Spatially defining the South African map requirements for Environmental Authorisations: a Gauteng Province perspective

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ABSTRACT

Geography is not limited to a single discipline and must be recognised as a study of the understanding and realisation of how various disciplines are connected and what role they play over time, space and scale in relation to world problems. The “four concepts underlying geography include space and place, scale and connection, proximity and distance and relational thinking”. Spatial mapping has the potential to encompass these concepts, which can provide great value to multiple users when correctly executed.

Environmental maps form an integral part and legal component of any Environmental Authorisation process within South Africa. In order for a new development to commence or when an existing project is amended or expanded, it may require a series of Environmental Authorisations. Environmental Authorisations require various maps and spatial input within its processes. These maps provide valuable information and insight to the intentions of the proposed activities as well as the present state of a study area. Spatial requirements and map outputs are currently unclear and may differ between various applications and projects. This study was therefore initiated to address this challenge and alleviate the difficulties experienced by department officials and the private sector in the application and decision-making processes pertaining to Environmental Authorisations in the Gauteng Province. The role of such a database and environmental maps, as an information source and decision making tool was also investigated to understand the value it could provide to both the private sector and Department Officials.

The first research objective was to understand the different types of South African Environmental Authorisations and the related mandatory map requirements with an emphasis on the value of these maps. This was achieved through systematic literature review and six (6) semi-structured interviews. One of the findings from the literature review was that multiple GIS databases exist, however they do not entirely complement Environmental Authorisations and the specific map requirements. The second research objective aimed to determine the specific spatial and map output requirements for the Environmental Authorisations generated in the Gauteng Province. A total of 25 relevant case examples were collected using framework structured from the purposeful sampling approach.

The literature review identified a list of various spatial map requirements to be included within each types of Environmental Authorisation. These Environmental Authorisations referred to include Basic Assessments, Environmental Impact Assessments; Water Use licenses; Waste

Management Licenses and Air Emission Licenses. A cross-evaluation checklist was constructed using the list of spatial map requirements for Environmental Authorisations within the Gauteng Province. The data indicated that more than 70% of the legally required map attributes were included within the EA processes. Additional map attributes such as the Gauteng Conservation Plan and the Gauteng Environmental Management Framework were highlighted as valuable data layers to be included in the GIS database as it contributes greatly to decision-making.

The third research objective aimed to spatially define the environmental maps in a Geographic Information System (GIS) database within the Gauteng Province boundary. The theory of ideal requirements distilled was used to design a spatial database capable of including and presenting all the legally required map attributes within the Gauteng Province for the five (5) types of Environmental Authorisations. The data indicated that although such an environmental GIS database would provide great value to the industry, it would have to overcome certain limitations and concerns. One of the biggest concerns and limitation is the ability to retain relevant and updated information within such a database, as certain information is updated at such a pace that it would prove difficult and costly to provide a constantly updated version of data. Regardless of the concerns raised during the study, the data proves that a theory of such a GIS database for Environmental Authorisations would demonstrate great value to the various processes.

The GIS database forms a user-friendly platform for both Environmental Consultants and Department Officials, consolidating all the required cartographical information layers for any of the five (5) types of Environmental Authorisations into one database for the Gauteng Province. The value of environmental maps within Environmental Authorisations was not only confirmed throughout this dissertation but provided enough evidence to envisage the evolution of environmental maps and the role it would play as an integral part of an application process.

KEYWORDS

Environmental Authorisations, Maps, Global Information System, GIS, Database, Gauteng Province.

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CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

1.1 Introduction and research problem

The field of geography encompasses a distinctive way of understanding how the world works. Geography is not limited to a single discipline and must be recognised as a study of the understanding and realisation of how various disciplines are connected and what role they play over time, space and scale in relation to world problems (Bonnett, 2012:39–41). Jackson (2006) identified four key concepts underlying geography which aligns with Bonett's view of geography and how geographers should interpret complex problems. These concepts include space and place, scale and connection, proximity and distance and relational thinking (Jackson, 2006:199–204). These underlying concepts of geography formed the basis on which this dissertation was built, by recognising the value they provide within spatial mapping. This dissertation therefore aimed, to provide a platform for spatial geography, furnished with these four concepts to address real world problems.

The United Nations (UN) has classified South Africa as a developing economic country (WESP, 2012; Zacarias & Fransman, 2013:1–31), meaning that the basic economic conditions of South Africa is low with a *per capita* gross national income (GNI) of $5 490 (2016) according to the World Bank (The World Bank Group Data, 2016). Therefore, in South Africa, development for the overall improvement of the country's economy and status is encouraged (National Planning Commission, 2011). The National Development Plan for 2030 provides long-term goals for the development of various sectors within strategic areas, with the aim of strengthening the economy and lowering poverty under the principles of collaboration and sustainable development (National Planning Commission, 2011).The willingness to improve South African infrastructure may not compromise the integrity of the environment (South African Biodiversity Institute (SANBI), 2013). In the 2012 – State of South African Biodiversity Report, the uniqueness and fragile state of the ecosystems responsible for providing the country with valuable goods and resources were highlighted (South African Biodiversity Institute (SANBI), 2013). Development must therefore be regulated in relation to environmental impacts as a result of such developments to ensure the sustainable management of South Africa's biodiversity resources.

(Shoket, 2014:512–518) defines research problems as the questioning of the uncertainties in the scope of knowledge. Therefore, this Chapter aimed to identify the current uncertainties regarding the specific map requirements in terms of environmental authorisations to thus clarify the aim and

objectives. Identifying research worthy problems/ gaps within current literature or practice, is however very difficult, as not every shortcoming constitutes meaningful research (Ellis & Levy, 2008:17). This section arguments the need for this study by identifying the research worthy problems/ gaps within current practice.

In order for a new development to commence or when an existing project is amended or expanded, it may require a series of environmental authorisations. The National Environmental Management Act (NEMA), GNR 107, 2016, as amended (South_Africa, 2014a:1–117) defines an environmental authorisation as the *"authorisation by a competent authority of a listed activity or specified activity in terms of NEMA, and includes a similar authorisation contemplated in a specific environmental management Act".*

Wessels, (2005) further defined an environmental authorisation as any *"document, directive or credential granted by a competent authority to an applicant enabling the applicant to commence with the activity that may impact the environment"* (Wessels, 2005). These authorisations as defined by Wessels (2005) are directly linked to various South African legislative acts, thus making the authorisations compulsory according to law. The type or extent of authorisation required may differ depending on the legislative "triggers" associated with the activity.

Each of these authorisations may require spatial maps to aid in the planning of the project and the decision-making process of competent government departments. Environmental maps form an integral part of any environmental authorisation within the confines of South Africa, and are legally required within these environmental authorisation processes. The problem being that spatial requirements and map outputs are unclear and may differ between various applications and projects. There are currently no freely accessible or publicly available databases in South Africa to aid in the effective generation of these maps. In relation to the EIA process, as an example, the only map requirement according to NEMA is a "locality map" or site plan, illustrating the area in which the proposed activity will take place (South_Africa, 2014:1–24, as amended).

Many provincial application forms and guidelines elaborate on more specified requirements such as a scale of 1:50 000; a clear indication of locality; details of any access roads and a North arrow (South_Africa, 2012:1–193). However, they do not collectively represent or account for a successful evaluation and decision-making processes that require the indication of aquatic resources, priority areas, protected species, geology, wetlands, and biodiversity amongst other environmentally sensitive aspects. Metropolitan municipalities including City of Johannesburg (COJ) and Ekurhuleni have created a well-established base of spatial information resulting in

more uniform and accurate map projections due to updated versions made available to end-users (CoJ, 2016; Ekurhuleni, 2017).

In 2014, the Gauteng Department of Agriculture and Rural Development (GDARD) published revision 3 of the Biodiversity Management Directorate specifying the requirements for biodiversity assessments and reports by EAP's and specialists throughout the Gauteng province (GDARD, 2014). These types of publications provide some clarity as to what the Department expects to be included in Environmental Authorisation Applications. Similar documents will be discussed in Chapter 3, but emphasis must be made on the availability of these types of publications regarding specific spatial requirements. However, no evidence has been found supporting a central database system generating all the required spatial information.

According to (Rutherford *et.al*, 2012) these types of databases do not only serve as storage sites for relevant data, but can serve as an essential source of information with its extensive range of potential applications. Databases providing spatial information are not a new concept and have been used for many years by private and governmental organisations as a management tool and a convenient method of displaying information. Information from international organisations including the Environment Agency in England (EAE), United States Environmental Protection Agency (USEPA), United Nations Environmental Programme (UNEP), Council for Scientific and Industrial Research Geospatial Analysis Platform (CSIR GAP), Free GIS DATA, GIS in Ecology, and the Environmental Systems Research Institute (ESRI) for Environmental Management was used to establish the foundation for national databases in South Africa. These databases include 1Map, the South African National Biodiversity Institute(SANBI), AviFauna SA online GIS map, and governmental databases such as the Department of Environmental Affairs (DEA) and COJ which have generated free and accessible databases for the interactive use and extraction of relevant spatial data (shape files and Metadata) (Díaz *et al.*, 2013:65–80).

These databases however only provide spatial data and are deficient of information and parameters needed to produce relevant and legitimate environmental maps. Therefore, the importance of this study is the generation of a database which specifies the required map categories that will provide a link between these databases and insight into the relevant requirements and information. This will ultimately aid the environmental and planning industry, as well as government, private and public sectors to generate maps more efficiently and accurately for environmental authorisation applications.

Ellis emphasises the importance of well-structured research through the implementation of each research element, identified as follow: a clear research aim which must be clearly identified throughout the study, short and direct research objectives in support of the aim, the extensive review of existing literature; a disciplined implementation of required methodologies, the analysing and discussion of results and a clear and direct conclusion (Ellis & Levy, 2008:17).

1.2 Research aim

The need for this study is, therefore, to spatially define the South African map requirements for Environmental Authorisations through the creation of a Geographical Information System (GIS) database for the Gauteng Province.

1.3 Research objectives

In order to achieve the aim and establish the scope of research, clear objectives were required. Ellis states that research objectives narrows the purpose of the study into clear goals to be assessed, but must however be clearly connected to the overall aim of the study (Ellis & Levy, 2008:17). Three (3) objectives were, therefore, identified for investigation, thereby constructing the backbone of the overall aim of this study. To keep within the scope of a Master's degree this study will be confined to the Gauteng Province of South Africa.

The specific objectives identified within this study, will be:

1. To understand Environmental Authorisations and the related mandatory map requirements in South Africa with an emphasis on the value of these maps.
2. To determine the specific spatial and map output requirements for the Environmental Authorisation generated in the Gauteng Province.
3. To spatially define the environmental maps in a Geographic Information System (GIS) database.

1.4 Structure of dissertation

The structure of this dissertation is depicted in Figure 1-1 below, and illustrates the format to be followed as recommended by (Ellis & Levy, 2008:17; Mauch, J.E & Park, 2003; Wessels, 2015) for the compilation of this dissertation.

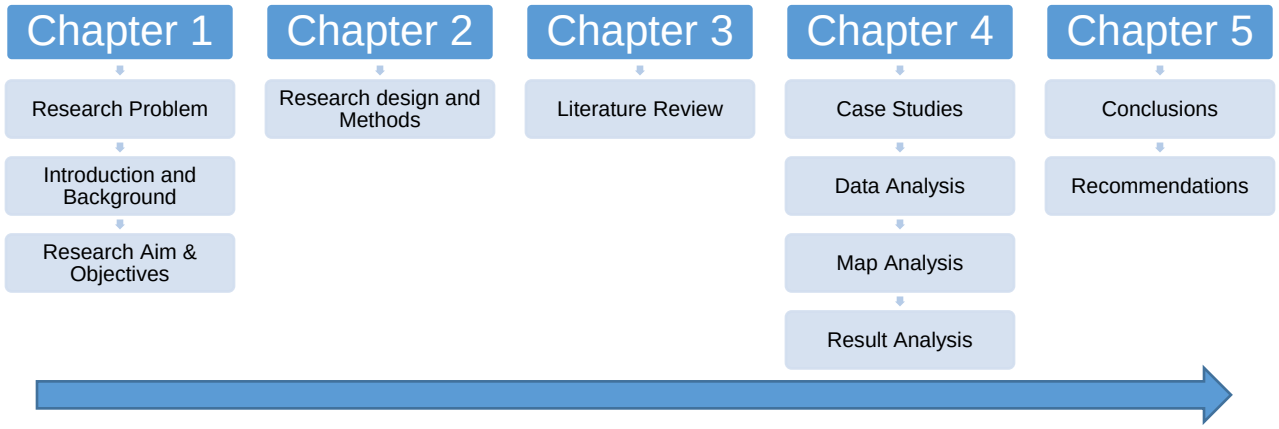

Figure 1-1: Structure of Dissertation

This dissertation consists of five (5) chapters:

- **Chapter 1** entails an introductory section describing the research problem, overall aim and objectives of this dissertation.
- **Chapter 2** depicts the research design and methodology, and methods to be followed for this study.
- **Chapter 3** presents an in-depth literature review relating to the specified subjects of study.
- **Chapter 4** focuses on analysing the research objectives individually, reflecting at the method and source of data, and finally the analysis of the collected data through the creation of a Global Information System (GIS) database for the generation of spatial maps.
- **Chapter 5** comprises of a conclusion to each objective, recommendations on the research topic followed by a final concluding statement regarding the aim of this paper.

CHAPTER 2: RESEARCH DESIGN, METHODOLOGY AND METHODS

2.1 Research Design

The research design portrays the approach followed to get to the respective data results. It forms the skeleton of study as it specifically defines a tested process to be followed (Mari *et al.*, 2012:2107–2115). A stipulated thought process can simplify the route of linking the objectives of this study to the conclusions to be made (Williams, 2007:65–72). This study was designed around three core structures of investigation:

1. A philosophical assumption based on the pragmatic;
2. The overall method to be followed;
3. And the specific methods to be followed in the collection, analysing and writing of data.

This chapter describes the philosophical assumption regarding the study, the research methodology and methods, followed by the limitations and trustworthiness.

2.2 Philosophical assumption

The philosophical research assumption is based on the pragmatic. Thus enabling a more individualistic research design by utilising only appropriate methods best suited for this study that focus on real word challenges (Hobson, 2006). According to (Russell, 2013), pragmatic assumptions allow the researcher to investigate detailed practice requirements and uncertainties by focusing on the scope and context of the study. This assumption allows a researcher to identify real word gaps and problems and combine it with current literature. The gap between government departments and the private sector related to information transfer and sharing has given rise to this study. By investigating the practice requirements of providing information to various government departments within Environmental Authorisation processes allowed for a focused scope of this study, thereby investigating the spatial information required and how this information can be shared/ transferred between various parties within such processes.

2.3 Methodology

The direction and approach of this study was determined by the research aim. “The research aim will ultimately determine the direction and approach to the study” (Ellis & Levy, 2008:17). In essence, the methodology depicts the steps to be taken to achieve the objectives set within the study. The research methodology can therefore be defined as the overall approach followed in achieving the research aim. To support the real word research, a mixed method approach was followed to utilise both quantitative and qualitative data (van Griensven *et al.*, 2014:367–371). “Quantitative data refers to numerical research such as the manipulation and experimentation with numbers in the pursuit of knowledge, were as qualitative data refers to the investigation and comparison of multiple studies (even quantitative studies) to find and construct similarities to build on theories or ideas” (Grant *et al.*, 2009:91–108). Curall, *et al* (1999) and Creswell (2009:25) defines the mixed method approach as the “simultaneous use of quantitative and qualitative methods during data collection or analysis”, thereby applying the strengths of both forms. Creswell, (2009:25) further emphasises that only using quantitative or qualitative data is not enough when it comes to large approaches in today’s social and human scientific studies, and that there is more insight to be gained from combining the methods (Creswell, 2003a:1–26); van Griensven, 2014:367–371). This method has also been referred to as a *multimethod*, *mixed methodology, integrated approach* and even *synthesis,* but is most commonly known today as the mixed method approach (Creswell, 2003a:1–26). When applying a mixed method approach, a common finding is that the quantitative and qualitative arms will interact sequentially or concurrently (van Griensven *et al.*, 2014:367–371).

The ultimate direction of study will only be determined by analysing the research aim. Therefore, the mixed method approach was used in this study, following the sequential exploratory strategy as suggested by (Creswell, 2003a:1–26). The strategy entailed two phases of research: firstly, focusing on the qualitative data collection and analyses ,and secondly, strengthening the findings through quantitative data collection and analysis with the sole purpose of adding value to the qualitative findings (Creswell, 2009:1–25). William explains that qualitative research can be used for confirming research data (Williams, 2007:65–72). Systematic Review is regarded as a meta-analysis tool that summarises the certainties and uncertainties pertaining to the research aim (Frizzo-barker, J *et al.*, 2016:403–413). Frizzo-barker (2016) further emphasises the value of using Systematic Review as it enables the user to utilise fragmented data as a means of evaluation and interpretation of all the available research on a specific topic, thereby bridging the gap between research and real-world practice.

This research was initiated with qualitative methodologies for investigative purposes, and supported by quantitative data in the hope of understanding the shift in Big data representation. The Big data referred to, represents the transition of thinking regarding data infrastructure and analytics (Frizzo-barker. J *et al.*, 2016:403–413). Big data analytics have not only become a more cost-effective option over the years but also provides the user an ability to measure and manage the predictability of an activity or event, thereby improving the overall accuracy of the particular study.

The overall methodology of this paper focuses on qualitative data and using the quantitative research to assist the interpretation of the qualitative findings, thereby explaining the connection and relationships between these vast sets of data between the qualitative and quantitative data (Creswell, 2006; Frizzo-barker. J *et al.*, 2016:403–413).

The methodology used within this research has been clearly identified and defined in the above section, however, to successfully implement this methodology, certain research tools had to be used to achieve each research objective as depicted below (Ellis & Levy, 2008:17).

2.4 Methods of data collection, analyses and writing

As mentioned above, a mixed method approach was followed by executing a Systematic Review. The Systematic Review, as a method of study, requires three distinct phases to be followed in order to successfully accomplish the objectives of a study (Frizzo-barker, J *et al.*, 2016:403–413). The first phase is the research design, which formally explains the method used to identify the data required to achieve each objective. The second phase places emphasis on the specific procedure of data collection for each individual objective. The third phase is data analysis, explaining the process of analysing the collected data. Creswell, (2009:25) identified data representation as a fourth phase when conducting a Systematic Review (Creswell, 2009:1–25). During the data representation phase, results gathered from the analysed data must be displayed in a formal manner before discussion. Therefore, each of the three (3) objectives was achieved by conforming to the four (4) phases of Systematic Review (Figure 2-1).

Figure 2-1: Four phases of Systematic Review utilised to achieve the various objectives.

2.5 Methods used for achieving objectives

The methods used to achieve the three (3) objectives are described below. The relevant data will be gathered by following these specific methods:

2.5.1 **Objective 1:** The first step was to subdivide the objective into primary and secondary objectives. The primary, focusing on Environmental Authorisations and the related mandatory maps for the Gauteng Province, and the secondary, on the value these maps add to the Environmental process. A literature review was conducted to gather and identify information relating to both the Environmental Authorisations and the associated mandatory map requirements in South Africa, as well as the value that these maps provide to the authorisation process as a whole. Due to the mixed method approach, a well-designed literature review was needed. Therefore, a Systematic Review was utilised to seek and review relevant research that ultimately drew a clear understanding on the research topics (Grant *et al.*, 2009:91–108). A Systematic Review seeks to thoroughly search, combine and evaluate information according to a specific structure (Grant *et al.*, 2009:91–108). The literature review provided a framework and criteria for the evaluation of relevant information to aid in achieving objective two.

To further understand the value that these maps add to Environmental Authorisations in a Provincial context, six (6) semi-structured interviews were conducted with both environmental practitioners and department officials. Environmental Authorisation applications are compiled by environmental practitioners and submitted to the respected departments for evaluation by department officials. To establish a holistic understanding of the perception of all parties associated with Environmental Authorisations, and parties whom stand to gain from a Global Information Systems (GIS) database, both practitioners and department officials were interviewed. The questionnaire aimed to investigate the

interviewee's perception and attitude towards a GIS-based database. Even though Semi-structured interviews are commonly used as a primary source of qualitative data within research projects, as explained by Dicicco-Bloom & Crabtree, (2006:314–321), it will only aim to strengthen the understanding of environmental maps within the contents of Environmental Authorisations. Furthermore, it provided an insight to peoples' attitude towards the potential of a single GIS database for all environmental map requirements (Barriball, 1994:328–335; Dicicco-Bloom & Crabtree, 2006:314–321). Rabionet states that such qualitative interviews can become a useful tool in capturing the opinion and inundated feelings related to the topics of discussion (Rabionet, 2011:563–566). Barriball further emphasised that Semi-structured interviews can examine perception and opinions of interviewee's often regarding complex topics with the freedom to enquire further or delve deeper into conversations (Barriball, 1994:328–335).

The Semi-structured interview contained a list of open-ended questions providing the potential for follow-on conversational questions (Dicicco-Bloom & Crabtree, 2006:314–321). Rabionet explains that Semi-structured interviews assist in covering certain topics of importance, but still allows the interviewee to share their stories and opinions (Rabionet, 2011:563–566). The benefits of conducting Semi-structured interviews allows for almost immediate data analysis as the interviewer can generate an evolving understanding of the research objectives and the attitude the interviewee has towards certain aspects of the study (Dicicco-Bloom & Crabtree, 2006:314–321). Dicicco-Bloom and Crabtree (2006) further states that Semi-structured interviews can provide valuable information regarding the interviewee's experience and views regarding subject matters and have become increasingly popular within mixed-method research (Dicicco-Bloom & Crabtree, 2006:314–321).

2.5.2 **Objective 2** - This study aimed to collect 25 relevant case examples by using a purposeful sampling approach. Purposeful sampling, also known as judgement sampling aims to actively source samples in line with the study criteria (Marshall, 1996:522–525). These cases consisted of different Environmental Authorisations sampled in the Gauteng Province of South Africa. The purposeful sampling approach was conducted using a framework (Clark & Smithers, 2006:465–472). The framework consisted of a list of requirements for each case sample to qualify as an appropriate sample. According to Marshall (1996), the number of cases may change as the study progresses and notes that the required number of samples only becomes clear further into the study due to "data saturation". The purposeful sampling allows the researcher to use the most productive samples to comply with the research scope and aims (Marshall, 1996:522–525). Frizzo-barker (2016) explained that the quality of samples is, in most cases, more important to the overall outcome of the study, even though the volume of samples collected is important to improve the accuracy of an analysis (Frizzo-barker *et al.*, 2016:403–413). He therefore suggests that a balance should exist between the quantity (volume) of samples and the quality of the content of samples to achieve the desired results. After the appropriate amount of case samples were collected, an evaluation was done to analyse the case examples to formulate a judgement of value for the different applications. The case method and evaluation allowed the researcher to build a theory on the ideal database to achieve objective 3.

2.5.3 **Objective 3** - The theory of ideal requirements distilled to accomplish this objective. Spatial database design was used to visually illustrate the findings. The requirements for constructing the database are summarised in Table 2-1.

A database was constructed using *ArcGIS version 10.4* (hereafter referred to as *ArcGIS*) to add both spatial and non-spatial value to the database (Table 2-1) (ArcGIS, 2017). These databases is being used for various applications in the past such as public transport, sewer systems and various engineering projects (Sinske & Jacobs, 2012:1–7). The database generated from this study followed a scenario-based strategy to simulate a listed activity which requires all the necessary legal Environmental Authorisations before development can commence. Stones (2006) emphasises the value that scenario-based strategies can create in decision making or learning-based activities by implementing theoretical characteristics into real-life scenarios or events (Stone, 2006:7–18). The

database consists of different maps, as required by the various Environmental Authorisations, illustrating the different specifications for each process. These types of databases could become internet-based and provide users with access as well as create a form of interactional use from different locations (Yeager & Steiger, 2013:1–4). It is hoped that a tedious database with so many variables could be automated for future work (Sinske & Jacobs, 2012:1–7).

Table 2-1: Summary of all the requirements needed to construct the database (Clark & Smithers, 2006:465–472).

Summary of content required for the database construction.	
Global Information System platform	*ArcGIS version 10.4* desktop software • The program contained the foundation for structuring the database. • In addition, the software provided the necessary spatial analysis tools for constructing the map. Online Municipal databases.
Existing Spatial Databases	Existing municipal databases: • Sourced as a guideline for structuring the GIS database.

Data inputs used within the GIS database	• Data shape files within the Gauteng Province
	• *Google Earth* files generated for case example
	• Non-Spatial data used within for database:
	  ○ Legislative map requirements
	  ○ Departmental application forms stipulating map requirements
	  ○ Case example map outputs used for Environmental Authorisations
	  ○ Suggestions brought forth during interviews

Coordinate system	As required by the Respected Departments: • WGS84 spheroid in a national or local projection
Design	The design for the spatial database was structured
Data Analysis and output	• Map outputs were generated using spatial tools available on the ArcMap software. • The database platform was constructed and formulated using the above-mentioned inputs.

2.6 Methodological limitations and ensuring trustworthiness of data

This section briefly discussed the possible methodological limitations related to the proposed objectives within this dissertation. Even though these objectives pose some methodological limitation, it can be overcome through the implementation of specific research measures.

2.6.1 Limitations for Objective 1

Shenton (2004) supports the debate of data validity and trustworthiness of qualitative data in relation to quantitative data, and states that through the incorporation of measures and strategies, such issues may be resolved (Shenton, 2004:63–75). Shenton further states that by implementing Guba's constructs of credibility, transferability, dependability and confirmability to qualitative research, validity may be addressed (Shenton, 2004:63–75). Morse *et.al* (2002) endorses this constructs by stating that without rigor, qualitative research is regarded untrustworthy, therefore attention must be brought to the validity and reliability of the data investigated (Morse *et al.*, 2002:13–22). Objective 1 is therefore limited to the amount of validated and reliable research available. This paper aimed to address this limitation through methodological coherence between the stipulated objectives and the methods applied (Morse *et al.*, 2002:13–22).

2.6.2 Limitations for Objective 2

The availability of approved and/or pending Environmental Authorisations from Gauteng was found to be the most significant limitation for Objective 2. These documents are not always published online and there is an apparent reluctance of private consulting companies to share their methods of processes. Collecting enough case examples was therefore the greatest challenge. Case examples were sourced through multiple platforms to collect the desired amount. In addition, interviews were conducted with professionals to add value to the dissertation and to provide validity to the research results (Dicicco-Bloom & Crabtree, 2006:314–321).

2.6.3 Limitations for Objective 3

The construction of a database illustrating the results gathered posed another challenge. These types of databases are usually highly sophisticated, data intensive, and not easily replicated on a large scale. A database illustrating the required information requires a large amount of data

information (in the form of shape files) which is difficult and expensive to acquire or generate. The limitations of this database will thus have to be researched further.

Hart (2007) defined spatial data standards as a written agreement proscribing technical specifications and requirements to be enforced on a continues basis, similar to a guideline or regulated rule, to ensure that products and services are standardised for specific uses (Hart, 2007). Thereby increasing data sharing and interoperability within GIS. The validation and verification of spatial data limiting objective 3 was addressed by using Internationally and nationally standardised spatial data and software in terms of ISO TC 211 (ESRI, 2017). This includes ArcGIS Desktop software which is structured under the ISO standards. Spatial data included area nationally accepted within governmental departments and International spatial databases under various accreditation criteria's.

CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

The second phase of conducting a Systematic Review is to place emphasis on the specific procedure of data collection for each objective (Frizzo-barker, J *et al.*, 2016:403–413). An extensive literature review was therefore conducted encompassing a variety of interrelating topics:

- The concept of Environmental Authorisations analysed through the investigation of environmental legislation, specifically focussing on the South African context.
- South African legislative framework.
- The specific spatial requirements requested by the Gauteng province for the submission of environmental authorisation applications.
- The legislation behind the formulation of a GIS database.
- Verification of spatial requirements needed for the construction of such a database through peer-reviewed articles and similar databases.
- Global Information System Databases, globally and in South Africa.

The information gathered will be sourced from the Gauteng Department of Agriculture and Rural Development application forms and finalised authorisations submitted by various environmental consultants.

3.2 Environmental Authorisations

3.2.1 An International Perspective

Development has always been in conflict with protecting the natural environment (Engelschalk, 2004:275–311; Mahayri, 1998; Ursul, 2017:37–51). It is therefore a requirement to protect the environment through the regulation of developments that may potentially have a negative impact or cause harm to the environment.

The Stockholm Declaration of 1972 pioneered the first recognition of the right to a healthy environment (United Nations, 1972:5–16). 92% of the UN member nations have since recognized the right to a healthy environment within their constitution and legislation (Boyd, 2012).

Figure 3-1: UN member nations whom have adopted the right to a healthy environment within their legislation (Boyd, 2012)

Once the right to a healthy environment was promulgated within a nation's legislation, enforcement was required. Objectives within such legislation included but was not limited to the insurance of careful and evaluated considerations before actions are taken which could affect the environment (CEAA, 2012:37). Gurney identified the benefits of implementing environmental legislation such as the Canadian Environmental Assessment Act, 2012 (CEAA, 2012:37). Gurney (2003) emphasised that the resultant of including environmental assessments within project

development, would be overall cost-effectiveness and the opportunity for beneficial impact identification (Gurney & Yap, 2003). The author further states that the absence of a framework or guidelines promulgated as a standard for implementation threatens the comprehensiveness and value of Environmental Impact Assessments. In the context of Syrian government, Mahayri (1998) questioned the effectiveness of EIA's due to government projects being overlooked and exempted from certain requirements in comparison to what small private sector projects are required to conform to.

Hadi (2003) conducted a study within Indonesia to evaluate the practice and quality of EIA's since the year 1986. The findings established a clear trend in poor quality EIA's due to its failure to address concrete issues within the scope of study (Hadi, 2003:76). A conclusion was made that the lack of public involvement and the availability of relevant information was the main drivers behind the quality of practice within Indonesia (Hadi, 2003:76).

An essential part of EIA's which is often overlooked is the evaluation of alternatives. The United States National Environmental Policy (UNEP) states that "alternatives are the heart of environmental impact statements" (Jesus, 2015). Jesus (2015) further states that EIA's should be approached systematically and addresses all relevant and available information to successfully investigate alternatives within the scope of a project. The lack of information available is regarded as a shortcoming which prohibits the successful evaluation of alternatives (Jesus, 2015).

Nations, in some instances, are required to implement environmental policies and legislation as a result of environmental degradation and continuous unregulated development. Such an instance was observed in Nigeria, where the Federal Environmental Protection Agency (FEPA) was established as a regulatory body to prevent the increasing illegal dumping of toxic waste. The success of this regulatory body lead to the proclamation of a National Policy to protect the environment within a developing Nigeria (Echefu & Akpofure, 2003:63–74). The Environmental Impact Assessment System within Nigeria has become a leading example within developing countries on conducting comprehensive impact assessments as a regulating system of development (Echefu & Akpofure, 2003:63–74).

Environmental Impact Assessments have not only been used as a tool to prevent unregulated and degrading activities within developing countries, but have been enforced as a mandatory requirement by multinational financial institutions before international investments are considered for projects in countries such as Tanzania. These policies are great steps forward towards sustainable development within developing countries without foundational environmental

legislation to regulate development (Katima, 2003:183–191). Katima (2003) states that the implementation of this policy is limited to the required departmental and institutional support, environmental legislation and trained personnel if sustainable development is to be achieved. Furthermore, regarding many developing countries, the lack of relevant information available continues to compromise the effectiveness of environmental impact studies (Katima, 2003:183–191).

Environmental Impact Assessments conducted without a legal foundation within Sudan, commonly known to be the largest country in Africa were investigated by Ali (2013). This study showed that like most developing countries, Sudan conducts EIA's as enforced by international investments. However, these investigations had to be conducted on a voluntary basis as no assessments were required by legislation and government (Ali, 2013:1–6). Even though EIA's were conducted, the issue of when to conduct such an assessment became extremely important. Ali (2013) identified projects where the EIA was only tendered for once construction had already commenced. This practice is regarded as a fatal flaw within Environmental Assessments, but is still regarded as a major issue within developing countries (Ali, 2013:1–6). The issue of belated timeframes are still holding back the process from its designed potential, but with an established legislative foundation and regulatory body to enforce a set procedure for conducting and evaluating EIA's, it may improve as a whole.

3.3 South African Legislation requiring Environmental Authorisation

The overview of key policy, legislation, plans and guidelines triggered by various environmental authorisations in South Africa are addressed in this section. The requirements set out in these Act's and Regulations must be adhered to throughout the applicable environmental authorisation processes.

The National Environmental Management Act defines an Environmental Authorisation as (South Africa, 2014:17):

"When used in Chapter 5 of the act, means the authorisation by the competent authority of a listed or specified activity contemplated in a specific environmental management act."

According to the NEMA's principles all development must promote social, environmental and economical sustainability. The principles also state that environmental management must be instigated to complement all the elements through the inelegant utilisation of best practicable

options (South Africa, 2014:17). These principles set the standard for how environmental authorisations should be approached.

The term environmental authorisation must first be broken up and discussed separately to fully understand the terminology. The National Environmental Management Act (NEMA) of 2014 (Act No. 107 of 198) as amended, defines the environment as:

"The surroundings within which humans exist and that are made up of-

(i) the land, water and atmosphere of the earth;
(ii) micro-organisms, plant and animal life;
(iii) any part or combination of (i) and (ii) and the interrelationship among and between them; and
(iv) the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being".

The term authorisation is defined as the process of giving someone or something permission to do, or have something specific (European Commission, 2015:1–49).

The term Environmental Authorisation, when analysed within the context of legislation within the NEMA, is defined within the framework of integrated environmental management (Chapter 5 of NEMA) as:

"The authorisation by a competent authority of a listed activity or specified activity in terms of the NEMA, and includes a similar authorisation contemplated in a specific environmental management act".

Wessels, (2005) further defined an environmental authorisation as any *"document, directive or credential granted by a competent authority to an applicant enabling the applicant to commence with the activity that may impact the environment"*.

In order for any development to commence with a listed activity described in the NEMA, an Environmental Authorisation form a competent authority must be obtained. The Environmental Authorisation has thus, for many years been regarded as a requirement rather that a valuable tool for decision making by applicants (Eijssen, 2017:2–3). The type of environmental authorisation depends on the nature and severity of the proposed activity and is therefore predetermined using the environmental legislation.

Project-dependent, these authorisations may include an EIA in terms of the National Environmental Management Act, 1998 (Act no. 107 of 1998) (NEMA), which is defined as an investigation of environmental impacts of a planned activity (Hadi, 2003:76) and a Water Use License Application (WULA) as required by the National Water Act 36 of 1998(South Africa, 1998:1–178). Other types of authorisations include Heritage Impact Assessments (HIA) according to the National Heritage Resources Act 25 of 1999 (South Africa, 1999: 1-45), as well as a Waste Management Licence in terms of National Environmental Management Waste Act 59 of 2008 (NEM:WA) (South Africa, 2008). In some cases, a Biodiversity Risk Assessment Permit (BRAP) must be granted as required by the National Environmental Biodiversity Act no. 10 of 2004 (NEM:BA)(South Africa, 2004:1–84). Approval may also be compulsory in terms of the Spatial Planning and Land Use Management Act no. 16 of 2013 (SPLUMA) (South_Africa, 2013:1–37) and finally with some activities an Air Emissions License will be required in terms of the National Environmental Management: Air Quality Act no. 39 of 2004 (NEM:AQA).

The recent amendment of the EIA regulations published on the 4th of December 2014(South Africa, 2014:3–74) emphasised the reduction of the timeframes of completing and submitting environmental authorisations. A summary of the timeframes is presented in Figure 3-2 below.

The flow diagram in Figure 3-2 presented in an Information seminar by the Department of Environmental Affairs (DEA) illustrates the strictness of the revised timeframes (DEA, 2014:1–39) in comparison to Figure 3-3 which illustrates the timeframes of the old regulations of 2010 (ERM, 2013). The revised timeframes aim to promote a “One Environmental System” concept that emphasises the importance of streamlining the mapping processes for Environmental Authorisations through a GIS database. The development of a “One GIS Database” where the different Environmental Authorisation (EA’s) maps could be generated may ensure compliance with the revised timeframes as it will reduce the task time of the environmental consultant/practitioner. A specific research aim with relevance to EA’s could thus be designed through the identification of the current shortcomings in practice and literature related to the generation of environmental maps.

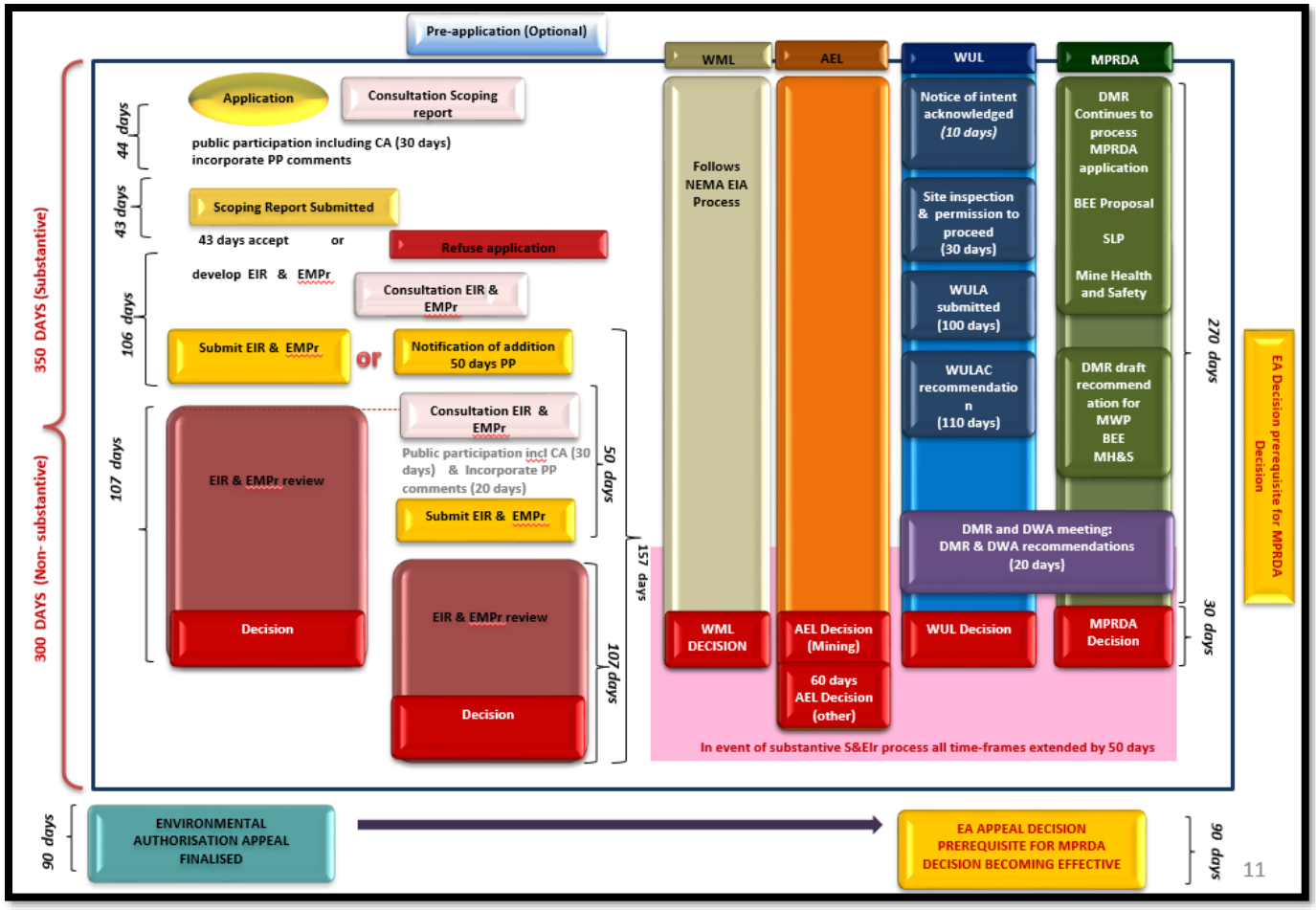

Figure 3-2: DEA Flowchart of S&EIR Process and timeframes 2014 regulations (DEA, 2014:1–39).

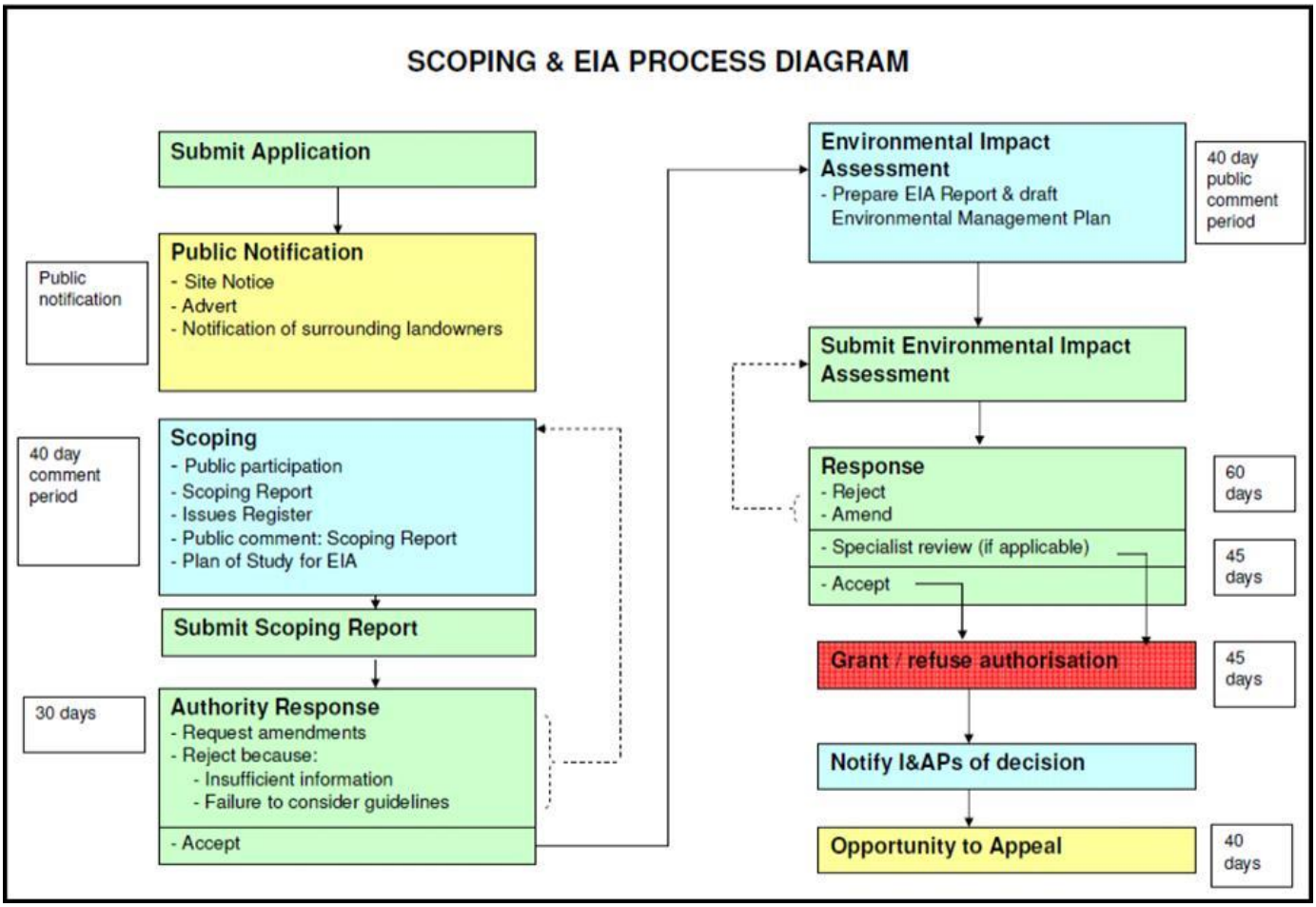

Figure 3-3: ERM Flowchart of S&EIR Process and timeframes 2010 Regulations (ERM, 2013).

Environmental Authorisations are administered under Spectral Specific Legislation within the framework of the NEMA (Figure 3-4).

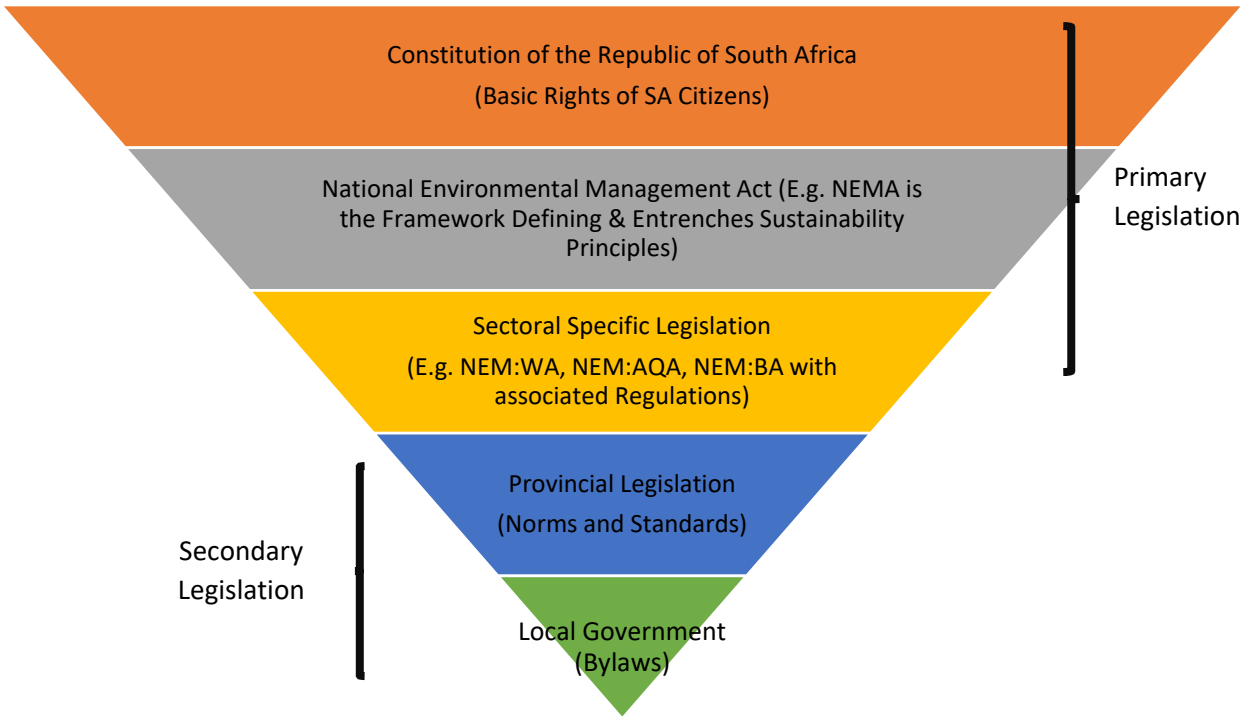

Figure 3-4: South African environmental legislation hierarchy.

Preventative Law Screening has become an effective tool in identifying applicable legislation for any proposed or existing activity and can prevent compliance notices or even prosecution if not attended too. It is therefore critical that all applicable legislation and processes associated with a set activity be identified within the early stages of planning to provide sufficient time to obtain the required authorisation (Moseley, 2004). The following Acts, Regulations, By-Laws and Guidelines are applicable for any environmental authorisation as required by South African law and must be adhered too before the commencement of a project/ activity.

3.3.1 Constitution of the Republic of South Africa, 1996

The Constitution of the Republic of South Africa (South Africa, 1996:1–177) can be seen as South Africa's "ultimate law" and overpowers any conflicting legislation within the confines of South Africa. The Constitution addresses the environment within Section 24 and states that:

"Everyone has the right to -

a) an environment that is not harmful to their health or well-being; and

b) have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –

i. Prevent pollution and ecological degradation;

ii. Promote conservation; and

iii. Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."

The Constitution of the Republic of South Africa is the highest form of law in South Africa and must be adhered to for any type of environmental authorisation (Figure 3-4). Section 24 of the Constitution forms the foundation for environmental legislation in South Africa and gave rise to the National Water Act (NWA), National Environmental Management Act (NEMA) and the associated Specific Environmental Management Acts (SEMA's).

A link can therefore be established between Environmental Authorisations, as permission to potentially affect Section 24 of the Constitution through a processed application within the context of the NEMA and/ or NWA.

3.3.2 National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998)

The NEMA forms the framework for all environmental legislation primarily to assist with implementing the environmental rights of the Constitution (refer to Section 3.3). The NEMA provides fundamental principles required for environmental decision making and to ultimately achieve sustainable development. It also makes provision for duty of care to prevent, control and rehabilitate the effects of significant pollution and environmental degradation, and prosecute environmental crimes. These principles must be adhered to and taken into consideration during any phase of an environmental authorisation process.

The NEMA (South Africa, 2014a:1–117) defines the "environment" as –

"the surroundings within which humans exist and that are made up of –

(i) the land, water and atmosphere of the earth;

(ii) micro-organisms, plants and animal life;

(iii) any part or combination of (i) or (ii) and the interrelationship among and between them; and

(iv) the physical, chemical, aesthetic and cultural, properties and conditions of the foregoing that influence human health and well-being."

The broad definition of the environment as stated in the NEMA generated the need for SEMA's as a supporting pillar within the environmental legislation framework. This created the basis and need for various environmental authorisations as per applicable SEMA's.

Section 24D and 24(2) of the NEMA makes provision for the publication of lists and associated regulations identifying activities that may not commence without obtaining prior environmental authorisation from the competent authority. These regulations are termed EIA Regulations and are interpreted in conjunction with the listed activities discussed in Section 3.3.3 below.

3.3.3 Environmental Impact Assessment Regulations, 2014 (GN R 982 of 4 December 2014) as amended, 2017

The EIA regulations were promulgated in terms of Section 24 of the NEMA for the purpose of providing methodologies and specific requirements for the undertaking of an EIA. The Regulations stipulate that any proposed activity listed in the associated notices must either initiate a Basic Assessment (BA) or Scoping & Environmental Impact Report (S&EIR) to obtain an environmental authorisation before the commencement of the specified listed activity. The environmental authorisation is subject to approval of the competent authority. The EIA Regulations provide the minimum requirements and contents of the impact assessment reports and all other aspects associated with BA's and EIA's.

The listed activities are categorised under:

- Listing Notice 1: GN R 983 of 4 December 2014, as amended. Activities listed within listing notice 1 require a Basic Assessment.
- Listing Notice 2: GN R 984 of 4 December 2014, as amended. Activities listed within listing notice 2 require a Scoping and EIA to be undertaken. Activities listed within this notice are usually of a large scale or have the potential to have a detrimental effect on the environment.
- Listing Notice 3: GN R 985 of 4 December 2014, as amended. Activities listed within listing notice 3 require a Basic Assessment, are subject to specific geographical areas as stipulated within each province.

These listed activities are not limited by the commencement of a new activity but also makes provision for the expansion and decommissioning of certain existing activities. Furthermore, depending on the scope and scale of the proposed activity, different competent authorities may be involved (South Africa, 2014:3–74). Therefore, if an activity affects the environment on a national scale (crossing provincial boundaries), the competent authority would become the National Department of Environmental Affairs (DEA) instead of the provincial department. This means that the basic process would stay the same in terms of legislative requirements; however the content, reporting and mapping parameters could change significantly. In short, when an application for environmental authorisation is sent to the national department, the application could look very different to an application sent to provincial departments as each department has different sets of requirements. An environmental authorisation associated with a mining activity (mining and prospecting rights or permits), would require the Department of Mineral Resources as the competent authority instead of the Provincial or National Environmental Government. The latter will be included in the process as commenting authorities.

3.3.4 National Water Act (NWA), 1998 (Act No. 36 of 1998)

The NWA is the primary regulatory legislation controlling and managing the use of water resources as well as the pollution thereof. The NWA is implemented and enforced by the Department of Water and Sanitation (DWS), previously the Department of Water Affairs (DWA).

In terms of Section 19(1) (Duty of Care) of the Act,

"Any owner of land, a person in control of land or person who occupies or uses the land on which – a) any activity or process is or was performed or undertaken; or b) any other situation exists; which causes, has caused or is likely to cause pollution of water resource, must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring" (South Africa, 1998:1–178).

It is therefore pertinent that the occupant or owner of land as stated above is only subject to permissible water uses as stipulated within Section 22(1) of the NWA. According to this section, a person may only use water in the following ways:

- "A water use activity permitted by a license issued under Section 21.
- An existing lawful water use.
- If the Minister has dispensed with the need for a license.
- A schedule 1 uses (Small scale, domestic agriculture).
- A water use in terms of a General Authorisation under S39".

Section 21 of the NWA lists water uses that must be licensed unless it is listed in the schedule (existing lawful use) and/or is permissible under a general authorisation, or if a responsible authority waivers the need for a Water Use License (South Africa, 1998:1–178). These listed water uses include:

a) "Taking water from a water resource
b) Storing water
c) Impeding or diverting the flow of water in a watercourse
d) Engaging in a stream flow reduction activity contemplated in section 36 of the act
e) Engaging I a controlled activity identified as such in section 37(1) or declared under section 38(1)
f) Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit
g) Disposing of waste in a manner which may detrimentally impact on a water resource

h) Disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process
i) Altering the bed, banks, course or characteristic of a watercourse
j) Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people."

The listed water uses are subject to specific thresholds and only require a Water Use License once the activity exceeds the stipulated threshold.

On the 24th of March 2017, the Department of Water and Sanitation (DWS) published the procedural requirements for Water Use Licence Applications and Appeals Act GN R 267 (South Africa, 2017:141–217). Under this act, an applicant is now required to undergo a similar process as with the full EIA process.

3.3.5 National Environmental Management: Biodiversity Act (NEM: BA), 2004 (Act No. 10 of 2004)

The NEM: BA addresses the management and conservation of South Africa's biodiversity within the framework of the NEMA (South Africa, 2004:1–84). The purpose of the NEM: BA is to protect ecosystems and species, and promote the sustainable use of indigenous biodiversity. During any Environmental Authorisation process the following regulations are considered and investigated where applicable:

- "Alien and Invasive Species Regulations" (DEA, 2014:3–27);
- "Alien and Invasive Species List" (DEA, 2014:3–74);
- "Lists of Critically Endangered, Endangered, Vulnerable and Protected Species" (DEA, 2007:4–11);
- "Threatened or Protected Species Regulations GN R 152 of 2007" (DEA, 2014:8–9);

According to these regulations, "an applicant may apply for a permit to conduct certain activities relating to threatened or protected species, by which the applicant may be subject to a formal application process including a full biodiversity risk assessment".

3.3.6 National Environmental Management: Waste Act (NEMWA), 2008 (Act no 59 of 2008)

The objectives of NEM:WA is the "protection of health, well-being and the environment by providing reasonable measures for the minimization of natural resource consumption, avoiding and minimizing the generation of waste, reducing, recycling and recovering waste, and treatment and safe disposal of waste as a last resort" (in terms of the waste hierarchy) (South Africa, 2008:1–48). The regulations, national norms and standards that regulate these activities are described in Section 3.3.6.1 below.

3.3.6.1 List of Waste Management Activities, 2013 (GN R 921 of 29 November 2013)

Waste management activities listed in terms of this notice must be licensed and the licensing procedure must be integrated with an impact assessment process (South Africa, 2013:3–8):

- "To undertake activities listed under Category A, the applicant must conduct a Basic Assessment process"; and
- "To undertake activities listed under Category B, the applicant must conduct a Scoping and EIR process".

Activities listed under Category C need not undertake an Environmental Impact Assessment, however the application must comply with the relevant required Norms and Standards that may be determined by the proposed activity. In addition, the applicant would be required to register the proposed waste activity.

3.3.7 Air Emissions License according to the National Environmental Management: Air Quality Act no. 39 of 2004 (NEM:AQA).

The Act is aimed at protecting the environment through the prevention of air pollution and enhancement of the quality of air, and ecologically sustainable development (South Africa, 2004:1–53). The Act does however make provision for the classification of priority areas which usually requires different management measures as per the norm. Section 23 and Section 26 of the Act makes provision for controlled emitters and fuels respectively and do not require authorisation, provided the Minister has gazetted such activity as a controlled emitter or fuel within the conditions and standards set within the respective gazette.

The National Environmental Management: Air Quality Act (NEM: AQA) regulates a strict licensing system for any small or large-scale emitters over certain parameters set within the Act. In accordance with section 37 of the Act, a person must apply for an Atmospheric Emissions License (AEL) for any activities listed in the National Environmental Management: Air Quality Act, 2004: Regulations, 2015 (South Africa, 2013:3–63).

The listed activities for Atmospheric Emissions Licenses (AEL) are divided into 10 categories with a total of 67 sub-categories describing the minimum standards and quality allowed (South Africa, 2013:3–63). All activities listed within these 10 categories require an AEL. Similarly, as with the NEM: WA, applications for AEL's will usually require the addition of an EIA as it will trigger Listing Notice 2 of the EIA Regulations.

3.3.8 Guidelines and Municipal Bylaws

The Environmental Authorisation application must adhere to the Departmental minimum requirements, guidelines and municipal bylaws applicable to the respective activity.

3.3.8.1 Bylaws

A bylaw is a set of rules which have been created by a society or local municipality to govern it's people's day-to-day activities (LGRC, 2015). There are many bylaws within the Gauteng Province depending on the municipality the activity is conducted in. These municipal bylaws can be retrieved from the respected municipality development department or websites, if available. It is therefore imperative that these bylaws be consulted during any Environmental Authorisation process.

Bylaws are developed to regulate specific situations and possible eventualities. In many cases a bylaw is used within the sphere of the municipality to give legal effect to policy, which may not be legally-binding, this makes bylaws a vital policy implementing tool within local government (LGRC, 2015).

3.3.8.2 Guidelines

Guidelines can be defined as a statement or other form of indication of policy or procedure to determine a particular or standardised course of action (DEA, 2010:234–249). It can thus be understood as a recommended practice or instruction on the future course of action for gazetted legislation. These guidelines are commonly published by National and Municipal Departments depending on the need and capability of these departments.

Governmental legislative guidelines have been published as the recommended way of interpreting the set legislation. Many laws are eventually accompanied by a guideline from the Department detailing the procedure to interpret and/ or implement a set law.

In terms of Environmental Authorisations, there have been many guidelines relating to the NEMA and the SEMA's. Many of these guidelines specifically referring to the process of Environmental Authorisations have been adopted as best practice. Examples of such guidelines are:

- "Companion Guideline on the Implementation of the Environmental Impact Assessment" (South Africa, 2012:1–193)
- "Guidelines on Need and Desirability" (DEA, 2014:3–25)
- "Environmental Management Framework Guideline" (South_Africa, 2012:1–193)
- "Guidelines on Public Participation" (DEA, 2012:234–249)

No guidance has yet been adopted nationally on environmental maps regarding Environmental Authorisation processes.

3.3.8.3 Environmental Management Framework

The Department of Environmental Affairs published a Notice of Intent on the 13th of April 2017 to adopt the Gauteng Environmental Management Framework (GPEMF) Standards and Exclusions of certain listed activities within the NEMA regulations (South Africa, 2017:1–50). The concept is aimed at eliminating the need for an Environmental Authorisation for certain listed activities depending on the location of proposed activities in relation to pre-determined zonal areas.

Lebogang Maile, Member of the Executive Council (MEC) for the Gauteng Province Economic Development, Environmental, Agriculture and Rural Development (GDARD) adopted and published the Gauteng Provincial Environmental Management Framework, in terms of Regulation 5(4) of the Environmental Management Framework Regulations, 2010, in May 2015 (GDARD, 2015:1–4). The intention of this framework is to guide/manage development within the Gauteng

boundary in accordance with the Regional Spatial Development Framework (RSDF). The Province was characterised under five (5) zones in which certain activities would be permitted and others (not designated to set area) would not be allowed. This live document forms a guide for both government and the private sector.

3.3.8.4 Zone 1 – Urban Development Zone

Zone one is intended to streamline urban development activities and to promote development infill, densification and concentration of urban development within the Urban Development Boundary (UDB) (Environomics, 2014:1–62). According to the EMF report (Environomics, 2014:1–62) the development of primary and secondary roads as well as railway systems are the highest development priorities in this zone and any conflicts in respect to this infrastructure development should be resolved in a fast track process between all the relevant authorities. Development networks should use the principles of sustainable building, using green infrastructure (bio-swales, street trees, permeable paving) where at all possible to reduce the impacts of infrastructure, pollution and storm water.

3.3.8.5 Zone 2 – Urban Control Zone (within the UDB)

According to the GEMF (Environomics, 2014:1–62) all sensitive areas within the UDB must be conserved and in cases where developments cannot avoid these areas, a proper assessment and implementation of alternatives must be undertaken. The construction of roads and other transport infrastructure are among the few conditionally compatible activities within this zone.

3.3.8.6 Zone 3 – Urban Control Zone (outside the UDB)

These zones are regarded as special sensitive areas outside the UDB. Therefore, these areas are sensitive to development activities and in several cases also consist of specific environmental values that must be protected. As such, no listed activities within NEMA may be excluded as part of an Environmental Impact Assessment. Certain activities such as roads are identified as conditionally compatible land use within this zone.

3.3.8.7 Zone 4 – Normal Control Zone

This zone is dominated by agricultural uses outside the urban development zone as defined in the Gauteng Spatial Development Framework and as such, no listed activities may be excluded from environmental assessment requirements in this zone.

3.3.8.8 Zone 5 – Industrial and large commercial focus zone

The intention with Zone 5 is to streamline non-polluting industrial and large-scale commercial (warehouses etc.) activities in areas that are already used for such purposes, and areas that are severely degraded but in close proximity to required infrastructure (such as decommissioned and even current mining areas).

Development in this area must be sustainable in relation to the capacity of the environment, and specifically the hydrological system to absorb additional increased sewage and storm water loads. Development in this area must identify any unmapped wetlands, especially seep areas that may occur on any site, and when necessary an application for the required water use license(s) must be initiated. Non-polluting industrial activities are to be excluded from EIA processes within the identified industrial promotion areas (Environomics, 2014:1–62).

3.3.9 Strategic Environmental Assessment (SEA)

Like EIA's, Strategic Environmental Assessment (SEA's) assesses the implications on the environment, but focuses on the implications of strategic decisions, plans and policies. SEA's can be regarded as strategic tools for the integration of environmental, social and economic objectives into national policies and plans (DEAT, 2004:1–18).

The objective of an SEA is to therefore provide a decision-maker with sufficient information to establish possible areas for certain development types, thereby categorizing priority activities with appropriate areas. SEA's therefore do not focus on single activities within a specific study area, but allocates "zonal areas" that are desirable for certain activities with the aim of streamlining and managing priority developments within specific areas (DEAT, 2004:1–18).

Table 3-1 summarises the Environmental Authorisations required as depicted in the applicable legislation of the Republic of South Africa. EIA's, EMF's and SEA's are tools, implemented to promote sustainability, and environmental and development symbiosis (Mahayri, 1998). Government is moving towards a more strategic assessment method in terms of the Gauteng

EMF and various SEA's to streamline development in a sustainable manner by managing and pre-determining certain areas for development (DEAT, 2004:1–18). SEA's play an integral part in the ever evolving development of best practices through the continues evaluation of the effectiveness of various procedures and plans and their roles in sustainable development (DEAT, 2004:1–18).

Table 3-1: Environmental Authorisation relating to the applicable environmental legislation

Legislation	**Regulation**	**Environmental Authorisation**
NEMA	EIA Listing Notice 1 & 3	Basic Assessment
	EIA Listing Notice 2	Scoping & Environmental Impact Assessment
NEM: WA	List of Waste Management Activities	Environmental Waste License
NEM: AQA	List of activities which result in atmospheric emission which have or may have a significant detrimental effect on the environment	Air Emissions License
NWA	Procedural Requirements for the Water Use License Application	Water use license

Environmental maps no longer only accompany Environmental Authorisation applications, EMF's and SEA's as a visual illustration, but plays an integral part in evaluation and decision making within the sphere of environmental management and sustainability.

The movement of geographical classification and categorisation of legislative requirements is becoming prevalent, thus emphasizing the importance of spatial database development in terms of map generation, and more specifically, environmental map presentation.

South African Legislation requires set processes to be followed in order to receive an Environmental Authorisation for certain activities with an overall objective of minimising the development footprint and investigating environmental sustainability. Within these processes, maps and visual evaluation tools are used to aid the decision-maker (competent authority). Spatial databases have become an essential information source and management tool within

government and the private sector, and will continue to evolve with technology (Kelly, 2007:1–11).

This section will address the value certain maps provide within Environmental Authorisations.

3.4 The value of Maps in Environmental Authorisations

Environmental Maps have become an essential part in the environmental authorisation process. The advancements in the field of map generation is due to the constant improvement of remote sensing, Geographic Information Systems (GIS) and wireless communication (Cao *et al.*, 2016:179–196). Effective environmental mapping may improve the authorities' ability to evaluate the environmental performance of a specific project. This, in turn, could prevent damage to the environment and improve the performance of future projects as stated by Kang *et al.* (2016:92–100). Cao *et al*. (2016) also states that the ability of maps to provide vital information have become so effective that it could replace many report writing scenarios like the generation of veld fire warnings and other natural disaster warning reports (Cao *et al.*, 2016:179–196). Furthermore, if maps prove to be more effective in providing the relevant information, then more resources must be invested in providing the right information and materials to generate such maps (Cao *et al.*, 2016:179–196).

Environmental maps provide the proponent reviewing the map with the ability to not only focus on the study area but to visually broaden the scope of the investigation (Valdor *et al.*, 2016). Visual analysis of site and surroundings will provide the proponent with a better understanding of the potential impact to the environment and surrounding area. This would not be possible without a visual presentation of the area. Environmental maps help to identify potential environmental impacts, evaluate the potential cumulative effect of the activity(s), and it may aid in establishing the site vulnerability to certain activities (Valdor *et al.*, 2016).

A common limitation regarding the use of maps for various processes is the lack of map reading literacy, especially in South Africa (Victoria Rautenbach *et al.*, 2016). The value of maps in an Environmental Authorisation may be considered implausible if the person reviewing the map is unable to evaluate the information presented. Another factor that needs to be accounted for is the experience level of the proponent reviewing the maps (Victoria Rautenbach *et al.*, 2016). Due to different levels of experience it is important to generate maps which could be successfully evaluated and understood.

The quality of maps provided to the respective departments must be presented in a standard that could easily portray the desired information to anyone reviewing the report, regardless of any map reading background/skills (Victoria Rautenbach *et al.*, 2016). Victoria emphasises the importance of quality maps in adding value to processes like an Environmental Authorisation application.

Maps provide vital information within Environmental processes, however, it is important to remember that accurate information be displayed within the correct map type as mentioned by Victoria (Victoria Rautenbach *et al.*, 2016). Each map must have a distinct and precise goal to prevent information overload or the illustration of invalid information. It is therefore critical to understand the value that different maps provide to specific scenarios.

Maps generally illustrate the extent of an activity in proportion to its surroundings/neighbouring area. It provides the decision-maker (competent authority) with a sense of place and position of the study area, and should aim to illustrate all existing facilities and infrastructure.

Maps have the ability to accurately portray semantically structured information due to its generalisation characteristics (Muhs *et al.*, 2016:71–84). These maps not only illustrate natural, artificial and cultural features but also accurately records location. General Maps can often overlay topographic maps which has a wide range of use from military planning to civil engineering and construction (Victoria Rautenbach *et al.*, 2016). Victoria states that these maps are generally used to illustrate a large amount of features and it is important to have a well-defined legend to accommodate such maps as it could easily result in unusable maps if the meaning behind certain features or landmarks are not understood (Victoria Rautenbach *et al.*, 2016).

Maps for Environmental Authorisations may provide value by generally illustrating feature locations in proportion to the study site. An Environmental Authorisation may sometimes have more than one map depending on the size and extent of the activity. Spatial databases requires location data to be utilised for information sourcing and reconciliation, but is dependent on scale and quality of data (Idowu & Sambo, 2012:114–120).

One of the biggest obstacles faced by governmental departments is the fragmentation of environmental legislation and procedures, especially observed within the various Environmental Authorisations which may prohibit sustainable governance and limit affective service delivery (Kotzé, 2006:1–44). Kotzé (2006) concludes by stating that integration and holistic environemental governance is needed if sustainable governance is to be achieved. The value of environmental maps may facilitate such integration if a spatail database populated with all required information could be made available.

Specialist maps provide a focussed result of the studies conducted and are usually limited to the study site or their scope of work. The inputs provided by specialists are vital to any Environmental Authorisation Process as it provides accurate estimations of the impact(s) that activities would have on the environment and surrounding areas. Once these impacts are illustrated on maps, it provides the decision-makers (competent authority) with valuable information in relation to the activity footprint.

3.5 Spatial requirements in South Africa

Environmental Authorisations require various maps and spatial input within its processes. As mentioned above, these maps provide valuable information and insight to the intentions of the proposed activities as well as the present state of a study area. Environmental Authorisations require specific information needed during the evaluation stages. These requirements are usually stipulated within the legislation, official departmental documentation and procedural guidelines. In some instances, special map requests are made by the Competent Authority due to the nature or geographical location of the project.

3.5.1 Determining specific spatial requirements in the Gauteng Province

There is a set of generically stipulated spatial attributed requirements within the environmental maps for each Environmental Authorisation process investigated. These requirements are contained within the official government application form or within gazetted guidelines and templates. Table 3-2 summarises the minimum spatial requirements for each environmental authorisation process. The attributes listed within this table are regarded as mandatory, providing the competent authority with the materials needed to deliver an informed decision on a proposed project/activity.

The information requested for these processes do not necessarily have to be illustrated within a single map output and is subject to the discretion of the proponent compiling the document. Environmental Authorisation processes such as a Basic Assessment Report and a Water Use License require a number of spatial attributes to be included within the maps. These types of Environmental Authorisation processes would therefore require multiple maps to accurately portray the information requested within a hard-copy map output. An Air Emissions License process, for example, requires the least amount of spatial attribute data (Table 3-2). This is due to the nature of the authorisation and the difficulty of spatially defining potential impacts of emitters without monitoring data.

Table 3-2: Specific spatial attributes required for each Environmental Authorisation process

Environmental Authorisations within Gauteng				
BAR	**Scoping & EIR**	**Water Use License**	**Waste License**	**Air Emissions License**
Scale indicated on map	Scale indicated on map	Scale indicated on map	Locality Map	Locality Map
1:100 year floodline	1:100 year floodline	1:100 year floodline	Access road	A3 Layout Plan
Access road	Access road	Access road	Accurate indication of site position.	Accurate indication of site position.
Accurate indication of site position.	Accurate indication of site position.	Accurate indication of site position.	All roads within 1 km of the site	Existing residential and industrial areas
Any environmental sensitivities within 100 metres of the site.	All roads within 1 km of the site	Activity requiring water use	Existing and possible future residential developments	Projection WGS84
Contours	Any environmental sensitivities	1Any environmental sensitivities within 100 metres of the site.	Existing residential and industrial areas	Scale 1:50 000 and bigger
Coordinates (degrees decimal minutes	Closest Town	Appropriate scale	North Arrow	Scale indicated on map
Cultural and Historical features	Coordinates (degrees decimal minutes	Coordinates (degrees decimal minutes	Other waste handling sites	Site and 5 km radius
Current land use and land zoning of proposed site and adjacent properties	Critical Biodiversity area	Current land use and land zoning of proposed site and adjacent properties	Possible future development	Site Layout Plan
Indigenous vegetation	Legend	Extent of riparian habitat	Projection WGS84	
Legend	Locality Map	Legend	Scale 1:50 000 and bigger	
North Arrow	North Arrow	Line scale	Scale indicated on map	
Position of activity elements	Prevailing wind direction	North Arrow	Security	

Position of services including electricity	**Property boundaries and numbers of all properties surrounding the site within 50 metres**	**Position of activity elements (Site layout plan)**	**Sensitivity Map**
Prevailing wind direction	**Scale 1:50 000 and bigger**	**Prevailing wind direction**	**Site and 5 km radius**
Property boundaries and numbers of all properties surrounding the site within 50 metres	**Sensitivity Map**	**Property boundaries and numbers of all properties surrounding the site which will be effected by the water use**	**Site Layout Plan**
Ridges	**Site Layout Plan**	**Relevant catchment**	**Surrounding road names and numbers**
Rivers & Wetlands	**Surrounding road names and numbers**	**Scale 1:50 000 and bigger**	**Topographical map**
Scale 1:50 000 and bigger	**Watercourse**	**Storm water Management Practices**	
Servitudes and information relating to servitudes		**Surrounding infrastructure**	
Surrounding road names and numbers		**Surrounding road names and numbers**	
Wall and fencing around the site		**Surrounding towns**	
		Topo-cadastral map	
		Water resource location	
		Water resources within 1km radius	
		Water works	

3.6 Existing Environmental Spatial Databases in the Gauteng Province

Eijssen (2017) emphasised the need to differentiate from conventional maps using a modern approach to generating Environmental Authorisations that is universally understood by everyone involved (Eijssen, 2017:2–3). The author further elaborated that the need to innovate Environmental Authorisations is essential to obtain the relevance and impact an Environmental Authorisation has during decision making. Eijssen's philosophy on the innovation of authorisation processes and data sharing is visible within National government and the Gauteng departments, as more publicly available spatial databases are developed (Eijssen, 2017:2–3). These databases provide valuable sources of information although their primary goal is to assist departments within their work environment.

Publicly available databases that are applicable and aid the Environmental Authorisation processes are briefly discussed below:

3.6.1 National Databases

National databases provide information on the entire country and are usually conducted on a large scale depending on the specific attribute. These databases provide valuable information, especially relating to inter-provincial data (Stretches beyond a single province).

3.6.1.1 South Africa National Biodiversity Institute (SANBI) – Biodiversity GIS

SANBI's Biodiversity GIS database provides several sets of data applicable to Environmental Authorisations (SANBI, 2016). The database provides an interactive platform where the user is able to scrutinise multiple data-layers applicable to a study site (Figure 3-5). The database also provides numerous reliable data sources to download for personal use, such as information sourcing business planning, research and private development, which makes it a valuable tool for information sourcing related to biodiversity on both a national and provincial scale.

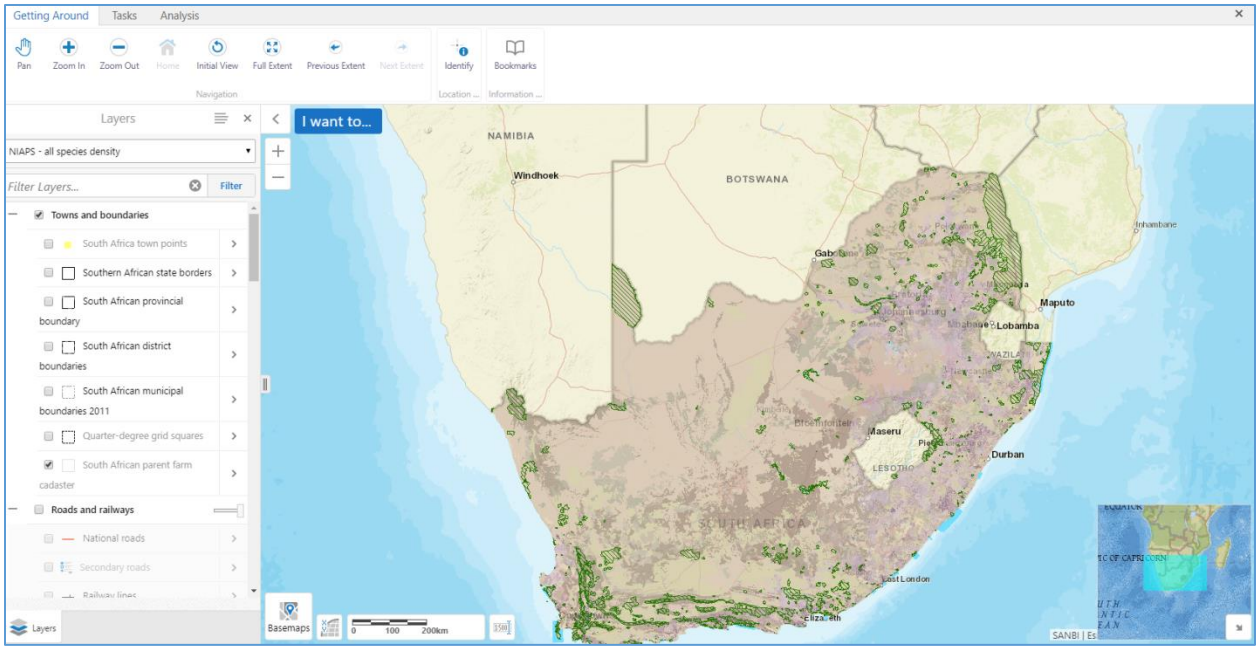

Figure 3-5: Biodiversity GIS platform (SANBI, 2016).

3.6.1.2 Department of Environmental Affairs (DEA) – Environmental GIS (EGIS)

DEA does not have an interactive GIS platform currently available to the public, but are undergoing the draft stages of providing an innovative Screening Tool. The Environmental GIS (EGIS) database provides useful spatial data available for download (DEA, 2016). The database contains information extending from small-scale project data to national data layers. The data released by DEA is screened and quality checked, making it valuable source of information for both public and departmental use during Environmental Authorisation processes.

3.6.2 Provincial Databases

Provincial databases refer to databases restricted to certain provinces. Such databases usually provide more detailed information on a much smaller scale, making the data more reliable and precise. The three Metropolitan Municipalities within the Gauteng Province each of have an interactive GIS database which is publicly available:

- City of Johannesburg Metropolitan Municipality (CoJ);
- City of Tshwane Metropolitan Municipality (Tshwane);
- City of Ekurhuleni Metropolitan Municipality (Ekurhuleni)

3.6.2.1 The City of Johannesburg Metropolitan Municipality (CoJ) – Corporate GIS online Map

CoJ's Corporate GIS Online Map database provides a publicly available browsing tool. This database contains a host of spatial information generated by the municipality, as well as provincially relevant information (City of Johannesburg, 2016). This database is primarily used by municipal officials, and furthermore allows public users to browse through selective information on an interactive GIS database (Figure 3-6).

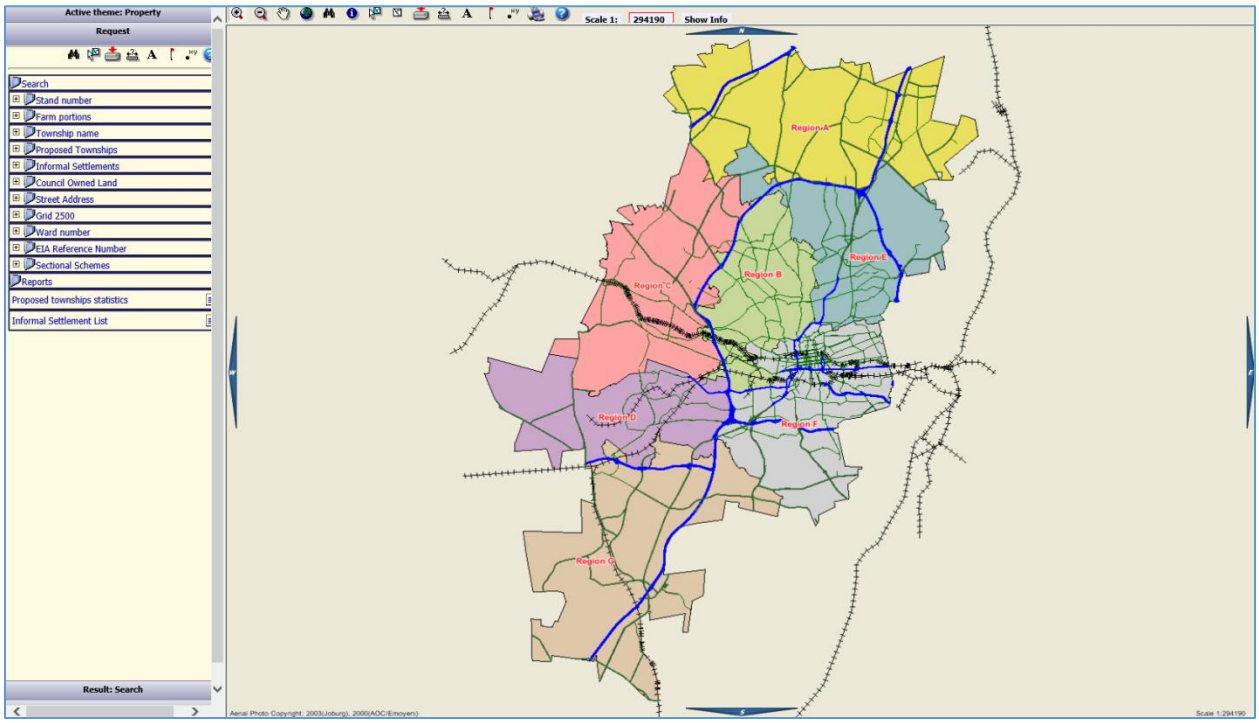

Figure 3-6: CoJ Corporate GIS online Map platform illustrating administrative regions (City of Johannesburg, 2016).

The CoJ Corporate GIS Online Map database does not allow the user to export any information required and can solely be used for information browsing. The amount of data contained within this database therefore makes it a valuable tool for any Environmental Authorisation process within the boundaries of the City of Johannesburg Metropolitan Municipality (City of Johannesburg, 2016).

3.6.2.2 The City of Tshwane Metropolitan Municipality – Geographical Information System

This The City of Tshwane Metropolitan Municipality database is designed similar to the CoJ's Corporate GIS Online Map database and also provides public access making this database just

as valuable for any Environmental Authorisation processes within the boundaries of the City of Tshwane Metropolitan Municipality (City of Tshwane, 2016).(See Figure 3-7).

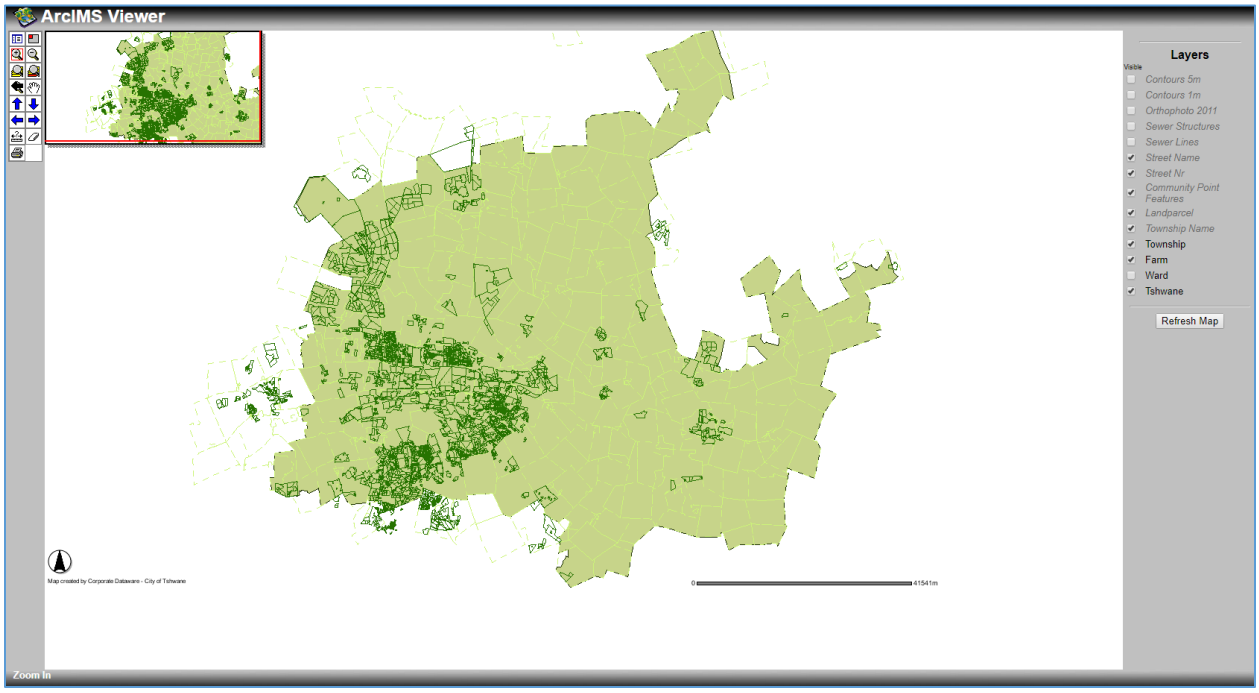

Figure 3-7: City of Tshwane Metropolitan Municipality – GIS illustrating municipal boundary and farm portions visible on such large scale (City of Tshwane, 2016).

3.6.2.3 The City of Ekurhuleni Metropolitan Municipality – Geographic Information Website

The Geographic Information Website of Ekurhuleni is similarly designed as the two (2) municipalities mentioned above, however, it provides a wider range of interactive public use (Ekurhuleni Metropolitan Municipality, 2017). The previously mentioned municipalities only provide a browsing function. The Ekurhuleni database allows for uploading of property information (Figure 3-8). This function allows the user to generate maps providing valuable information required for Environmental Authorisation processes within the boundaries of the City of Ekurhuleni Metropolitan Municipality.

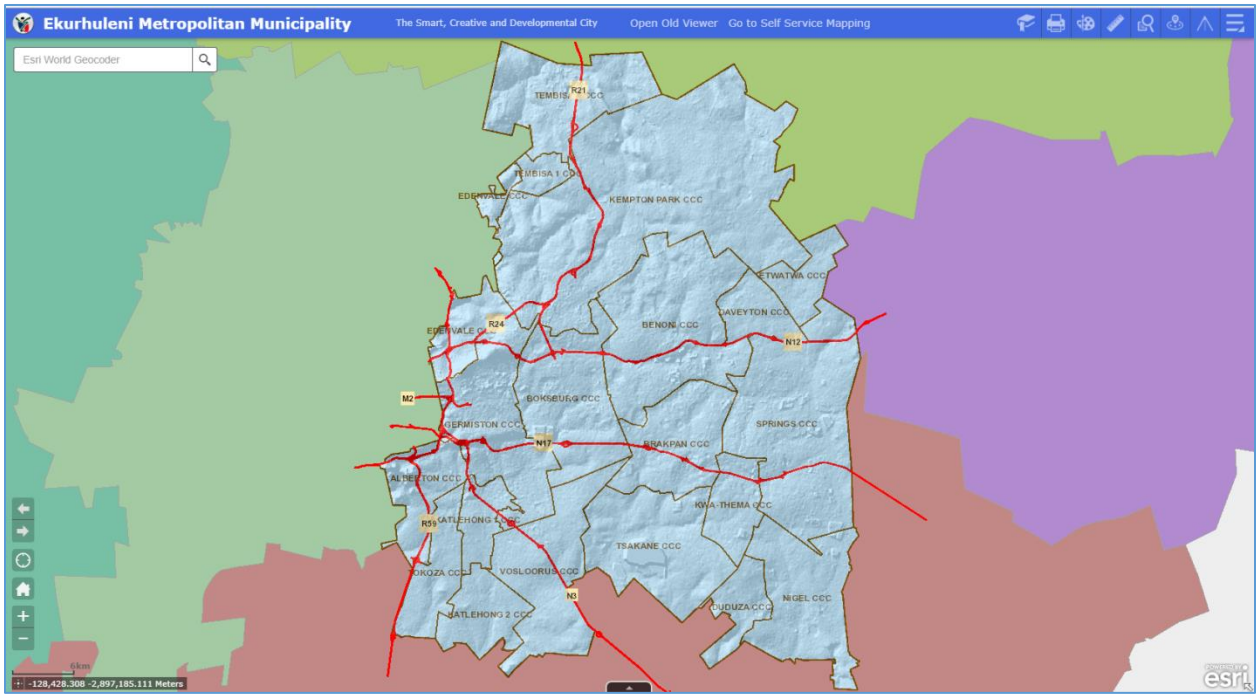

Figure 3-8: The City of Ekurhuleni Metropolitan Municipality - GIS website illustrating the municipal boundary and national roads within municipality (Ekurhuleni Metropolitan Municipality, 2017).

3.7 Geographic Information System database

Granell *et al.* (2016) emphasised the consistency in which spatial geographical information technology have evolved in the last four decades supporting earth and environmental sciences (Granell *et al.*, 2016:1–15). Eijssen (2017) further states that the rapid progression in information communication technologies (ICT) enables improved public participation and engagement processes, which in turn offers great opportunities to develop a *"transparent, accessible and interactive"* digital database (Eijssen, 2017:2–3). A database of this nature will ultimately optimise the use of technology and empower stakeholders across the industry (Eijssen, 2017:2–3).

The idea of data sharing and publicly available geographic databases remains generally resisted despite the apparent benefits that can be derived from such activities (Nedov*i et al*., 2000:15–29). Even though countries like the United States have been participating in the data development and distribution to achieve data coordination for many years, the data and initiatives have remained rather isolated. This is mainly due to a lack in development standards and recognised mechanisms through multiple levels of government and private initiatives (Nedovi *et al.*, 2000:15–29).

Granell *et al.* (2016) stated that majority of environmental applications have to process a large collection of data sets. A large portion of today's maps focuses on the visual aspects of the map for the increase in appeal but neglects the importance of data sharing and providing relevant and updated data (Cao *et al.*, 2016:179–196).

There are three (3) challenges regarding the development of geodatabases (Granell *et al.*, 2016:1–15):

- How to keep up with the constant changes in environmental legislation, societal expectations, data gathering and limited budgets.
- How to satisfy the societal expectations of data/information presentation without jeopardising or compromising the integrity of the business and departmental industry.
- And how to accumulate data from various internal and external sources without compromising the quality of the output data.

Granell *et al.* (2016) further states that the end result of such databases should aim to provide "holistic, flexible and scalable" solutions by integrating legal, policy and regulatory framework which can be used by various parties such as private, public and the departmental sectors (Granell *et al.*, 2016:1–15). Therefore, focusing on a single discipline is prevented and a platform for multi-disciplinary research is provided. Providing information using maps, imagery and even videos other than the traditional text-based reports, will still retain the essential integrity of Environmental Authorisation's but will move into a more modern, fast, transparent and accessible method of evaluation (Eijssen, 2017:2–3).

According to Rutherford *et.al* (2012) electronic spatial databases do not only serve as storage sites for relevant data, but can serve as an essential source of information due to its extensive range of potential applications (Rutherford *et.al.* 2012). These databases promise to stimulate inter-organisational cooperation and collaboration and is expected to improve information sharing and strategic decision making (Nedovi *et al.*, 2000:15–29; Eijssen, n.d.:2–3). Nedovi *et al.* (2000) further states that GIS and GIS databases enable the integration of data across divergent organisations and government departments (Nedovi *et al.*, 2000:15–29). This is especially important in the practice of environmental management as it often requires the input of various state and municipal departments within individual applications.

A major challenge is that although there has been a rapid growth in governmental adoption, a general inability and unwillingness to cooperate and share data across the boundaries of government and the private sector still exists (Nedov*i et al*., 2000:15–29). Obstacles such as the

processing and presenting of spatial data from various sources has restricted the development of such databases. These obstacles include the integration of information to single datum projections, and the incorporation of scaled data. Government Departments associated with Gauteng Province projects require the use of the WGS 1984 Geographic Coordinate System when providing the required environmental maps within Environmental Authorisations. This requires a level of processing before the data can be included within the GIS Database. Accurate data scaling has always been regarded as a limiting factor for printed maps. This is mainly due to the ability of balancing the information required and the extent of the area to be included. This is where the interactive GIS based database provides for an interactive investigation of all the information provided within such a database without having to struggle with scaling limitations. Ali *et.al* (2004) states that such a database can be instrumental for inter-organisational studies because it enables the combination and presentation of socio-ecological and environmental features onto a single platform (Ali *et al.*, 2004:1–8). Eijssen (2017) supports this through the theory of a digital EIA system with the aim of making information more accessible to both decision-makers and stakeholders, thereby narrowing the distance between both parties by getting more involved throughout the entire Environmental Authorisation process (Eijssen, 2017:2–3). This theory is applicable to this study as it aims propose a similar database.

Nedovi *et al*. (2000) identified three motivations for data sharing (Nedov*i et al*., 2000:15–29):

1. Sharing of data will amount to cost saving as the need for data duplication, archiving and individual gathering will no longer be needed.
2. It will provide for a more comprehensive source of data, improving the availability of data over a large platform.
3. Sharing data over a single platform will also enhance inter-organisational relationships between departments and the private sector.

The most common and widely cited reasons for inter-organisational data sharing includes “common goal/objectives, the saving of resources and the functional reliance it may provide” (Ned*ovi et al*., 2000:15–29). It is however certain that through digital environmental databases the environment will be a higher priority, as stated by Eijssen (2017). A GIS database provides a platform for suitable data gathering, storage, retrieval and analysis. Thus, providing an effective tool in developing such an EIA database.

Ettanzarini (2010) conducted a similar study by creating a multi-source GIS database consisting of thematic maps constructed from digitized natural and human data for two development sites,

with geology, hydrogeology and climate being the main areas of focus (Ettazarini, 2011:1437–1445).

3.8 GIS database limitations and uncertainty

Spatial data includes some degree of uncertainty, hence there will always be difficulties related to such spatial databases (Jeremy, 2001:967–975). Discrepancies of this nature can affect the precision and accuracy of attribute data, and the extent of spatial data. The author further states that database uncertainty could also arise during the capturing of data, the management and uploading of data, and even during the application within the database itself (Jeremy, 2001:967–975). In the field of environmental investigation, raw data is often collected by private party professionals in employment of developers. The validation of this raw data must therefore be regulated before it may be included in a reliable database (Boyd & Foody, 2014:157–160). This however, may prove to be difficult due to the sheer amount and nature of data collected annually. According to Eijssen (2017), one of the concerns raised for such a database would be to uphold the integrity of data and information shared (Eijssen, 2017:2–3). One of the biggest concerns and limitations is the ability to retain relevant and updated information within such a database. Certain information is updated at such a pace that it would prove difficult and costly to provide a constantly updated version of data. The Department of Environmental Affairs is committed to generating relevant and updated spatial data to both sectors of society (Private & Department sector), and have devoted sizable amounts of resources to the generation of a single GIS based platform. Most importantly, they have committed to the continues improvement and maintenance of this site with updated and relevant data. Once this “Screening Tool” is provided to the public, it is hoped that the limitations related to the capturing and presentation of updated data could be overcome to provide all users not only with updated data, but with the same information across the entire platform.

3.9 Summary

The purpose of environmental management is to ultimately predict the environmental impacts which may result from a proposed listed activity, followed by the decision as to whether such an activity is possible on a proposed site, and lastly to mitigate the proposed activities to minimise the impact to the natural environment (DEAT, 2004:1–18). Environmental Authorisation applications in accordance with the NEMA, NWA and associated SEMA's must therefore be submitted to provide the competent authority with the information needed to enable a calculated and informed decision, and furthermore whether such an activity should be approved or denied.

Environmental maps form an integral part of these applications and have the potential to provide benefits that surpass visual illustrations. Research has shown that if such maps, in the form of geographical spatial databases, was developed and contained all the relevant information, it would provide great value in the field of environmental management and sustainability.

An environmental GIS database can provide standardisation to all environmental applications and not be considered an exception to the authorisation process. Similar cases have shown the value of standardisation in environmental applications (Granell *et al.*, 2016:1–15).

The environmental GIS database envisaged could provide value in the field of geography when furnished with Jackson's four concepts underlying geography(Jackson, 2006:199–204). A GIS database capable of displaying legally required spatial data in relation to specific places (1); providing connectivity between users on various scales of society and project size, as well as previously disconnected individual projects within close proximity to each other (2); minimising the social distance of individuals from project participation (3); and providing the opportunity and means for relational thinking within individual projects or the effects of these projects if evaluated on a greater scale (4).

CHAPTER 4: DATA ANALYSIS AND MAPPING RESULTS

4.1 Introduction

A framework, following the purposeful sampling approach, was used to select twenty-five (25) case studies for this dissertation. The framework identified equally consistent case studies with similar parallels related to the research aim of this study (Dicicco-Bloom & Crabtree, 2006:314–321). These case studies were then analysed using a checklist comprising a table of map requirements (depending on the type of Environmental Authorisation) (See Appendix 1, for case studies analysed). Dicicco-Bloom and Crabtree (2006) stated that data should preferably be analysed during data collection, thus providing the researcher with an emerging understanding of the research topic. This would create the possibility of further investigation and a more comprehensive understanding of the research aim (Dicicco-Bloom & Crabtree, 2006:314–321). The results from these tables (see Appendix 1) enabled the construction of a GIS database that illustrated the legal requirements and additional data captured in the checklist tables. The data captured was then investigated in the form of semi-structured interviews to achieve an opinionated idea of the value such a database would provide.

To spatially define the environmental maps in a Geographic Information System (GIS) database (as discussed in Objective 3), a *scenario-based strategy* was utilised to implement the theoretical characteristics identified in Objective 2 into a real-life scenario to emphasise the value environmental maps provide within a database structure.

A GIS database was constructed to visually illustrate the map requirements for each Environmental Authorisation (as identified in Chapter 3) onto a single platform (see section 4.4). The data outputs () illustrate the maps generated for the real-life scenario.

4.1.1 Scenario super-emphasising Environmental Authorisations within the Gauteng Province

A property location was selected within the Gauteng Province to provide a super-emphasised example of a real-world scenario which apply to all five (5) Environmental Authorisations investigated. Due to the nature and associated activities, the feedlots were used as a fictitious development aimed at illustrating the database capabilities.

The property, and activities associated with the feedlots, was used to illustrate the database capabilities for various map requirements, even though some circumstances may result in a BAR or EIR not being required for the same activity within a real-life scenario (see Chapter 3).

4.2 Case Studies

Twenty-five (25) case studies were selected using the purposeful sampling approach framework. These case studies were generated from various sources to provide a comprehensive spectrum of the general practice of consultants within the Gauteng Province. The case studies qualified once it had passed the framework checklist (refer to Table 4-1). This enabled the researcher to only evaluate studies within certain criteria, and that aligned to the scope and objectives of this dissertation.

4.2.1 Construction of a Framework

Purposeful sampling through the use of a framework checklist provided a list of requirements for each case sample to be validated against to determine the relevance to the study, as mentioned by Clark and Smithers (2006) (Clark & Smithers, 2006:465–472).

The study aimed to investigate five (5) samples of each authorisation process within the Gauteng Province boundary to provide a total of 25 case studies:

1. Basic Assessment Authorisation (BAR)
2. Scoping and Environmental Impact Assessment Authorisation (S&EIR)
3. Water Use License Application (WULA)
4. Waste Management License
5. Air Emissions License (AEL)

Case studies related to these five (5) environmental authorisation processes were required to meet the following criteria (Table 4-1) to qualify as an eligible case sample.

Table 4-1: The framework of requirements for the purposeful sampling of case samples.

	Requirement	Reason/ motivation
1	**Study must be located completely within the Gauteng Province.**	The scope of this investigation is focussed primarily on the Gauteng Province.
2	**The study had to be conducted after 2010.**	To maintain relevance and provide updated results the case sample had to be conducted under the 2010 or the 2014 EIA regulations. The 2014 regulations were provided, however, if the sourcing of >2014 case samples proved problematic, 2010 applications would still be accepted.
3	**Only final versions of the documentation may be evaluated.**	No draft versions may be accepted as it could still be subject to changes and amendments. This may compromise the accuracy of the data and provide an ambiguous reflection of the documentation submitted to the competent authority.
4	**Application has to be conducted by suitably qualified practitioners**	In order to validate the case studies and add value to this dissertation, the application had to be conducted by a suitably qualified practitioner, a person with relevant experience in the field of environmental management, or be signed off by one.

As mentioned, using this framework (Table 4-1) allowed for the sampling of 25 eligible case samples to be evaluated. The case samples were evaluated using a checklist of map requirements as listed in Table 3-2 above. All maps included within each case sample were evaluated against the checklist, to establish the inclusiveness of these samples in relation to the map requirements. Table 4-2 provides an example of the checklist used for a Basic Assessment Report (BAR). This table provides for a checkbox, to indicate whether the required parameters are included, a column for any additional parameters included in the maps not required by law, and a column for any notes or remarks on the maps included in the case sample (See Appendix 1). Figure 4-1 provides a visual illustration of the case studies sampled for each Environmental Authorisation. The location of each Environmental Authorisation (case samples) was obtained from the reports and maps within, to illustrate were the case samples were situated.

Table 4-2: Example of checklist used to evaluate case samples for Basic Assessment Reports (see Appendix 1).

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	This column was used to indicate whether the listed map parameters were included or excluded within the evaluated case samples.	Within this column, additional map parameters featured within the case samples evaluated, were listed.	This column was added to mention any observations or remarks identified during the evaluation of the case samples.
Scale 1:50 000 and bigger			
Accurate indication of site position.			
Access road			
Surrounding road names and numbers			
North Arrow			
Legend			
Prevailing wind direction			
Coordinates (degrees decimal minutes			
Property boundaries and numbers of all properties surrounding the site within 50 metres			
Current land use and land zoning of proposed site and adjacent properties			
Position of activity elements			
Position of services including electricity			
Wall and fencing around the site			
Servitudes and information relating to servitudes			
Any environmental sensitivities within 100 metres of the site.			
Rivers & Wetlands			
1:100 year floodline			
Ridges			
Cultural and Historical features			
Indigenous vegetation			

Contours			

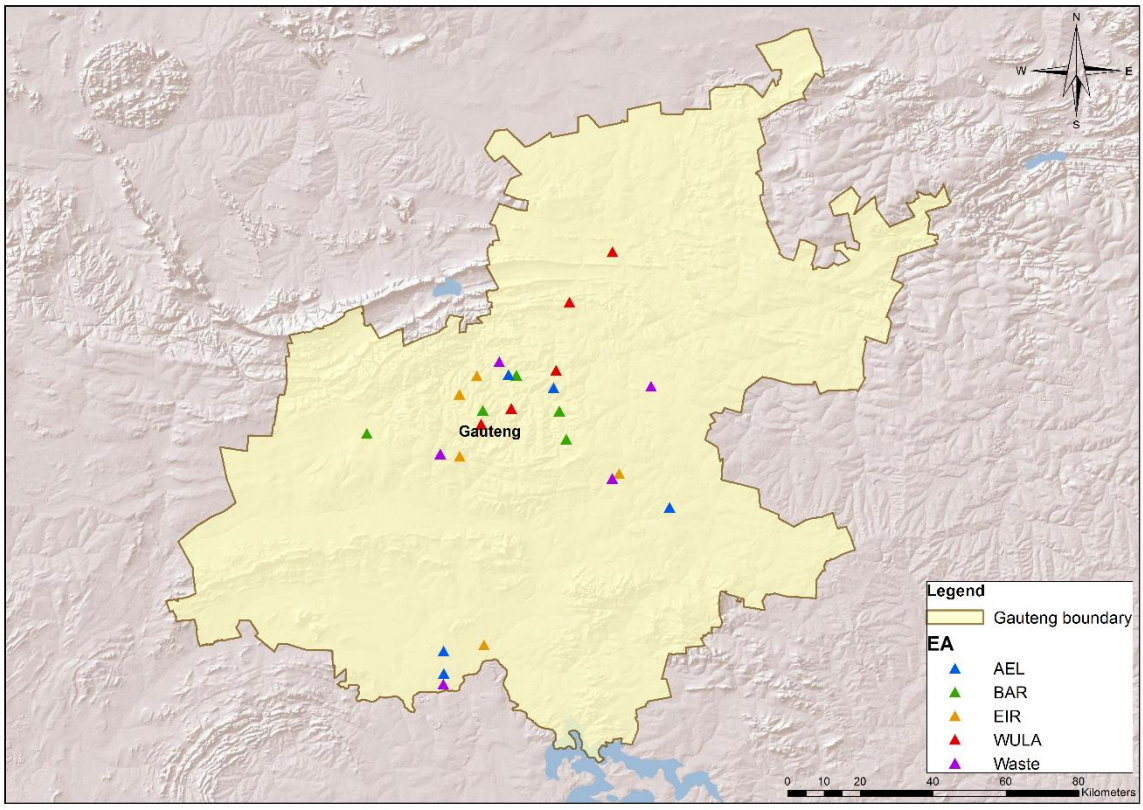

Figure 4-1: Case Studies sampled within the Gauteng Province.

4.3 Data Analysis

Objective 2 was achieved through purposeful sampling of various Environmental Authorisations using a framework. The data analysed were sourced from the case study investigation as well as the semi-structured interviews that were conducted. The data analysed from case samples allowed for the building of a theory on the ideal database to achieve objective 3. Spatial database design was used to visually illustrate the findings captured during the data analysis. This finding included, but was not limited to the map requirements stipulated within the checklist compiled and the additional map parameters included within the recorded case samples.

4.3.1 Case Study Results

The percentage of legally required map attributes included within the environmental maps for each environmental authorisation (see Appendix 1 for completed case samples evaluated) is presented in Figure 4-2. The Basic Assessment Reports, according to this study, contained the least amount of legally required map attributes (62%), in comparison to the other environmental authorisations. This could be related to the specific samples used or the nature of the respective projects not requiring the information. The assumption may be made that the information required could not be sourced at the time of the study by the EAP. The data revealed that Environmental Impact Assessments Reports and Air Emissions Licensing Applications contained the most comprehensive maps within the reports sampled (both 74%).

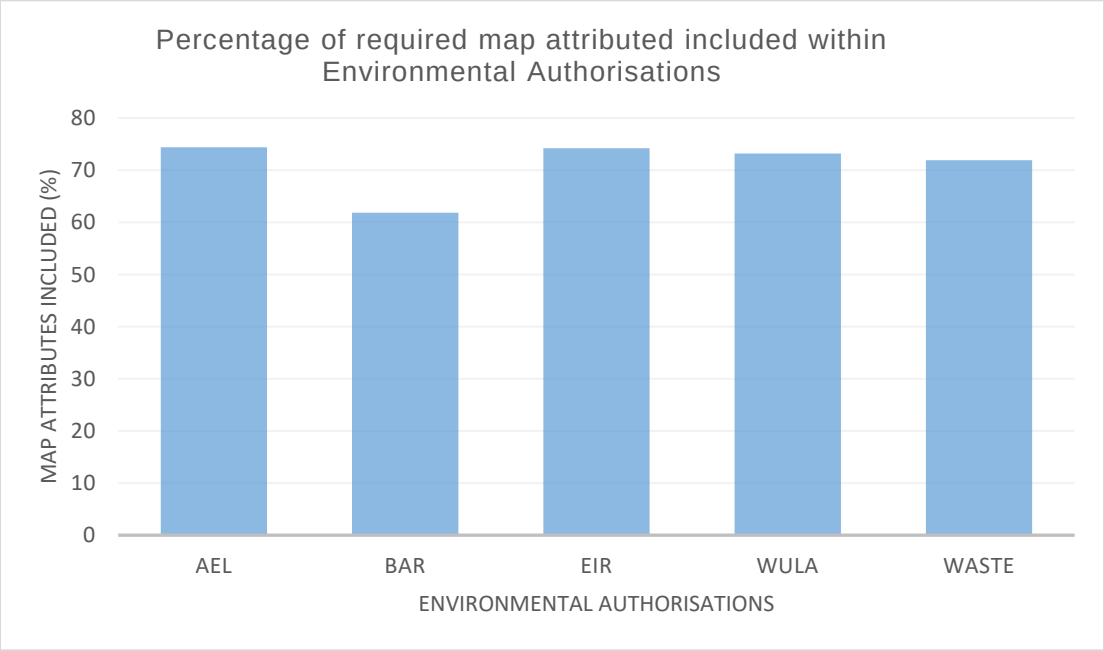

Figure 4-2: Percentage of required map attributes included within Case samples.

Majority of the cases investigated included more than 70% of the required information. However, neither included all the listed requirements. It must also be noted that all the required map attributes were divided into multiple maps for each case study. This was important to prevent the distortion and information overload of certain listed information as the scale used to present information varies. The use of multiple maps within a single authorisation application provides insight to the value of a single GIS database, as the potential of interactive map platform could address the need for multiple hard copy maps.

4.3.2 Semi-Structured Interviews

The Semi-Structured interviews were aimed at collecting opinionated input on environmental maps within EA's and the value GIS databases could provide. The opinions of these interviewees provided insight to the real-world struggles related to environmental map generation within EA's. The practitioners and departmental officials were able to elaborate on the value of maps within Environmental Authorisation applications and where they foresee the future of maps heading.

4.3.2.1 Structuring of Semi-Structured Interviews

The Semi-Structured Interviews were conducted with three (3) interviewees during a Gauteng Environmental Assessment Practitioners Forum on the 11th August 2017 at the Gauteng Investment Centre, Sandton. One of these interviewees holds a position as a Department Official at the Gauteng Department of Agriculture and Rural Development (GDARD). Two (2) additional interviews were conducted during office hours at Prism Environmental Management Services on the 10th August 2017. The interviews were structured with the intention of directing the conversation to certain topics. It was the intention of the questions to investigate the opinions of the interviewees based on their experiences within the field of Environmental Impact Assessments (see Table 4-3). The Gauteng Environmental Assessment Practitioners Forum also provided the opportunity to interview Department Officials present at the time. Each interview was recorded for analysing purposes.

Table 4-3: Semi-Structured Interview Questions

Interview Questions
1. Name Surname
2. Current Occupation
3. Would you regard maps as an important decision-making tool?
4. What map attributes would you regard as a necessity?
5. Have you identified any gaps in the legally required Environmental Maps?
6. What is your opinion on existing databases such as CoJ or Ekurhuleni GIS database?
7. What is your opinion on an EA GIS database
8. What do you regard as the biggest limitation to such a proposed database?

The interview was divided into three sections. Questions 1 and 2 provided background on the interviewee as well as established whether they represented the private or government sector. Questions 3 to 5 provided the interviewer with the interviewee's opinion on environmental maps within environmental authorisations, and to establish any possible gaps and weaknesses in the current requirements. Questions 6 to 8 were most valuable to this study as the questions focused on spatial databases, and investigating the interviewee's opinion on existing GIS databases and the potential for future developments.

4.3.2.2 Semi-Structured Interview Results

The information gathered from the Semi-Structured Interviews provided a clear consensus on the value environmental maps provide within the process of Environmental Authorisations. All interviewees had strong opinions that maps are vital for any decision-making process for Environmental Authorisations. Interviewee 1, an EAP from Prism EMS (environmental consultancy) stated that environmental maps provide a holistic perspective on a proposed development. She also stated that well designed maps provide information often overlooked or poorly described in the reports (Interviewee 1, 2017). Interviewee 2, an Environmental Officer at the GDARD added that environmental maps provide a "summary" of the scope of work and all the intentions of the applicant. He further stated that maps strengthen the report/application and

provides significant value when assessing the impact on the natural environment (Interviewee 2, 2017). Interviewee 3, an EAP from MDT Environmental (environmental consultancy), however, mentioned that the map requirements stipulated within departmental application forms and documentation should rather be sourced as a guideline and not seen as mandatory. She states that environmental maps should be generated based on site specific attributes and not be regarded as a generic output (Interviewee 3, 2017). None of the interviewees were of the opinion that there are any gaps within the legal requirements for environmental maps or available information. However, the spatial data requirements referred to by the interviewees largely consist of information requested via the various application forms from the respected departments, thereby creating potential situations where data required is left to the discretion of the applicant (person compiling the application form). All interviewees were of the same opinion as interviewee 3 that the legal requirements provide a good foundation for any maps, but must include site specific sensitivities and activities. Furthermore, there was consensus regarding the Gauteng Conservation Plan, as the importance of including the data-layer was mentioned by all. Neither of the interviewees makes use of the existing municipal databases (Biodiversity GIS, City of Johannesburg Corporate GIS, City of Tshwane Metropolitan Municipality – GIS; City of Ekurhuleni Metropolitan Municipality – GIS website. See Section 3.6 to source information. Interviewee 1 did however mention that existing municipal databases are useful sources of information, but is difficult and frustrating to use.

Information sourced from the interviews clearly indicated that an Environmental Authorisation GIS database would provide an asset to environmental consulting and could even be regarded as a Best Practice approach. It was apparent from the interviews that providing a GIS database would be useful, but to keep it updated with relevant information may pose some challenges. The provision of relevant and up to date information was found to be the greatest limitation and concern regarding the EA GIS database.

4.3.3 Compilation of Input data and structure of database.

The data-layers included in the GIS database was primarily focussed on providing sufficient information to comply with the legal requirements. In addition, certain information was added to the database to complement the additional information included in the case studies investigated. The Gauteng Conservation Plan and the Gauteng Environmental Management Framework for example, was some of these layers. The inclusion of these data-layers was endorsed by majority of the interviewees as it provides valuable information to the competent authority i.e. information

on the present state of the area as well as the strategic planning for the area in terms of government initiatives.

The data-layers sourced were categorised in seven (7) folders:

- Transportation
- Hydrological
- Cadastral
- Vegetation
- Geology and Soils
- Gauteng EMF
- Basemaps

Figure 4-3 illustrates the input data-layers within each categorised folder. Categorising the data-layers improves the interactive experience of a database (Smith, 2016:106–117). Harley stated that by categorising data during data set-up, enhances the map drawing performance and reduces time spent significantly (Harley, 2005:38–40). The input data-layers are compiled in *APPENDIX 2: GIS DATABASE LAYERS*.

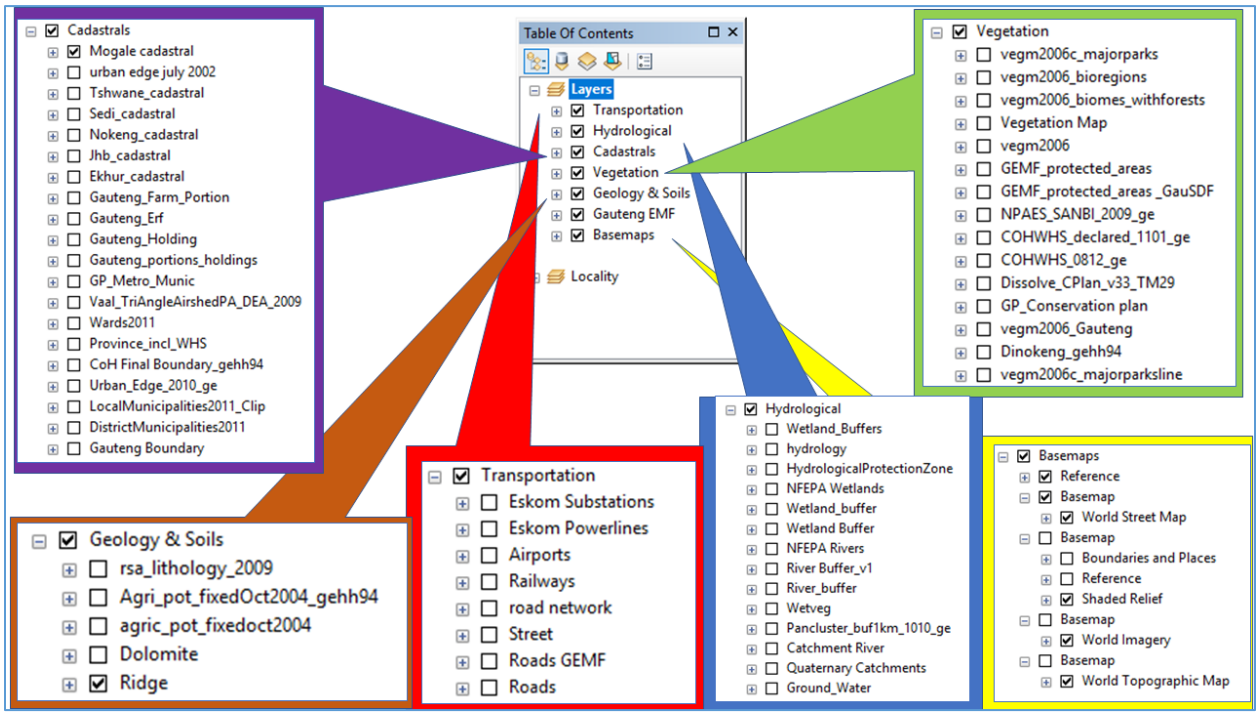

Figure 4-3: Database outline of all data input-layers categorised within GIS database (APPENDIX 2: GIS DATABASE LAYERS).

4.4 Environmental Authorisation GIS Database

This section aims to visually illustrate the GIS database capabilities, by spatially defining the environmental maps and map requirements as stipulated by the NEMA's. Spatially defining data, generally relates to the visual display of information over time, position and size. Table 3-2 listed all the legally required map attributes to be included within environmental maps. Figure 4-4 illustrates the GIS database design as an interactive platform. Such a platform provides the potential for the addition of spatial data and the interactive use. Figure 4-5 to 4-8 illustrates examples of the GIS database outputs.

If such a GIS database could be made available to both EAP and Department Official, it would fast-track information sourcing and even decision making as all required information could be uploaded and used as required. Similar databases are currently being implemented like the GDARD online application system. EAP's are provided with the means to electronically submit Environmental Authorisation applications, where as Department Officials could extract these reports for evaluation and or request additional information, all on one online platform. It is envisaged that the same could be done with a GIS Database. Were EAP's and Specialist could upload study area boundaries and spatial data for investigation in relation to existing spatial data, Department Officials could in turn evaluate the proposed activities using the same layers. The assumption could be made that such a database could minimise the gap in communication between various departments, EAP's and the private sector. The time spent on sourcing all the information required, as an independent entity such as environmental consultancies or private specialists could be reduced significantly, if everyone could be provided access to a GIS Database with a platform of all required data.

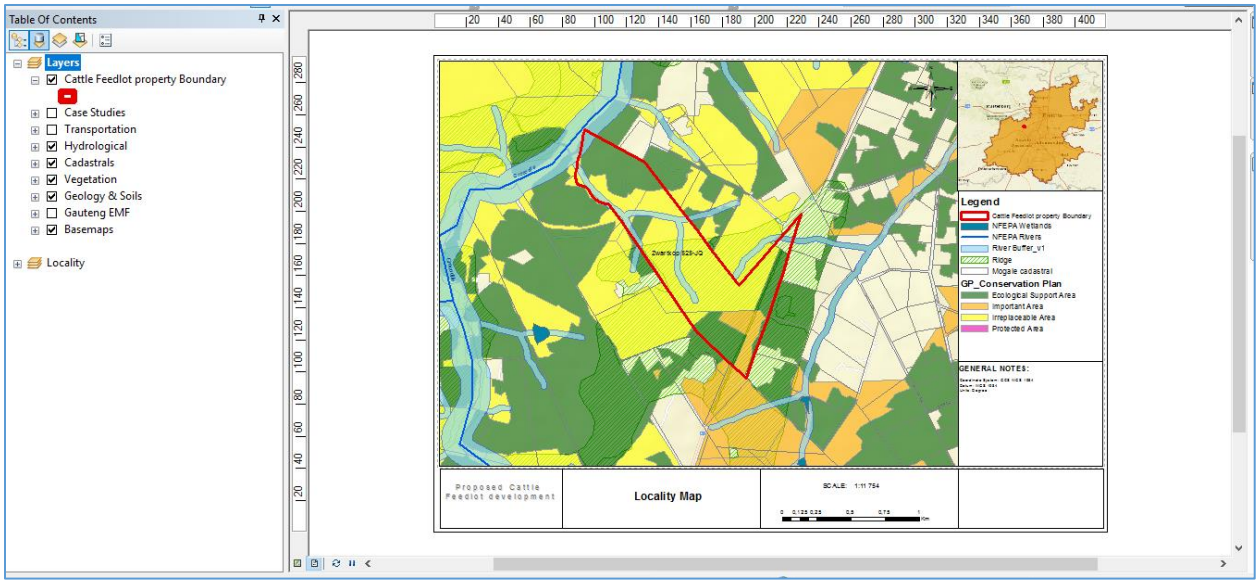

Figure 4-4: Illustrates an example of the GIS database work interface.

Best practice initiatives and procedures could be implemented if everyone used the same data-layers. Uniformity often increases the quality, efficiency and accuracy of any work outputs (WHO, 2011:246). Thus, uniforming environmental mapping for EA's could potentially create best practices. Providing accurate and quality environmental maps within EA applications could in turn provide for efficient evaluations by Department Officials and reduce the turn-around times, thereby increasing the value of environmental maps within EA's exponentially.

Reducing the timeframes of information sourcing, mapping and evaluating within Environmental Authorisation applications, could potentially change people's perception regarding EA's, as these applications are commonly related to lengthy waiting periods which discourages development and even economic growth.

Figure 4-5 illustrates a map exported from the database providing information on the vegetation type of a proposed study area. This data is especially useful to ecological specialists and various Environmental Authorisation and is most often included within the case samples evaluated. Even though various spatial data-layers of the South African biomes, bioregions and vegetation types have been created, the most commonly one used is the Mucina and Rutherford (see APPENDIX 2: GIS DATABASE LAYERS). The data-layer provides conservation objectives and valuable information related each vegetation type. To specialists, this data-layer provides a valuable starting position in identifying the ecological status of a study area.

The Gauteng Environmental Management Framework illustrated in Figure 4-6 has become a useful screening tool in Environmental Authorisations as curtain activities may be excluded from obtaining an Environmental Authorisation if located in certain zones (see Environmental Management Framework). The spatial data-layer was included in the database to identify the zonal area a study site is located in. This data-layer not only provides information on activities to be exploded, but provides information on the strategic planning of the Gauteng Province.

Figure 4-7 provides an example of a locality map required by each governmental department as part of an Environmental Authorisation Application. The locality map utilised an aerial basemap to illustrate the study area and the surrounding properties. It also provides some indication of the current state of the area and activities occupying it.

The final example included within this paper illustrates the Gauteng Province Conservation plan. The data-layer is constructed from existing environmental data-layers and specialist studies. It therefore provides useful information for both the private sector (EAP's) and the government departments, by illustrating the current sensitivities of the study area. The data-layer is therefore very useful for baseline investigations and provides an indication of the possible specialist studies required before an Environmental Authorisation may be obtained.

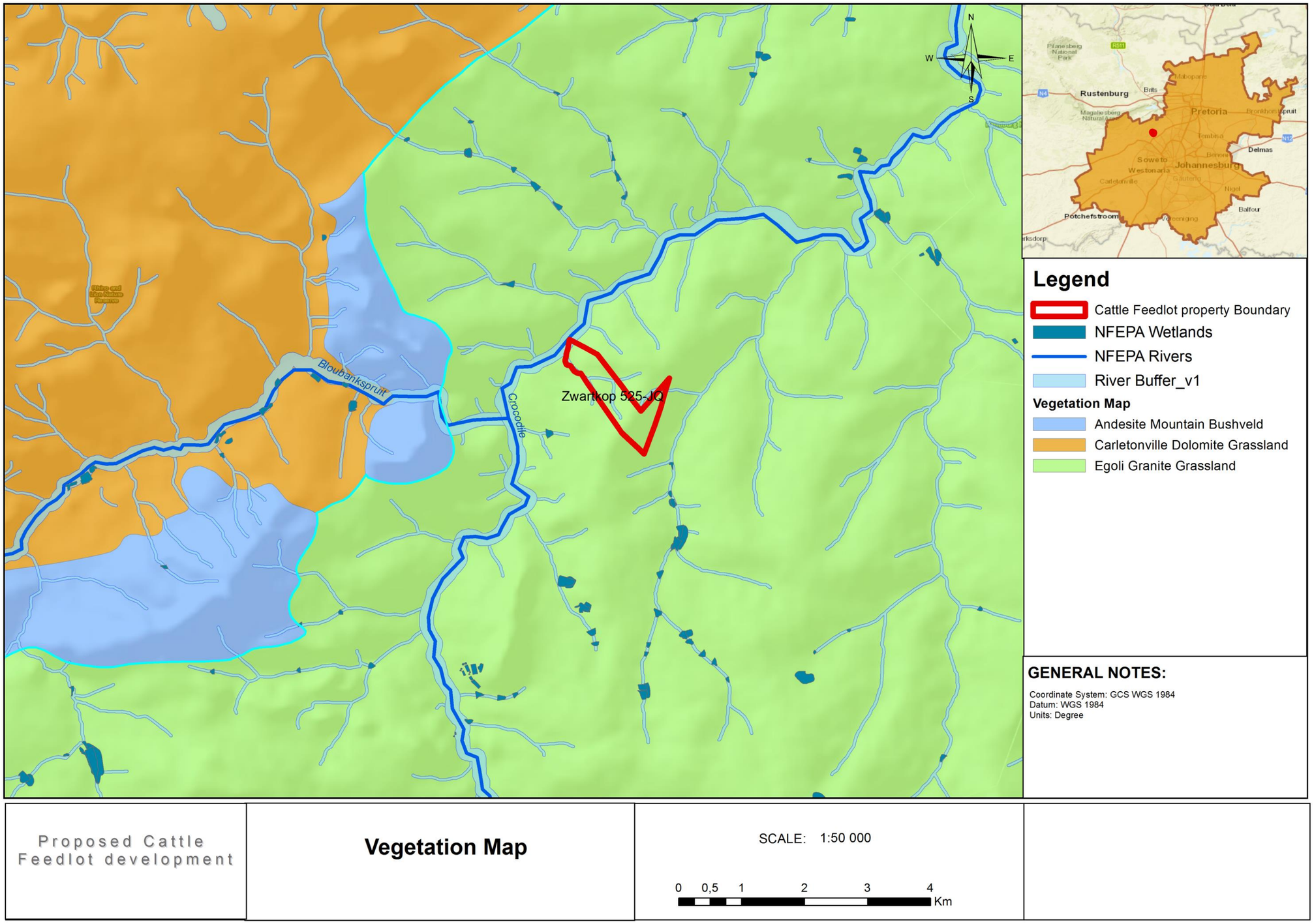

Figure 4-5: Illustrates an example of the Muncina & Ruthorford Vegetation Type data-layer in relation to the study area.

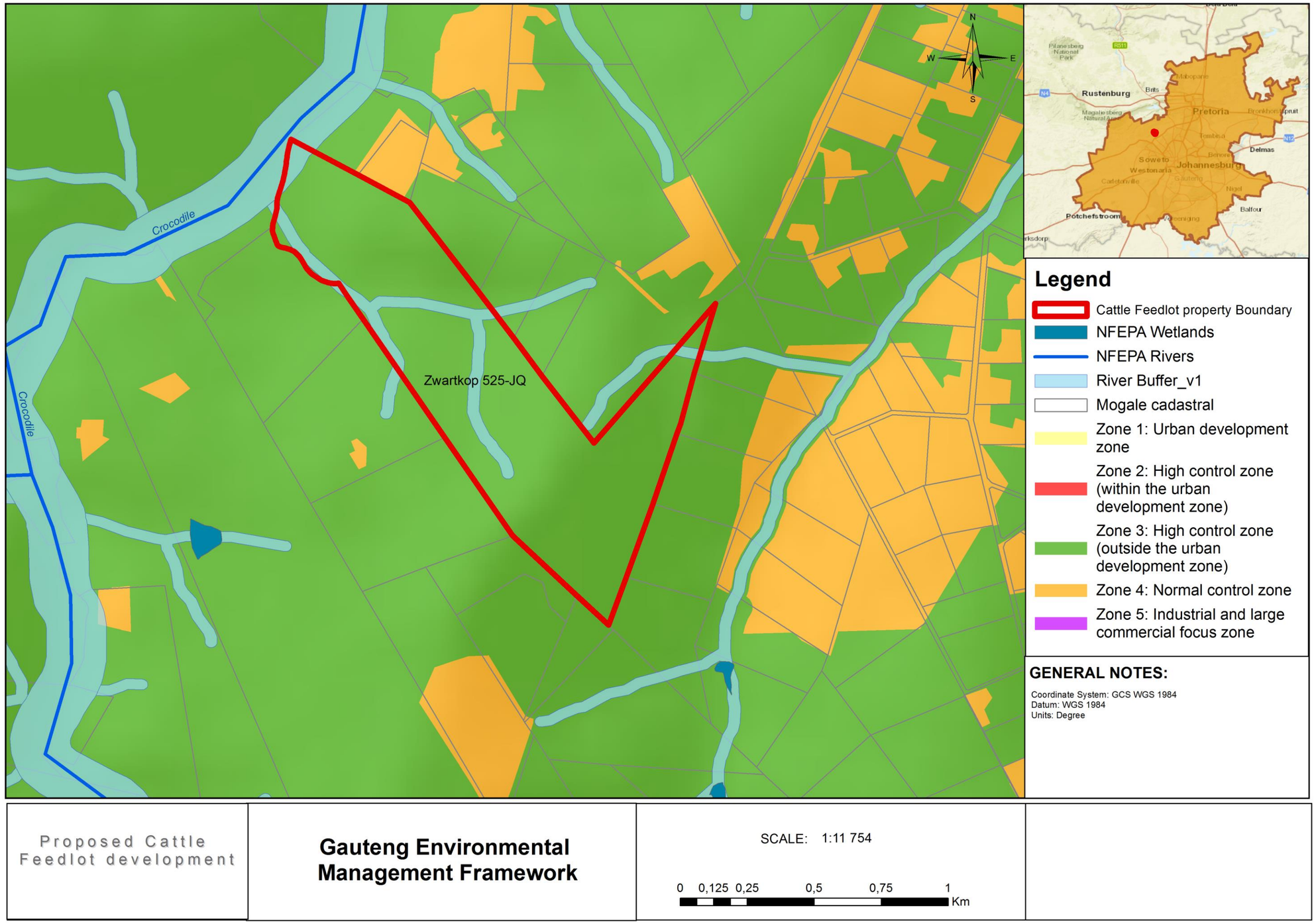

Figure 4-6: Illustrates the Gauteng Environmental Management Framework Zones data-layer in relation to the study area.

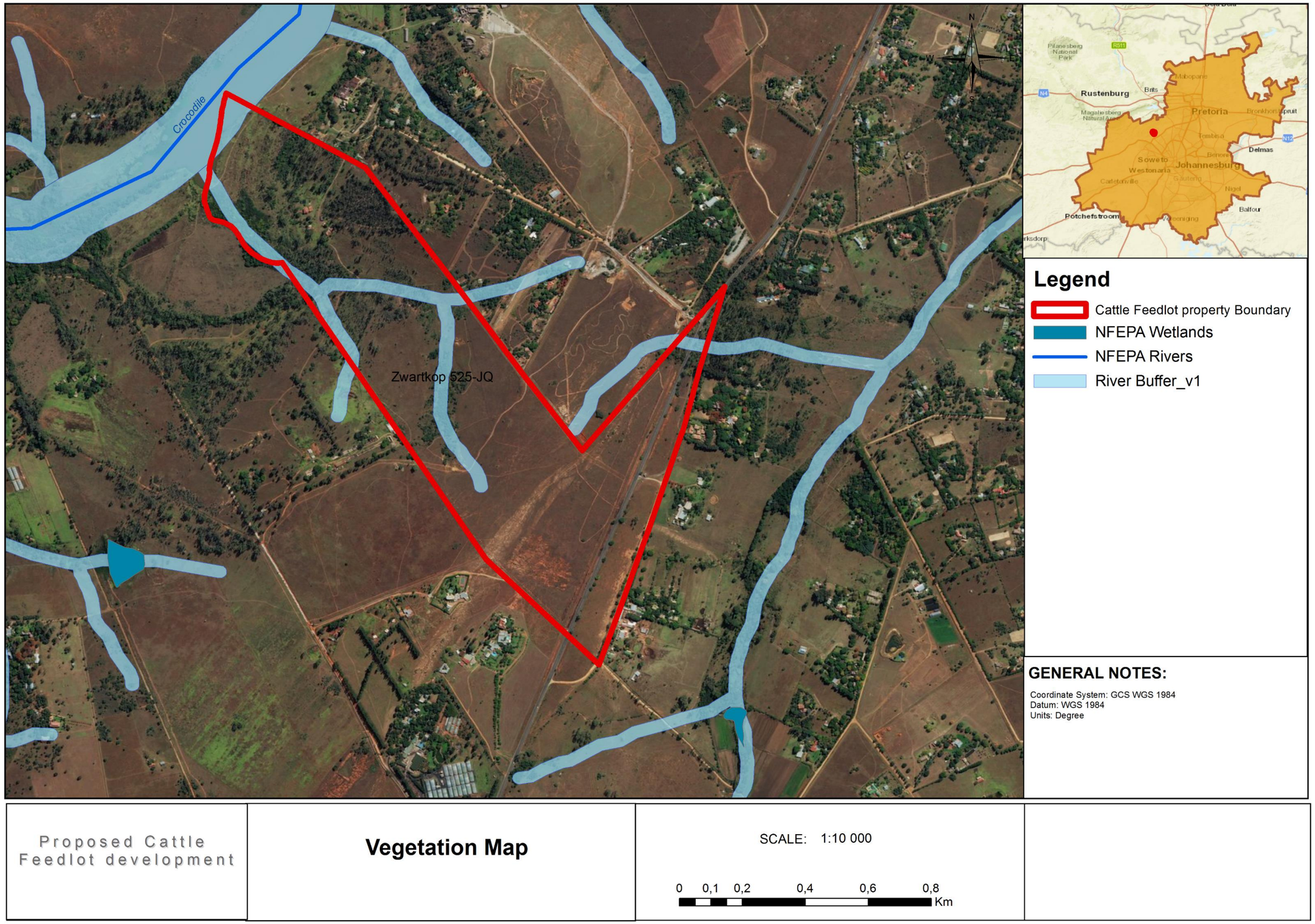

Figure 4-7: Provides a Locality Map of the study area using an Aerial satalite data-layer as a basemap.

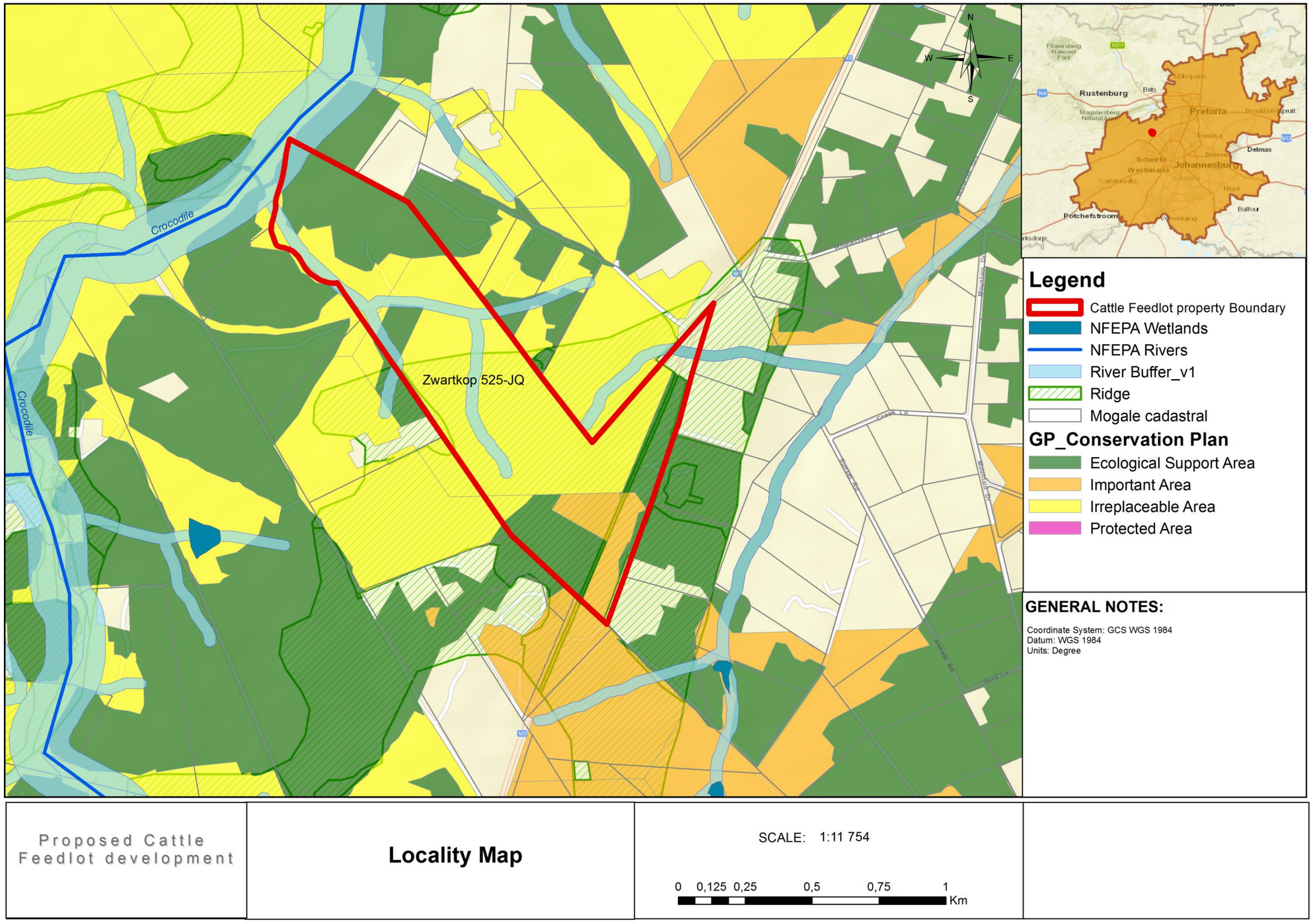

Figure 4-8: Illustrates the Gauteng Province Conservation Plan as an overlay data-layer to identify the conservation requirements of the study area according to GDARD..

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This dissertation aimed, to provide a platform for spatial geography within the field of environmental management, based on Jackson's (2014) four concepts underlying geography to address real world geographical problems. Spatial mapping has the potential to encompass space and place; scale and connection; proximity and distance and relational thinking, which can provide great value to multiple users when correctly executed.

Environmental maps form an integral part and legal component of any Environmental Authorisation process within South Africa. Spatial requirements and map outputs are currently unclear and may differ between various applications and projects. Furthermore, there are no freely accessible or publicly available databases in South Africa to aid in the effective generation of these maps. This created a major challenge for Environmental Consultants and Department Officials. This study was therefore initiated to address this challenge and alleviate the difficulties experienced by the both parties in the application and decision-making processes pertaining to Environmental Authorisations in the Gauteng Province. The role of such a database and environmental maps, as an information source and decision making tool was also investigated to understand the value it could provide to both the private sector and Department Officials.

5.1.1 Conclusion: Objective 1

The first research objective was to understand the different types of South African Environmental Authorisations and the related mandatory map requirements with an emphasis on the value of these maps. This was achieved through Systematic literature review and semi-structured interviews.

One of the findings from the literature review was that multiple GIS databases exist, however they do not entirely complement Environmental Authorisations and the specific map requirements to date. A gap was therefore apparent within the current literature regarding a publicly available GIS database for Environmental Authorisations within the Gauteng Province.

The interviewees indicated that the mandatory map requirements provided the department officials with sufficient spatial information to successfully evaluate Environmental Authorisation Applications.

The literature review and interviews conducted endorsed the value environmental maps provide within Environmental Authorisation processes, as it offers the competent authority a visual indication of the scope and intention of the applicant. Environment maps were therefore found to be a fundamental component within Environmental Authorisation processes as it provides value to the content of any application submitted. The literature review promoted the need for an Environmental Authorisation GIS database as it could provide public access to useful and compulsory environmental map attributes.

5.1.2 Conclusion: Objective 2

The second research objective aimed to determine the specific spatial and map output requirements for the Environmental Authorisations generated in the Gauteng Province. A total of 25 relevant case examples were collected using framework structured from the purposeful sampling approach. The literature review identified a list of map requirements needed for Environmental Authorisations within the Gauteng Province which was used to construct a cross-evaluation checklist. The case examples were evaluated using this checklist of map requirements to identify whether the legally required map attributes were included within the Environmental Authorisations and if any additional attributes were added.

The data indicated that more than 70% of the legally required map attributes were included within the EA processes. This may fluctuate depending on the nature and extent of specific projects/cases. Additional map attributes such as the Gauteng Conservation Plan and the Gauteng Environmental Management Framework were highlighted as valuable data layers to be included in the GIS database as it contributes greatly to decision-making.

5.1.3 Conclusion: Objective 3

The third research objective aimed to spatially define the environmental maps in a Geographic Information System (GIS) database within the Gauteng Province boundary. The theory of distilled ideal requirements was used to design a spatial database capable of including and presenting all the legally required map attributes within the Gauteng Province for the five (5) types of Environmental Authorisations.

The data indicated that although such a database would provide great value to the industry, it would have to overcome certain limitations and concerns. One such concern includes the

maintenance of relevant and up-to-date data within an ever-changing world. This is regarded as a major limitation due to the value such a database could pose as the cost and resources needed to maintain such a database may prove excessive. The resources mentioned refer to the accessibility to an ArcMap software platform. To date this software is still regarded as an expensive tool to acquire. By providing a publically available internet based database with all required capabilities would address all concerns and limitations related to accessibility. Regardless of the concerns raised during the study, the data proves that a theory of such a GIS database for Environmental Authorisations would demonstrate great value to the various processes.

5.2 Recommendations

The aims and objectives of this study were achieved, producing a GIS database that aligned to the mapping requirements of Environmental Authorisations for the Gauteng Province. The findings from this study, however, only form a basis for future studies and improvement of the GIS database. This section aims to provide recommendations for industries of practice and future research endeavours.

5.2.1 Recommendations for industry of practice

Environmental Authorisations processes are being directed towards a more generic-electronic method approach with the aim of achieving time efficiency, improved record keeping, and holistic communication. It is therefore imperative that more resources are designated and focussed to these aspects of GIS databases. Such a database could potentially promote best practice within any Environmental Authorisation process. This GIS database aimed to spatially define the environmental map requirements for Environmental Authorisations within an ArcGIS Desktop platform. However, it is recommended that similar work be conducted within new geodatabases. This will allow for improved accessibility over multiple GIS software platforms. A similar database should be improved and implemented for the Gauteng Province, and expanded to provide relevant information on a national scale.

As this database is centred on an ESRI ArcMap software, it is recommended that a database be developed online, to provide similar workability on a free and publicly available platform.

Additionally, it is recommended that the potential of adapting this database or the theory of this database be investigated for other environmentally related practices such as Environmental Control Officers, Environmental Management Systems (EMS) and Auditing.

5.2.2 Recommendations for future research.

The GIS database formulated from this study will not only provide valuable information for Environmental Authorisation processes, as it is envisaged to provide a set methodology for future databases (Sinske & Jacobs, 2012:1–7). One of the biggest obstacles for GIS databases is the constantly updating requirements of data within a rapidly growing industry, it is recommended that future research be dedicated to the creation of strategies to prevent public GIS databases from using outdated data, even though, research has shown that the development of a database with the aim of providing relevant information has proved challenging. However, this database may provide a foundation or example for future similar structured databases.

It is recommended that future research be dedicated to the value such databases could provide to the field of environmental management and sustainability as this study aimed at providing a general concept that aids Environmental Consultants and Department Officials during the Environmental Authorisation process.

5.3 Conclusion: Research Aim

The aim of the study was to spatially define the South African map requirements for Environmental Authorisations through the creation of a Geographical Information System (GIS) database for the Gauteng Province. The aim was achieved through the implementation of the three (3) research objectives. The GIS database forms a user-friendly platform for both Environmental Consultants and Department Officials, consolidating all the required cartographical information layers for any of the five (5) types of Environmental Authorisations into one database for the Gauteng Province. The value of environmental maps within Environmental Authorisations was not only confirmed throughout this dissertation but provided enough evidence to envisage the evolution of environmental maps and the role it would play as an integral part of an application process.

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APPENDIX 1: CASE SAMPLES ANALYSIS

APPENDIX 1: CASE SAMPLE ANALYSIS

This section illustrates the analysis of all case studies sampled within the Gauteng Province. The Appendix is sorted into five (5) chapters for each Environmental Authorisation investigated.

1. Basic Assessment Report (BAR)

1.1. BAR: Sample 1

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓	Line Scale & Word scale	
Scale 1:50 000 and bigger	✗	Aerial Basemap	Scale of the 6 maps differ in size, however no 1:50 000 identified
Accurate indication of site position.	✓	Streetmap Basemap	
Access road	✓	Engineer site layout plan	Construction of a Road, therefor no access is Required
Surrounding road names and numbers	✓		Only Major roads are indicated
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✗		
Coordinates (degrees decimal minutes	✓	Geographical Grid	Coordinates indicated on the Grid
Property boundaries and numbers of all properties surrounding the site within 50 metres	✗		
Current land use and land zoning of proposed site and adjacent properties	✗		Proposed intersection is crossing existing road
Position of activity elements	✓	Detailed Layout plan inserted onto layout map.	
Position of services including electricity	✓		In Engineering Layout map
Wall and fencing around the site	✗		Intersection does not require fencing around.
Servitudes and information relating to servitudes	✓		In Engineering Layout map
Any environmental sensitivities within 100 metres of the site.	✓	C-Plan	Ecological important area surrounding site.
Rivers & Wetlands	✓	Ecological sensitivity map	
1:100 year floodline	✗	Water Management Area	

Ridges	✘	Quaternary Catchment areas (Hillslope basemap included with this layer = improves result presentation)	
Cultural and Historical features	✘		No Cultural and Historical features were identified close to site.
Indigenous vegetation	✘		Could be as a result of developed area.
Contours	✘		No contours were identified on any maps

1.2. BAR: Sample 2

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓	Word scale and bar scale is included in all the maps.	The individual maps indicating the environmental sensitivities are illustrated on a 1:8500 scale which makes it difficult to read.
Scale 1:50 000 and bigger	✓		
Accurate indication of site position.	✓		With the proposed site being relative small, it's difficult to see the site with such a large scale
Access road	✓		Locality with aerial view indicates all access routes. Site layout plan also indicates access.
Surrounding road names and numbers	✓		
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	The city's urban edge is included	Cadastral layer is included in the layout map
Current land use and land zoning of proposed site and adjacent properties	✓	Surrounding landuse and future developments in the area.	Aerial view does give some indication of land use but not conformation given.
Position of activity elements	✓	Detailed site-layout	Activity elements indicated in site layout plan
Position of services including electricity	✘		Scale of the locality map is too large to indicate any services.
Wall and fencing around the site	✓		Property boundary and fencing indicated on site layout
Servitudes and information relating to servitudes	✓	Route servitudes are indicated	Scale of the locality map is too large to indicate any servitudes.

Any environmental sensitivities within 100 metres of the site.	✓	The following sensitivities are indicated on separate maps: Hydrological properties; Agricultural potential; Gauteng conservation plan; Orange listed plant species; Irreplaceable vegetation areas according to C-Plan; Habit delineation; Habitat sensitivities Due to the nature of the project the soil depth was illustrated	All the surrounding waterbodies and sensitivities are indicated on a single map. The environmental sensitivities in and around the site is included.
Rivers & Wetlands	✓	A separate map illustrating all the hydrological sensitivities, including appropriate buffers was included.	Waterbodies illustrated on the topographic map shows nearby water but at a very large scale with little detail.
1:100 year floodline	✘		
Ridges	✘		
Cultural and Historical features	✘		
Indigenous vegetation	✘		
Contours	✘		
Notes: The report illustrates a large number of maps, all these maps indicate valuable information pertaining to the project. Some information could however be combined to reduce the number of maps.			

1.3. BAR: Sample 3

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		1:15 000 1:10 000
Scale 1:50 000 and bigger	✘		
Accurate indication of site position.	✓	Reference map	Reference map using a larger scale to indicate site locality in proportion to surrounding areas
Access road	N/A		Site access was not indicated as the activity involves the installation of a sewer line crossing multiple sites
Surrounding road names and numbers	✓		
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✘		Aerial imagery was used for the locality map.

Current land use and land zoning of proposed site and adjacent properties	✘		
Position of activity elements	✓		Sewer line with associated buffer lines were indicated on the locality map
Position of services including electricity	N/A		Proposed activity involves the installation of a sewer services line.
Wall and fencing around the site	N/A		Linear activity involves multiple sites. Fencing will only be installed around construction camp
Servitudes and information relating to servitudes	✓	Sewer 30 m buffer	
Any environmental sensitivities within 100 metres of the site.	✓	C-Plan	
Rivers & Wetlands	✓	Non-Perennial river 32 m river buffer Non- FEPA Wetlands	
1:100 year floodline	✘		
Ridges	✘		
Cultural and Historical features	✘		
Indigenous vegetation	✘		
Contours	✘		
Notes: Alternative alignment is indicated on same map.			

1.4. BAR: Sample 4

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		Made use of google earth, which resulted in poor representation of scale
Scale 1:50 000 and bigger	✓		Topographical Map: 1:50 000
Accurate indication of site position.	✓		
Access road	N/A		Linier construction over multiple properties
Surrounding road names and numbers	✓		Major roads only
North Arrow	✓		
Legend	✓		No Legend in Locality map. Legend in Topo Map
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✓		Google Earth Imagery Degrees, minutes, seconds

Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Separate map illustrating neighbouring properties with associated property information	
Current land use and land zoning of proposed site and adjacent properties	✓	High level indication of surrounding landuses	Generalisation of areas
Position of activity elements	✓	Facility illustration indicating alternatives and servitudes	
Position of services including electricity	✓		Activity involves the installation of electricity line
Wall and fencing around the site	N/A		Linier activity, only construction camp will be fenced off
Servitudes and information relating to servitudes	✓		Within facility illustration
Any environmental sensitivities within 100 metres of the site.	✓	SANBI CBA area	SANBI's Gauteng C-Plan was utilised.
Rivers & Wetlands	✓		Topo-maps indicate some waterbody layers SANBI interface utilising NFEPA layer
1:100 year floodline	✘		
Ridges	✘		May be that no ridges were observed within scope of site
Cultural and Historical features	✘		
Indigenous vegetation	✓	Using C-Plan	
Contours	✓		Topo-map indicates 20 m Contours
Notes: Additional maps were included through the specialist Aquatic assessment compiled by the specialist.			

1.5. BAR: Sample 5

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		Both line and word scale
Scale 1:50 000 and bigger	✘		Unclear
Accurate indication of site position.	✓		
Access road	✓		Project refers to a linear project which makes access indication unclear
Surrounding road names and numbers	✓		Scale is to such extent that little detail regarding the surrounding roads are visible
North Arrow	✓		Google Earth tools were used.
Legend	✘		

Prevailing wind direction	✗		
Coordinates (degrees decimal minutes	✓		Google earth footer indicates a coordinates of map general location
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓		
Current land use and land zoning of proposed site and adjacent properties	✓		To some extent
Position of activity elements	✓		
Position of services including electricity	✓		
Wall and fencing around the site	✗		
Servitudes and information relating to servitudes	✓		
Any environmental sensitivities within 100 metres of the site.	✓	GAPA 3 map was included in the report	Sensitivity overlay was included. The map however, does not indicate the nature of sensitivity only the level and area.
Rivers & Wetlands	✗		
1:100 year floodline	✓		
Ridges	✗		
Cultural and Historical features	✗		
Indigenous vegetation	✗		
Contours	✓		Indicated on layout plan
Notes: It must be noted that no environmental map was included within the appendices as a" stand alone map". However, various environmental illustrations were used within the report as reference.			

Table 1 1: Data Analysis of Map Requirements Included within BAR Case Samples

Map Requirements	BAR 1	BAR 2	BAR 3	BAR 4	BAR 5	T
Scale indicated on map	1	1	1	1	1	1.0
Scale 1:50 000 and bigger	0	1	0	1	0	0.4
Accurate indication of site position.	1	1	1	1	1	1.0
Access road	1	1	N/A	N/A	1	1.0
Surrounding road names and numbers	1	1	1	1	1	1.0
North Arrow	1	1	1	1	1	1.0
Legend	1	1	1	1	0	0.8
Prevailing wind direction	0	0	0	0	0	0.0
Coordinates (degrees decimal minutes	1	0	0	1	1	0.6
Property boundaries and numbers of all properties surrounding the site within 50 metres	0	1	0	1	1	0.6
Current land use and land zoning of proposed site and adjacent properties	0	1	0	1	1	0.6
Position of activity elements	1	1	1	1	1	1.0
Position of services including electricity	1	0	N/A	1	1	0.8
Wall and fencing around the site	0	1	N/A	N/A	0	0.3
Servitudes and information relating to servitudes	1	1	1	1	1	1.0
Any environmental sensitivities within 100 metres of the site.	1	1	1	1	1	1.0
Rivers & Wetlands	1	1	1	1	0	0.8
1:100 year floodline	0	0	0	0	1	0.2
Ridges	N/A	N/A	N/A	N/A	N/A	
Cultural and Historical features	0	0	0	0	0	0.0
Indigenous vegetation	0	0	0	1	0	0.2
Contours	0	0	0	1	1	0.4
Total Requirements Included (%)	**55**	**64**	**47**	**80**	**64**	**62.2**

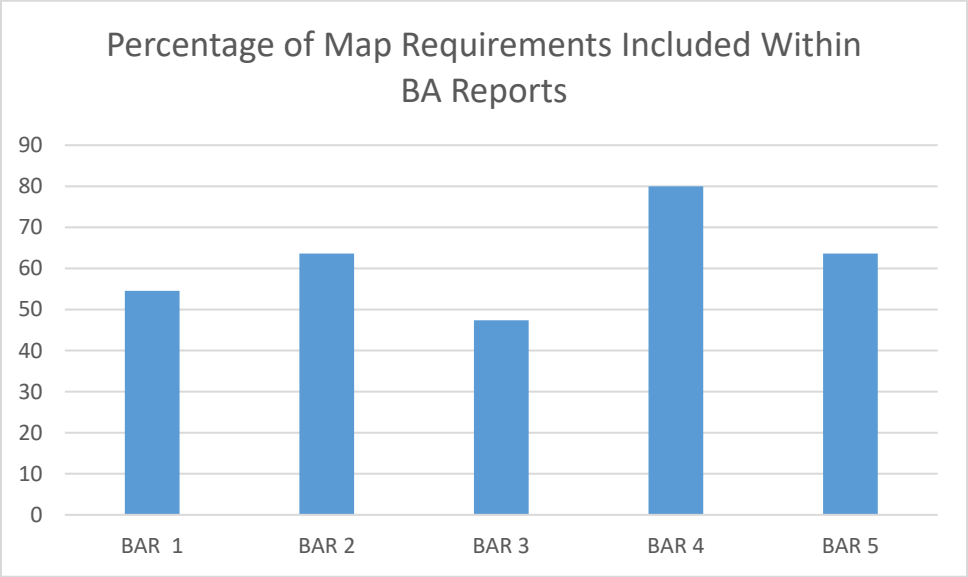

Figure 1 1: Figure explaining percentage of map requirements included within BAR case samples.

2. Environmental Impact Assessment Report (EIR)

2.1. EIR: Sample 1

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓	Line Scale & Word scale	
Scale 1:50 000 and bigger	✗		Scale 1:50 000
Accurate indication of site position.	✓		
Access road	✗		Additional pictures do, however indicate access road position
Surrounding road names and numbers	✓		
Any environmental sensitivities	✓	C-Plan	
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✗		
Coordinates (degrees decimal minutes	✗		
Locality Map	✓		
Site Layout Plan	✗		Pictures in the report indicated some form of layout.
Sensitivity Map	✓		
All roads within 1 km of the site	✓		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Cadastral map	Cadastral was not used but surrounding properties were clearly defined
Watercourse	✓	River and streams Wetland Buffer	
1:100 year floodline	✓		Was included by an independent specialist study
Critical Biodiversity area	✓	C-Plan	
Closes town[1]	✗		

[1] DEA:Red

2.2. EIR: Sample 2

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓	Line Scale & Word scale	
Scale 1:50 000 and bigger	✓		Scale 1:50 000
Accurate indication of site position.	✓	RSDF for City of Johannesburg	
Access road	✓		Access roads are indicated in the final layout plan. Due to the size of the site, there are more than one access road into the site.
Surrounding road names and numbers	✓		
Any environmental sensitivities	✓	C-Plan	
North Arrow	✓		
Legend	✓		In some of the maps the legend was too small to make out what the labels illustrated.
Prevailing wind direction	✗		
Coordinates (degrees decimal minutes	✗		
Locality Map	✓		
Site Layout Plan	✓	Revision stage was also indicated on the map. Open space map	
Sensitivity Map	✓	The Sensitivity layer was presented by a GAPA layer Environmental Composite map. Layout plan combined with Environmental Composite map.	
All roads within 1 km of the site	✓		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Cadastral layout included in the layout plan, surrounding land uses is also presented.	Topographic map does not indicate neighbouring boundaries. But the cadastral layouts are illustrated in the site layout
Watercourse	✓	Watercourse layer was included with the C-plan layer. Temporary and seasonal wetlands. Existing water reticulation and sewer lines and future developments	
1:100 year floodline	✓		Floodlines are indicated in the layout plan.
Critical Biodiversity area	✓	GDARD C-Plan	
Closes town[2]	✓	Current and future developments around the site.	Topographic map clearly indicates surrounding towns

[2] DEA:Red

			at a scale of 1:45 000 on the locality map.
All the necessary information was illustrated throughout the 14 maps included in the report. Some layers were combined and others where illustrated individually.			

2.3. EIR: Sample 3

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		The scale on the first map is indicated through a line-scale.
Scale 1:50 000 and bigger	✓		
Accurate indication of site position.	✓		
Access road	✓		Due to the nature and scale of the project the access roads to the wells is not clearly stipulated.
Surrounding road names and numbers	✓		The location of the study sites makes it difficult to indicate clear road names as many of the roads are informal/ gravel.
Any environmental sensitivities	✓	Environmental Sensitivity protected coastal areas and catchments are indicated on a separate map.	Sensitivities surrounding the river is indicated.
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Locality Map	✓	Some of the landuses and potential “land of importance” areas are indicated on a separate map, like high tourism area potential.	
Site Layout Plan	✓	A map was added to indicate the possibility and extent of pollution and possible danger if a major spill would occur.	Due to the nature of the project the design does not require a detailed layout plan as it only indicates where the wells will be placed and the train line between them. Additional maps are included on a smaller scale to indicate more detail.
Sensitivity Map	✓	Due to the nature of the project, the emissions range(buffer) is indicated on a separate map The noise buffer and extent Is indicated on a separate map, as well as the relation towards nearby houses.	The first map does not indicate any sensitivities, even though the wetland and pans are indicated on the map.

All roads within 1 km of the site	✓		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✘		The proposed site is very rural with little to no set out boundaries, the scale of the subject map is also too large to indicate any property boundaries.
Watercourse	✓	Small scaled map indicating the crossing of the river system and all associated sensitivities.	
1:100 year floodline	✓	Floodlines and no-go areas are indicated on a map	
Critical Biodiversity area	✓		
Closes town	✓		
A map extracted from the heritage impact assessment specialist report was included in the report indicating all archaeological important locations.			

2.4. EIR: Sample 4

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		
Scale 1:50 000 and bigger	✘		
Accurate indication of site position.	✓		
Access road	✓		Adjacent to existing road
Surrounding road names and numbers	✓		Use of Google Streetmap
Any environmental sensitivities	✓		Ecological Specialist data overlaid
North Arrow	✓		
Legend	✓		Size very small on some maps
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Locality Map	✓	Various locality maps with different scales were included within report.	
Site Layout Plan	✓		Engineer drawings included within report
Sensitivity Map	✓		Included within specialist reports (specialist map included within report)
All roads within 1 km of the site	✓		Within Streetmap
Property boundaries and numbers of all properties surrounding the site within 50 metres	✘		
Watercourse	N/A		No watercourses in close proximity

1:100 year floodline	N/A		No watercourses in close proximity
Critical Biodiversity area	✘		Gauteng Conservation plan not included
Closes town	✘		Not clearly indicated
None			

2.5. EIR: Sample 5

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓	Both bar and word scale	
Scale 1:50 000 and bigger	✓		Single map exceeding 1: 10 000 scale included
Accurate indication of site position.	✓		
Access road	✓	Included within all maps	
Surrounding road names and numbers	✓		
Any environmental sensitivities	✓		Individual maps for each sensitivity separately.
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Locality Map	✓		Google Earth Image extraction
Site Layout Plan	✓		Basic sketch of proposed activities
Sensitivity Map	✓		
All roads within 1 km of the site	✓	Untarred roads were also named and included	
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Large farm portions (and small farms) within area were mentioned	
Watercourse	✓		NFEPA river layer were overlaid
1:100 year floodline	✓		Only section in close proximity to river
Critical Biodiversity area	✓		Gauteng Conservation plan included
Closes town[3]	✘		Site not close to any towns
Gauteng Environmental Management Framework Included			

[3] DEA:Red

Table 2 1: Data Analysis of Map Requirements Included within EIR Case Samples

Map Requirements	EIR 1	EIR 2	EIR 3	EIR 4	EIR 5	T
Scale indicated on map	1	1	1	1	1	1.0
Scale 1:50 000 and bigger	0	1	1	0	1	0.6
Accurate indication of site position.	1	1	1	1	1	1.0
Access road	0	1	1	1	1	0.8
Surrounding road names and numbers	1	1	1	1	1	1.0
Any environmental sensitivities	1	1	1	1	1	1.0
North Arrow	1	1	1	1	1	1.0
Legend	1	1	1	1	1	1.0
Prevailing wind direction	0	0	0	0	0	0.0
Coordinates (degrees decimal minutes	0	0	0	0	0	0.0
Locality Map	1	1	1	1	1	1.0
Site Layout Plan	0	1	1	1	1	0.8
Sensitivity Map	1	1	1	1	1	1.0
All roads within 1 km of the site	1	1	1	1	1	1.0
Property boundaries and numbers of all properties surrounding the site within 50 metres	1	1	0	0	1	0.6
Watercourse	1	1	1	N/A	1	1.0
1:100 year floodline	1	1	1	N/A	1	1.0
Critical Biodiversity area	1	1	1	0	1	0.8
Closes town	0	1	1	0	0	0.4
Total Requirements Included (%)	**65**	**85**	**80**	**61**	**80**	**75.0**

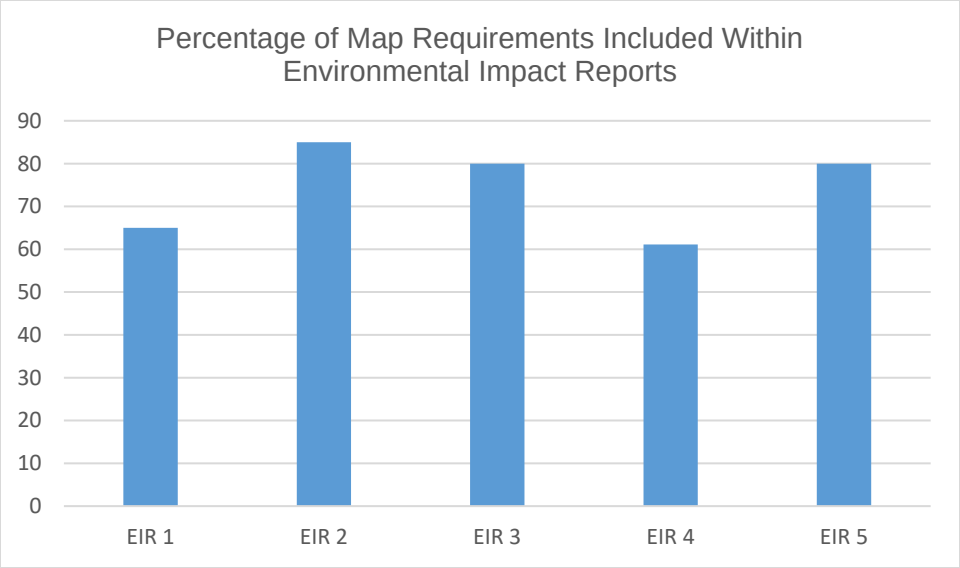

Figure 2 1: Figure explaining percentage of map requirements included within EIR case samples.

3. Environmental Waste management License (WML)

3.1. WML: Sample 1

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓	Aerial Basemap	
Site Layout Plan			
Sensitivity Map	✓		
Projection WGS84	✓		
Scale indicated on map	✓	Line Scale & Word scale	
Scale 1:50 000 and bigger	✓		Scale differs for various maps
Topographical map	✓	Topographical Basemap	
Site and 5 km radius	✓		Scale vary large, information not vary clear
Existing residential and industrial areas	✘		Surrounding area is dominated by agriculture
Possible future development	✘		
Other waste handling sites	✘		No other waste handling sites identified within the scope of the study
Existing and possible future residential developments	✘		No residential, future residential close to site
Security	✘		
Accurate indication of site position.	✓		
Access road	✓		
Surrounding road names and numbers	✓		
All roads within 1 km of the site	✓		
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✘	Site Boundary	
Current land use and land zoning of proposed site and adjacent properties	✓		Is also discussed in report
Position of activity elements	✓		
Position of services including electricity	✘		

Servitudes and information relating to servitudes	✘		No servitudes identified close to the site.
Any environmental sensitivities within 100 metres of the site.	✓	C-Plan Layer	
Watercourse	✓	Rivers, dams & wetlands	
Rivers & Wetlands	✓		
1:100 year floodline	✘	Water delineation	Water Buffer layers
Ridges	✘		No ridges on site
Cultural and Historical features	✘		No Historical features identified near the site
Indigenous vegetation	✘	C-Plan Layer	
Critical Biodiversity area	✓	Geology Layer C-Plan	
Contours	✓	5 m Contours	
Closes town	✓		

3.2. WML: Sample 2

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓		
Site Layout Plan	✓		
Sensitivity Map	✓		
Projection WGS84	✓		
Scale indicated on map	✓	Both bar scale and line scale included	
Scale 1:50 000 and bigger	✓		
Topographical map	✘		Only Aerial and Street map included
Site and 5 km radius	✓		Not accurately indicated but scale makes provision for 5 km radius
Existing residential and industrial areas	✓		Indicated within aerial map
Possible future development	✘		
Other waste handling sites	✘		
Existing and possible future residential developments	✘		
Security	✓		
Accurate indication of site position.	✓		Layout indicated on all maps
Access road	✓		
Surrounding road names and numbers	✓		

All roads within 1 km of the site	✓	Use of Google Street Maps	
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✘		Was not indicated within maps but within report
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Cadastral layer	
Current land use and land zoning of proposed site and adjacent properties	✘		
Position of activity elements	✓		Layout Map
Position of services including electricity	✓		Engineering Drawings
Servitudes and information relating to servitudes	✓		Planned provincial road servitude indicated with centre line and buffer
Any environmental sensitivities within 100 metres of the site.	✓		Gauteng Conservation Plan
Watercourse	N/A		
Rivers & Wetlands	N/A		
1:100 year floodline	N/A		
Ridges	N/A		
Cultural and Historical features	N/A		
Indigenous vegetation	✓		Within specialist Report
Critical Biodiversity area	✓		Gauteng Conservation Plan
Contours	✓	Within Engineering Drawings	
Closes town	✓		

3.3. WML: Sample 3

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓		
Site Layout Plan	✓		No formal layout, only general designated areas as the proposed project involves a construction waste facility
Sensitivity Map	✓		
Projection WGS84	✓		
Scale indicated on map	✓		

Scale 1:50 000 and bigger	✓		Additional Locality map included with 1: 50 000 map
Topographical map	✗		
Site and 5 km radius	✓	1:50 000 map makes provision for 5 km radius	
Existing residential and industrial areas	✓	CoJ development framework included to identify existing zonings and activities.	
Possible future development	✗		This data is not easy to obtain. Predictions can however be made by looking at Municipal development plans
Other waste handling sites	✓	No waste sites in close proximity illustrated, however, note was made on one map that none was identified	
Existing and possible future residential developments	✗		Existing but not future
Security	✓		Identified at proposed gate offices
Accurate indication of site position.	✓		
Access road	✓	Used Street basemap	
Surrounding road names and numbers	✓	Used Street basemap	
All roads within 1 km of the site	✓	Used Street basemap	
North Arrow	✓		
Legend	✓	Some layers were explained in detail below map	
Prevailing wind direction	✓		
Coordinates (degrees decimal minutes	✗		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	CoJ cadastral layer was included	
Current land use and land zoning of proposed site and adjacent properties	✓		Aerial map makes is clear enough
Position of activity elements	✓		Indicated within general layout
Position of services including electricity	✗		
Servitudes and information relating to servitudes	✗		
Any environmental sensitivities within 100 metres of the site.	✓		Gauteng EMF was used as a basemap in sensitivity map
Watercourse	✓		NFEPA layers
Rivers & Wetlands	✓		NFEPA layers
1:100 year floodline	✓		Within Outline Scheme Report

Ridges	N/A		
Cultural and Historical features	N/A		
Indigenous vegetation	✓		Ecological study included a google earth image
Critical Biodiversity area	✓		
Contours	✓		Within Outline Scheme Report
Closes town	✓		

3.4. WML: Sample 4

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓		
Site Layout Plan	✓		
Sensitivity Map	✓		Map indicating all environmental sensitivities
Projection WGS84	✘		Unknown
Scale indicated on map	✓	Line Scale	
Scale 1:50 000 and bigger	✓		Scale differs for various maps
Topographical map	✓	Topographical Basemap	
Site and 5 km radius	✓		Satellite Imagery
Existing residential and industrial areas	✘		Satellite Imagery must however make own assumptions
Possible future development	✘		
Other waste handling sites	✘		
Existing and possible future residential developments	✘		
Security	✘		
Accurate indication of site position.	✓	Drone Survey of study area was used as basemap overlaid with proposed layout	
Access road	✓		
Surrounding road names and numbers	✓		
All roads within 1 km of the site	✓		
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all	✘		

properties surrounding the site within 50 metres			
Current land use and land zoning of proposed site and adjacent properties	✓		Adjacent properties were labelled in additional map
Position of activity elements	✓	Layout map	
Position of services including electricity	✘		
Servitudes and information relating to servitudes	✘		Not visible
Any environmental sensitivities within 100 metres of the site.	✓		Gauteng Conservation plan and unknown Aquatic layer
Watercourse	✓		Unknown Aquatic layer
Rivers & Wetlands	✓		Unknown Aquatic layer
1:100 year floodline	N/A		
Ridges	N/A		
Cultural and Historical features	N/A		
Indigenous vegetation	✘		
Critical Biodiversity area	✓		
Contours	✓	Within Drone Survey	
Closes town	✓		

3.5. WML: Sample 5

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓		
Site Layout Plan	✓		
Sensitivity Map	✓		
Projection WGS84	✘		
Scale indicated on map	✓	Line Scale & Word scale	
Scale 1:50 000 and bigger	✓		Study area small, thus, large scale provides no value
Topographical map	✓	Topographical Map from Archaeological report included	
Site and 5 km radius	✓		
Existing residential and industrial areas	✓		Site within big industrial zoning
Possible future development	✘		Area completely built up
Other waste handling sites	✘		
Existing and possible future residential developments	✘	Ekurhuleni Municipality Development Plan extracted	

Security	✓		
Accurate indication of site position.	✓		
Access road	✓		
Surrounding road names and numbers	✓	Ekurhuleni Cadastral Data	
All roads within 1 km of the site	✓		
North Arrow	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✓		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Ekurhuleni Cadastral Data	
Current land use and land zoning of proposed site and adjacent properties	✘		
Position of activity elements	✓		Simple schematic drawing attached
Position of services including electricity	✓	Existing services indicated	
Servitudes and information relating to servitudes	✓		No servitudes identified close to the site.
Any environmental sensitivities within 100 metres of the site.	✓		Gauteng EMF used, identified entire area as zone 5
Watercourse	N/A		
Rivers & Wetlands	N/A		
1:100 year floodline	N/A		
Ridges	N/A		
Cultural and Historical features	N/A		
Indigenous vegetation	✓	Mucina & Rutherford layer	
Critical Biodiversity area	✓	Gauteng Conservation Plan	
Contours	✓	20 m Contours	
Closes town	✓		

Table 3 1: Data Analysis of Map Requirements Included within WML Case Samples

Map Requirements	Waste 1	Waste 2	Waste 3	Waste 4	Waste 5	T
Locality Map	1	1	1	1	1	1.0
Site Layout Plan	1	1	1	1	1	1.0
Sensitivity Map	1	1	1	1	1	1.0
Projection WGS84	1	1	1	0	0	0.6
Scale indicated on map	1	1	1	1	1	1.0
Scale 1:50 000 and bigger	1	1	1	1	1	1.0
Topographical map	1	0	0	1	1	0.6
Site and 5 km radius	1	1	1	1	1	1.0
Existing residential and industrial areas	0	1	1	0	1	0.6
Possible future development	0	0	0	0	0	0.0
Other waste handling sites	0	0	1	0	0	0.2
Existing and possible future residential developments	0	0	0	0	0	0.0
Security	0	1	1	0	1	0.6
Accurate indication of site position.	1	1	1	1	1	1.0
Access road	1	1	1	1	1	1.0
Surrounding road names and numbers	1	1	1	1	1	1.0
All roads within 1 km of the site	1	1	1	1	1	1.0
North Arrow	1	1	1	1	1	1.0
Legend	1	1	1	1	1	1.0
Prevailing wind direction	0	0	1	0	0	0.2
Coordinates (degrees decimal minutes	0	0	0	0	1	0.2
Property boundaries and numbers of all properties surrounding the site within 50 metres	0	1	1	0	1	0.6
Current land use and land zoning of proposed site and adjacent properties	1	0	1	1	0	0.6
Position of activity elements	1	1	1	1	1	1.0

Position of services including electricity	0	1	0	0	1	0.4
Servitudes and information relating to servitudes	0	1	0	0	1	0.4
Any environmental sensitivities within 100 metres of the site.	1	1	1	1	1	1.0
Watercourse	1	N/A	1	1	N/A	1.0
Rivers & Wetlands	1	N/A	1	1	N/A	1.0
1:100 year floodline	N/A	N/A	1	N/A	N/A	1.0
Ridges	N/A	N/A	N/A	N/A	N/A	
Cultural and Historical features	N/A	N/A	N/A	N/A	N/A	
Indigenous vegetation	0	1	1	0	1	0.6
Critical Biodiversity area	1	1	1	1	1	1.0
Contours	1	1	1	1	1	1.0
Closes town	1	1	1	1	1	1.0
Total Requirements Included (%)	**65**	**75**	**80**	**62**	**78**	**50.9**

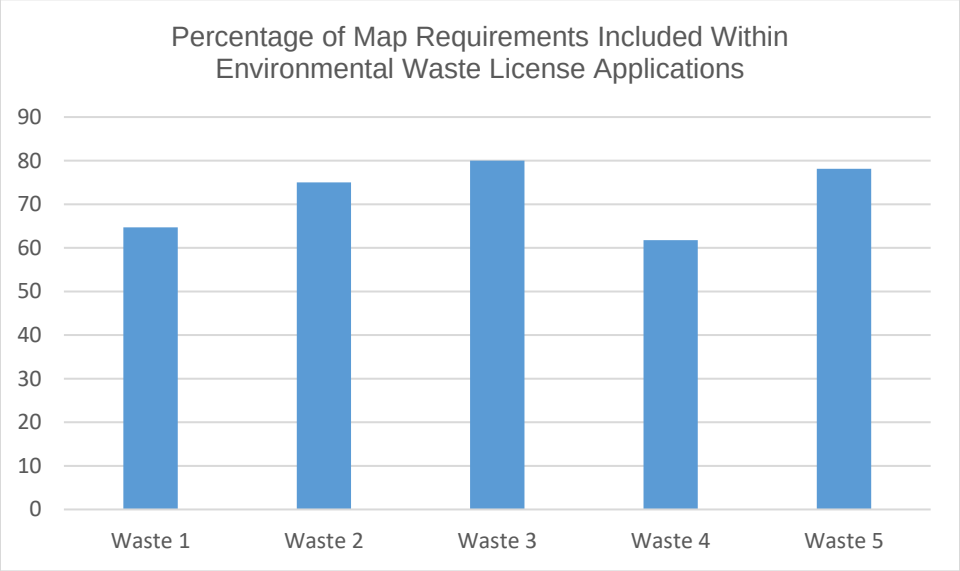

Figure 3 1: Figure explaining percentage of map requirements included within WML case samples.

4. Water use licence application (WULA)

4.1. WULA: Sample 1

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓	Line Scale & Word scale	
Scale 1:50 000 and bigger	✓	Aerial basemap	Catchment map >50 000
Topo-cadastral map	✓	Street Basemap	
Appropriate scale	✓	Locality Map	
Accurate indication of site position.	✓		
Activity requiring water use	✓		
Access road	✓		Engineering plan
Surrounding road names and numbers	✓		
North Arrow	✓		
Line scale	✓		
Legend	✓		
Prevailing wind direction	✗		
Coordinates (degrees decimal minutes	✓		Engineering plan
Property boundaries and numbers of all properties surrounding the site which will be affected by the water use	✗		Boundaries not clearly demarcated
Relevant catchment	✓	Quaternary Catchments	
Current land use and land zoning of proposed site and adjacent properties	✗		Not indicated on maps but is discussed in report
Surrounding towns	✓	Reference map	
Surrounding infrastructure	✓		Is seen on areal map but is also discussed in report
Extent of riparian habitat	✓	Servitudes	Engineering plan
Stormwater Management Practices	✓	Water Management Area	Included in the stormwater management plan
Position of activity elements (Site layout plan)	✓	Eco- Region layer	Engineering plan
[4]Any environmental sensitivities within 100 metres of the site.	✓	Hillslope Basemap	
Water resource location	✓	Rivers & streams Layer	

[4] Included:Orange

Water resources within 1km radius	✓		Also indicated in catchment map
Water works	✘		No waterworks identified off site
1:100 year floodline	✓	1:50 000 Floodline	Engineering map

4.2. WULA: Sample 2

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		
Scale 1:50 000 and bigger	✓		
Topo-cadastral map	✘		Only Aerial basemaps are included in the report
Appropriate scale	✓		
Accurate indication of site position.	✘		Even though the scale of the map is appropriate, it does not display an appropriate scale to distinguish the location of the study site.
Activity requiring water use	✓		
Access road	✓		
Surrounding road names and numbers	✘		Due to the remote location of the site, the roads around the property are mostly untarred and informal.
North Arrow	✓		
Line scale	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site which will be affected by the water use	✘		The surrounding properties are large farm portions but does not indicate the boundaries or names of the surrounding properties.
Relevant catchment	✓		
Current land use and land zoning of proposed site and adjacent properties	✓		
Surrounding towns	✘		The scale of the attached maps does not indicate local ore surrounding towns.
Surrounding infrastructure	✓		
Extent of riparian habitat	✘		No noticeable waterbodies are located on ore close to the study site.

Stormwater Management Practices	✘		
Position of activity elements (Site layout plan)	✓		
[5]Any environmental sensitivities within 100 metres of the site.	✘		No environmental sensitivities are indicated on the map.
Water resource location	✘		
Water resources within 1km radius	✘		
Water works	✘		
1:100 year floodline	✘		

4.3. WULA: Sample 3

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		`Word scale
Scale 1:50 000 and bigger	✘	1:30000 topographic map was included	
Topo-cadastral map	✓		Cadastral data is clearly indicated.
Appropriate scale	✓		Detailed Layout plan
Accurate indication of site position.	✓		
Activity requiring water use	✓		
Access road	✓		
Surrounding road names and numbers	✓		
North Arrow	✓		
Line scale	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✓		
Property boundaries and numbers of all properties surrounding the site which will be affected by the water use	✓		
Relevant catchment	✘		
Current land use and land zoning of proposed site and adjacent properties	✘	Portion size of neighbouring properties were included	

[5] Included:Orange

Surrounding towns	✓		
Surrounding infrastructure	✓		Existing infrastructure is included in the Layout plan
Extent of riparian habitat	✓		
Stormwater Management Practices	✓		Stormwater infrastructure was included
Position of activity elements (Site layout plan)	✓	Construction camp layout plan was also additionally included	
[6]Any environmental sensitivities within 100 metres of the site.	✓	Vegetation map	
Water resource location	✓		In the form of floodlines
Water resources within 1km radius	✓		Project falls within riparian area
Water works	✓		
1:100 year floodline	✓	32m Buffer zone was included	
Note: The report was very extensive as it incorporated 15 maps in total within the WULA, the above mentioned requirements was not all included into one single map but was rather separately illustrated in more specialised maps.			

4.4. WULA: Sample 4

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		Line Scale
Scale 1:50 000 and bigger	✓		
Topo-cadastral map	✘		Ekurhuleni cadastral data overlaid a topographic map
Appropriate scale	✓	1: 2 500 scale to super emphasise study area	
Accurate indication of site position.	✓		
Activity requiring water use	✓		Clearly labelled within map
Access road	✓		
Surrounding road names and numbers	✓		Ekurhuleni cadastral
North Arrow	✓		
Line scale	✓		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✓		For all water use activities indicated on map
Property boundaries and numbers of all properties surrounding	✓		Ekurhuleni cadastral

[6] Included:Orange

the site which will be affected by the water use			
Relevant catchment	✓		Quaternary Catchment
Current land use and land zoning of proposed site and adjacent properties	✗		
Surrounding towns	✗		
Surrounding infrastructure	✓		Displayed using aerial imagery
Extent of riparian habitat	✓		Only section affected
Stormwater Management Practices	✗		
Position of activity elements (Site layout plan)	✓		
Any environmental sensitivities within 100 metres of the site.	✓		Gauteng Conservation Plan
Water resource location	✓		
Water resources within 1km radius	✗		Only affected area
Water works	N/A		
1:100 year floodline	✓	Engineering report	

4.5. WULA: Sample 5

Map Parameters	Include/ excluded	Additional Map features	Notes:
Scale indicated on map	✓		Only Word Scale
Scale 1:50 000 and bigger	✓		
Topo-cadastral map	✓		
Appropriate scale	✓		Study area well defined. However, Water Use area not clearly visible.
Accurate indication of site position.	✓		
Activity requiring water use	✓		Area pinned but not clearly visible.
Access road	✓		
Surrounding road names and numbers	✓	CoJ Cadastral data	
North Arrow	✓		
Line scale	✗		
Legend	✓		
Prevailing wind direction	✗		
Coordinates (degrees decimal minutes	✓		

Property boundaries and numbers of all properties surrounding the site which will be affected by the water use	✓	CoJ Cadastral data	
Relevant catchment	✓		Quaternary Catchment
Current land use and land zoning of proposed site and adjacent properties	✓		Labelled within 1: 50 000 aerial map.
Surrounding towns	✘		Not clearly indicated
Surrounding infrastructure	✓		Existing servitudes
Extent of riparian habitat	✓		Riparian area clearly indicated
Stormwater Management Practices	✓		Proposed Stormwater infrastructure was included
Position of activity elements (Site layout plan)	✓	Construction camp layout plan was also additionally included	
Any environmental sensitivities within 100 metres of the site.	✓		
Water resource location	✓		Engineering delineations
Water resources within 1km radius	✘		
Water works	N/A		
1:100 year floodline	✓		Engineering Reports and floodlines included.

Table 4 1: Data Analysis of Map Requirements Included within WULA Case Samples

Map Requirements	WULA 1	WULA 2	WULA 3	WULA 4	WULA 5	T
Scale indicated on map	1	1	1	1	1	1.0
Scale 1:50 000 and bigger	1	1	0	1	1	0.8
Topo-cadastral map	1	0	1	0	1	0.6
Appropriate scale	1	1	1	1	1	1.0
Accurate indication of site position.	1	0	1	1	1	0.8
Activity requiring water use	1	1	1	1	1	1.0
Access road	1	1	1	1	1	1.0
Surrounding road names and numbers	1	0	1	1	1	0.8
North Arrow	1	1	1	1	1	1.0
Line scale	1	1	1	1	0	0.8
Legend	1	1	1	1	1	1.0

Prevailing wind direction	0	0	0	0	0	0.0
Coordinates (degrees decimal minutes	1	0	1	1	1	0.8
Property boundaries and numbers of all properties surrounding the site which will be affected by the water use	0	0	1	1	1	0.6
Relevant catchment	1	1	0	1	1	0.8
Current land use and land zoning of proposed site and adjacent properties	0	1	0	0	1	0.4
Surrounding towns	1	1	1	0	0	0.6
Surrounding infrastructure	1	0	1	1	1	0.8
Extent of riparian habitat	1	0	1	1	1	0.8
Stormwater Management Practices	1	0	1	0	1	0.6
Position of activity elements (Site layout plan)	1	1	1	1	1	1.0
Any environmental sensitivities within 100 metres of the site.	1	0	1	1	1	0.8
Water resource location	1	0	1	1	1	0.8
Water resources within 1km radius	1	0	1	0	0	0.4
Water works	N/A	N/A	1	N/A	N/A	1.0
1:100 year floodline	1	0	1	1	1	0.8
Total Requirements Included (%)	**85**	**46**	**81**	**73**	**81**	**74.1**

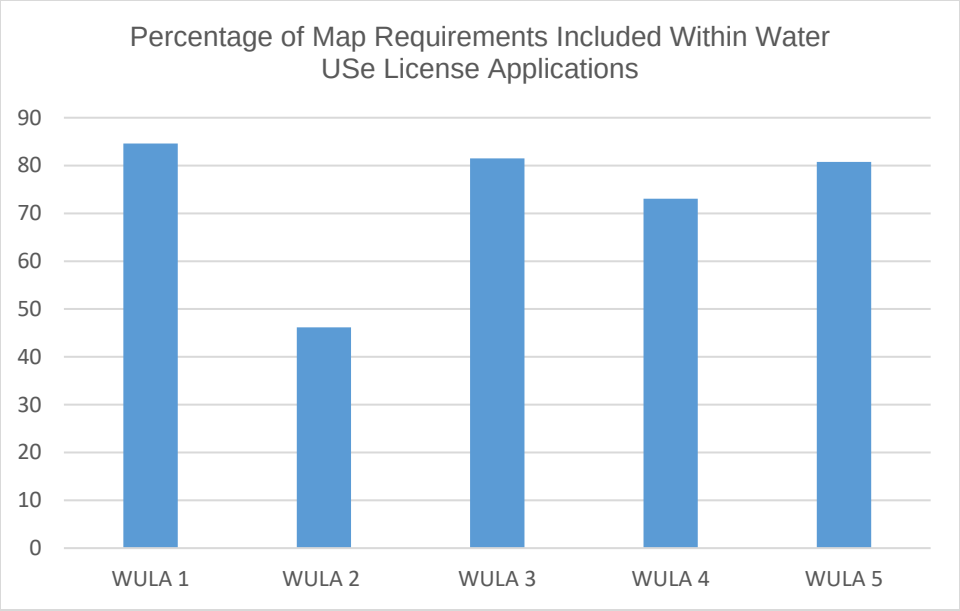

Figure 4 1: Figure explaining percentage of map requirements included within WULA case samples.

5. Air Emissions Licence (AEL)

5.1. AEL: Sample 1

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓		
Site Layout Plan	✓		
Projection WGS84	✘		Use Transverse Mercator
A3 Layout Plan	✓		
Scale indicated on map	✓		
Scale 1:50 000 and bigger	✓		Scale for the locality plan was 1:60 000
Site and 5 km radius	✓		7 km Radius due to Diesel Depot
Existing residential and industrial areas	✓		
Accurate indication of site position.	✘		
Access road	✓		
Surrounding road names and numbers	✓		Due to the remoteness of the site the number of formulised roads is very limited.
North Arrow	✓		
True north arrow	✘		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✘		Situation is understandable due to the remote location of the study site, Surroundings is dominated by Agricultural land portions
Current land use and land zoning of proposed site and adjacent properties	✘		Some of the key land uses and activities are highlighted in on the locality map.
Position of activity elements (Site Layout)	✓		
Any environmental sensitivities within 100 metres of the site.	✘		
Watercourse	✓		2 non-perineal rivers are displayed on the map.
1:100 year floodline	✘		No water is found on the study site, and the non-perineal river is located far from the study site.

Cultural and Historical features	✘		
Critical Biodiversity area	✘		No environmental sensitivities are indicated.
Closes town	✘		Site is situated on a remote location far from the site.

5.2. AEL: Sample 2

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓	Aerial map included	
Site Layout Plan	✓		Basic schematics of proposed activity included
Projection WGS84	✘		
A3 Layout Plan	✓		
Scale indicated on map	✓		Line/ Bar scale included
Scale 1:50 000 and bigger	✓		Proposed project small, large scale does not provide value
Site and 5 km radius	✓		Proposed project relatively small
Existing residential and industrial areas	✓		Map makes provision for this, however, no residential area identified in close proximity (within 5 km)
Accurate indication of site position.	✓		
Access road	✓		Farm gravel road identified on aerial map
Surrounding road names and numbers	✓		
North Arrow	✓		
True north arrow	✘		
Legend	✓	Some maps had two individual legends to better explain map attributes	
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓		Proposed project situated within large farm land
Current land use and land zoning of proposed site and adjacent properties	✘		Not clearly defined, however, can make some presumptions from aerial photography
Position of activity elements (Site Layout)	✓		
Any environmental sensitivities within 100 metres of the site.	✓	Gauteng Conservation Plan	

Watercourse	✓	Shown on reference map, however, not close to proposed activity	
1:100 year floodline	✓		Riparian buffer indicated on reference map, however, not applicable to study
Cultural and Historical features	N/A		
Critical Biodiversity area	✓		
Closes town	✓		Shown on reference map, however, not close to study site.

5.3. AEL: Sample 3

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓		
Site Layout Plan	✓		
Projection WGS84	✘		Projection unknown
A3 Layout Plan	✓		
Scale indicated on map	✓		Word scale used
Scale 1:50 000 and bigger	✓		
Site and 5 km radius	✓		
Existing residential and industrial areas	✓		Study Area located within industrial area
Accurate indication of site position.	✓		
Access road	✓		Access to plant area clearly identified
Surrounding road names and numbers	✓	Ekurhuleni Metropolitan Cadastral included.	
North Arrow	✓		
True north arrow	✘		
Legend	✓		
Prevailing wind direction	✓	Labelled in top left corner across from north arrow	
Coordinates (degrees decimal minutes	✓		Four corners of plant labelled with coordinates for reference
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Ekurhuleni Metropolitan Cadastral included	
Current land use and land zoning of proposed site and adjacent properties	✘		Not clearly labelled
Position of activity elements (Site Layout)	✓	Engineering reports included.	

Any environmental sensitivities within 100 metres of the site.	✓	Gauteng Conservation Plan & Ekurhuleni Development Plan included	However, as the study area is located within industrial zones no sensitivities indicated
Watercourse	N/A		
1:100 year floodline	N/A		
Cultural and Historical features	N/A		
Critical Biodiversity area	✓	Gauteng Conservation Plan & Ekurhuleni Development Plan included	
Closes town	✓		

5.4. AEL: Sample 4

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓		
Site Layout Plan	✓		
Projection WGS84	✘		Projection Unknown
A3 Layout Plan	✓		
Scale indicated on map	✓		
Scale 1:50 000 and bigger	✓		Study Area small in proximity to scale
Site and 5 km radius	✓	5 km Buffer around study area indicated	
Existing residential and industrial areas	✓	Gauteng Cadastral indicated	
Accurate indication of site position.	✓	Engineering reports included	
Access road	✓		
Surrounding road names and numbers	✓		
North Arrow	✓		
True north arrow	✘		
Legend	✓		
Prevailing wind direction	✘		
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Gauteng Cadastral indicated	
Current land use and land zoning of proposed site and adjacent properties	✘	Gauteng EMF included	But does not clearly indicate area zoning, even though area is well known as industrial
Position of activity elements (Site Layout)	✓		Engineering reports included

Any environmental sensitivities within 100 metres of the site.	✓	Gauteng Conservation Plan	
Watercourse	N/A		
1:100 year floodline	N/A		
Cultural and Historical features	N/A		
Critical Biodiversity area	✓	Gauteng Conservation Plan	
Closes town	✓		Streetmap indicating surroundings towns

5.5. AEL: Sample 5

Map Parameters	Include/ excluded	Additional Map features	Notes:
Locality Map	✓		
Site Layout Plan	✓		Basic Schematics included in map
Projection WGS84	✓		Indicated within all maps
A3 Layout Plan	✓		
Scale indicated on map	✓		
Scale 1:50 000 and bigger	✓		Study area not clear on large scale
Site and 5 km radius	✓		
Existing residential and industrial areas	✓	Ekurhuleni Metropolitan cadastral included	
Accurate indication of site position.	✓		
Access road	✓		Property entrance
Surrounding road names and numbers	✓		Streetmap basemap included
North Arrow	✓		
True north arrow	✘		
Legend	✓		
Prevailing wind direction	✓	Indicated within map using direction arrows	
Coordinates (degrees decimal minutes	✘		
Property boundaries and numbers of all properties surrounding the site within 50 metres	✓	Ekurhuleni Metropolitan cadastral included	
Current land use and land zoning of proposed site and adjacent properties	✓	Gauteng EMF & Ekurhuleni development plan map included	
Position of activity elements (Site Layout)	✓		Engineering schematics included
Any environmental sensitivities within 100 metres of the site.	✓	Gauteng Environmental Conservation Plan Included	

Watercourse	✓	NFEPA Rivers included	
1:100 year floodline	✓	Engineering delineations for area close to proposed activity included	
Cultural and Historical features	N/A		
Critical Biodiversity area	N/A		
Closes town	✓		

Table 5 1: Data Analysis of Map Requirements Included within AEL Case Samples

Map Requirements	AEL 1	AEL 2	AEL 3	AEL 4	AEL 5	T
Locality Map	1	1	1	1	1	1.0
Site Layout Plan	1	1	1	1	1	1.0
Projection WGS84	0	0	0	0	1	0.2
A3 Layout Plan	1	1	1	1	1	1.0
Scale indicated on map	1	1	1	1	1	1.0
Scale 1:50 000 and bigger	1	1	1	1	1	1.0
Site and 5 km radius	1	1	1	1	1	1.0
Existing residential and industrial areas	1	1	1	1	1	1.0
Accurate indication of site position.	0	1	1	1	1	0.8
Access road	1	1	1	1	1	1.0
Surrounding road names and numbers	1	1	1	1	1	1.0
North Arrow	1	1	1	1	1	1.0
True north arrow	0	0	0	0	0	0.0
Legend	1	1	1	1	1	1.0
Prevailing wind direction	0	0	1	0	1	0.4
Coordinates (degrees decimal minutes	0	0	1	0	0	0.2
Property boundaries and numbers of all properties surrounding the site within 50 metres	0	1	1	1	1	0.8
Current land use and land zoning of proposed site and adjacent properties	0	0	0	0	1	0.2
Position of activity elements (Site Layout)	1	1	1	1	1	1.0
Any environmental sensitivities within 100 metres of the site.	0	1	1	1	1	0.8
Watercourse	1	1	N/A	N/A	1	1.0

1:100 year floodline	0	1	N/A	N/A	1	0.7
Cultural and Historical features	N/A	N/A	N/A	N/A	N/A	
Critical Biodiversity area	0	1	1	1	N/A	0.6
Closes town	0	1	1	1	1	0.8
Total Requirements Included (%)	**52**	**76**	**83**	**74**	**88**	**73.9**

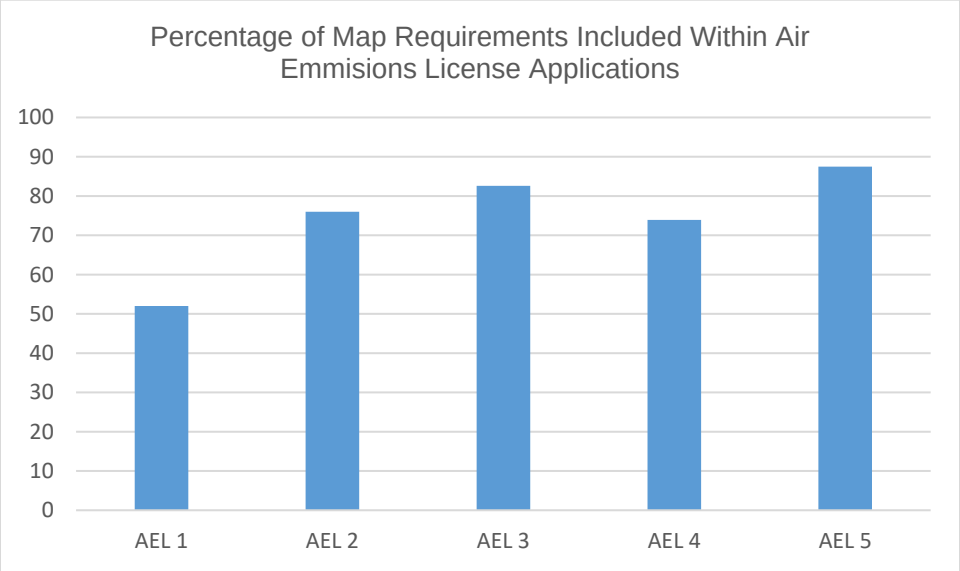

Figure 0-1: Figure explaining percentage of map requirements included within AEL case samples.

6. Consolidated Analysis

Table 6 1: Consolidated Analysis of Case Samples.

Case Samples:	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total (%)
AEL	52	76	83	74	88	**74**
BAR	55	64	47	80	64	**62**
EIR	65	85	80	61	80	**74**
WULA	85	46	81	73	81	**73**
WASTE	65	75	80	62	78	**72**

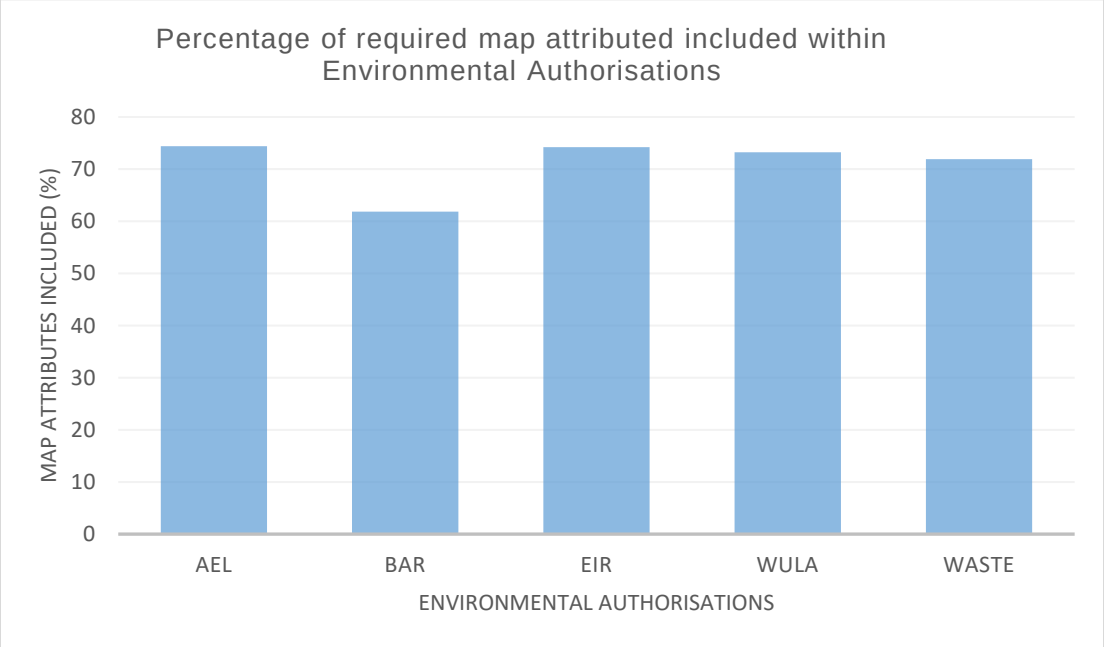

Figure 6 1: Illustrating consolidated analysis.

APPENDIX 2: GIS DATABASE LAYERS

APPENDIX 2: GIS DATABASE LAYERS

This section lists the data-layers used within the GIS database, and identifies the source of the layers.

Table 1: List of Data-layers included within GIS database.

Data Layer Name	Reference
Transportation	
Eskom Substations	Ekurhuleni Metropolitan Municipality papered by Environomics in association with MetroGIS (2009)
Eskom Powerlines	Made available by Gauteng Department of Agriculture and Rural Development (GDARD),
Airports	Made available by Gauteng Department of Agriculture and Rural Development (GDARD),
Railways	Made available by Gauteng Department of Agriculture and Rural Development (GDARD),
Road Network	Made available by Gauteng Department of Agriculture and Rural Development (GDARD),
Street	Made available by Gauteng Department of Agriculture and Rural Development (GDARD),
Road GEMF	Gauteng Department of Agriculture and Rural Development (GDARD), papered by Environomics CC (2014). Debbie Claassen.
Roads	Made available by Gauteng Department of Agriculture and Rural Development (GDARD),
Hydrological	
Wetland Buffer	Water Research Commission, prepared by CE van Ginkel, 2011
Hydrology	Department of Water Affairs and Forestry, 2001
Hydrological Protection Zone	Department of Water Affairs and Forestry, 2001
National Freshwater Priority Area Wetlands	South African National Biodiversity Institute, constructed by the CSIR (Jeanne Nel), 2011
National Freshwater Priority Area River	
National Freshwater Priority Area Wet Vegetation	
Wetland Buffer	Water Research Commission, prepared by CE van Ginkel, 2011
Pancluster 1 km Buffer	Gauteng Wetland Forum Google Earth Database, Gauteng Wetland Forum, 2011

Catchment River	Water Research Commission, prepared by CE van Ginkel, 2011
Quaternary Catchments	Water Research Commission, prepared by CE van Ginkel, 2011
National Freshwater Priority Area Ground Water	South African National Biodiversity Institute, constructed by the CSIR (Jeanne Nel), 2011
Cadastral	
Urban Edge July 2007	Gauteng Department of Development and Planning, Estee Campher
Tshwane Cadastral	Municipal Demarcation Board, 2011
Sedimeng Cadastral	Municipal Demarcation Board, 2011
Dinokeng Cadastral	Municipal Demarcation Board, 2011
Ekurhuleni Cadastral	Ekurhuleni Metropolitan Municipality, papered by Environomics in association with MetroGIS (2009)
Gauteng Province Metropolitan Municipality	Municipal Demarcation Board, 2011
Vaal Triangle Air shed Protected Area 2009	Department of Environmental Affairs
Gauteng Wards 2011	Municipal Demarcation Board, 2011
Province Including World Heritage Sites	Department of Environmental Affairs
Cradle of Humankind Final Boundary	Cradle of Humankind World Heritage Site Management Authority, Hein Pienaar, 2003
City of Johannesburg Urban Edge 2010	Gauteng Department of Development and Planning, Estee Campher
Local Municipalities 2011	Municipal Demarcation Board, 2011
District Municipalities 2011	Municipal Demarcation Board, 2011
Gauteng Boundary	Municipal Demarcation Board, 2016
Vegetation	
Vegetation Maps 2006 – Major Parks	Mucina & Rutherford, The Vegetation of South Africa, Lesotho and Swaziland, 2006
Vegetation Maps 2006 – Bioregion	
Vegetation Maps 2006 – Biomes with Forests	
Vegetation Map	
National Protected Areas	South African National Biodiversity Institute
Cradle of Humankind World Heritage Site	Cradle of Humankind World Heritage Site Management Authority, Hein Pienaar, 2003
Gauteng Vegetation Map 2006	South African National Biodiversity Institute, Bude Manaka
Gauteng Province Conservation Plan Version 3.3 (2011)	Compiled by PC Compaan, Bioregional Planning on behalf of the Gauteng Department of Agriculture and Rural Development (GDARD).
Dinokeng Conservation Area	South African National Biodiversity Institute, Bude Manaka
Vegetation Map 2006 Major Parksline	South African National Biodiversity Institute, Bude Manaka
Geology & Soils	
Lithology Layer 2009	Gauteng Department of Agriculture and Rural Development (GDARD).

Agricultural Potential 2004	Department of Agriculture, Conservation and Environment, The Gauteng Agricultural Development Strategy (GADS)
Dolomite Layer	Gauteng Department of Agriculture and Rural Development (GDARD).
Gauteng Ridges	Gauteng Department of Agriculture and Rural Development (GDARD).
Gauteng EMF	
Zone 1	Gauteng Department of Agriculture and Rural Development (GDARD), papered by Environomics CC (2014). Debbie Claassen.
Zone 2	
Zone 3	
Zone 4	
Zone 5	
Basemaps	
World Street Map	ESRI
Shaded Relief	ESRI
World Imagery	ESRI
World Topographic Map	ESRI