient environmental policies, is leading to environmental disaster caused by the decanting of acidic mine water in the West Rand Goldfield.

In this section the focus was on the analysis of theoretical concerns of AMD and the extent of its impact on the environment and how it is being managed. The discussions show that institutional management of the AMD situation in the West Rand Goldfield is not producing positive results. Therefore, the next section will analyse some of the land management approaches in South Africa, in order to establish the link between land management institutions and the management of AMD situation in the West Rand Goldfield.

2.3.1. Land Management Definition

Dale *et al.* (1998:3) define land management as "the process whereby the resources of land are put to good effect". This means that land management helps nations to better strategise the use of land and resources by means of policies and strategies.

Faure (1996) at the One Day International Conference in Budapest, Hungary, argued that land management as an area of concern, has no internationally accepted definition other than the one that relates to the management of land-including land covered by water and sea. As such land management can be seen as virtually encompassing anything and everything that is related to land.

Williamson (2001), quoted in Wermann and Magel (undated) defines land administration as the process of determining, reckoning and disseminating information about tenure, value and use of land, as well as an adequate land policy which has to provide the legal base consistent with the individual situation of a country by simultaneously respecting and guaranteeing human rights. For the purpose of this research, the above definitions are adopted.

Significance of Land Management

The significance and the need for land management are growing and accepted by countries across the globe regardless of their political system, socio-economic and environmental factors. However, land management is applied differently depending on the political or economic system such as socialist (Faure, 1996). In this view, land management approach is influenced by political and economic principles and approach set in place by the government of a country. Faure (1996) quoting Bershidsky (1995) argues that the socialist view of land is that land cannot be bought and sold

Therefore, according to Dale *et al.* (1988), the significance of land management is translated by the need and desire to carefully manage the resource, and by so doing, prevent the wastage of the resource. This means that while there is a need for the management of land resources for human survival and sustenance, it is therefore important to have land management systems to help prevent mining waste from damaging the environment, and where environmental contamination has occurred, there is the need to manage the situation in order to ensure the survival of humans and other ecosystems.

This means that land management approach will determine which government institutions will be responsible for the management of environmental disasters such as AMD in the West Rand goldfield. As such, land management will involve on one

hand the making of fundamental policy decisions about the nature and extent of land development, while on the other hand including the routine operational decision made each day by land administrators such as surveyors, valuers, and land registrars (*ibid*).According to Dale *et al.* (1988), the land management hierarchy and organization can be represented by the following diagram:

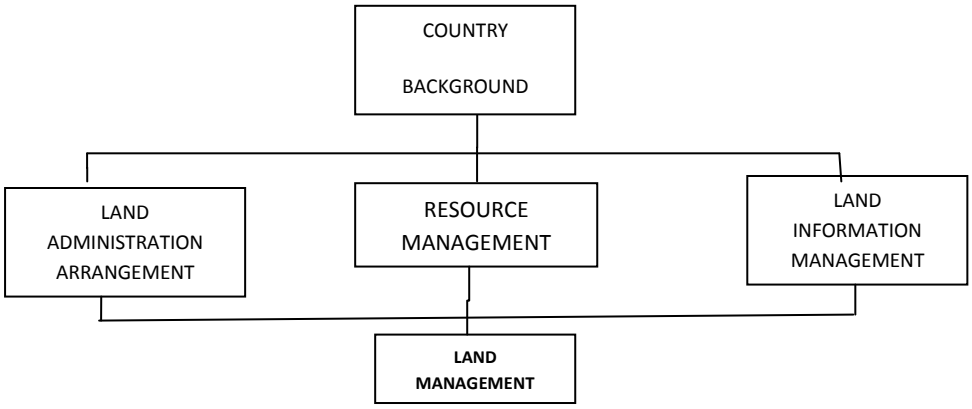


Figure 2.2: Land Management Hierarchy

Source: Dale *et al* (1998)

Based on the above land management hierarchy, Dale *et al.* (1988) provides a detailed list of broader matters it seeks to address. These are:

- Conveyance of property, including decisions on mortgages and investment;
- Property assessment and valuation;
- The development and management of utilities and services;
- The management of land resources, these include forestry, soils, agriculture;
- The formation and implementation of land use policies;
- Environmental impact assessment;
- The monitoring of all land based activities in so far as they affect the best use of land.

It is clear from Dale et al (1988) that when assessing broader matters, the issue of AMD should be covered by land management system due to the fact that mining activities are regulated through land management.

There are a number of institutions involved in land management in South Africa. The multitude of these institutions can weaken state action when clear responsibilities are not defined, and there is a lack of capacity (human resources). Furthermore, Dale *et al* (2008) have identified different stages that are involved in land management which are important for state institutions and they include the following:

- *Monitoring phase:* this phase consists of gathering information about the environment in order to determine where decisions and actions are required. For example, detecting derelict land through the use of remote sensing techniques
- *Planning phase:* it consists of developing models that will facilitate the analysis of alternative courses of action. This is an important phase because it gives direction to different state institutions to tackle issues that are affecting the land in general.
- *Policy making phase:* during this phase the course of action is selected;
- *Operation phase:* consists of the implementation of the chosen course of action.

South Africa's Land Management System

According to Mahubane (1998) and Sisya (1998) quoted by Mabin (2007), land management in south Africa, is generally understood as the manner in which land is controlled, managed, planned for, utilised and transacted. This means that all related land matters past, present and future fall within the prerogatives of land management. These include the protection of the environment against harmful activities and waste generated by human activities such as AMD that can lead to land degradation and environmental damages.

Mabin (2007) further states that land management in South Africa encapsulates systems of land administration, land use management, land information management, and taxation. These include various hybrid systems which bring together the formal, informal and the customary land systems. As such, any human

activity (examples mining and agriculture, etc.) that requires land is regulated by land management under land use management. In this regard, Charlton (2008) argues that land use management generally refers to the officially recognised system that determines and regulates the use of land.

Hence, land use management is placed at the centre of regulation of most activities that require the use of land. Ovens *et al.* (2007) state that land use management as a component of land management deals with the process by which land is developed; it is defined as the usage of land and how the activities on land are regulated.

As such, mining activities fall within land use management, therefore a weak land use management system in relation to mining activities for example, can lead to the generation of hazards such as AMD which degrade the quality of land. Therefore, in my view, the strength of land management institutions will also depend on the strength of land use management regulations to prevent the degradation of land quality as well as the level of commitment to monitoring the activities of land users.

In South Africa, land management systems have been influenced by historical past of the colonial movement, the political and socio-economic system of the apartheid system. Bollen (2005 as cited in Rubin 2008) argues that the systems, devices and regulations of land use management were used to achieve the objectives of racial and spatial segregation in South Africa. However, post-apartheid land management system changed in order for it to respond to the new government directives, pragmatic and technical challenges, as well as new international and global dynamics (Rubin, 2008). Therefore, post-apartheid land management system is characterised by a large number of land use management and planning legislation (ibid.), including SDF, IDP and RSDF.

Regardless of a number of policies at national or local level, Ovens *et al*. (2007 cited in Rubin 2008) states that there has been little advancement and innovation in thinking and practice around land management, and south Africa's towns and cities continue to developed without any adequate framework for managing land development in a way that supports the goals of democracy, equity, efficiency and sustainability. This means that even though there have been shifts and

rearrangements of the government policies to deal with environmental challenges, these changes have barely contributed to addressing some environmental issues, such as the threats of Acid Mine Drainage to water resources in the West Rand.

2.3.2 Environmental Management Institutions in South Africa and their Responsibilities

According to Nhamo (2001), institutions understand their roles and interpret the laws in different ways resulting in disharmonies in the environmental legislation application. It is further noted that such misperceptions originates from the ambiguity of environmental laws and constitutional frameworks which fail to differentiate power relations, responsibilities and roles associated with each institution (Nhamo, 2001).

That is, the roles and responsibilities of each institution seem unclear. South African government functions on three levels- that is, the national, provincial and local governments, with all of these spheres involved in addressing environmental matters. Nhamo (2001) states that the three levels of governance are very complex when dealing with pressing matters such as AMD. This is because no institution wants to take responsibility for this and because institutional responsibilities can overlap, resulting in the slowing down of the procedure. Another reason is that there are conflicting ideas and interests amongst different institutions in such a way that, they can all have different views and approaches regarding the same issue (Nhamo 2001).

Even though the environmental laws have been transformed and reorganized there is an absence of agreement on how to address environmental challenges (*ibid*). This means that there is no consensus among government institution on how to respond to some environmental challenges. Furthermore, Nhamo (2001) suggests that some environmental challenges occur and aggravate the problems, resulting in the failure of the relevant institutions and stakeholders to communicate with each other horizontally and vertically in dealing with these issues. This means that there is no real communication among government departments and within departments on the management of environmental issues.

The arrangement and responsibilities of different institutions are regulated by the White Paper on Environmental Management which was released on 28 July 1997. This regulation sets out the environmental management policy in South Africa as well as defining the mission of the Department of Environmental Affairs and Tourism and its activities. The vision of the White Paper on Environmental Management is that "it seeks to unite the people of South Africa in working towards a society where all people have sufficient food, clean air and water, decent homes and green spaces in their neighbourhoods enabling them to live in spiritual, cultural and physical harmony with their natural surrounding" (White Paper on Environmental Management, 1997: 14).

This means that government institutions must work towards the realisation of this vision and ensure that in all activities the rights of all citizens to a clean environment are put first. This mission can only be achieved if all government institutions that have the responsibility of stewardship of land work together in a collaborative manner and thus, protect the environment against harmful hazards such as AMD. And also, government institutions and other stakeholders should work together to efficiently respond to environment challenges.

In this regard, the White Paper on Environmental Management 1997 states that this vision can only be achieved through the use of a new model or paradigm of sustainable development which will be based on integrated and coordinated environmental management. Moreover, the suggested model or paradigm will promote the environmental health and well-being of all South African citizens by addressing the following issues (*ibid*):

- People's quality of life and their daily living and working environment;
- Equitable access to land and nature resources;
- The integrations of economic development, social justice and environmental sustainability;
- More efficient use of energy resources;
- The interaction between population dynamics and sustainable development;
- The sustainable use of social, cultural and natural resources;

- Public participation in the environmental governance, the custodianship of our environment.

However, since the introduction of the new paradigm, a number of environmental disasters still occurred, especially in areas that are dominated by mining activities, like in the Witwatersrand goldfield. There is also the West Rand Goldfield area where environmental disasters caused by AMD raised concern for residents and the nation as a whole.

2.3.3 Environmental Management Institutions Arrangement

In their quality of guardianship of the environment in the country, the Department of Environmental Affairs and Tourism has appointed other government institutions at provincial and local levels that play the role of monitoring and whistle blowing whenever the environment is threatened.

Chapter 2 (part 1 and 2) of NEMA made the provision of other institutions that could assist DEAT in the management of the country's environment, these are:

- The national environmental advisory forum (NEAF); Established in 2005 with the aim to advise the minister on any environmental management matter and governance; it also sets the achievement objectives and priority for environmental governance, and appropriate methods of monitoring compliance of section 2 of NEMA legislation (Walmsley *et al.* 2007);
- Committee for environmental coordination (CEC); this committee is in charge for the promotion of integration and coordination of environmental functions of appropriate states institutions and in particular it promotes the purpose and objectives of environmental management plans (*ibid*).

Section 11 (1) (2) (3) (4) of the National Environmental Management Act (No 107 of 1998) gives details about different spheres of government and their organs responsible for the management of environmental issues in South Africa.

Schedule 2 section 11 (2) list different national departments exercising administrative functions in the management of the environment. The following national departments are responsible for the management of the environment.

- Department of Environmental Affairs and Tourism;
- Department of Water Affairs and Forestry;
- Department of Minerals and Energy;
- Department of Land Affairs;
- Department of Health Department of Labour

2.3.4 Roles and Responsibilities of Government Institutions

There are a number of government departments at all three levels of government that have been given the authority to act on behalf of the nation to protect the environment against harmful substances and activities. Therefore in this section the focus will be on the role and responsibilities of these institutions.

a) The National Department of Environmental Affairs and Tourism.

According to Walmsley *et al.* (2007) all EIA must be submitted to the provincial department. However, there are exceptions to this prescription. For example, in the case of matters and situations which can have an impact at the national level, such cases are directly channelled to the national executive authority (minister) for a decision. Section 24 (c) (2) NEM: second Amendment Act of 2004; provides a list of matters that require the national executive interventions.

b) Provincial Departments

According to section 42 (10) of the National Environmental Management Act (NEMA), on its first amendment Act of 2003, the minister of Environmental Affairs and Tourism can designate provinces as competent authority to deal with and take certain decisions in relation to the environment in their jurisdiction. In turn, the province can also delegate this competence to local authorities (municipality) in accordance with section 42A (1) (c) of NEMA (Walmsley *et al*. 2007). However, it should be noted that the management of environmental affairs at the provincial level is placed under natural resources management, tourism, conservation or agriculture portfolio (*ibid*).

Drawing from the attributed roles and responsibilities of the national Department of Environmental Affairs and Tourism, the national government should be at the forefront of the battle to find long lasting solutions to the issue of AMD, due to the

magnitude and impacts that environmental damages and land degradation can have at the national level.

The government institutions across the three spheres must have a cooperative approach and must consult other departments when taking decisions that concern other departments. For this reason, the Strategic Plan for the Environmental Sector SPES (2008/2013: 23) states that "it is vital that there is an effective response mechanism in place within government to ensure that pollution incidents are dealt with in a way which minimises harmful impacts on both society and the environment". As stated by the SPES, the management and response to environmental pollution will require the implication and cooperation within the environmental sector across spheres (*ibid*). Regardless of this provision, the management of AMD that is threatening the environment and the wellbeing of the population in the West Rand goldfield show that there are no effective interventions by government institutions. This explains why government intervention is delayed in finding adequate solution to the issue of AMD in the West Rand goldfield.

2.3.5 The National Environmental Management Act No 107 of 1998

The National Environmental Management Act (NEMA) Act No. 107 of 1998 also emphasizes the Integrated Environmental Management (IEM) and Sustainable development. Hence the principles that are relevant to this report according to ETU (2008) are as follow:

- Development ought to be socially, economically and environmentally sustainable;
- Environmental management must put people and their needs first;
- Equal access to environmental resources, benefits and services to meet basic human needs;
- the promotion of public participation when making decisions concerning the environment;
- Authority should be extremely cautious when granting new permit for development.

The key aspect of NEMA is that it is to be acknowledged as the 'framework legislation' (Todes *et al*. 2005; Van Wyk, 2007; ETU, 2008). Therefore, it is important to note that there are other legislations which have been developed in terms of NEMA framework (Enviropaedia, 2007). These are:

- National Environmental Management: Protected Areas Act (Act No. 57 of 2003);
- National Environmental Management: Integrated Coastal Management Bill;
- National Environmental Management: Air Quality Act (Act No. 39 of 2004);
- National Environmental Management: Biodiversity Act (Act No. 10 of 2004)

In relation to co-operative governance, the NEMA Act provides that different spheres of government which include government departments have the obligation to develop Environmental Implementation Plans (EIP) and Environmental Management Plans (EMP) (Glazewski, 2002; Todes *et al*. 2005).

As noted by Todes *et al. (*2005), that this shows that government values integrated decision-making as well as government institutional co-ordination for better environmental management. However the EIP has not been successful in achieving the implementation of institutional co-ordination. The IDP and SDF at the provincial level must also conform to the EIP principles, however Todes *et al.* (2005:42) suggests that, whilst the plans have great potential to achieve "integrated planning for land development and environmental management", co-operation between environmental and planning institutions are to be promoted, rather than introducing new planning systems. This means that AMD situation that is currently threatening the environment in the West Rand could have been avoided since 2002, if all government institutions had co-operated effectively to enable effective response to the problem.

Another important aspect of NEMA Act which is relevant to this report is the fact that further amendment of NEMA Act (Act No. 46 of 2003) has made provisions for the prosecution of anyone who will contravene the Act, as well as its principles and associated regulations (ETU, 2008; Feris, 2006). Hence, the Act made provision for

the establishment of a law enforcement organisation known as the 'green scorpions' (Enviropaedia, 2007).

According to the Enviropaedia (2007: unpaginated), the 'green scorpions' consist of 800 inspectors which "provide a co-ordinated response to environmental law enforcement across all departments and spheres of government. It includes park rangers, conservation officers, air-quality officers, marine and coastal enforcement officers, pollution and waste enforcement officers and officials monitoring urban development." The work of this body should also align with those of existing inspectors of government institutions that conduct different activities on different developments that take place in the environment. Thus, due to the multitude of government institutions involved in environmental management, a co-ordinated action is required between the green scorpions, inspectors from different government departments and NGOs such as the Federation for Sustainable Environment to prevent environmental disasters

2.3.6 Environmental Legislation Governing the Mining Industry

The growing concern about public health and the progressive deterioration of the aquatic environment has resulted in the promulgation of legislation to control the quality of effluents and receiving water (Hellawell, 1989 in Bervoets *et al*. 1996). The South African mining industry is governed by a number of legislation which intends to protect the environment. It is organized under the following legislations:

- National Environmental Management Act 107 of 1998 (Dalton *et a*l, 1998a)
- The Water Amendment Act 58 0f 1997 (Dalton *et al.* 1998b)
- Mines and Work Act 67 of 1956 (Dalton *et a.* 1998a)
- Environment Conservation Act 73 of 1989 (Dalton *et a.* 1998b)
- Minerals and Petroleum Resources development Act 2002

Grimbeek (undated) argues that over the past years South Africa's environmental regulation has experienced significant changes. According to the minerals Act of 1991, mining companies ought to submit an Environmental Management

Programme (EMPR) performance assessment report to the government every year that will help track the levels of compliance to the law.

The 1998 National Water Act Section 19 emphasizes the fact that mining companies should be held responsible for environmental pollution happening on their sites and surrounding environments. That is, mining companies are not only expected to submit an EMPR but to take responsibility for their activities. Furthermore, Section 153 of the National Act of 1998 made the provision of firm unlimited penalties and clean-up costs for the companies held liable for environmental pollution (Grimbeek, undated).

The National Environmental Management Act of 1998 also allows the general public to take legal action against any company that is in violation of the environmental laws and the punishment is extended to the directors of these companies (Grimbeek, undated). In a recent case, the Federation of sustainable development laid a charge against AngloGold Ashanti mine for repeated spillage of contaminated water leaking out of the company's tailings dams in Stilfontein, in the North West. The water is spilling in a dolomitic rock area, which can affect ground water. If nothing is done to stop the spillage, the Vaal Rivers could also be affected due to the fact that the mines are established just 7 kilometres away (Mail &Guardian, 2013).

The basis of this charge was founded on the contravention of section 19 of the National Water Act, which says that a company must prevent and mitigate pollution. The company was also found in contravention of Section 28 of the National Environmental Management Act (*ibid*). This shows that in the absence of government actions, the public can take environmental polluters to court in order for them to pay for the damages.

The above case shows that there has been some improvement in the fight against environmental disasters linked to AMD with some mining companies making the effort to comply with the environmental regulations. More so, the government is making efforts to keep the environment clean and safe by imposing laws, but it is the level of implementation that still poses problems (Grimbeek, undated). After, the analysis of the National Environmental Act, the next section delve into the analysis of

the South African mining policy especially its evolution over time in order to established how it led to the current situation of AMD in the West Rand Goldfield.

2.4. History of Mining and Mining Legislation in The West Rand Goldfields

Adler *et al*. (1997) state that the history of mining in South Africa can be best understood which are equally important for the analysis of how these events have affected mining policy over the years. The first phase or period is characterized by the struggle to profit from the largest gold reserve in the world and is exemplified by the Anglo Boer war (Barber 1999; Farwell 1999; Nasson 1999; Porch 2000; Turton, *et al*. 2006 as discussed by (Adler *et al*. 2007), and the second phase is characterized by the growing impact of a century of advantaged mining industry by government under which the industry maximized earnings and externalized costs (*ibid*.). These phases took place under a different legal system that was used in the country and that has had an impact on the mining legislation.

According to Cawood and Minnitt (1998), two major approaches were used to regulate the mining industry leading which the dual private and state are owned mineral rights that has developed over a long period of time (300 years). Therefore, the analysis of the mining legislation should be placed within a historical context to understand how different legal systems and historical events have affected the mining legislation.

In this regard, Turton (2009:197), in his study of South African Water and mining policy, observes that the crucial problem related to mining activities and how it impacted on the environment "reflects a historic legacy in which powerful interests of racially defined political elite, which saw government becoming a collaborator rather than a regulator of the mining industry".

The focus of this section will be on the analysis of the layers of the legal system that has influenced mining legislation in South Africa, the second part will look into different mining policy paradigm as elaborated by Turton (2009) and to finish, this section delves into the analysis of the Minerals and Petroleum Resources

Development Act, Act 28 of 2002 (MPRDA) and how it relate to the issue of acid mine drainage.

2.4.1. Layers of Legal System and Their Impact on Mining Legislation

According to van Wyk, (1999), the South African legal system has four layers. These are: the Roman, Dutch, English law and indigenous (customary) law). The most influential legal system in terms of mining legislation is the Roman Dutch Law and the British Law. In addition to this, Turton (2009) gave five mining paradigms that explain the historical mining policy background in the context of extracting minerals and who benefited from those practices and how it led to the current situation of acid mine drainage in the West Rand Goldfields.

The first period was influenced by the Roman Dutch legal system. Hence the principle of rule of property law that characterized the Roman law was adopted in the country that says the owner of land own the surface of the land as well as the fruit of the land (Cawood and Minnitt, 1998). This means that minerals discovered on private owned land were the property of the land owner. This legal system led to recognition of private property right (*ibid*).

The second period in mining policy was influenced by the British layer of South African Law. It was characterized by the Cradock Proclamation of 1813 (Cawood and Minnitt, 1998). The quintessence of the Cradock proclamation is that it reserves the right to mine precious material, gold and silver for the Government of the Cape Colony as it is the custom in English Law. The influence of the Cradock proclamation on mining policy is that it led to an important adjustment in the individual characteristics of mineral rights ownership (Hartwick and Olewiler, as discussed by Cawood and Minitt, 1998). This occurrence marks the first step away from private ownership towards states ownership of mineral rights (*ibid*).

The third historical period that had an impact on mining policy in South Africa is the 'independent provincial states' era that established independent provincial government in the Transvaal, Orange Free State and Natal (ibid). Each of the independent provinces approved their status which reserved a number of minerals to the established provincial state. It is important to note that during this period only the

right to mine was affected by this status, which means that the initial private ownership of minerals was not in danger.

The fourth period in mining legislation history is the Union Era which was symbolized by the unification of the former independent republics of the Transvaal, Orange Free State, Natal and Cape Colony into one entity called the Union of South Africa in 1910 (*ibid*). Furthermore, Cawood and Minnitt (1998) stress that the unification of the state was marked by the adoption of the Land Settlement Act of 1912 which reserved the ownership of all mineral rights to the State. This decision was later overturned in 1917 to reserve the mineral right to the land owner (This marked the most important step toward privatization of mineral rights ownership). Regardless of this aspect of privatization of mineral rights, the state wanted to keep a control over mining industry and thus decided in 1925 through the Reserved Minerals Development Act of 1925 to reserve for itself the right to mine gold, silver and precious stones on all categories of land (*ibid*).

This act also gave the right to the union to administer the mining lease procedure that was introduced by the Transvaal Republic (*ibid*). All mining rights and prospection should be obtained from the central government. As such environmental effects of mining activities such as AMD becomes the responsibility of a land owner and the state should make sure that a land owner does not destroy the environment. In 1942, the Union government passed another law in relation to mining activities called the Minerals Development Act 39 of 1942 Amended by Act 22 of 1955. The key aspect of this act was that it gave the state the right to intervene in the case when a land owner did not exercise the right of mineral prospection on his/her land.

The last period in the evolution of mining legislation in South Africa is the Republic Era, marked by the formation of the Republic of South Africa in 1961 (*ibid*). The Mining Right Act of 1967 was passed by the state in an attempt to unify the plethora of mining statutes. Precious stones however, remained under the administration of the Precious Stones Act 73 of 1964.

In 1975 the Mineral Laws Supplementary Act was passed with the particularity of regulating the manner in which mining companies could obtain mineral right over land where:

- "Private minerals rights ownership was separated from the land,
- The mineral rights were held in undivided shares, and
- Permission to exploit the mineral rights could not readily be obtained"; (Cawood and Minnitt, 1998: 371)

The innovation of this law was that it prevented supplementary disintegration of private mineral right without state agreement (*ibid*). Thereafter, the Mineral Supplementary Act and the Minerals Act 50 of 1991 in 1992 were passed and marked the end of the 'right to mine' principle as the legal cornerstone of the mineral exploitation in South Africa (*ibid*). The Mineral Act was also the steps that consolidated the private mineral rights ownership in the country. An important element of the mineral act that needs to be mentioned is the section 43 that states that the surface owner of alienated state land has the first right to prospect the minerals as such mining companies, that have to negotiate with the surface owner for prospection and not with the state. The state was contacted only after the discovery of mineral deposits and this is when the state would lease the land for the mining operations (*ibid*).

In my view this practice is also to blame for negative environmental effects of mining activities such as AMD, because in this kind of arrangement the State was forced to issue the lease due to the cost of mining prospect (*ibid*). Hence, the environmental and social considerations of mining activities were not taken into consideration.

2.4.2. Mining Policy Paradigm

According to Turton (2009), there are five mining policy paradigms that explain how mining legislation has evolved over time as well as how it has culminated in the current mining policy.

a) Policy paradigm One : British Hegemony and Gold (1910 – 1948)

During this period, water policy was driven by the need to establish a high assurance of supply for the mines, therefore it was the British military engineers who used to perform the task until the Rand Water Board (RWB) was established in 1903 (Tempelhoff, 2003 as quoted by Turton, 2009). In 1910, the Act of Union established

self-government of the British colony which comprised four smaller entities (*ibid*.). Two of these were former British Colonies (Cape Natal) and the vanquished Boer republics (Transvaal and Orange Free State) in which gold was found (Geldenhuys, 1984 as cited by (Turton, 2009). The union was characterised by the practice of 'resources capture approach', and which still relevant today. becomes later a driver in the policy paradigm of extraction, is still relevant today (*ibid*.).This paradigm was driven by the British with the sole objectives of extracting mineral wealth from South Africa, and as such it gave rise to the policy of extraction which took place in the total absence of any human rights culture (*ibid*.). It is clear from this paradigm that environmental protection regarding mining activities such as AMD and the human right to a clean environment did not feature in the mining activity plan at this level and paved the way for the current situation of AMD in the West Rand Goldfield.

b) Policy paradigm Two: Rise of Afrikaner Hegemony (1948 -1961)

This policy paradigm was split between economic power concentrated in British hands and political power in Afrikaner hands, but against a notable backdrop of growing Black resistance (Liebenberg, 1994). The sharing of power between these two colonial administrations shows that the economic drive based on mining activities was still in British hands and, as such they wanted to protect it at any cost Turton (2009). An example of the British approach during that time is the repression of protest march against black civilians in Sharpeville 1960 (Spitz and Chaskalson, 2000 quoted by Turton (2009).

c) Policy paradigm Three: Collaboration of State and Industry (1961- 1976)

According to Turton (2009), this period was characterized by policy instabilities which gave rise to transition and the banning of various liberation movements. Furthermore, Turton (2009) indicates that economic policy was based on growth driven by a strong gold mining industry but also aimed at diversifying the economy and restoring investors' confidence. Not only that, this period marked the turning point in mining practice in the West Rand Goldfield as the Jordaan Commission of Enquiry recognized that the only way to mine the deep ore bodies was to dewater the dolomites above the reef (Jordan et al., 1960 as quoted in Turton, 2009).

Consequently in 1963 an agreement on dewatering of the dolomites of the Far West Rand was reached between government and the Chamber of Mines (van Eeden, 2007 as cited in Turton, 2009). This practice was supported by two commissions:

- The State Coordinating Technical Committee on Sinkholes and Subsidence (SCTC), with the responsibility to deal with the loss of life and property damage from sinkhole formation and land instability arising from the dewatering process (Kleyweght and Pike, 1992; Adler et al., 2007b cited by Turton, 2009)
- The second commission was the Far West Rand Dolomitic Water Association (FWRDWA), with the responsibility to deal with compensation matters arising from dewatering (van Eeden, 1992; Adler et al., 2oo7 quoted by Turton, 2009).

The relevance of the two commissions is that during this time it seemed like the apartheid government started to shows concerns about mining effects on the environment such as sinkholes (but not sinkholes') effects on the surface and groundwater. As such, the issue of AMD generation and its future effects on the environment, socioeconomic and human health could not have been prevented.

As well, the key element of mining practice during this time in the study area was "the extraction of mineral wealth, using water as a strategic resource, in order to grow the economy rapidly for the purpose of political survival" (Turton 2009: 203). This practice further led to resources captured of minerals to coincide with the resource capture of water, the two becoming a key element of the SA hydraulic mission with a merging of the interest of mining houses and the apartheid state (*ibid*). Thus the consequence of merging of interest was that the supervision was weak with the two parties (industry and state) becoming collaborators, with environmental degradation being ignored and the cost of mining being externalized onto an uninformed public (Adler et al., 2007a: 2007b)

d) Policy paradigm Four: State survival and Total Onslaught (1976-1994)

The mining policy during this period was driven by political instabilities and high levels of inflation. According to (Frankel, 1984), the total national strategy saw the mobilization of the entire country finances, natural and human resources for the war

to maintain order and stability in the country. This period was also characterised by policy monopoly that strove to achieve the objectives of protecting the goose that laid the golden eggs (Turton, 2009). This means that, it was important for the apartheid government to protect the mining companies because they were the major tax payer and the government needed money to support it politics. The consequence of this approach was that, there was minimum oversight on mining industry practice and operations as long as these paid their taxes (*ibid*.). Similarly, Adler et al. (2007b as quoted by (Turton, 2009) reveal that the lack of oversight allowed mining companies to maximize their profit.

The relevance of the above is that according to (Turton, 2009), the way government was managing the mining industry that time, led to the emergence of power polarization in the country by two forces, each of them concerned with self-interest:

- The state was concerned only with its own survival against political unrest whilst ;
- The mining industry was concerned only with profit maximization.

e) Policy Paradigm Five: Redistribution of wealth and Privilege (1994 to Present)

This period is characterized by the revision of a number of policies including the Constitution of 1996, thus solidifying Turton's (2009) argument that key reform turned around the scrapping of all Apartheid-related legislation. The consequences of these changes were that the administrative and legal precedent that was necessary for service delivery was lost. Furthermore, the major thrust of policy reform was the nationalization of strategic resources that has been in the past subject to resource capture, however, the policy reform on the mining side was less remarkable (ibid).

Additionally, according to Adler *et al*. (2007b) quoted by Turton (2009), the mining industry during this period used its experience to outplay the government effort to regulate their activities. As such, the mining industry approach was regarded as a policy opponent whose strategy was to destroy any evidence that could incriminate it (Turton, 2009).

2.4.2 The Minerals and Petroleum Resources Development Act and Acid Mine Drainage

As it has been noted above, the newly elected government of the ANC inherited a very complex web of mining legislation and mining practice that was used in the country, especially the concept of mineral rights ownerships. It was thus important for the new government to come up with a unified set of mining policies that would overcome the legacy of past mining practice and inequalities.

The West Rand District Environmental Framework Revision (2013: 104) states that "the Minerals and Petroleum Resources Development (MPRDA), aims to make provision for equitable access to and sustainable development of the nation's minerals and petroleum resources by vesting custodianship thereof to the state and not to the landowner". In this regard, the new mining legislation approach may be argued to be law that wants to expand the opportunities to access the wealth of land to previously disadvantaged population, promote economic growth and employment as well as improve social security conditions of all the people of South Africa (*ibid*.).

"To give effect to section 24 of the Constitution by ensuring the nation's mineral and petroleum resources are developed in orderly and ecologically sustainable manner while promoting justifiable social and economic development". Therefore, in order to achieve this objective, the MPRDA specifically provides that regards must be given to NEMA principles which:

- Apply to all prospecting and mining operations and any matter relating to such operation.
- Serves as a guideline for the interaction, administration and implementation of the environmental requirement of MPRDA.

Based on the aforementioned it is important to note that mining activities have a major effect on the environment and can harm the health and well-being of the South African citizenry. With regard to AMD, it appears that the MPRDA is not very clear about the issue. However, it is important to know the kind of implications that mining activities can have for the environment in order to establish the provision that MPRDA has made for the management and prevention of AMD occurrence. Thus, the mining impact on the environment has been categorised as follows:

- Mining waste;
- Water pollution;
- Atmospheric pollution.

According to Botha et al. (2012) The MPRDA regulation makes provision for the prevention of atmospheric pollution from tailings, through the covering of mine dumps in order to prevent airborne pollution and control of dust fumes released into the atmosphere. However, in the new legislation there is no clear indication of how to protect surface and groundwater from heavy metal contamination via AMD.

2.5 Land Degradation

The consequence of AMD mismanagement in the West Rand District Municipality could lead to land degradation if environmental management institutions do not act quickly and efficiently to deal with the issue. The protection of land against any activities that can degrade its quality is due to the fact that, land is an environmental, social and economic good and key resource for the realisation of development opportunities. According to UNIP (2006), the good quality of land must be preserved. However, the quality of resources and the potential of land to contribute to South Africa's development are threatened (WR SoER, 2011).

Therefore, land degradation is define as the reduction or loss of biological or economic productivity of agricultural lands, woodland and forests that form the cornerstone of human activities, whereas desertification is considered land degradation in arid, semi-arid and dry sub-humid areas United Nations Convention to Combat Desertification (UNCCD: undated). The relevance of this definition in this report is that, South Africa is comprised of 91% of dry lands (Gibson *et al*. 2005) and more importantly, south Africa is susceptible to both land degradation and desertification, and these issues are very critical for the country (DEAT, 2008d).

The New Partnership for Africa's Development (NEPAD, 2002), states that even though land degradation is caused by natural factors such as drought and climate change, poor land use management and planning are the key cause of land degradation in most parts of Africa. This means that poor environmental management coupled with weak land use management legislation is at the core of environmental mismanagement and can lead to situations such as AMD in the

WRDM. Furthermore, NEPAD (2002) notes that in many African countries, environmental degradation and unsustainable exploitation of natural resources threaten to reduce the future productivity of agricultural land and natural resources.

2.6 Conclusion

This chapter has reviewed the literature on acid mine drainage, and land management approach in south Africa in relation to the current situation of AMD in the west Rand goldfield. The analyses and discussions also draw from international experience in relation to the management of AMD. It was established that it is very costly to mitigate AMD once it has spilled into the surrounding environment. Therefore, government institutions must take necessary measures to prevent it from decanting and contaminating the environment. Thus, in order to prevent AMD from destroying the environment, environmental management institutions must work hand in hand to strengthen their response to the issue of AMD in the West Rand Goldfield.

This chapter also focused on identifying different government institutions and their responsibilities in the management of the environment. Even though much of the responsibilities to deal with the issue of AMD are conferred on the national government, there are other institutions which provide the necessary support to the national government.

CHAPTER THREE:

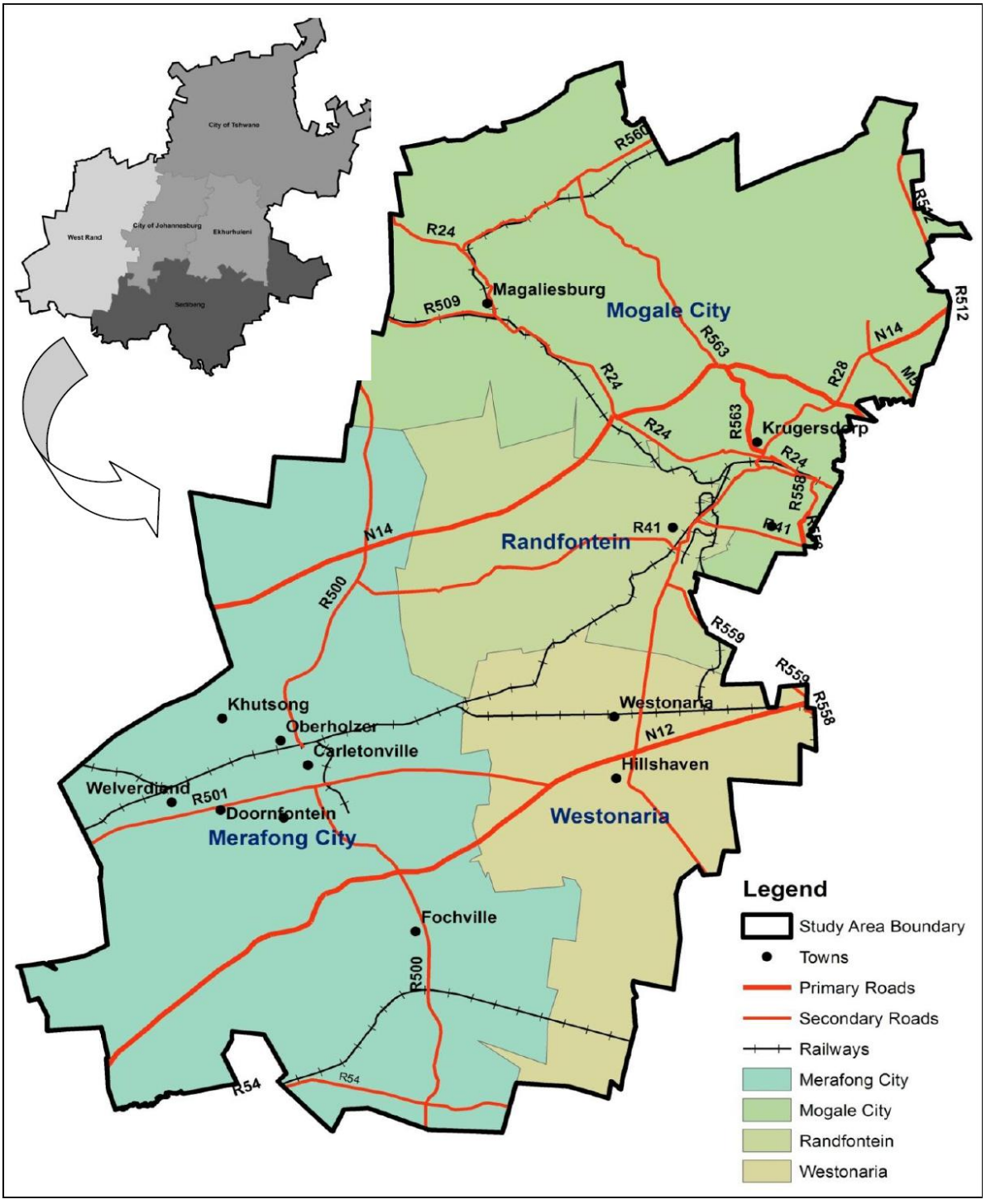
WEST RAND GOLDFIELD CASE STUDY DESCRIPTION

3.1. Introduction

The West Rand Goldfields is one of South Africa's largest and most lucrative mining areas, however recent research conducted in the area shows that soils in the mining districts of the Witwatersrand region are contaminated with heavy metals Lishman (2009). In addition the groundwater within this mining region is severely polluted and acidic as a result of AMD (*ibid*).

3.2. West Rand Governance Structure

The west rand goldfield is part of the West Rand District Municipality (WRDM) which consists of four local municipalities that is: Randfontein, Merafong City, MogaleCity and Westonaria. It is located to the South Western edge of Gauteng Province and it also serves as a local municipality in the District Management Area (DMA) known as the Cradle of Humankind. The West Rand area covers an area of 4,095 km^2, with 848, 597 total number of population.



Source: *WRDM, IDP Marketing & Investment strategy (2012)*

Spatial planning and land use of the area is characterised by:

- The main structure element in the district which is the N14 and N12, that cutting parallel to each other and forms a strong South-East to North-East linkage (WRDMIDP, 2011/12 to 2015/16).The R28 act as a seam in the context of the

District connecting the most important movement lines in a north-south direction (ibid).

- The relief of the WRDM is characterised by mountain ranges of Magaliesberg to the North West.

- Most development and settlements are concentrated toward the East side of the district.

- The main economic centres in the district are scattered and fragmented across the region due to the dominance and development of mining activities that triggered the economic activities.

- Due to the dolomitic character of land, it acts as a structuring element/restrictive factor in terms of land use patterns (*ibid*).

- There are tourist activities and opportunities present within the district municipality mainly in the north and north-east, as well as the Cradle of Humankind World Heritage Site.

- The development patterns of the area reflect the dynamic relations that exist between the historical residential patterns and trends, social and economic profile of the population, spatial economic activity concentration, transport infrastructure, engineering infrastructure, land available and planning initiatives (*ibid*).

- The development pressure of the area is translated through a permanent sprawl of development into rural areas that needs to be controlled in order to conserve and maintain the rural character of the area (*ibid*).

- The major environmental challenges of the area that need to be considered are dolomite, slopes, red data species, mining activities, nature reserves and undermined areas (*ibid*).

- Road and rail play a major role of stream of development as it links different development zones in the area and the rest of the Gauteng region.

- The district is also characterised by quite a number of important mine dumps known as “Golden Sand”, which shows the significant impact of mining activities in the district and Gauteng.

3.2.1 Demographic Information

As indicated earlier, the population in the WRDM is 848, 597 which can be subdivided as follows, among the four local municipalities:

- Mogale city local municipality has a population of about 371,360 this local municipality represent 43.76% of the total population on a total area of 1345 km^2 (West Rand District Municipality IDP, 2011/12 to 2015/16)
- Merafong city local municipality has a population of 220,640, which represents 26.0% of the total population on a total area of 1634 km^2(ibid)
- Randfontein local municipality, has a population of 147,232 that is 17.30% on a total area of 478 km^2(*ibid*)
- Westonaria local municipality has a population of 109,366 that is 12.88% on a total area of 639km^2 which make it the smallest local municipality within the WRDM (*ibid*).

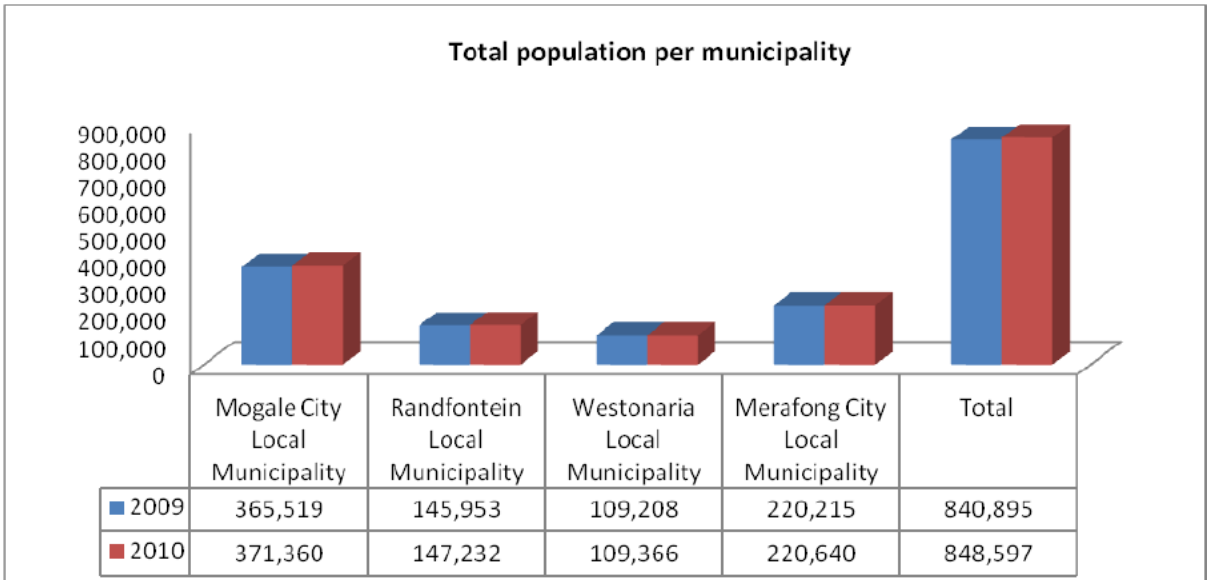


Figure 3.1: Total population Per Municipality

Source: WRDM IDP (2011/12 to 2015/16)

Based on the Global Insight Data 2011, and the West Rand District Municipality IDP, 2011/12 to 2015/16, the distribution of population per race and per local municipality in the WRDM, is comprise of:

- 79% of African of the total population of the WRDM,
- 17.9 % of white,
- 1.9% of coloureds,
- 1% of Asians

The WRDM municipality is predominantly inhabited by black people and the explanation for this highest number can relate to the fact that more blacks were employed by mining companies and most of them are living there with their families.

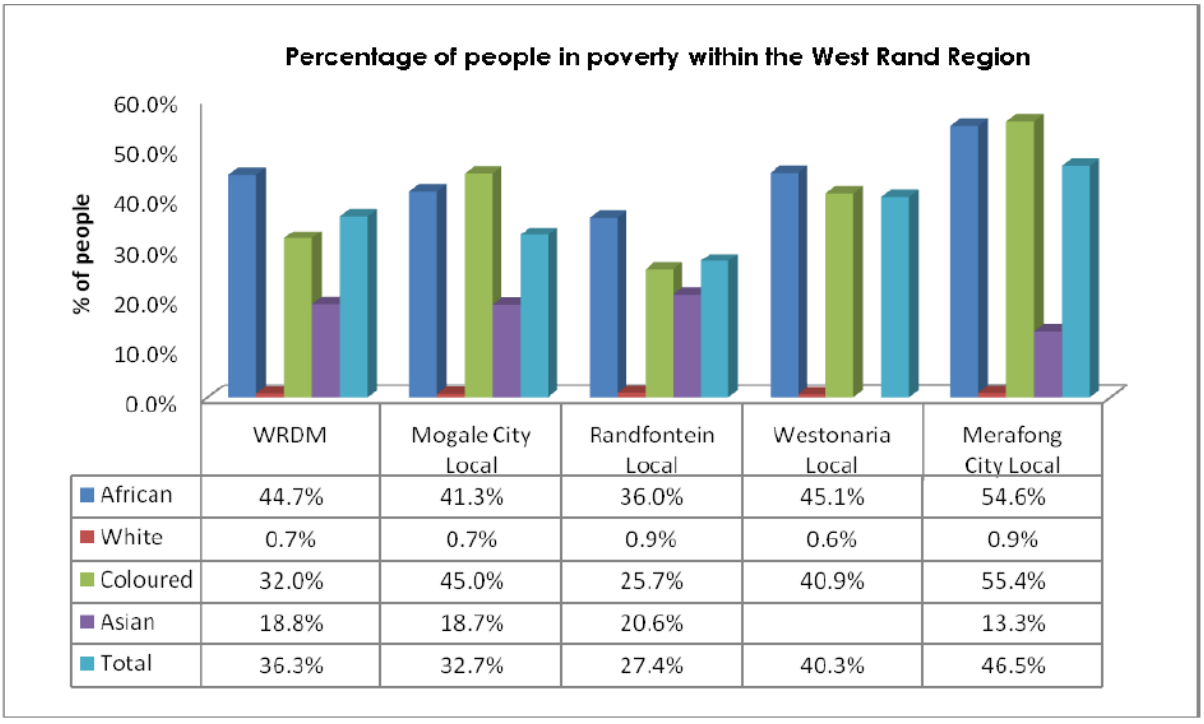
In relation to acid mine drainage, it is also important to look at the poverty level in the WRDM and the income level per household. This approach will help identify the sections of the population that are most vulnerable to AMD effect and the damage that AMD can cause to the local environment in a short and long term.

Therefore, according to Global Insight Data 2011, and the West Rand District Municipality IDP, 2011/12 to 2015/16, the percentage of people living in poverty within the West Rand District Municipality shows in one hand that Merafong City Local Municipality is the major area within the WRDM that is experiencing the highest rate of poverty 46.5%. This region is followed by Westonaria Local Municipality which is also still experiencing a high level of poverty 40.3%.

According to the WRDM IDP (2011/12 to 2015/16: 39), the reason behind the poverty level in both Merafong and Westonaria could be justified by the fact that most mining companies in these two areas have closed down and other mining companies have laid off most of their employees. On the other hand, Randfontein Local Municipality area appears to have the lowest percentage of people living in poverty. The reason behind this low poverty rate in the area is that most people living within Randfontein area are employed in different sectors that are currently operating in other sectors such as agriculture, manufacturing, trade, transport and finance. However, this situation could change due to the negative effect of AMD in this area as stated by the report of expert on the situation of AMD in the Witwatersrand area that. There is an alarming situation of AMD which is developing in the Randfontein

Area (West Basin) which requires an immediate and efficient intervention as reported to the inter-ministerial committee (Report to the inter-ministerial committee on AMD, 2010). This means that, failure to act immediately and effectively by land management institutions could have devastating consequences, on the environment, human health and socio-economic aspect. More so, the report by Parliamentary liaison office (2012) stressed that, the consequences will be devastating for communities living in the rural areas adjoining to mines in the Western Gauteng and North West Province who depend heavily on groundwater form boreholes due to lack of municipal water. The graph below illustrates the percentage of people living in poverty in the WRDM.

Graph showing percentage of population living in poverty in the west Rand Area:



	WRDM	Mogale City Local	Randfontein Local	Westonaria Local	Merafong City Local
African	44.7%	41.3%	36.0%	45.1%	54.6%
White	0.7%	0.7%	0.9%	0.6%	0.9%
Coloured	32.0%	45.0%	25.7%	40.9%	55.4%
Asian	18.8%	18.7%	20.6%		13.3%
Total	36.3%	32.7%	27.4%	40.3%	46.5%

Figure 3.2: Total population Per Municipality living in poverty in the WRDM

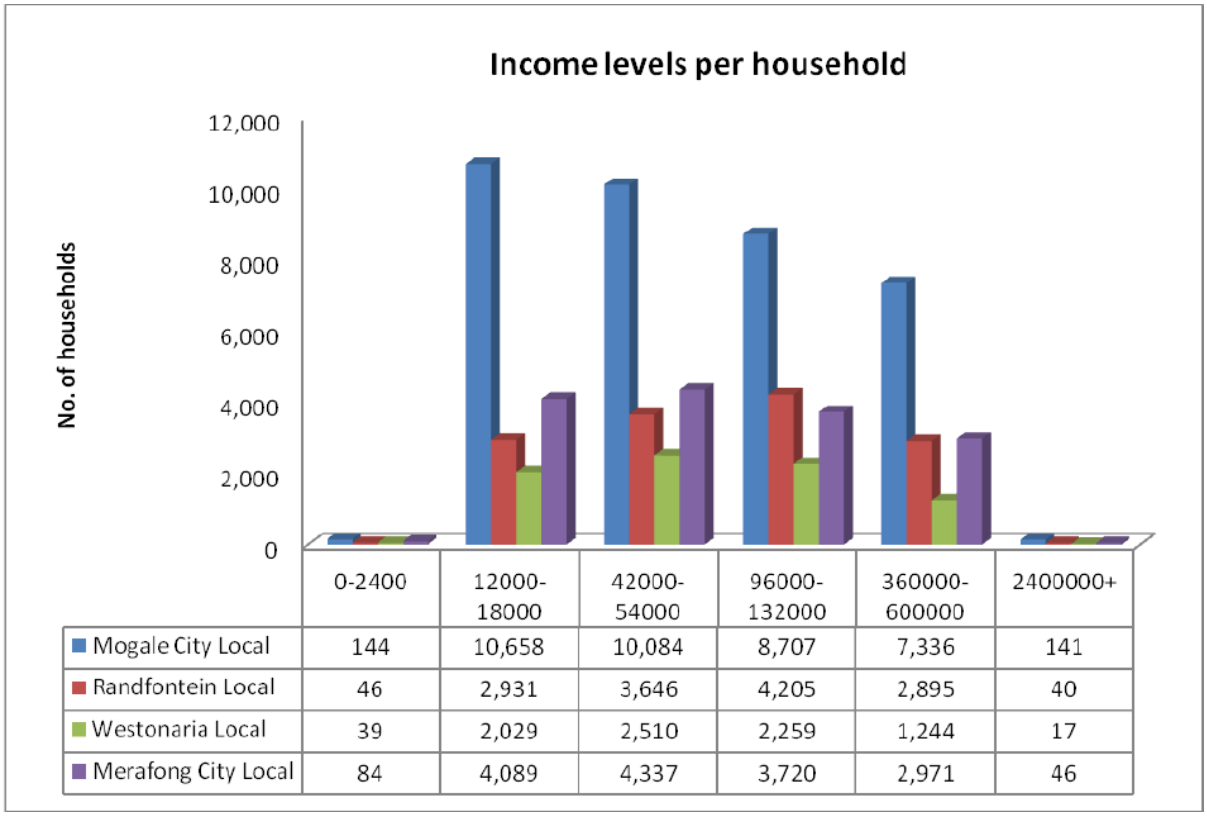
Source: WRDM IDP (2011/12 to 2015/16)

Subheading on the socio-economic status

While the level of poverty is very low in Randfontein, however According to the WRDM IDP (2011/12 to 2015/16), it is the Mogale City, including DMA, which is the area with the highest households income ranging from R 2 400 to R 2400 000 per month. It is important to note that most people identified in this bracket earning a

living in Mogale city are employed by private companies within the Johannesburg Metropolitan Municipality. However, the IDP is silent on the reasons why this group of people chose to live in the Mogale City local municipality area while working in the Johannesburg Metropolitan (*ibid*). Moreover, the general impression about the income level in the WRDM is that most household in this area earn more than R 2 400 per month. This level of income per household is impacting positively on the municipality income and profit because there are more households that can afford to pay their monthly services rate. Below is the graph that illustrates the income level per household within the WRDM.

Graph showing the level of income per household in the study area.



	0-2400	12000-18000	42000-54000	96000-132000	360000-600000	2400000+
Mogale City Local	144	10,658	10,084	8,707	7,336	141
Randfontein Local	46	2,931	3,646	4,205	2,895	40
Westonaria Local	39	2,029	2,510	2,259	1,244	17
Merafong City Local	84	4,089	4,337	3,720	2,971	46

Figure 3.3: Income level per household in the WRDM

Source: WRDM IDP (2011/12 to 2015/16)

The demographic analysis of the study area shows that some municipalities are more populated than the others and also the income level across the district municipality seems to be disproportionate, as the graph shows that Mogale city residents have high income household compared to other cities within the WRDM.

However, in terms of poverty level, Randfontein area has the lowest level of poverty and most of it residents are employed by companies that are based within the municipality compared to residents of Mogale city who are the highest income earners but most of them are employed by companies that are established in the Johannesburg Metro. This means that environmental effect of AMD within the area will be felt across the four local municipalities in the West rand area however in terms of negative economic effects, it is the Randfontein area that will be more affected due to the fact that some residents are employed in the farming sector and its related companies may lose their livelihoods due to surface and groundwater contamination.

The West Rand State of the Environment Report (2011) states that there is a general acceptance about the fact that AMD effects can cause costly environmental and socio-economic impacts. In this regards, the federation for a sustainable environment FSE (2011: 4) comment on the desired state report of the WRDM stated that "AMD has become one of the most perilous environmental hazards due to its current and potential impacts on the West Rand's natural and social environment, including inter alia, serious threats to groundwater resources, aquatic biota and ecosystems, and inevitably, human health."

3.3. Background Information on West Rand Goldfield

According to Winde *et al.* (2010), mining activities started in this area one year after the discovery of Gold in 1887 when the 'West Rand Consolidated' the first mining to operate in the area. At the same time the Krugersdorp town was established by the Transvaal Government to provide the administrative services for the public proclaimed in the area (Erasmus, 2004; Robb and Robb, 1998; Marais, 2000. cited by Winde *et al.* (2010). Early established mining companies such as the Randfontein Estates Gold Mine (REGM) stopped their underground mining activities in the 1990s. A system of connected voids, known as 'western basin' which were created by 4 different mines over a century mining activities started to fill with naturally inflowing water (*ibid*: 70). As a result of mine closure these four mining, the underground water started to rise and reached the ground level in 2002. It should be noted that the water coming out these mine shafts was of very poor quality due to the presence

of chemicals known as ' acid mine drainage' (Fourie and associates, 2004. Quoted by Winde, 2010).

3.4 Mining Related Urbanisation in the West Rand District Municipality

According to Winde *et al.* (2010), mining activities have helped the development of a number of settlements which were associated with the gold mines in the far west area, these include places such as; Carletonville (1948), Blyvooruitzicht village (1943), West and East Driefontein villages (1952 and 1972), the Deepkraal and Elandsrand villages, the Venterpos settlement (1935), the Libanon village (1936) as well as Westonaria (1959). Hence, it is estimated that 600 000 people live in former black township community areas that were developed along mining industries, such as Bekkersdal in Westonaria and Khutsong in Carltonville. However, these areas still suffer from substandard infrastructure including water and sanitation system (DWAF, 2004).

In addition, a possible increase in the population within these areas is estimated at 10% per year, which will result in a further extension of these settlements (Spies, 2007 quoted by Winde, 2010). Consequently, due to the level of poverty in the area most people will be forced to use and be exposed to cheap polluted substances such as water, soil and tailing (*ibid*).Government institutions in their capacity of environmental stewardship are supposed to prevent the population from using this kind of substance for construction or allow any form of settlement to take place on and around tailings. However, the failure of government institutions to enforce the law and the failure to provide adequate shelter to previously disadvantage people has led to the establishment of informal settlement such as Tudor shaft informal settlement in the West Rand.

3.5. WRDM Environmental Management Institutions

This section will briefly describe the layout of the WRDM department involves in environmental management.

Based on the Constitution of the republic of South Africa Act 108 of 1996, there are three spheres of government in the country, these are: the national, provincial and

local government (WRDM SoER, 2011). Furthermore, the constitution has made provision of the need for co-operative governance among the three spheres; this means that the Constitution has defined their respective executives and legislatives duties. As such all three spheres of government have particular functions and responsibilities to perform for their citizens and environmental wellbeing. However, all three spheres have equal rights. Section 151(3) and (4) of the constitution, 1996 states that " a municipality has the right to govern, on its own initiative, the local government affairs of its community, subject to national and provincial legislation…and…national or provincial government may not compromise or impede its ability or right to exercise its powers or perform its functions." Therefore according to the WRDM SoER (2011: 188), the local government local government objectives are as follow:

- Provide a democratic and accountable government for local communities;
- Ensure the provision of services to communities in a sustainable manner;
- Promote social and economic development;
- Promote a safe and healthy environment; and encourage the involvement of communities and community organisations in the matters of local government." (Section 152 of the Constitution, 1996).

Therefore, the national and provincial government have a concurrent environmental competence with principles of delegation of functions to local government (ibid). Hence, municipalities may have executive authority and the right to administer any matter assigned to them by the national or provincial legislation (WRDM, 2005 quoted in the WRDM SoER, 2011). Thus, environmental management falls within the district municipality competences and not a local level (*ibid*). This means that in the WRDM, the responsibility of environmental management is at the district level and not the four local municipalities.

According to the WRDM IDP (2011), the Environmental Management Department (EMD) falls within the transport directorate of the WRDM. However, according to the SoER (2011), the EMD is responsible for environmental issues in the WRDM and its duties are:

- Monitoring of the ROD: this focuses on producing a monthly audit report on all development;
- Air quality license authorisations
- Review the EIA: this consist of reviewing and comment on EIA report and process;
- Manage strategic project on behalf of the local constituent resident such as the SoER process, the integrated waste management plan, etc.

Furthermore, it is noted in the SoER (2011) that there are a number of sectoral plans that are also used to manage the environment affairs in the WRDM, these are; Environmental Management Framework, Spatial Development Framework, Integrated Development Plans and State of the Environment Report. This means that, environmental management in the WRDM is covered at the same time by a number of departments depending on the nature and magnitude of the issue at hand. As such environmental management does not fall within one specific department in the WRDM (*ibid*).

In the same way, Humby *et al.* (2009) notes that environmental management is not a functional area, it is extremely fractured area of competence due to the listing of various aspect of the environment which are scattered across Schedules 4 and 5 of the Constitution of 1996. Hence, the level and quality of the environmental management will depend on the level of municipal governance capacities and their strategy to respond to environmental challenges such as AMD (SoER, 2011). Therefore, weak environmental management in most cases will lead to the following situations:

- Loss in biodiversity (*ibid*);
- Negative impact on the water resources, with the consequence that the quality and of water will deteriorate (*ibid*);
- Loss in agriculture potential; and
- Erosion and pollution (*ibid*).

Drawing from the above list it is clear that due to the occurring of the current situation of AMD in the WRDM, the environment in this area is endangered and this situation may have a negative impact on the social-economic situation as well as human

health. I assume that the failure to deal effectively with the issue of AMD at the local level, can be associated to the multitude of government department that are involves in environmental management. The WRDM SoER (2011) further states that local municipalities have indicated that most environmental management issues are completed by the WRDM (ibid). This means that the district municipality is the steward of the environment and should manage environmental affairs of local municipalities. This system of environmental management will require a cooperative and communicative approach among local and district department. However, a weak interdepartmental co-operation may pose problem by weakening government action by lack of common vision and objectives, for the realisation of the constitutional right of all South African to live in a clean environment.

3.6. Overview of Acid Mine Drainage situation in the West Rand

According to Turton and Oelofse (2008), AMD manifestation started in the West Rand with water decanting from closed flooded underground mine working on the West Rand in August 2002. Thereafter, AMD has spread across the region and found its way into the natural water course and flooded a game reserved to the north of the Cradle of the Humankind World Heritage Site. Moreover, in recent times, there have been media reports about AMD contamination of Loskop Dam, Randfontein and WonderfonteinSpruit areas.

The contamination of existing water courses in this area could have devastating consequences on the environment and threaten human health for a long time on an extended area from where it first started decanting. As argued by Naicker *et al.* (2003) cited in WRSoER, (2011), the contamination of water by AMD can spread over 10km beyond the starting point. The consequence of such contamination is that the entire WRDM region will be affected and beyond. Therefore social-economic sector of the WRDM will be affected as many industries around the area such as farming activities will be force to close down for lack of enough potable water and thus affect food security.

Durkin and Herrman (1994 quoted in the WRSoER, 2011) noted that AMD is the most challenging mine waste problem to address. As such, the best prevention

approach is sustainable mining which is appropriate to prevent AMD to develop and thus protect the environment in areas where mining activities are taking place.

Moreover, due to the negative impact that AMD can have on the environment and human health, it is important to constantly check the level of acid and heavy metals in streams within the study area and prevent further damages. This will include constant monitoring of abandoned mines and mine dumps as stated by the WR SoER that important volumes of contaminated water need to be managed and monitored on a constant basis for many years to come (*ibid*).

Another issue that needs to be mentioned in relation to the matter at hand is the issue of mine dumps that are radioactive and threaten human health through airborne contaminants and groundwater. In this regards, I have observed during my visit in the Mogale city that some settlements in the area are built within close proximity of these mines dumps and this is in contravention of the right to clean environment stated in section 24 of the Constitution. van Eeden, (1992; 2008a) quoted in Durand *et al.* (2009) stressed that urbanisation in the 1930s amplified in conjunction with mining and associated industries, more so that urbanisation continued further until people were living and working within tens of metres away from mines dumps.

Four years since the time that AMD has polluted surface water in the West Rand, including the Tweloppiespruit which flows through the Krugersdorp Game reserve, the pH level in the dam in the game reserve downstream of the AMD source, has dropped to around 3pH and the concentration of other heavy metals such as sulphate and iron has rose dramatically, with a consequence that water from the Twelopiespruit could be unclean for human and farming consumption (Krige& van Biljon, 2006 cited by Cobbing, 2008).

The decant of contaminated mine water in the study area, comes from shaft, boreholes, and springs which are all caused by the interruption of pumping of water from the mine void (van Biljon and Krige, 2005 quoted by Durand *et al.* 2009). The consequence of the decant of contaminated water in the surface water and ground water is that, most people living downstream will be deprived of an important source of portable water for personal use and farming activities. In this regards Durant *et al.*

(2009) note that communities in the rural areas, neighbouring mines in the West Gauteng and North West province depend on groundwater from wells due to a lack of municipal water supply. This means that poor communities and vulnerable people living in rural areas adjacent to mine and mine dumps are the most vulnerable to the effect of AMD in the West Rand. Furthermore, Durant *et al.* (2009) argued that people living in informal settlements use groundwater and surface water for drinking and farming activities, therefore in case of contamination of water used for irrigation of crops, the presence of metal substances in crops will pose a human health risk (Van Biljon, 2007; van Eeden, 2006).

The presence of substance from mine water decanting from abandoned mines in the West Rand has been detected in the Vaal River to the South and the Limpopo River to the North, the presence of this substance in the two rivers are justified by the fact that, they both originate from the Continental Water Divide (Coetzee *et al.* 2006 in Durant *et al* 2009). More importantly, is the negative impact that contaminated mine water will have on the quality of groundwater which occurs close to the dolomite of the Malmani Subgroup, an important aquifers and important source of good natural water quality (Barnard, 2000; Hodgson *et al*. 2001 quoted in Durand *et al*.2009). Cobbing (2008) also noted that, the dolomite aquifer exposed to the danger of AMD is a source of drinking water and an important source of irrigation water to a number of users in the region.

Therefore, due to the negative impacts of AMD on the receiving environment in the West Rand region and the fact that South Africa is a water scarce country, the decant of AMD in the West Rand must be prevented and where it has occurred necessary measures must be put in place for the protection of the dolomitic aquifer which is a source of portable water to many households and also a source of water for irrigation for farmers. Hence, there is a need for a combination of actions which will see different stakeholders such as government institutions; NGO's and local communities come together in order for them to tackle the issue of AMD effectively in the WRDM.

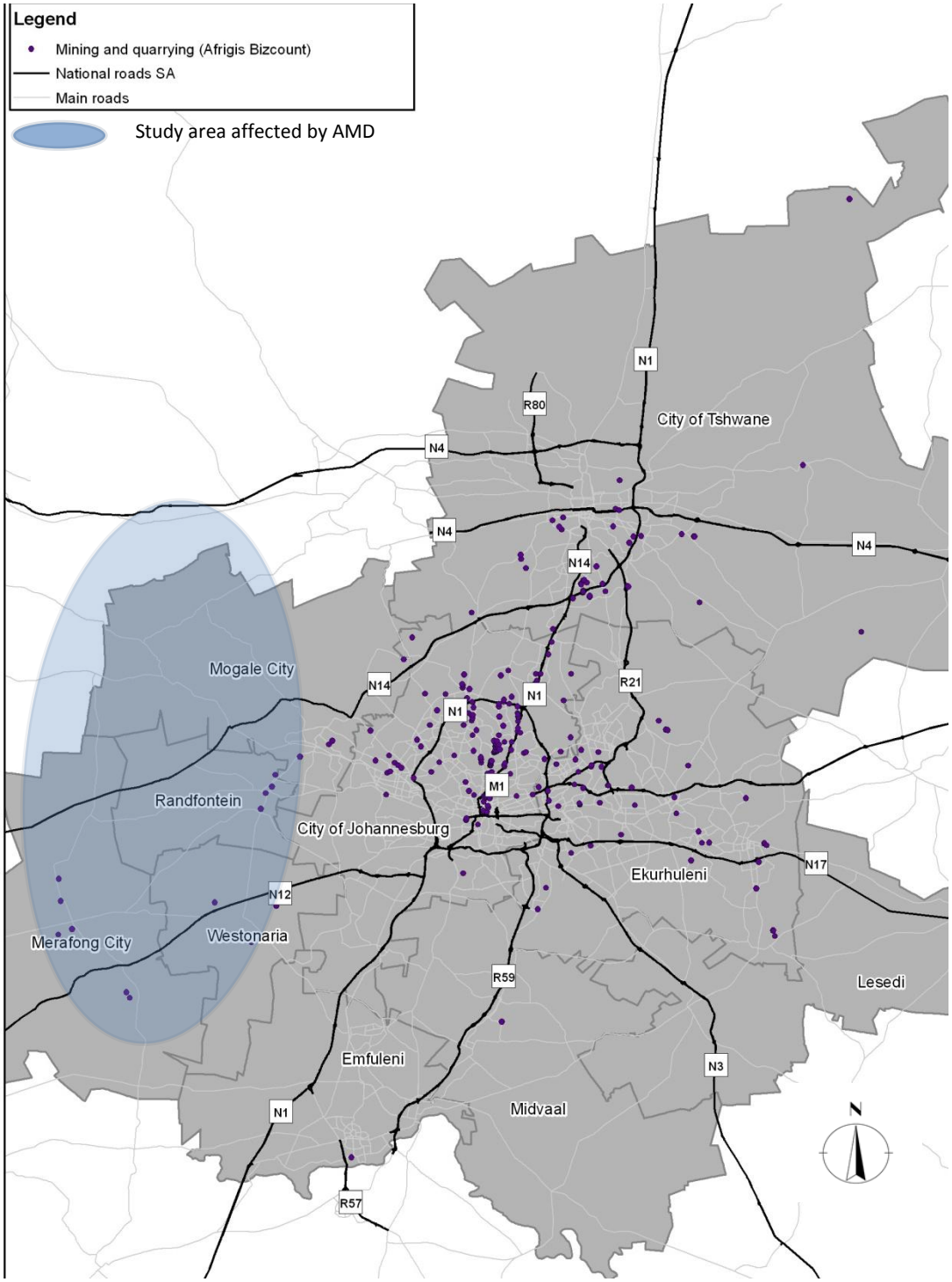


Figure 3.4: Mining and Quarrying area in WRDM

Source: AfrigisBizcount

3.6.1 AMD Management System in the West Rand District Municipality

The management of AMD issue in the West Rand has raised so many concerns about the way in which government institutions are responding to it occurrence, and the negative effects that it can cause to the receiving environment. Hence, this section of the report focuses on the system put in place by the WRDM to tackle the issue of AMD.

According to the WRDM Integrated Development Framework (IDP) 2010/ 2011, the municipality has approved an integrated waste management and air quality management plan (IWMP) that will ensure the management of a safe and healthy environment of the study area, and this will be done in accordance with the principles of the constitutions of the republic of South Africa.

Therefore, the WRDM IDP 2012/2013 has adopted a Green IQ plan for the management of the environment. This is a comprehensive strategic plan dedicated to make the WRDM the greenest district in the country and serve as an example of how sustainable development is not just a good choice but the best choice. This means that the current situation of AMD that is threatening the environment in the WRDM will be managed efficiently and achieve the IQ vision. Therefore, the Green IQ is built on 5 pillars which are very important for the realisation of WRDM objectives to build a sustainable environment for all its citizens, these are:

1. People: this pillar focuses on building a better place for the people first, a place where which is characterised by equity, dignity and possibility for everyone (WRDM IDP, 2012/13)
2. Economy: the economic pillar will be shaped in way that will canalise opportunities to local residents (*ibid*)
3. Environment: this is an important pillar in relation to the issue of AMD at hand in this report. Hence this pillar will preserve and ensure the availability of natural resources for future generation; create a low carbon built environment which will be based on quality of life; and regenerate rural areas with a new sense of purpose (*ibid*).

4. Energy: this pillar will enable the creation of new forms of energy such as renewable, affordable and reliable energy which will boost new industry and the competitiveness of the study area.
5. Innovation: the focus of this pillar is to focus on establishing the WRDM as a centre of excellence for green technology and green living. As such the WRDM aims to attract best mind and encourage industries of the future.

The Green IQ strategy comes in addition to already existing environmental management framework in place. As such it does not take the place of existing framework but will serve as a guiding tool. However, the success of Green IQ pillars will depend also in my view on institutional arrangement and their capacity to collaborate with one another in a coordinated manner and deal with environmental challenges facing the municipality, such as the current situation of AMD. The structure of the Department that manages the AMD situation in the West Rand District is shown below.

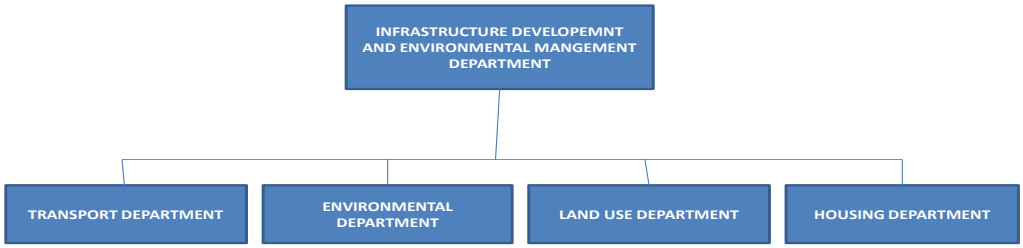


Figure 3.5: WRDM Infrastructure Development and Environmental Management Department

3.7 Chapter Conclusion

The focus of this chapter was on the West Rand Goldfield. An overview of the West rand District Municipality, structure of the city governance, historical background and demographic information as well as the situation of AMD in the area was delivered. The second section scrutinised the management situation of AMD in the study area. The analysis reveals that there issues with the role and responsibilities of local institutions in relation to the management of environmental issue such as AMD. The analysis also reports that there is a lack of environmental protection strategies within the district municipality even though they are aware of the constant danger of AMD that surround them.

Therefore, the WRDM must be given more prerogatives in a way that they will have personal capacity to deal with the situation of AMD that is threatening their environment as well as strong planning system to protect local communities against the negatives effect of AMD.

CHAPTER FOUR:

ANALYSIS AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter is based on an analysis and discussion of different issues that have been identified in the literature review and it is divided into five sections. The first section focuses on the analysis of environmental management institution's response to the issue of AMD in the West Rand Goldfield. The second segment discusses the issue of the causes and effects of AMD mismanagement in the West Rand Goldfield as established by the study's review of literature. The third part by way of identifying planning theory that best responds to the mismanagement of ADM in the West Rand Goldfields – seeks to show how planning can intervene and lessen the challenges of ADM drainage and land degradation in the West Rand Goldfields. The identification of the planning theory in the third segment makes way for the definition of interested stakeholders with regard to the challenge of AMD in West Rand Goldfields, done in the fourth segment , The chapter's fifth and last section makes recommendations concerning AMD management frameworks that include three stages of mining eras : pre-mining, during and post mining. From that, a conclusion sanction is made at the end of this chapter. The analysis of the findings looks at the plans by government in terms of how different departments are going to deal with environmental issues from mining activities such as AMD in the West Rand Goldfields and how these have been implemented on the ground as well as different published report on the management and prevention of AMD in the West Rand Goldfield.

4.2 Environmental Management Institutions' Response(s) to the AMD situation in the West Rand Goldfields

Acid Mine Drainage (AMD) has been in recent times designated as the most single significant threat to South Africa's environment. This section has aimed to describe how government institutions that are responsible for land management and environmental management have so far responded to AMD challenges, and how these issues have affected the economic growth of the West Rand District Municipality.

In 2002, a number of people in government and mining companies were taken aback when the Western Basin flooded and AMD started to decant at numerous locations on the West Rand Goldfield. From henceforth the main government institutions that have been active on the ground are the Department of Water Affairs and the Department of Mineral and Energy. In 2002, the DWAF issued a direct order against a number of mining companies; namely, DRD Gold, Mogale Gold (currently known as Mintails SA) and Harmony Gold (now Rand Uranium) to deal with the problem of AMD (Humby and Liefferink, 2010). The order given to these mining companies specified the regulatory limits for the quality of water that mining companies were supposed to maintain (*ibid*). This was the first government response to the 2002 decant of acidic water in the study area which focused more on finding technical solutions that would help separate heavy metals from water.

This approach was however taken with little consideration for other important aspects of the effects of AMD on the environment such as human settlements, human health, land degradation and the economy. Moreover, this intervention was a short term solution that sought to solve the problem without redressing – or at least addressing - the source of the problem. It was for these reasons that the approach was hugely unsuccessful (Humby et al 2009). Humby *et al*. (2009) argue water treated using the facility on the property of Harmony Gold's Randfontein Operations - an old uranium treatment facility - were often in no compliance with the regulation limit for drinking water and the supply for agricultural activities. This suggests that the regulations recommended by the DWAF were not applied and observed because the water discharge on the Tweelopiespruit still contains a higher rate of sulphates 2500 to 2800 ppm above the regulation limit of 500ppm (*ibid*).

The failure of this approach could also be seen as an indication that there is a problem with the implementation process and enforcement of the directive order given by the DWAF, and this negative result may be attributed to the fact that some of these decisions are taken by one government institution without association of other interested parties such as the Department of Environmental Affairs in the decision-making process. In addition to the directive order, Humby *et al.* (2009) note that there is a committee that was established by the DWAF - the Western Basin Void Decant technical working and monitoring Committee - as the channel to

connect and discuss with the public on AMD-related issues in the Western Basin. This shows that the process that the DWAF followed to engage with other stakeholders was to conduct regular monitoring of ground and surface water sources as well as communicate the findings to interested parties and affected parties at the meeting of the committee. Therefore, the committee's meetings are also attended by the organs of state representatives (GDACE) as well as local municipalities WRDM and Mogale City Council. This was the first attempt to include other government institutions in the process of AMD management in the West Rand.

The involvement of the mining companies at this stage was very decisive in the management of the AMD process in the West Rand Goldfield due to their responsibility as the sources of pollution in the area associated with their technical expertise to provide technical solutions. Thus , the government instituted liabilities to the mining companies which were based on a polluter-pays principle (The PPP, as outlined by the White Paper on Environmental Management Policy for South Africa and the National Water Act of 1998, stipulates that those who are responsible for producing, permitting, or causing pollution, should be held liable for the clean-up costs and the costs of legal enforcement associated with that pollution.) and their ownership of the sand dams, tailings disposal facilities which include rock dumps; length of river; surface area of mined area or mine void, and surface area of undisturbed/disturbed geology (Krige 2009 as cited in Humby *et al.* 2009).The consequence of this decision was that any mining companies and owners of mining land should be held responsible for AMD issues and pollution of the surrounding environment where their operations are established. Any mining company found in contravention of this directive would thus be liable for environmental damages. Consequently, every mining company is expected to incorporate into their planning and assessment of AMD generation and prevention of AMD to decant and (or) to separate heavy metals from mine water before it could be released into the environment. In this regard, Humby *et al.* (2009) observe that the environmental impacts of mining activities are to be managed as an integral part of the mining operation (Act 50 0f 1991 and Minerals and Petroleum Development Act 28 of 2002). This includes monitoring and auditing compliance.

Regardless of all these measures, efficient AMD management is still a difficult feat to achieve because due to the fact that some, if not most, mines in the affected area are no longer operational or are ownerless, which makes it difficult to enforce compliance (DWAF, 2010). In the event of such an incidence , the state government takes the responsibility in the interest of the community in order to protect the community from harmful contamination, particularly when the matter has to be dealt with immediately (*ibid*). However, government institutions' failure to respond to the AMD situation efficiently from the first time it decanted in the West Rand Goldfield has resulted in the aggravation of AMD and has led to negative impacts on the environment in the West Rand Goldfield (*ibid*).

This shows that isolated management approach is not working and there is a need for an inclusive and put around the same table all interested parties around the same table. This means that the government institutions' approach should be inclusive rather than preventive of other government departments and public participation. This is because a solution taken in isolation and without the without collaboration/communication of concerned/interested parties is highly likely to result in failure or non-application of the recommended solution to the problems. However, decisions taken with the implication of all relevant parties - the Department of Water Affairs, Department of Environment and Tourism, local community, mining companies and non-government organisations - from inception raises the level of commitment and may increase the likelihood of all parties striving for a successful implementation of the decision taken.

In relation to the protection of residential areas against the effects of AMD in the West Rand Goldfield, in 2009, the Department of Mining and Energy issued a direct order to DRD Gold Mining company to fence areas in close proximity to residential settlement, after the occurrence of an accident when two children drowned in AMD on DRD Gold's property (Tempelhoff, 2009 as discussed in Humby and Liefferink, 2009). The government order (only) came after the accident had led to a public outcry and forced the government to intervene in order to protect communities from entering contaminated zones (*ibid)*. This was an indication of how slow the government's response was to the matter of AMD in the West Rand Goldfield. Moreover, the visit conducted on the mining areas and shaft in decant by the

researcher brought to light the fact that there are RDP houses being constructed next to tailings dump which is airborne and acid materials can seep into groundwater that is a source of domestic water for rural populations. In spite of the fact that NEMA prohibits residential development within a 500 metre buffer zone of tailing dams, there are residential areas that have been allowed and developed in very close proximity to mine dumps and acidic mine water (see picture below). In some cases, informal settlements are built right on top of tailings such as the case of the Tudor shaft informal settlement (see picture below).

Below is an example of informal settlement 'Tudor shaft' built on top of contaminated tailing in the study.

Figure 4.1: Tudor Shaft Informal Settlement

Source: Liefferink (undated)

In this regard, most human rights in relation to living conditions such as living in an environment that is clean and not harmful to human lives (Section 24 of the Constitution), as well as the right to adequate housing, are being compromised.

In my views, settlement and human health risks are not being adequately addressed when dealing with the situation of AMD in the West Rand Goldfield. For example when talking to one of WRDM manager, she claims that populations living in Bekkersdale Westonaria used the Dam that is highly acidic for water baptism and other domestic use (personal communication).

In the same way Adler et al (2007) stressed that Robinson Lake, a mine-waste location with water 28 approaching a pH of 2.0 containing elevated levels of heavy metal contamination, has been sold by a large mining company to a developer with plans to create an up-market complex, that will have shopping centre, private residences, and a hotel (Coetzee *et al*. 2005 as discussed by Adler *et al*. (2007). More so, there are acidic mine water decanting upstream into the Cradle of Humankind, a World Heritage Site that contains some of the oldest known hominid fossils (Templehoff, 2007b).This touristic attraction is vital for the social economic development of the study area as emphasised by Fourie (2005) that many tourists and research scientists are attracted. Hence, human settlement and human health should be taken into account whenever a development is about to take place so that it does not compromise the development of other sectors such as Touristic attraction. A development was proposed and constructed in the West Rand District Municipality 'the retirement village' but it was never occupied because it was built on mine land with sinkholes.

This kind of situation could have been avoided if all interested parties in the management of the issue of AMD and mines related effect in the West Rand Goldfield are associated in the process of taking decision that are sensible with the potential to affect human lives and the social economic development of the area. This situation sheds light on the actuality that there is no efficient collaboration between government institutions in areas where AMD is occurring, with respect to human health and environmental protection. As such, the DME as well as the DWAFT are to be included in the process of approving development in the West Rand Goldfield area for their on hand experience to prevent environmental and human disasters.

Regardless of the fact that some government Departments are 'flying solo' in the management of the issue of AMD and its impacts on the environment, some progress has been made by the DME and the DWAF who decided to join their forces for the protection of the environment and water resources in the study area. The aforementioned departments concluded a general memorandum of understanding whose purpose is to ameliorate the working relationship of/between the two departments through minimization of potential conflict and ambiguity (DME, 2008 as

discussed by Amby and Liefferink, 2009). Another effort towards an efficient management of the AMD and all mines related activities affecting the environment was the establishment by the DME of a Government Task Team (GTT).The team plays the role of a facilitator of solutions and decision-making on mine-water management and related problems and the implementation of safe and sustainable mine closure options. Chaired by a representative of the DME, the GTT includes representatives of DWAF, DEAT and the various branches of the DME such as regulation, policy and promotion and the Mine Health and safety Inspector (ibid). Furthermore, Humby *et al*. (2009) indicate that the DEAT, which is supposed to play a leading role in the management of environmental matters nationwide and in the West Rand Goldfield, has particularly not been efficient and evident regardless of the fact that it was part of the GTT (*ibid*).

The analysis of the way government responded to the environmental disaster of AMD since its first decanting in the West Rand Goldfield shows a weak state management at all three levels of government. As argued by Adler et al 2007 that although the legislation on mining activities, water, and waste management has been amended subsequent the fall down of apartheid, a number of these changes have not been effectively implemented. Therefore, mining companies post-apartheid took advantages of these weaknesses to continue externalising some of their costs (*ibid*).

Therefore, Adler *et al*. (2007) as well as Humby and Liefferink are of the views that some of the reasons that could be attributed to failure by government for the non-implementation of legislation for the protection of the environment and the management of environmental disasters caused by mining activities are inadequate specificity and interdepartmental disagreements about which policies are primary. In this regards (Adler, Claassen, Godfrey, and Turton, 2007) gave an example of mine water management that is managed through four primary and numerous secondary pieces of legislation concurrently by three diverse government departments.

Moreover, the DEAT as a department responsible for the management of environmental affairs in the country is lagging behind and leaving the initiative to other departments to do something within their administrative and legislatives powers (Humby *et al*. 2009). Therefore, based on the aforementioned, the environmental management policy as well as conflict of roles and responsibilities is

also to be blamed when it gives powers not to one institution but too many without clarifying which department is to take the lead when it comes to AMD and mining-related environmental effects. By simultaneously creating legislative and administrative competencies among different spheres of government regarding the management of mine water and the management of environmental impact, the possibility for conflicting legislation is created (Adler et al. 2007). For example, water quality standards are managed at national level; however, local governments are in charge for legislation pertaining to the treatment of water and sanitation services. (*ibid*). In such situation the potential for legislative conflict is high; hence the promotion of government integration is hindered (*ibid*). The analysis of different report on government interventions on the issue of AMD in the West Rand Goldfield reveals inconsistency on their approach and implementation however some government department have been the leading driver by seeking different approach and solution to the problem.

For example, in 2008 the DEAT published the 'Emerging Issues on mine water pollution', a report based on describing the nature and extent of the issue of AMD - and acknowledged the fact that AMD is the single most significant environmental concern for mining activities (Oelofse, 2008 as discussed in Humby *et al.* 2009). The 'emerging issues' report, as such didn't make provision on the management of AMD issue rather made recommendations which could help government understand the extent of the contamination and the effect on human health. These recommendations were:

- Conducting of a study focusing on the fate and pathway of heavy metals and radionuclide associated with AMD, in order to determine the 'destination' of the pollution and the nature and extent of human risk involved (*ibid*)
- Conducting of a high epistemological study of off-mine populations affected by mining activities (*ibid*)

Building from the realisations and recommendations made by the 'Emerging Issues' report, Humby *et al*. (2009) observe that the DEAT final reports did not necessarily specify which institutions should be the leading agents in conducting the required studies and recommendations. Moreover, four years after these recommendations

were made, nothing has been done to establish the extent of AMD's effect on the population and which categories of West Rand populations are the most vulnerable.

Another government intervention towards the management of AMD in the West Rand Goldfield was made by the National Nuclear Regulator (NNR) which plays the role of monitoring any form of radioactive contamination from mining operations. In its capacity as monitor, the NNR has instructed all mines in operation to provide a report on the issue of radioactivity on their mines as well as to reassess and inform the public of the public hazard assessments of the mines (*ibid*). Furthermore, the DWAF and the NNR have a team of experts with the responsibility of identifying high radiological areas within the Wonderfonteinspruit Catchment region (*ibid*). Regardless of all these efforts and measures put in place, some mining companies operating in the West Rand Goldfield area are not complying with these provisions and/or regulations. Thus, the order given by the NNR to mining companies to put up restrictions and warning signs around sites with radiological hazards to the public has only been observed to some extent (*ibid*). This implies that disadvantaged communities living in poor conditions such as Tudor shaft informal settlement will continue to live on polluted land and consuming contaminated water.

The analysis of different report on the management of the current situation of AMD in the West Rand Goldfield show that, mining companies have also played an important role, these companies are DRD Gold, Mintails SA and Rand Uranium; they have facilitated the development of the West Utilities Corporation (WUC) which plans to establish a water treatment facility for AMD on a larger scale (Humby *et al.* 2009). In the same vain, the Report to the inter-ministerial committee (2010) on acid mine drainage acknowledge that mining companies have to major role in the management of AMD. Therefore the report recommends that

- The installation of pumps to extract from mines contaminated water for treatment
- The construction of on site treatment plant in every basin of the Witwatersrand with the possibility to refurbish and upgrade the existing water treatment owned by mining companies,
- The installation of adequate infrastructure that will convey treated water to near by water course

The use of mining companies for the treatment of mine water and it purification for domestic and industrial use could be partially an answer to the scarcity of potable water in South Africa. However, this kind of operation could be costly for the consumer due to high cost of purification.

The analysis of government effort to manage effectively the issue of AMD in the West Rand Goldfield area shows that much of the actions have been directed toward technical solutions for the treatment of mine water, identifying areas that are radioactive contaminated and detecting areas and which thus have the potential to generate AMD. However, most of government decision and effort to manage the situation of AMD have not been successful as acknowledged by the Report to the inter-ministerial committee that most significant in the management of AMD situation is the lack of monitoring data necessary to prioritised or implement recommendations. The consequence of this situation has been that that the quality of the environment continues to deteriorate with the possibility to negatively affect human health, water resources and the socio-economic sector of the West Rand Goldfield. This situation can be attributed to the fact that many of these decisions and recommendations were taken in isolation. According to Turton (2009), the state government did not respond to a number of warning reports immediately after having been made aware of the negative implications of mining activities and practice on water resources in the West Rand Goldfield.

4.3. Causes and Effect of AMD Mismanagement in the West Rand Gold field

This section will focus on the discussion of cause and effect of AMD mismanagement in the West Rand Goldfield before making suggestion of AMD management framework.

Causes of AMD Mismanagement in the West Rand Gold field

As has been argued by the literature reviewed in the second chapter, an analysis of the institutional management of AMD in the West Rand Goldfield reveals that a number of issues have been identified as the source of environmental mismanagement and the delays in government response to effectively respond to the challenging and threatening issue of AMD in South Africa and the West Rand Goldfield. These issues, in effect, can be classified under three general categories:

mining legislation, policy framework in relation to environmental and AMD, lack of interdepartmental coordination as well as legal issues (law enforcement). These categories are discussed in this section.

4.3.1. Lack of Interdepartmental Coordination/Cooperation

Interdepartmental coordination is a prerequisite of the Constitution of the Republic of South Africa Act 108 of 1996; therefore, all government institutions ought to coordinate their actions and efforts towards a common goal. However, interdepartmental coordination and cooperation are lagging behind due to a multitude of sectoral policy frameworks and other legislation that gave concurrent responsibilities and power to more than one department at all three levels of government. A typical example is given by Adler et al (2007: 36): "… mining waste legislation is fragmented and is addressed through by about two primary and eleven secondary pieces of legislation and by three primary and six secondary government departments". This implies that there is no unifying legislation that exhaustively defines and/or describes how mining waste and mine water such as acid mine water should be addressed (Adler *et al*. 2007).The consequence of this situation is that the driving force/reasons for the management of mineral residue and mine waste are deeply disjointed between economic development and environmental protection as shown in the graphic below (*ibid*).

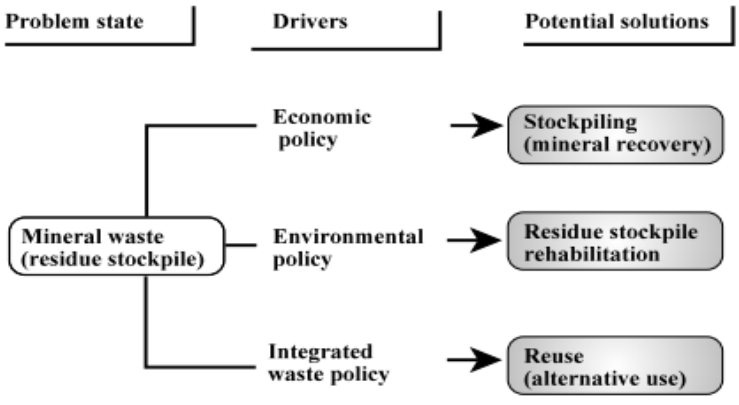


Figure 4.2: Drivers of Minerals waste management in SA

Source: Turton (2009)

4.3.2. *Policy Framework*

Nel (2009) argues that in as much as the land use management system in South Africa is guided by national and provincial government, the effective operation of this system happens at the local level. The backbone of this system - the strategic spatial development framework (SDF) – is a requirement for every local municipal to include in their respective IDPs. While the SDF is relevant in the sense that it gives direction on the desired form of spatial development at the local level, it appears that mining activities, mining rights and mining-related areas of competence are regulated by the national government and provincial government (see Schedule 4 of the Constitution). Thus, functional areas which are closely linked to land and mining (such as nature conservation, environment and pollution control) are concurrently the competence of both provincial and national spheres of government (Nel, 2009). On the other hand, environmental challenges associated with mining activities, for example air pollution, and are the responsibility of local government (see Schedule 5 of the Constitution). Thus, the environmental challenges associated with mining activity, some of which can be derived from AMD, are split among the three levels of government and or government department and thus creating an institutional conflict to a certain extent.

The CSIR (2009) observe that there are two major policy issues at the heart of AMD mismanagement. The first issue relates to the unclear allocation of powers among different government departments at the national, provincial and municipality levels, which in turn means that institutional roles and responsibilities are disjointed, overlapping and vaguely defined (CSIR, 2009). The second issue relates to the fact that the present environmental management policy frameworks situate the government in the *reactive* position rather than *proactive* position, meaning that the government has to wait for a problem to emerge before government can act to counteract the problem (*ibid*). A notable instance of this is manifest by the case of the West Rand Goldfields; in which government, instead of acting from the time it was first approached about the AMD issue, waited until the first decant in 2002 to react and take measures against the effects of AMD

a. Mining legislation

Due to the impact on and place of mining operations in the South African economy, the national government takes the responsibility to provide mining rights to those interested and it is required to conduct an environmental impact assessment before making a decision. In addition to this, if anyone has land zoned for agricultural activities but then discovered mineral deposits underneath he or she must apply for a rezoning permit to local municipality to grant him/her permission to conduct mining activities on that particular piece of land. However, if this rezoning is not in accordance with local municipality SDF, there is a high likelihood of conflict between the state in charge of issuing mining permits, the local government responsible for zoning as well as Environmental Impact Assessment (EIA) practitioners and or planners.

In addition to the aforementioned policies pertaining to mining waste and mine water, it can be argued that management pays little attention to the short term and long-term impacts of mining activities on human health (Turton, 2009). Currently, the only health-related concerns that are addressed by the legislation pertain to occupational health and safety of mineworkers themselves, ignoring off mine populations. Health impact assessments conducted prior to the establishment of a new mining facility tend to be environmentally focused as part of the EIA but are often superficial and reactive in nature. No high confidence epidemiological studies of mining populations have been done yet, and so there is no baseline data to use for comparison on changes in a population's health over time.

Therefore, looking at the manner in which AMD is generated as discussed earlier in chapter two, it can be concluded that the MPRDA left the gap for mining operator to get away with negatives effects caused by their activities such as AMD. Because it did not make provision in the policy on the prevention of surface and groundwater contamination from tailings or acid mine water decanting from abandoned mines.

In addition to the above mentioned, the government has failed the people of South Africa in their responsibility to ensure that mining companies complies with the Minerals and Petroleum Resources Development Act (Act no. 28 of 2002), which emphasised on the importance of environmental management programmes (section

38) as well as mine closure plan (section 43). The last must be approved by the government which took a financial approach regarding mine closure (section 41).

b. Law enforcement

Section 34 of NEMA and the National Water Act 36 of 1998 both stress the need concerned parties to take all realistic measures in preventing pollution and degradation from happening, continuing, or recurring as a result of mining operation (Van Eeden *et al*. 2009). As stated by Section 34 of NEMA, offenders must pay in relation to environmental contamination (*ibid*). However, most of the mines in the West Rand where the decanting started are abandoned and ownerless, a scenario which makes it virtually impossible to hold the owners/offenders/perpetrators accountable. As such, the remediation of environmental disasters caused by abandoned mine becomes the government‘s responsibility. Moreover, the fact that mines in operation are not adhering to the aforementioned regulation raises the question of effectiveness of law enforcement, which more or less implies that lack of law enforcement, which in turn leads to environment disasters.

The interdepartmental conflicts are magnified by the shortage of governmental officials, and the high turnover of government officials tasked to enforce policies pertaining to water and waste. The inability to integrate across government departments through policy leads to the mismanagement or abandonment of the mine- abandoned residue stockpiles and “dumps” that scatter the South African landscape. Where abandoned mine dumps remain on privately owned property, property owners have neither the mandate nor finances to re-mine, reuse, or rehabilitate them, making the underlying land a personal liability and difficult to sell. The result is a loss in private land value due to on-site abandoned mine dumps over which the landowner has no legal right but bears environmental and social liability, and the loss in private land value due to environmental degradation from neighbouring abandoned mine dumps. Additionally, these stockpiles and dumps compromise local water quality through the mobilization of chemicals from run-off and airborne particulates that accumulate in water sources or sediment.

Until existing legislation can be enforced in 23 a logical, organized fashion at all levels, and until the various government departments can learn how to coordinate with one another to maximize overall efficiency, conflict arising from the lack of government enforcement of current policies and their cumulative impacts will persist in South Africa.

4.3.2. The Socio-economic and Political Implications of AMD for Municipal and Spatial planning in the West Rand Goldfield

Whilst the implications of AMD for human health are still not succinctly clarified by scientific research, it is common belief among scientists that long-term exposure to and/or use of water contaminated by AMD has a high likelihood of causing cancer, skin cancer, skin lesions and decreased cognitive function (Adler and Rascher, 2007)

In the case opposing Fuel Retailers Association of Southern Africa v director-General, the Judge emphasised on the fact that environment and development are directly connected and that one cannot exist without the other because poor land use management can lead to environmental disasters. This means that development decisions are supposed to be reached after an assessment of their impacts on the environment has been taken into account. In the same vein, Development such as human settlements cannot be allowed in areas characterised by precarious environmental conditions such as contaminated water and degraded land because. Such development does not constitute sustainable human settlements. This is in accordance with Section 24 of the South African constitution, a clause which succinctly states that “everyone has the right to an environment that is not harmful to their health or well-being…” As such, government institutions have the responsibility of helping citizens realise their right to a contamination-free environment. . Surprisingly, in the West Rand Goldfield, some developments have been allowed in areas exposed to AMD danger, the most notable of which are RDP houses that have been constructed in close proximity to tailing dumps. This means that there are people living in close proximity to operating mines and abandoned mines in the West Rand Goldfield, which poses a direct danger to local communities due to spillage

and seeping of acidic mine water into different water resources and that is important for human consumption, industrial and agricultural activities.

The consequences of AMD spillage into the West Rand Goldfield and its surrounds make such an area unclean for human settlement. In addition to water contamination and biodiversity destruction which are important for human and animal survival, there is the issue of surface instabilities and sinkholes which will affect any form of spatial planning in the affected areas. As argued by the Federation of Sustainable Environment (2006), there are people and businesses within the areas that are affected by AMD and these people should be warned about the possible danger of ground instability and contamination of borehole water for drinking.

According to Molden and Merrey, (2002), Gilbert *et al*. (1997) as quoted Oelofse, *et al*. (2007), clean water is accepted has a precondition for economic and social development. As such, it is an important source for drinking, household use and food production (*ibid*). Any pressure on water resources such as AMD compromises local and national development due to several socio-economic consequences of which human and animal health (ibid).

According to Akcil and Koldas (2006), the AMD issue has become a political issue in South Africa, and that the situation could become worse with the closure of mines which previously supported local communities. Moreover, there is a wide acceptance that AMD is to blame for the most costly environmental and social-economic impacts in the country. This means that the closure of mines that are generating AMD in the West Rand has resulted in loss of job opportunities and has increased unemployment (Ochieng *et al*. 2010). Some of the implications of AMD for socio-economic activities of the West Rand as established by the literature review relate to the likelihood of industries such as the agricultural sector being affected due to water resource contamination. The contamination of water resources by AMD implies that some farms and other related agricultural companies may in the long run be forced to close down or reduce the number of their employees, possibly due to low productivity. The consequences of such a situation will be that families of the retrenched could face the risk of family dislocation/displacement. In terms of planning, local government may then be obliged to plan for more social grants to

sustain the unemployed population in the study area, which could it become an extra burden for government to look for finances that will help support the affected families health wise and in terms of education.

4.4 Conclusion

Contrary to the need for cooperative governance as stipulated by the South African constitution, there appears to be a lack of government collaboration among the three different spheres. This lack of co-operation between the local, provincial and national spheres of government manifests itself in the case of AMD management in the West Rand Goldfield. The vague and unclear allocation of powers among the three spheres of government further ads to the confusion concerning which sphere of government is assigned the task of managing the threats posed by AMD. The challenges of AMD are not only limited to the physical dimensions because they further extend to the socio-economic and political fabric of the West Rand Goldfield. AMD poses health and livelihood threats for the citizenry of the West Rand District Municipality, particularly the residents concentrated in the West Rand Goldfield, some of whom use the contaminated water for domestic purposes – cooking, drinking, and washing.

Not only that, but the contaminated water may lead to low productivity of farms in the area, resulting in some agricultural firms closing down which in turn may lead to loss of jobs. It is in the best interests of policy-makers and planning professionals to devise effective strategies to counteract AMD and the effects it imposes on the environment, as well as educate the public about the dangers of AMD.

CHAPTER FIVE:

RECAPITULATION AND RECOMMENDATIONS: EXPLORING HOW (COMMUNICATIVE/COLLABORATIVE) PLANNING CAN INTERVENE AND MITIGATE CHALLENGES OF ACID MINE DRAINAGE

5.1 Introduction

The issue of AMD and the threatening environmental, political and socio-economic challenges/consequences associated with it are matters of urgency and/or critical concern for professionals such as policy makers and planners. Planners especially – as professionals concerned with ameliorating the livelihoods of the poor– are placed in the centre of this challenge and thus have to act in the interests of the vulnerable. This then begs the question: how can planning 'meddle' and lessen the negative implications of AMD for the concerned parties and South African environment as a whole. This concluding chapter tries to answer this question by arguing that communicative/collaborative planning – by virtue of its emphasis on public reasoning as the basis for the transformation of society – can help ameliorate the challenges and threats posed by AMD. However, it should be noted from the outset, that communicative/collaborative planning is not the ultimate solution to the environmental, socio-economic and political problems arising from the AMD; rather, communicative/collaborative planning acts as a backbone for the 'ironing out' of conflicts arising from AMD.

This chapter is divided into three sections. The first section is a recapitulation of the main findings generated by the study. The second segment is based on general recommendations made by the researcher regarding how the issue of AMD can be addressed – if not redressed – by concerned institutions and/or organisations. The last section delves into how planning, particularly communicative/collaborative planning can intervene and mediate the challenges associated with AMD.

<u>The Challenges Associated with Acid Mine Drainage</u>

Using the complex, yet interesting case of the West Rand Goldfield as an example of Acid Mine Drainage in Gauteng Province and the challenges associated with it and/or arising from it; the study shows that the issue of ADM is a delicate one which has unfortunately been mismanaged by the relevant government institutions. The

(mis)management of the AMD situation in the West Rand Goldfield is more complex than meets the eye because not only does it have negative impacts on physical resources (water bodies, land as a source of agricultural production); it also has negative implications for the socio-economic well being of citizenry of the West Rand Goldfield (as suggested by poor health and job loss as derivatives of this phenomenon).

Regarding the mismanagement of the AMD issue by institutions, the land management system in relation to mining activities, as well as mining legislation and law enforcement, is partly to blame for AMD mismanagement. For one thing, in the supreme law (the Constitution), it is not succinctly spelt out which sphere of government is responsible for the issue of AMD as an environmental threat, especially in the light of the fact that the challenges associated with ADM, such as pollution control, threats to nature conservation, environment, air pollution seem to be spread out across the three spheres of government.

The notion of co-operative governance is not actually manifesting itself on the ground because government spheres appear to have been working in 'silos' regarding issues such as the AMD issue. It is hardly surprising that the undefined allocation of powers/responsibilities pertaining to different levels of government may not only lead to conflict among the different institutions, but may also create lack of accountability. As well, the conflict and lack of accountability may arise from the fact that there is a lack of institutional collaboration among different state institutions responsible for environmental management, which already suggests the problem of governance at the institutional level.

Another significant challenge in connection with the phenomenon of ADM pertains to its treatment by government. It appears that government has not treated the matter of ADM as a matter of urgency, reacting only when disaster struck in the form of the first decanting in 2002, as well as the death by drowning of children in the West Rand. This not only suggests that the state had not really anticipated the mine closures and the negative effects that would come with the closures; it also sheds light on the fact that the issue of AMD and its environmental impacts has not received urgent attention from governmental institutions. Whereas the decanting of

acid mine water in the West Rand Goldfield area was/is urgent (because it is threatening the Cradle of Humankind and has reached streams and the results are devastating to the area, as reported by the team of experts), government does not appear to have treated the matter with urgency. Thus, government action in response to the ADM phenomenon has thus been reactionary rather than preventative. This, in the long run, may jeopardise relations of the (local) government with the local citizenry. There is thus a need for government to treat the matter urgently and involve different state and non-state institutions in countering the problem of AMD.

5.2 Recommendations

In the light of all the problems presented by the ADM and the causes of the process/phenomenon, the research indicates that there is a need for land management institutions to collaborate with each other and with other stakeholders in order to respond to the current situation of AMD in the west Rand Goldfield and prevent it from spreading across to other areas in the Gauteng region. There is thus a need for collaboration between the state institutions and non-state stakeholders.

A collaborative planning approach for better management of the issue of AMD is required in the West Rand Goldfield, because past solutions proposed were taken in isolation by one or two government departments without involving all stakeholders such as mining companies, government, scientific institutions, non-government organisation and local community.

Moreover, it is of great importance that environment and water resources in the area are safeguarded in order to ensure food security for current and future generations. In this regard, the Environmental Mining Council of British Columbia (2001) quoted in Ochieng*et al*. (2010: 3352) stated that “in the interest of current and future generations, there is a need to safeguard the purity and quantity of water against irresponsible minerals development. Such irresponsible mineral development can result in a reduction of the quality of water, through increased pollution and sedimentation loads, leading to a reduced quantity of water being available for us by current and future generations”. Based on the above mentioned statement, the

research emphasised the need for sustainable land management practices, which will protect the environment from AMD

In light of this summary and conclusion, the research report has recommended that land management institutions take into account the effects of AMD in order for them to be able to respond appropriately to this issue

Acid mine drainage (AMD) has in recent times been described as the single most significant threat to South Africa's environment (Lishman, 2009). South Africa is a water scarce country and this, coupled with the increase in the population of South Africa, the demand for potable water for domestic use and industrial activities will increase, as well as the need for maintenance of a clean environment that is not harmful to human health and does not negatively affect socio-economic life.
These alarming occurrences should not be used to fuel anger, hatred, or resentment toward the mining industry or the current government; rather, they should be used as motivation for the public to participate in the political process and to encourage government to work toward more unified, proactive policy and legislative frameworks.

The residents and the public should be informed about the potential of the collapse of some of important national roads such as the N14 (Lishman, 2009). Therefore, future spatial planning in the study area should take into account the danger of water contamination and ground collapse in planning for human settlement and industrial development in the area, and avoid human and environmental disaster. The extent to which the current situation of AMD has reached could have been avoided if government institutions reacted on time and prevented the decanting of acidic water into the surrounding environment. Hence, future spatial planning for the development of the West Rand District Municipality such as road infrastructures, hospital, schools etc must be planned away from areas with the potential to develop AMD. In relation to the place where people live in close proximity to contaminated environment, government should consider settlement relocation in the form of housing provision for the affected families. And this approach supports the Section 24 constitution that states that everyone has the right to clean environment which is not harmful.

Therefore, in view of the challenges that AMD poses to the environment, human health and socio-economic life, land management institutions must take necessary steps for the management of the current situation of AMD in the West Rand Goldfield that will help mitigate its negative effect to the environment and human health. The following are some recommendations for the successful management of AMD in the West Rand Gold Field:

- Policy reform to clarify the role and responsibilities of government institutions in the management of AMD;
- Reducing the number of current government institutions and procedures in order to make government action more effective and faster. The reasons for this are to facilitate collaboration among different government agencies involved in the management of AMD;
- The West Rand District Municipality must be equipped with the necessary tools such as well-trained environmental management personnel who will constantly be monitoring areas with high AMD risks and blow the whistle for government to intervene;
- Establish a joint task force with the representation of members from all stakeholders who will meet regularly to discuss the implementation progress on AMD management plans and mitigating the effects of AMD in the area;
- Intensify community awareness programs through different media

5.3 Alternatives for better Institutional AMD Management

The management of AMD in the West Rand Goldfield will be done under the supervision of the Department of Environmental Affairs and Tourism, including a specialised team of experts with the responsibility to report regularly to the municipality and the DEAT on the effect of AMD. This alternative plan will have also a group of whistle blowers with the responsibility to report any wrongdoing from mining companies as well as government institutions

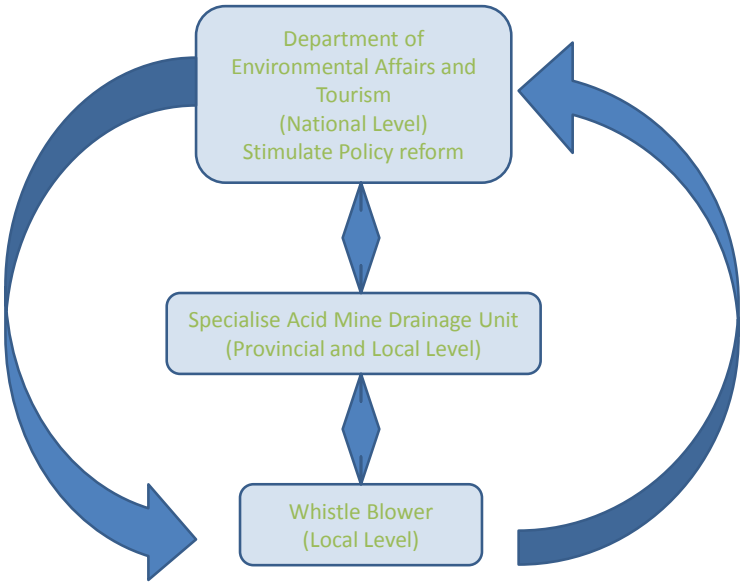


Figure 5.1: Proposed AMD Management Diagram

5.4 Communicative/Collaborative Planning to the Rescue: The Notions of 'Institutional Collaboration' and 'Communicative Governance'

Ansell and Gash (2007: 544) define collaborative governance as a

> … governing arrangement where *one or more public agencies* directly *engage non state stakeholders* in a *collective decision-making process* that is *formal*, *consensus-oriented*, and *deliberative* and that *aims to make or implement public policy or manage public programs or assets* (Ansell and Gash 2007: 544; added emphasis)

This definition by Ansell and Gash (2007) sheds light on the distinctive characteristics of collaborative governance – emphasis on notion of formal 'invited spaces'; discussion/deliberation and public reasoning; collective decision-making; collaboration of state and non-state stakeholders.

5.5 Concluding Notes

Our environment – as a source of natural resources/materials that are necessary for our livelihoods and survival - is precious and we need to protect it at all costs. Acid Mine Drainage poses a threat to our environment in its entirety – it pollutes and

degrades our land, contaminates water bodies, pollutes the air, and thus poses severe health risks for the West Rand Goldfields citizenry. In the context of the West Rand goldfield, professionals such as planners need to take it upon themselves to not only protect natural resources from possible extinction but to also shield the citizenry's right to a safe environment. Measures need to be put in place to ensure citizenry's realisation of this right. Perhaps the most effective of these measures include penalties against perpetrators (environmental polluters), some of whom are previous mine owners responsible for the abandonment of closed mines contributing to the Acid Mine Drainage.

While Acid Mine Drainage is largely attributable to the closure and abandonment of mines as well as failure of the previous mine owners to account for their mistakes, it still remains that the problem of AMD is perpetuated by many other factors, most of which are institutional factors. For instance, there appears to be lack of collaboration among the three different spheres of government, a challenge to the overcoming of the AMD issue especially given the fact that the Constitution – which makes provision for cooperative governance – assigns all spheres of government the task of addressing the challenges associated with AMD.

This has implied that government spheres work in isolation rather than collectively, thus contravening the provisions made for by the South African constitution and leading to conflict and lack of accountability regarding the issue of AMD. Furthermore, there appears to be lack of urgency on the part of government in dealing with the issue and/or challenges of AMD, meaning that government tends to wait for tragedy to strike before taking responsive action. The government has to act urgently to counteract the problems associated with AMD, rather than sitting and waiting for another AMD-related atrocity to occur in order to act. Thus, government has to act *actively* rather than *reactively* in redressing the problem of AMD if relations between it and the non-state actors are not to be jeopardised.

The issue of AMD is a critical one for professionals such as (development) planners because it places planners in a very awkward position. It means that planners, as 'social scientists' concerned with the public interest and the livelihoods of the vulnerable societal members, are caught in the middle of "the politics that characterises their work" (UDY 1994). Confronted with the pressure from the

politicians that the planner works for, as well as that of civil society, the planner has to mediate and find a common middle ground. With its emphasis on collective consensus through public reasoning and deliberation, sensitivity to context, the public sphere, communicative/collaborative planning may just be a way of ironing out conflicts/differences between the state and non-state actors, differences caused in large part by the challenge of AMD in this context.

The planner is tasked with the responsibility of not only being an 'experiential learner' (and learning from community the extent of AMD on their lives and livelihoods and environment); he/she must create a conducive environment for getting the state to engage with the local citizens about how best to combat the issue of AMD in the West Rand Goldfields. The outcomes of these discussions and the experiential learning can be used to influence environmental policy in the WRDM.

5.6. Future Research Avenues

The issue of institutional management of the challenging situation of Acid Mine Drainage is very complex and it requires government to take into consideration a number of factors such as finance, legal, socio- economy, health system, food security and water management systems for better management of this issue. This research report could not cover all the aspects involved in the management of AMD. Therefore, in the future, researchers should look into the effects of AMD on people living in close proximity to tailings such as Tudor shaft. The focus should be on new baby born malformation, skin lesion, and respiratory disease. More importantly, future research should also focus on institutional reform to adapt to the current situation of AMD because this situation is here to stay.

6. REFERENCES

Abiye, T.A. (2011) Provenance of Groundwater in the Crystalline Aquifer of the Johannesburg area, South Africa. *International Journal of the Physical Science* vol. 6(1) pp. 98 – 111. Available online at http://www.academicjournals.org//JPS

Adler, R. and Rascher, J. (2007). A Strategy for the Management of Acid Mine Drainage from Gold mines in Gauteng. Contract Report for Thutuka, Submitted by the Water Resource Governance Systems Research Group, CSIR: Pretoria.Pretoria: CSIR Report No. CSIR/NRE/PW/ER/2007/0053/C;

Akcil, A. and Koldas, S. (2006). Acid Mine Drainage: Causes, Treatment and Case Study. *Journal of Cleaner Production* 14, 1139 -1145

Amler, B. Betke, D. Eger, H. Ehrich, C. Hoesle, U. Kohler, A. Kusel, C. Lossau, A. lutz, W. Muller, U. Schwedersky, T. Seidemann, S. Siebert, M. Trux, A. Zimmermann,W. (1999). Land Use Methods, Strategies and Tools. Germany: Eschborn, Germany

AngloGold Ashanti. (2009). Social and Land Use Baseline Assessment. Golder Associates. South Africa

ANZMEC. (1995). Baseline Environmental Guidelines for New and Existing Mines. Australia and New Zealand Minerals and Energy Council . Report 95.02, March, Canberra.

Ansell, C and Gash, A. (2007). Collaborative Governance in Theory and Practice. *Journal of Public Administration Research and Theory* 18:543–571. Oxford University Press,

Bervoets, L. Baillieul, M. Blust, R. and Verhagen, R. (1996). Evaluation of soil Ph with Green Plants. Paper presented at International Conference of the Society for Environmental Geochemistry and Health, New Orleans, USA.

Beierle, TC. and Konisky, MD. (1999). Public Participation in Environmental Planning in the Great Lakes Region. Discussion paper pp 99 – 150. Washington, DC: Resources for the Future.

Booher, D.E. and Innes, J. (2002). Network Power in Collaborative Planning, *Journal of Planning Education and Research* 21: 221 – 236

Botha, C, Botha, D., Bischoff, c and Fourie, JD (2012) Progress in implementing the Mineral and petroleum resources development Act 28 of 2002 (MPRDA) provisions for the employment of women in mining. *the Journal of Southern African Institute of Mining and Metallurgy*, Vol 112 p

Brodie, M. J. Broughton, L.M. and Robertson, A. (1989). A Conceptual Rock Classification System for Waste Management and a Laboratory Method for ARD Prediction from Rock Pile. British Columbia Acid Mine Drainage Task Force, Draft Technical guide, 1, 130-135.

Coetzee, H. (Undated). An overview of Acid Mine Drainage in South Africa. Council forGeoscience.INTERNET:http://www.nstf.org.za/ShowProperty?nodePath=/NSTF%20Repository/NSTF/files/Workshops/2011/overview.pdf Accessed on the 8 august 2012

Coetzee, H. Nengobela, N.R. Vorster, C. Sebake, D. and Mudau, S. (2008a). South Africa's Strategy for the Management of Derelict and Ownerless Mines. In: Mine Closure 2008; Proceedings of the third international seminar on mine closure, (A. Fourie, M. Tibbett, I. Weiersbye and P. Dye, eds). Johannesburg: Australian Centre for Geomechanics.

Cocks K.D, Davis.J.R and Ive J.R. (1986). Developing Policy Guidelines for the Management of Public Natural Lands, South Africa: Butterworth

Cobbing, J.E. (2008). Institutional Linkages and Acid Mine Drainage: The Case of the Western Basin in South Africa, *International Journal of Water Resources Development* 24:3, 451-462

Coetzee, H. Winde, F. and Wade, PW. (2009). An Assessment of sources, pathways, mechanisms and risk of current and potential future pollution of water and sediments in gold mining areas of the Wonderfonteinspruit catchment: WRC Report No 1214/1/06

Cresswell, J. (2003). Research Design: Qualitative, Quantitative and Mixed Methods Approaches, 2ndedition. New York: Sage.

Creswell, J. (2009) Research Design: Qualitative, Quantitative and Mixed Methods Approach, 3rd edition, SAGE Publications: Thousand Oaks.

Council for Scientific and Industrial Research. (2009). Acid Mine Drainage in South Africa. Briefing Note August. Manders, P (ed) Resources and Environment

Currey, J. (1990). General History of Africa, Volume VII, Africa under Colonial Domination 1880-1935. Adu Boahen, A (ed). Unesco

Dale, P. and McLaughlin, D. (1998). Land Information Management: An Introduction with special reference to cadastral problems in third World Countries, Oxford University Press, Oxford, UK

Dalton, R. Abrahams, L. and Morkel, G (Eds) (1998a). Juta's Status of South Africa; Electrical, Energy & Mining: Labour, Transport. Volume 4,8th Edition

Dalton, R. Abrahams, L. and Morkel, G (Eds) (1998b). Juta's Status of South Africa; Agriculture, Fisheries, Forests and Water: Property. Volume 6, 8th Edition.

Department of Environmental Affairs - Republic of South Africa, "State of the environment", 19 November 2007; World Wide Fund, "Environmental problems in South Africa: Water on the Run". INTERNET: http://wwf.panda.org, accessed 10 August 2012

Department of Environmental Affairs and Tourism (DEAT) Second Edition Environmental Implementation and Management Plan (March 2008) GN 1138 GG 31415 of 15 September 2008.

Department of Water Affairs. (2010). Acid Mine Drainage West Rand. Media release

Department of Minerals and Energy. (2008). Environmental Management Plan Second edition. Published Under section 15 (2) (b) of the National Environmental Management Act, 1998 (Act No 107 of 1198)

Department of Agriculture and Rural Development Gauteng Province. (2012). Study on Reclamation and Rehabilitation of Mine Residue Areas for Development Purposes: Phase 2. Strategy and Implementation Plan

Department of Minerals and Energy Second Generation Environmental Management Plan GN 798 GG 31188 of 16 July 2008.

Muller, M. et al. (2009). Water Security in South Africa. Development Planning Division. Working Paper Series No. 12

Durant, J., Meevnis, J., and Fuorie, M. (2010). The Treat of Mine Effluent to the UNESCO status of the Cradle of Humankind World Heritage site. *The Journal for Trans-disciplinary research in Southern Africa* 6(1), 73 - 92

Durand, JF. Liefferink, M. Van Eeden, ES. (2009). Legal Issues Concerning Mine Closure and Social Responsibility on the West Rand. *The Journal for Transdisciplinary Research in Southern Africa*, Vol 5 no. 1 pp 51 – 71

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

Ferguson, K.D. and Erickson, P.M. (1988). Pre-Mine Prediction of Acid Mine Drainage. Dredget Material and Mine tailings. W. Salomons and U. Forstner. Berlin Heidelberg, Springer Verlag.

Federation for a Sustainable Environment. (2011). Comments on the desired state report for the West Rand District Municipality

Franks,D.M. Boged,DV. Cote, C.M. and Mulligan D.R. (2011). Sustainable Development Principles for the Disposal of Mining and Mineral Processing Waste. Resources Policy 36, 114 – 122

Franks, D.M. Boger, D.V. Cote C.M. and Mulligan D.R. (2010). Sustainable Development Principles for the Disposal of Mining and Mineral Processing Wastes. Resources Policy 36 (2011) 114–122

Frame. T. M. Gunton. T. and Day, J.C. (2003). The Role of Collaboration in Environmental Management: An Evaluation of Land and Resource Planning in

British Columbia. School of Resources and Environmental Management, Simon Fraser University, Burnaby, British Columbia, Canada

Faure, P.M. (1996). Framework for Land Management. Paper presented on one day International conference. Land Management in the Process of Transition. Budapest, Hungary 18 Jjune 1996

Forester, J. (2006). Making Participation Work When Interests Conflict, Journal of the American Planning Association, 72 (4): 447 - 456

Fulton, W. (1989). Reaching Consensus in Land Use Negotiations. Chicago: American Planning Association

Fuel Retailers Association of Southern Africa, Director-General: Environmental Management, Department of Agriculture, Conservation and Environment, Mpumalanga Province 2007 6 SA 4 (cc) par 44 x Fuel Retailers Association of Southern Africa v Director-General: Environment, Department of Agriculture, Conservation and Environmental, Mpumalanga Province 2007 2 SA 163 (SCA)

Funke, N. Nienaber, S. and Gioia, C. (2012). AN interest group at work: Environmental activism and the case of acid mine drainage on Johannesburg's West Rand in Heather A and Thuynsma (ed) Public Opinion and Interest Group Politics. South Africa's Missing Links

Funke, N. Nienaber, S. and Gioia, C. (2011). An interest group at work: Environmental activism and the case of acid mine drainage on Johannesburg's West Rand. Public opinion and interest groups politics: South Africa's missing links? Pretoria : Africa Institute of South Africa. Pretoria, South Africa

Fuggle, R.F. and Rabie, M.A. (1992). Environmental Management in South Africa, 2nd Ed, Juta and Co, Ltd. Johannesburg

Glazewski, J. (2000). Environmental Law in South Africa. Butterworth, UK

Godfrey, L. Oelofse, S. Phiri, A. Nahman, A. and Hall, J. (2007). Mineral Waste: The Required Governance Environment to Enable Reuse. CSIR Report CSIR/NRE/PW/2007/0080/C. Pretoria, : CSIR.

Harries, J. (1997). Acid Mine Drainage in Australia: Its Extent and Potential Future Liability. Supervising Scientist Report 125, Supervising Scientist, Canberra.

Hartnady, C.J.H (2009). South Africa's Gold Production and Reserves. *South African Journal of Science* 105(9/10) pp 328-329, September/October 2009 pp?

Harington, J.S. McGlashan, N.D. and Chelkowska (2004). A Century of Migrant Labour in the Gold Mines of South Africa. *The Journal of the South African Institute of Mining and Metallurgy* pp 64-71

Healey, P. (1997). Collaborative Planning: Shaping Places in Fragmented Societies, Hampshire: Macmillan.

Humby, T. and Liefferink, M. (2009). Looking at Co-operative Governance through the Lens of Acid Mine Drainage on the West Rand. Paper Presented at the Environmental Law Association Conference held from 29 – 30 May 2009 at Glenburn Lodge, Johannesburg, South Africa.

Hobbs, J et al. (2006). Novel ecosystems: theoretical and management aspects of the new ecological world order, Global Ecological and Biogeography, No 14, pp. 1 - 7

Jennings, S.R. Neuman, D.R. and Blicker, P.S. (2008). Acid Mine Drainage and Effects on Fish Health and Ecology: A Review. Reclamation Research Group Publication, Bozeman, MT.

Kleinman, R. (1989). Acid Mine Drainage. Engineering and Mining Journal. No190 pp 7: 16i-16n.

Kempton, H. Bloomfield, T.A. Hamson, J.L. and Limerick, P. (2010). Policy Guidance for Identifying and Effectively Managing Perpetual Environmental Impact from New Hardrock Mines. Environmental Science and Policy Vol13, 558 -566.

Kemp, D. Bond, C. Franks, D.M. and Cote, C. (2010). Mining, Water, and Human Rights: Making the Connection. *Journal of Cleaner Production* 18, 1553 – 1562

Kresge, G. (2009). Environmental Consultant, African Environment Development.

Lishman, K.I. (2009). The Acid Mine Drainage Potential of the Platreef, Northern Limb of the Bushveld Complex, South Africa,Unpublished Reseach Report, University of Witwatersrand, Johannesburg.

Liefferink, M. (Undated). A South African Perspective: Radioactive contamination and Acid Mine drainage (AMD): Discussing Pollution Risks within the Gold Mining Sector. The Federation for a Sustainable Environment

Liefferink, M. (2010). Johannesburg Acid Bath. http://www.fm.co.za/Article.aspx?id=117799# retrieved on 22 April 2012

Limpitlaw, D. (2004). Mine Closure as a Framework for Sustainable Development Practices on Mines Sites. Tools and Techniques. University of the Witwatersrand, 8 – 10 March, 2004

Kome, LM (personal communication 3 May 2013) Environmental and waste management administration officer, Department of Infrastructure, Development and Environmental Management, west Rand District Municipality

Mandres, P. Godfrey, L. and Hobbs, P. (2009). Briefing Note: Acid Mine Drainage in South Africa. Pretoria: CSIR.

Mac Carron, G. (2009). The Relationship between Planning and Environmental Management in Gauteng. (M.Sc. Development Planning), Thesis, University of the Witwatersrand, Johannesburg

Mine Environment Neutral Drainage. (1995). Economic Evaluation of Acid Mine Drainage Technologies, MEND Report 5.8.1, Energy Mines and Resources Canada, January, Ottawa

Minerals and Petroleum Resources Development Act, Act 28 of 2002 (MPRDA).

Mohring, R. P. Phillips, H. R. Morgan, P. M. Grobbelaar, C. J. Stewart, J. M. and van derRiet, M. (2001). South African Coal Related Research and Development, 2000/2001, Country Report to the International Committee for Coal Research, Prepared by the South African ICCR Delegation,26th ICCR Meeting, Strasbourg (France), 23-24 October 2001.

Muthreja, I.L and Paithankar, A. (1994). Impact of mining on Water Regime-with Special References to Heavy Metal Contamination. A Conference Proceedings from the International Symposium on “The Impact of Mining on the Environment, Problems and Solutions”, Nagpur, India. Published by Oxford & IBH Publishing Company.

Ministry of Agriculture and Land Affairs. (2001). White Paper on Spatial Planning and Land Use Management. South Africa

Mining Minerals and Sustainable Development Report. (2002). Breaking New Ground:, London: Earthscan Publications, London.

Naidoo, B. (2009). Acid Mine Drainage Single Most Significant Threat to SA’s Environment’ Mining Weekly 8 May 2009.

Naicker, K. Cukrowska, E. and McCarthy, T.S. (2003). Acid Mine Drainage Arising from Gold Mining Activity in Johannesburg, South Africa and Environment. Environmental Pollution, No 122: 29 - 40

Oelofse, S.H.H. Hobbs, PJ. Rascher, J. Cobbing, JE. (2007). The Pollution and Destruction Threat of Gold Mining Waste on the Witwatersrand, a West Rand Case Study. Natural Resources and the Environment Department. Pretoria: CSIR: 617.

Ochieng, GM., Seanego, ES and Nkwonta, O. (2010). Impacts of Mining on Water Resources in South Africa: A Review. Scientific Research and Essay, Vol. 5922), pp. 3351-3357

Ovens, W., Kitchin, F., Parnell, S., and Williams, A. (2007). Land Management and Democratic Governance in Five South African Metropolitan Areas: Overview Report, Commissioned by Urban LandMark, Planact and CUBES, with Ford Foundation

Rubin, M. (2007) Land Management and Democratic Governance in the City of Johannesburg. Joint Planact and Cubes Study, Synthesis report

Reeves, S., Albert, M., Kuper, A. and Hodges, B. D. (2008) Why use Theories in Qualitative Research? In BMJ, 337, 13 September: 631 – 634.

Philip, L. J. (1998) Combining Quantitative and Qualitative Approaches to Social Research in Human Geography – an Impossible Mixture, in Environment and Planning, 30: 261 – 276.

Sager, T. (2006). The Logic of Critical Communicative Planning: Transaction cost Alteration. Norwegian University of Science and Technology (NTNU), Norway

Sarantakos, S. (2005) Social Research. 3rd edition. Palgrave Macmillan: London, pp 92 -101.

Twerefu, D.K. (2009). Mineral Exploitation, Environmental Sustainability and Sustainable Developement in EAC, SADC and ECOWAS Regions. African Trade Policy Centre. Work in Progress No. 79

Tempelhoff, E. (2009). 2 se Verdrinkingsbekyk.Tienerssterf in Dam Volsuur water.Beeld 16 january January 2009

Turton, A. (2009). South African Water and Mining Policy: A Study of Strategies for Transition Management. In Huitema, D. and Meijerink, S (eds) Water Policy Enterpreneurs. Edward Elgar Publishing, Cheltenham, UK

Turton, A and Oelofse, S. (2008). Mine Water Pollution – Acid Mine Decant Effluent and Treatment: A consideration of Key Emerging Issues that may Impact the State of the Environment. Department of Environmental Affairs and Tourism (DEAT)

U.S. Environmental Protection Agency. (1995). Mining Metallic Ores and Minerals, Technical Support Document International Training Workshop, Principles of Environment Enforcement

Walter D. Lawhorn. (2010). Acid Mine Drainage, the Unseen Enemy. Valdosta State University.

www.southafrica.info. Mining and Minerals in South Africa. Accessed 16th November 2011 at 2:00 am.

Van Wyk, J. (1999). Planning Law. Principles and procedures of land use management, Juta and Co. Ltd, Kerwyn, Cape Town

Walmsley, C.A., Smithers, R.J., Berry, PM., Harley, M., Stevenson, M.J. and Catchpole, R. (eds)(2007). Monarch – Modelling Natural Resources Responses to Climate Change – A synthesis for biodiversity conservation. UK Climate Impact Programme, Oxford.

West Rand District Municipality (2010). Integrated Waste Management Plan 2010 – 2020

West Rand District Municipality (2010). Integrated Development Plan 2007/08 to 2011/12

Winde, F. and Stoch, EJ. (2010). Threats and Opportunity for Post-closure Development in Dolomite Gold Mining Areas of the West Rand and Far West Rand (South Africa) – A Hydraulic View. Part 1: Mining Legacy and Future Threats. Water SA Vol. 36 No. 1 January 2010

Witthuser, K.T. and Holland, M. (2008). Hydrogeology of the Cradle of Humankind World Heritage Site, South Africa. The 21st International Conference of International Association for Computer Methods and Advances in Geomechanics (IACMAG)

Younger, PL. (2001). Passive Treatment of Ferruginous Mine Water Using High Surface Area Media. Elsevier Science Ltd. Great Britain.

Zainal, Z. (2007) Case Study as a Research Method, *in Journal Kermanusiaan*, 9, June: 1 – 6.