THE ROLE OF SELF-GOVERNANCE IN MITIGATING THE EFFECTS OF MINE WATER POLLUTION: A CASE STUDY OF ANGLOCOAL EMALAHLENI RECLAMATION PLANT IN MPUMALANGA PROVINCE, SOUTH AFRICA

BY

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ABSTRACT

The main purpose of this study was to explore the role of self-governance in mitigating the effects of mine water pollution. Based on a case study of the Anglo Coal eMalahleni Reclamation Plant in Mpumalanga Province, South Africa, the objectives of the study were to investigate the nature of water quality management in eMalahleni; to probe the water institutional arrangements of Anglo Coal mine; to establish how the self-governance principle of rulemaking in the reclamation plant helps in mitigating mine water pollution and improving water quality; and to assess the effectiveness of monitoring and enforcement of the water treatment guidelines.

A qualitative research approach was used in the study to gain an in-depth understanding of the study phenomenon. A case study method was selected as part of a qualitative research design involving one-on-one semi-structured interviews. In order to triangulate data from different sources and to enhance the credibility of the study findings, documentary reviews were used as an additional data collection tool. The population from which a sample was selected for inclusion in the study was made up of environmental managers and water quality and efficiency managers from the three mines in the study area, and from the eMalahleni local municipality. The study found that due to inadequate oversight of mining operations by the central government, coupled with weak institutions, alteration in hydrological regimes has resulted in a decline of the quantity and quality of downstream water flows. The study also found that Anglo Coal has come a long way in implementing an institutional framework that supports self-governance through the endorsement of mine water management and continual monitoring of water quality as an essential part of its water management. The company developed a self-governance strategy which has integrated the value of water into its institutional processes. Anglo Coal facilitated the replication of this strategy to the local eMalahleni situation. The strategy requires that mine water from its three collieries must be treated to potable standards. The study shows that regular checks and balances are carried out at the reclamation plant to ensure that the water quality meets all compliance standards. Collectively, these strategic interventions have played a major role in mitigating the effects of mine water pollution.

DECLARATION

I Luyanda Ngomane hereby declare that this thesis presented in partial fulfilment for the degree Master of Philosophy in Integrated Water Management contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

The work was done under the guidance of Associate Professor Bimo Nkhata at Monash University, South Africa.

_____ 18 July 2018

Luyanda Ngomane Date:

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LIST OF ACRONYMS

ACRONYMS	MEANING
CMA	Catchment Management Agency
CPR	Common Pool Resources
CEO	Chief Executive Officer
DAWN	Department of Water Affairs
DEA	Department of Agriculture
DMR	Department of Mineral Resources
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water & Sanitation
ERMITE	Environmental Regulation of Mine Water in the European Union
MPRDA	Mineral and Petroleum Resources Development Act
NFEPAs	National Freshwater Ecosystem Priority Areas
NWA	National Water Act
NEMA	National Environmental Management Act
NWRS 2	National Water Resources Strategy 2
SWPN	Strategic Water Partners Network

RQO	Resource Quality Objectives
TDS	Total Dissolved Solids
UES	Uniform Effluent Standards
WAP	Water Action Plan
WMA	Water Management Areas
WSA	Water service Authority
WWF	World Wildlife Fund

CHAPTER ONE

RESEARCH CONTEXT

1.1 Introduction

This research study explores the role of self-governance in mitigating the effects of water pollution. It takes the form of a case study that examines the coal mining activities and associated mine water pollution at the Anglo Coal eMalahleni Water Reclamation Plant. The study examines the nature of water quality management at eMalahleni, and the water institutional arrangements of Anglo Coal. It was premised on the need to establish how the self-governance principle of rulemaking facilitated the mitigation of water pollution and the improvement of water quality. This information assisted the researcher in assessing the monitoring and enforcement of water treatment guidelines undertaken by Anglo Coal. This first chapter introduces the study by giving the context. The chapter further discusses the problem statement and scope of the study. The main research aim and objectives are detailed later in the chapter, together with the thesis outline.

1.2 Study Background

eMalahleni is built on land which is rich in coal, and its local economy is mainly run by the coal mining and other related industries. However, there are some negative socio-ecological effects of mining, and the approach in which these pollution effects are managed. It is believed that these influences will ultimately determine the long-term sustainability of water resources in this region. There is evidence which suggests that mining has already greatly polluted rivers and streams in and around EMalahleni catchments, including the Olifants catchment, where this study was located (Oelefste 2008; Basson & Rossouw 2003; Brown 2002).

Mining as an industry is dependent on large volumes of water, particularly during excavation. The World Wildlife Fund (WWF) believes some of the Water Management Areas (WMA) will not have enough water to meet demand by 2030 (WWF, 2011). Water is an integral part of mining and involves the release of mine water that gives rise to serious problems as water pollution problems. Mining therefore poses a significant risk to the water sector both in terms of water quality security, and the long-term sustainability of water resources.

Whilst the department of mineral resources is mandated in terms of the National Environmental Management Act 107 of 1998 (NEMA 107 OF 1998) to ensure that mining houses do make financial provision rehabilitation. The Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) states that the mines remain responsible for environmental pollution, ecological degradation, pumping and treatment and compliance and sustainable closure until a mine closure a certificate is issued. Prior to the promulgation of NEMA 107 OF 1998 and MPRDA 28 of 2002, that required the mines to provide insurance guarantees for future environmental liability, mines were not obligated to adhere to their rehabilitation promises that they usually make to communities when they want to secure mining rights. The legislation now stipulates that all mining operations within South Africa must make provision for environmental rehabilitation during the lifetime of the mines and at closure.

A critical issue for coal mining in South Africa is the rigorous oversight and enforcement of pre-requisite ecological conditions that are often lacking once environmental approvals are given (Hobbs et al., 2008; WWF, 2011; Strategic Water Partners Network, 2013). Practitioners in the water sector believe that the regulatory capacity related to mining and water is inadequate to control and enforce the rules, and to mitigate mine water pollution at a mine or on a regional scale (Strategic Water Partners Network (SWPN), 2013).

Hobbs et al (2008) believe that mine water is one of the major liabilities of the mining industry, due to its inherent threat to water resources. The inherent risks of on-going land volatility, flooding, and water quality impediments such as acid and metal mobilisation, and other contaminants are not uncommon in areas where coal has been exposed by opencast mining. Some practitioners (Hobbs et al., 2008; Soni & Wolkersdorfer, 2015) argue that the promise of rehabilitation of opencast coal mining sites in relation to the water table and surrounding land is always uncertain considering the monitoring incapabilities of the mineral resources department.

The Olifants WMA is considered as one of the national strategic economic zones as the coal-fired power stations in this coal-rich eMalahleni region help generate more than half of the country's electricity supplies. The electricity provider, ESKOM, is a major player in several of the inter-basin transfer schemes across the country, and in the Olifants catchment in particular. Eskom also counts on the high-quality water

transfers from other basins for its cooling towers. Observable in the Olifants Water Management Area (WMA) from numerous water quality and water resource reconciliation studies commissioned by the Department of Water Affairs (DWAF, 2006; DWAF, 2007; DWAF, 2010), is the water resources vulnerability and consequential poor water quality and pollution challenges due to coal mining. This has not only impacted on the sustainability of current mining operations, but has also highlighted serious water governance challenges that exist in the study area.

With regard to future water governance and the country's water quality priorities, a decision needs to be made whether to continue with business as usual or to advance towards a new age of strategic foundation towards long-term natural resources security and the country's water quality priorities (SWPN, 2013; WWF, 2011). This is critical, as persistent pollution challenges and a range of water quality challenges are on the rise, particularly in catchments where these mining operations are located. In the current context as prescribed by Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA), mine planning and feasibility determination cannot be done without considering and predicting post-mining effects, post-reclamation water quality, and designing mitigation plans. Thus, water management and integrated water use is essential throughout the life cycle of a mine.

Given the understanding of how crucial water is to mining operations, Anglo Coal continues to value the preservation of water, as approximately 75% of their current portfolio is located in the high-water risk Olifants catchment, (Anglo Coal Annual Sustainability Report, 2016). Compounded by significant drinking water shortages in the local eMalahleni municipality, water quality challenges within the Olifants catchment continue to besiege Anglo Coal's several coal-mining projects. According to Soni and Wolkersdorfer (2015), although one of the best ways to mitigate mine water pollution would be the reduction of overall water consumption, site-specific mine water treatment methods are usually suited to the particular mine type. This suggests that mines need to review their own procedures in order to identify the most appropriate methods for treatment of polluted mine water.

In the case of Anglo Coal, local institutional arrangements were designed to address the distinct local conditions of the water-stressed eMalahleni local municipality, in order to commission a suitable water reclamation plant. Using reverse osmosis, the

reclamation plant has to date treated in excess of 70 billion liters of water and purified it to potable standards, of which 50 billion litres is sent to the local municipality, thereby providing better elasticity and self-reliance in terms of water usage (Anglo Coal, 2012).

In 2012, the reclamation plant was already meeting around 12% of water requirements for the eMalahleni local municipality by supplying 16 million litres a day into the municipal reticulation system. According to the CEO of Anglo Coal, the water reclamation plant will eventually help promote a sustainable future for water resources in the eMalahleni region, not only for the mines, but also for the surrounding communities in which the Anglo Coal mines operate (World-Water-Week, 2011). Considering the remaining 20- to 25-year life of coal mining in this region and the mine water treatment sustainability pillars, it is envisaged that reclamation plants will cater for communities long after the mines close.

Scholarly writings dealing with common property (Ostrom, 1990; Castella, 1994; Chaffin, Gosnell & Cosens, 2014) have demonstrated cases where self-governance by resource users has proved to be a successful and sustainable alternative to state and private management of resources. This research study is set on the same model of governance, whereby mining companies make rules to reduce the environmental impacts of mining, and minimise the footprint of their actions throughout the life cycle of the mine. Such a model includes collective-choice arrangements that allow the enforcement of such rules through effective monitoring to restore water quality.

Although Anglo Coal's mine water management system consists of an assortment of systems that allow the mine to closely monitor and manage their water consumption in accordance with its commitments to the Department of Water and Sanitation (DWS), the case study of eMalahleni Reclamation Plant is one of the integrated mine water solutions fundamental to Anglo Coal achieving a step-change in water-efficient mining. While mining has generally affected its nearby environment, advances in technology and modifications in water management practices, as seen in the Anglo Coal Reclamation Plant case study, imply that many negative effects can now be averted.

The intention of this study using the case study of Anglo Coal Reclamation Plant in this research, was to explore opportunities for innovative institutional arrangements to address the mine water pollution challenges by turning mine water into a reliable water

resource contributing to the reconciliation of water supply and demand in the Olifants catchment. Furthermore, through showcasing the case study of Anglo Coal Reclamation Plant, this current study might inspire other mining houses to establish area-based mining institutions that would coordinate and integrate the development of mine water reclamation projects and find points of connection between their mining activities and water quality security within the catchment.

Olifants catchment is no exception when it comes to the deteriorating quality of water, which is synonymous with the overall effects of mine water. According to the SWPN (2013), poor mine water management practices by some operating and closed mines in the eMalahleni coalmines have created immense water pollution challenges for downstream water users and those in close proximity to the affected water resource. Bebbington and Williams (2008) state that the intricacies and diversity of resource systems around the world, and the range of misgivings they face, are challenges beyond the management capacity of central governments.

The South African situation is compounded by the non-functioning Catchment Management Agencies (CMA) that should be supporting effective management of mine-affected water in line with catchment plans. The National Water Act (36 of 1998) (NWA) provided for the progressive establishment of Catchment Management Agencies (CMAs) to conserve and protect the water resources within the 19 Water Management Areas; however, countrywide that number has since been reduced to nine (9) Water Management Areas.

The nine CMAs are Limpopo, Olifants (Mpumalanga Province), Inkomati-Usutu, Pongola-Umzimkulu, Vaal, Orange, Mzimvubu-Tsitsikamma, Breede-Gouritz and Berg-Olifants (Western Cape) (DWA 2013). At present there are two operational CMAs in South Africa: Breede-Gouritz CMA and Inkomati-Usutu CMAs, the remaining seven CMAs are considered to be the so-called proto-CMAs since they are in the process of being established in accordance with section 80 of the NWA. The objective of establishing these CMAs was to promote the decentralisation of water resource management to a catchment level, and to support the participation of local communities in water resource management within the framework of the National Water Resource Strategy (NWRS).

However, it cannot be ignored that decentralisation in the water sector is still challenging, as South Africa has experienced a range of challenges in implementing the South African Water Act No 36 of 1998. Hence, the emerging and growing consensus among scholars and practitioners (Oelefste 2008; Basson & Rossouw 2003; Brown 2002), that there is an urgent need for water governance improvement in the Olifants catchment. For forward-thinking mines, sound environmental practices are prerequisites for the sustainable management of mining operations, including water management, and monitoring.

Scholarly focus in this study is given to the Anglo Coal Reclamation Plant and its ability to deal with the restoration of water quality through employing mine water treatment as part of its self-governance strategy. The theoretical premise of this thesis is based on 'the tragedy of the commons', as developed by Hardin[1], and other self-governance models that use the fundamental social dilemma of the governance of natural commons. The study drew on the essential concept of polycentricism, wherein resource user groups are able to resolve their own difficulties based on options that are institutionally enabled in a self-governance system, as proposed by Ostrom[2]. As such, the study sought to respond to the growing need for collective action to deal with the evident water quality risks and mining impact mitigation efforts, wherein the first dimension to be addressed is the role of self-governance in mitigating the effects of mine water pollution.

1.3 Theoretical and operative definitions

The following theories and definitions were applied during the course of this research study:

Common-Pool Resources (CPR) – Advocates for common pool resources define CPR as natural or man-made resources where an individual's usage takes away from another's use, and where time and again it is essential, nonetheless tricky and pricey, to control other consumer's outside the group from gaining access to the resource. Examples of such resources include fisheries, forests, and freshwater resources. CPR exists when the upkeep of the shared resources remains well looked after and preserved by the collective that use them. Furthermore, the viability of ecological

[1] Hardin, G. (1968). *The Tragedy of the Commons*. Science, (162) (3859), 1243-1248
[2] Ostrom, E. (1990). *Governing the Commons*: The evolution of institutions for collective action.

assets under CPR supervision is influenced by the choices made around arrangements for resource utilization, usage charges, and implementation of user privileges. Design principles discussed in this study have an essential role to play in the success of CPR institutions.

- **Communities** – In the context of this study, 'communities' are resource users who have mutual interests and a corporate understanding that is emergent from their common characteristics.
- **Mine Water** – This was defined by the European Union in the Environmental Regulation of Mine Water, 2004b (in Oelofse, 2008), as water in excavated land, as well as discarded tailings of rocks, stockpiles released into adjacent bodies of water as well as lagoons, rivers, swamps, aquifers and oceans.
- **Water Quality** – This refers to the suitability and composition of water supportive of a variety of water standards, for human consumption, the environment as well as maritime life including recreation. The terminology 'water quality' is from time to time comprehensive considering the water biodiversity and natural signs of river/catchment environmental 'health'.
- **Design Principles** – The design principle concept has reference 'to the ability to play a part in supporting institutions and its resource-base, and acquiring user allegiance to the rules in use'.
- **Water Governance** – is defined by Bakker and Nowlan (2007) 'as a way of the collective administrative, organisational, and political processes by which interests are expressed, contribution is engaged, resolutions are taken and realized, and rule-makers are held liable in the improvement and water resources management and provision of water services'.
- **Self-governance** – makes reference to the institutional requirements that profile actors' choices and how they conduct themselves, as well as the use of authority within organisations or and groups.
- **Mine Water Pollution** – Refers to the contamination that follows mining activities creating a threat both for the water resources and water quality.
- **Institutions** – This was defined by Ostrom (1990) as formal rules and informal traditions and norms that shape repetitive and structured interaction that can be seen as the 'rules of the game'. These traditions might be commonly viewed as implicit behavioural codes that hypothetically decrease uncertainty, reconcile self-

interest whilst expediting joint action. To be 'long-lasting', associations should have endured through numerous groups of users.

- In the context of this study, institutions are viewed as the degree to which behaviours are capable of successfully protecting water quality from extreme mining exploitation leading to the perpetual water resources degradation.

1.4 Research problem formulation

Despite the fact that more evidence is needed in the literature on how self-governance could support water quality management and how environmental managers in mines could manage mine water efficiently several studies have been undertaken to determine the role of self-governance in promoting efficient fishery and forest resources (Feeny, Hanna & McEvoy, 1996; Ostrom, 1998; Ostrom, 2005a; Cunningham & Bostock, 2007; Forester, 2012).

An account is given in the literature (Cunningham & Bostock, 2007) wherein fishery organisations themselves were at liberty to make governance decisions and rules. This has increased the organisations' performance accountability, as they support their affiliates in ensuring that they are compliant with the rules. Furthermore, Cunningham and Bostock (2007), and Feeny et al. (1996), indicate that by giving users competence in rulemaking ('The Ten Commandments'), the chances are that those simple and clear rules will lead to an efficient use of resources.

In recent decades, scholars have investigated a range of water governance models and how water governance institutions and processes can be made more effective in resolving complex socio-ecological issues and adapting to change (Gupta, et al 2010). These water resources management approaches have provided an instrument for stakeholders to plan and synchronize reactions and strategies to resource degradation.

Alternative decentralised community-based governance arrangements and models, which include polycentric governance models (Ostrom, 2010), adaptive management (Carlsson & Berkes, 2005; Plummer, 2006), and integrated water resource management, might well be possibly regarded as the guiding principle behind water resources management in South Africa. Furthermore, water resource management is strengthened by the National Water Resource Strategy for 2013, that talks about the

active improvement of water management (Biswas & Tortajada, 2010), which has been widely documented and analysed from a multitude of perspectives, and applied to water in addition to other common-pool resources like fisheries as well as forests.

Previous studies have focused on how environmentalists and interest groups are the voice of communities affected by mining activities, and how the state has failed to help mitigate the effects of pollution. However, more evidence around self-governance and mine water management is needed. Despite some guidance in the literature regarding the challenges and benefits of the self-governance approach (Ostrom, 1999, 2001; Forester, 2012), self-governance models that address the mining water quality nexus are limited. Thus, taking the sustainability of mining activities and the resilience of water quality into consideration, such governance reflections should be made in all the various stages of mineral investigation, construction, mine operation and closure, and mine water reclamation (Veiga, Scoble & MacAllister, 2001).

Given the fact that a large part of the eMalahleni landscape in Mpumalanga Province has been characterised by coal mining since the Bronze Age, the result has been cumulative environmental impacts with multiple developments and competing land uses that came with it (Tanner, Annandale & Rethman, 1999). According to Bebbington and Williams (2008) and Meinzen (2007), these mining operations, coupled with weak institutions and little oversight from central government, have resulted in continuing alteration of hydrological rules and decline the quantity and quality of downstream water flows. Of significant concern is the impact of an increasing number of abandoned and/or closed mines, which could lead to a rise in mine-impacted water if not managed appropriately (Tanner et al., 1999). While companies struggle to bring about the controls of their internal processes, they are equally not capable of addressing the cumulative effects.

The inadequate performance of any one mine in the catchment area is inevitable and bound to impact public sensitivities against all the mines in that area, considering that reputational impressions remain felt (Humphreys, 2000). Thus, what is required are sustainable approaches to mining which integrate socio-economic and environmental considerations into the planning processes, from the initial stages of exploration until post-mine closure (World Coal Institute, 2002). Therefore, a need has arisen for mining houses currently operational in the eMalahleni Coalfields to mitigate the risks related

to mine water pollution and take the responsibility for its management.

1.5 Rationale of the study

This study was developed due to the need for improved water governance, the researcher's interest in water quality, and the underlying fact that the mineral industry interacts with water resources in many different ways that directly affect the environment and communities. The researcher concurs with the suggestion made by Hughey and Booth (2012) that the 21st century water crises in many ways stands out as a water governance tragedy and institutional failure to manage water resources for the benefit of humans and environment.

Regarding the study area, it is considered that the current trajectory of mining-related development is not moving in the right direction; it requires a shift to include the social and environmental considerations that designate sustainable development. The institutional option analysis report (SWPN, 2013) suggested that, at present, social formal provisions to fulfil community desires and requirements in an environment that is continually changing are a rare characteristic in South African mining towns. The causes for concern, according to Ostrom (2005), are the types of institutions that could be viewed as legitimate and utmost resourceful for governing and dealing with diverse CPR, and from which at least some prospective beneficiaries cannot be excluded.

Based on the views of Ostrom (1990), this research acknowledges that governance of complex, modern cultures have a need of diversified institutions exemplified by well-designed, multilevel, multi-purpose, as well as multi-sectoral governance entities (Ostrom, 1999, 2001, 2005). This study was designed to extend the application of Ostrom's framework for local common pool resources to mine water management. It also examined the institutional failures that may hinder the development and implementation of welfare-augmenting policy decisions that would help mitigate mining activities and promote environmental management.

This research examined the notions of 'efficiency' and 'adoptability' of potential institutional arrangements; in so doing it contributes to a clearer understanding of alternatives for dealing with mine water management. As such, the study sought to determine the role of self-governance in mine water management, thereby enhancing water quality recovery and the value-add to local water supply, thus shaping water

governance and alleviating the cumulative impacts of coal mining in the catchment.

1.6 Research aim and objectives

1.6.1 Aim of Study

The main aim of this study was to explore the role of self-governance in mitigating the effects of mine water pollution in the eMalahleni Anglo Coal Reclamation Plant.

1.6.2 Objectives of Study

To achieve the study goal, the following research objectives guided the project:

- To investigate the nature of water quality management in eMalahleni region;
- To probe the water institutional arrangements of Anglo Coal mine;
- To establish the extent to which rulemaking in the reclamation plant has advanced the mitigation of mine water pollution and improvement of water quality; and
- To assess the monitoring and enforcement of water treatment guidelines

1.7 Case Study

Case study methodology as described by Stake (1995) remains a strategy of investigation wherein the researcher conducts an in-depth enquiry of a programme, event, practice on a single entity or more. Inevitable in case studies is the period as well as action, then throughout a continuous period researchers undergo a comprehensive data collection process by means of a range of processes for collecting data. The design of this case study is both descriptive and explorative in nature, and an intensive analysis stressed developmental factors in relation to the environment. The data was collected through in-depth interviews, additionally to the reviewed documents obtained from the Water Research Commission and others provided by the mine where the study was conducted. Conversations during interviews were recorded and later written down in preparation for data analysis.

The unit of exploration is a defined area of focus for the study (Merriam, 1988; Strauss & Corbin, 1998). This study resolved to select Anglo Coal case study as a definite unit to be explored, rather than to produce a representative sample and generalise the outcomes to other management instruments or other frameworks. Hence, a random sampling approach was unsuitable for the exploration of the study's central

phenomenon. The unit of analysis consisted of water quality managers and environmental managers from Anglo Coal eMalahleni.

The linking of data to the intended objectives is another element of case study research design which carried out subsequent to the data collection stage. During data analysis, noticeably themes emerged, and the researcher endeavoured to link patterns and data appearance to theoretical submissions of the study. Therefore, themes that appeared in this study functioned as responses to the study objectives outlined in Chapter 1. The proximity of the case being explored to lifelike conditions along with their extent of detail was one of the reasons this method was chosen for this research. The researcher was afforded an opportunity to capture and verify factors relating to human interaction, and to assess whether the mine personnel and management share a sense of the water quality problems they would have to confront, if not properly managed.

1.8 Study limitations and delimitations

Commissioned in 2007, the Anglo Coal Reclamation Plant, the first in South Africa, leads developments in mine water treatment. Whilst expectations that self-governance and related institutional arrangements and treatment processes are entrenched amongst the plant users at Anglo Coal and therefore present an ideal organisation wherein rules to treat mine water and turn it into potable water have been implemented, the researcher refrained from being too deterministic that self-governance presents benefits for efficient mine water management. Given that an individual case study was the basis of this research therefore not representative of the mining sector as a whole, and the fact that the study was thus narrowed in scope could be viewed as a delimitation (Creswell, 2003).

Despite the aforementioned limitation, it was expected that the case study of Anglo Coal Reclamation Plant would provide useful insights into how rulemaking in the reclamation plant and enforcement of such rules would be used in mitigating mine water pollution and improving water quality in the catchment. Furthermore, the study was undertaken at the peak of current debates on coalmining impacts on water resources, causing apprehensiveness and reservations by mines to release data. As a result, the researcher encountered some delays in obtaining data on time from some envisioned participants. Conversely, data triangulation in the study supported the

verification of results, and to support the precision of the themes determined from the interview records.

1.9 Thesis outline

This thesis comprises five chapters, as outlined below:

Chapter I

Gives background and motivation for the research and addresses the problem statement and debates around water quality issues, and the resultant local water shortages. Also described in the chapter are the concepts and meanings used throughout this research, and the problem that brought about the conception of the study. The intended objectives for conducting the study, and the foreseen study limitations and ethical considerations are presented.

Chapter II

Presents the conceptual framework on which the study was modelled. Furthermore, the chapter gives an account of the legislative requirements that are aimed at mitigating mine water pollution, and an overview of the mining activities and mine water pollution challenges in eMalahleni. Various concepts and theories of governance that place emphasis on self-governance cases and their associated benefits towards improving the natural resources and tangible ecological benefits are explored.

Chapter III

Illustrates the research study area, its geography and history of mining activities. The second part of the chapter addresses the approach taken in conducting the research, methods used for data collection and the analysis tools utilised for the study. Also presented in this chapter is how the study's trustworthiness and reliability were ensured.

Chapter IV

In line with the case study design of this report, chapter four summaries the results of the investigation of the self-governance at Anglo Coal as purposed in the objectives of the study. Furthermore, Anglo Coal mine water institutional arrangements are explored, and how these arrangements have informed their decisions on mine water

management.

Chapter V

Presented in this chapter are the research findings and discussions on the implications thereof.

Chapter VI

Presents the conclusions reached on institutional arrangements, self-governance, rulemaking, rule monitoring and enforcement, and their implications on mine water management in eMalahleni.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORKS

2.1 Introduction

Whilst the preceding chapter gave background to the study, this chapter sets forth the legislative requirements and policy frameworks on mine water management and the study theoretic framework. Lastly, the chapter looks at the self-governance institution's framework in detail, and its focus on usage, access, and governance of CPRs, founded upon Ostrom's design principles of stable common resource management.

2.2 Legislative Requirements and Policy Frameworks on Mine Water Management

The many environmental features of mining impacts have triggered an array of environmental legislation to govern mine water and environmental liability. Since the 1994 comprehensive policy, institutional changes and legislation in water-related governance have been followed by South Africa. These comprised of the National Environmental Management Act No. 107 of 1998, the National Water Act (NWA) No. 36 of 1998 and the Mineral and Petroleum Resources Development Act (MPRDA) No. 49 of 2002. Mining companies were expected to comply with these various legislations, policies and transformations delineated by government, to achieve natural resources resilience and efficient mine water management. These legislations were promulgated as instruments to guide the mines in implementing strategies to abate the impending water pollution and avert the discharge of such polluted mine water into the environment.

In South Africa the constitution gives prominence to the cooperative governance concept by instituting codes for cooperative governance and intergovernmental relations. Included in these constitutional philosophies are the codes which offer liberty to exercise their powers and carry out their functions to all management spheres and to the entire organs of state in each domain, in a way that does not infringe on the ecological, efficient, or recognized reliability of regime in a different sphere. The aforementioned is at the heart of the national government's pursuit to exercise parallel statutory capability and policymaking ability to deal with a variety of supplementary

ecological concerns within provincial government, for example the regulation of pollution, environmental management, and conservation of nature.

The Minerals Act No. 50 of 1991 regulates, inter alia, the mining for ideal exploitation of natural resources, and land surface rehabilitation for the duration of prospecting and after mining operations has ceased. For the most part, the operational phase of mining is deemed as the phase that brings about most of the ecological effects of mining process which contribute to numerous effect that are hostile to the environment. These include the key forms of pollution such as water pollution, local ground water quality and quantity dynamics, and aquifer dewatering, in which underground water would turn out to be polluted and consequently cause pollution on water resources if not elevated to the surface then treated properly.

In some instances, legislative changes in the NEMA No.107 of 1998 are responsible for financial provision regulations, but they have since been moved from the MPRDA no. 28 of 2002, yet enforcement remains within the Department of Mineral Resources (DMR), and this has resulted in enforcement protocol relapses. The environmental management principles outlined in Section 2 of NEMA No. 107 of 1998 is the cornerstone of environmentally friendly governance; whilst accountability in South Africa is underpinned on viable development. The Act stipulates and obliges: 'rule-makers that make use of approaches that are opposed and cautious to risks taking into account the confines of the present understanding of their decisions and actions and their detriments thereof' (NEMA No. 107 1998).

Furthermore, mines are mandated to take comprehensive material actions to avert enduring, or habitual resource contamination or degradation due to their mining activities as specified in the (NWA No. 36 of 1998, and NWA No.107 of 1998, section 19 of NEMA of 1999 and section 28 of the No. 107 of 1998). Thus, in terms of the MPRDA No. 28 of 2002, coalmines and mines in general are duly obligated to have a rehabilitation blueprint once mining activity has come to a close, whilst addressing the threatening communal and ecological effects of mining into consideration in the short term. Mines are explicitly indebted to distribute reserves to execute land rehabilitation upon the cessation of mining activities. These financial provisions may take the form of a) cash paid into a DMR trust; b) using Section 37(A) of the DMR trust that permits short-term guarantee to be utilised as an indemnity amount; and c) by providing of a

surety from a DMR-approved financial institution or short-term guarantor, who will administer environmental rehabilitation until a definite stage where the mine proved unable to carry on with operations.

The National Water Act No. 36 of 1998 sets out how water resources should be managed in South Africa in order to realize equitable access to water resources and their viable and efficient use. This Act requires that all water resources should be protected in order to secure their future and sustainable use. It lays out a plan where each significant water resource (surface water, groundwater, and estuaries) is classified according to the Water Resource Classification System (WRCS). In the process, the reserves of each water resource are also determined i.e. the amount of water and its quality, which is required to sustain both the ecosystem and delivery of basic social needs.

Water reserves contribute to the resource classification, which subsequently results on an apportionment of management class and associated water resources Resource Quality Objectives (RQOs), which then give direction to future management activities in the catchment. The purpose of RQOs, according to the NWA No. 36 of 1998, remains the institutionalisation of untainted goals concerning the appropriate water resources quality. It further specifies that in determining RQOs, a sense of balance needs to be pursued between the prerequisite to look after water resources and conservation for future use (DWA, 2011).

Whilst Regulation 704 of the NWA No. 36 of 1998 requires mine water management systems to comply with best practice, this regulation also comprises provisions associated particularly to the responsibility of water reliability. Therefore, the water management hierarchy becomes the basis for water management at mines. This chain of command founded on a preventative outlook and arrangements marks the subsequent hierarchical mine water management agenda: pollution avoidance; reclamation of water or re-use; treatment of water; and release. Responsiveness to these priorities calls for an integrated mine water management approach.

The MPRDA No. 28 of 2002 utilised the ‘polluter pays’ principle, in an endeavour to transform the mining industry. This principle promotes that those liable for polluting the environment are liable for the overheads associated with pollution treatment

solutions, environmental degradation and averting, monitoring recurrent contamination, ecological destruction, or adversarial effects on human health. In essence, the ‘polluter pays’ principle suggests that users of natural resources and subsequent polluters (mines in this case study) ought to accept the total social and environmental costs of their activities.

South African legislation has embraced the principle as echoed on numerous policy documents that include the White Paper on Minerals and Mining Policy for South Africa 1998, thus acknowledging that this principle is a fundamental role player in the mining industry’s regulatory environment. Conversely, the reality is the limited application of the polluter pays principle both in the regulation and implementation of environmental management. In a nutshell, according to this principle, the polluting individual mines ought to subsidize effects of pollution, recompense the environment in addition to those communities that have suffered the undesirable outcomes of pollution.

Strict enforcement of the polluter pays principle could aid in holding the industry financially responsible for its mining activities through the establishment of an accountability platform for environmental impairment, measuring pollution costs, recovering and evaluating reasonable historic damage. However, there are few independent specialists who facilitate these assessments and have them signed off by an external financial auditor, thus there is no conformity towards the collective sustainable development conventional codes as specified in Section 38 (1) of the MPRDA No. 28 of 2002.

Despite clauses of the MPRDA No. 28 stipulating that non-adherence to the requisite provisions for subsidising mine rehabilitation would be to bring about quite a few penalties, some mines have opted to pay such fines rather than comply with legislative requirements (Swart, 2003; Ochieng, Seanego & Nkwonta, 2010). Where these mining houses fail to mitigate such effects, then the state may use the fines paid by the polluter to fulfil the environmental obligations on behalf of the mine. While waiting for a closure certificate to be issued, the mine’s obligation to retain and maintain these finances continues to be active.

Considering that the obligation for financial provision is attached to current mine authorisations, denotes that it applies only in instances where a mining house has just

applied for, or have an impending environmental authorisation. Ochieng et al. (2010) maintain that an upsetting question can thus be probed as to whether the current fiscal provision is adequate to effectively address historic mining related pollution. The magnitude and failure by some mines to appropriately address the mine water pollution problem, becomes a concrete suggestion substantiating the argument on the insufficiency of these financial provisions.

Although these legislative requirements were put in place by various governmental departments, there has been a visible and steady degeneration of water quality in various catchments. This degeneration to a certain extent is ascribed to the cooperative governance deficiencies as well as misalignment between relevant legislative instruments, with the responsibilities of the Environmental Affairs and the Mineral Resources Departments being unclear about their functions, despite the amendments to the MPRDA No. 28 of 2002, the NEMA 107 oF 1998 No. 107 of 1998, and the NWA No. 36 of 1998, which seem to have been made in isolation.

In the absence of an overarching policy to assist mines to set up the institutional and financial arrangements for their treatment works, coupled with the complexity of mine water management, an institutional options analysis is required to ensure sustainable mine water management that can be led by different role-players, namely government or the mining industry. There are likely to be a number of institutional/financial business models required to enable the cooperative management of mine water within the catchment. According to the SWPN (2013), the form of these institutional-financial business models needs to reflect mandatory functions, address current viability and long-term sustainability as conditions change, and may require adjustment to the enabling policy and regulatory environment.

Despite the international water community's claim that the South African NWA Act No. 36 of 1998, and other legal frameworks adaptable to the environmental rehabilitation of mines to be amongst the world's utmost advanced water legislation, according to Schreiner (2013), its execution has only been partly fruitful. Furthermore, Schreiner (2013) argues that regulatory institutions have not kept pace with water governance and do not adequately protect water resources and have contributed to the failure of achieving the initial ambitions of the South African water sector. This is evident in many instances where mine water failure can be directly traced to profound failures in local

governance.

Furthermore, the DWS took a policy decision to divide South Africa into nineteen WMAs, later cut to nine, as stipulated in the 2013 National Water Resources Strategy (NWRS-2), wherein Catchment Management Agency (CMA) through an envisaged Catchment Management Strategies are responsible for water resources management within each WMA. It is argued that the multifaceted adaptive method that expresses the water realities of today calls for the development of similar complex systems of governance, and that the CMAs have the potential to meet this requirement.

However, the pace at which full establishment of these CMAs, including the area in which this study is based (the Olifants WMA), has been regrettably slow and consequently has missed the opportunity of supporting the effective management of mine-impacted water in the eMalahleni coalfields. This should have been in line with the catchment plans. Whilst the CMAs might still require the strengthening of existing governance capacity, the introduction of regulatory mechanisms for improved governance could allow mining companies to take ownership and self-govern. Functional CMAs would ideally monitor mine water pollution and ensure that it does not further deteriorate the quality of water in the catchment, whilst also promoting water resource rehabilitation as well as the implementation of long-term solutions concerning management of water quality.

With regard to mine closure and rehabilitation, for instance, some mining companies in eMalahleni have been found not to be observing the practices as mandated by government legislation, but no rigorous action has been taken in this regard (SWPN, 2013). At the parliamentary Water and Sanitation Committee meeting, (2015) the DWS Minister, Nomvula Mokonyane, revealed that since the inception of the NWA Act No. 36 of 1998, 17 years ago, only four cases relating to mines violating the legislation have been prosecuted successfully.

The mining sector claims that there is no monitoring of the principle-based NEMA 107 of 1998 Act No.107 of 1998, that outlines rehabilitation requirements for mining companies and stipulates that mines must perform three basic risk assessments for closure planning every year. In all the above legislation (MPRDA No. 28 of 2002; NEMA 107 of 1998; and NWA No. 36 of 1998), onus to avoid and mitigate pollution or

resource degradation attest to the fact that remediation is indeed embedded in the South African law; however, government's monitoring and enforcement efforts have been widely criticised, particularly those granting water-user mining licenses. Thus, although the legislation was meant to catalyse effective mine water management, in many instances it has failed in achieving the intended objective to ensure that the quality of water being discharged from the mining sites does not undesirably affect water user's downstream (Ochieng et al., 2010; WWF, 2011; Schreiner, 2013: SWPN, 2013,).

2.3 Theoretical and conceptual governance frameworks

The intent of reviewing literature was to integrate the related and theoretically consistent concepts of governance, which include CPR, local institutions, adaptive governance, and self-governance. This chapter further explores where else these concepts have been utilised to promote common natural resource protection.

2.3.1 The Commons Tragedy versus the Commons' Governance

The main conceptual frameworks used in this thesis are found in Garrett Hardin´s *The Tragedy of the Commons* (1968) and Elinor Ostrom´s *Governing the Commons* (1990). Hardin's work is founded upon conventional liberal economic model as well as its traditions in relation to the logical maximisation of profits that leads to over-exploitation. Ostrom (1990) builds upon the assumption that CPR are often not open-access resources but rather are subject to rules concerning the misappropriation and management of shared resources which are usually modified to local conditions.

Until the 1970s, it was generally understood that only clear public or private property rights over natural resources could ensure their sustainability. The work of Hardin (1968) was influential to this regard as he argued that firstly, the appropriation benefits on CPR remain private, whereas the overheads are communal (appropriation dilemma), secondly, furthermore the costs for provision of commons that are deemed valuable are private, for a collective benefit (provision dilemma). According to Hardin (1968), this makes for over-exploitation and degradation of the commons an inescapable result of the struggle concerning the human tendency intended for the pursuit of self-interest, as well as the need to sustainable benefits resulting from the conservation of commons for indigenous and other community groups. This is the argument that led Hardin (1968) to make an influential case for public or private

management of forests. The presumption was that forest areas in which appropriation and provision rules were not imposed by either the state or the market, were devoid of any rules, and were used as open access (Ostrom, 1990; Ostrom and Cox, 2010).

However, since the 1980s an emergent body of literature on CPR has revealed that what Hardin called ‘open access’ may actually be managed as common property, with communities crafting their own rules to deal with appropriation and provision dilemmas (Baland & Platteau, 1996; Dietz, Ostrom & Stern, 2003). This study looked at the same argument that proved central in a forest setting, where forest users have, in some situations, acted collectively to craft and maintain their own forest institutions.

Throughout the mid-1980s scholarly reports stimulated stern questions around the reflections on considerable will power to enforce certain institutional measures on the CPR users (Feeny et al., 1990). Considering that some of these concepts are study variables and attributes, different views of these theoretical proponents are discussed hereunder as part of the governance framework.

2.3.2 Governance theoretical arguments

In the field of governance, a universal, overall perception of governance being a topic wide-ranging beyond ‘government’ does exist. Stoker (1998) considered supremacy as the spreading out of prevalent styles wherein limitations between and within public and private sectors had become blurry. Various studies have explored whether governance may offer opportunities to both promote natural resources protection and allow greater inclusion of the stakeholders most directly affected by change and uncertainty regarding water resources.

Stoker (1998) viewed the governance style equally an innovative governing practice or a different form of systematic rule, or as a diverse system by which resource use by the general public is directed. Despite the reality of policy and legislative frameworks, environmental circumstances in and around mining areas have continued to decline over the years, hence Stoker (1998) recognised the limitations of a unitary government in his five governance propositions, and conceded to government’s loss of power to inter-governmental and inter-dependent sets of institutions and actors that could collectively deal with environmental and natural resources protection issues. Whilst Stoker (1998) viewed governance as a mechanism that does not rely on

recourse to authority or government sanctions, Pierre and Peters (1998) emphasised that governance is about process, and new public management is about outcomes.

Furthermore, governance theorists argue that the assortment of communal resources' environmental, socioeconomic, and ownership perspectives, and improvement programmes related to the will power of local people towards resource management, has more potential to yield improved outcomes as opposed to standard treatments that are executed top-down and frequently unresponsive to local conditions. The researcher concurs per Stoker's (1998) five governance propositions that recognise the limitations of a unitary government and concede to government's loss of power to inter-governmental and inter-dependent sets of institutions and actors that could collectively deal with environmental and natural resource protection issues. This could be viewed as a case for self-governing by the mines. However, some environmental activists including (Benchmarks 2014 & Bebbington, A. and Williams, M. (2008) are of the strong opinion that in many cases, loopholes in coal-mining impacts are intentionally overlooked given the significance of coal for electricity generation and the serious impact on economies as a result of any distraction in coal supply.

In reviewing the literature on governance, different schools of thought are applied to water governance, yet, minimal research effort has been targeted towards understanding how private actors (mining houses in this study) shape water governance. With resource extraction occurring in the eMalahleni area, ignoring the role of industry in governance, or excluding them from governance arrangements in practice, will not solve the most complex Olifants catchment water quality challenges. Perhaps there is a need for catchment-wide methods to water governance to improve decision-making procedures and outcomes, particularly where high-risk activities like mining exist.

Many elements of water governance are based on institutional arrangements that shape and dictate the level of capacity for mine water management (Dominguez, 2012). Institutional arrangements represent the legislation, regulation, policies, and political and administrative structures that facilitate or limit specific activities (Patrick, Sheelanere & Noble, 2008).

Competing interests between water sustainability goals and continuing economic

dependence on natural resource abstraction poses challenges for accelerating water governance reform. Consequently, a growing consensus is emerging among scholars and practitioners that water governance reform is urgently needed in mine water management.

It is certainly needed in Mpumalanga Province, where coal mining is still prevalent. Various networks of strategic water partners have since instituted progressive water planning and source water protection approaches to address mine water problems (SWPN, 2013). However, this study has looked at governance not only as a new set of managerial tools, but more as an institutional arrangement for achieving greater efficiency in natural resources management, and the potential for new forms of mine water management.

2.4 Adaptive governance

Adaptive governance (Chaffin et al., 2014) speaks to the advancement of the procedures and rules recommending the fulfilment of primary social desires and predispositions, considering deviations of the thoughts, intentions, and the socio-economic, as well as ecological context. The term ‘adaptive governance’ is partially suitable for socio-ecological governance system whilst the literature review associated with it shows significant results with regards to socio-ecological methods, resilience as well as environmental governance.

The key focus of the adaptive management proponents is on policy identification as the prominent component of management — as well as drawing attention to various uncertainties to impending consequences (Holling, 2002). Management in the adaptive governance literature essentially refers to a situation wherein the resources as well as the managers’ behaviour are directly controlled, as opposed to a situation wherein a single representative or an alliance of agents exerts power or ‘indirect control’ above the preferences or behaviours of others (as that is epitomizing governance instead of management).

Holling (2002) further states that these comprise: recognition of the forces at work and connections between structural changes, though prior to encountering structural restrictions might not be evident (subsequently reclamation might be complex if not at all impractical), variation an essential attribute of natural arrangements, wherein

resources as well as measures are seldom equally dispersed within the area.

The research agenda outlined by Olsson, Folke and Berkes (2004) advocate the necessity for inordinate and thoughtful functioning of the institutional recommendations of adaptive management, and the manner through which institutional provisions advance the fulfilment of community requirements and needs in a flexible environment. Literature on adaptive management embraces some persuasive recommendations: cooperation around a polycentric governance arrangement, community involvement, a rather cautious approach to resource management, as well as regional scale management. A brief account is given below of each of these institutional recommendations:

i. Cooperation in Polycentric Governance Arrangements

An organisational arrangement where various self-governing actors normally structure interactions amongst themselves as part of a universal rulebook characterised polycentric governance (Ostrom, 2010).

Proponents of a polycentric governance system argue that polycentricism remains a concept whose era has arisen resultant from its dominant repercussions aimed at post-governance dialogue. The principle remains a modest: governance of intricate, modern-day culture call for an institutional range exemplified in multilevel, multi-purpose, multi-sectoral as well as valuable components of governance. Thus, in this study, the researcher believes that management initiatives aimed at mitigating mine water pollution may necessitate a shared and polycentric solution.

Collaborative water governance initiatives can also make use of accountability mechanisms, including third-party verification. The role of these auditing organisations, verification bodies, and/or independent review organisations as defined by Walker, (2009) and Zorilla, (2009) is to provide systematic and objective reviews summarising whether legal requirements are being met and ecological outcomes are being achieved.

Third-party verification can be applied to government or industry activities, and perhaps to the activities of a delegated decision-making body. Measures such as independent environmental monitoring and ‘watch-dog’ organisations can also be

considered third-party verification techniques (Walker, 2009; Zorilla, 2009; Ochieng et al., 2010; Benchmarks, 2014). Third-party verification focuses on holding a separate governing body to account, as opposed to a range of non-hierarchical forms of accountability increasingly being applied to water resources focusing on holding water users to account.

There are quite a few watch-dog organisations looking over the shoulders of mining companies operating in the eMalahleni region. These include the Southern African Mineral Governance Barometer, the Benchmarks Foundation, the WWF, and the Institute of Security Studies). These third parties furnish data on water quality compliance and regulatory performance, as well as provide opportunities to educate and persuade regulated mines to comply, and free up government resources.

ii. Public Participation

Public participation within a polycentric governance model, is viewed as group efforts amongst governmental and non-governmental stakeholders. Whereas in governance literature collaboration remains a crucial subject particularly in managing common-pool resources. Central to the theory of polycentricism is the proficiency of individuals in resolving internal difficulties built on opportunities that are formally facilitated. In the water sector, for example, the public participates in natural resources administration through water users' associations. Public participation becomes vital whenever government does not have adequate resources, finances, and material authority to effectively manage resource concerns, as is typically the situation in the South African water resource management space.

iii. Experimentation

The provision of a logical foundation for management experimentation is regarded as the source for ecosystem reaction to various interventions by the management. In the literature on governance (Fischer, 1995; Huitema, 2009) experimentation received much attention as a research technique. Most experiments are described in the governance literature as policy experiments relating to the presentation of different policy mediations: for example, mine water management regulations at several similar localities, to evaluate the causal characteristics of their efficiencies. Literature on governance considers experimentation to be an extremely laborious policy appraisal

(Fischer, 1995).

iv. Regional – River Basin Approach

Scholars in governance view river-basin policy as a prospect towards the promotion of adequate linkages between ecosystems and the governance system. In order to accomplish riven basin water management alliance may possibly be introduced amongst current organisations, considering that these river basins are connected. Meaning that outlining basin boundaries necessitates an ultimate implication on politics. Even though the basis for unitary river-basin organisations is recommended regularly, scholars have recently begun putting emphasis on cooperation among the current institutions as the desired alternative.

Those advocating the formation of river-basin organisations refer essentially to the existing bodies and their apparent failures. Poor acknowledgment of interdependencies at the river-basin scale; limited collaboration amongst institutions; transparency deficiencies, building of institutional structures hard for external people to comprehend thus restrictive to public participation; disregarding anomalies that are not fitting within well recognized programme, are some of these failures.

In recent times, the advocates of adaptive governance view it as an institutional model that deals with the advancement of institutions aimed at handling shared assets, particularly common pool resources. Hence, this study puts forward the adaptive governance concept as an up-and-coming institutional arrangement of environmental governance that should progressively be utilised by practitioners to bring together resource management systems given the of intricacies and uncertainties associated with rapid environmental change.

Considering the earlier research on self-governing institutions led by Ostrom (2005), this study has looked at the concept of adaptive governance and whether the established positioning of adaptive management resound with the water governance writings. The effectiveness and the feasibility of these requirements were assessed by the researcher, and whether these were replicable in practice, whether they would bring about improvements in water quality in the eMalahleni region.

In the study, the researcher explored self-governance as an institutional instrument

that can be used for efficient mine water management. Although there is some research on self-governance in forest and fishery management, there is little literature on self-governance in mine water wherein self-government has successfully resulted in the consistent and coherent regulation of mine water during mine operation and rehabilitation.

2.5 Top–down theoretical arguments

Writing about top-down theorists Schrijver (1997) advocated for state-based parliamentary sovereignty wherein the natural resources within their own territory are exclusively under the management of the state whilst ensuring a sustainable and safe utilisation of such resources. This classic communal governance system commenced around the mid-1990s onwards, and its communal-centered biodiversity conservation approach has made momentous in-roads into conservation practice (Twyman, 1991; Sullivan, Barnes Matka 2002).

These top-down theorists believe that the development of the people is the state's responsibility, particularly in relation to the constitutional privileges of local people, the ecological use and conservation of mineral deposits as well as security of the environment. In contrast, governance theorists (Akcil & Koldas, 2006; Lemos & Agrawal, 2006) argue that centralised governance by means of top-down instructions or command-and-regulator policies time and again fail to make available operational answers for extremely contextualised situations, and frequently undersized in its efforts to bring together governance through comprehensive ecosystems extending across various jurisdictional boundaries.

Research has characterised South Africa's approach to water governance as historically being top-down, broad-based and fragmented, often lacking appropriate oversight, and failing to involve key interests and water users, in decision-making around water resource use and development (Marshall, 2005; Lemos and Agrawal, 2006; WWF, 2011; Scarlet, 2013; SWPN, 2013). Whilst practitioners view current as a window of opportunity that requires new and possibly complex policy, institutional and financial arrangements in the South African water governance. A need for a more uncommon business towards a more regulatory hierarchy and oversight related to mining and water, including arrangements for regular monitoring and evaluation and the requirement of the discharger providing regular information, including DWS

overseeing water-related matters.

In complex societies considerable ecological regulation has been command and control, however, Soni and Workersdorfer (2015) are of the view that the stakeholders should be completely involved, proposing mine water management by the individual mines rather than imposing government regulation.

Following Ostrom (1990), who characterized institutions by means of prescribed rules and informal customs and standards that shape repetitive as well as structured interaction that can be seen as the 'rules of the game' (Ostrom, 1990: 95-97). Possible penalties or prison guidelines were required in order to discipline those breaking the rules if governments were to prohibit specific actions or technologies. These methods are effective once adequate means for supervision and prosecution remain available. However, the top-down approaches are mostly malfunctioning when government lacks the drive and or finances to safeguard 'endangered zones', once massive ecological cost emanates from hard-to-spot 'nonpoint causes' and once the need remains the motivation for invention in behaviours.

Detailed in Marshall (2005) is a rising number of bottom-up methods towards governance that have emerged through the use of indigenous groups, social systems, as well as team efforts of the community leadership, who realises the necessity for options to top-down management as well as innovative methods towards ecological choices. Stoker (1998) observes that governance systems that are predominantly government orientated, top-down characterised by parliamentary sovereignty like the Westminster model, are restrictive and misleading. According to Gamble (1990), whilst this Weberian perspective finds its reflection in the Westminster model of a unitary state that regards governing as a restricted group of connected institutions, a divergent organising framework of broader, movable, organisations linked through an intricate combination of interdependencies offers the networked community governance perspective. Stoker (1998) believes that the Westminster model of a unitary state lost its state power in service delivery to more intergovernmental and local and regional levels failure to seize the complex reality of the British system.

In Britain, agencies are being established in the school and health-care system and the increased private sector and voluntary sector are now involved in decision-making

and service delivery. In many countries public-private partnerships are now a reality in the public service space, and have moved from previously exclusive government responsibilities towards a more shared responsibility. Beyond the Westminster mode, the government structure has since been transformed into a local governance system having migrated from local government, connecting multiple sets of vulnerable and private sector organisations. This appreciates governance as a comprehensive term than government, with amenities provided as a result of government transformation and the private and voluntary sectors.

In a South African situation, at present a lot of catchments in the Upper Vaal and Olifants catchments for example, are heavily polluted by mining waste and projections are that by 2030 there would be Water Management Areas without enough water to meet demand (Benchmarks, 2014). Hence the WWF calls to the South African water resource authorities to strategically plan in an integrated manner to ensure future water security (WWF, 2011). Echoing the need for highly adaptive environmental governance systems going forward, the DWS Mpumalanga stakeholder engagement strategy (2014) agrees that collaboration would allow the water sector to be able to bring a sense of balance and accountability among the mining houses, the private and agricultural sectors, government departments, municipalities, and civil society, through stakeholder engagement.

Ostrom (1990) criticised top-down national regimes and rule-systems, arguing that they do not allow local users and officials to have adequate self-reliance and obligation to design effective institutions and management systems. Ostrom (2005a) argued that rules created on government driven models have no or little credibility among the users, and consequently, compliance is relatively low, and resistance to obey the existing regulations is not uncommon. Reflecting on the commons in her lecture, Ostrom (1999) stated that creating an institution to deal with and managing collective action is required on every occasion where there is dependence on communal resources used by everybody yet not one person owns it, whereas an individual's usage affects somebody's resource consumption abilities, and the inhabitants over-consumes and/or fails to replenish.

2.6 Common-pool resource proponents

Ostrom (2005) believes that establishing governance systems promoting sustainable usage of resources on earth, including valuable resource quality lifespan, involves decisiveness in unclear as well as difficult situations entangling substantial biophysical restraints and conflicting social standards as well as benefits. The rulebooks generated in a particular natural environment are subject to alterations since the socio-economic and technological developments contribute towards the increased possibility for resource acquisition, or environmental changes at resource collection points. Literature on common pool resources has been growing with global concerns about resource depletion and concerns about environmental degradation and how collective action problems can be solved.

The widely held research of the CPR to date (Agrawal, 2001; Adams, Brockington, Dyson & Vira, 2003; Ostrom, 2005) remained in forestry sector, cropping schemes, fisheries, environment, water resources, farming and agrarian organisations, land occupancy and use, community organisation systems as well as worldwide commons (environment alteration, airborne pollution, trans-boundary water disagreements, etc.). Ostrom (2005) further states that in managing the CPR of systems, misuse, provision, observing, execution, conflict management, and governance undertakings are arranged in several layers of nested initiatives.

Ostrom (1990) formulated eight principles, suggesting that the ability by the groups to productively organise and rule its group behaviour, is discernible through the design principles listed hereunder:

- Visibly demarcated boundary groups.
- Local needs and conditions well-coordinated with rules governing the use of collective goods.
- Individuals generally affected by these rules know how to participate in decision-making and rule modification processes.
- Resource user rights to formulate individual guidelines are indeed recognised by authorities outside their organisation.
- Member's behaviour is monitored through an established system which is undertaken by resource users themselves.

- Various levels of sanctions for resource appropriators violating set rules.
- Resource appropriators' right to use reasonably low-priced mechanisms for conflict resolution.
- Rules are organised and enforced through multiple levels of nested enterprises in cases of superior common pool resources.

Fundamental characteristics adapted from Ostrom (1998) design principles, are: an economical and an informal way of excluding outcasts (non-Anglo Coal mines in this case study); administering private assets is considered to be costly; efficient arrangement for making local choices; real observations on the resource as well as the consumers; guarantee of restraints for those users who do not adhere to rules; and government officers acknowledging the control of resources by the indigenous communities. However, these principles have since been refined, supplemented, and amended, mainly based on case study research (Agrawal, 2001; Andersson, Ostrom & Cox, 2010; Benavides & León, 2014).

Considering the extensive review of the rapidly increasing commons literature, Agrawal (2001) suggested that the successful management of the commons might be affected by a number of factors approximately between 30 and 40, with significant overlap between those facilitating the emergence of institutions and their continuation. These factors are clustered as follows: resource system features, collective features, formal provisions, as well as the external background (Agrawal 2001,2004, 2007)). Similarly, Ostrom and Cox (2010) reported that scholars who found the institutional focus of the original design principles to be incomplete, suggested adding factors covering the social values of the group, the resource characteristics, and external socio-economic factors.

In their review of literature on institutional arrangements, Andersson et al. (2014) found that rulemaking process in the institutions, and the associated rule features, the compliance monitoring and enforcement of rules, and execution of sanctions on rule breakers, were important characteristics for success. When resource consumers are afforded an opportunity to partake in the formation as well as advancement of procedures that outline their rights and responsibilities, there is likelihood to find arrangements that are equally acceptable and adjustable to change.

2.6.1 Design Principles Demonstrating Long-term CPR Institutions

Design principles upheld by Ostrom (1990) are the "vital elements or circumstances that support the successful sustenance of the CPR institutions and advancing the compliance of the rules in use, not only by appropriators but for generations to come" (Ostrom, 1990: 90). According to Ostrom (1990) the community of individuals has for a long time been dependent on institutions to govern resource systems without state or market interventions. Ostrom (1998) contends that to determine the applicability of the design principles to govern the commons, further theoretical and experimental effort must be done. The application of design principles for long-enduring CPR are frequently communally obligatory to the local users where the individuals or groups living within particular boundaries. It is both through formal and informal provisions that the public may find collective ways to be able to manage the public good that surrounds them.

Effective governance is achievable only when rules governing the usage of resources are commonly obeyed, with a sound criterion for mild but enduring rule destructions. Imposing mild penalties on primary offenders, and progressively applying severe sanctions to individuals who are not remorseful of being rule breakers, has generally proven to be effective. Successful compliance in institutions founded on communal rulebooks is often possible when using less formal approaches and relying on members' pledge to guidelines as well as restrained group agreements.

Appropriation and use of common pool resource is usually controlled through monitoring. However, despite the fact that users contribute in rule-making processes that are appropriately designed for their local circumstances, the lure to cheat does occur. It is through monitoring that prospects to observe and consequently hold cheaters accountable, is increased. In managing successful CPR organizations, the observers are motivated to remain responsible resource consumers. It is imperative for resource users to recognise rule enforcement as effective and legitimate, whether rule execution mechanisms are formal or informal, otherwise opposition as well as avoidance would overthrow the strategy for governing commons.

A dilemma relating to the community's self-governing capacity has been revealed through lessons learnt in local-level CPR governance (Agrawal, 2001). Van Laerhoven (2007) argues that a group's capability to collectively take action and

overcome dilemmas becomes crucial if the tragedy of the commons were to be avoided. However, external actors are by and large given certain roles in the execution of government policies aimed at facilitating self-governance whilst upscaling the lessons learned. In the context of CPR governance, where struggle between self-governance and need for external intervention to implement wide-scale CPR governance policies is obvious, the question is to what extent can external players be able to encourage durable forms of collective action?

By the same token scholars and practitioners are yet to earnestly deal with this question, as the conservative emphasis has been on substantiating that CPR appropriators do not always need outside assistance towards alleviating the tragedy of the commons (Ostrom, 1990). In this case study these are the strategy principles that have been applied in assessing the role of self-governance in mine water management.

2.7 Self–governance and institutional analysts

Founded upon the direction of Ostrom et al., (1994) and Agrawal, (2003) self-governance has been the single supreme hypothetically rational and persuasive research framework for community-based institutions. Ostrom (1990) argued that rules governing resource use and required contributions must suit the local situation. She further maintained where the rules are reflective of the user circumstances, consumer groups tend to comply with responsibilities and put up with constraints. Agrawal (2001) believes that the self-governance design principle specifies two distinct and divergent conditions.

Firstly, the prerequisite condition is for rule appropriation and provision to equally conform to local conditions in some way, as Ostrom emphasised local conditions of the CPR. The second condition is that similarities should be present between the appropriation and provision rules. Considering that the Anglo Coal mines are situated in the water-stressed Olifants catchment, this poses a significant risk to the local mining industry, both in terms of security of supply for the routine mine operations and for long-term sustainability.

The decline of the quality of water in the Olifants catchment and water shortages in eMalahleni local municipality, were existing local conditions in the study area. Hence,

the management at Anglo Coal facilitated institutional arrangements in the treatment plant to address the mine water in this region, on the other hand deliver acceptable quality of water to the Upper Olifants Catchment that is enduring lack of good quality water. Self-governance well describes institutional arrangements that shape the choices and behaviour of actors, as well as the use of authority within groups or organisations.

A key question often posed is: “are people using a common natural resource capable of contributing to governing the exploitation of that resource?” In practice, this question is relevant when communities feel that government agencies intended to manage the utilisation of natural resources were unsuccessful in preventing negative effects on the resource that would bring about sustainable resource use.

The proponents of autonomous institutes openly contest the presupposition that the best way to resolve the tragedy of the commons is by enforcing the use of external proficient administration. Ostrom (2005) cites several cases of autonomous institutional arrangements, which have for centuries resulted to the sustainability of common pool resources, and identifies the universal ideologies as well as situations which allow adaptive governance and administration.

Conversely, Agrawal (2001) argues enabling conditions that are critical for the sustainability of commons could be manipulated through external intervention. He contends that in the absence of appropriate leadership to organise CPR self-governance arrangements by means of collective action is usually prohibited, then it becomes unrealistic to expect external actors to rectify the situation without difficulty.

Traditionally, water resources are regulated by the National Water Act No. 36 of 1998 which also prescribes rules and obligatory duties of local users in terms of water user licensing conditions. Furthermore, the South African National Standard (SANS) (241: 2011) as well as the DWS Aquatic Ecosystem Guidelines regulate water quality. Despite the fact that through these legislations, mines are subject to the obligatory mine water management rules throughout the mining lifecycle, they also have the right to create their own institutions and have the right to self-govern.

Thus, in this study, the management of the Anglo Coal Reclamation Plant was found to have the ability to successfully craft treatment rules and enforce them in order to

solve observed mine water dilemmas. The mine also explored possible water re-use, giving due consideration to the local conditions while adopting environmental and water quality standards. This study also examined how Anglo Coal has since adapted the water resource quality objectives and community water security requirements of the DWS into its business planning, to fit local circumstances (Ostrom, 2005a).

Using the building blocks of institutional analysis, the study looked at how Anglo Coal best met the local municipality's needs for good quality water by treating mine water beyond the department's quality discharge rules, and opted to treat water to potable standards. The probability to observe and hold rule breakers accountable is increased through proper monitoring. In commons literature the underlying reasoning for institutions shaped by appropriators are the fixed rules that are aimed at restraining resource use and providing systems for successful monitoring and sanctioning.

2.7.1 Framework of Local Institutions

Ostrom articulated concern over the forms of institutions viewed as suitable and most well organized for leading and managing various CPRs, and from which at least exclusion of potential beneficiaries is avoided (Ostrom 1990, 1992, 2005a). Whilst drawing on complex sets of institutes of actors within and beyond government, Ostrom interpreted them as including prescribed rules and norms that are enforceable, these include the conventional decrees through a statutory act, as well as practice-assisted by several practices of permissible consents (Ostrom 1987, 2005a, 2011).

However, Ostrom emphasised that analysis in some cases make a distinction concerning 'operational guidelines' impacting on behaviour, as well as 'regulation procedures' that essentially remain disobeyed otherwise not applied. In the current study, it was found that the 'rules in operation' are understood; for instance, where Anglo Coal was able to take the final decision on mine water management and treatment alternatives and chose to treat mine water beyond quality discharge rules to potable standards. 'Rules in law' could be seen as Regulation 704 of the NWA No. 38 of 1998, that requires mine water management systems to comply with and meet best practice. However, it has been found that government's monitoring and enforcement efforts have not been complied with, and that since the NWAs inception 19 years ago,

only four cases relating to mines contravening legislation have been successfully prosecuted (Parliamentary Water and Sanitation Committee Meeting, 2015).

Taking his main inspiration from the ideology of localism, Twyman (1991) argues that the key task of local institutions is to meet the needs of its community (or the resource users in this case study), either directly or indirectly. Twyman (1991) maintains that localism places far more emphasis on the search for issues and what the solutions might be, compared to either the post-war model or the new public management approaches. The overarching goal of localism, according to Stoker (1998), is meeting resource users' requirements as clearly defined by the community within the framework of the intricate system burdens of multi-level governance. Twyman (1991) claims that in the present-day era, approaches founded on community participation remain signalled as remedy for complications related to natural resource management initiatives and biodiversity conservation worldwide.

Although proponents of this approach present it as a 'win–win' scenario that could safeguard biodiversity, enable local communities, to participate in economic development, Stoker (1998) observes that its critics argue that local institutions undergo management teething troubles across complex natural features (e.g. large catchments and river basins), and is therefore uncertain of the success of these sections of local governance and their acceptability to communities. Ostrom (2005a) maintains that the achievement of enhancements towards the efficiency of institutional arrangements normally requires the progress in 'efficient, attractive, as well as implementable cooperative approaches resulting to prosperity advances and being administratively smart in related to preferred timeframes and configurations. This is where ultimate governance concerns with regards to generating the conditions for well-ordered rule and collective action become apparent (Stoker, 1998; Pierre & Peter, 1998). Ostrom (2005a) further asserts that resource users are likely follow recommended institutional norms in terms of common approaches, principles, well-shared and sustained behaviours communicated through a wide range of constructive and undesirable prizes including appreciation, resource user rights, community upkeep, as well as arrangements for risk distribution.

Research and practice have pointed out that if administered accurately, certain

fundamental components do contribute towards successful operation of local institutions over time. Concurring with Ostrom's argument (Ostrom 1990, 2005a) on the attributes of resources that are conducive to appropriators' self-organisation, Anglo Coal realised that the CPR system was pivotal to continuing its operations, hence the motivation to self-organise in mitigating mine water pollution. Furthermore, given that water is inherent in everything Anglo Coal does in their coal mining business, the mine recognised that the benefits of the treatment plant in mitigating total suspended solids in water affected by mining activities, far outweighed the costs incurred for treatment. This cost-benefit analysis is a highly important aspect of self-governance.

2.7.2 Self-Governance in Forestry and Fishery Management

As previously stated in Chapter 1, there are limited studies on self-governance in mine water management recorded in the literature; hence, the literature reviewed was focused more on fishery and forestry management. This portion discusses Ostrom (1999) earlier work on self-governing institutions in fishery and forestry management, which overruled the suggestion that the unsurpassed way to deal with common pool resource tragedy is through enforced outside management professionals. Numerous examples of nearby locally self-ruling institutional arrangements as cited by Ostrom (1999) have conserved common pool resources (forests and fisheries) for centuries, and recognized the wide-ranging values that facilitated adaptive governance and management.

In order to develop and maintain forestry institutions, Ostrom (1990) states that users must overcome three types of dilemmas associated with collective action. Firstly, they must agree on access and withdrawal rules (Schlager, 2016); secondly, they must organise the monitoring of compliance to the rules; and thirdly, they must decide on the sanctioning of rule infractions (Andersson et al., 2014). This study sought to find out how these locally evolved autonomous institutional arrangements could be replicated by mining companies for the purpose of mitigating water pollution.

Ostrom (1999) demonstrated that when fishery resources are very much critical to users, there is probability for self-governance to succeed. She further stated that prospects of self-governance are possible once consumers share a common appreciation of their problems, or those with insignificant concession ratio, once there

is confidence and self-rule amongst users, and when they have had prior organisational experience. In Sweden, for example, an informal type of self-governance has existed in the water sector around Koster as well as the Swedish west coast regions, since 2000. Its administration entailed cooperation amongst qualified fishermen, researchers, the country's executive panel, the marine agency, as well as the cities of Tanum and Strömstad (Sarker et. al., 2015). This collaboration presented an opportunity for fishermen to attend marine ecology lessons on local ground, whilst those making decisions took part in the rule-making. Led by professional fishermen, the area's history and the present practices of small-scale fishermen were outlined.

As a result of allowing the Swedish CPR appropriators to participate in the rulemaking process, access to indigenous environmental knowledge existing within the community was facilitated (Olsson & Folke, 2001). Although this collaboration was not legally mandated, it impacted on the governing structures in ensuring that resolutions taken are advancing and bridging the mistrust gap amongst the fishermen, the experts, and the rule-makers (Olsson & Folke, 2001; Sarker et al., 2015). Rulemaking process is well recognised by considerable literature on common pool resources governing bodies.

Rulemaking in community forest institutions is seen in cases where rules in forests are used to regulate the products extracted from communal-governed forests, the extent, by means of what methods, and by whom. The landscape of the rules and the manner in which these are framed can unfavourably interrupt the institutional sustainability, given their possible impact on the obligation and incentive to protect. Once these rules are adopted, the parties follow them without legal recourse, until and unless one of the parties seeks legal assistance or protection.

Ostrom (1999) used these design principles and its features as a guide in forest management research to give details of the comparative achievements or let down by communal-centered institutions for indigenous sustainable neighbourhoods. The researcher appreciates that these features and design principles should not be used by way of speculating the strength or whether or not the local institutions were vigorous. Hence, these tools were used in the research to help assess the role of self-governance as an alternative theoretical concept that offers potential to bring local institutions into the mine water governance paradigm and mitigate the effects of

pollution thereof. This study was empirically tested, along with the theory's applicability to mine water management and how these models primarily developed from previous common pool resources efforts and how they might be applied to this study of mine water management.

Ostrom (1999, 2000) further maintains that the costs and benefits of institutional change affects the characteristics of a resource and, hence, when resources are abundant, users tend to have few reasons to devote costly time and energy in organising. The study found that Anglo Coal appreciated the local conditions of water shortage in the eMalahleni municipality, where its mines are located, and made a decision to invest costly time and effort in treating the mine water and distributing increased volumes of water to the local municipality, which was experiencing shortages of good quality water.

Self-governance, according to Ostrom (1999), remains prospective once consumers perceive considerable resource shortage. Given that there is not an abundant water supply in the Upper Olifants Catchment, it was against this background and the current looming water scarcity that this research's central objective was to evaluate the role of self-governance in mine water management. The Anglo Coal Reclamation Plant was central in ensuring the mitigation of water resource pollution in the region meaningfully, but also provides water of acceptable drinkable standards to meet the supply needs of the water-stressed eMalahleni local municipality.

2.8 Conclusion

The chapter outlined the operationalisation of the research concepts as well as how the thesis design was motivated by the tragedy of the commons and the governing the commons theories. Examples of previous studies were reported, and how the concept of self-governance impacted on the management of the (fishery and forestry) CPR. Chapter 3 looks at the area of the study as well as the research methods adopted for this study.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODS

3.1 Introduction

This chapter gives an overview of the mining activities in eMalahleni as well as the study area. Complex mine water management issues are covered, and the chapter outlines the research methodology, the data gathering procedures and data analysis tools utilised. Ethical considerations, measures undertaken to ensure study trustworthiness and data reliability are also discussed in this chapter.

3.2 Study setting

The study was undertaken in the eMalahleni area of Mpumalanga Province in South Africa. With about 55 collieries in operation in the area, the DMR (2015) regards this area as the centre of the country's current coal mining activity.

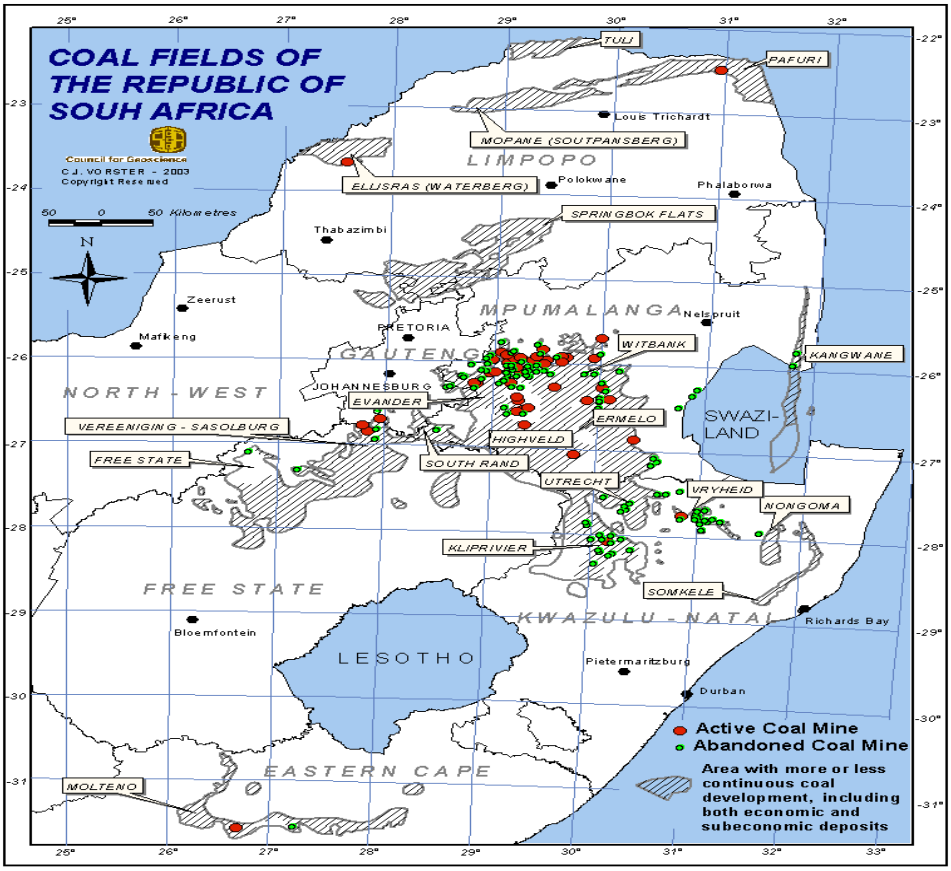

Figure 3.1: Map of the Coalfields of South Africa: abandoned and active mines
Source: SWPN, (2013)

This study area was chosen due to its rich coal deposits. South African Chamber of Mines figures show that at present South Africa is positioned the world's sixth-major coal exporter (2015). There are five major coal producers operating in the eMalahleni area: Anglo Coal, Glencoe Xstrata, Sasol, and BHP Billiton Coal, as well as South African Energy Coal (South 32), and four of the largest black economic empowerment (BEE) companies: Exxaro Resources, Optimum Coal Holdings, Mcebo Mining, and Shanduka (DMR, 2015[3]). Many coal- related industries are found northeast of eMalahleni and Middelburg in the Mpumalanga Province of South Africa.

Around 61% of Mpumalanga's population resides in the less densely populated rural environment, and their livelihood primarily depends on agriculture. This rural environment is also associated with concentrations of people in close proximity to mining, forestry and power station activities (Mpumalanga Province, 2001). Furthermore, the Highveld power stations situated in this area are due to be operational for the next 30 to 40 years (DMR 2015). Whilst the South African Yearbook (2003), revealed that the agricultural sector remains one of the key commercial sectors in the province, generating about fifteen percent of the total agricultural productivity in South Africa. The increasing demand for agricultural crops continue to be the incentive in the agrarian sector, and this emphasises the importance of acceptable land use patterns that reflect the value of water in the Province. The day-to-day management of irrigation water allocations has been the responsibility of the irrigation boards. The eMalahleni coalfields fall within the Olifants River Management Area. The landscape in the southern and central part of the catchment is led by mining operations and mining-related infrastructure.

The Upper Olifants constitutes the catchment of Middelburg eMalahleni through to the Loskop Dam, which primarily supplies water to urban and agricultural users. Much of the Upper Olifants catchment falls within the Highveld coalfields and its economy is characterised by intensive coal mining-associated energy and manufacturing. Dewatering and leachate/runoffs from operating and reopened mining facilities, as well as decant and leachate from the non-operational and abandoned mines, affect the surface water in the catchment.

[3] http://iisdb.stanford.edu/pubs/23082/WP_100_Eberhard_Future_of _South_Africa_Coal.pdf.

3.3 Overview of mining activities in eMalahleni

Effective governance of mine water in the Olifants catchment is required to address the current frantic battle raging across many regions of Mpumalanga Province of South Africa amid water quality security and coal mining prospects on the one hand. The mine water challenges in developing operational and non-operational mines are summarised into twelve issues as presented in the systems diagram in Figure 3.2.

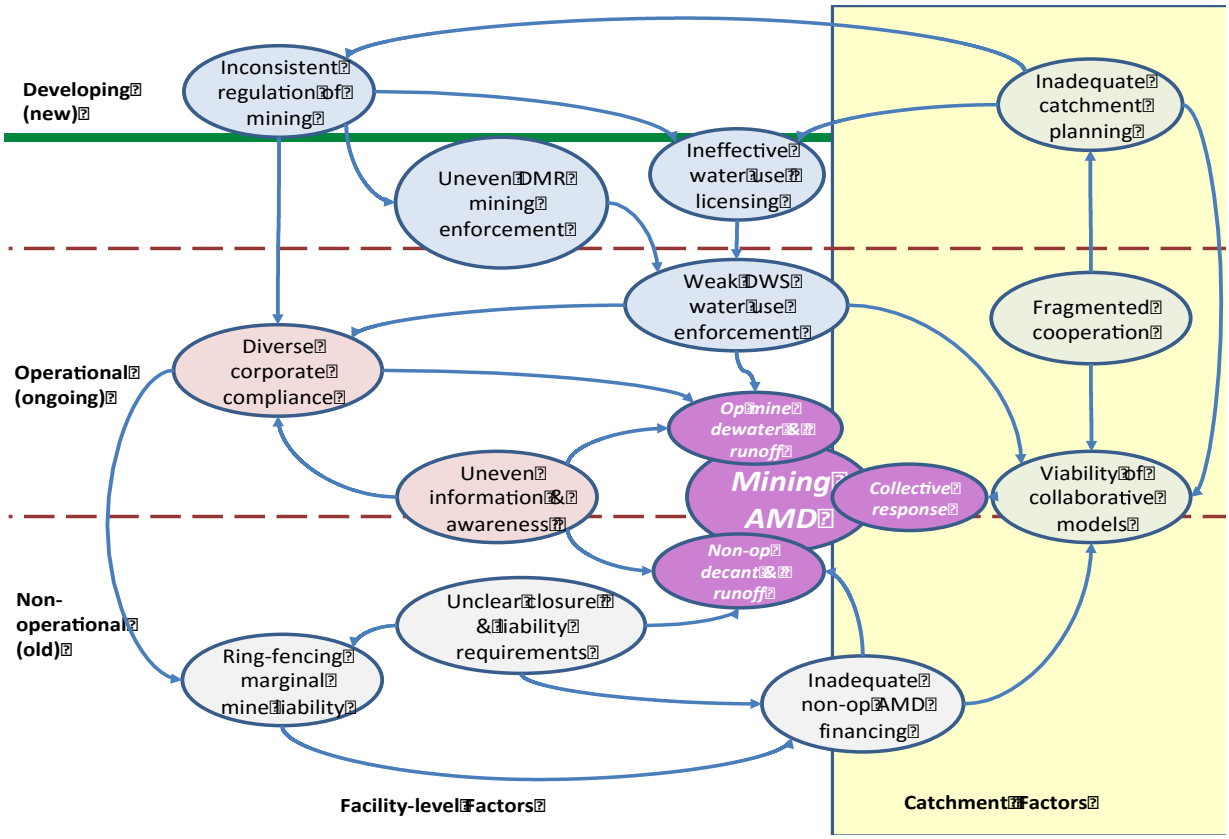

Figure 3.2: System Diagram of the Twelve Clustered Mine Water Management Issues in eMalahleni Source: Adapted from SWPN, 2013

There is significant concern over the impact of an increasing number of abandoned and/or closed mines in this area, which may lead to a rise in mine-impacted water if not properly managed; especially given the estimated remaining 20-year lifespan of coal mining in this area, with a total of about 20 billion tons of coal still expected to be extracted (Tanner et al., 1999; SWPN, 2013). Surface water is affected by dewatering, leachate/runoff from operating and reopened mining facilities, as well as decant and leachate from the non-operational and abandoned mines and is due to unclear mine closure liability requirements and inconsistent regulation of mining.

The Witbank Dam catchment was classified as a Management Class III (DWA, 2013). This means that it is a heavily used water resource, and that the general condition of the water resource is transformed considerably from its pre-development condition, including significantly altered aquatic ecosystems. The region is considered water-stressed; water supply and the quality of available water resources are attributed to inadequate catchment planning and weak water use enforcement by the DWS.

According to the SWPN (2013), vast water pollution challenges for populations and users in close proximity to the affected water resource, and those downstream, are a consequence of modest mine water management practices by some existing and closed mines in eMalahleni, and uneven DMR mining enforcement. These factors contribute to the constraints on the existing water resources, which are either not fit for use or are not sufficient to supply the region's water demands.

The WWF (2011) states that coupled with the need for sustainable water resource use and protection within this catchment, is the need for voices calling for collective action and viable collaborative models in dealing with enduring effects of the coal mines on the security of water. Considering that much of the Olifants catchment falls within the Witbank coal mining area, this calls for immediate coherent conversations between interested and affected parties around sustainable mine water management in the Olifants catchment. The WWF (2011) states that the Olifants catchment is notoriously identified as one of South Africa's utmost low-quality rivers because of coal mine effects in particular. The WWF report on coal-mining in South Africa emphasises that ecologically responsible practices, in relation to water particularly, have come to be fundamental for the feasibility and reception of present mining operations, and are a critical business risk that affects the ability of individual mines to establish, operate, and close (WWF, 2011). Likewise, awareness on ecological effects and apprehensions for the environment have been on the rise in recent decades, resulting in more rigorous worldwide environmental protocols and parallel responses, particularly from the international mining trade (Idowu, Lorentz, Annandale, McCartney & Jovanovic, 2008; Mupeta, Child, Muyengwa & Libilo, 2014).

Social conflict and discontent by other potable water users such as the agricultural sector, which requires a higher quality of water than others, usually result when there are suspicions that certain mines are polluting the water. This state of affairs might even impose a further consideration in water allocation (WWF, 2011). Younger and Wolkersdorfer (2004) outlined four impending mining effects that have negative impact on water and the environment: hydrological interferences; discharge of polluted seep into aquifers; inaccessible water table nearby the dewatered area; and mine water abstraction, should all be addressed through sound environmental practices.

The negative effects of mine water on water resources and the environment has increased concentrations of suspended solids, causing to mobilisation of essentials for example cadmium, manganese, iron, sapphire and zinc as well as reductions in the pH of the water on the receiving end. The deteriorating quality of water in various sources of surface water that may perhaps influence other water users is synonymous with the overall effects of mine water. Efficient mine water management requires mine operators to find a balance between meeting regulatory compliance whilst strategically planning for its water resource requirements and monitoring water quality.

3.4 Research methodology

The qualitative approach used in this research was preordained to guide collection of data and analysis so as to achieve the study goal, which was to explore the role that self-governance plays in mitigating the effects of mine water pollution. A case study was selected as a qualitative study design whereby the case of Anglo Coal eMalahleni Reclamation Plant, in Mpumalanga Province of South Africa was studied. Data was collected between April and June 2016. Document analysis together with semi-structured interviews are the main instruments utilised. Sections in the methodology chapter cover a full account of how this qualitative research was designed, the research paradigm informing the execution of the research methods, and ethical considerations in the case study.

3.5 Research design

This section gives the case study research context, defining the relevance of the methods utilised, explores the features and false impression of case study approaches, whilst describing how the enquiry was designed. When reviewing incidences under normal situations and when endeavouring to realize social

procedures in context, the qualitative research approach remains the ideal method (Denzin & Lincoln, 2011; Du Plooy-Cilliers, Davis & Bezuidenhout, 2014). Brewer and Hunter (2006) maintain that qualitative methods are especially useful in understanding how people are influenced by and respond to the things that are happening in their environment. The entire research design elements are linked; however, these networks are flexible (Maxwell, 2005). The 'rubber band' correlation as explained by Maxwell (2005) depicts a qualitative design by way of its substantial flexibility, but wherein there are limitations enforced by the diverse measures and controls which, if disrupted, might make the design ineffective.

Qualitative research methods are recommended where there is inadequate literature documented on a particular research topic. Hence, the research opted to use a qualitative research design due to limited self-governance studies in mine water management. The choice concurred to Flyvbjerg (2006) who believed that case study research could stimulate and strengthen more social science research if new trustworthy case studies were recorded.

Nevertheless, Flyvbjerg (2006) cautioned academics to remain fully conscious of five misinterpretations around case study research. Firstly, hypothetical understanding is more valued than real-world knowledge; secondly, from a distinct case its becomes difficult for one to generalise, hence, the sole-case study is unable to contribute towards systematic growth; thirdly, whilst additional techniques remain appropriate particularly for testing hypotheses as well as building theory, in creating hypotheses the case study remains the most suitable; fourthly, case studies holds have partiality concerning substantiation; lastly, frequently it is demanding to give summary on detailed case studies (Flyvbjerg 2000).

The role of the researcher is well emphasised in qualitative research, hence, in collecting data the analysis process as well as the interpretation of data results in this study, the researcher was a prominent participant and crucial instrument. (Creswell, 2003). Well-known case study researchers mostly recorded on case study research, also recommended systems for organising at the same time as piloting those research cases successfully (Merriam, 1998; Strauss & Corbin, 1998; Creswell, 2003; Babbie, 2013; Du Plooy–Cilliers et al., 2014). These researchers promote qualitative case study research as an approach that allows people to understand the world of self-

governance, which cannot be interpreted by numbers, but through social behavioural deliberations along with the jurisdiction where they reside.

Furthermore, these authors indicate that qualitative data is a foundation that facilitates well descriptive and articulated sound processes that occur in local contexts. According to Creswell (2003), research methods concept speaks of the suitable usage of data collecting and analysis techniques. Thus, the researcher opted for multiple evidence sources by interviewing key informants and analysing documents in order to ensure a robust study. This investigative nature of the research questions of how mines undertake mine water management, and what form of institutional arrangements are used by Anglo Coal was the basis for the methodology used in this research.

3.6 Research paradigm

Given its naturalistic approach, an interpretivist research paradigm was used in this study. The 'explanatory tradition' emphasized by Prasad (2005) was founded on an academic position which tolerates "analysis by humans to be the initial idea designed for emerging awareness of the communal creation" (Prasad 2005, p. 13).

This qualitative case study research is founded on an explanatory theoretical viewpoint, which guided and anchored the gathering and data scrutiny. Whilst the inclination towards a hypothetical view on qualitative research case studies and the manner in which the research project is designed as advocated by Jones, Torres and Arminio (2006) enhances the theoretical efficiency as well as the significance of the case study. However, Crotty (1998: 66) is of the view that the theoretical position behind a methodology is the theoretical perspective wherein its depth and design are rather complementary, than merely being disconnected components.

Whilst in interpretive research the focus is on actions and or achievements, researchers using the optimist's methods presumed to be giving interpretation on such achievements, (Crotty, 1998; Schwandt, 2000). Creswell (2003) recapped that researchers subscribing to the interpretive perspective possess their distinct understandings, with peculiar persuasions, their particular theoretical orientations, and that they, as well, are affiliates of a precise historic moment with detailed culture. Likewise, "to discover significance of an action, or even say one comprehends the

meaning of a particular action, necessitates that one understands what is being done by actors in a certain way", as recommended in Schwandt (2000: 191).

Founded on interpretivism, this research wanted to know exactly how mines could embrace self-governance as an institutional option to mitigate mine water pollution. Furthermore, this paradigm allowed the researcher to study the situation in its natural setting (Denzin & Lincoln, 2011; DuPlooy-Cilliers et al., 2014). In line with the epistemological position of interpretivism, the study results were not generalised beyond the context of Anglo Coal in eMalahleni, where the case study was conducted, but reality was dependent on people's interpretation of facts and the study results. However, in using a case study method, findings cannot accordingly be generalised from a single case (Flyvbjerg, 2000). As a result, in the designated case study, the information was interpreted in the context of Anglo Coal's self-governance in mine water management (Du Plooy-Cilliers et al., 2014).

3.7 Research techniques

In qualitative research, several data collection methods exist, but interviews are amongst the paramount and most generally used instruments, as suggested by Bryman and Bell (2007), and Charmaz (2010). As a result, one-on-one interviews were used as the primary data collection technique to unearth the context and structure of the participants' lives.

3.7.1 Sampling Method

Appropriate identification of interview participants and 'key informants' was undertaken by means of a purposive sampling (Charmaz, 2010). Key informants are usually those people from whom knowledge is solicited as they generally well-informed on the topic being reviewed and are expressive in their understanding of the subject. Their intuitions are generally useful in supporting the researcher to recognize activities that have since transpired, as well as the causes for such actions. The key informants in this case were drawn from the people working in environmental mining and water quality management who are responsible for managing water balance, assessing mine water risks, and predicting foreseeable environmental impacts within the area of influence. They also deal with environmental management verification audits and develop corrective/preventive action plans.

Consequently, the interviews were conducted with the water quality and efficiency managers and the environmental managers from the three mines in the study area (Anglo Coal, Exxaro and South 32), who had agreed to be key informant interviewees. In all these three mines there is only one manager from each of the divisions (water quality and efficiency managers and the environmental managers). Furthermore, key informants included the director for water and sanitation in eMalahleni municipality, officials from the water quality division at the DWS, and officials in mining regulation at the DMR.

Founded upon a "purposeful selection" method which, by Maxwell's definition, is "a strategy choice wherein some state of affairs, individuals or actions are deliberately nominated to offer relevant data to your questions and goals, that can't turn out to be as well from other choices", individual participants in this research were chosen (Maxwell, 2005: 88). An overall sum of eight individuals partook in the study of whom two were female and six were male. This was because the study was based on of AngloCoal and the sample was purposefully selected to include certain individuals working in specific divisions and had targeted tasks. The researcher was also interested in the quality of the information that was shared by managers in the study and not the quantity of the interviewees. This male predominance may be a reflection of gender predisposition in the mining industry, although it could also indicate that an opportunity exists in the industry for female individuals to acquire the necessary training and assume levels in the mining sector. Most of the study participants age ranged between 36 to 59 years, often defined as the 'adult category'. Further, none of the participants in the study were below the age of 36, which could indicate that a gap exists for young people wishing to participate. in the industry. Only one participant was in the 60 years and above age range, which is usually termed the 'older' age category. None of the participants have been working for Anglo Coal for less than four years, and all had been employed by the mine for periods of between five and nine years. Only one of the participants have been an employee of the mine for than more than a ten-year period. Tables 3.1 to 3.4 indicate the gender, age, length of service and position of the participants.

Table 3.1: Gender

Gender	Number	Percentage
Female	2	25%
Male	6	25%
Total	**8**	**100%**

Table 3.2: Age

Age	Number	Percentage
18–35 Years	0	0%
36-59 Years	7	87.5%
60+ Years	1	12.5%
Total	**8**	**100%**

Table 3.3: Length of Service

Length of Service	Number	Percentage
0–12 Months	0	0%
2-4 Years	0	0%
5-9 Years	7	87.5%
10+ Years	1	12.5%
Total	**8**	**100%**

Table 3.4: Position

Position	Number	Percentage
Water quality Division	3	37,5%
Environmental Management Division	2	25%
Director Water & Sanitation	1	12,5%
Hydrology Operations	2	25%
Total	**8**	**100%**

It's worth noting that regardless of the trivial the study sample, it was purposefully selected to include individuals who have specific responsibilities and roles in relation to water quality and environmental regulation. However, the sample may have been too small for the researcher to conclude that it was representative of the demographic profile of the three mines. The fact that participants had been in the employ of Anglo

Coal for at least five years, points to the longevity that Anglo Coal mine has enjoyed in the industry, and may suggest that with experience, they have come to a deeper understanding of the industry, thus prompting their decision to institute self-governance strategies.

3.7.2 Semi-Structured Interviews

The primary instrument selected for collecting data in this study were the one-on-one semi-structured interviews. The partial-structured interview design by way of open-ended questions was considered most appropriate. The following considerations were the basis for this choice:

i. Using semi-structured interview technique offers participants sufficient time and space to express their varied insights and perceptions on the self-governance in mine water management, thus allowing responses from the researcher and opportunity to keep an eye on emerging concepts and unfolding events (Bryman & Bell, 2007)

ii. Open-ended questions give participants an opportunity voice their experiences without obstruction and minimise the influence of the preceding findings and researcher's point of view (Creswell, 2009).

iii. Semi-structured interviews do not permit only the assessments of participants' sentiments, testimonials, and beliefs are permitted, but likewise consent to the creation of narratives about their personal experiences (Bryman & Bell, 2007).

iv. Qualitative interviewing is ordinarily perceived as being flexible, as it allows the researcher the ability to adjust and respond to the interviewee, having excessive concentration in the respondents' point of view. Comprehensive and rich answers are anticipated. The interviewer can proceed from any program that is being utilised as new questions arise, and may revise the order of questions (Bryman & Bell, 2007).

It is imperative that interviews are cautiously conducted to ensure reliability. Therefore, purposeful sampling, due consideration is given to individual reflections as opposed to a group focus, along with the size of the sample and choice of suitable participants for the interviews. Babbie (2004) believes that respondents do most of the talking in the interview process, and therefore help to achieve this goal.

However, Charmaz (2010) recorded that: “interviewing turns out to be very supple in some instances, when the interviewer has the liberty to frame questions as they come to mind around the topic under investigation; whereas, it can be inflexible at times, when the researcher has to strictly go through the questions decided beforehand” (Charmaz, 2010: 123). In order to ensure that the issues of interest to the study are addressed by all respondents in the interview process, the compiled list of guiding questions was used for the interviews. Nevertheless, this list was not meant to standardise the data collection process, but it only provided a structure for the deliberations and was envisioned to prompt and guide the narratives.

Esterberg (2002) proposed a design for wide-ranging and detailed ‘open-ended’ questions, nevertheless, opposed to questions that may possibly lead to an impassable way of questioning. The intention of this study was to allow colloquial interviews. These open-ended face-to-face interviews ranged from broad pre-planned questions, whilst allowing the interview to progress in a conversational manner as suggested by Du Plooy-Cilliers et al., (2014). Satisfactory and all-inclusive appreciation of mine water management, a questionnaire was drafted. Questions were broken up into sub-questions with the aim of getting additional likely responses, in so doing augment the participants’ indulgence on the assignment aims and increasing their confidence on the researcher. At times, in structuring precise responses, various altered approaches were used in asking the questions. These interviews lasted for not more than 55 minutes. Based on Ostrom’s (1990) principles. See Appendix A for the interview schedule that was developed as a data collection instrument in the study Based on Ostrom’s (1990) principles.

In collecting the data from participants working at the Anglo Coal mine, the researcher made use of one-on-one semi-structured interviews. Using a case study allowed the researcher to fully engage with Anglo Coal and thoroughly examine its concept and implementation of self-governance in mitigating the mine water and its resultant contamination effects. Making use of semi-structured questions, the researcher was able to further enquire likewise explore relevant issues raised by participants during the interviews. Therefore, the research methodology used in the study was sufficiently comprehensive to deliver on the goals and intentions of the study.

3.7.3 Secondary Data Collection and Document Review

Case study research necessitates the validation of data through a process of cross verification from two or more sources, known as triangulation. The researcher therefore drew information from multiple sources, including Google Scholar, research articles from the Water Research Commission Mine Water Division, and mining, environmental, and annual reports from Coal-Tech South Africa. As a means of triangulation, Charmaz (1990) submits that document analysis does not serve as a substitute but rather as a supplement to interviews and questionnaires. Hence it would not have been easy to learn about mining house interactions from other resource users except through records.

Despite strong reservations on treating records as firm evidence of what they report on, however 'official', documentary data cannot be ignored or downgraded (Charmaz, 1990). Document analysis of academic, peer-reviewed and non-academic literature supplemented the interviews in this study, thus promoting the amalgamation and validation by means of diverse sources of data, whilst ensuring that semi-structured interviews yield comprehensive results. The addition of the secondary literature assisted the researcher in providing supplementary proposition for the theories on self-governance and mine water management.

3.7.4 Data Analysis

Esterberg (2002) advocates being intimate with data and he contends that the core objective of the researcher to be engross in interview records is to fill the memory with the collected data. Hence, the researcher created a data file in which all the completed interview transcripts were stored. The interplay process between the researcher and the data commenced on completion of the first interview, in to order identify evident patterns of meaning emerging from the data. Data analysis on the lived experiences of the research participants gave significance to the first impressions and final collations of the researcher.

This study applied the data analysis and coding procedures according to Creswell (2003), whereby the first step was for the researcher to organise and prepare the data for analysis. This step has to do with transcribing the interviews as they were initially audio recorded. The researcher transcribed prior to analysis.

The second step was that of reading through and working intensively on the collected data, line-by-line, categorizing the participants' general ideas to determine overall depth and usefulness of the information. The main aim of in this step is to read through data so that the researcher familiarises themselves with it and is able to get a general sense of what the participants are saying. The researcher then started to read through the data repeatedly in order to get an initial impression of what the participants are saying and also to started to notice the general themes that were emerging in the data.

The third step was that of organising the data into 'chunks'. This involves the use of the coding process which involves identifying similarities and irregularities that are emerging from the data and organising them into different themes and categories. Prior to bringing meaning to those chunks, the researcher sought after new categories and emerging themes. Apart from identifying themes for the duration of the coding process, an attempt was made by the researcher to construct extra layers for elaborate analysis.

The fourth step taken by the researcher was that of in-depth analysis which began with the coding process that had identified categories of themes for the analysis. It is in this step that a researcher would test the emergent understanding by begin to formulate an understanding of the overall findings of the study through examining all the themes and categories that have developed. The emerging themes were analysed and gathered into various narrative passages, wherein the findings arose logically from the participants' responses.

The last step in the data analysis process described by Creswell (2003) is that of interpreting the findings of the study and finding meaning in the data.

The data analysis process in the study was conducted manually. The researcher did not develop an analytical framework prior to assuming the actual data analysis process by coming up with pre-determined themes to be used during the analysis. Rather, the researcher identified themes that emerged from reading through data and conducting the data analysis process. Lessons learned captured an essence of the researcher's understanding resultant from comparing findings with information gathered from the literature. It was at this step that the findings confirmed previous evidence on the success of self-governance in forest management, and that it is replicable in mine

water management. Questions resulting from the analysis of the data that the researcher did not formerly anticipate in the study, were also raised.

3.8 Study trustworthiness

Du Plooy-Cilliers et al, (2014) trust that a different criterion is used to measure the trustworthiness of research findings in qualitative studies**.** Qualitative research compels the investigator to be devotedly involved in data gathering and interpretation, assigning credible meaning to it, and determining the significance of the findings. Contrary to restricted reasoning, Creswell (2003) instead suggested that qualitative researchers should be accommodative of the respective participants on the research, instead of imposing their own assumptions. The researcher achieved this by self-administering the questionnaires and conducting the interviews.

Triangulation by means of using several sources of data was used to ratify the emergent results of the study, and to intensify trustworthiness and decrease threats to credibility (Charmaz, 2000; Creswell, 2003). In-depth interviews and document analysis were validated against each other. Credibility of the study findings was achieved by giving participants their interview copy and requested them to confirm content accuracy and endorse the credibility of the results (Du Plooy-Cilliers et al., 2014). The exploring researcher ensured the study dependability through a quality data integration process and facilitated conformability by means of a fully described research process, thus allowing research design scrutiny by others (Du Plooy-Cilliers et al., 2014).

In order to present a sound case and to gather sufficient evidence, different perspectives and various sources were engaged. Furthermore, the researcher incorporated additional strategies into the study for ethical reasons and trustworthiness as suggested by Merriam (2002): These include:

i. Triangulation by using several sources and data collection methods to confirm emerging results.
ii. Participant checks, whereby the researcher took the transcribed records and analyses to the individuals who contributed in data gathering, to confirm acceptability.
iii. Reviews by peers, through conversing about the study process and the

congruency of the emergent results and its tentative deductions with colleagues.

Coupled to triangulation and reviews by peers, Merriam (2002) maintained that researchers that are reliable embrace the following supplementary recommendations.

iv. The researcher attains feedback by employing vital replication concerning expectations, preconceptions, as well study connection, which may affect investigation
v. Commitment that allows for sufficient time to collect data, such that it turn out to be saturated.
vi. Extreme variation by resolutely pursuing distinction or diversity in selecting a sample to permit a better choice for research users to apply the findings.
vii. Stocktaking that offers a full description of the procedures, processes, along with the resolution to undertake the research.
viii. In-depth descriptions giving sufficient rich, concentrated narrative towards the study context, so that person who reads can still able to match their state of affairs with the research context.

3.9 Ethical considerations

In engaging with participants and ensuring that participants are in no way harmed through their participation in the study, the researcher ensured that ethics were observed and upheld throughout the study's. Key research informants and participating mines were reminded about the study purpose, research processes, and anticipated benefits.

Study participants were advised by the researcher about their voluntary contribution, along with their prerogative to pull out from the research. Once participants agreed to take part in the study, they signed written consent forms. Furthermore, written consent for audio recording the interviews was given by some of the participants and the discussions were transcribed after each interview session. However, some key informants felt uncomfortable with the voice recorder, and hand- written notes were taken throughout their interview.

The researcher also assured participants of the confidentiality of shared information, and that the information would be used only for the purpose of the study. Anonymity

was another ethical issue that the researcher attended to by giving an opportunity to participants to liberally put forward their viewpoints whilst giving them assurance that none of their responses would be linked to them in the research report.

3.10 Conclusion

Chapter 3 provided the study setting and an overview of mining activities in the eMalahleni area. The chapter also delineated the hypothetical as well as epistemological foundation, the study approach, together with the ways and choices that influenced the design of the research. The intepretivist model has been well-defined alongside the underlying qualitative research principles.

The theoretical methodology and viewpoints illuminated numerous intricacies and experiences undertaken in the research, such as the process to collect data, analyse, as well as solving problems relating to self-governance in mine water management. The chapter concluded with strategies employed towards enhancing trustworthiness of study results, and ethical considerations.

CHAPTER FOUR

RESEARCH FINDINGS

4.1 Introduction

Presented in this chapter are the study findings regarding the role of self-governance in mitigating mine water pollution effects. By so doing, the chapter looks at the nature of water quality management in eMalahleni, and the water institutional arrangements of Anglo Coal. This information assisted in assessing the monitoring and enforcement of water treatment guidelines and necessitated the understanding of how rulemaking as the self-governance principle facilitated the mitigation of water pollution along with water quality improvement.

Corresponding with the emergent trend and emphasis on the potential for increased resource sustainability through resource governance approaches, the researcher focused on Ostrom's (1990) self-governance proposition, and how resource users have together created lasting institutions.

Using Ostrom's design principles that characterise an enduring and successful common pool system, this case study of the Anglo Coal Reclamation Plant in eMalahleni was conducted to ascertain whether self-governance may possibly have a role to play in mitigating mine water pollution effects on the quality of water. It was not within the scope of this study to perform an in-depth exploration of each of these principles also to determine how they relate to self-governance and mitigation of mine water pollution.

However, the researcher examined two of these principles: rulemaking and local conditions, and regular monitoring and enforcement. Nevertheless, it should be noted that all eight principles could provide useful insights into areas of improvement in the existing mine water governance regime, or subsequent steps for on-going policy initiatives. Furthermore, the eight principles could be considered as a checklist for mine water self-governance regimes created to ensure good water quality in the eMalahleni municipality. Given the objectives of the study highlighted in chapter 1, the findings were as follows:

4.2 Research Objective 1: To investigate the nature of water quality management in eMalahleni region

Finding 1: Water quality management in eMalahleni

Given the paramount importance and complexity of the coal-water nexus and water security, there is an emergent consensus among scholars and practitioners at the Federation for Sustainable Environment, Coal-tech, and the Water Research Commission, that self-governance and improvement in mine water institutional arrangements is urgently needed in the Olifants River catchment (World Coal Institute, 2002). Critical narratives continuously argue for major paradigm shifts in mine water management, contending that prevalent management approaches are mechanical and technocratic, overlooking complex integrated water management and the human dimension (Huitema et al.,2009 Holling & Meffe, 1996). The WWF (2011) account regarding Coal and Water Futures in South Africa has called for a moratorium on new coal mining prospecting in catchments that are water supply source areas and key conservation areas (National Freshwater Ecosystem Priority Areas – NFEPAs). This WWF-SA study provides evidence that supports the need to champion new approaches to environmental governance whereby water users organise themselves to mitigate mining activity impacts and avoid the social costs associated with common-pool resource management.

Apart from satisfying the sustainability requirements of various government departments which include the license to mine, the water user license, and the rights to replenish the ecological reserve, Anglo Coal integrated its water management practices into local community drinking water resource management systems even though such levels of integration are not required either by the DWS or DMR. Thus, Anglo Coal, as part its collective-choice arrangements for the management of mine water, has been involved in making and adapting rules to treat water to potable standards. These rules focus on the enforcement of inclusion or exclusion rights involving participants that use the eMalahleni Water Reclamation Plant (see Figure 4.1). Commissioned in 2007, the main objective of the Anglo Coal Reclamation plant was to mitigate the cumulative environmental impacts and curb local water quality challenges that come from its three member collieries (Landau, Kromdraai, & Kleinkopje). Anglo Coal collieries are the major users of the reclamation plant. The rules bring to the fore important principles related to self-governance such as the

responsibilities of the participants, monitoring and sanctioning, and resolving conflicts.

Anglo Coal was able to take the final decision on mine water management and treatment alternatives on whether the plant should treat mine water in accordance with quality discharge rules or treat it to potable standards. Thus, the findings of this study articulate an empirical assessment of the rulemaking and regular monitoring and enforcement of water quality rules by Anglo Coal at the eMalahleni reclamation plant. Figure 4.1 depicts an aerial view of the eMalahleni water Reclamation Plant.

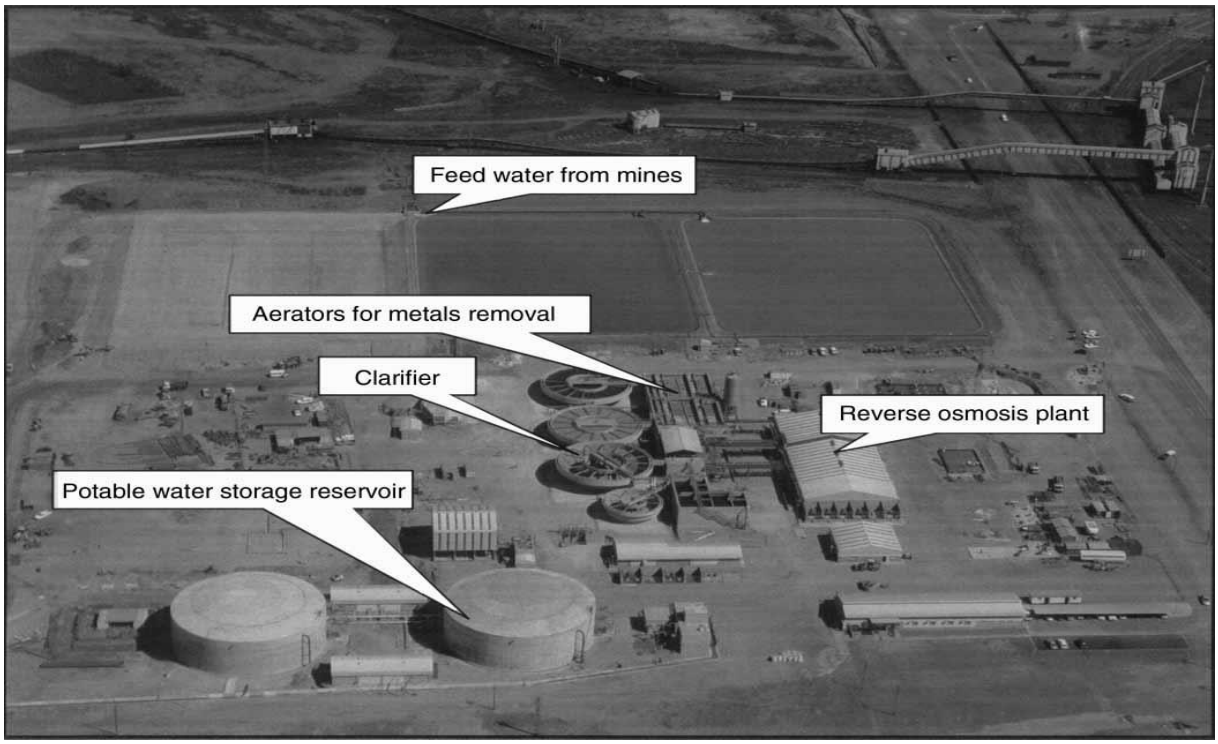

Figure 4.1: Aerial photograph of the eMalahleni Water Reclamation Plant
Source: Photo courtesy of Anglo Coal, (Adapted from Hobbs et al., and Tshwete et al.)

The plant makes use of the high recovery precipitating reverse osmosis (HiPRO) process. Its main physical components comprise: 'abstraction of mine water, feed water collected from the contributing mines; mine water centralised storage; mine water neutralisation, metal removal and desalination treatment; potable water storage and distribution to the respective reservoirs in the municipality'. In this section, the researcher looks at the progression of mine water pollution in the eMalahleni area. Historically, the reliance on coal-fired power mainly supplied by the eMalahleni coalmines, including Anglo Coal, resulted to increased South Africa's greenhouse gas (GHG) emissions to almost twice the international average per capita and per GDP.

Coal mining in eMalahleni took place approximately hundred years back, when water had been to some degree considered as a commodity to be avoided in mining operations (Hobbs et. al., 2008). However, at the time massive opencast mines were commissioned later in the 1970s as well as early 1980s, the use of water in mine developments was reconsidered. However, the complete effects of mining on water resources remained neither valued nor recognised at the time (Grobbelaar, Usher, Cruywagen, de Necker & Hodgson, 2000). Hence, in eMalahleni– water resources like other resources on the planet that human beings depend on as commons – are in a way or the other also vulnerable to misappropriation through the tragedy of the commons. Mining as expected demolishes, distracts, and also capable of extremely polluting water resources (Miller, 1999).

Coal mining, particularly opencast mining, results in far-reaching environmental damage, and has enormous impacts on local water resources. In order to access the coal there is a need to pump groundwater out of the ground, and in the process valuable underground aquifers, streams and rivers are affected and sometimes destroyed. In addition, water quality is degraded downstream, and depleted aquifers can become polluted with contaminants from the mining.

When filling the voids created by opencast or underground mining, the eMalahleni collieries have been beleaguered by water decanting at the surface or seeping along strata (Grobbelaar et al., 2000). The snowballing mining impacts on water resources coupled with those of the sizeable manufacturing as well as municipal tons were signalled as the reasons behind the deteriorating quality of water. This had induced objections from the ecological, water, as well as mine regulators. As the Anglo collieries have been accumulating excess water, mine water is forced out at the lowest interconnection between the mine and the surface. It is projected that Anglo Coal had about 108 Mm3 of water stored in all its mechanisms (Golder Associates, 2010; Anglo Coal, 2012). As early as 1986, the Witbank and Middelburg Dams within the Olifants catchment began displaying a rise in sulphate and total dissolved solids (TDS), associated mainly with the coal mining (Grobbelaar et al., 2000). As highlighted in the Olifants water management classes report on national resource water quality objectives, in dams nearby mining operations, sulphate concentrations varied between 120–160 mg/l, and it is predictable that these concentration levels would have been

much lower (20–40 mg/l) if mining activities were not present (WWF 2011).

According to Ochieng et al. (2010), since the 1990s the growing regulatory burden, and the imported water price tag caused the introduction of some water management measures in the coal mining industry that were considered best practice at the time. Central to mine water management was the regulatory hierarchy that primarily encouraged the stoppage, before minimisation, then finally mitigating the consequential effects of mining on the water resources (Basson & Rossouw, 2003). Until that time, the plan to manage water would typically include the following measures:

i. Water stored in surface dams built with the aim of dispersing surplus water;
ii. Underground water storage or opencast mine workings; and
iii. Usage of mine water for coal beneficiation and mine waste transmission to excess disposal sites (Ochieng et al., 2010).

Obviously, solutions to the problem are by no means easy, but rigorous efforts by the likes of Anglo Coal mines have steered massive developments as well as reduction of ecological effects linked to the legacies of these notable coal-mining zones. Before 1991, the water quality management policy of the Department of Water Affairs and Forestry (DWAF) remained aligned to the Uniform Effluent Standards (UES) practice, (Younger, 2004). This policy on water quality management had its prime emphasis on point discharges, in order to deal with the perpetual causes of water pollution on the receiving water body.

Consequently, in relation to the established directives concerning engagements in the mines, further deficiencies were a result of combination of issues wherein management of water quality pertaining to mining was done independently by DWAF. Thus, water quality regulation relative to mining remained fragmented to additional actions. On the other hand, mining-related matters were handled by diverse offices though the management zone is not worlds apart (Brown, 2002).

This supports Ostrom's argument that "many cases of centralized governmental systems were not found to be effective, like the locally self-organized common-pool governance systems" (Ostrom, 2005: 222). This author maintains that there are different configurations of relationships among governmental, private, and non-profit

organisations that generate different solutions to social problems (Ostrom, 2005). This is evident due to the apparent lack of collaboration between the Department of Water Affairs and the Mineral Affairs Department that are primarily accountable for monitoring the impact of mine activities on water usage.

Addressing water quality in isolation could be short-sighted, as it may allow degradation of other water resource attributes and result in more pronounced water quality problems in the longer term. This was the case in the eMalahleni area, where environmental management and water use licensing was seen merely as compliance with legal requirements and formalities, as opposed to being critical issues for water governance. Hence, it was important for the researcher in this study to see the actors (including water quality managers, mineral resources managers, and environmental regulators, etc.) demonstrating the ability to devise own institutions to mitigate the effects of mine water pollution through treatment, re-use, and rehabilitation.

The DWAF Water Quality Management report (1993) on water quality management, revealed that, the Witbank Dam became the primary dam to suffer mine-related water quality effects, mostly owing to its locality and the number of coalmines in the Upper Olifants Catchment. Water quality monitoring studies show that the quality of water in the Olifants catchment, which spans the eMalahleni area, has unacceptably worsened over the years (Grobbelaar et al., 2000). As a result, the Olifants catchment remain notorious as one of the utmost contaminated rivers in South Africa (Palmer, 2001).

Due to surplus water decant from their mine processes, mines in their latter ages of mining lifecycle along with those beyond post-closure stage, have proven that treating excess mine water to acceptable stream discharge levels, as well as for alternative valuable usage, was still needed (Gunther et al., 2006). Consequently, the mining industry developed an inclination towards embracing and constantly applying ways to minimise the impacts of mine water on the environment. Grobbelaar et al. (2000) however, maintains that the economic and practical assessment of the alternatives to treat mine water resolved that owing to the high standards for river discharge, the treatment of potable domestic or mining use remains attractive. It was this final treatment option that indeed allowed Anglo Coal to commission the reclamation plant and sell the treated mine water to an end-user (eMalahleni local municipality), thus reducing water abstraction from the stressed Olifants catchment.

Since the National Water Act No. 36 was promulgated in 1998, the aim was partially to regulate mine water management to meet best practice mine water quality standards, an interesting history has shaped the current outcomes of the Anglo Coal reclamation plant to recover drinkable water from acid mine drainage in quite a few of its eMalahleni collieries. Mining companies in the Olifants catchment area have, for a long time, been investigating and in search of various mine water management options in order to tackle the water quality challenges associated with mining operations.

As revealed by the DWAF (1993) report on management water quality in the Witbank Dam, by 2001 mine water usage in the catchment averaged 4.6% and added about 78% to the total sulphate capacity (WWF, 2011). Whereas, by 2004 a projected fifty thousand cubic meters of mine water were released everyday into the Olifants river, and sixty-four thousand cubic meters per day was released from closed mines and those mines with unknown owners. According to the WWF (2011), such pollution levels had negative effects on the population residing in the catchment, as well as on local farmers, holidaymakers and the environment in the Kruger National Park.

In recent times, the emphasis has progressed, wherein nowadays the centrality of mine water to the management of mine operations, is recognised. The change from looking at excess mine water as an impediment to being a treasured resource, within the Upper-Olifants Catchment is the order of the day, at present (Gunther et al., 2006). Treating mine water to an appropriate class suitable for human consumption whilst meeting the discharge water quality requirements, was the reason that Anglo Coal commissioned the eMalahleni Reclamation Plant.

Thus, the use of membrane-based salt removal as a technology of choice, has resulted in the huge supplies of surface and underground water that occurred at the Anglo Coal mines, which nowadays remains the main source augmenting potable water supply. It is therefore evident that water of good quality has turn out to be a valued product for certain mines; placing the availability of excess mine water in a new perspective in the mine beleaguered Olifants catchment (Grobbelaar et al., 2000). Treating the mine water does not merely help with the meaningful mitigation of water course pollution in the area, but also delivers good quality water to the Upper Olifants Catchment that is going through water supply insufficiency.

The successful commissioning of the Anglo Coal Reclamation Plant in 2007 brings testimony to this paradigm change (Gunther, et al., 2006). Concurring with Ostrom's (1990) argument on the attributes of resources that are conducive to appropriators' self-organisation, Anglo Coal realised that the common pool resource system was vital to its continued livelihood, hence the motivation for self-organisation in mitigating mine water pollution. Furthermore, given that water is inherent in all aspects of Anglo Coal's mining business, the mine recognised that the benefits of the treatment plant in mitigating total suspended solids in water affected by mining activities far outweighed the costs incurred for treatment. This cost-benefit analysis is a highly important aspect of self-governance. Thus, the following sections explain the institutional arrangements of Anglo Coal and, using Ostrom's design principles, determine whether the mine was successful in sustaining local environments and its own livelihood.

4.3 Research Objective 2: To probe the water institutional arrangements of Anglo Coal mine

Research Finding: Anglo Coal mine and its institutional arrangements

Amidst the change in mine water management models, self-governance is uncommon in the South African mining sector. In considering Ostrom's disposition for a self-governance arrangement that users themselves develop and put into effect protocols concerning the common resource, Anglo Coal has opted for such a system as part of their institutional arrangements to mitigate the local condition of limited water resources and/or diminished water quality in the eMalahleni area. Anglo Coal has been determined in adopting an institutional framework that supports self-governance through the endorsement of mine management's continual water quality monitoring as a crucial measure for managing its water.

Tshwete et al. (2006) argue that efficient management of mine water is a regional matter in the Upper-Olifants Catchment; hence suitable answers to mine water problems are not linked to the boundaries of coal mining rights. However, the study revealed that Anglo Coal has set clear boundaries for both the managed resource and individual mines with the right to use the reclamation plant. It was within these parameters of rights between the three member collieries using the plant where well-tailored operational rules to facilitate and sustain the treatment system were established.

4.4. Reseach objective 3: To determine what extent did rulemaking in self-governance of the reclamation plant succeed in mitigating mine water pollution and improving water quality?

Research Finding 3 - Extent to which rulemaking in self-governance of the reclamation plant succeeded in mitigating mine water pollution and improving water quality

Ostrom's principles of self-governance hold that users of common pool resource should institute then put into effect own rules to safeguard the shared resources (Ostrom 1992). The results of this study show that the governance of the reclamation plant has several characteristics in common with what is regarded as an enduring self-governing CPR. The findings suggest that even though mining has historically negatively affected its surrounding environment, Anglo Coal's efforts to establish an institutional framework through advances in technology (such as its reclamation plant), and adaptations in water management systems, imply that many negative effects on the quality of water were avoidable. The successful self-governance of the reclamation plant and associated mine water can be attributed to Anglo Coal's self-styled institutional arrangements (Gunther, 2006). "The operational rules and the self-governance collaboration amongst the big mining houses (Anglo Coal, South 32 and Glencore has assisted these mining houses in managing their water volumes associated quality of water and building of water treatment plants", (Gunther, 2006).

Anglo Coal adopted the following three-tier strategy that integrates the value of water into their institutional processes and decisions:

a) Be Disciplined: get the basics right;
b) Be Proactive: encourage operations to go beyond compliance (hence they treat mine water to drinking water standards); and
c) Build Resilience: recognise the mine as part of the broader, catchment-level water quality solutions.

The study found that the condition of the water quality improved from the time the three-tier strategy was established, and that Anglo Coal has considerably minimised the impact of mine water pollution during and after mining. According to one participant in the study, Anglo Coal operates the reclamation plant in line with the above three-tier strategy, which is designed to deal with, among other aspects, the dewatering of opencast and underground reserves from its member mines, Landau, Kromdraai &

Kleinkopje. It should be noted that under the three-tier strategy, there are official provisions regarding decision-making and the right to participate on equal terms of all three water quality managers from Landau, Kromdraai and Kleinkopje mines.

Like many other local municipalities in South Africa, eMalahleni municipality struggles to provide high-quality and reliable supply of municipal water services as result of resource as well as capability limitations. According to a study participant, Anglo Coal, through their three-tier strategy, was able to influence treatment rules, making it feasible to pump excess mine water from its Kleinkopje, Landau and Greenside Collieries, and treat it to drinking water standards that suited local conditions. This participant indicated that water quality managers were able to successfully mobilise mining resources and capability to support the provision of the necessary service to local communities, which ensured that the 25ML/day reclamation plant capacity was fully realised. In addition, with the adopted treatment rules, the reclamation plant managed to successfully achieve the overall recovery design value >99.0%, and a liquid waste production not as much of than 1%. The three-tier strategy thus made it possible for the eMalahleni community to have a guaranteed source of drinking water that needed no further treatment.

In agreement with Tshwete et al. (2006), assuming an ecological viewpoint, the study showed that the three-tier strategy treatment rules to reclaim mine water to potable standards helped to clean an enormous body of polluted water and prohibited severe environmental damage caused by excess mine water. One participant insinuated that, without the effective governance of the reclamation plant, the contaminated mine water might constantly rise to a decant level, bringing about undesirable impacts on the receiving water bodies downstream (Naauwpoort Spruit, Witbank Dam, & Olifants River). Rulemaking, based on the three-tier strategy, thus prevented polluted water decant from taking place. The participant at Anglo Coal further confirmed that adopting this common-sense ethic of making their own mine water treatment rules was the only way to guarantee remarkable mining prospects do not turn out to be terrible polluted streams.

Being a conscientious mining house, Anglo Coal has mitigated many of the potential mine water pollution impacts. While there is always a necessity to employ unsurpassed strategies for pollution prevention in cases wherein the water quality

threats are managed, a key informant maintained that self-governance through rulemaking is a basic condition for the formation of sustainable and efficient water quality management at Anglo Coal.

The study revealed that rulemaking through the three-tier strategy enabled the company to involve members of the public in its decision-making processes. Municipal officials revealed that because of their vested municipal and environmental interests, they had the ability to influence Anglo Coal's decision-making processes through participating in discussions, without feeling any intimidation. Moreover, participants in the study affirmed that their views were considered when the decisions regarding treatment of mine water to potable standards were made.

The study found that contemporary mine planning rules and feasibility determination assisted Anglo Coal in predicting water quality during post-mining, post-reclamation, and the designing of mitigation plans. A respondent observed that the sulphate associated with coal mining typically represents about 50% of the total salinity load in the catchment. Hence, the focus on mine water rules and regulations supported the Anglo Coal Reclamation Plant in keeping acceptable water quality standards.

An official interviewed at the Water Research Commission claimed that it is worth noting that not all mine waters issues are 'bad news'. The official contended that the eMalahleni Reclamation Plant was the best practical example in which rulemaking, based on the three-tier strategy, allowed mine managers to treat mine water to potable standards, and to distribute more volumes of water to the local municipality, which otherwise would have experienced shortages of good quality water. In line with the self-governance principle of adapting to local conditions the plant met around 12% of the water requirements of the water-stressed local municipality. To date, the eMalahleni Reclamation Plant has treated more than 70 billion litres of water, 50 billion of which have been supplied to the eMalahleni local municipality (Anglo Coal, 2015).

Further worth noting, the eMalahleni Reclamation Plant has been issued with Blue Drop certificates since 2011 (DWA, 2011), and in 2012 Anglo Coal Water Reclamation Plant scooped the award for Best Community Project in Africa category at the Asia Mining Global Sustainability Awards (Bhagwan, 2012). As required by the DWS, the mine must take environmental conservation seriously, avoiding any decants as well

as discharge of contaminated mine water. It must also adhere to the environmental liabilities post-closure ensuring that such are commensurate with in-stream and recommended water quality objectives for the catchment. It is thus remarkable to note that, despite being subject to the obligatory state rules for coalmine water management throughout the mining lifecycle, Anglo Coal has exercised its right to create its own institutions and the right to self-govern. As highlighted by Tshwete et al. (2006), the three-tier strategy enabled the management of coal mine water to potable standards and facilitated the discharge of good-quality water to the Naauwpoort Spruit. This was developed in support of the limited water resources and also reserve the least possible base flow of good quality water in the local streams (the water resource reserve in terms of the National Water Act No. 36 of 1998). Somehow, this was a reward to the catchment for the destruction of the regular base flow in watercourses connected to operations in proximity to coal mines.

4.4 Research Objective 4: To assess the monitoring and enforcement of water treatment guidelines

Research Finding: Role monitoring and enforcement played in the self-governance of the reclamation plant in mitigating mine water pollution

According to Ostrom (1990), appropriators need to put forward their own operational rules, which are to be monitored by those who are answerable to them. Ostrom (1990) further defined rule enforcement as a situation wherein observers, who enthusiastically audit common pool resource conditions as well as the behaviour of the appropriators, are themselves held responsible. By participating in monitoring, the appropriator learns about the level of self-styled voluntary compliance required to make self-governance work. In other words, Ostrom argues that rules are better enforced through effective monitoring by monitors who have the responsibility of checking the physical condition of the resource and the users. This is because even in cases where rules are prepared to suitable indigenous situations together with consumers' participation in decision-making, lure towards breaking up rules may exist (Ostrom, 1990).

Monitoring thus increases the likelihood of violators being seen and held accountable. The costs of monitoring are kept relatively low in many long- surviving common pool resources as result of the rulebooks being used (Ostrom et al., 1994). This study

revealed that a comprehensive programme to monitor plant performance is in place at Anglo Coal. This monitoring programme helps to prevent periodic failure of the stage one reverse osmosis feed pumps. This systematized discharge patterns were proclaimed in 1997, with the support of industrial stakeholders in the catchment.

Businesses in the Mpumalanga Province (comprising mining houses and power stations) contributed substantial resources as well as in service investment in the reclamation project. In order to monitor and maintain the proper water quality levels, Anglo Coal alone invested millions to fit the online instrumentation required for constant monitoring (Gunther & Mey, 2008). According to participants in the study, the reclamation plant uses a HiPRO process, wherein less saline water is produced by means of a membrane technique. The produced water is stored batch-wise in reservoirs, and quality re-tested before it is pumped to the municipal reservoirs.

The participants in the study further confirmed that 35 staff members were actively involved in monitoring plant processes and were responsible for maintaining plant operability. The mine water flows from the collieries are monitored through feed ponds for optimal monitoring. At each water quality monitoring point, the monitors ensure that the discharged water meets the quality standards and complies with the specified parameters and standards for water quality.

The study observed that feeds are monitored using a methodology based on rules established from an assimilated hydrodynamic salinity model which, regulates the scheduling as well as extent of discharges. It was revealed that Greenside and Kleinkopje collieries discharges were not far from neutral pH, whilst the discharges from Landau have high acidity. It had been suggested that over time, a blending programme should be existent to circumvent fluctuating discharge chemistry triggered by disproportionate flows to some extent from one source, even though the reclamation plant could put up with this, in keeping with the requirements for proportionate amounts of feed and operator safety optimised controls, it was realised that continuous blending throughout the day is more appropriate to help achieve an overall recovery design value >99.0% and making waste of less than 1%.

The study succeeded in instituting a level of similarity amongst the stated rules and the local conditions under which the plant was expected to operate. It was revealed

that the eMalahleni Local Municipality and Anglo Coal had signed a bulk water supplier agreement which requires the mine to supply water that meets the 2006 SANS241 drinkable water standards. These standards outline the determinants as well as parallel parameters to be measured in order to standardize drinking water quality that is nontoxic for human consumption. Any water that is found not compliant with SANS241 (2006) standards is not added to the municipal water supply and is instead returned to the reclamation treatment plant for re-processing. Furthermore, the findings showed that monitoring of the plant and routine maintenance was fully automated, requiring human intervention only for chemical changeovers.

The study also established that the rules for using water resources as well as the mandatory water quality guidelines are suitable for the local conditions. The water quality managers have developed site-level water action plans (WAPs) that take local catchment priorities into consideration. According to one participant, on-going enforcement of the WAPs has assisted the managers in implementing the policies and standards of the company in congruence with the local context.

Applied to all stages of the mining water cycle, the WAPs are used to promote efficient water management through avoiding waste, minimising loss, and reusing and recycling water. An intrinsic part of the WAPs enforcement is continuous stakeholder engagement that links with other local operational plans, including local community development, social investment, and biodiversity conservation programmes.

The study revealed that the reclamation plant management has the ability to influence the plant operations and maintenance rules that are required to ensure the necessary physical and geochemical heterogeneity and post-closure water balance. This ability has helped management in applying active pollution prevention management actions relevant to local conditions, and in ensuring that the quality of the discharge and the impact of the seepage on the water resource are acceptable.

The participants in the study confirmed that comprehensive recordings of the routine operations in the plant were saved automatically, also manual copies were safely stored for imminent referencing. Consistent reviews are undertaken to make sure that the reclamation plant addresses the entire water quality suggested criterions. It was revealed that besides the automated machinery, a comprehensive quality guarantee

along with an operative controller arrangement is in place. This ensures that important water testers are periodically abstracted in order to continuously validate the accuracy of on-line outcomes. The key informants indicated that in order to ensure on-going monitoring and compliance with water quality standards, Anglo Coal is required to submit detailed water quality monitoring reports to the DWS. The mine also undertakes regular performance assessments (usually every two years) and submits the results to the DMR.

The case study established that Anglo Coal and the municipality have established an operations liaison committee for the purpose of monitoring performance against water quality targets and planned volumes of water coming out of the plant treatment processes. An arrangement that was agreed after a supplier agreement was signed between the two parties. Regular meetings held by the committee serve as a mode to standardize contracts to supply water and service provision arrangements between Anglo Coal and the eMalahleni municipality. Monitoring ensures that rule-breakers not complying with the stated rules are noticeable to the community. This approach enables the success of rule implementation instruments whilst informing the deliberate as well as conditional behaviour of participants who adhere to the rulebook. Given the foregoing, the situation serves to reason that the Anglo Coal self-governance system far surpasses the monitoring capacity of government. In fact, it is important to note that it was due to the limited capacity of government that led Anglo Coal to take up self-governance by making its own rules for mine water treatment and monitoring and enforcing such regulations.

Although the DWS has appointed the Blue Scorpions water law enforcement unit to execute these responsibilities, evidence elsewhere has shown that government monitors tend to be inexperienced (WWF, 2011). The institutional capacity of the DWS has been found to be no match for their private sector allies, the well-experienced and well-versed mining managers. This study thus corroborates findings yielded by similar studies which have shown that managing common pool resources effectively depends on the local users' capability to oversee performance and the conditions that affect the resource.

4.4 Conclusion

In assessing self-governance role in mitigating the effects of mine water pollution, we

can conclude that indeed, where effective rulemaking by mining companies and extra monitoring and enforcement controls are in place, successful interventions are contingent upon the users' competency to define the CPRs rules. In the context of this case study, Anglo coal developed appropriate rules and monitoring mechanisms that were consistent with the conditions that characterised the way in which the mine is operated. It was clearly demonstrated that self-governance offered significant payoffs in the operations of the Anglo Coal Reclamation Plant, which augmented the efforts aimed at the improvements on the water supply and the quality of water in the eMalahleni local municipality.

The eMalahleni Reclamation Plant may have largely been successful in accomplishing its intended objectives to reduce sulphate uses and improving the mine water quality in the Olifants River catchment. Employing self-governing principles involving rulemaking, monitoring and enforcement of those rules, Anglo Coal managed to address the water quality problems in the Olifants catchment successfully, thereby providing valuable support to the local municipality as well as the community. This has increased awareness about the nature and substance of self-governed water quality management amongst other coal-mining operators in the catchment.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

5.1 Introduction

This chapter discusses the study's findings and their implications for policy makers, mining sector and the water sector in general. The main aim of this study was to explore the role of self-governance in mitigating mine water pollution effects, using the case study of the Anglo Coal Reclamation Plant in eMalahleni. It appears from the overall findings of the study that there is supplementary evidence to support the concept of self-governance and its potential to promote sustainable mine water management and improved water quality. Based on the theoretical framework in Chapter 2, this chapter also presents a summary of key findings linked to the case-interrelated study objectives stated in Chapter 1. The study examined the mine water challenges and governance responses in complex commons systems in the light of increasing socio-ecological conditions and deteriorating quality of water in the Olifants catchment. This case study attempts to contribute some important components of contemporary mine planning rules and feasibility determination in predicting water quality during post-mining, post-reclamation, and the design of mitigation plans.

5.2 The extent to which rulemaking in the reclamation plant succeeded in mitigating mine water pollution and improving water quality

Ostrom (1990) stressed the significance of aligning institutional arrangements to resource conditions. As argued at the beginning of this study, the water supply situation in eMalahleni municipality was such that the demand exceeded the supply. Hence, the study has demonstrated how Anglo Coal's three-tier strategy has integrated the value of water into their institutional processes and adapted their decision-making to the local situation, as well as determining that mine water from its three collieries must be treated to potable standards. As a result, the study concluded that the institutional framework of Anglo Coal Reclamation Plant has assisted in dealing with the water resource dynamics in the eMalahleni area. The researcher found, therefore, that the alignment of institutional arrangements with local conditions is suggestive of the benefits of self-governance in providing good quality water to the eMalahleni municipality, whilst allowing for Anglo Coal to continue with its mining operations.

In view of the quality of mine water that was released into the Olifants Catchment, which, prior to the commissioning of the Anglo Coal Reclamation Plant, was often severely polluted, the researcher found proportional equivalence between the institutional framework of self-governance and the improved water quality management. Logically, Ostrom's principles (1990) have undeniably provided a strong framework for successful institutions, that were from this time forth useful in providing guidance on mine water management at Anglo Coal and have contributed towards improved water quality management. Furthermore, the appropriation of the rulemaking principle has successfully addressed the sustainability of a good quality water supply and improved the livelihood of the eMalahleni community, who are now receiving potable water treated at the reclamation plant.

This study set out to determine how rulemaking has succeeded in mitigating mine water pollution and improving water quality. Throughout the study, the researcher found evidence confirming the potential for the mining sector to fulfil effective self-governance arrangements as advocated by Ostrom. Furthermore, the researcher concluded that the features of the Anglo Coal Reclamation Plant and the adopted treatment rules made it viable to pump excess mine water from the Kleinkopje, Landau and Greenside Collieries, and treat it to drinkable water standards. The achievement of the overall plant recovery design value >99.0% and the documented liquid waste production of less than 1%, illustrates how rulemaking in the reclamation plant was used to improve water quality.

After applying Ostrom's principle of rulemaking, the researcher found that it indeed brings about a new perspective in water quality management. Water quality managers can now implement and encourage autonomous arrangements within the parameters established by the DWS, as the water resources custodian. Although there are not many documented examples that illustrate how self-governance can be used to improve water quality, there is a corresponding case, as reported by Ostrom that promotes the sustainable governance of forests in India. Rulemaking in community forestry institutions in India was used to promote the sustainability of institutions. These examples communal forestry institutions are well documented in the literature on institutions governing common pool resources. In a Japanese case study of sustainable fisheries working under a self-governance system, regulations were set

up for the fishermen to follow. Hence, with the freedom given them to govern the resource using the self-governance framework, sustainable fisheries were promoted (Sarker et al., 2015). These regulations were reasonable and essential particularly for the lobster fishery to ensure that a viable lobster stock is well-preserved.

5.3 The role played by monitoring and enforcement at the reclamation plant to help mitigate mine water pollution

Ostrom (1990) maintains that despite the assumed resource users' lack dedication to spend time monitoring and endorsing one another's performance, there is enough evidence that suggest that they do both in this situation. Consents and enforcement give rise to opinions suggesting that some consumers might put up with the set rules, therefore resulting to the obvious possibility that their contribution will yield benefits. "This gives the impression on the resource users capability to recognize benefits in pledging some of their time to observe the behaviour of other users as this offers confirmation for compliance levels that the user may bring into play in support of their tactical resolutions, as well as redeliberating the guidelines for reducing the potentials for rule-violation behaviours witnessed" (Ostrom, 1990:97). Indeed, an interesting conclusion, because it challenges preceding rulebooks on the preparedness by consumers through their dedicated efforts to monitor and also recommends an added responsibility towards resource monitoring driven mainly by various users in the water sector.

5.4 Self-governance as a strategy to mitigate mine water pollution

The study's aim was to determine the role of self-governance in mitigating the effects of mine water pollution in eMalahleni Anglo Coal Reclamation Plant. The researcher's first objective was to determine water quality management in eMalahleni. The study has established that little oversight of mining operations by the central government, coupled with weak institutional oversight, has resulted in the alteration of hydrological regimes and a continuing deterioration of quantity and quality of water downstream. This substantiates Ostrom's argument that: "many cases of centralised governmental systems were not found to be effective like the locally self-organised common-pool governance systems". Of significant concern is the impact of an increasing number of abandoned and/or closed mines, which, if not properly managed, may lead to a rise in mine-impacted water. However, in recent times, there has been new insights on mine water wherein it is now regarded as a valued resource critical to the management of

mining operations in the Upper-Olifants River Catchment, particularly by the irrigation sector. The implication is that the impact of coal mine water irrigation on aquifers should be minimal when irrigating for a short period.

Study results suggest that Anglo Coal has succeeded in implementing an institutional framework that supports self-governance through the endorsement of mine water management, and its continual water quality monitoring as an essential part of its water management. In line with Ostrom (1990) design principles, Anglo Coal has set clear boundaries for both the managed resource and the individual mines that have the right to use the reclamation plant. It was within these borders and bundles of rights that its member collieries (Kleinkopje, Landau, Greenside and the South Witbank Collieries), established well-crafted operational rules to facilitate and maintain the treatment system. The three-tier strategy made it possible for the eMalahleni community to have a guaranteed drinkable supply of water that required no additional purification.

From the study findings, it can be concluded that the institutional framework of Anglo Coal Reclamation Plant has assisted in dealing with the water resource dynamics in the eMalahleni area. Thus, it must be concluded that the alignment of institutional arrangements with local conditions does, to a large degree, suggest the benefits of self-governance in providing good quality water to the eMalahleni municipality, and that it allows for Anglo Coal to continue with its mining operations.

The results demonstrated that the Anglo Coal's three-tier strategy has incorporated the value of water into their institutional practices, and has adapted their decision-making to the local context by ruling that mine water from its three collieries must be treated to potable standards. Furthermore, with the adopted treatment rules, the reclamation plant managed to successfully achieve a complete reclamation design value.

The governance system of Anglo Coal is that of developing and enforcing regulations concerning their mine water management. With respect to rule enforcement at the reclamation plant, the water quality results show that systematic monitoring is conducted essentially to make sure that the reclamation plant is compliant with rules.

This supports Ostrom's principles of maintaining frequent uncompromising communication, thus confirming that the users in the case study are supportive of effective monitoring and rule enforcement, and are aware that sanctions can be invoked.

The water balance from the collieries is monitored as part of the mine water management system which included forecasting and sufficient monitoring of hydrological conditions. At each water quality monitoring point, the monitors ensure that the discharged water meets the prescribed quality standards and complies with such parameters and standards as specified for water quality. The study observed that feeds were monitored using a rule-based approach succeeded in promoting an integrated replication model that prompts the control and capacity of releases. It was confirmed from the detailed plant performance records that the reclamation plant has was useful in achieving a mine water quality monitoring programme that included outflows and mine water inside the mine.

Most important aspects of successful resource management rely on an efficient monitoring system, regular participation by the users in local management, and the legal right to exclude outsiders and evict encroachers. However, the underlying practices of systems matters little if the users do not accept and support the rules and norms established for the common property resources. It was confirmed in this study, that all member collieries using the plant (Kleinkopje, Landau, Greenside, and the South Witbank Collieries) support the treatment rules and norms of the mine water management.

5.5 Implications of the study

In the next section, the researcher discusses the study findings and the implications thereof for the water and the mining sectors.

5.5.1 Policy Implications

Ostrom's (1990) design principles reveal several core challenges that occur in mine water governance and water quality in South African context. These include the requisite consumer as well as resource borders, the significance of participants' aptitude towards collaborative development and monitoring of the rules, whilst

enforcing the penalties. The effective management of mine water in the Upper-Olifants River Catchment is undoubtedly a regional issue; hence a proper way out of mine water problems is not automatically bound by the rights to coal mining. Despite the fact that the DWS anticipated that CMAs would address local-level organisation and rulemaking, as a result of the relaxed approach to put these regional institutions into operation, that has not materialized. Recently, mine water governance system adopt rules according to the regulations, taking the form of agreements on water quality management plans. Therefore, the onus remains with the DWS to expedite the establishment of CMAs in order to deal with mine water management and water quality at the regional level.

Ostrom (1994) argue that characteristics of successful institutions gives light to the fundamental areas that need strengthening. Thus, stronger infrastructure is needed if DWS were to succeed in facilitating further support towards local governance and establishment of institutions in addition to communal rulemaking, modernize the monitoring network, and initiate cooperative governance for all complex stages in managing mine water (from the regulating department to the CMA to community-level). Thus, policy and legislation should advance to address more conventional water and mining management approaches. This requires reframing of the policy to address the specific challenges of mine water management that relate to improved water quality security. Ostrom (2005a) innovative design principles of operating CPR management institutions remain supportive to those developing countries planning to advance in building the most practical, involved as well as hands-on resource governance arrangement at a local level. In scrutinizing the execution analysis literature, it is evident that efforts by government to shape local involvement absorbed on its water quality governance regime have progressively came across some bottlenecks. However, findings from the eMalahleni Reclamation Plant clearly confirm the researcher's proposition that self-governance is an opportunity to innovative institutional arrangements to address mine water pollution.

Appreciating the challenges facing the South African mining sector, however, call for the focus be move beyond Ostrom's concentration on socio-economic and institutional levels. Ostrom argues that a political regime has a role to play in facilitating joint-select rules when "tolerating considerable local self-rule whilst investing in a regulatory

system of government" (Ostrom, 1990: 212), such as the current under-resourced Blue Scorpions of the DWS. Although Ostrom expresses her views on this subject, Agrawal (2001) contends that Ostrom's devoted attention on the political variables is rather lacking in certifying successful local organizations such as government strategies and governance systems. Agrawal further claims that Ostrom effectively pays no attention to state policies as well as governance provisions hence in the design principles they were not built-in as variables (Agrawal, 2001). However, these counter arguments do not by any means suggest defects in Ostrom's research, but rather some ambiguity leading to the prevalent unanimity in the commons literature that no single solution is suitable for all resource challenges, also under certain conditions, government aid remains indispensable if progress was to be accomplished in the management of commons, while in others, it may perhaps not be required at all.

5.5.2 Research Implications

Given the on-going studies on managing water quality, the need for further research focusing on the positive recognition of mine water as a water resource that contributes to closing the gap between water availability and water requirements, has been identified. Further research may also consider a framework for the authorisation of mine water treatment at a regional level. Additional research on how the local Water Services Authority (WSA) or any other sector is willing to use reclaimed mine water for their operations is required. New contractual agreements with the respective users of bulk water supply would create an assurance of supply at the required water quality standards.

Mines apply varying water quality governance standards due to weak enforcement and inconsistencies in various license requirements. While some mines may comply with minimum licensing requirements, others like Anglo Coal are more proactive, applying stricter water quality governance practices to appease external governance pressures such as listing requirements, investor and client demands, or the risk of reputational damage. Others may not comply at all, as the net cost of compliance exceeds the penalty imposed for non-compliance. Hence, mine water treatment at regional level is recommended.

5.6 Conclusions

The study sought to establish whether self-governance has an influential part to play in mitigating the effects of mine water pollution. Founded upon the findings from the eMalahleni Reclamation Plant case study, there is indeed evidence supporting the researcher's proposition that self-governance creates an opportunity for innovative institutional arrangements to address mine water pollution. The self-governance principle of rulemaking and local conditions was also confirmed in this case study, wherein it was found that the Anglo Coal institutional arrangements for treating water to potable standards does address the local conditions of the water-stressed eMalahleni local municipality. As the plant purifies water to potable quality, Anglo Coal meets around 12% of the water requirements of eMalahleni local municipality.

It emerged from the overall findings that there is supplementary evidence supporting the concept of self-governance and its potential to promote sustainable mine water management and improved water quality. Furthermore, evidence from the findings suggests that an institutional framework for self-governance that endorses mine water management and the continual water quality regulation remains an indispensable measure of managing water in a mine. The evidence confirms that by employing self-governing principles involving rulemaking, monitoring, and enforcement of those rules, the mine can successfully address the interim water quality problems in the catchment, and thereby provide numerous benefits to the local municipality and the community, as can be seen in the eMalahleni Reclamation Plant case study.

It can be concluded that where mines practice self-governance, there is less likelihood that they will transgress the mine water treatment rules, whereas, if the responsibility of monitoring is left to government alone, the transgression of rules will continue because the punitive measure of issuing fines to transgressors, and the cost of paying those fines, is far less than the benefits of extraction.

5.7 Recommendations

From the findings yielded on this research on the role of self-governance in mitigating the effects of mine water pollution, the following recommendations are made to intensify efficient mine water management in the eMalahleni region.

- Replication of self-governance by other mines in the region treating mine water and turning it into a reliable water resource should be considered in order to promote reconciliation of water supply and demand in the Olifants catchment.
- Given that mining houses like Anglo Coal have implemented an institutional framework that supports self-governance through the endorsement of mine water management, it is recommended that cooperation and collaboration between various mines in close proximity to the eMalahleni Reclamation Plant should add to and share the benefits of joint mine water management. Catchment-based institutional arrangements should be explored that will coordinate regional mines and mine water rehabilitation planning, thus ensuring cooperation between key mining houses in the eMalahleni region.
- It is recommended that there should be more convergence between the focal statutory regulations in the NEMA107 of 1998 and the NWA 36 of 1998, as well as the departments that respectively regulate and inform the industry rules with regard to environmental and water quality management. Furthermore, vital cooperation should be promoted between the officials dealing with water quality as informed by the NWA36 of 1998 and those of the NEMA107 of 1998.
- The Mineral Resources Department and the Water and Sanitation Department should ensure that their planning and functions are aligned with the objectives of coherent regional mining and water management. Opportunities to ensure this association through mining or water licenses must be explored and recommended.
- A proactive approach to mining should be adopted if the mining sector were to avoid environmental hazards. Thus mines can achieve this by developing good models during the early stages in the mine- life cycle until final closure and rehabilitation.
- The importance of the ‘polluter pays’ principle should be elevated, as currently some mines still perceive that the positive benefits from extraction outweigh the cost of the fines; therefore, the extraction and resultant pollution of water resources will, in all likelihood, continue. However, for the principle to be effective, it needs to be supported by strict central government oversight of mining operations by using strong institutions in order to avert the continued alteration of hydrological systems together with the decline of water quality downstream.

- Considering the effectiveness of the self-organised reclamation plant, it is recommended that other mines should consider self-governance strategies whereby they would make, enforce and keep the rules internally rather than leaving that duty to the government.

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