THE IMPACT OF LICENSING ON SELECTED HAZARDOUS WASTE DISPOSAL FACILITIES IN SOUTH AFRICA

by

Zinhle Teresa (Mbili) Dlamini

Submitted in accordance with the requirements for the degree of

Master of Science

in the subject of

Environmental Management

at the

University of South Africa

Supervisor: Dr R du Plessis

Co-supervisor: Prof L Sandham

February 2023

DECLARATION

Student number: 48533718

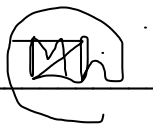
I hereby declare that the dissertation, which I hereby submit for the degree of Master of Science in Environmental Management at the University of South Africa, is my own work and has not previously been submitted by me for a degree at this or any other institution.

I declare that the dissertation, '*The impact of licensing on selected hazardous waste disposal facilities in South Africa',* does not contain any work presented by other persons whether written, pictures, graphs or data or any other information without acknowledging the source. I declare that where words from a written source have been used, the words have been paraphrased and referenced and where exact words from a source have been used, the words have been placed inside quotation marks and referenced.

I declare that I have not copied and pasted any information from the Internet, without specifically acknowledging the source and have inserted appropriate references to these sources in the reference section of the dissertation or thesis.

I declare that during my study I adhered to the Research Ethics Policy of the University of South Africa, received ethics approval for the duration of my study prior to the commencement of data gathering, and have not acted outside the approval conditions.

I declare that the content of my dissertation/thesis has been submitted through an electronic plagiarism detection program before the final submission for examination.

Student signature:  Date: _24/02/2023_____

(Ms Z.T. Dlamini)

PREFACE

Ethical considerations

This dissertation is based on data collected at hazardous waste disposal facilities and from external audit reports that belong to one waste management licence holder. Letters of consent were obtained from the licence holder (Appendix ii) concerned and from the Department of Forestry, Fisheries and Environmental Affairs (Appendix iii) responsible for issuing the waste management licences. Therefore, based on the research proposal and the necessary consent letters, ethical clearance was obtained from UNISA (Ref #: 2016/CAES/043 attached as Appendix iii) to continue with the research.

An attempt was made to protect the identity of the sites and the respondents, I have endeavored to avoid any direct reference to the name of the waste management license holder and the names of the sites. However, in a relatively small country with few licensed hazardous waste sites, those familiar with the waste industry will most likely be able to identify the sites. Despite this realization, the waste management licence holder granted consent and approved the study to proceed. The study is in fact a collaboration with the waste management licence holder to possible improve the governance processes. Furthermore, the waste management licence holder had an opportunity to review the dissertation and approved that the results of the study become part of the contents of the dissertation are suitable for examination. I believe that any potential ethical problems are eliminated.

ACKNOWLEDGEMENTS

- I wish to express my sincere gratitude to my supervisor, Dr Roelien du Plessis and my co-supervisor, Prof Luke Sandham, for their guidance and support. I would not have made it without them.
- To the research participants and the company, thank you for so much for trusting me with this.
- I also wish to thank my husband, Dr Zakhele Dlamini, for making me realise that it is possible ngithi Sibalukhulu, Mdlovu Magaduzela. To the big five (Sthabiso, Mongezi, Qiniso, Ukhona and Okuhle), for driving me crazy at times. Nevertheless, you are loved.
- Another acknowledgement goes to the Mbili family, for instilling in me the importance of education and that the sky is not the limit, ngithi Nontshongela, Ngoyi, Veshe, Shota. I will always treasure you and the seeds you planted.
- Last but not least, I express my thanks to God. I tried doing it on my own, but it did not work. When I invited You to come through, You enabled me. I shall continue to serve and praise You.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 2

CHAPTER 3

CHAPTER 4

LIST OF TABLES

CHAPTER 1

CHAPTER 2

CHAPTER 3

CHAPTER 4

LIST OF ACRONYMS

ECA	Environmental Conservation Act
DFFE	Department of Forestry, Fisheries and the Environment
DWAF	Department of Water Affairs and Forestry
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EU	European Union
GIS	Geographic Information System
IPPC	Integrated Pollution Prevention and Control Directive
LAWMA	Lagos Waste Management Authority
LCT	Leachate Control Threshold
LD	Land Directive
MPRDA	Mineral and Petroleum Resources Development Act
NEMWA	National Environmental Management: Waste Act
NWA	National Water Act
PPP	Public Participation Process
SANS	South African National Standard
SAWIC	South African Waste Information Centre
S&EIR	Scoping and Environmental Impact Report
TCT	Total Concentration Threshold
TDS	Total Dissolved Solids
TOC	Total Organic Carbon

UK	United Kingdom
US	United States
USA	United States of America
VAGO	Victorian Auditor-General's Office
WAC	Waste Assessment Criteria
WEEED	Waste Electrical and Electronic Equipment Directive
WFD	Waste Framework Directive
WHO	World Health Organisation
WML	Waste Management Licence
WWTW's	Wastewater Treatment Works

ABSTRACT

This research evaluates the impact of waste licensing conditions on the operations of three selected hazardous waste disposal facilities, particularly in terms of compliance with conditions of the issued waste management licences (WML). Furthermore, the costs that are associated with complying with WML conditions, the difficulties encountered by the landfill operators when complying with the WML conditions and the impact of licenced waste disposal on groundwater, was also evaluated.

In South Africa, at the time of this study only seven commercial hazardous waste disposal facilities were licensed. However, construction at one of these facilities had not commenced, operations had just commenced at another, and one site was being decommissioned. Therefore, three waste disposal facilities were selected for this study when access to the fourth facility was withdrawn.

Qualitative research methods were used to collect data, to evaluate difficulties encountered by landfill operators while ensuring compliance and the costs that were incurred while ensuring compliance. An open-ended questionnaire was used to collect data on difficulties, while a semi-structured questionnaire was used to collect data on the costs that were incurred, and the responses to the questionnaires were provided during site visits conducted by the researcher. The effects of licenced waste disposal facilities on groundwater and the evaluation of landfill compliance with waste management licence conditions were assessed by reviewing external audit reports for the past three years.

The findings of the study revealed that the landfill operators have largely been able to comply with WML conditions even though there were difficulties with some of the WML conditions. The study revealed that the costs of complying with conditions of a WML for a hazardous waste disposal site were very high. The study also revealed that the impact of waste disposal activities on groundwater quality was minimal at all three facilities at the time when the external auditors conducted the audits. The study recommends that authorities should work on improving efficiency when processing WML variation applications and there is an opportunity for future research on how authorities should improve efficiency in decision making.

CHAPTER 1
INTRODUCTION

1.1 Background

Numerous problems and potentially dangerous situations associated with hazardous waste disposal have caused increased public concern (Mokgae, 2011). This has led to the introduction of a range of legislative measures, aimed at improving waste management in the country by the Department of Forestry, Fisheries and the Environment (DFFE) as the department that is responsible for the protection of the environment in South Africa. The promulgation of the National Environmental Management: Waste Act, 2008 (NEMWA) led to the introduction of the licensing requirement as stipulated in Chapter five, thus repealing Section 20 of the Environment Conservation Act, 1989 (ECA) which required landfill owners to apply for a permit to operate a waste disposal site. While waste disposal is ranked the lowest in the waste hierarchy, it remains as the most common waste management practice (Mokgae, 2011). Hazardous waste disposal is also listed on the list of waste management activities that require a waste management licence (DEA, 2013d).

According to Oelofse (2014), policies and regulations are often identified as a potential limiting factor for growth in the waste sector. Furthermore, Oelofse (2014) states that compliance with the various requirements hampers the sustainability and growth of businesses, especially in the waste sector. Daily human activities result in the generation of waste that requires safe disposal. Waste management, from collection, storage, transportation and, to disposal stage, is therefore essential for the protection of human and animal life, plant species, together with the entire environment at large. This requirement is magnified in the disposal of hazardous waste, hence the introduction of licensing waste disposal in South Africa (DEA, 2008). In fact, Blackman (2016) stated that hazardous waste management has become a central issue in many fields, including the natural sciences, engineering, toxicology, epidemiology and technology, among many others.

Hazardous waste is defined as *any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental effect on health and the environment and includes hazardous substances, materials or objects within the business waste, residue deposits and residue stockpiles* (DEA, 2014b). On the same note, Mmereki, Baldwin, Hong and Li (2016) classified waste as hazardous if it displays hazardous properties like radioactivity, being flammable, irritant, toxic, explosive or carcinogenic.

According to Mmereki et al., (2016), hazardous waste is generated from clinical products, medical products, the use of vehicles and from fuel products like oil. As such, it is usually in the form of *industrial solvents, waste oils, industrial sludge and chemical wastes* (Mmereki et al., 2016: 40). Therefore, industrial waste could be classified as hazardous waste regardless of whether the waste is solid or liquid. It is important that hazardous waste disposal is conducted in a regulated and controlled manner. However, research by Mmereki et al., (2016), on hazardous waste disposal in developing countries, revealed that in many instances, it is disposed on unlicensed facilities.

Molleda and Lebo (2011) argued that over the past few decades, landfills have gradually developed from uncontrolled to controlled amenities for waste disposal, through the introduction of measures aimed at protecting the environment. Regardless, great concern remains about landfills because they require large spaces of land and controls to manage the sites and ensure environmental compliance. Moreover, they have great environmental pollution potential, because of both gas and leachate emissions (Molleda & Lebo 2011).

Pienaar and Howard (2014) defines waste disposal sites, as facilities whose main purpose is to store unwanted substances. These substances pose a threat to the larger ecosystem, including the environment, plant, as well as animal life. Acknowledging this, the South African government introduced Section 20 of the Environment Conservation Act of 1989 (ECA), as a step towards regulating the disposal of waste in landfills, while protecting the health of the environment and the mandate rested with the Department of Water and Forestry (DWAF, 1998). ECA therefore provided the first legal understanding

or definition of waste together with valuable requirements for waste management. In September 1994, the Department of Water Affairs and Forestry published the first Minimum Requirements for Waste Disposal by Landfill (DWAF, 1994). This series of publications focused on the implementation of the Minimum Requirements as a guideline to set standards for landfill establishment and operation (DWAF, 1998). The Minimum Requirements for Waste Disposal by Landfill series were developed in accordance with Section 20(1) of ECA.

Due to difficulties associated with the Minimum Requirements for landfill disposal being a guideline document that could not be legally enforceable, there was a need for legislation and regulations that could be enforceable. This led to the promulgation of the National Environmental Management: Waste Act, 59 of 2008 (NEMWA) (DEA, 2008) and later the enactment of the Waste Classification and Management Regulations, GN 634 of 2013, the National Norms and Standards for Assessment of Waste for Landfill Disposal and the National Norms and Standards for Waste Disposal to Landfill (DEA,2013b). The main objective of NEMWA was to improve waste management and regulation in the country (DEA, 2011a) and it did not only become useful in institutional planning, but also in controlling activities surrounding waste management and in ensuring compliance monitoring and enforcement.

On the 3rd of July 2009, a list of activities that were regarded as detrimental to the environment was published (GN 718), together with a prohibition on undertaking such activities without a waste management licence (WML) (DEA,2009). However, this list was repealed in November 2013 when Government Notice 921 published another list of waste disposal activities that could not be conducted without a WML (DEA, 2013d). While there was no change in the list of activities, it contained revised thresholds to ensure that small waste management facilities would not be subjected to the licensing process. It should be noted that since then, it has become mandatory to have a waste management licence before proceeding with activities listed in Categories A and B of the notice, which was later amended to include Category C (DEA, 2008). In addition, certain Norms and

Standards need to be followed when waste management activities are listed under Category C (DEA, 2013b).

General waste disposal is a listed activity in Category A and hazardous waste disposal is a listed activity in Category B as per the Government Notice 921(DEA, 2013d), however for the purposes of this study which focuses on hazardous waste, the activity is listed as, '*The disposal of any quantity of hazardous waste to land'* in Category B*.* Therefore, before attaining a waste management licence, in order to dispose waste in a lawful manner, there is a need to conduct an environmental impact assessment, in accordance with the Environmental Impact Assessment Regulations, 2017 (DEA, 2017) since these regulations were already an established system and had been the tool used to obtain an environmental authorisation. Therefore, the waste management licensing process followed suit.

1.2 Problem statement

DEA (2018) states that South Africa has more than 2 000 waste disposal facilities, yet most are not licenced (DEA, 2018). Oelofse (2014) stated that there is still much uncertainty about the legal requirements, especially because continuous amendments to regulating waste management activities were enacted over the past few years and this presented yet another challenge Oelofse (2014), hence the study will evaluate whether licenced waste disposal facilities comply with conditions. According to the National Waste Management Strategy, the reason for making licensing mandatory for waste management facilities is to ensure precise conditions to regulate waste management activities that may damage the environment (DEA, 2011a). Chapter 5 of NEMWA prescribes the licensing of waste management activities. DEA (2011b) states that WML conditions should be monitored, and enforcement actions taken to ensure environmental protection (DEA, 2011b). Hence the study would evaluate to what extent are hazardous waste disposal facilities able to comply with WML conditions.

According to a February 2014 newsletter about EnviroServ's Holfontein landfill facility, the site was meeting 99.5% of the applicable conditions (EnviroServ Waste Management,

2014). The newsletter points out that current economic conditions in South Africa can influence waste management facility operators to look for cheaper avenues for conducting business in a profitable manner, but such alternatives may end up being more expensive if conditions of the WML have requirements that might be expensive to comply with (EnviroServ Waste Management, 2014). Oelofse (2013) argued that business owners incur significantly higher costs in landfill design and construction in order to comply with the new approved requirements. While Oelofse (2014) indicated that the benefits of environmental protection were perceived to have increased because of new waste laws and policies. As a result, costs incurred may be justified from an environmental perspective, but not necessarily from a business perspective (Oelofse, 2014). Therefore, the impact of licensing on selected hazardous waste disposal facilities must be investigated to quantify cost in order to ensure compliance with WML conditions. There is therefore the possibility that authorities are unaware of the difficulties that licence holders face in ensuring compliance. The study would provide insight on the costs associated with complying with WML conditions.

Misra and Pandey (2005) argue that there is a threat regarding the contamination of ground water, including downstream surface water and water from wells, because of contamination from landfill leachate. This is one on the major difficulties associated with landfills, as evident in literature by Akinbile, Yussoff and Zuki (2012), on the treatment of landfill leachate. Akinbile et al., (2012) indicated that groundwater pollution was indeed occurring and that the water in close proximity to the landfills was considered unsuitable for consumption. In Nigeria, Aderemi, Oriaku, Adewumi and Otitoloju (2011) conducted a study on groundwater contamination by leachate near a municipal landfill site. According to Aderemi et al., (2011), the site where the study was conducted is known as Soluos, which is located in the metropolitan area of Lagos, therefore it is managed by the Lagos Waste Management Authority (LAWMA). The results from Aderemi et al., (2011) concur with the arguments by Misra and Pandey (2005) and Akinbile et. al., (2012), as they indicated that groundwater resources located in close proximity to waste disposal sites were unsafe for consumption. Therefore, the study will evaluate the effects of hazardous waste disposal on the groundwater resources.

Oelofse (2013) was the first person to conduct research to focus on the licensing of landfills in South Africa by reviewing the pieces of legislation to determine how waste management has evolved over the years. From that research, she published an article titled, “Landfills and the Waste Act Implementation – what has changed?” This article centred on issues pertaining to the licensing of waste disposal activities, a critical evaluation of the implications of NEMWA, and other waste management policies on landfilling in South Africa. One problem that was highlighted by Oelofse (2013) was the adequacy of literature and her inability at the time to find relevant articles and research that solely focused on licensing waste disposal and the same problem applied for this study.

Government has made progress in fulfilling the environmental right as enshrined in the Constitution of the Republic of South Africa, 1994, by publishing legislation that is specific to environmental protection (RSA, 1994). However, Oelofse (2014) argued that the government has conducted limited research or assessment on the possible impacts of new regulations on business operators before such policies are enacted for implementation (Oelofse, 2014). Because of that gap and the lack of a shared understanding between government bodies and businesses, new environmental legislation can present potential difficulties to business owners, while they are required to ensure environmental compliance. This study focused on commercial hazardous waste disposal facilities because authorities expect these facilities to comply with conditions of a WML and non-compliances lead to enforcement actions by the authorities. Oelofse (2014) stated that there is still much uncertainty about the legal requirements, especially because continuous amendments to regulating waste management activities were enacted over the past few years and this presented difficulties (Oelofse, 2014). Therefore, this study seeks to determine the governance difficulties encountered by landfill operators when ensuring compliance with WML conditions.

1.3 Study aim

The aim of this study is to determine the impact of licensing conditions on the operations of four selected hazardous waste disposal facilities, particularly in terms of compliance with conditions.

1.3.1 Research questions

1. To what extent are waste management licence conditions for the selected sites achievable?
2. What is the cost impact on complying with waste management licence conditions?
3. What are the effects of licenced waste disposal on groundwater?
4. What governance difficulties concerning compliance with waste management licences are encountered by landfill operators when ensuring compliance?

1.3.2 Research objectives

1. To evaluate the extent to which the landfill operators are able to comply with waste management licence conditions.
2. To determine the costs associated with complying with waste management licence conditions.
3. To assess the effects of licenced waste disposal on groundwater; and
4. To understand governance difficulties associated with complying with waste management licence conditions.

1.4 Study areas

According to the South African Waste Information Centre (SAWIC) only six commercial hazardous waste disposal facilities were licensed in the country at the time of the study. However, one of these facilities' construction had not commenced and the other facility had just commenced with operation, therefore four waste disposal facilities were selected for the purposes of this study. More details on the study areas are discussed in Chapter 3 of this dissertation.

1.5 Methodology

For the purposes of this study, the qualitative research method was used to collect data, external audit reports for the past three years were reviewed in order to gain a better understanding of the history of compliance at the selected waste sites and to fulfil Objective 1.

While a semi-structured questionnaire was used to collect data on the costs associated with complying with waste management license conditions which is Objective 2 of the study.

External audit reports were reviewed to assess the effects of licenced waste disposal facilities on groundwater resources which is Objective 3 of the study.

An open-ended questionnaire was used to collect data to understand the governance difficulties associated with complying and interviews were conducted with the relevant personnel and that is Objective 4 of the study.

Table 1.1: Summary of the research design

Objective	Method	Expected Outcome
1. Compliance with conditions	Review 12 External audit reports, site visits	Compliance/non-compliances ascertained
2. Cost of compliance	Semi-structured questionnaire	High costs determined
3. Effects on groundwater	Review 12 External audit reports	Compliance/non-compliance detected
4. Governance Difficulties	Open-ended questionnaire	Governance Difficulties identified

Source: Author's notes

1.6 Chapter summary

This chapter introduced the entire research outline by setting out the background, purpose and approach of the study. The aim and objectives that guided the study were outlined and the study areas for the collection of primary data, were described. The following chapter reviews legislation and relevant literature, within the auspices of the study objectives.

CHAPTER 2
LITERATURE REVIEW

2.1 Background

This chapter reviews the procedures for hazardous waste permitting and licensing internationally, in countries such as Europe, United States of America and Australia. Regionally, this chapter discusses waste permitting and licensing requirements in Botswana, Ghana and Nigeria. It further discusses the history of waste management licensing legislation that made licensing a mandatory requirement for waste disposal in South Africa. It is important to note that when literature was reviewed, it became apparent that there was limited literature on the impact of licensing of waste disposal facilities, hence the review of legislation and licensing requirements.

2.2 International legislation and practices

This section covers international waste legislation and regulations from countries in Europe, the USA and Australia that deal with the licensing of waste disposal facilities.

2.2.1 Europe

European waste management legislation governs requirements pertaining to the issuing of permits, the classification, and the monitoring of waste disposal activities. Such legislation includes, the Landfill Directive, the Waste Framework Directive (WFD), the Waste Assessment Criteria (WAC), the Waste Electrical and Electronic Equipment (WEEE) Directive and the Restriction of Hazardous Substances (RoHS) Directive (European Commission, 2012).

2.2.1.1 The Landfill Directive, 2014 (LD, 2014)

The main purpose of the Landfill Directive is to avert or reduce the negative implications of waste from landfills on the environment (LD, 2014). Based on the Landfill Directive, landfills are divided into three categories i.e., landfill for hazardous waste; landfill for non-

hazardous waste; and landfill for inert waste (LD, 2014). The category of landfill follows standard waste acceptance procedure, so as to mitigate the impacts posed by the landfill operations (LD, 2014). In the Landfill Directive, landfills are defined as *a waste disposal site for the deposit of the waste onto or into land (that is underground) and installations fulfilling this definition usually are subject to permit obligations under the Waste Framework Directive* (LD, 2014). It is the obligation of the permit holder to solemnly communicate that the landfill facility will be managed by a technically competent individual who can manage waste disposal, before the permit is issued (LD, 2014). Before obtaining a permit authorising the activities, proof of financial security needs to be given by the intended permit holder, as insurance that the obligations stipulated within the permit (even post-closure) can be fulfilled (DMR, 2002). As a result, even when the site is no longer operational, rehabilitation and monitoring processes continue to take place (LD, 2014).

Unless the business owner is able to prove that landfill activities adhere to legislative requirements, the governing authority will not issue a permit (LD, 2014). Landfill facilities must be operated with the necessary precautions in place to not only avert accidents, but to limit the consequences of accidents (LD, 2014). Financial security is a provision that is made to ensure the fulfilment of closure procedures, as indicated in the Landfill Directive (LD, 2014).

Finally, information pertaining to the landfill classification, operation, monitoring and control processes, landfill preparation conditions, as well as the authorised type and quantity of waste suitable for the facility is stipulated in the permit (LD, 2014). The permit also stipulates requirements in case of decommissioning, and these have to be complied with post closure (LD, 2014). Most importantly, the permit holder is obligated to report to the issuing authority, at least once a year, on the types and quantities of waste being disposed of at the facility, as well as on the results of monitoring assessments (LD, 2014).

2.2.1.2 The Waste Framework Directive (WFD, 2008)

According to the WFD (2008) any establishment with the intention of venturing into the treatment of waste should undertake a process of acquiring a permit. The WFD further

indicates that waste treatment pertains to the *recovery or disposal operations, including preparation prior to recovery or disposal* (WFD, 2008).

2.2.1.3 The Integrated Pollution Prevention and Control Directive, 2010

The Directive allows for integration in the permitting system and promotes cleaner production with less waste production (IPPC, 2010). Furthermore, according to the Integrated Pollution Prevention and Control Directive (IPPC, 2010), Member States of the European Union should cater for the participation of interested members of the public in the issuing of permits for new sites and when amending permits for existing facilities (IPPC, 2010). After the competent authority reaches a decision, members of the public should be notified of the resulting outcome (IPPC, 2010).

2.2.1.4 The Waste Acceptance Criteria Decision

The Waste Acceptance Criteria Decision regulates the process for waste acceptance. The process starts with an in-depth explanation of the waste depiction, waste composition and leaching values, together with acceptance processes to be followed at the landfill facility (WAC, 2004). When it comes to hazardous waste, the WAC is concerned with, granular waste leaching limits, together with Loss of Ignition (LOI) limits, Total Organic Carbon (TOC), as well as Acid Neutralisation Capacity (ANC) (WAC, 2004). In the event that some limits exceed those stipulated for the EU, the Member State determines the best procedures to ensure the same amount of environmental protection as stipulated by the WAC (WAC, 2004). Below is the process for waste acceptance at landfills (WAC, 2004):

- Basic characterisation

A thorough explanation of the waste to be disposed should be given. This is done so that limit values can be established on the basis of that characterisation. Moreover, it helps in determining the relevant frequency for the assessment of compliance. On the basis of this characterisation, the waste facility is placed in the appropriate class.

- Fundamental requirement for basic characterisation

Fundamental information which is important for the completion of the basic characterisation should be provided. It also contains the necessary information on the production, composition, appearance and sources of waste.

- Testing

Since testing is a critical part of the basic characterisation process, it is obligatory for every type of waste. However, testing methods differ for waste that is regularly generated or not regularly generated.

- *Cases where testing is not allowed*

Particular circumstances exist when testing is not allowed. Details of these circumstances should be provided.

- *Compliance testing*

At least once a year, compliance tests are necessary, in order to assess waste streams that regularly arise. The basic characterisation determines the parameters to be followed during the testing. Member states should indicate the timeframe for the operator to store the required information.

- *On-site verification*

Before and after loading, waste delivered to a landfill facility should be inspected. Again, Member states decide on the on-site verification testing requirements and the timeframe for the keeping of samples.

2.2.2 The United States of America (USA)

The Resource Conservation and Recovery Act, which was promulgated by the Environmental Protection Agency (EPA) introduced the waste permitting process in the US (RCRA, 1976). The act introduced requirements that were essential to follow for the treatment, storage and disposal of hazardous waste. In the United States therefore, waste treatment permits are granted by states such as the California, Texas and Washington or by the EPA, through their regional branches (RCRA, 1976).

The United States Environment Protection Agency has set out steps to follow in the permit application process and this is depicted in the table below:

Table 2.1 US EPA permit application process

Step	Action
Pre-application Meeting	*Meeting held between the applicant and the members of the public*
Application	*Applicant submits EPA forms 8700-23 and a lengthy narrative of the application is submitted*
Permit Agency Review	*The permitting office commences with its review and notices are mailed to individuals who were at the pre-application meeting to confirm receiving the application*
Notice of Deficiency	*A Notice of Deficiency (NOD) is issued by the permitting authority. This informs the applicant of any revisions or additional information that is required in the application*
Permit drafted	*After the necessary revisions are made to satisfaction, a draft of the permit is published for further public review.*
Decision Announcement	*A letter is sent to all individuals on the mailing list created from the pre-application meeting to announce the permitting agency's decision. Notices are also placed in local newspapers and broadcasted on radio*
Final Decision	*A final decision is made by the permitting authority to either grant or reject the issuance of the permit.*

Source: RCRA, 1976

In New Jersey, USA, a study was conducted by Montague (1982). The study focused on four landfill facilities that had been authorised to dispose of hazardous waste. The four facilities were, DuPont de Nemours & Co. Inc, Monsanto Industrial Chemical Corp, J.T. Baker Chemical Co. and Toms River Chemical Corp chemical waste disposal facilities.

In order to detect liner leakages in the four facilities, Montague (1982) used indicators such as Phenol Compounds, Chemical Oxygen Demand, as well as Colour and Total Dissolved Solids (TDS). All four facilities had fluid in the leak detection areas, in periods ranging from one to three months. Regardless, the study results indicated that there was no evidence of groundwater or environmental contamination. Montague (1982) also analysed permit conditions for the four landfill facilities and found key elements that had been omitted by the EPA. Hence, the EPA had not indicated the baseline period for the comparison of new observations, and they did not indicate in their regulations when a landfill should be declared as leaking, based on monitored parameter increases (Montague, 1982).

2.2.3 Australia

Australia has three different types of landfill facilities as stipulated in the Environment Protection Act, 1970. There are active landfills, which can only be operational with the issuance of a permit from the EPA. There are also closed landfills whose owners receive notices to manage risks, and there are landfills that can be operated without licenses (EPA Victoria, 2004). Because landfills are the least desired option for waste disposal, the Waste Management Policy was introduced in Australia on the 14th of December 2004, to regulate them (EPA Victoria, 2004). It is imperative to regulate waste disposal by landfill, because inspite of being least preferred method, landfill activities have continued (EPA Victoria, 2004). In Section 17 of the Waste Management Policy, specific landfills may receive exemption from acquiring licenses, but there should be a partnership between waste groups and the local government, so that guidelines can be developed for the design and management of such landfills, as part of a strategic programme to protect the environment (EPA Victoria, 2004).

According to the Victorian Auditor-General's Office (VAGO) (2014) in Australia, there is need for licence regulations that can be easily comprehended and upheld, that people can readily adhere to, and that bring into focus the dangers of non-compliance in the licensing and monitoring of waste disposal facilities. VAGO further indicates that there is silence regarding licenses that were issued before 2010. Furthermore, VAGO highlights

that licence regulations are mainly focused on managing risks at landfill facilities constructed after 2010.

There are numerous risks that are identified by VAGO as of high importance in the operation of landfill facilities. One of them is possible environmental pollution as a result of leachate generation (VAGO, 2014). Assessing this particular risk was of central importance in the current study, especially in light of the possible contamination of groundwater. VAGO further indicated that, though it is rare, landfill gas movement can have implications for human health. Moreover, the ineffective management of landfill facilities, coupled with the emission of bad odours can negatively affect the livelihood of local communities, aesthetics and historical sites (VAGO, 2014). For the current study, this information was crucial as it demonstrates factors that need to be considered as part of managing the aesthetics, health and livelihood of the citizens in areas where landfill facilities are located. Compliance in this regard becomes pertinent, because it is the bedrock that underlies the protection of the environment. The report that was compiled by VAGO concluded that the EPA utilised the same licence regulations for all landfills. The lack of site-specific conditions increases the risks of non-compliance (VAGO, 2014).

2.3 Regional legislation and practices

This section covers waste regulations in regional countries i.e., Botswana, Ghana and Nigeria. Legislation is presented first followed by the published research papers. This is aimed at allowing comparison of South Africa's progress with that of other countries and to determine alignment with other countries.

2.3.1 Botswana

The Waste Management Act (WMA), 1998 which was introduced by the Department of Sanitation and Waste Management regulates waste disposal activities in Botswana. Section 15(2) of the act prohibits waste disposal activities on any premises or land without a licence (WMA, 1998).

In order to obtain a licence in Botswana, an application should be made through the Department of Sanitation and Waste Management. When the application is lodged, the department may approve the licence if it meets the requirements stipulated in Section 8 of the WMA, (1998). The department also has to determine beforehand if the intended activities will not cause harm to the environment, to humans, or to plant and animal life (WMA, 1998). Also, consultations with the Department of Water Affairs are necessary in terms of Section 17, before the approval of every licence, in order to protect groundwater resources (WMA, 1998). It is important to note that according to Blight (2006), Botswana adopted the South Africa's Minimum Requirements, therefore the process is similar to that described under the Minimum Requirements

In terms of Section 8 of the WMA, persons undertaking waste treatment activities should be fit and proper and this refers to the applicant or the person appointed by the applicant. Interestingly, it is stipulated that the department's officers should also be fit and proper. They are required to have the necessary qualifications and experience in the area of waste, as the Minister may direct, from time to time, (WMA, 1998).

2.3.2 Ghana

In Ghana, the Government's Sanitation Agency requires that the certification and licensing of landfills for environmental protection should be done by the Environmental Protection Agency (EPA) (EPA, 2002). Ghana has three instruments to regulate waste management in the country (Sackey, 2015), namely the Environmental Assessment Regulations, 1999 (L.I. 1652); Landfill Operating Licences, issued by the District Assemblies, and the Landfill Guidelines, 2002 (EPA, 2002). These are discussed in more detail below.

2.3.2.1 Environmental Assessment Regulations (L.I. 1652) (1999)

The Environmental Assessment Regulations were introduced in 1999 (Sackey, 2015). Similarly, to South Africa, the regulations require that the assessment of environmental

impacts is conducted prior the construction of landfills. The EPA should issue a permit authorising waste disposal activity within 18 months and the development of the landfill facility can only commence once the Environmental Permit has been issued (Sackey, 2015). The permit is the first approval that has to be obtained after which a detailed Environmental Management Plan (EMP) should be submitted by the operator within 24 months of commencing with operations, to obtain an Environmental certificate which serves as the second approval (EPA, 2002) and contains liner requirements (EPA, 2002). For that reason, there needs to be confirmation of environmental compliance from the operator, based on in-situ results and inspections conducted on-site by the EPA (EPA, 2002). This indicates that, just as is the case in South Africa, Ghanaian authorities recognise the importance of compliance with specified regulations.

Environmental protection procedures that will be followed during landfill operations should be included in the EMP (EPA, 2002). These procedures should cover the period when the landfill is operational and the period after its closure (EPA, 2002). Annually, environmental reports should be submitted and after every three years, the operator should submit an updated EMP (EPA, 2002). In the event that the operator fails to comply with stipulated conditions in the Environmental Certificate, thus failing to uphold the obligation to protect the environment, the certificate may be revoked (EPA, 2002). This highlights the importance of conducting waste disposal activities with constant reflection on the impact of those activities on the environment.

2.3.2.2 Landfill operating licences

In Ghana, the licensing of waste disposal activities is done in accordance with each District Assembly's by-laws. Also, model by-laws effected by the Ministry of Local Government and Rural Development are essential (EPA, 2002). Like in South Africa therefore, landfill operators in Ghana cannot commence with operations prior to licensing, for the protection of the environment.

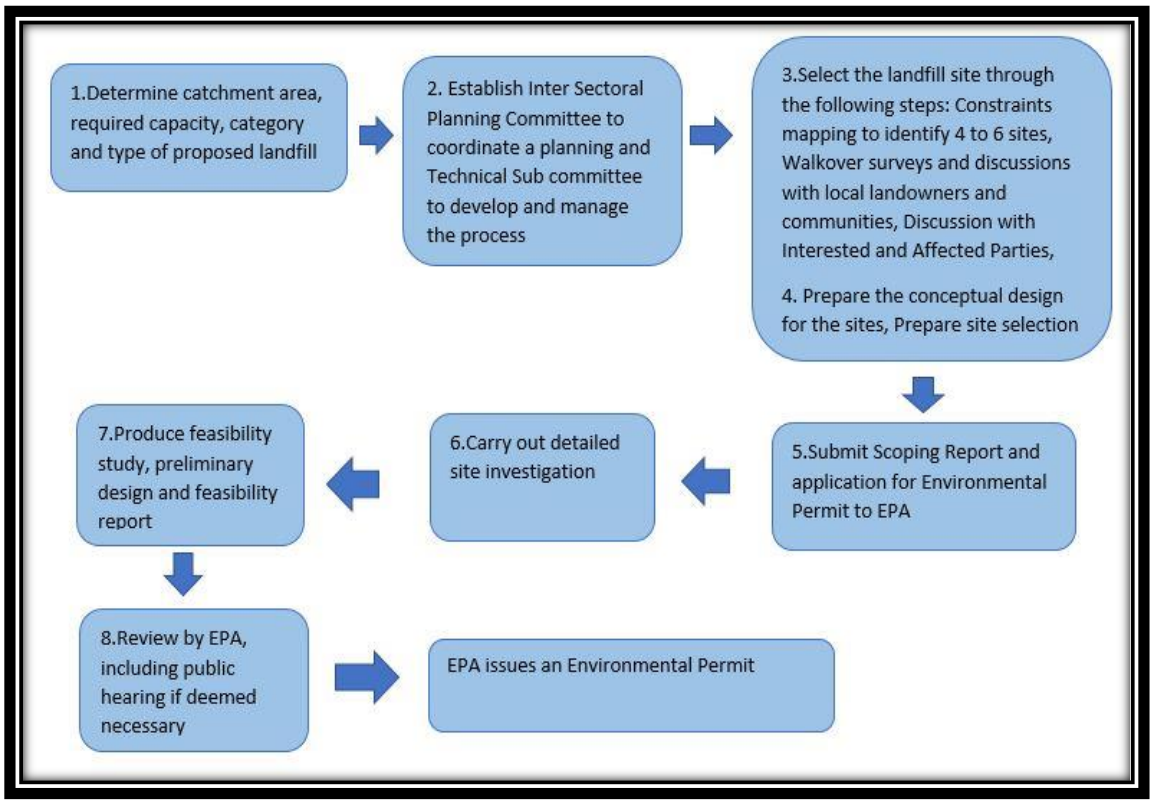
The Assembly issues a waste disposal licence if the applicant proves to be competent to manage such a facility (EPA, 2002). Thereafter, the EPA should issue an Environmental

Certificate within twenty-four (24) months, to ensure continuation. This certificate is renewed annually (EPA, 2002). The operator is mandated to surrender landfill operations to the assembly if the Environmental Certificate or the licence is revoked (EPA, 2002).

When the operator intends to introduce a new waste stream at the landfill site, the EPA regulates that the site classification should also be amended appropriately to cater for the new waste stream (EPA, 2002). The landfill operator may appoint individuals regarded as responsible persons to ensure compliance, however legal responsibility rests with the operator (EPA, 2002). Once the landfill facility is decommissioned, the operating licence ceases to be effective and operator's responsibilities post closure are contained in the EMP (EPA, 2002).

2.3.2.3 Ghana Landfill Guideline (2002)

EPA (2002) asserts that the main goal of the Ghana Landfill Guidelines is to guide the issuing of Environmental Permits and Certificates. The issuing and renewal of authorisations for landfill operations are conducted by District Assemblies in Ghana (EPA, 2002). Adequate and practical information that empowers licence applicants, licence holders and their designated advisors and managers are made as provisions to the applicants to comply with the policy of the District Assembly and related legislative requirements (EPA, 2002). This is illustrated in Figure 2.1, which highlights the process followed in Ghana (EPA, 2002)



Source: EPA, 2002

Figure 2.1: Ghana Landfill site selection process

2.3.2.4 Studies in Ghana

Groundwater at the Dompoase landfill

In Ghana, Owasu-Sekyere (2013) conducted a study the Dompoase Landfill in the Kumasi metropolitan area to determine impacts of the landfill on groundwater. Interviews were conducted with both the authorities and managers of landfill facilities. The aim of the research was to assess the benefits and the health and environmental effects of the Dompoase Landfill. The research used qualitative techniques to collect and analyse data. The study indicated that the Dompoase Landfill was a source of livelihood to peri-urban agriculturalists that use the fertile lands on the fringes of the landfill yet there were negative environmental and health effects. The results that were obtained indicated that though the landfill has been a source of 'blessing' to some actors, it could also be a 'curse'

due to its health hazards as a result of groundwater contamination from leachate generated at the site (Owusu-Sekyere, 2013).

Landfills: Investigating their operational practices in Ghana

Another study was done on three landfill sites in Ghana (Kusi et al., 2016), to assess operational costs, possible difficulties experienced during operations and to determine landfill operational practices (Kusi et al., 2016). The three facilities were Nkanfoa Landfill, Kpone Landfill and Abokobi Landfill. It should be noted that the methodological approaches used in the above-mentioned research were both qualitative and quantitative. Hence, interviews and questionnaires were used as data collection methods. The study found that one of the major limitations of operating a landfill was high operational costs (Kusi et al., 2016).

The results obtained by Kusi et al., (2016) indicated that vehicles and equipment contributed between 58.8% and 61.9% of the total operational costs. These results were consistent in all three landfill facilities. On the other hand, 22% of the total operational costs was attributed to lubricating fluids and fuel (Kusi et al., 2016). The frequent breakdown of equipment was identified as a common problem at the landfill facilities (Kusi et al., 2016). It was also discovered that engineered facilities adhered the most to operation and maintenance requirements (Kusi et al., 2016). As indicated by Kusi, et al. (2016), classification methods for landfills in Ghana have not been developed. However, the system that is currently in place is that there are small facilities (less than 5 hectares), medium facilities (between 5 to 20 hectares of land) and large facilities (occupying more than 20 hectares of land) (Kusi et al., 2016).

2.3.3 Nigeria

According to Makinde and Adekoye (2007), it is the responsibility of the State to ensure the protection of land, air and water resources, in accordance with the Constitution of the Federal Republic of Nigeria (Section 20). Section 2 of the Environmental Impact Assessment Act of 1992 (EIAA, 1992) requires the assessment of possible risks to the

environment, before the authorisation of waste disposal activities (Makinde & Adekoye, 2007).

Several laws have been introduced in Nigeria, by the Federal Government, in order to safeguard the environment (Makinde & Adekoye, 2007). These include:

- The Harmful Wastes Act of 1988, which introduced criminal provisions regarding waste disposal activities.
- The Federal Protection Agency Act of 1988 (FEPAA, 1998) was promulgated with the National Environmental Protection Regulations to ensure environmental protection of the environment against pollution and from solid and hazardous waste impacts.
- The Environmental Impact Assessment Act of 1992 (EIAA, 1992) was also introduced in Nigeria to protect the environment.

The EIAA (1992) made it mandatory for operators who intend to conduct activities associated with environmental risks (Makinde & Adekoye, 2007). Three main pieces of information which should be contained in the report are the possible environmental impacts from the waste disposal activities, preventative measures to be taken and clean-up strategies. The Federal Ministry of Environment is the competent authority for reviewing and approving the reports (Makinde & Adekoye, 2007). Attached to the EIA Act is a schedule of activities and industries for which environmental impact assessments are mandatory (Makinde & Adekoye, 2007). The process is similar to that which is employed in South Africa through the use of EIA Regulations.

2.4 The evolution of South African legislation and the waste management licensing

NEMWA was published in 2008, for the sole purpose of governing waste management activities through a well-structured framework (Oelofse, 2013a). It should be noted that, prior to 2008 and the introduction of NEMWA, South Africa depended on Section 20 of the Environment Conservation Act, 1989 (ECA) (Act No. 73 of 1989) for the authorisation

of waste disposal. There was also reliance on the series of Minimum Requirements, for the management of landfills for waste disposal in accordance with Section 20 of ECA, (1989). Oelofse (2008) however clarified that the Minimum Requirements series was a single entity of guidelines that lacked legal standing; thus, it was the incorporation of these guidelines into disposal site permits that made them legally binding.

The South African Waste Information Centre (SAWIC) provides valuable information on the process for obtaining a WML with the waste activity list being the first point to determine whether a WML is required for a particular waste management activity. Once the proponent has determined the applicable activities a waste licence application form has to be completed. As mentioned in the previous chapter, the waste management licensing process is done in terms of the Environmental Impact Assessment Regulations, 2014 (GNR982) which is an established method. Therefore, the application form will have to be submitted, accompanied by proof of payment as prescribed in the fee structure for the consideration and processing of applications for waste management licenses (DEA, 2014a). The amount to be paid for a WML is determined by whether a basic assessment process or a full scoping or EIA process has to be followed, and this determined by the application category on the waste management activity list (GN 921, 2013). While the basic assessment process applies to activities contained in Category A, a full scoping or EIA process is necessary for activities in Category B. The applicant has to ensure that the application is submitted to the competent authority because according to NEMWA, the Minister is the competent authority for hazardous waste activities, while the Members of Executive Council in different provinces responsible for the environment are the competent authorities for general waste activities.

During the processing of an application for a WML, the licensing authority considers certain matters, in accordance with Section 48 of NEMWA. These matters include the amount of pollution that may result from the waste disposal activity, the availability of other alternatives, together with the need and desirability of the proposed activity. Since the licensing authority has a mandate to protect the environment, the best environmental options are considered as this is essential in the prevention and mitigation of pollution.

The licensing authority also considers issues that pertain to wider environmental circumstances, including safeguarding people's health, economic and social conditions, as well as protecting cultural heritage from any harm that may be caused by the waste management activity. Most importantly, the decision that is agreed upon needs to be made in terms of regulations issued under section 24 of NEMWA. Section 49 (2) of NEMWA indicates that the approval of a WML depends on the agreement by the Minister of Water Affairs and Forestry. Furthermore, Section 50 (3) stipulates that the provision of a WML is contingent on the incorporation of any factors carried in a Record of Decision given by the Minister responsible for water resources. This includes conditions that the Minister deems essential for the protection of water resources, based on Section 22 (3) of the National Water Act, 1998 (Act No. 36 of 1998). Therefore, the Minister responsible for issuance of a WML may not issue the WML for a disposal facility without concurrence by the Minister responsible for water resources.

The contents of a WML are listed in Section 51 of NEMWA. However, for the purpose of this study, it is imperative to note that Section 50 stipulates that a WML is subject to the conditions and requirements set out in Section 51, as the licensing authority may determine and specify in the licence; and as the Minister or MEC has prescribed for the waste management activity in question. After a waste management licence is issued on the basis of Section 49 (1) of NEMWA, the holder of the licence bears the responsibility of ensuring compliance with WML conditions. The holder of the licence is therefore liable to pay costs incurred as a result of the conditions of the licence (DEA, 2008).

2.4.1 The need for post regulatory assessment in waste management licensing

The South Africa government has been able to introduce various legislative measures aimed at enhancing environmental quality (Mokgae, 2011). The Department of Forestry, Fisheries and the Environment (DFFE) has to deal with the enforcement of legislative frameworks, in order to ensure sufficient compliance in the regulation of hazardous waste, while Provincial Departments of Environmental Affairs deal with compliance by general waste disposal facilities (DEA, 2008). According to Mokgae (2011) environmental taxes and subsidies have the capacity to motivate people to seek alternatives other than final

disposal to landfill sites. To sum up his argument, Mokgae (2011) reported that is it especially important to monitor landfills, not just when they are in operation, but even up to 30 years post closure. This monitoring process should be aimed at assessing elements like the level of groundwater under and around the facility, landfill gas, and production of landfill gas.

Minimising groundwater contamination which is caused by leachate produced at a landfill is one of the major reasons why stringent conditions need to apply for waste management licenses (Pienaar and Howard, 2014). This view is supported by Misra and Pandey (2005), who indicated that groundwater quality is a serious environmental concern. It is argued by Misra and Pandey, (2005), that the greatest difficulty associated with the contamination of groundwater as a result of leachate from landfills is the danger that this poses to wells and downstream surface water. For this reason, safeguarding the environment requires the regulation of such hazardous waste in a manner that is environmentally friendly (Misra and Pandey, 2005).

2.5 Minimum Requirements for waste disposal by landfill and Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste (DWAF,1998)

The Minimum Requirements for waste disposal by landfill were developed in South Africa in 1998 as the first tool aimed at guiding waste disposal by landfill and were also adopted by other countries such as Botswana and Namibia (Blight, 2006). The Minimum Requirements were utilised by the Department of Water Affairs (DWAF) as a series of documents that covers issues relating to the classification, siting, investigation, design, operation and monitoring of landfill facilities. According to the series of documents, classification is conducted according to specific criteria which include the size and capacity of the landfill, the class of waste that is disposed at the site, together with potential risks to the environment, as a result of noteworthy leachate generation (DWAF, 1998).

According to DWAF (1998), the main aims of the Minimum Requirements for Waste Disposal by Landfill series was to enhance the quality of waste disposal processes in South Africa, by providing environmentally friendly guidelines for different landfill types and sizes. The Minimum Requirements for Handling, Classification and Disposal of hazardous waste sets a bottom line with regards to acceptable waste disposal standards, thus ensuring build-up to even higher standards (DWAF, 1998).

2.5.1 Enforcement of Minimum Requirements

The requirement for landfills to obtain permits was provided for in Section 20(1) of the ECA. The Act stipulates that an individual who intends to manage waste disposal facilities need to obtain permits from DWAF. At the time, before the introduction of NEMWA, a Landfill Site Permit authorised waste disposal activity, thus the implementation and enforcement of the Minimum Requirements were ensured through a condition in the permit (ECA, 1989). As such, the issuing and retention of a permit was contingent on the adherence of the landfill with the necessary Minimum Requirements (ECA, 1989). The Minimum Requirements were therefore implemented within an existing legislative framework. Once a Minimum Requirement was included in a Landfill Site Permit, it was legally enforceable (ECA, 1989).

2.5.2 The landfill classification systems in South Africa

The landfill classification system was developed with due consideration of the types of waste disposed at a facility, the likelihood for considerable leachate production, and the size of the waste stream in waste disposal situations. This reason for this was to advance landfill categories that capture different waste disposal requirements and to utilise these categories to grade Minimum Requirements accordingly. This was meant to assist with the selection, investigation, design, operation, and closure of landfills in a cost-effective manner.

In accordance with this classification system, landfills were grouped and there were only two classes of waste streams (DWAF, 1998). While general waste was symbolised by the

letter (G), hazardous waste was symbolised by the letter (H). There were nine classes for hazardous waste, and these were created according to international danger groups. In these classes, hazard rating was allocated based on factors such as acute mammalian toxicity, ecotoxicity, environmental fate, chronic toxicity and other criteria. Hazardous waste was classified as follows:

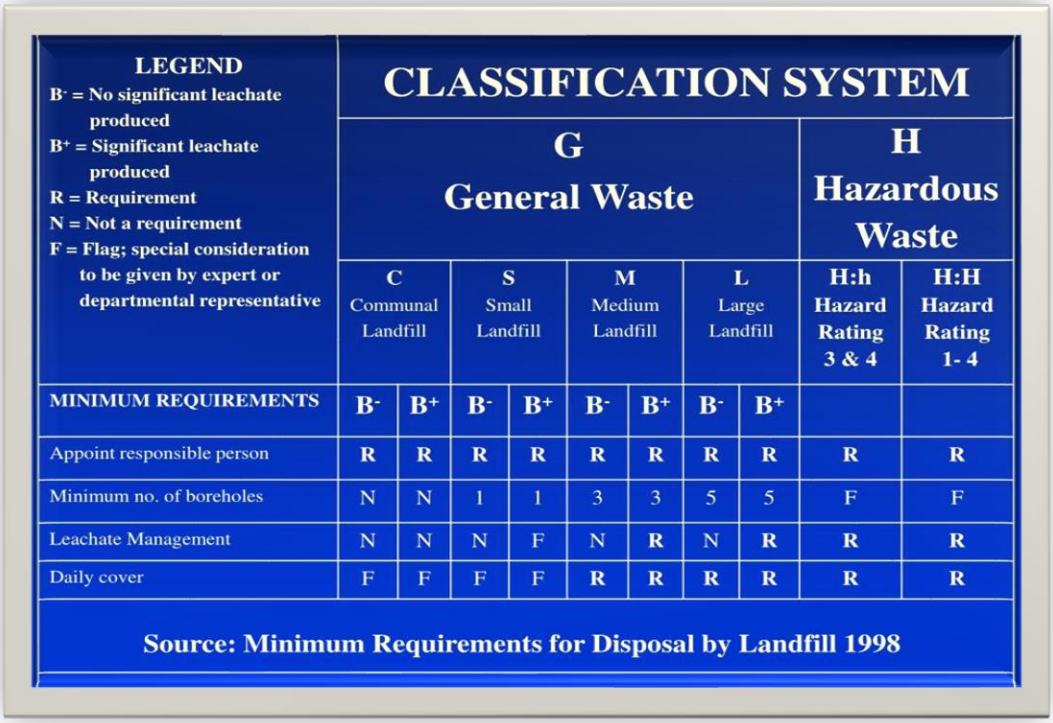
- Hazard Rating 1: Extreme hazard;
- Hazard Rating 2: High hazard;
- Hazard Rating 3: Moderate hazard; and
- Hazard Rating 4: Low hazard.

On the other hand, landfills are sub-divided into four classes. This sub-division was premised on the size of the operation, together with the extent of the waste stream. The landfill classes were, Communal (C), Small (S), Medium (M) and Large (L). As indicated earlier, hazardous waste landfill classification considered hazard rating, as opposed to size. The above classes of landfill were further sub-divided based on Site Water Balance. A B - landfill potentially generated only sporadic leachate and did not require a leachate management system. A B+ landfill generated significant leachate. All B+ sites, with the exception of communal sites, required leachate management systems, comprising liners and leachate collection systems. The Minimum Requirements for B+ landfills were more stringent than for B- landfills.

Due to the risk presented by landfills on the environment, hazardous waste landfills were therefore lined containment sites, regardless of the Site Water Balance. There was therefore a need to install a liner, coupled with a leachate collection system as a measure of separating the hazardous waste from the ground water system (DWAF, 1998). Landfills which were classified under hazard ratings 1 and 2 were referred to as **H:H** sites.

These landfills were designated for all types of hazardous waste. Hazard ratings 3 and 4 were for landfills capable of handling less toxic hazardous waste. Such landfills were termed **H:h** sites; hence the hazardous waste disposed in such facilities was clearly specified. While **H:h** landfills had higher design standards than **G:L:B+** sites, they were

however not as strict as the design standards for **H:H** sites. The landfill classification system under the MR is depicted in Figure 2.1:



LEGEND
B⁻ = No significant leachate produced
B⁺ = Significant leachate produced
R = Requirement
N = Not a requirement
F = Flag; special consideration to be given by expert or departmental representative

CLASSIFICATION SYSTEM

	G General Waste								H Hazardous Waste	
	C Communal Landfill		S Small Landfill		M Medium Landfill		L Large Landfill		H:h Hazard Rating 3 & 4	H:H Hazard Rating 1- 4
MINIMUM REQUIREMENTS	**B⁻**	**B⁺**	**B⁻**	**B⁺**	**B⁻**	**B⁺**	**B⁻**	**B⁺**		
Appoint responsible person	R	R	R	R	R	R	R	R	R	R
Minimum no. of boreholes	N	N	1	1	3	3	5	5	F	F
Leachate Management	N	N	N	F	N	R	N	R	R	R
Daily cover	F	F	F	F	R	R	R	R	R	R

Source: Minimum Requirements for Disposal by Landfill 1998

Source: DWAF, 2008:11

Figure 2.2: Landfill Classification according to the Minimum Requirements,1998

It should be noted that the landfill classification system has since been changed. The old classification system was based on the type of waste to be disposed, the size of the waste stream and the site's potential concerning the generation of leachate. However, the new classification system under NEMWA considers barrier design, as well as the chemical components of the waste (IWMSA, n.d.). The new classification system, namely the Waste Classification and Management Regulations GNR 634 (23 August 2013) were promulgated with the National Norms and Standards for the Assessment of Waste for Landfill Disposal, GNR 635 and the Norms and Standards for Disposal of Waste to Landfill GNR 636 (23 August 2013), (DEA, 2013b). The regulations deal with hazard assessment through the Globally Harmonised System of Classification and Labelling of Chemicals (SANS 10234) (DEA, 2013a).

According to EnviroServ (2018), the new landfill classification system recognizes the potential risk for the contamination of groundwater through landfill activities. The new classification system was therefore promulgated, based on the idea of determining the risk to leach and the total concentration. The new classification therefore allows for different waste types of be disposed at different classes of waste facilities as follows:

- Class A: High risk waste;
- Class B: Moderate risk waste;
- Class C: Low risk waste; and
- Class D: Inert waste.

As the DEA (2013a) classifications are being implemented, **H:H and H:h** facilities, which were classified under the Minimum requirements are supposed to be phased out and replaced with new ones. This also applies to **G:L:B+, G:M:B+, G:L:B-** and other such general waste landfills, which need to be replaced with designs that fit either Class B or Class C, which are more strict landfill designs than a **G:L:B+** design. Class D is viewed as equivalent to old **G:L:B-** facilities (EnviroServ, 2018).

2.5.3 Leachate management

Leachate management frameworks are necessary in all landfills designated for hazardous waste in the old as well as the new systems. These frameworks have two main purposes, namely, to prevent the pollution of groundwater and to contain the magnitude of leachate generation through leachate collection and treatment mechanisms. In such instances, climatic conditions in the area where the facility is located are assessed, in order to establish whether they will likely cause significant leachate production. The Climatic Water Balance is instrumental in alerting the developer in advance of the need to cater for the management of leachate during the design of a landfill (DWAF, 1998).

Since the above prescriptions and its implementation there have been further recent developments concerning landfills and leachate management. The South African Department of Environmental Affairs has placed a ban on all forms of liquid waste from

being dumped in landfills (Averda, 2018). The regulations came into effect on the 23rd of August 2019 and forced many waste management providers to rethink their liquid waste disposal methods (Averda, 2018). According to Averda (2018), the DEA previously banned hazardous waste with a high calorific value from being disposed of at landfills in August 2017. The regulations are intended to promote waste management according to the waste hierarchy (EnviroServ,2018).

2.6 The Waste Management Activity Lists

In order to give effect to NEMWA, a waste management activity list was published and contained activities that had the potential to negatively affect the environment. These were first published on the 03rd of July 2009 (DEA, 2009) with amendments and published on the 29th of November 2013 (DEA, 2013d). Waste management activities on the lists were grouped into categories A and B. Activities under Category A could be authorised through conducting a basic assessment process, while a full scoping and environmental impact process was established as necessary for activities listed under Category B (DEA, 2009) and Category C was introduced in 2013, which stipulated that, activities under this category had to be conducted in compliance with the Norms and Standards for Storage of Waste (DEA, 2013b).The list was further revised in 2017 amending Category C activities (DEA, 2017).

2.7 The Waste Classification and Management Regulations (DEA, 2013a)

The Waste Classification and Management Regulations were issued for enforcement on the 23rd of August 2013 (DEA, 2013a). The motivation behind such regulations was to provide different classifications for the industry and to regulate waste management practices, while giving effect to NEMWA and its provisions. The Waste Classification and Management Regulations contained responsibilities of waste generators, transporters and managers. It also entrenched methods for the categorisation of waste management activities that could be conducted without a WML. Moreover, it provided the requirements for the disposal of waste to a landfill, and prescribed timeframes for the handling of certain

types of waste. Therefore, it also provided solutions for dealing with historical stockpiles of waste, while at the same time preventing the escalation of stockpiles (DEA, 2013a).

2.7.1 Norms and Standards for the Assessment of Waste for Landfill Disposal (DEA, 2013b)

The National Norms and Standards for the Assessment of Waste for Landfill Disposal were introduced as an improved strategy to regulate landfill activities. This legislation allows for the alignment of site classifications with chemical substances present in waste, leachate concentrations, and total concentrations. Furthermore, these guidelines are concerned with the manner in which facilities are managed and regulate the design of new cells within existing waste disposal facilities and at new waste disposal facilities (DEA,2013b).

The main purpose of the Norms and Standards for the Assessment of Waste for Landfill Disposal's is to determine to which class of landfill a waste may be disposed in accordance with NEMWA. The Norms and Standards also simplify and reduce the requirements needed in waste disposal; hence they specify the conditions needed to investigate possible risks associated with the disposal of waste to landfills. The chemical substance concentration of waste, or the elements present in the waste now inform the exact requirements for Leachate Control Threshold (LCT). Also, international standards upheld in the United States (US), European Union (EU), Australia, the United Kingdom (UK), New Zealand and so forth, together with LCT (as regulated by DWAF, SANS, WHO and USEPA water drinking standards) determine Total Concentration Threshold (TCT) values. It should be noted that the limits in thresholds constitute a cautious evaluation of the decline in possible risks, which can be achieved through proliferating environmental protection measures. These measures are called for in the requirements for landfill construction, as well as in operation. Methods used by laboratories are accredited by the South African Accreditation System SANAS to ensure that the method used is accurate and reproducible.

The assessment process is used in the Norms and Standards in order to determine the type of waste (Type 0/ 1/ 2/ 3/ 4). It applies to both general and hazardous waste, excluding Annexure 1 waste (pre-classified general and hazardous waste). Each type of waste is accompanied by specified criteria or requirements for landfill disposal. See Table 2.2 below:

Table 2.2: Assessment approach to determine waste type

Type of Waste	Element or chemical substance concentration
Type 0	LC > LCT3 **OR** TC > TCT2
Type 1	LCT2 < LC ≤ LCT3 **OR** TCT1 < TC ≤ TCT2
Type 2	LCT1 < LC ≤ LCT2 **AND** TC ≤ TCT1
Type 3	LCT0 < LC ≤ LCT1 **AND** TC ≤ TCT1
Type 4	LC ≤ LCT0 **AND** TC ≤ TCT0 for metal ions and inorganic anions **AND** all chemical substances are below the total concentration limits provided for organics and pesticides listed
Wastes that do not need assessment	Refer to Annexure 1 of the WC&MR

Source: Costley, 2013:18

Key: TC – Total Concentration, LC – Leachable Concentration, TCT – Total Concentration Threshold, LCT – Leachable Concentration Threshold

Waste that is not included in the norms and standards, when it has a hazard classification, in accordance with SANS 10234, should be regarded as Type 1 waste. Furthermore, waste should be classified as Type 1, if TC exceeds > TCT2, while LC is < LCT 3 (Costley, 2013). If all metal ions within waste have an LC of ≤ LCTO, it is classified as Type 3, regardless of TC of the elements (Costley, 2013). This is because the chemical substances will be below the limits for organics, as well as for pesticides.

Once the type of waste is determined, the Norms and Standards will dictate the type of landfill that the waste has to be disposed in. See Table 2.3 below:

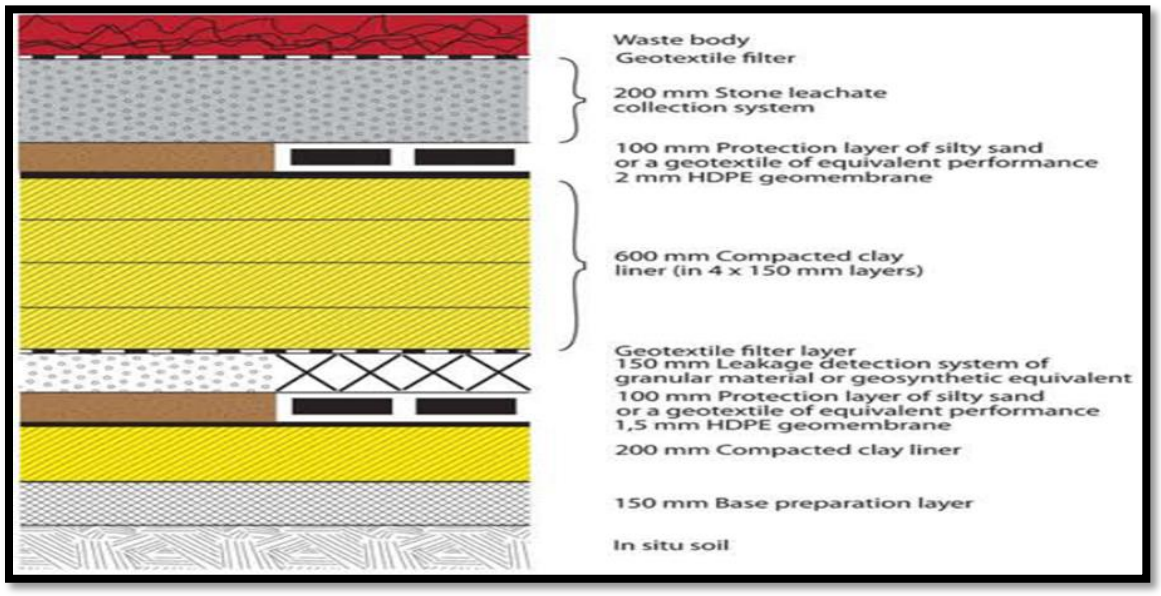
Table 2.3: Disposal Requirements

Waste Risk Level	Disposal Requirements
Type 0: Very High Risk	Disposal **not allowed**. The waste must be treated first and then re-tested to determine the risk profile for disposal.
Type 1: High Risk	Disposal only allowed at a landfill with a **Class A** or **Hh/HH** containment barrier design.
Type 2: Moderate Risk	Disposal only allowed at a landfill with a **Class B** or **GLB+** containment barrier design (or Class A).
Type 3: Low Risk	Disposal only allowed at a landfill with a **Class C** or **GLB+** containment barrier design (or Class B or A).
Type 4: Inert Waste	Disposal allowed at a landfill with a **Class D** or **GLB-** containment barrier design.
General Waste	Disposal only allowed at a landfill with a **Class B** or **G S/M/L B-/B+** containment barrier design.

Source: Costley, 2013:18

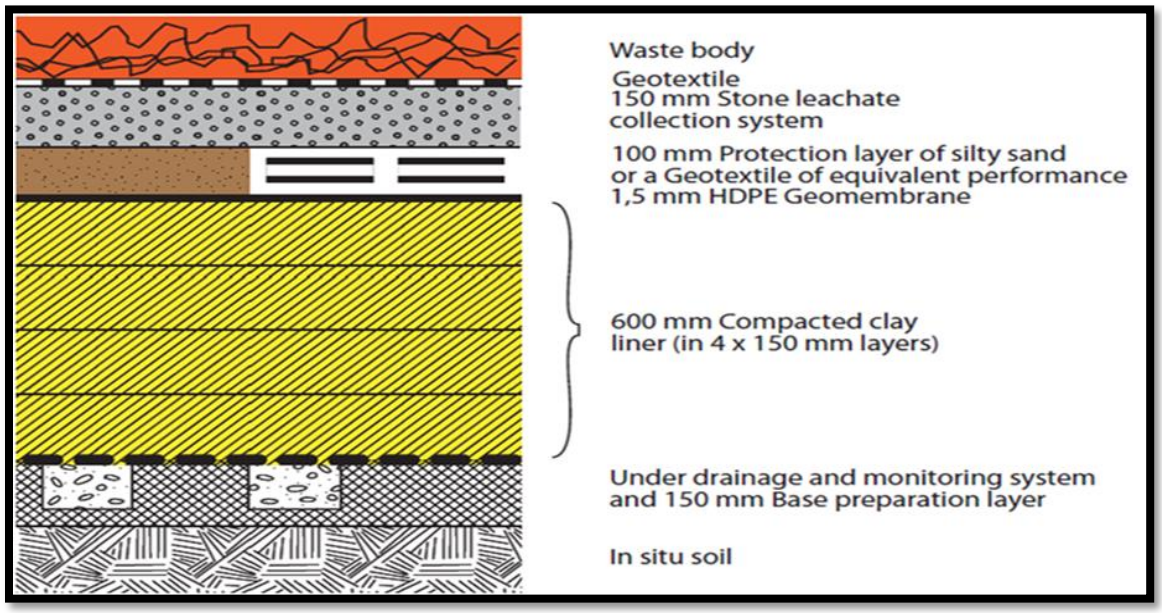
2.7.2 Norms and Standards for the Disposal of Waste to Landfill

The Norms and Standards for waste disposal have several purposes. They are imperative in establishing containment barrier standards; in stipulating acceptable methods for landfill disposal; and in mapping out prohibited or restricted activities, to motivate waste generators to seek viable alternatives for landfill disposal. For the purposes of this research, the focus was only on Class A and Class B landfill barriers, since the focus was on hazardous waste disposal facilities. As evident below (Figure 2.3 and 2.4), the Class A barrier is thicker and more complex therefore providing more protection than a Class B barrier:



Source: DEA, 2013a.

Figure 2.3: Class A landfill containment barrier



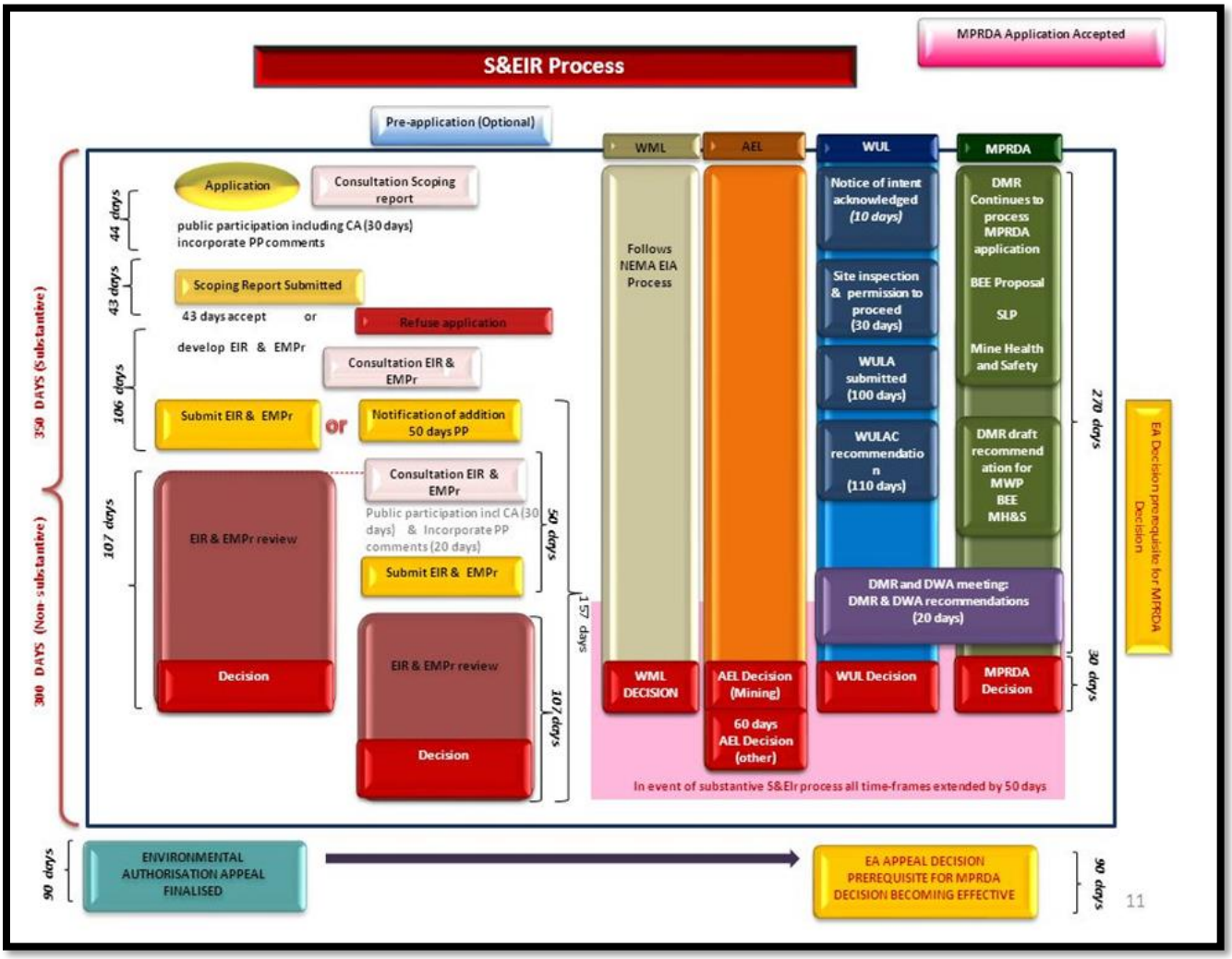
Source: DEA, 2013a

Figure 2.4: Class B landfill containment barrier

2.8 The EIA Regulations (GN982, 2014 and GN 326, 2017)

The National Department of Environmental Affairs has continuously amended EIA Regulations since 2006. The current regulations were introduced in 2014, with Government Notice 982 (DEA, 2014a). The list of activities that are prohibited from commencing in the absence of environmental authorisation are identified in the regulations (DEA, 2014a). The EIA Regulations were amended on 7 April 2017 (Government Notice 326) and published for implementation (DEA, 2017). The amendments did however not bring about any change into the waste management licensing process. To apply for a waste management licence, applicants have to follow the process prescribed by the EIA Regulations (DEA, 2014a).

The initial stages of applying for a WML for the disposal of hazardous waste, the activity would be listed in category B of the waste management activity list. As such the process has to follow a Scoping and Environmental Impact Assessment process (S&EIR) which can be described as follows: To begin with, the applicant submits a draft scoping report to the Competent Authority (CA). The CA with all interested and affected parties then have to provide comments as part of the public participation process so that their comments are addressed on the EIR. Prior to submission of the EIR, the Environmental Assessment Practitioner (EAP) has to ensure that all comments raised by the CA and the interested parties have been addressed. Other factors that are considered when applications are made for a WML include the ability of the permit holder to comply, even after the closure of the facility (DEA, 2009). Thereafter, the CA reviews the application and decides whether to grant or refuse a waste management licence. The full process is outlined in Figure 2.5 below.



Source. DEA, n.d

Figure 2.5: Scoping and the EIR process

The figure above paints a clear picture of the process flow for obtaining an environmental authorisation or WML in terms of the EIA regulations when a full scoping and environmental impact assessment process is followed. Figures 2.2 and 2.3 address the containment barrier standards for Class A and Class B landfills. Figure 2.4 depicts the S&EIR process that waste disposal facility operators need to adhere to when lodging an application for a waste management licence.

2.9 A literature perspective on achievability of waste licence conditions

The following studies were conducted previously in South Africa and other regional and international countries. These sources thus provided insight on the difficulties that landfill operators face when ensuring compliance with legislative regulations or conditions in waste disposal facilities.

2.9.1 Cost implications

Oelofse (2014) argued that legislation impacts on business mainly in terms of time and costs. This is in order to comply with NEMWA, together with the National Water Act (NWA), 1998, when assessing environmental impacts. Oelofse (2014) also raised a concern over the delays in the issuance of waste management licenses. She further indicated that an increase in the perception that the introduction, as well as improvement of legislation has resulted in increased environmental benefits. However, while the costs of complying with such legislature may be justifiable in the context of environmental protection, the opposite might be true from a business perspective (Oelofse, 2014). She concluded that the national government conducts limited or no investigations on the possible implications of intended legislation on businesses (Oelofse, 2014).

Pienaar and Howard (2014) shared an experience that they had as AECOM South Africa, when the company was appointed by the National Department of Environmental Affairs (DEA) to conduct the environmental impact assessment process in order to licence 50 municipal waste disposal sites in the Western Cape. This was done as part of the “Licensing of unlicensed sites” project that was managed by the Licensing Directorate in the Department. According to Pienaar and Howard (2014), the waste disposal activities at these waste sites were not conducted in accordance with NEMWA since the sites were not authorised. However, the DEA (now DFFE) was compelled to provide support to the municipalities as a sphere of government, in order to promote compliance with legislation. When the waste management licences were issued to the respective municipalities, Pienaar and Howard (2014) had to explain the conditions of the licences, as a means of ensuring adherence and understanding of the implications to the municipalities.

Municipalities raised concern regarding the costs of adhering to the requirements as stipulated in the licenses; since the landfills were poorly managed prior to the issuance of the waste management licences (Pienaar and Howard, 2014). It became evident then, that compliance with some of WML conditions such as conditions that refer to leachate collection system and landfill liner designs would be an issue for the authorities after licensing these facilities (Pienaar and Howard, 2014). This clearly supports the assertion that the cost of complying with waste management licence conditions is a difficulty.

The high cost of operating waste disposal facilities that comply with set regulations is a difficulty not just in South Africa, but in many other countries. In Malaysia, Agamuthu and Fauziah, (2011) cited this as a major factor hindering both efficient waste disposal, and environmental protection in that country. Agamuthu and Fauziah (2011) cited several issues that caused this problem in Malaysia, including lack of government funding (to help landfill owners with operational costs), national policies, which prohibit certain institutions like banks from investing in this sector (leaving landfill operators vulnerable), the inaccessibility of bank loans and the high cost of land (which results in landfill operators resorting to undeveloped land, thus increasing developmental costs) (Agamuthu et al., 2011). Because of this, landfill managers in Malaysia just aim for the bare minimum when it comes to compliance, since reaching a level of excellence is unachievable, as a result of high costs associated with complying with the requirements for post closure monitoring (Agamuthu et al., 2011). However, this leaves loopholes that exacerbate the risk of pollution.

2.9.2 The effects of licenced waste disposal on groundwater

The possible contamination of groundwater sources because of leachate generated from landfill facilities is a real threat to environmental wellness. Aderemi, Oriaku, Adewumi and Otitoloju (2011) conducted a study to that effect in Lagos, Nigeria. The landfill facility became operational in 2008, and this was prior the requirement of engineering landfills hence the landfill was not engineered (Aderami et al., 2011). Moreover, it caters for both domestic and commercial waste, therefore combustive fires are common at the facility during summer months (Aderami, et al. 2011). Groundwater samples were collected from

eight locations around the landfill facility and the results obtained from this study suggested that leachate generated from landfills is a threat to groundwater (Aderemi et al. 2011).

According to Aderami et al., (2011), in some of the samples that were collected, conventional contaminants exceeded the levels permitted by WHO, thus indicating pollution. They attributed this to the absence of a leachate collection system at the site, together with lack of leachate monitoring. It should be noted however, that the overall conclusion of this study was that contamination was minimal, but this was because the site was located in an area with clay soil, which increased natural attenuation (Aderami, et al. 2011).

El-Salam and Abu-Zuid (2015) conducted a similar study in Egypt to assess possible ground water pollution from the Borg El-Arab landfill facility in the city of Alexandra. This is a Mediterranean port city, located along Egypt's shoreline. The same assessment was also done at El-Hammam landfill, which is located 30km from Borg El-Arab landfill. Samples were collected from wells around the landfills. The physical and chemical examination of samples indicated that the water contained inorganic and organic chemicals, as well as a heavy metal water concentration, but the contamination was not severe. Just like Aderami et al., (2011), El-Salam and Abu-Zuid (2015) reported that Total Dissolved Solids (TDS), chlorides in the water, sulphates, and iron exceeded the limits stipulated by WHO (El-Salam et al., 2015).

In China, Han, Ma, Shi, He, Wei and Shi (2016) reviewed secondary data in their study. Their original articles were based on 32 studies that were conducted to assess groundwater pollution from landfills throughout the country. Information was also obtained from an environmental assessment report and a field survey. According to Han et al., (2016), the observed groundwater quality is very bad. These researchers discovered that the water on an overall basis contained a total of 96 pollutants, six aggressive pollutants, two visual pollutants and three indicators of organic matter (Han et al., 2016). A significant analytical observation was that groundwater contamination was mostly observed within

200 m of landfill facilities, and even worse, within 1000 m of landfill facilities (Han, et al. 2016).

Sibiya, Olukunle, and Okonkwo (2017) collected samples near Goudkoppies, Robinson Deep, Marie Louis, Soshanguve, Onderstepoort, Hatherly and Garankuwa landfill facilities in Gauteng Province. They specifically focused on the infiltration of Polybrominated Diphenyl Ethers (PBDEs) into groundwater (Sibiya, et al. 2017). The results indicated that concentrations were higher in samples that were collected near landfill facilities that do not have geomembrane liners (Sibiya, et al. 2017). This indicates that landfill design requirements that are included in WMLs also play a role in preventing groundwater pollution from leachate. Hence this issue was considered during the data analysis and discussion phases of the study.

Daso, Fatoki, Odendaal and Olujimi (2013) conducted a similar study to assess PBDE contamination of groundwater from landfill facilities in Cape Town. The results confirmed those obtained in Gauteng by Sibiya et al. (2017), indicating that groundwater sources were being contaminated from PBDEs, from landfill leachate (Daso et al. 2013).

Results from the reviewed studies indicate that the contamination of groundwater from landfill leachate generation is a persistent threat to the environment at large. While climatic conditions and topography cannot be controlled, they determine leachate generation. Authorities have it within their means to regulate other aspects of waste disposal, one of which is landfill design. Therefore, it appears that stricter conditions for landfill designs are necessary for the protection of groundwater from leachate, even though this may result in landfill operators incurring higher costs.

2.9.3 Governance difficulties faced by landfill operators

While this study is based on the impact of licensing conditions on waste disposal facilities, other studies have revealed more complex concerns. Kolar, (1989) indicates that the process of acquiring a permit or licence so as to conduct hazardous waste disposal activities is lengthy and onerous (Kolar, 1989). Kolar (1989) raised these concerns in the

context of waste disposal in the United States of America. He further raised concern over complexities that are faced during this process and argues that the authorising process is very political, because it is the responsibility of the government to grant permission (Kolar, 1989). Kolar (1989) also argues that business owners need to navigate through different requirements, as stipulated by different bodies within the same government, making the process even more complex (Kolar, 1989). Because these regulations are constantly changing, continual awareness is required from business owners, even at the draft proposal stage (Kolar, 1989). Therefore, this study was useful in determining if the same difficulties exist in the South African context.

The issue of inadequate infrastructure and operational equipment is another difficulty that may hinder compliance with legislative framework. The problem was revealed in a study by Meidiana and Gamse (2011). This problem is a byproduct of the financial struggles highlighted in section 2.7.1 regarding municipal landfills in Indonesia. According to Meidiana and Gamse (2011), without the necessary funds, landfills are characterised by sub-standard infrastructural designs, equipment shortages, and poor maintenance (Meidiana and Gamse 2011). This cycle in the operation of landfill facilities perpetuates the risk of environmental degradation. It appears therefore that, when it comes to landfills, the difficulties seem to be interrelated, thus a lack in one area, particularly in the financing of operations creates non-compliance, which in the long term leads to environmental degradation.

Thus far, this chapter has covered the development of legislation regulating waste management in South Africa and some literature. The difficulties encountered by landfill managers with regards to compliance and the threats of groundwater contamination from leachate are highlighted in literature. The following section covers South African pertaining to compliance monitoring and enforcement in waste management context.

2.10 Compliance monitoring and enforcement of landfills in South Africa

Though the Department of Forestry, Fisheries and the Environment (DFFE) is currently mandated with the function of monitoring compliance at hazardous waste disposal

facilities according to DEA (2009), the monitoring requirements are prescribed, except in specific waste management licences. Therefore, waste disposal facilities that are licensed can be monitored for compliance and if there are non-compliances, the licence holder may be charged criminally (DEA, 2008). The authorities responsible for the environment acknowledge that a complicated process is required in the monitoring of landfill facilities' impacts on groundwater, therefore NEMWA stipulates that for a waste management licence to be issued for a waste disposal facility, this must be executed concurrently with the Department of Water and Sanitation (DEA, 2008). Therefore, this results in the inclusion of water monitoring requirements on the WML (DEA, 2009) hence compliance monitoring inspections are conducted jointly by both Departments.

There are differences in the groundwater system in South Africa and those in other countries around the globe (DWAF, 1998). As such, the applicability of monitoring systems developed in other countries is very limited, resulting in unnecessary confusion and spending practices (DWAF, 1998). These differences are in terms of monitoring the environment, through procedures and policies that regulate waste disposal activities. On the basis of this information, Pienaar (2017:4) reported that in South Africa, the closure of landfill facilities is immediately followed by maintenance and inspection initiatives aimed at ensuring the continuity of environmental protection post closure of the waste disposal site. Pienaar (2017) wrote this in reflection to uMzimkhulu Landfill, located in the Eastern Cape. "Post closure monitoring initiatives include the following:

- Preventing people from trespassing into the site through the maintenance of the surrounding fence.
- Re-vegetation programmes must ensure that there is a blend with vegetation found naturally in the environment.
- At least 80% grass cover is required, thus by the end of the maintenance periods, all plants must be able to grow independently.
- When sodding is used, specified vegetation should reach 100% cover.
- When there are bare areas remaining after three months of rehabilitation, topsoil must be spread in such areas, and they should be ripped to 100mm. After that, planting, sodding, hand sowing or hydro seeding can be repeated.

- The landfill facility location must continue to be inspected. Inspections should cover the following:
    - Identifying any cracks, seepage, settlement or erosion;
    - Checking for structural integrity;
    - Assessing of wildlife or the existence of rodents and the resulting impacts;
    - Evaluating containment of leachate from the leachate collection system; and
    - Checking for the need for maintenance activities."

Pienaar (2017) further stated that in the first year, inspections should be conducted every month. After that, they should be conducted quarterly. The guidelines indicate some of the areas where attention is needed from people with the responsibility of developing or refining legislative frameworks to govern landfill activities in South Africa. All aspects specified in the above licence conditions are essential in protecting environmental integrity and none can be regarded as less important.

According to Pienaar (2017:26), the management of storm water can be effective when there is proper landscaping and if surface run off is allowed to flow naturally from the facility as a design measure. Proper vegetation of the landfill site with improved storm water management is important. Furthermore, there is also a need to develop a post-closure management strategy for the continual monitoring of the critical aspects of the facility, in accordance with the licence (Pienaar, 2017: 26). The post-closure management plan includes the following:

- "There is need for the excavation of any eroded material;
- After that, eroded material will have to be filled with the excavated material and then re-compacted; and
- Impermeable material has to be capped, compacted, and covered with top soil, in accordance with specifications."

As indicated by the DWAF (1998:4), a specific sequence of events needs to be followed in the monitoring of waste management sites. This sequence is as follows:

(i) Information should be gathered on the disposal practices, together with types and volumes.

(ii) Information should be gathered pertaining to, existing wells, boreholes and excavations, fountains, dams, stream flow, as well as topography. The possible presence of pollutants should be determined and implications for other human activities as a result of the waste should be examined. Possible pollution plumes should be delineated.

(iii) Risk assessment should be conducted as it helps to decipher the level of the impact study and the required monitoring initiatives.

(iv) Geophysical investigations have to be conducted, in order to locate groundwater barriers and aquifers.

(v) Boreholes need to be drilled. The purpose of these boreholes is to record geological and geohydrological data, when necessary.

(vi) Water samples should be collected and analysed for elements found both in the natural environment and in waste disposal areas.

(vii) Collected data needs to be imputed into the computer database, Waste Manager, so that it can be processed and interpreted. Anomalies in the data are also interpreted in this manner.

(viii) Recommendations need to be made for the client and they are developed from data collected through frequent sampling and analysed.

(ix) Such information should be included in an operator's waste management permit application, be it for general or hazardous waste and submitted to the Department.

(x) There is also a need to train on-site employees, so that they can be able to make use of sampling equipment, use the database and interpret the findings.

It is imperative to consult with the authorities when current licence conditions are different from the abovementioned information or when they are not applicable to the specific site.

2.11 Examples of variations of Waste Management Licence Conditions

2.11.1 A Hazardous Waste Storage Licence

To provide detail on conditions, a waste management licence for a facility that was authorised for hazardous and general waste was downloaded from SAWIC. It was noted that the specific licence had also been varied or amended twice, therefore it was necessary to determine what could have led to two variations/amendments. The first variation referred to a condition that had been written as follows "*Weatherproof, durable and legible notices in at least three official languages applicable in the area must be displayed at each entrance to the Site…..*". The condition was then amended by the authorities to read as follows: "Weatherproof *and durable and legible notices in one official language applicable in the area must be displayed at each entrance to the Site…..*"

Another condition from the original waste management licence read as follows:" The *Licence Holder must appoint an independent external auditor to audit the storage areas biannually and this auditor must compile an audit report…."*. The condition was varied as follows: "*The Licence Holder must appoint an independent external auditor to audit the storage areas annually and this auditor must compile and audit report.*" It is crucial to note that both these conditions have a cost implication on the licence holder since these must be executed by external parties to ensure compliance.

2.11.2 A Hazardous Waste Treatment Facility Licence

Another WML for a hazardous waste treatment facility was downloaded and reviewed. The facility is in KwaZulu Natal, and it was noted that the WML had been varied. The original condition read as follows: "*The Licence Holder must ensure that the waste residue is stored in impermeable, leak proof and enclosed containers for no longer than 96 hours before collection for final disposal at a suitably licensed disposal facility".* When reviewing the approved variation of the WML, the condition had been amended to read as follows: "has been varied to read as follows: "*The Licence Holder must ensure that the waste residue is stored in impermeable, leak resistant and enclosed containers for no longer than 96 hours before collection for final disposal at a suitably licensed disposal facility*".

In this WML the authorities did not take into consideration the fact that treated waste was relatively dry and did not pose a leakage risk. The condition could have been written such that it is specific to the waste management process applicable to the site.

2.11.3 A Closure and Rehabilitation Licence

A company in Gauteng province had been issued with a WML for closure of a waste disposal facility and the WML contained the following conditions:

"Condition 6.6.1 of their waste management licence: *"The Licence Holder must maintain gas monitoring test pits VOC-01: Southwestern boundary of the site (downwind) and VOC-02: Northeastern boundary of the site (upwind) and concentration by volume in air at standard Temperature and Pressure, of flammable gas and carbon dioxide shall not exceed 1% and 0.5% respectively in the test pits".*

Condition 6.6.2 of their waste management licence: *"Gas monitoring must be conducted monthly from the date of this license for a period of two years and thereafter send the results to the Director for determination of monitoring frequency if further required".*

Condition 12.2.3 of their waste management licence: *"Operation and maintenance of the landfill gas control system whereby gas monitoring by the licence holder as described by condition 6.6 must continue after closure for a period of two years or such time longer as determined by the Director. Should the atmospheric levels be between 0.1% and 1% during remediation measures a higher monitoring frequency should be installed. Should the levels be above 1% the licence holder must submit contingency plan regarding occupational safety to the Director. This must be implemented after approval".*

The WML was varied, and all the above-mentioned conditions were removed based on the fact that the analytical Air Quality Assessment results performed showed that inhalation exposure to the ambient concentration of Volatile Organic Compounds is therefore very unlikely to cause any adverse health effect. Results obtained revealed at that ambient concentration at all three sampling locations were below South African Ambient Air Quality Standard. The authorities could have requested the air quality assessment to be conducted during the environmental impact assessment process

before the issuance of the WML. The report could have produced these results during that stage and the conditions would not have been included in the WML.

2.12 Chapter summary

This chapter included a review of international, regional, and local waste legislative requirements a waste management licence that was issued in South Africa was also reviewed. Furthermore, previous studies were reviewed, with specific attention to how they address the objectives of the current study. The following chapter focuses on the methodological approaches that were followed in conducting this study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter covers the methodological approaches that were utilised to conduct the study. Specifically, it justifies how the chosen methods allowed for the achievement of the objectives, with the broader aim of investigating the impacts of licensing commercial hazardous waste disposal facilities in South Africa.

According to Thorpe (2014), there are only a handful of commercial licensed hazardous waste disposal sites in South Africa, located in only four of South Africa's nine provinces (Thorpe, 2014). The facilities have been in operation since 1979, which is over 35 years. Therefore, this study allowed the site operators to share their experiences with the waste legislation and regulations as they evolved over the years. According to the South African Waste Information Centre, the four selected waste disposal facilities were the only commercial hazardous waste disposal facilities, until 2011, 2012 and 2015, when an additional three hazardous waste disposal facilities were authorised. Thus, the country only has seven (7) commercial hazardous waste disposal facilities at the time when the study was undertaken (DEA, 2013c).

3.2 Study scope

Even though the research proposal had initially intended to collect data from four hazardous waste facilities, gatekeeper access could no longer be granted for Site B. As a result, this study was limited to three hazardous waste disposal facilities that are authorised in terms on NEMWA, 2008.

3.3 Study areas

The study focused solely on licensed commercial hazardous waste landfill facilities. Hence, four waste disposal facilities in four different provinces viz Gauteng, KwaZulu-Natal, Eastern Cape and Western Cape in South Africa.

All sites are described individually below in detail, specifically the topography, ecology, climate and the geology. Topography can affect the climatic conditions and in the case of waste facilities rainfall affects the amount of leachate that is generated. The geology of the sites is also important as it describes the ability of the site to be permeable to leachate containing toxins resulting from waste disposal and lastly the ecology around waste facilities is affected by waste disposal. Therefore, this requires the discussion of these factors in detail for each waste facility below.

3.3.1 Site A

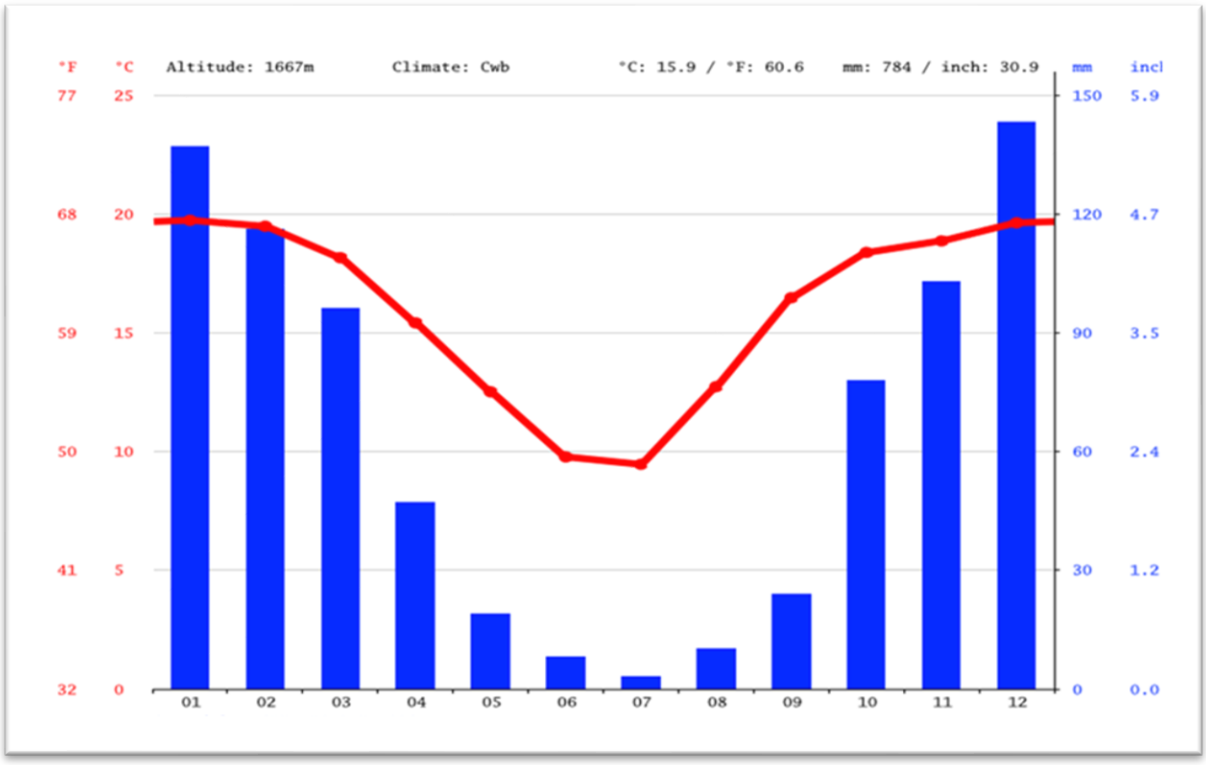
Site A hazardous waste disposal site is located in Gauteng Province. The facility is historically classified as an H:H facility in terms of the Minimum Requirements and this is equivalent to Class A landfill in terms of the Waste Classification and Management Regulations (GNR636) (DEA, 2013c). The class of the landfill simply indicates that the facility can accept extreme and high-risk waste (DWAF, 1998). Re-use, recycling and treatment of hazardous waste are some authorised activities at the waste disposal facility.

3.3.1.1 *Climate*

According to Kohler (2015), the waste disposal site is located in the Highveld climate region, which is typified by summer rainfall. The region experiences severe thunderstorms and periodic hail in the rainy season. Winters are generally dry with severe night frost (Kohler, 2015).

More than 80 % of the rainfall in this region occurs in high-intensity events that are largely confined to the summer months (October to April). The mean annual precipitation (map)

for the quaternary catchment is 693 mm (Kohler, 2015). The average monthly rainfall is listed in Figure 3.1 below:



Source: Climate-Data.Org (2021)

Figure 3.1: Monthly rainfall for Ekurhuleni Metropolitan Municipality

Winter night-time temperatures are often below freezing point while summer temperatures are mild, seldom exceeding 30°C. The average maximum temperature for the area is approximately 26°C in summer and 18°C in winter (Kohler, 2015). According to Cheremisinoff (1998), the increase of rainfall can cause a significant rise in leachate and contaminants. This is because rain leads to storm water run-on, as well as run-off, which can contaminate surface, together with sub surface water. From Figure 3.1, it can be anticipated that leachate is likely to increase in the summer season, between October and March. Cheremisinoff (1998) further indicated that other factors also affect the volume of leachate generated at a landfill. These factors include environmental air temperature, the permeability of the refuse, the age of the landfill, as well as waste composition.

3.3.1.2 Topography

The area surrounding the waste disposal site can generally be regarded as having a flat undulatory topography (1 525 m to 1 640 m above sea level) (Ekurhuleni Metropolitan Municipality, 2008). The region is largely characterised by low hills, together with natural pans, as well as wetland topographic features (Ekurhuleni Metropolitan Municipality, 2008). The Waste Disposal Site is a large topographical feature in the Ekurhuleni Metropolitan area; thus, it stands 35 m high at its highest point. The site is further characterised by both natural and artificial physical features, including hills, valleys and leachate dams.

3.3.1.3 *Geology*

Geologically, dolomite rocks which belong to the Malmani Sub-group of the greater Transvaal Super-group dominate the north-east and south-east areas and they are fundamental in Karoo formation (Ekurhuleni Metropolitan Municipality, 2008). It should be noted that the topographical features in the area around the landfill are influenced by fairly horizontal strata dominating the Karoo formations. Moreover, the area is characterised by dolerite, together with pre-Karoo diabase sills (Ekurhuleni Metropolitan Municipality, 2008). These are embedded together with banded ironstones, quartzites, conglomerates and shales from the greater Witwatersrand Super-group. As a result, towards the west of the landfill, there are rocky hills and outcrops.

3.3.1.4 *Ecology*

Wetlands are located within 500 m of the waste disposal site. These wetlands are currently being used for intensive agricultural purposes, including crop cultivation. However due to numerous activities in the area, the wetlands have been greatly impacted.

The area around the waste disposal facility is also part of the Blesbokspruit Highveld Grassland Ecosystem; hence, this area is currently regarded as threatened (South African Biodiversity Institute, 2011). The Gauteng C-Plan 3.3 (2011) also acknowledged

that some areas surrounding the site, together with adjacent natural habitat are critical for ecological support. Given such information, it suggests that the Gauteng C-Plan and Geographic Information System (GIS)-based support systems need to be established on assessments that are conducted on-site, because results obtained in such a practical manner will likely vary from desktop information systems.

The area has been greatly impacted, and it is thus under pressure because of activities such as wastewater treatment works (WWTWs), and waste disposal (DRDLR, 2014). There are also surrounding agricultural activities and informal settlements. These activities are currently placing stress on the environment and (Figure 3.2) below depicts the condition of the site.

Source: Enviro Waste Management, 2014

Figure 3.2: An image of the waste disposal facility

3.3.2 Site B

The second waste disposal site is in KwaZulu-Natal Province. This facility is classified as an H:h site, in terms of the Minimum Requirements for disposal of waste by landfill (DWAF,1998) and it is utilised for the disposal of hazardous waste, re-use and recycling and treatment of hazardous waste. Since this is an H:h site, it can only accept moderate

and low risk waste (DWAF, 1998). However according to the Norms and Standards for waste disposal, this site is a Class A and would be able to accept the same waste types as H:H facility. Figure 3.3 below depicts the working face of the site.

Source: Site B waste disposal facility presentation

Figure 3.3: Working Cell at Site B

3.3.2.1 *Climate*

The climate in the area around the site is well known for warm temperatures and summer rainfall, which tends to be heavy. Moreover, climate conditions in the area are consistent with coastal regions, thus humidity tends to be elevated. These conditions can promote the generation of elevated leachate within the landfill (Hemming, 2010).

The average annual rainfall is usually around 789 mm, while average annual A-pan evaporation is around 2200 mm. The summer months are also characterised by high-intensity rainfall events. The average daily maximum temperature for the area is approximately 32°C in midsummer and 22°C in midwinter. The average daily minimum temperature for the area is 10°C in midsummer and 3°C in midwinter (Hemming, 2010).

3.3.2.2 *Topography*

According to the Local Area Plan, (2010) the area contains a range of topographic conditions, including incised valley systems, which inform the variety of landform conditions. Roberts (1993) described the topographical characteristics and view of the area in which the waste disposal site is located amongst low-lying hills and valley slopes. These valley systems represent important tributaries for the major rivers on the study site, namely the Umlazi and Sterkspruit rivers. The waste disposal site itself is in a valley area. A number of man-made features are present, including a storm water dam, leachate containment tanks and a leachate dam.

3.3.2.3 *Geology*

Archaean granite-gneiss is found in the area around the landfill, overlayed arenaceous sandstones (Roberts, 1993). Other geological formations within the area include shale from the Karoo family, together with the glacial dwyka series (Roberts, 1993). In terms of soil composition, the area consists of boulderbed and Berea red sand and the clay content of much of this formation means that it generally has a low permeability (Roberts, 1993).

3.3.2.4 *Ecology*

The eThekwini Metropolitan Municipality area wherein the waste disposal site is situated, is an ecologically diverse area. It is an area that is characterised by a wide variety of plant and animal species (eThekwini Municipality Environmental Management Department, 2009). There are also large indigenous forests in the area and open spaces. The greater ecosystem is comprised of forests, grasslands and aquatic systems (eThekwini Municipality Environmental Management Department, 2009) and these are likely to be impacted upon by leachate as a result of hazardous waste disposal

Note: even though this site was included in the research proposal, hence included in the dissertation, gate keeper access was no longer obtained for research to proceed at this site. The following chapters only refer to Sites A, C and D.

3.3.3. Site C

The third waste disposal site is located in the Eastern Cape Province. The facility is classified as an H:H site in terms of the Minimum Requirements. The facility's liner requirements are equivalent to a Class A landfill in terms of the Waste Classification and Management Regulations and can accept both extreme and high-risk waste. Besides the disposal of hazardous waste onto land, the facility is also authorised to store hazardous waste in artificial lagoons, and to recover and treat hazardous waste.

3.3.3.1 Climate

The climate of the Eastern Cape Province in South Africa is largely consisting of several climatic conditions; hence, the most dominant conditions are subtropical and temperate weather, and there tends to be variations in rainfall, wind patterns and temperature. (Stone, 1988). The region is also susceptible to high temperatures in winter, when berg winds blow, with temperatures exceeding 30°C The summer season is also characterised by extreme temperatures, with little accompanying wind. The areas that are closer to the coast experience cooling due to onshore sea breezes (Burger & Scorgie, 1998). The city of Gqeberha (formerly Port Elizabeth) is well known for bimodal rainfall, peaking both in spring and in autumn. The range of rainfall within the region is usually between 400 mm and 800 mm per annum. Table 3.1 below shows Port Elizabeth's average monthly rainfall (Burger & Scorgie, 1998).

Table 3.1: Average monthly rainfall (mm) listed for Port Elizabeth 2021

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall in mm	38	40	56	59	60	61	44	63	62	60	45	39

Source: weather-and-climate.com 02.08.2021

3.3.3.2 Topography

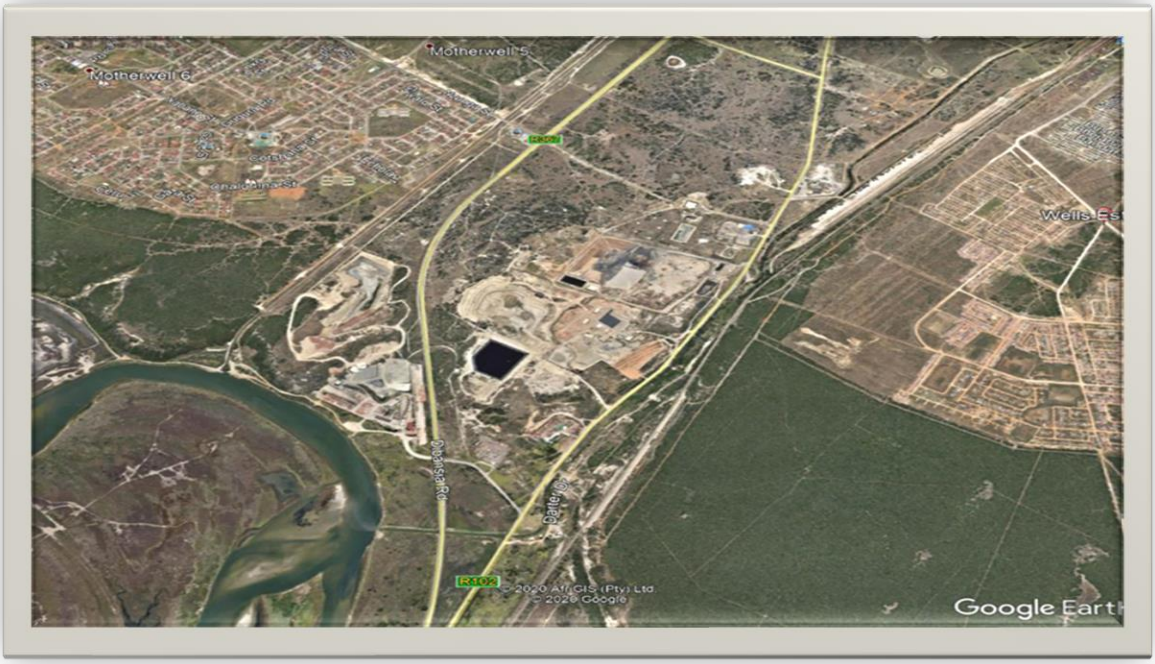
According to Hamann and Tuinder (2012), the northern part of the province is very mountainous, being part of the Great Escarpment, commonly referred to as the Drakensberg Mountains. Towards the south, the folded mountains are situated between East London and Port Elizabeth, where the landfill is located (Hamann and Tuinder,

2012). The waste disposal facility in question is situated on a plateau, which is part of the watershed that lies between the Sundays River and Coega River catchments (Niehof, 2018).

3.3.3.3 Geology

One of the features of the area is the basin structure which emerged as a result of the erosion of the folded basement of the Cape Supergroup (Meyer, 2008). During the late-Jurassic period, there was an accumulation of pebble and boulder alluvial deposits. Since there was clay deposit onto the Enon formation, resulting in the formation of mudstones and siltstones in the Kirkwood formation (Meyer, 2008). It should be noted also that the Sundays River formation was the result of the deposition of both estuarine and marine clays into the basin of the Eastern Cape (Meyer, 2008).

The Eastern Cape's geological landscape has terraces in cretaceous sediments. There are also calcareous sandstones. The Cape Supergroup rocks are made distinct because of its extreme east-southeast trending folding. Towards the south is the Elands River syncline and towards the north the Swartkops River anticline (Toerien & Hill, 1989). Another major geological feature of the area is the Coega fault, traceable eastwards from the Groendal Dam to the coast; hence there is substantial displacement, which is vertical along this fault line (Toerien & Hill, 1989). Figure 3.4 below depicts the locality map of where site C is located.



Source: Google Earth, 31.10.2020

Figure 3.4: Locality map for the Site C waste disposal facility

3.3.3.4 Ecology

The Eastern Cape is ecologically diverse, with all South Africa's biomes present, except the desert type. The most prominent biomes in the region are the Savannah, Grasslands and Nama Karoo (Hamann & Tuinder, 2012). The area of Gqeberha is a convergence zone for two biodiversity hotspots, namely, the Maputaland Pondoland Albany and the Succulent Karoo (Hamman & Tuinder, 2012). The Eastern Cape is known for its estuaries. However, Hamann and Tuinder (2012) reported that, while most of the estuaries in the rest of the province were ecologically intact, the same was not true for Gqeberha.

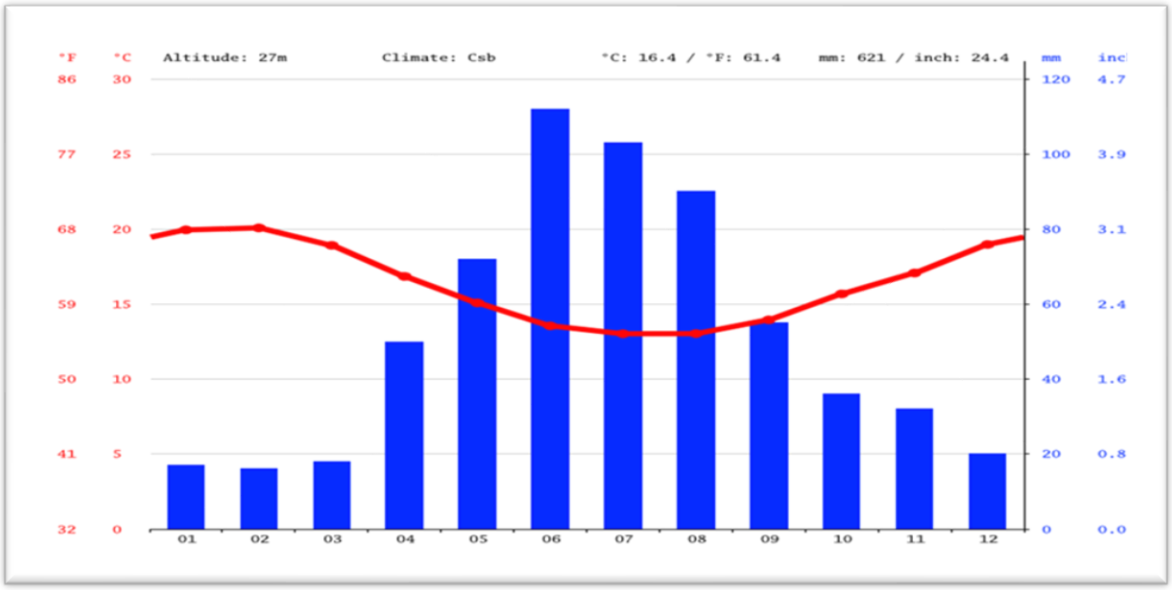
3.3.4 Site D

The fourth waste disposal facility is located in the Western Cape Province. This facility is also classified as a H:H in terms of the Minimum Requirements. Therefore, it is equivalent to a Class A landfill in terms of the Waste Classification and Management Regulations.

This means that the facility can accept high hazardous waste and all other waste types (DWAF, 1998).

3.3.4.1 Climate

A Mediterranean type of climate is characteristic of the area (Midgley, et al. 2005). As such, winter conditions are usually cool and wet, while summers are warm and dry. The province at large has a wide range of climatic gradients, including the steep south-north aridity gradient, coupled with an east-west rainfall seasonality gradient (Midgley, et al. 2005). The mean yearly rainfall in the area is in the range of approximately 400mm. Evaporation is high and in the range of approximately 1600mm per annum (Midgley, et al. 2005). The mean annual rainfall of where the site is located is depicted in Figure 3.5 below.



Source: Climate-Data.Org 02.08.2021

Figure 3.5: Mean annual rainfall of the Western Cape

3.3.4.2 Topography

The site at which the study will be conducted is located on a piece of land where it is relatively flat with slight differences in altitude, so while the south is located 40m above sea level, the north of the site is 60 m above sea level (SRK Consulting, 2018). Man-made topographical features at the site include infrastructure for the management of

surface water, pipes and sumps, which are part of the leachate collection system. Areas surrounding the site can be described as gently undulating coastal plains (SRK Consulting, 2018).

3.3.4.3 Geology

The area where the waste disposal site is located has a profile of mudrock (phyllites), which is from the Malmesbury Group. According to SRK Consulting (2018), there is one to eight metres of aeolian dune sand. These are on top of three to eighteen metres of residual mudstone in the area, which in turn is mostly made up of clayey sandy silt with friable, soft rock, Malmesbury mudstone. This also lies on top of nine to seventeen metres of friable soft rock mudstone, which also contains some sandy silt. The bedrock comprises of fractured rock mudstone. SRK Consulting (2018) further indicated that the area does not have any significant dykes or faults. For this reason, the aeolian sand, together with the upper residual mudstone and friable Malmesbury mudrock, have largely been removed from areas in the vicinity of the waste disposal facility, because of clay brick mining.in close proximity to the site but the clay is an advantage in terms of impermeability to leachate.

3.3.4.4 Ecology

The site is situated between peri-rural and rural classified areas. As a result, the surrounding land has been greatly disturbed because of ongoing agricultural activities which has driven animal species away from the site. The landfill area does not have a wide variety of animal species. This is because of the waste, which only attracts scavengers, with the most frequent ones being house rats and stray dogs (SRK Consulting, 2018). This has created a lot of alien vegetation (SRK Consulting, 2018). Towards the south of the facility, there has been growing urban development.

3.4 Research method

There are three main approaches to gathering and reporting information while conducting research, namely qualitative, quantitative and mixed methods approach (Maree, 2009). The quantitative method employs strategies that quantify the problem; thus, data is

generated and analysed in the form of numbers and then transformed into statistics (Maree, 2009). On the other hand, qualitative data is more concerned with the quality of information provided, thus it is more exploratory. Qualitative data is used to gain in-depth insight into phenomena, underlying issues, motivations, and opinions (Maree, 2009).

The qualitative research method was used in order to achieve the objectives. Information gathered through qualitative research is usually detailed and rich because such information is generated in a non-quantitative form, thus it is in the form of words and cannot be subjected to rigorous quantitative analysis (Ritchie et. Al., 2013). The most important aspect of qualitative research is that it is premised on uncovering and understanding people's experiences with a particular phenomenon (McCusker & Gunaydin, 2015). The method suited this study whose broader aim was to understand the difficulties faced by hazardous waste landfill operators when complying with the conditions of a WML including the costs associate with complying with licence conditions.

Table 3.2: Methods and approaches used for the study objectives

Objective	Specific approaches
1. To determine to what extent are landfill operators able to comply with waste management licence conditions	Analysis of external audit reports
2. To determine the costs associated with complying with waste management licence conditions	Open-ended questionnaire
3. To assess the effects of licenced waste disposal on groundwater	Analysis of external audit reports
4. To determine governance difficulties associated with complying with waste management licence conditions	Semi-structured Questionnaire

Source: Author's notes

3.5 Research design

The case study design was used for this research. According to Maree (2009: 75), this design is a “systematic inquiry into an event or a set of related events which aim to describe and explain the phenomenon of interest.” A similar explanation is given by Creswell, Hanson, Clark-Plano and Morales (2007), who indicated that the case study design takes away focus from the individual or the corporation, to the issue of focus which is hazardous waste disposal. Therefore, the three facilities where the data collection occurred, constitute the cases upon which the study is based. However, the information that was obtained through the study highlights industry-wide experiences on the subject matter. An interesting aspect of the case study design is that it is phenomenological, thus it is based on people’s experiences of the phenomenon (Maree, 2009).

3.6 Primary and secondary data sources

The study was based on primary data and secondary data. According to Levine-Clark (2019), if the researcher is the originator of primary data, such data open avenues for the generation of new knowledge and observations. Secondary data pertain to data from studies conducted by other researchers in the past (Ajayi, 2017). The following sections show how primary and secondary data were collected and analysed.

3.6.1 Primary data collection

This type of data was collected from landfill operators. The data was purposely collected from them because they are responsible for ensuring compliance with the waste management licence conditions at their respective sites. This aspect of the research was meant to provide information to fulfil Objectives 2 and 4 of the study. Before and while the data were being collected, the following procedures were followed.

3.6.1.1 Purposive sampling

Purposive or target sampling, which is a non-probability sampling technique, was used in the selection of study participants for the study. According to Alvi (2016), in purposive

sampling, the researcher uses judgement to select participants that meet the study criteria. In this instance, landfill operators were selected because they managed the facilities and were willing to participate. Purposive sampling was therefore used to select three participants from the three sites for data collection. The three participants were able to provide information on the governance difficulties that were encountered while complying with waste licensing regulations, and the costs that were incurred in the process.

3.6.1.2 Data collection instrument

Two separate questionnaires were developed, as data collection instruments. The first questionnaire was open-ended (see appendices) and focused on difficulties experienced by landfill operators which is the fourth objective of this study. The questionnaire consisted of 12 open-ended questions which are listed below:

1. What are some of the difficulties that are encountered by you as the landfill operators when ensuring compliance with waste management licence conditions?
2. What fraction of these difficulties are as a result of the waste management licence itself? Discuss.
3. What avenues have the landfill operators explored in order to address the difficulties that have to do with the waste management licence itself? Have these yielded any positive results?
4. Has the landfill operator managed to discuss some of these difficulties with the authorities? Yes or No? If yes kindly discuss how the response has been from the authorities.
5. Was the landfill operator satisfied with the response of the authorities? Why?
6. What would the landfill operator suggest as solutions to difficulties that are faced by licence holders as a result of waste management licence conditions?
7. What is the landfill operator's view of the licensing requirement in terms of NEMWA 2008?
8. What other regulatory mechanisms would the landfill operator have recommended to the authorities for regulating landfills?

9. What is the landfill operator's view on the alignment of the waste management process with the NEMA EIA regulations?
10. How does the landfill operator view the process of obtaining a waste management licence as currently executed by authorities?
11. Would you suggest that the licensing system has resulted in improved compliance and minimal impacts on the environment as compared to the permitting system? Elaborate.
12. What is the landfill operator's view on the Waste Classification and Management Regulations, as compared to the Minimum Requirements?

The second questionnaire focused on determining the costs of complying with waste management licence conditions (see appendices) which is the second objective of the study. The questionnaire was semi-structured with a total of eight questions written as follows:

1. What is the estimated cost of complying with each condition of the waste management licence?
2. What is the estimated cost of complying with the conditions of a waste management licence per month?
3. Which conditions of the waste management licence are most costly to comply with?
4. Which of these conditions do you feel escalate compliance cost because of the way that they are communicated in the waste management licence? Could their objectives be achieved in a different manner?
5. Which of these conditions would you recommend being removed from the waste management licence in order to reduce the cost of compliance without loss of effectiveness?
6. Which of these conditions would you recommend being varied or changed from the waste management licence in order to reduce compliance cost?
7. Should the waste licence conditions be varied or removed, how would this impact on the environment?

8. What would you suggest the authorities take into consideration when drafting waste management licence conditions to reduce cost?

3.6.2 Secondary data

3.6.2.1 External audit reports

External audit reports document and record whether the facility is compliant or non-compliant with the waste management licence conditions. Furthermore, external auditors capture summarised findings of the groundwater monitoring results within the external audit reports. For the purposes of this study the external audit reports were able to address Objective 1 and Objective 3 of the study. External auditors are appointed by the company to audit the sites as a requirement of the waste management licence. The initial plan was to review a total of 12 external audit reports for the purposes of this study, however 8 external audit reports were reviewed as a result of the gatekeeper access to audit reports for site B

3.7 Data analysis

3.7.1 Thematic analysis

Thematic analysis was used in the analysis of transcribed interview data from both questionnaires. Alhojailan (2012) indicated that thematic analysis allows for the identification of the frequency of a theme, in relation to the topic. This view is supported by Maguire and Delahunt (2017) who stated that thematic analysis entails analysis of qualitative data by identifying recurring themes and patterns within the data. Thematic analysis is a step-by-step process. These are the steps that were followed in this study:

- The answered questionnaires were read thoroughly for the purpose of familiarisation.
- Thereafter, coding was done, which involved attaching labels to issues that were recurring.
- The labels attached to specific parts of the data were further analysed, in order to identify common issues. At this stage themes were identified.

The themes were then discussed in accordance with the objectives and then appropriately named.

3.8 Ethical considerations

The research was conducted with full consideration for ethical standards. These are laws and guidelines that researchers need to follow, especially when working with human participants (Driscoll, 2011). The following ethical standards were upheld:

3.8.1 Voluntary participation

Prior to participating in the study, potential participants were contacted by telephone and email. The nature of the study was thoroughly explained to and they were given adequate time to ask questions for clarity. Those who consented to participate, signed a consent form. This was a prerequisite to indicate that they voluntarily accepted to participate and that there would be no compensation. Participants were also informed that they were free to leave the study at any stage of the process, without any consequences to them personally or to their work.

3.8.2 Confidentiality

The consent letter was signed by an individual designated by the waste management licence holder. The data that were recorded and transcribed were being kept in a secure facility for seven years. Thereafter, all information will be permanently destroyed. The researcher ensured that the names of the participants were not revealed.

3.8.3 Honesty and Integrity

The values of honesty and integrity were upheld throughout the research process. Honesty was practiced not just with regards to communicating with landfill managers, but also in compiling this research report. Therefore, even authors whose articles were used were duly acknowledged through referencing.

3.9 Site Visits to the Study areas:

To ensure that the questionnaires were completed speedily, site visits were conducted to all the waste disposal facilities and data were obtained on the same day. The images below were taken by the researcher at the waste disposal facilities. Access is controlled at the gate and trucks are directed to the weighbridge where the waste is weighed as shown in the figure 3.6 below. This information that is obtained from the weigh bridge feeds into the waste information system in order to quantify the amount of hazardous waste that is disposed at waste disposal facilities in the country

Figure 3.6 Control of access at the site and the weigh bridge where trucks are weighed for waste information purposes

Once the truck has passed the weigh bridge, it is directed to the working face of the site, which acts as a functional area for waste acceptance. As soon as the working face has reached a certain capacity, then a new working face is created and that is where trucks are directed to dispose the waste. Figure 3.7 and 3.11 depicts the working face at the time when the site visit was conducted.

Figure 3.7: Operational cell at waste disposal site where trucks are disposing waste

A leachate dam is a legal requirement in terms of NEMWA, to protect the environment as it collects any leachate generated from the waste disposal facility and acts as an evaporation dam. Figure 3.8 and 3.10 depicts the different leachate dams at the site.

Figure 3.8 HPDE lined leachate dams where leachate is stored and treated to reduce the toxicity levels of the leachate.

Encapsulation means coating the waste with inert materials. The coating materials are chemically stable, adhere to the waste, and resist biodegradation. High-density polyethylene (HDPE) and polybutadiene are most often used to perform encapsulation. Figure 3.10 below depicts the encapsulation areas at the site.

Figure 3.9 Encapsulation area at a waste disposal site.

This method is used for the disposal of waste drums containing chemicals or hazardous waste material or components thereof, the method comprises of adding the hazardous waste material to a settable composition, the composition comprising a calcium carbonate, a caustic magnesium oxide and an additive, and wherein the additive is an organic acid selected from the group consisting of citric acid, lemon acid, acetic acid, glycolic acid, oxalic acid, and other di or poly carboxylic acids, tartaric acid, salicylic acid, ethylenediamine tetra acetic acid and other tetra acids; forming a slurry; and allowing the slurry to set to encapsulate the hazardous waste material or components thereof, the additive accelerating the formation of strong binding agents and assisting the recrystallisation of the composition to make it set.

Figure 3.10: A leachate dam at a site

Figure 3.11 An operational cell and the working face of the site

Figure 3.12 Waste pickers that sort recyclable waste materials. This is done to create opportunities for the nearest community. The waste pickers are provided with the necessary personal protective equipment by the landfill operator.

3.10 Limitations of the study

The term research limitations pertain to problems that were encountered while conducting a study, or the shortcomings of the study itself (Olufowote, 2017). While conducting this study, the following limitations became apparent.

- Due to the limited number of licenced hazardous waste disposal facilities, only four sites were selected since the licence holder accepted the request to conduct research at these facilities. However due to unforeseen circumstances with the fourth site, data could only be collected from three facilities.
- Three participants provided the data for compiling this report; whereas when the research proposal was submitted to the institution of higher learning, it was indicated that there will be four participants.
- Interviews relied solely on the subjective experiences, as well as on the perspectives of the participants. As a result, there are always risks of dishonesty or the manipulation of the information particularly on the aspect of compliance with legislation.

- Quantitative methods were supposed to be used to assess the effects of the landfill facilities on groundwater. However, the measurement of this phenomenon could not be accomplished with the external audit reports due to the lack of data as compared to the groundwater monitoring reports. Therefore, Objective 3 cannot be achieved thoroughly without the groundwater monitoring data or reports.

3.11 Chapter summary

This chapter included a description of the methods and procedures that were followed to conduct this study, together with the ethical considerations and study limitations that were encountered throughout the research process. The results that were obtained from those methods are presented and interpreted in the following chapter.

CHAPTER 4

RESEARCH RESULTS

4.1 Introduction

This chapter presents the results from analysing the data in order to understand the impact of licensing on the selected three commercial hazardous waste disposal facilities in South Africa.

Based on the study objectives, this chapter is divided into four sections. Firstly, the results of the audit reports are presented in Section 1. These results indicate WML holder's ability to comply with the WML conditions. The results from the questionnaire on the estimated cost of complying with WML conditions are presented in the second section. The section also highlights cost implications in the case of the removal of specific conditions that exacerbate the cost of compliance. Section three includes further results from the audit reports, which indicate the effects of licenced waste on groundwater. The fourth and last section in the chapter contains results which pertain to the difficulties experienced by licence holders. Issues covered in this section include some of the difficulties as a result of the waste management licence itself; avenues that licence holders have explored to address these difficulties with waste management licences; and whether licence holders have managed to discuss some of the difficulties with the authorities, along with the outcomes of these efforts. The results are then presented thereafter, and the chapter concludes with a summary.

4.2 Section One: Compliance with waste management licence conditions

Objective 1: To determine to what extent, the landfill operators were able to comply with waste management licence conditions.

Eight external audit reports were analysed to determine to what extent to which landfill operators were able to comply with the waste management licence conditions of the facilities they manage. Two of the reports were from Site A landfill facility, for years 2014 and 2015. Three reports were from Site C Landfill facility, for the years 2013, 2014 and

2015. There were also three reports from Site D landfill facility, for the years 2014, 2015 and 2016. Following the analysis of the audit reports, both positive and negative results were noted, and they are presented below.

Table 4.1 External audit reports obtained

Waste Disposal Site	*Number of reports*	*Years*
Site A	*2*	*2014, 2015*
Site C	*3*	*2013, 2014, 2015*
Site D	*3*	*2014, 2015, 2016*

Source: Author's notes

Compliance with licensing conditions

The results of the analysis indicated that all three facilities were compliant with licensing conditions. It was evident that there were comments that had been given by the auditors with regards to the ability of the landfill operators from all three facilities to comply with the WML conditions for their respective facilities. For example, at landfill Site A, Baldwin (2015) reported in an external audit report that,

"Of the 126 auditable conditions listed in the Site and Treatment Plant Licences, the facility is only showing four (4) partial compliances and non-compliance to none of the conditions. If two points are assigned to compliance, one point to partial compliance and zero points to a non-compliance then the site is meeting 98.4% of the applicable conditions."

Likewise, the landfill operators for Sites C and D, were to a greater extent, able to comply with the conditions as stipulated in their licences. Some extracts from audit reports which were analysed from these sites confirm this.

At Site C, Baldwin (2015) suggested that "*the site, the Leachate Impoundment Dam and the Effluent Treatment Plant meet nearly all of their licence requirements and the management of these facilities is very acceptable. The Site licence and the Treatment Licence contain 137 applicable conditions that were auditable and were not repeated, i.e.,*

between the two licences. Only two partial compliances and no non-compliances were identified, i.e., 99.3% compliance."

At Site D, Baldwin (2016) indicated that, *"the audit shows that the Waste Management Facility generally complies very well with the new licence and this is reflected in the audit checklist. Of the 208 auditable conditions, only one instance of partial non-compliance was noted, i.e., the site is complying 99.6% of the time. This is an excellent score, as many of the issues identified in previous audits have been corrected and a system has gradually been developed to ensure that the required licence and management requirements are carried out, as and when required."*

These findings from the external auditors, suggest that the level of compliance at all three facilities was at least 98%. This was a positive result since the three facilities from which data were collected were operating within the stipulations of their respective licenses. Nevertheless, because compliance for all three landfill facilities never reached 100%, it is necessary to investigate the incidences of non-compliance that were reported by the external auditors. The following issues were therefore identified:

Dangerous fire outbreaks

Dangerous fire outbreaks had emanated from Site A and Site D and these were identified by the external auditors as difficulties that were encountered by the landfill operators. At landfill Site A, there was a partial non-compliance in 2014, when chlorine waste which is highly reactive was disposed and due to its reactive nature, there was a fire outbreak at the facility. As indicated by the external auditor, fire at a landfill facility where there are numerous hazardous chemicals and gases poses a great risk to the environment and may perpetuate environmental damage. On this case of partial non-compliance, Baldwin (2014) indicated that,

"A fire occurred at the site due to chlorine, HCLl which was inadvertently disposed at the site. This disposal of a reactive waste is not allowed in terms of the licence and regulations and has been recorded as a partial non-compliance rather than a non-compliance, as it

appeared that all other wastes were disposed according to the requirements and a procedure is being developed to prevent reoccurrence of this problem."

Similar non-compliance incidences were reported in 2015 at Site C and at Site D in 2016. Baldwin (2015) indicated indicated that,

"A fire broke out on the Western slope of the facility. The fire quickly spread over the entire slope as a result of continuous SE wind."

Despite the fire outbreak of 2015, another fire caused partial non-compliance at the facility in 2016. The fire was not of a similar magnitude, but nonetheless contravened the WML condition. Baldwin (2016) indicated that,

"A small chemical fire broke out in the trench on Cell 2. The fire was attributed to a stock of lime obtained from a new supplier".

Therefore, dangerous fire outbreaks were identified as one of the non-compliance difficulties encountered by landfill operators.

Insufficient knowledge of conditions and/or regulations

Another challenge is that landfill managers did not have sufficient knowledge of the conditions that are stipulated in their operational licenses. This results in unintentional incidences of non-compliance. An example of this can be drawn from Site A, where in 2013 the external auditor expressed concern about the site operator's potential lack of awareness of new waste classification regulations. The external auditor's concern was focused mainly on the disposal of certain types of waste, like sanitary waste. According to the auditor, the classification of sanitary waste had been changed to health care risk waste, thus the report indicated that:

"The current sanitary waste accepted on the site may not meet the new standard…"

This inadequate knowledge that results in facility non-compliance was also reported in the 2014 and 2015 audit reports from Site D. In particular, the reports indicated that the site operator was not abreast with the requirements of water monitoring at hazardous waste facility. Because of this, the landfill operator was not complying with the WML conditions in terms of monitoring the levels of tritium in surface water, groundwater and leachate. The tritium was only being monitored once a year, whereas the licence indicated that this had to be done twice each year. Therefore, the external auditors reported respectively that,

"The frequency of the monitoring of Tritium must therefore be increased to two per year, in accordance with the new requirements".

"As noted in the previous audit, the new condition requires that Tritium is monitored biannually in the surface and groundwater and the leachate but was only being monitored once a year in June/July".

The need for the variation of the waste management licence conditions as stipulated in NEMWA

Landfill facilities operate according to strict WML conditions therefore, in certain instances changes that occur either to legislation or at the facility may warrant variation of the WML conditions and this provision is stipulated in Section 54 of NEMWA. Moreover, as was indicated in the literature, there are incidences where WML conditions are not clear or easily understandable. These issues were identified both at Site C and at Site A waste disposal facilities.

The 2013 external audit report from Site A raised a critical issue identified by the landfill operators that some conditions in the WML were difficult to comprehend, while some were repeated, and this was specifically stipulated on the external audit report as follows:

"There is need for clarification from the DEA e.g., condition 5.11 is a repeat of 4.5."

Identification of this issue at Site A meant that there was a need for the variation of the WML. At Site D the need to revise the Operations Manual was also identified in 2015 and 2016. The manual had to be in line with the changes to the legislation governing the disposal of hazardous waste. Thus, the external auditor reported that,

"The Operations manual requires to be updated particularly as the licence has replaced the permit and because of rapid development on site."

The permits had been issued in terms of ECA and the waste management licences are issued in terms of NEMWA. Furthermore, permits were issued using the Minimum Requirements whereas the waste management licences follow the Waste Classification Regulations. This would ensure that the Operations Manual is relevant to current legislation and regulations.

Non-treatment of leachate

This issue was identified during data analysis, and it was peculiar to Site A. The treatment of leachate is an essential component of hazardous waste disposal facilities. However, at the time when Site A's 2014 audit report was compiled, there was partial non-compliance with regards to the treatment of leachate. This problem emanated from lack of function of the treatment plant, which had been shut down. During that time, a new treatment plant was being built and tested as a pilot as evidenced in the following remarks from Baldwin (2014):

"The Leachate Treatment Plant has been shut down and is, therefore, not operating. A new facility is to be built possibly by the next Annual External Audit in September 2015. The closure of the plant, therefore, results in two partial compliances to the Site Operating Licence because the proposed new treatment plant is being tested on a pilot plant scale."

Delayed responses from the DEA (Now DFFE)

The lack of efficiency from the DFFE in terms of providing responses to applications, appears to be an ongoing challenge and it was identified as one of the major themes in

the analysis pertaining to the first objective. While this appeared consistently in Site C audit reports, it was also cited by landfill operators. In 2014, applications were made to the DFFE for variation of WMLs, but DFFE did not provide responses to the applications.

Also, in 2015, the licence holder requested approval to revise the Waste Management Plan (WMP) at Site C and once again, the DFFE delayed the approval process of the WMP. Therefore, the external auditor stated the following:

"Revision of the WMP was necessitated because of new licence conditions and the construction of the new cell. However, no response has been received from the Department, despite requests from the company."

4.2.1 Discussion of the results

Data were collected from the external audit reports that were compiled after assessing all three waste facilities. The results indicate that the landfill operators have largely been able to comply with licensing conditions. As indicated in the available literature (DEA, 2014b), the conditions are meant to protect and enhance environmental quality. The results indicate that the landfill operators of the waste disposal facilities where data were collected understand the importance of protecting the environment thus were able to a greater extent to comply with the WML conditions as prescribed. However, the results confirmed some of the concerns raised in the literature review.

Furthermore, the results revealed that some waste licensing conditions were repeated and when variation applications were submitted to the authorities, the responses were delayed. The licensing authority does not only have a responsibility to process WML applications, but also to ensure that landfill operators comply with the WML conditions through compliance monitoring. Therefore, the inability of the authorities to timeously provide responses to the variation applications, led to non-compliances with some of the WML conditions at the hazardous waste disposal sites and this was particularly noted by external auditor at Site C. This issue was raised in literature by Kolar (1989), and the results therefore concur with the literature reviewed.

The literature review indicated that waste management laws and regulations are constantly changing, with the aim of improving waste management processes to increase environmental protection. As indicated by the DEA (2014b), licence holders have the responsibility of ensuring compliance and this encompasses their knowledge of existing legislation. Therefore, as legislation changes, landfill operators need to constantly update their knowledge. At Site A, there was an incident when chlorine, which is reactive waste, was disposed at the waste disposal site. Reactive wastes occasionally enter waste disposal sites in mixed waste loads supplied by a client that has failed to correctly disclose the presence of the reactive substance to the landfill operator. At Site C, the landfill operator was also at one point cited by the external auditor as not being capacitated with the new regulations on the disposal of hazardous waste. Such difficulties were also discussed by Kolar (1989), thus there appears to be greater need by landfill operators to constantly update their knowledge of waste legislation and regulations, to enhance compliance with the WML conditions.

The results that were obtained regarding the ability of the landfill operators to comply with licensing conditions, confirm assertions by Pienaar and Howard (2014), that waste will constantly threaten environmental quality, and this is one of the concerns considered when licensing waste disposal facilities. However, if the conditions of a waste management licence are adhered to, they minimise risk and pollution to flora and fauna (Pienaar and Howard 2014). At Site A, the leachate treatment plant was closed, while another was being constructed. During that time, there was inadequate infrastructure to treat leachate. Thus, there was a risk of groundwater resources pollution should the leachate dams have been overfilled as a result of heavy rainfalls during that period. The general lack of adequate infrastructure is duly noted by Meidiana and Gamse (2011) as being common in waste disposal. This is one of the issues that the licensing authority needs to take into account when issuing licences, and waste disposal facilities need to be constantly monitored by the authorities to ensure adequate infrastructure to cater for the amount of waste that is disposed and to cater for the amount of leachate generated. Due to inadequate capital and funding, many facilities fail to improve their infrastructural

capabilities. At Site C, there were reports of bad odour that was affecting air quality, while Site D experienced both a fire outbreak and elevated levels of Tritium in surface and ground water. It is therefore evident that while non-compliances by landfill operators may have been minimal, measures must definitely be taken to achieve full compliance. The non-compliances identified were found to be contingent on other matters, in particular the costs associated with operating the facilities.

4.3 Section Two: Understanding the cost implications of waste management

Objective 2: To evaluate the costs associated with complying with waste management licence conditions.

The focus of this section is on understanding the cost implications of complying with waste management licences. These results were obtained from a questionnaire that was answered by the respondents (landfill operators). The section begins with the estimated costs of complying with each condition of the waste management licence. Data were collected from three respondents who participated in this study, each representing one of the three facilities. The responses are presented in this section and in section four of this chapter.

4.3.1 Estimated costs of complying with each condition of the waste management licence (Question 1)

In Question 1 the respondents were asked about the estimated costs of complying with each condition of the waste management licence. The responses are presented in the following table.

Table 4.2: Estimated cost of complying with each condition

Respondent	Response
Respondent 1	*Between R50 000 and R100 000 depending on the condition.*
Respondent 2	*Depends on the condition.*
Respondent 3	*Below R10 000*

The responses provided by the respondents varied significantly, by they did indicate that complying with some of the WML conditions involved high costs. The explanations by Respondents 1 and 2 provided a key aspect about costs; the cost for each of the conditions within the WML was therefore different. As such, it is likely that some conditions may be too expensive to comply with. Therefore, if WML conditions are not site specific, a landfill operator may have to ensure compliance with WML conditions that are not applicable to the site. Therefore, if those conditions appear on the WML thus, it may likely be incurring unnecessary costs. Therefore, it is imperative that WML conditions are site specific to avoid unnecessary costs for landfill operators when ensuring compliance.

4.3.2 Estimated cost of complying with all conditions of a waste management licence for a hazardous waste disposal site per month (Question 2)

In contrast to the answers to the previous question, there was a unanimous consensus among the respondents that the estimated costs of complying with conditions of a waste management licence for a hazardous waste disposal site were extremely high. The responses are presented in Figure 4.1.

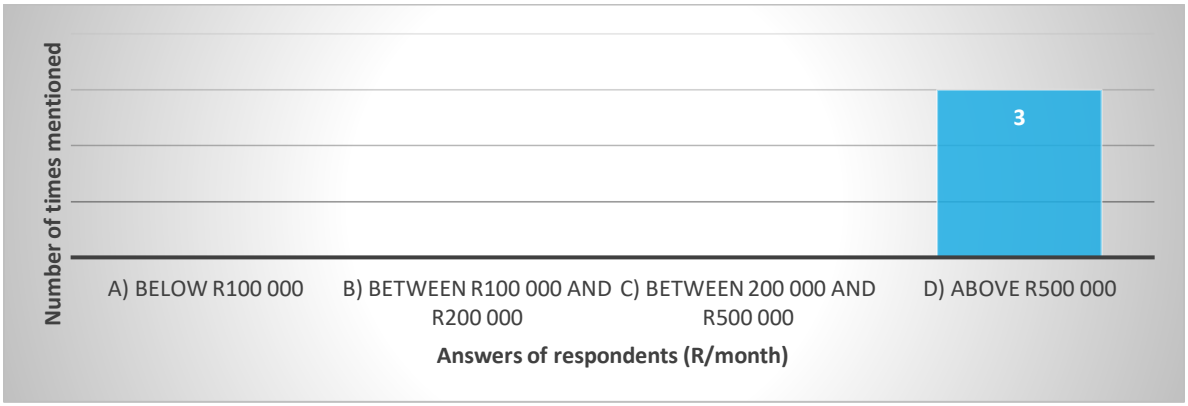


Figure 4.1: Estimated cost of complying with conditions for a hazardous waste site

As presented in Figure 4.1, all three respondents stated that costs exceeded R500 000 per month. Respondent 2 indicated that the costs could even reach R*2.5 million per year excluding the monitoring committee meetings.* Respondent 1 also reported that the costs were higher and *between R1 million and R1.5 million per month.*

4.3.3 Conditions of the waste management licence that cost most for compliance (Question 3)

The study also attempted to evaluate which conditions of the waste management licence were particularly expensive to comply with in Question 3. Figure 4.2 below depicts the results were obtained.

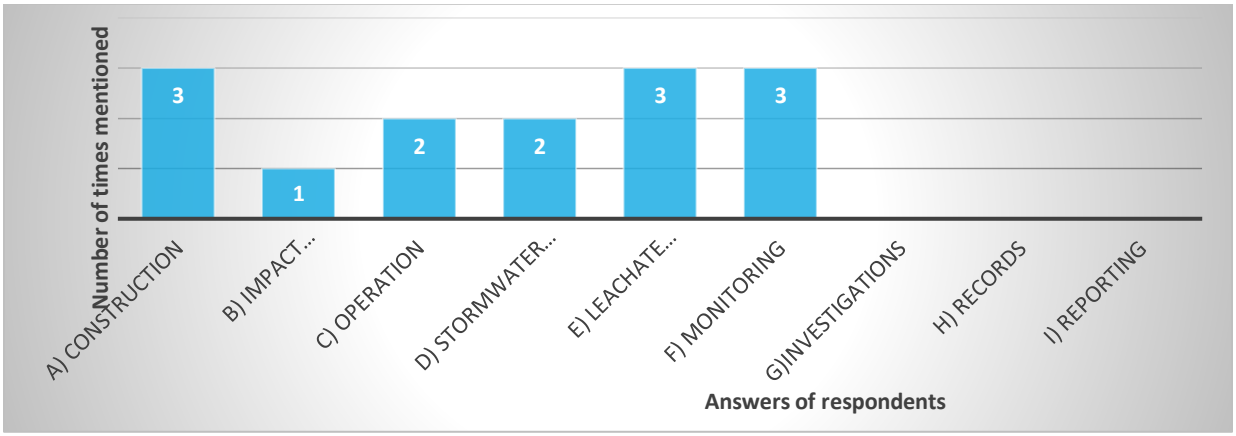


Figure 4.2: Costly conditions for a waste management licence (Question 3)

The conditions of the waste management licence that were more costly to comply with, were construction, because engineering is required and installation of liners for protection of groundwater resources which explains the high cost. Furthermore, leachate management and monitoring WML conditions were also identified to be costly by all the respondents. The conditions for operation and storm water management were mentioned by two of the respondents, suggesting a moderate degree of consensus about these as costly factors for licence holders to ensure compliance. One of the respondents listed impact management as a costly condition. The conditions of reporting, records and investigations were not listed as costly areas for compliance.

4.3.4 Conditions that escalate compliance cost by the way that they are written in waste management licences (Question 4)

There were only four conditions that were identified to be escalating the cost of compliance as a result of the way that they were written in the WMLs, and these were responses to Question 4. These were construction, stormwater management, leachate management, and monitoring WML conditions. Unlike in the previous question, impact management and operation conditions were not identified to be escalating the compliance cost because of the way that they had been written into the WML. Figure 4.3 below depicts the conditions that the respondents felt escalate compliance costs.

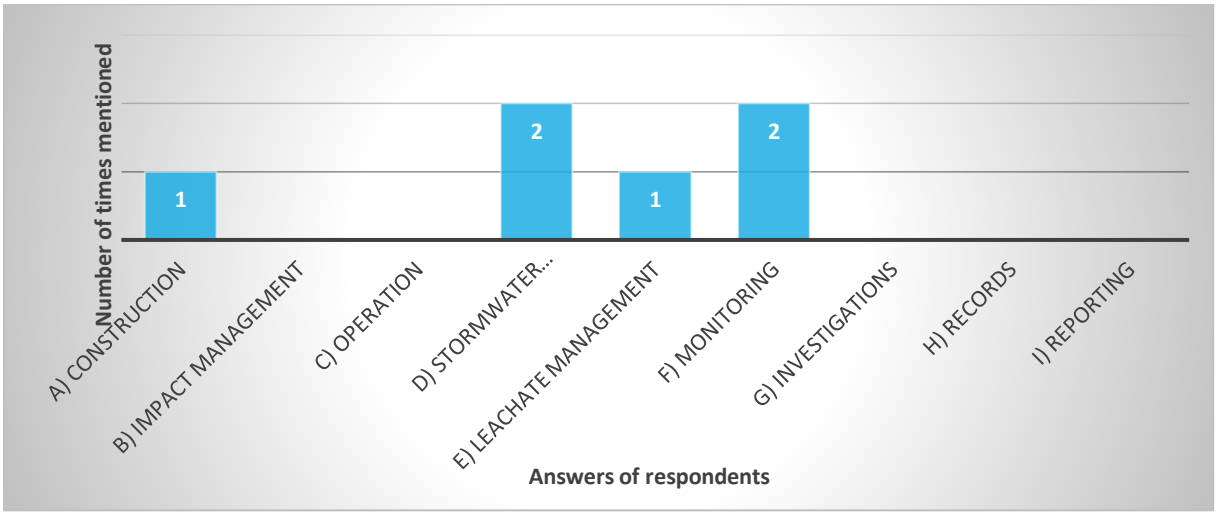


Figure 4.3: Conditions that escalate compliance costs because of the way they are written in the WML (Question 4)

Two of the respondents made some additional comments relating to the water quality monitoring parameters and protocols that the landfill operators have to comply with. This appeared to be a considerable problem among landfill operators. For instance, Respondent 2 noted that it would be better *if the monitoring parameters and protocols were to be approved by the authorities*, while Respondent 1 reiterated that there should be a *monitoring protocol that is specific to each site instead of generic monitoring protocols.*

4.3.5 Conditions that should be removed from the waste management licence in order to reduce compliance costs (Question 5)

The respondents were unanimous in their answers to Question 5, that none of the conditions should be removed from the waste management licence in order to reduce compliance costs.

Respondents 1 and 2 justified why they thought that none of the conditions should be removed. Respondent 2, for instance argued that none of the conditions should be removed because *they are all important to protect the environment.* Respondent 1 confirmed this by stating that there should be other ways of reducing costs of compliance, such as through adjustment of the way the licences are written, since the ultimate goal *is to protect the environment.* These responses confirm the views regarding the importance of protecting the natural environment by minimising impacts on the environment through compliance.

4.3.6 Conditions that should be varied to reduce compliance costs (Question 6)

Four conditions were noted by the respondents as conditions that should be varied to reduce compliance costs. These conditions are presented in Figure 4.4 below.

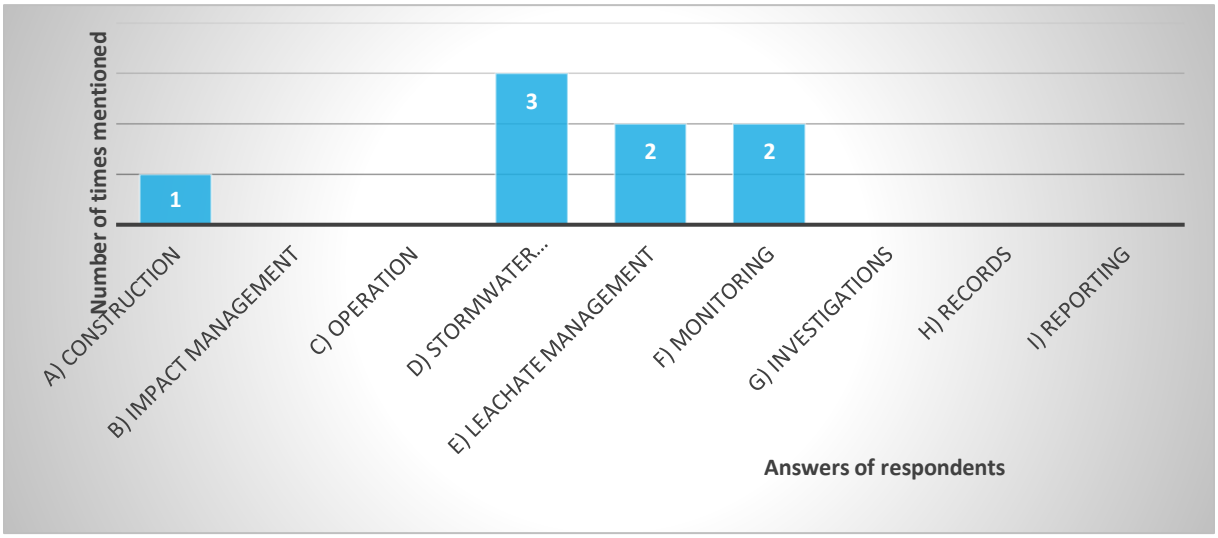


Figure 4.4: Conditions that should be varied to reduce compliance costs (Question 6)

Storm water management conditions were identified by all three respondents as a point of concern in all three facilities. Leachate management and monitoring conditions were also listed by two of the respondents, while the construction condition was mentioned by only one respondent. These conditions appear to require re-consideration by authorities, as they have been shown to increase compliance costs. Variation of these conditions would likely lead to protection of the environment while compliance would likely be easier for landfill operators. An example would be for the water monitoring parameters to be specific for each based on the waste streams that are received and the surrounding land uses.

4.3.7 Licence holders' views on how the variation or removal of waste licence conditions would impact the environment (Question 7)

There were mixed views by the respondents over how the variation or removal of waste licence conditions would impact the environment and these views are expressed in Figure 4.5 below

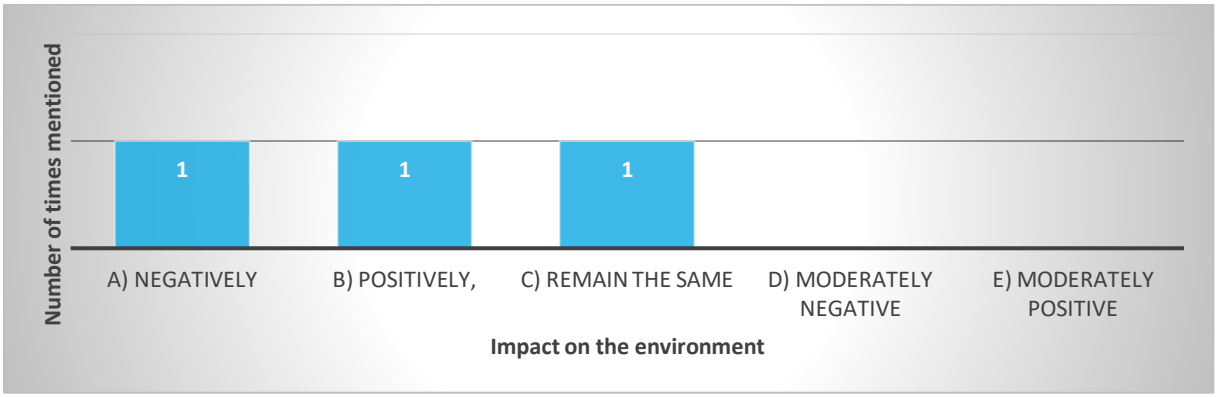


Figure 4.5: Views on how the variation or removal of waste licence conditions would impact the environment (Question 7)

On this question, though, the respondents appeared to have different views since one indicated that the variation or removal of waste licence conditions would negatively impact the environment, one indicated that it would positively impact the environment, and one

indicated that there would not be any change. These results appeared to be somewhat contrary to the responses in Section 4.3.6, which queried what conditions should be removed or deleted from the waste management licence in order to reduce compliance costs. As noted in that section, there was a unanimous consensus that none of the conditions should be removed from the WML. However, these results concur with the mixed responses in Section 4.2.2.1, on whether there had been improved compliance and reduced environmental impact from the licensing system relative to the permitting system. Deliberations on the reasons for these discrepancies are presented in the discussion chapter.

4.3.8 Suggested considerations by the authorities when drafting waste management licence conditions in relation to costs (Question 8)

In the final question, six general themes were suggested by the respondents to indicate considerations by authorities when drafting WML conditions. After thematic analysis, these themes were identified and coded as increased efficiency; drafting licence conditions quicker; improving the focus on intended goals; improving practicality; considering site costs; and considering site history. Basically, landfill operators believe that the licensing process should be efficient, effective but at the same time be considerate of site history, time and costs of ensuring compliance with each condition.

In emphasising their points, Respondent 2 stated that the authorities should "*Focus on intention and give licence managers the right to manage the site in an environmental acceptable way".* Respondent 3 stated that "*The construction costs of a hazardous waste facility were high and should be taken into consideration*. Finally, in emphasising the past reputations of sites, Respondent 1 explained as follows:

"The authorities should take into account the history of the site, in terms of impact (if it is an old site) when drafting waste licence conditions. If the site has a history of good compliance, then this could be used to reduce certain requirements. In the same way, sites with a 'bad' record of compliance need to have their requirements increased".

4.3.9 Discussion of results

It was evident from the results obtained from the study that the costs associated with complying with WML conditions for a hazardous waste site are very high because each of the conditions stipulated in the WML requires expenditure for compliance. Interestingly, the results corresponded with the literature that was reviewed in the second chapter. The cost implication of operating a waste disposal facility was thoroughly investigated in Oelofse's study (2014). A major point raised in the article rightly encapsulates the same concerns that were raised by the landfill operators of the three waste facilities. Their sentiments mirror Oelofse (2014)'s results, which indicated that, while improved regulation and licensing conditions promote environmental protection, compliance significantly increases the costs that are incurred by the licence holders. While there was lack of congruence with regards to the exact amounts that licence holders incurred in order to comply with different licence conditions, there was consensus that compliance with all WML conditions exceeded R500 000 per month.

The results were focused enough to indicate the different WML conditions that were likely more costly for the landfill operators to comply. Essentially, construction, leachate management and monitoring were identified as WML conditions that are more costly. It should be noted that this basically echoed the discussion in the previous section, which also identified infrastructural difficulties as a precursor to non-compliance or partial compliance. The leachate management condition was also identified to be costly to comply with since appropriate infrastructure and monitoring are required. In view of this, this study is similar to Pienaar and Howard's study (2014) about municipal landfill facilities in the Western Cape that required licensing. Pienaar and Howard (2014) discovered that, while the facilities would be licenced, adhering to the condition would still pose a major challenge, as the facilities did not have the financial muscle to fully comply with all WML conditions. Results further indicated that operations and storm water management WML conditions also required significant amounts of money, followed lastly by impact management conditions. The results therefore concurred with the arguments that were raised by Oelofse (2014), Pienaar and Howard (2014), and Agamuthu and Fauziah

(2011). This indicates that failure to comply with stipulated WML conditions are likely due to incurring high costs that are associated with compliance.

The landfill operators from the three facilities unanimously agreed that while compliance was difficult due to high costs, all conditions were important and rightful in the WML. Because of that, instead of advocating of the removal of WML conditions, they identified conditions that could be varied as this is a provision in terms of section 54 of NEMWA in order to reduce the costs of compliance but while ensuring protection of the environment. The results indicated that variation of conditions that pertain mostly to storm water management, leachate management, monitoring, and construction would help mitigate the high costs. However even though the variation of the WML conditions was identified as a solution, when variations are submitted to the authorities they must be processed timeously.

4.4 Section Three: Effects on groundwater

Objective 3: To determine the effects of licenced waste on groundwater.

This section covers the results pertaining to the possible contamination of groundwater resources from waste that is lawfully disposed of at hazardous waste facilities. In the WMLs there are conditions that require monitoring of boreholes for any groundwater contamination as a result of waste disposal. The following results were obtained from the external audit reports that were analysed.

4.4.1 Site A

The overall results of water quality from Site A were good and both audit reports indicated that impact has been minimal. There are however a few concerns that were raised in both audit reports. With regards to surface water, both reports indicated sewage contamination of on-site storm water, as indicated below.

“The on-site storm water, in general, is contaminated to the point that it is no longer used for dust suppression outside the cell areas”.

In the 2014 the external auditor also pointed out a concerning issue with regards to the contamination of off-site surface water, citing that,

“Some limited off-site surface water quality impacts were detected in the last Annual Water Quality Report in 2013”.

With regards to groundwater resources, the analysis of samples from both upstream and downstream boreholes at the facility indicated that there was no contamination and that the water quality was good.

4.4.2 Site C

At the Site C waste facility, the audit reports indicated that there was limited impact of waste disposal activities on groundwater resources. The 2013, 2014, and 2015, audit reports indicated the following respectively:

“Results indicated that there was limited impact on both groundwater and surface water from the waste body”.

“The water quality results are satisfactory, and the waste body appears to be having limited impact on both groundwater and surface water”.

“There is very limited impact from the waste facility on groundwater and surface water quality”.

Despite the general analysis that water quality had been minimally impacted both in and around the facility, there are concerning issues that were raised thus posing a risk to water quality. In 2012, the external auditor reported the seeping of leachate from side walls at the facility and that the problem had not been resolved when the 2013 audit report was compiled. The external auditor in 2013 further cited a problem with the co-disposal ratio and that leachate could be observed from the slopes of one of the sites. Therefore, the report indicated that,

“There is need to improve the co-disposal ratio, by increasing dry waste, limiting sludge, revising the target co-disposal ratio and extending the site”.

Another major threat to the quality of water resources in 2013 was the discharge of sewage into Site C (I), which had been reported in February 2008, but had not been resolved after five years. Because of this, the report indicated that,

“There is still evidence of contamination of groundwater upstream of the site due to this leak”.

In 2014 and 2015, possible leachate contamination was indicated in the external audit reports, particularly with regards to the co-disposal ratio. In 2014, it was the auditor’s opinion that,

“Clearly there have been problems maintaining the co-disposal ratio because of limited space. This issue continues to persist”.

In 2015, the auditor reported that, there was still a problem with maintaining the co-disposal ratio, thus the report indicated that,

“The most recent co-disposal ratio calculated by the engineer in the period November 2014 to October 2015 was 4.75 m/m, which was well above the existing target ratio of 3 m/m.”

“The co-disposal ratio should be reviewed annually and that was in the site licence. Because this is not done since the previous calculation in May 2014, the site was therefore partially non-compliant with that condition since the co-disposal ratio had not been reviewed”.

4.4.3 Site D

At Site D landfill facility, the three external audit reports all reported that there was impact on groundwater resources. However, this contamination was limited only to the site area. with all three reports stipulated the following:

“The water quality results indicated that there is some impact of the landfill on the groundwater, but this appears to be contained onsite”.

4.4.4 Discussion of results

The impact of waste disposal activities on groundwater quality was minimal at all three facilities at the time when the audit reports were compiled. This echoes the sentiments raised in the first section that managers have, to a large extent, been able to comply with licensing conditions, with a few minor partial and non-compliances. The importance of constantly monitoring groundwater, as well as surface water resources in and around a hazardous landfill facility is emphasised in literature sources. Pienaar and Howard (2014) conveyed this notion with specific emphasis on the possible dangers of failing to adequately control and manage leachate at landfill facilities. The same sentiments are shared by Misra and Pandey (2005), who likewise indicated that leachate production is a great threat to groundwater resources, together with downstream wells and surface water, thus safeguarding the environment requires that stringent measures are applied to the disposal of hazardous waste. This is the major reason why the 2013 Site C external audit report indicated great concern over leachate that was a seeping from a wall at the site, an ongoing problem that had not been resolved from 2012.

Although leachate poses the greatest risk to groundwater quality, the results also pointed to yet another challenge. The external audit reports from Site A and Site C highlighted that there were sewage contamination problems. Both external audit reports that were analysed from Site A indicated that sewage had contaminated on-site surface water to such an extent that it could no longer be used for dust suppression at the site. At Site C landfill facility, the impacts on groundwater and on surface water resources were reported

as minimal. However, there is a need for improved compliance to minimise groundwater contamination. For this reason, it is vitally important that landfill operators take seriously the importance of protecting water resources by ensuring compliance with the WML conditions and monitoring water quality as required by the monitoring protocol and parameters stipulated by the authorities.

4.5 Section Four: Compliance Governance Difficulties

Objective 4: To determine governance difficulties associated with complying with waste management licences.

In this section, results are presented on difficulties encountered by waste licence holders when complying with WML conditions. Results were obtained from the analysis of the questionnaires that were answered by the landfill operators. It is evident that the results that were obtained specifically in this section, confirm many of the difficulties that were noted by the external auditors.

4.5.1 Difficulties encountered while ensuring compliance (Question 1)

Firstly, the respondents were asked in Question 1 about some of the difficulties that they encountered when ensuring compliance with waste management licence conditions. The responses from the three respondents were combined and analysed using thematic analysis, and three coded themes emerged. The most common problems hindering compliance pertained to issues around generic or non-site-specific waste management licence conditions, as respondents 1 and 2 raised the same concern. On the other hand, respondent 3 raised two separate themes, citing that licensing conditions had persistent grammatical errors, coupled with the citing of reference documents that did not exist. The specific responses are presented in the Table 4.3 below.

Table 4.3: Difficulties encountered by landfill operators when ensuring compliance with waste management licence conditions (Question 1)

Theme	Respondent	Response (Verbatim)
G	1 and 2	*Some of the licensing conditions are not site specific i.e. they are too general. The geology and proximity of the site to communities and or warehouses should have a bearing on the licence conditions. There is a cut and paste approach to issuing waste licenses.* *Conditions are not site specific; storm water and leachate conditions are written together, whereas they should be separate.*
LG	3	*Grammatical errors in conditions.*
RD	3	*Reference documents that do not exist.*

Therefore, the three themes that were developed concerning the difficulties that were faced by waste management licence holders were, 1. Generic condition (G), 2. Licensing Grammar (LG) and 3. Reference Documents (RD).

4.5.2 Proportion of the difficulties as a result of the waste management licence (Question 2)

The respondents were then asked about the proportion of difficulties they encountered, as a result of the waste management licence in question 2. This section was a follow-up on the difficulties that were being encountered by the respondents. Of significance is the fact that all three respondents indicated that the difficulties they faced are attributed to licensing conditions. However, the theme that emerged was that the difficulties indicated in the previous section were dependent on the waste management licence. The following responses were obtained from the respondents:

- **Respondent 1**: *The way in which the site is operated and the cost of operation of a site is highly dependent on the site licence. The monitoring (ground, air and water) is a very high cost, as is the buffer zone, as well as leachate treatment.*

Respondent 1 raised the issue of high cost of compliance, and this was repeated in the different section of these results.

- **Respondent 2**: *water quality monitoring parameters. The annexures seem to be just a copy and paste from the department.*

WMLs for waste disposal sites have annexures that contain parameters that should be monitored when monitoring water quality. The frequency is determined by the authorities and findings have to be submitted to the authorities. Therefore, this response is similar to the response from the first respondent about the issue of conditions that were not site specific. The fact that respondents identified that the conditions were just copied and pasted, confirms the initial argument about the lack of capacity and competence by the authorities to determine site specific conditions for waste disposal facilities.

- **Respondent 3**: *Both issues above are related to the licence itself and may cause misunderstandings and non-compliance issues.*

Based on all three responses, there is a need for the licensing authorities to ensure that the waste licence conditions and the parameters that are to be monitored are relevant to the specific site. The NEMWA, Norms and Standards and other legislative frameworks that govern waste management are sufficiently detailed to ensure that WML conditions are site-specific. Therefore, there is an indication of negligence from the side of the authorities.

4.5.3 Avenues that the licence holders have explored to address difficulties with waste management licences; and the outcomes of these efforts (Question 3)

In Question 3 the landfill operators were asked if they had explored other avenues in dealing with the difficulties they faced and the outcomes of such efforts. All three of the respondents indicated that they had contacted the respective authorities as a means of addressing the difficulties with waste management licences. Two concerning themes emerged. Firstly, there had been efforts from all three landfill managers to engage the authorities for improvements of licensing conditions. Secondly, all efforts had been

fruitless. The following table shows how the two themes were extracted from the responses given.

Table 4.4: Avenues explored by licence holders to address difficulties with waste management licences and the outcomes of these efforts (Question 3)

Respondent	Authorities were engaged	Efforts were fruitless
1	*Variations has been submitted to the authority…*	*…without a positive result to date.*
2	*Yes the applicant has applied for variations and held meetings with the authorities…*	*… however the decision on the variations have not been issued after long periods of time.*
3	*Submitted letters to DEA to correct problematic conditions.*	*None was resolved.*

4.5.4 Did the licence holders discuss difficulties with authorities, and what were the outcomes? (Question 4)

In response to question 4, which was focused on evaluating whether the difficulties have been discussed with the authorities, the respondents indicated the following:

- **Respondent 1**: *Yes, we have followed up through our head office, but the response is still delayed.*
- **Respondent 2**: *Yes, however this has not yielded any positive results as the Department is not keen and quick in making decisions.*
- **Respondent 3**: *No.*

Two of the respondents who had contacted the authorities, had managed to discuss some of the difficulties with WMLs with the authorities. While the third respondent contacted the authorities but did not discuss the difficulties of WML conditions.

Respondents 1 and 2 argued that there have been virtually no outcomes from their efforts made. The emerging themes from the results above are that DFFE has delayed processes and that they are slow to respond to queries raised by landfill operators. This

appeared to align with the answers from the previous question, thereby affirming that the respondents did not have any positive outcomes from their efforts to amend their WML conditions.

4.5.5 Satisfaction of licence holders with the response from the authorities (Question 5)

The respondents were subsequently asked in Question 5 if they were satisfied with the responses they had received from the authorities, regarding their queries. The respondents said,

- **Respondent 1**: *Not as yet as we have not yet had a response to our variation application.*
- **Respondent 2**: *No progress has been made because of the change in structure at the DWS and capacity is not enough which then affects the response time.*

Based on these findings the respondents' efforts to approach the authorities, had not achieved the intended purpose. While the third respondent did not answer this question, Respondent 2 raised a key issue that may explain the delay from the authorities, namely the lack of capacity from the authorities

4.5.6 Suggested solutions to difficulties for waste management licence conditions (Question 6)

The three respondents presented widely differing solutions to the difficulties faced by waste management licence conditions in response to Question 6.

- **Respondent 1**: *Perhaps the Authority could employ a division with experts whose sole responsibility is to respond to variation applications.*
- **Respondent 2**: *More of a pragmatic approach; they need to get out to site and understand the dynamics. Desktop study is not working, and reports are not thoroughly reviewed.*
- **Respondent 3**: *Annual meetings between DEA and licence holder to discuss difficulties and requests.*

Three primary themes emerged, which pertained to (a) the employment of experts specifically for dealing with variation applications, (b) decision-making based on site visits, and (c) annual meetings with the DEA (now DFFE).

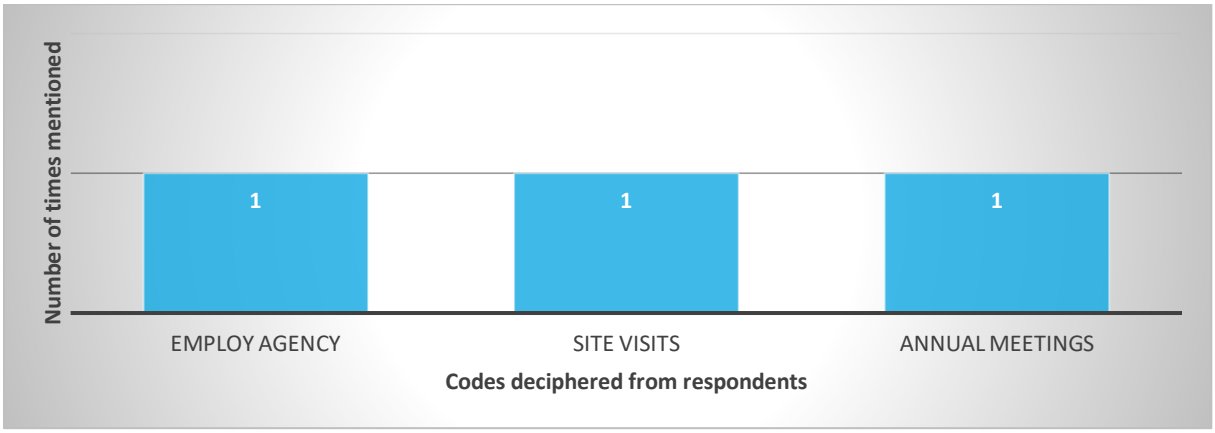


Figure 4.6: Suggested solutions to difficulties faced from waste management licence conditions (Question 6)

The landfill operators feel that there is a need for platforms or avenues for increased communication such as annual meetings. Authorities could conduct site visits at the waste facilities in this way, there can be shared understanding between licence holder and authorities, therefore resulting in improved WML conditions and compliance. Another suggestion was that services of a separate agency to process variation application as this could prevent delays.

4.5.7 Licence holders' views of the licensing requirement in terms of NEMWA 2008 (Question 7)

Question 7 asked the respondents about their views concerning licensing requirements, as regulated by NEMWA 2008. The responses were as follows:

- **Respondent 1**: *It could be more site specific and less generic.*
- **Respondent 2**: *The requirement is necessary. It is a good way to regulate and control. The DEA has a responsibility to control the environment.*
- **Respondent 3**: *It is a good principle to apply.*

The dominant theme that emerged from respondents 2 and 3 was that having WML conditions was a good measure. These responses show understanding of waste legislation and requirements from landfill operators because the major aim of such regulations is to protect the environment. This can only be achieved through WML conditions and while .WML conditions are one of the controls and the conditions could still be improved.

4.5.8 Recommended regulatory mechanisms for regulating landfills (Question 8)

When the respondents were asked in Question 8 to recommend other regulatory mechanisms for regulating waste disposal facilities three themes emerged, namely forums, judges and site visits and they are presented in a Table 4.5 below:

Table 4.5: Other regulatory mechanisms recommended for regulating landfills (Question 8)

Theme	Respondent	Response (Verbatim)
Forums	1	*It would be helpful to have workshops between the Waste Licence Holder and the Authority, so that better relationships can be forged, with a better understanding of the site.*
Judges	3	*Panel of adjudicators to appoint independent auditor for external audits.*
Site Visits	1	*Before the waste licence is issued, an information sharing session, with on-site visits should be held.*

The recommendations given by Respondents 1 and 3 are fully embedded in NEMWA and EIA regulations, since these are the tools used when licensing waste disposal facilities. Therefore, meetings between applicants and authorities and on-site visits, prior to licensing, would enable the drafting of better licensing conditions. Respondent 2 went so far as to stress the importance of regulatory mechanisms for waste disposal facilities, stating that "*Licensing should remain, as the requirement because the risk is too high".*

4.5.9 Alignment of the waste management licensing process with the NEMA EIA Regulations (Question 9)

When respondents were asked about their opinion regarding the alignment of the waste management licensing process with the NEMA EIA Regulations, two of the respondents thought that the alignment was fine, while one of the respondents instead chose to indicate that it needed to be more aligned with the EIA regulations, especially in terms of timeframes, and that the waste management licensing process should strictly comply with EIA Regulations. Table 4.6 presents the respondents' opinions on the alignment of the waste management licensing process with the NEMA EIA regulations as asked in Question 9.

Table 4.6: Alignment of the licensing process with NEMA EIA regulations (Question 9)

Theme	Respondent	Exact Response
Alignment is fine	1	*Seems to be fine.*
	2	*Timeframes are fine if the operator is serious.* *It's fine but there are double standards being practiced by the department.*
Not Aligned	3	*Must be aligned and EIA regulations to be applied for all WML applications.*

The responses presented in Table 4.6 presents another more subtle challenge in the waste management licensing process. i.e. that double standards were being practiced by the department, implying that regulations were not being complied with fairly for all applicants when WML applications are processed. Interestingly, this corresponds with what was mentioned by Respondent 3, that compliance with the EIA regulations should be applied for all WML applications. Though it is difficult to thoroughly capture the respondents' meaning without further probing, the main issue seems to be centered around unfairness because there is a belief that some applications are processed within timeframes while others are processed outside timeframes.

4.5.10 The process of obtaining a waste management licence as currently executed by the authorities (Question 10)

Only one respondent thought that the process of obtaining a waste management licence was good, stating that "*It is a solid and sound process to follow"* in response to Question 10 (see Figure 4.7). The other two respondents took the opportunity to emphasise difficulties the process being slow, inconsistent, long and knowledge of departmental staff being poor.

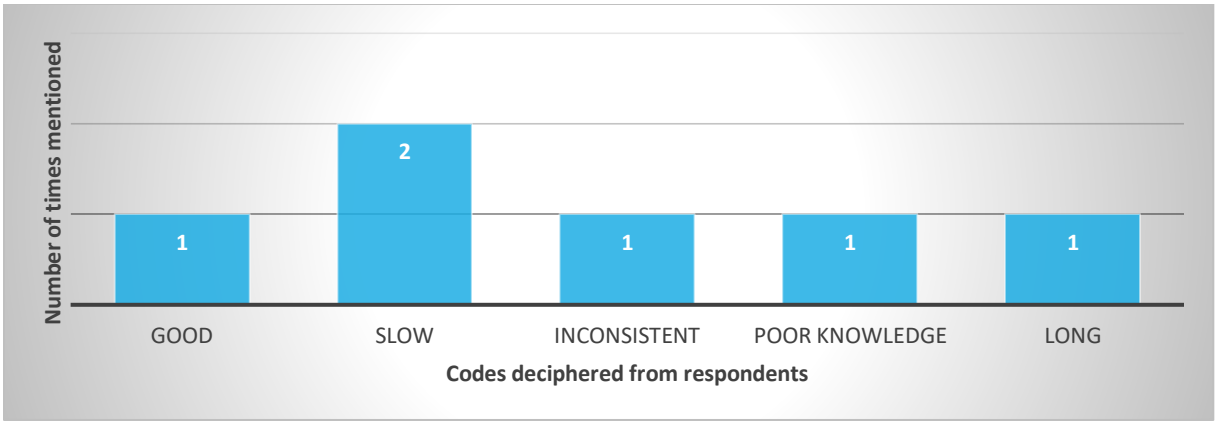


Figure 4.7: Responses to the process of obtaining a waste management licence (Question 10)

The themes that emerged was that the slowness of the process as pointed out by two of the respondents. To emphasise the problem of the tediousness of the process, Respondent 1 stated that "*It is quite a long-winded process, that can take many years",* while the theme of inconsistency emerged from Respondent 2 who indicated that "*Sometimes there are different approaches".* In recommending what should be done to address the issues, Respondent 2 stated, "They *need to operate in accordance with the timeframes,* and *they need to know the standard that is acceptable to the department".*

4.5.11 Improved compliance and impacts on the environment from the licensing system as compared to the permitting system (Question 11)

The respondents had mixed views when asked in Question 11 whether there had been improved compliance and reduced environmental impact from the licensing system compared to the permitting system. The respondents stated the following:

- **Respondent 1**: *Personally, I don't think the licensing system has resulted in more costs, as we had to comply with the Permitting System in any event. I do feel however, that if the variations application process could be speeded up, we could save on unnecessary licence conditions.*

This respondent raised a point that was central to the study on the costs of compliance, i.e., that the permits issued in terms of ECA had conditions that required compliance, just like the WMLs that are issued in terms of NEMWA. However, high costs seemed to be the result of too many conditions that came with the licensing process, yet some of them could be avoided if the process is more efficient, particularly in variation applications. This point again drew from licensing conditions that were not site specific, resulting in landfill operators having to comply with some conditions that may not be applicable to their particular site.

- **Respondent 2**: *Timeframes in ECA were more relaxed but the turnaround time was faster as compared to now. More stakeholder engagement in NEMWA than in ECA.*

The issue of lack of efficiency was echoed by Respondent 2. Moreover, the respondent indicated that even though the timeframes were relaxed during the ECA regime, compared to the licensing process, the permitting system turnaround time was faster. Yet one would expect that the licensing system with stricter timeframes, efficiency would improve. However, on the positive side, the respondent reported more stakeholder engagement under NEMWA compared to the previous permitting system, whereas this was not a specific requirement in the permitting system and thus an improvement in the system.

Respondent 3: *Yes, most definitely. The permit system had a closure condition which was a generic condition, now with the WML application the process takes into consideration applicable legislation.*

Respondent 3 expressed satisfaction with the WML process by indicating that it takes applicable legislation into account. This response acknowledges the importance of the new processes particularly because decommissioning of facilities has to follow the licensing process, whereas this was not a requirement in terms of the old permitting system.

4.5.12 Licence holders' views of the waste classification and management regulations as compared to the minimum requirements (Question 12)

Question 12 on the difficulties questionnaire in phase one of the study required the respondents to explain their views of the waste classification and management regulations (WCMR), as compared to the Minimum Requirements (MR), and the results are presented in Figure 4.8 below:

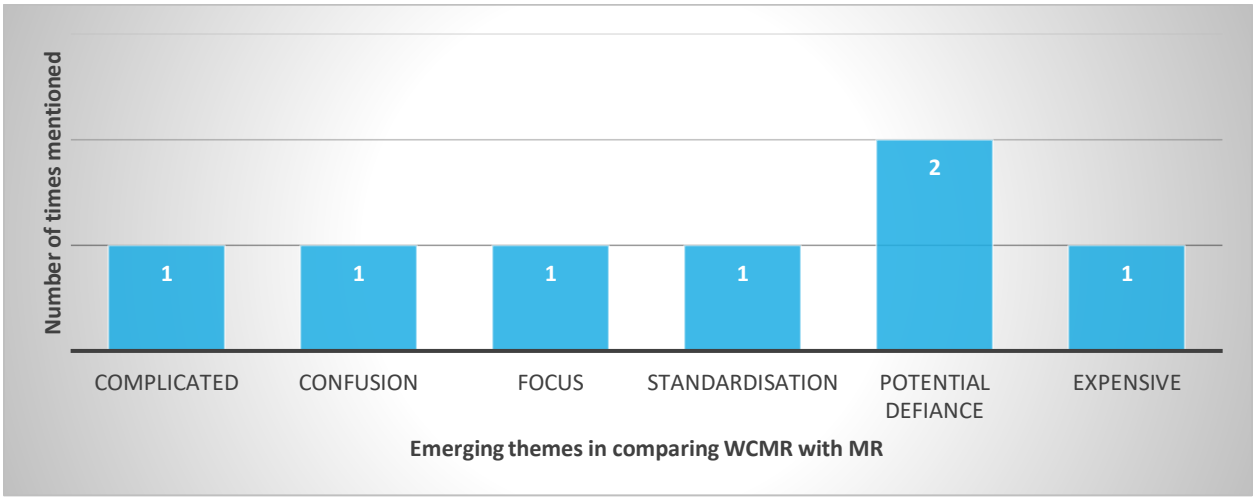


Figure 4.8: Waste classification and management regulations, compared to minimum requirements (Question 12)

The first, and broadest problem with the general conceptualisation of the waste classification management regulations, was presented by four individual themes explaining that the WCMR were ‘complicated’, that there was ‘confusion’ with the regulations, that they lacked ‘focus’, and that they need to be standardised. Respondent 1 emphasised the point by stating that “*Minimum Requirements focused more on hazard rating, to determine how hazardous the waste was, in order to determine where it should be landfilled. With the current regulations waste type are determined and then linked to the class of landfill. The waste can be classified as non-hazardous, but that does not mean it can be disposed at a general landfill.* On the other hand, Respondent 3 stated that “*It is extremely complicated compared to MR*. Respondent 2 further indicated that there was *controversy regarding Class A & Class B landfills,* and that this was causing confusion.

The second theme that emerged related to an increased potential of non-compliance during the waste disposal process as a result of the WCMRs. Respondent 2 indicated that the current WMCRs introduced the possibility of waste being *disposed in a wrong site*. Also, in line with this theme of defiance, Respondent 3 in fact directly blamed the waste classification and management regulations for non-compliances during the waste disposal process, by stating that, *“it forces generators to illegally dump waste”.*

A third theme related to the expenses that were not thought of when the WCMRs were developed. In this regard, Respondent 2 stated that the waste classification and management regulations were *more expensive to comply with than the minimum requirements,* hence, *clients do not want to incur the cost because it’s expensive to send to a landfill.*

4.5.13 Discussion of results

This section of the dissertation highlighted many compliance difficulties faced by landfill operators. As indicated by Mokgae (2011), the main agenda behind waste management licensing and the associated conditions, is environmental protection. However, failure of the licensing authorities to develop site specific conditions defeats that purpose and this

is one of the major cited compliance difficulty. This is indicative of difficulties that may be occurring in the licensing process, including failure to comply with the regulations and failure to conduct site visits for all WML applications. This results in the issuance of WML with generic conditions which in certain instances, may not be relevant to a particular site. The importance of site visits is taken seriously in Europe (WAC, 2004) because it allows for the authorities to include conditions that are specific to that waste disposal facility. Making decisions based on desktop studies has resulted in problematic WML conditions that render it difficult for landfill operators to comply.

The respondents' feedback corresponds with literature, for example by Kumar et al. (2017) who researched this topic by using India as a case study and concluded that compliance with set regulations and environmental protection can only improve if WML conditions are made more specific and not generic.

The lack of specific conditions or policies was cited by Salihoglu (2010), with particular reference to hazardous waste disposal in Malaysia. The respondents highlighted that possible contamination of groundwater resources from leachate is exacerbated by the ambiguous conditions for storm water and leachate management. The study by Aderami et al. (2011) in Lagos, Nigeria suggested that the ineffective management of leachate can result in the contamination of groundwater. Therefore, even though the contamination of groundwater could not be measured in the current study, the results from the external audit reports (discussed in the previous section) indicate unresolved difficulties that could potentially result in disastrous effects. The situation is exacerbated by rampant grammatical errors in WML conditions, which limit the understanding of the licence holders. This is coupled with poor document referencing and cross referencing of the WML conditions.

The issue of the costs associated with adhering to licensing conditions appears to be a central theme that is repeatedly raised in all data sources. Studies reviewed in the literature chapter particularly that of Oelofse (2014) and (Pienaar and Howard,2014), highlighted how high compliance cost resulted in problems for landfill operators in the

Western Cape. It appears that this issue cannot be overlooked as it affects every aspect of the waste management process, from infrastructure to human capital management. This should be taken seriously by both authorities and the landfill operators in order to avoid non-compliances with WML conditions.

The respondents also emphasised that the licensing authority was slow to responding to the concerns of landfill licence holders. This corresponds with a study conducted by Oelofse (2014), which analysed the issue extensively, citing that licensing authorities do not take into account how regulations affect licence holders. Oelofse (2014) further states that when licence holders are unable to comply with the WML conditions, the environment is subsequently affected negatively. It appears that there is need for efficiency within authorities in addressing difficulties that are faced by landfill operators as a result of WML conditions. Another perspective on the difficulties that are faced by licence holders, it was noted that without the necessary technical knowledge and experience, authorities would not be able to issue conditions that are achievable.

A recommendation made by one of the respondents is that the licensing authority should have a separate division that deals with variation applications. This recommendation holds value, because employing a separate division of experts responsible for handling variation applications, could improve response time. Studies in the literature review did not allude in any way to the fact that the licensing process was biased, except for a remark made by Kolar (1989), that the licensing process was influenced by politics. This indicator may point to possible unfair treatment, based on political affiliation and other issues that surround government offices. Regardless, while the results did not allow for a concrete opinion on this matter, it just highlighted that the licensing authority may have some discrepancies when licensing waste facilities.

4.6 Chapter summary

The respondents indicated numerous difficulties that were encountered by landfill operators when ensuring compliance with WML conditions. The respondents mentioned the concept of generic or non-site-specific waste management licence conditions as the

most common problem hindering compliance. They further indicated that some of the difficulties encountered by landfill managers or licence holders when ensuring compliance with waste management licence were because of the conditions. Respondents had mixed opinions on whether there had been improved compliance and reduced environmental impact from the licensing system, relative to the permitting system. They highlighted various problems to indicate why this was the case.

In determining the estimated costs of complying with each condition of the waste management licence, it was found that the cost of compliance was relatively high but varied depending on the WML condition. The estimated costs of complying with conditions of a waste management licence for a hazardous waste disposal site were high, exceeding R500 000 per month. The WML conditions that were said to be most costly to comply with were construction, leachate management, and monitoring conditions. The construction, stormwater management, leachate management, and monitoring conditions were seen by respondents as conditions that are problematic in the way they were written in waste management licences for example where the stormwater has to be treated even when it has not mixed with leachate. However, the respondents did not suggest the removal of these conditions since the ultimate goal is to protect the environment. There were also mixed views among the respondents over how the variation of waste licence conditions should be handled by the authorities to improve compliance with waste management licences. Nevertheless, the respondents felt that each of the aspects of efficiency, time, practicality, site visits and site history would be good considerations for authorities to reduce costs, when drafting waste management licence conditions. Deliberations on these results are presented in the following chapter.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS FOR AN EFFECTIVE WASTE LICENSING PROCESS TO PROMOTE COMPLIANCE

5.1 Introduction

Environmental protection has become an essential item on the agenda of the global platform. One of the major considerations on the issue pertain to the increase of the world's population, coupled with advanced technology and manufacturing, which has resulted in the increase of waste production, including hazardous waste. Such waste has to be disposed of in a controlled manner, in order to minimise environmental degradation. With that in mind, this study was conducted with the overall aim of assessing to what extent are landfill operators able to comply with hazardous WML conditions. Another considering factor was whether the licensing system has led to the reduction of environmental damage. The study findings were obtained through two questionnaires that were answered by landfill operators from three waste disposal facilities, and through the review of external audit reports. The findings of the study indicated that, to a large extent, the facilities were being operated in accordance with the WML conditions and they also had a minimal impact on groundwater. The findings did however suggest various difficulties for landfill operators when complying with WML conditions at the hazardous waste disposal facilities.

5.2 Conclusion

The discussions below are indicative of how each objective of the dissertation was achieved.

Objective 1: To determine the extent to which landfill operators are able to comply with waste management conditions

It was essential to determine the extent to which landfill operators who operate waste disposal facilities are able to comply with the conditions that are stipulated in the WML for each facility. While it appeared that compliance was high in all three facilities, a common problematic occurrence identified in the licensing of hazardous waste. There was consensus between the landfill operators' responses and the observations of external auditors regarding the licensing authority and WML conditions. It emerged that the licensing authority has been failing in some instances to include site-specific conditions in the waste management licences. The findings also revealed that the licensing authority was inefficient in processing requests to vary the WML conditions. In some instances, licensing conditions were ambiguous or written with poor grammar, resulting in landfill operators' inability to understand and comply with such conditions.

Given the results that were obtained in this study, one can therefore conclude that landfill operators are able to comply with the majority of the waste management licence conditions. All three facilities had minor non-compliance and partial compliances, which can be rectified. However, for them to be rectified, both the licensing authority and the landfill operators need to strive for greater excellence in their specified roles, be it the disposal and/or licensing of hazardous waste.

Objective 2: To determine the costs associated with complying with waste management licence conditions

It was determined that the costs that landfill operators incurred while complying with WML conditions were very high. These costs emanated mostly from construction or the building of suitable infrastructure, leachate management, monitoring, as well as from storm water management. While some conditions were too costly to comply with, compared to others, it emerged that monthly costs were normally over R500 000 to R1 million per month. These high costs of operating waste disposal facilities make it difficult to comply with WML

conditions, however the landfill operators ensured compliance with the conditions of the WML regardless of the high cost associated with compliance.

It was concluded that while the improvement of hazardous waste management licensing conditions has long lasting effects with regards to safeguarding the environment, compliance with extensive conditions however results in greatly increased costs on the part of license holder. These costs would limit compliance capability for licence holders with less financial muscle and this is a major concern for landfill operators as this would impact negatively on the environment. The high costs that are incurred are also influenced by issues identified under the first objective, which include infrastructural construction and maintenance, as well as the processing of variations applications which would reduce costs if the conditions were amended.

Objective 3: To assess the effects of licenced waste disposal on groundwater

According to the external audit reports, hazardous waste disposal activities at the three facilities had very minimal impacts on the quality of groundwater and surface water resources according to the external audit reports. Nevertheless, the results also indicated some concerning difficulties that would need to be closely monitored at all three facilities, i.e. ensuring that the seepage of leachate into ground water is curbed, and the inability of the landfill operator to review the co-disposal ratio in one of the sites. Again, with difficulties that included leachate contamination, there is a correlation with issues raised regarding the first objective, pointing towards the notion that while landfill operators are complying to a large extent with WML conditions, there is definitely room for improvement.

Based on the results that were obtained through analysing the external audit reports regarding the effects of licenced waste disposal on groundwater, the study concluded that the outcomes were favourable, thus the impacts were minimal. Though minimal, the study further concluded that landfill operators were in some instances inefficacious with

leachate control, sewer control, and with maintaining the desired co-disposal ratio. This can prove to be costly for the environment in the long term.

Objective 4: To determine governance difficulties associated with complying with waste management licences

The results indicated that landfill operators face governance difficulties when ensuring compliance with WML conditions. To begin with, the results indicated that WML conditions were not site specific, that they referred to non-existent reference documents, and that they were marred with grammatical errors. Results further indicated that, because of some of the conditions, operational costs were very high; hence these increased the possibility of non-compliance. While landfill operators had applied for variations of the WMLs, it emerged that the licensing authority lacked efficiency in responding to the variations. Thus, leading to long-term delays and landfill operators expressed dissatisfaction with the authorities. They however indicated that, the situation could improve if the licensing authority created a separate division responsible for resolving the problems that were encountered by licence holders, coupled with intensifying site visits and having meetings with landfill operators. The general impression obtained from the results was that licensing conditions were imperative for the protection of the environment; there are however the above-mentioned problems that may result in negative impacts on the environment when full compliance is not achieved. These difficulties need to be resolved accordingly.

The study concluded that the difficulties associated with complying with waste management licences mostly pertain to the WML conditions not being clear or difficult to comprehend with, which can be tedious on landfill operators. While landfill operators unanimously agreed that the regulations and the WML conditions were essential to protect the environment, it is clear that the licensing authority should be issuing site-specific conditions, ensuring that conditions are easy to understand and finally by being more efficient in processing variation applications when submitted.

5.3 Recommendations

Based on the findings for each of the objectives, the following recommendations are made

Objective 1 Recommendation: To determine whether the landfill managers are able to comply with waste management conditions.

- There is need for the licensing authority to address the issue of ambiguous WML conditions. Three approaches to address this challenge are proposed. Firstly, before a licence is issued, it should be reviewed by different experts to ensure that the conditions are clear. Secondly, the licence holder and licensing authority should have a meeting prior to the issuance of the licence. In the meeting, the licensing conditions can be explained to the licence holder and any concerns can be addressed for clarity purposes. Thirdly, the licensing authority should obtain the services of a professional English technical editor to rectify grammatical and sentence construction errors. Once all the licensing conditions are clear, increased compliance on the part of the licence holders will be achievable.

- Landfill operators cited that the licensing authority was very slow to respond to licensing variations. It is therefore necessary for the department to work towards improving efficiency, because such delays result in non-compliances which negatively affects the environment. However, since the results indicated that decisions were taking too long, there is need for focused attention on the variation applications and it is recommended that there should be officials that would be solely responsible for processing variation applications and to review WMLs to ensure relevance of conditions to the site.

- Because inadequate infrastructure is a major contributor to non-compliance, there is need for the licensing authority to increase compliance monitoring at hazardous

waste disposal facilities. They should ensure that landfill operators constantly upgrade their facilities to cater to the changing environmental requirements. At the same time, authorities should ensure that licence holders provide proof of land rehabilitation funds that may utilize to ensure compliance when waste disposal facilities fail to comply with conditions of the WML. With reserved financial resources, landfill operators would be able to maintain infrastructural resources as a measure towards mitigating environmental damage.

Objective 2 Recommendation: To determine the costs associated with complying with management licence conditions.

The costs incurred by landfill operators are very high. Therefore, the following recommendations are made.

- There is need for the licensing authority to intervene by not only relying on leachate monitoring variables that are conducted by the licence holders, but to at least verify the accuracy of the results once a year by doing their own tests. This would allow authorities to reduce the frequency of monitoring that is done by the licence holders hence reduce costs for the licence holder. Based on the amount of hazardous waste disposal facilities in the country, this can be achieved by the authority.

- Variations should be made to WML conditions that refer to stormwater treatment even when the stormwater treatment system is separate and not contaminated by leachate. These variations would lead to reduced expenditure and compliance would still be achieved as the environment would be protected.

Objective 3 Recommendations: To assess the effects of licenced waste disposal on groundwater.

The competent authority should review the external audit reports and the groundwater quality monitoring reports to in order to assess impacts on groundwater as a result of a licensed waste disposal facility. If these reports are not reviewed by the authorities as a monitoring mechanism, then non-compliances would not be identified hence resulting in no corrective action being undertaken.
Once non-compliances with conditions have been identified in an external audit report, the landfill operators should ensure that corrective measures are taken so that there is no recurrence of the non-compliance.

Objective 4 Recommendation: To determine the difficulties associated with complying with waste management licences.

- When new cells at each site are planned, authorities should place greater focus on the EIA process, before issuing of a waste management licence for a waste disposal site. Each site should have licensing conditions that are site specific, taking into consideration the climatic conditions, waste streams and the dynamics of each site. It is imperative that the authorities recognise the critical need of having site specific conditions so that compliance can be fully achievable by landfill operators. However, with the strict implementation of site visits both before and after the issuing of a waste management licence, this challenge can be alleviated.

- Moreover, the EMP, which is mandatory for hazardous waste disposal facilities according to the DEA (2009), should be compiled in such a manner that the report is detailed enough to guide the compilation of site-specific conditions. As recommended by one of the respondents in the study, the competent authority should consider allocating resources for the creation of a separate unit that would

be responsible for processing variation applications that have been submitted by licence holders. This could potentially result in much needed efficiency.

Recommendations for future research in the field

The following recommendations pertain to future studies in the field of hazardous waste management.

- The current study focused on facilities owned by the same organization. For this reason, future studies should include other landfills operated by different companies, both municipal and privately-owned landfills.

- Future studies should also adopt more experimental methodologies. One of the study objectives was to determine the impacts of hazardous waste management on groundwater. With experimental designs, researchers would be able to measure the parameters in a laboratory to ensure accuracy of the data contained in the external audit reports.

  There is need for further studies to focus primarily on the difficulties encountered by the licensing authority. While many studies provide the same rhetoric on the shortcomings of the licensing authority, it would be valuable to explore why these deficiencies exist.

5.4 Dissertation Conclusion

This study has sought to provide an evaluation of the impact of licensing on the selected three hazardous waste disposal facilities in South Africa. This was evaluated through determining the extent to which landfill operators were able to comply with waste management licences, the costs associated with complying with waste management licence conditions, the effects of licensed waste disposal on groundwater and determining

the governance difficulties faced by landfill operators when ensuring compliance with waste management licence conditions.

Based on the findings of the study landfill operators were to a large extent complying with the WML conditions, however for a single non-compliance to be re-occur consecutively in external audit reports means more emphasis should be on striving to achieve full compliance. The costs associated with complying with WML conditions were found to be high and these could be reduced should variations to WML conditions be processed timeously and if authorities could consider also verifying the accuracy of the results by conducting annual tests for monitoring variables.

The effects of licensed waste disposal on groundwater were found to be minimal, however in some instances leachate control, sewer control, and co-disposal ratio maintenance was a problem. Due to the seriousness of the impacts on groundwater associated with non-compliance with these conditions, it is necessary for landfill operators to ensure full compliance with these conditions.

Governance difficulties encountered by landfill operators relate to WML conditions being ambiguous and when variations applications are submitted, authorities are reluctant to respond. For full compliance to be achieved, variations should be processed timeously, and more resources should be allocated to deal with variation applications. It is undisputed that the licensing requirement is an effective tool to minimize impacts of hazardous waste disposal, but more strategic actions are still required from the authorities for the benefits of licensing to be fully appreciated.

References

Aderemi, A. O., Oriaku, A. V., Adewumi, G. A. & Otitoloju, A. A., (2011). Assessment of groundwater contamination by leachate near a municipal solid waste landfill. *African Journal of Environmental Science and Technology*, *5*(11): 933-940.

Agamuthu, P. and Fauziah, S.H., 2011. Challenges and issues in moving towards sustainable landfilling in a transitory country-Malaysia. *Waste Management & Research*, *29*(1): 13-19.

Ajayi, O. V. (2017). Distinguish between primary sources of data and secondary sources of data. *Business State University, Makurdi*.

Akinbile, C. O., Yusoff, M. S. & Zuki, A. A., (2012). Landfill leachate treatment using sub-surface flow constructed wetland by Cyperus haspan. *Waste management*, *32*(7): 1387-1393.

Alhojailan, M. I. (2012). Thematic analysis: A critical review of its process and evaluation. *West East Journal of Social Sciences*, *1*(1): 39-47.

Alvi, M. (2016). *A manual for selecting sampling techniques in research*. Available from: https://mpra.ub.uni-muenchen.de/70218 (Accessed 04 September 2019).

Anon.; n.d. (Online). Available from https://weather-and-climate.com/average-monthly-precipitation-Rainfall,Port-Elizabeth,South-Africa (Accessed 02 August 2021)

Anon.; n.d. (Online). Available from http://en.climate-data.org/africa/south-africa/western-cape/cape-town-155/ (Accessed on 02 August 2021)

Anon.; n.d. (Online). Available from https://en.climate-data.org/africa/south-africa/gauteng/boksburg-236/ (Accessed 02 August 2021)

Averda. (2018). South Africa rethinks liquid waste disposal. Available from: www.averda.co.za (Accessed 11 April 2019)

Baldwin, D.A (2009). Shongweni Hh Landfill Site, Kwazulu Natal. External Compliance and Environmental Audit (Accessed 15 June 2016)

Blackman, W. C. (2016). *Basic hazardous waste management*. Washington DC: Crc Press.

Blight, G. E. (2006). Graded landfill requirements in South Africa-the climatic water balance classification. *Waste management & research*, *24*(5), 482-490.

Burger, L. W. & Scorgie, Y. (1998). Assessment of potential deposition of contaminants at Coega saltworks due to future industry and development of a model for emission limit estimation. *Environmental Management Services cc. Wierdapark*, *149*.

Cheremisinoff, N. P. 1998. *Groundwater remediation and treatment technologies*. New Jersey: Noyes Publications

Costley, S. (2013). *Waste Classification and Management Regulations and Supporting Norms and Standards*. Available from: https://www.environment.gov.za/sites/default/files/docs/wasteclassification_regulations_disposalstandards.pdf (Accessed 30 August 2019).

Creswell, J. W., Hanson, W. E., Clark Plano, V. L. & Morales, A. (2007). Qualitative research designs: Selection and implementation. *The counseling psychologist*, *35*(2): 236-264.

Daso, A. P., Fatoki, O. S., Odendaal, J. P. & Olujimi, O. O. (2013). Polybrominated diphenyl ethers (PBDEs) and 2, 2′, 4, 4′, 5, 5′-hexabromobiphenyl (BB-153) in landfill leachate in Cape Town, South Africa. *Environmental monitoring and assessment*, *185*(1): 431-439

Department of Environmental Affairs (DEA). (2008). National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008). *Government Gazette*. (No. 32000).

Department of Environmental Affairs (DEA). (2009). List of waste management activities that have or are likely to have a detrimental effect on the environment. *Government Gazette.* (No. GN718).

Department of Environmental Affairs (DEA). (2011a). National Waste Management Strategy. Available from: https://www.environment.gov.za/sites/default/files/docs/nationalwaste_management_strategy.pdf (Accessed 17 August 2019).

Department of Environmental Affairs. (DEA). (2011b). Report on the determination of the extent and role of waste picking in South Africa. *Government Gazette.* Available from: http://sawic.environment.gov.za/documents/5413.pdf (Accessed 17 August 2019).

Department of Environmental Affairs. (DEA). (2013a). Waste Classification and Management Regulations. *Government Gazette.* (No. GN R634).

Department of Environmental Affairs. (DEA). (2013b). National Norms and Standards for assessment of waste for landfill disposal. *Government Gazette.* (No. GN R635).

Department of Environmental Affairs. (DEA). (2013c) National Norms and Standards for disposal of waste to landfill disposal. *Government Gazette* (No. GN R636).

Department of Environmental Affairs. (DEA). (2013d). List of waste management activities that have or are likely to have a detrimental effect on the environment. *Government Gazette.* (No. GN921).

Department of Environmental Affairs. (DEA). (2014a). National Environmental Management Act (Act No.107 of 1998), Environmental Impact Assessment Regulations. *Government Gazette* (No. GN 982).

Department of Environmental Affairs. (DEA). (2014b). National Environmental Management: Waste Amendment Act (Act No. 26 of 2014), Government Gazette (No. GN 446)

Department of Environmental Affairs(DEA). (2017). Report on the Determination of the Extent and Role of Waste Picking in South Africa; DEA: Pretoria, South Africa, 2017

Department of Environmental Affairs. (DEA). (2018). South Africa State of Waste. A report on the state of the environment. Final draft report, Pretoria

Department of Environmental Affairs. (n.d). *The Scoping and Environmental Imp act Reporting Process*. Available from: https://www.environment.gov.za/sites/default/files/docs/chapter5_scoping.pdf (Accessed 5 September 2019).

Department of Mineral Resources. (DMR). (2002). South Africa State of Waste. A report on the state of the environment. Government Gazette, Pretoria

Department of Rural Development & Land Reform. (DRDLR). (2014). *Gauteng rural development plan 2014: Annexure 2: institutional fit*. Available from: http://www.ruraldevelopment.gov.za/phocadownload/SPLUMB/Dev_Plans2017/Gauteng/grdp-annexure2.pdf (Accessed 17 August 2019).

Department of Water Affairs and Forestry (DWAF). (1989). Environment Conservation Act. (Act No.73 of 1989). *Government Gazette* (No. 11927).

Department of Water Affairs and Forestry. (DWAF). (1998). *Minimum Requirements for Waste Disposal by Landfill*. Pretoria: CTP Book Printers.

Department of Water Affairs. (DWAF). (1998). Waste Generation in South Africa: Baseline Studies, Waste Management Series. *Government Gazette*. Pretoria

Department of Water and Environmental Affairs. (DWEA). (2010). Revised final environmental impact report (EIR) and draft environmental management plan (EMP) for

the proposed regional general and hazardous waste management facility in the Eastern Cape. Available from: http://www.cesnet.co.za/pubdocs/CDC%20Hazardous%20Waste%20Site%20EIA%20200916BR292/3a%20Regional%20GHWMF%20Revised%20Final%20%20EIA%20Report%20Jul10%20Part1.pdf (Accessed 17 August 2019).

Department of Environmental Affairs. (n.d). *The Scoping and Environmental Imp act Reporting Process*. Available from: https://www.environment.gov.za/sites/default/files/docs/chapter5_scoping.pdf (Accessed 5 September 2019).

Department for Environment, Food and Rural Affairs (2010). Environmental Permitting Guidance: The Landfill Directive available from (http://www.defra.gov.uk)

Department of Mineral Resources. (2002). Strategies for waste management in South Africa. *Government Gazette*. Pretoria

Department of Water Affairs. (1998). Waste Generation in South Africa: Baseline Studies, Waste Management Series. *Government Gazette*. Pretoria

Department of Water Affairs and Forestry (1994) Waste Management Series. Minimum Requirements for Waste Disposal by Landfill, 1st edn. Pretoria

Driscoll, D. L. (2011). Introduction to primary research: Observations, surveys, and interviews. *Writing spaces: Readings on writing*, *2*: 153-174.

Ekuhruleni Metropolitan Municipality. (2008). *Biodiversity report*. Available from: https://www.ekurhuleni.gov.za/council/reports/environmental-reports/467-biodiversity-report-2008/file.html (Accessed 16 August 2019).

EnviroServe Waste Management. (2014). *February Client Newsletter.* Available from: http://www.vibrantmedia.co.za/m/2014/enviroserv/february/online.html (Accessed 15 August 2019).

EnviroServe Waste Management. (2018). *Legislative Framework*. Available from: https://www.enviroserv.co.za/about-us/legislative-framework (Accessed 30 August 2019).

Environment Protection Act. (1970). Available from: https://epa.vic.gov.au/about/acts (Accessed 16 August 2019)

EPA, M. (2002). MLGRD, Ghana Landfill Guidelines: Best Practice Environmental Guidelines. *Accra: Ghana: EPA, MES, MLGRD, Ghana Landfill Guidelines*.

EThekwini Municipality Environmental Management Department. (2009). *Our bio-diverse city: The value of Durban's biological diversity*. Available from: http://www.durban.gov.za/City_Services/development_planning_management/environmental_planning_climate_protection/Publications/Documents/Our%20Biodiverse%20City.pdf (Accessed 16 August 2019)

European Commission. (2012). Services to support member states' enforcement actions and inspections concerning the application of EU waste legislation: Guidance on permitting and inspection of waste management operations. Available from: https://ec.europa.eu/environment/waste/framework/pdf/Guidance%20on%20permitting%20and%20inspection.pdf (Accessed 6 September 2019).

Gauteng Province, Agriculture and Rural Development. (2014). *Environmental Management Framework Report*. Available from: https://www.ekurhuleni.gov.za/council/reports/environmental-reports/3653-section-a-introduction-and-status-quo/file.html (Accessed 16 August 2019).

Godfrey, L. & Oelofse, S. (2017). Historical review of waste management and recycling in South Africa. *Resources*, *6*(4): 57-68

Hamann, M. & Tuinder, V. (2012). *Introducing the Eastern Cape: A quick guide to its history, diversity and future difficulties*. Available from: https://sapecs.org/wp-

content/uploads/2013/11/Eastern-Cape-Background-Report.pdf (Accessed 17 August 2019)

Han, Z., Ma, H., Shi, G., He, L., Wei, L. & Shi, Q. (2016). A review of groundwater contamination near municipal solid waste landfill sites in China. *Science of the Total Environment*, *569*: 1255-1264.

Institute of Waste Management of Southern Africa. (n.d). *New landfill classifications*. Available from: https://iwmsa.co.za/downloads/landfill27feb.pdf (Accessed 20 August 2019).

Integrated Pollution Prevention and Control (IPPC). (2010). Directive 2010/1/EC of the European Parliament and of the Council of 15 January 2010 concerning integrated pollution prevention and control

Kohler, N. (September 2015). *Final environmental impact assessment for the proposed Imadwala Integrated Waste Management Facility.* Report No.12614887-12023-11

Kolar, D. (1989). Practical Advice for Permitting a Waste Disposal Facility. *Natural Resources & Environment*, *4*(2): 11–42. Available from http://www.jstor.org/stable/40922982 (4 February.2016).

Kumar, S., Smith, S. R., Fowler, G., Velis, C., Kumar, S. J., Arya, S., Rena, Kumar, R. & Cheeseman, C. (2017). Difficulties and opportunities associated with waste management in India. *Royal society open science*, *4*(3): 1-11.

Kusi, E., Nyarko, A. K., Boamah, L.A. & Nyamekye, C. (2016). Landfills: Investigating its operational practices in Ghana. *International Journal of Energy and Environmental Science*, 1:19-28.

Landfill Directive (LD). 14/31/EC of the European Parliament and of the Council on landfill, 2014. *Official Journal of the European Union*.

Levine-Clark, M. (2019). Primary Sources as a Vital Part of An Academic Library Collection: The University of Denver Experience. *Against the Grain*, *29*(5): 26-28

Maguire, M. & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *AISHE-J: The All-Ireland Journal of Teaching and Learning in Higher Education*, *9*(3): 3351-33514.

Makinde, O. & Adekoye, T. (2007). *Environmental law in Nigeria, in The International Comparative Guide to PFI / PPP Projects 2007*. 4th edition. London: Global Legal Group

Maree, K. (2009). *First steps in research*. Pretoria: Van Schaik Publishers.

McCusker, K. & Gunaydin, S. (2015). Research using qualitative, quantitative or mixed methods and choice based on the research. *Perfusion*, *30*(7): 537-542.

Meidiana, C. & Gamse, T. (2011). The new Waste Law: Challenging opportunity for future landfill operation in Indonesia. *Waste Management & Research*, *29*(1): 20-29.

Meyer, R. (2008). *Geological and geohydrological report: Part of the permit application for the development of a Regional General and Hazardous Waste Disposal Facility on the farm Grassridge 190 Remainder near Addo, Eastern Cape*. Report 015/08, Pretoria. Available from: http://www.rhdhv.co.za/media/Appendix%20E%20Geology-Geohydrology.pdf (Accessed 17 August 2019).

Midgley, D. C., Pitman, W. V. & Middleton, B. J., (1994). Surface water resources of South Africa 1990. *Water Research Commission Report* (No. 298/5.1/94).

Midgley, G.F.,Chapman, R.A, Hewitson B, Johnson, P, de Wit, M.,Ziervogel, G, Mukheibir, P., van Niekerk, L., Tadross, M., van Wilgen, B.W., Kgope, B., Morant, P.D.,Theron, A.,Scholes, R.J., Forsyth, G.G., (2005) A Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic effects of climate change in the Western Cape. CSIR Report no. ENV-S-C 2005-073, Stellenbosch (Accessed 31 October 2020)

Misra, V. & Pandey, S. (2005). Hazardous waste, impact on health and environment for development of better waste management strategies in future in India. *Review Article, Environment International*, 31(3): 417-431.

Mmereki, D., Baldwin, A., Hong, L. & Li, B., (2016). The management of hazardous waste in developing countries. *Management of Hazardous Wastes*: 39-50.

Mokgae, M. (2011). Key Areas in Waste Management: A South African Perspective. *Integrated Waste Management*, II: 69-82.

Molleda, A. & Lobo, A. (2011). Effects of Mechanical Biological Treatments on Landfill Emissions–A Literature Review. In *Fourth International Workshop "Hydro-Physico-Mechanics of Landfills". Santander, Spain*: 27-28.

Montague, P. (1982). Hazardous Waste Landfill: Some Lessons from New Jersey. *Civil Engineering—ASCE*, *52*(9), 53-56.

Nahman, A. & Godfrey, L. (2010) Economic instruments for solid waste management in South Africa: Opportunities and constraints. *Resources, Conservation and Recycling*, 8: 521-531.

Nicholas, P., Fred E. Resource Conservation and Recovery Act (1976), United States of America. Available https://epa.org/rcra/resource-conservation-and-recovery-act-overview (Accessed 6 September 2019)

Niehof, M. (2018). Environmental Impact Report for Bay Terminals Group Coega Tank Farm: 53-54.

Oelofse, S. (2008). Towards improved waste management services by local government–A waste governance perspective. In *Proceedings of Science: real and relevant Conference* (pp. 17-18).

Oelofse, S. (2013). Business + Waste Act implementation = Business unusual. Available from: https://infrastructurenews.co.za/2013/08/15/business-waste-act-implementation-business-unusual/ (Accessed 6 September 2019).

Oelofse, S. (2013). Landfills and the Waste Act Implementation - What has changed? Available from: https://pdfs.semanticscholar.org/190e/51354e0f5ac396bdfd795a989862f69155c3.pdf (Accessed 6 September 2019).

Oelofse, S. (2014). *The Impacts of Regulation on Business on the Waste Sector: Evidence from the Western Cape*. Cape Town: Institute of Waste Management of Southern Africa.

Oelofse, S. H. & Nahman, A. (2013). Estimating the magnitude of food waste generated in South Africa. *Waste Management & Research*, *31*(1): pp.80-86.

Olufowote, J. O. (2017). Limitations of research. In *The SAGE Encyclopedia of Communication Research Methods*. Edited by Allen, M. Thousand Oaks: SAGE Publications, Inc.

Owusu-Sekyere, E. (2013). Forecasting and planning for solid waste generation in the Kumasi metropolitan area of Ghana: An ARIMA time series approach.

Pienaar, R. A. (2017). Potential solution to pollution of groundwater by diffusion of volatile organic compounds through the primary HDPE geomembrane in composite lining systems of landfills. *Journal of the South African Institution of Civil Engineering*, *59*(1), 35-44.

Pienaar, R.A & Howard, M. (2014). *From 50 Dump Sites to 50 Waste Disposal Facilities - Difficulties and Lessons Learnt*. Proceedings of the 20th WasteCon Conference 06-10 October 2014, Somerset West, Cape Town: Institute of Waste Management of Southern Africa . (Accessed 17 August 2019).

Republic of South Africa (RSA). (1994). The Constitution of the Republic of South Africa, 1994, Act 108 of 1994. Pretoria: Government Printer.

Ritchie, J., Lewis, J., Nicholls, C. M. & Ormston, R. eds., (2013). *Qualitative research practice: A guide for social science students and researchers*. New York: Sage Publications.

Roberts, D. C. (1993). The vegetation ecology of municipal Durban, Natal. Floristic classification. *Bothalia*, *23*(2): 271-326.

Sackey, L. N. A. (2015). Assesement of the quality of leachate at Sarbah landfill site at Weija in Accra. *Journal of Environmental Chemistry and Ecotoxicology*, *7*(6), 56-61.

Salihoglu, G. (2010). Industrial hazardous waste management in Turkey: Current state of the field and primary difficulties. *Journal of hazardous materials*, *177*(1-3): 42-56.

Sibiya, I.V., Olukunle, O.I. & Okonkwo, O.J. (2017). Seasonal variations and the influence of geomembrane liners on the levels of PBDEs in landfill leachates, sediment and groundwater in Gauteng Province, South Africa. *Emerging Contaminants*, *3*(2): 76-84.

South African Waste Information Centre (Online). Available from http://www.sawic.environment.gov.za/sawis-license (Accessed 02 August 2021) and (Accessed 29 September 2022)

SRK Consulting. 2018. *Vissershok North Landfill Waste Management Licence Scoping Report. Report 508446/1A, Cape Town*. Available from: https://www.srk.co.za/sites/default/files/File/South-Africa/publicDocuments/Vissershoek/2018/508446_VHN_WML_Scoping_Report_2018.pdf (Accessed 17 August 2019).

The Environmental Impact Assessment Act (EIAA), Nigeria (1992) The EIA Decree No. 86 of 1992

Thorpe, B. K. (2014) *Evaluating the quality of EIA Scoping Reports associated with hazardous waste management activities in South Africa*. Johannesburg: University of Johannesburg

Torrien, D. K. & Hill, R. S. (1989). *The geology of the Port Elizabeth area. Explanation: Sheet 3324 (1:250 000)*. Pretoria: Geological Survey of South Africa.

VAGO, J. C. (2004). The Uncertain Future of Flow Control Ordinances: The Last Trash to Clarkstown. *N. Ky. L. Rev.*, *22*, 93.

Victoria, E. P. A. (2004). Waste Management Policy (Siting, Design And Management of Landfills).

Waste Acceptance Criteria (WAC). (2004) Decision 2004/33/EC landfill Amendment Regulations.

Waste Framework Directive (WFD). (2008) Directive 2008/98/EC of the European Parliament and of the Council on waste. Official Journal of the European Union, November, 22, 2008.

Waste Management Act, Government of Botswana. Act 15 (1998) *Chapter 65:06*

APPENDICES

Appendix i: Permission letter to conduct research from DEA

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Private Bag X 447, PRETORIA, 0001· 473 Steve Biko Road, Environment House, Arcadia

Reference: Ethics (Student no. 48533718)
Enquiries: Mr. Bonginkosi Dlamini
Tel: (012) 399 9778 **Fax:** (012) 359 3625 **Email:**bdlamini@environment.gov.za
www.environment.gov.za

Ethics Committee – College of Agriculture and Environmental Sciences
UNISA

LETTER OF CONSENT TO CONDUCT RESEARCH FOR A MASTER OF SCIENCE DEGREE FOR MS ZINHLE MBILI (DLAMINI) ON A WASTE LICENSING RELATED TOPIC

This serves as confirmation that we are cognizant of the research on waste licensing within the borders of South Africa over which the Department of Environmental Affairs (Directorate: Licensing) have jurisdiction. This Directorate within the Department does not have any objection to the research.

It is our understanding that the research will entail determining the impact of licensing hazardous waste disposal facilities in four different provinces. The objectives of the research will be to determine whether landfill managers are able to comply with licence conditions, to determine the costs associated with complying with conditions, to determine the effects of licenced sites on groundwater quality and the challenges associated with complying with the licence conditions.

The information will be obtained from the chosen waste disposal facilities' landfill managers and any other information that may be at the disposal of this Department may be obtained through the Promotion of Access to Information Act.

Mr. Bonginkosi Dlamini
Director: Licensing
Department of Environmental Affairs
Chemicals and Waste Management
Date: 26/08/2015

Appendix ii: Permission letter to conduct research from licence holder

Company approval letter - Zinhle Mbili.pc

Appendix iii: Ethics approval from UNISA

UNISA

CAES RESEARCH ETHICS REVIEW COMMITTEE

Date: 17/03/2016

Ref #: **2016/CAES/043**
Name of applicant: **Ms ZT Mbili**
Student #: **48533718**

Dear Ms Mbili,

Decision: Ethics Approval

Proposal: To determine the impact of licensing on selected hazardous waste disposal facilities in South Africa

Supervisor: Mrs R Du Plessis

Qualification: Postgraduate degree

Thank you for the application for research ethics clearance by the CAES Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the project.

Please note point 4 below for further action.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the CAES Research Ethics Review Committee on 16 March 2016.

The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the CAES Research Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.*
3) *The researcher will ensure that the research project adheres to any applicable*

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Appendix iv: Questionnaire on governance difficulties faced by licence holders

Questionnaire-Challenges.pdf

Appendix v: Questionnaire on cost associated with licence conditions

Questions Cost.pdf

Appendix vi:

Title: The Impact of licensing on selected hazardous waste disposal facilities in South Africa

Authors: Z. Dlamini, Dr R. du Plessis and Prof L Sandham

Targets: WasteCon 2024

Year: 2024