The quality of Ecological Reserve Inputs in Environmental Impact Assessments for water resource development projects in South Africa

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PREFACE AND ACKNOWLEDGMENTS

To all my friends and family and my loving fiancé who has supported me throughout my research dissertation, thank you all so much. Words cannot express how much it has meant to me. Not only have I learned a lot these past few months about my own abilities and limitations, but I have also seen how important it is to have people in your life who support and love you. It would have been a much more challenging journey without you!

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“don’t dig up in doubt what you have planned in faith”

- Elisabeth Elliot

ABSTRACT

The Ecological Reserve characterises the quantity and quality of water required to maintain long-term ecological functioning of an aquatic ecosystem and is regarded as a key element of integrated water resource management. Furthermore, in South Africa obligations for implementation of the Ecological Reserve are binding in terms of the National Water Act (Act 36 of 1998). Water resource developments such as dams and hydropower developments are associated with several environmental and social impacts, which may implicate meeting the Ecological Reserve within a water resource.

Environmental Impact Assessment (EIA) is one of the most important and widely implemented regulatory instruments for protection of the environment. The quality of EIAs may therefore, exercise an influence on the protection of aquatic ecosystems and the statutory obligation of realising the Ecological Reserve.

The quality of Ecological Reserve Inputs in Environmental Impact Assessments for water resource development projects in South Africa was investigated as part of this study. A review package was developed in order to determine the quality of Ecological Reserve inputs in EIAs. Similar to previous studies the Lee and Colley review package was adapted. Key criteria related to the Ecological Reserve were added to the Lee and Colley Review package and applied to 7 water resource development EIAs.

This quality review of Ecological Reserve inputs into EIAs for water resource developments in South Africa shows that seventy-one percent (71%) of the selected EIAs were satisfactory. This demonstrates a relatively good overall quality of the EIAs in the water resource development sector. Areas of strengths include descriptive and presentational areas. However, several omissions and inadequacies, specifically at subcategory level, were shown in all the EIAs despite the overall satisfactory results, which included hydrology and flow inputs, ecosystem goods and services, significance to the affected community, and public participation.

Keywords:

Ecological Reserve, environmental impacts assessment, quality review, water resource development

ABBREVIATIONS AND ACRONYMS

EIA	Environmental Impact Assessment
EI & ES	Ecological Importance and -Sensitivity
EWR	Ecological Water Requirements
NEMA	National Environmental Management Act (Act 107 of 1998)
NWA	National Water Act (Act 36 of 1998)
PES	Present Ecological State
REC	Recommended ecological category

KEY DEFINITIONS

Ecological Reserve means the quantity and quality of water required
(a) to satisfy basic human needs by securing basic water supply, as prescribed under the Water Services Act. I 97 (Act No, 108 of 1997). For people who are now or who will, in the reasonably near future. be—

(i) relying upon;
(ii) taking water from; or
(iii) being supplied from,

the relevant water resource; and
(b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use the relevant water resource.

Water Management Area: An area established as a management unit in the national water resource strategy within a catchment management agency will conduct the protection, use, development, conservation, management, and control of water resources, in term of the NWA (Act 36 of 1998)

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CHAPTER 1 INTRODUCTION

The section of this dissertation focuses on the need for the consideration of the Ecological Reserve in Environmental Impact Assessments (EIAs) for water resource development projects. In Chapter 1 an overview of the key concepts related to the research dissertation is provided including the research aim and research questions. An overview is given of the structure of the dissertation to assist the reader to review the content.

1.1 Problem statement and rationale for the study

Aquatic ecosystems, such as rivers and wetlands, are essential in providing ecosystem goods and services to society. A certain quantity and quality of water is required to maintain functioning and resilience of aquatic ecosystems and is internationally known as environmental flows. However, according to the World Bank (2009) the allocation of such environmental flows remains a highly contested process during water resource development.

As a key factor in the protection of aquatic ecosystems, environmental flows have been recognised by some countries as part of national legislation and initiatives have been taken towards implementation of the environmental flows (Chen *et al*., 2013). However, no international agreement specifically related to environmental flows has been determined.

As mentioned previously, in South Africa (SA) environmental flows are referred to as the Ecological Reserve. Rights to water are provided for in the National Water Act (Act 36 of 1998) (NWA) and secures basic human needs as well as the Ecological Reserve (hereafter the Reserve). The Reserve has priority over other water users and is utilised for protection of aquatic ecosystems for the sustainable development and use of water resources and relates to quantity and quality of water required to protect the aquatic ecosystems of a water resource. Several methods, known as environmental flow assessments, have been developed in SA to determine the reserve and to assess the ecological condition of water resources (King & Louw, 1998; Hughes & Munster, 2000; Hughes & Louw, 2010)). The Minister responsible for water affairs is required to determine a Reserve for water resource of significance in terms of Chapter 3 of the NWA. Once a Reserve is determined for a water resource, it becomes a binding statutory obligation to consider the quantity and quality of water attributed to environment for a particular water resource during water resource planning and development.

Water resource developments, such as dams, hydropower schemes and abstraction weirs, are prevalent in streams and rivers globally due to increasing demands for irrigation, energy, and drinking water (Arroita, et al., 2017). In SA there is an estimated four thousand four hundred and

fifty-seven (4 457), small to large, registered dams (SANCOLD, 2009), and currently eight (8) large operational hydroelectric power stations (Klunne, 2017). Water resource developments can have significant environmental impacts and have become of global concern (Zelenakova & Zvijakova, 2011). These developments have been noted to change hydrological cycle processes (Gleick, 2000) which in turn cause negative responses of aquatic and terrestrial ecosystems (Nilsson & Breggren, 2000).

The potential impacts of these water resource development projects on the environment can be broadly classified as follows (Adgolign & Srinivasa, 2014:182): "*impacts within and around the area in which the development is located, downstream impacts as a result of the alternation in hydraulic regime, and regional impacts including resources use and socio-economic impacts*".

According to Nilsson *et al*. (2005), impacts due to river fragmentation and flow regulation occur in fifty-nine percent (59%) of global large river systems. Loss of regionally distinct flow regimes and the proliferation of alien invasive species have been noted to occur due to these modifications (Poff, et al., 2007). Other impacts associated with water resource developments include abiotic impacts to water quality and sedimentation, and biotic impacts such as changes in fish migrations and vegetation composition (McCartney, 2009).

Similar impacts have also been noted for South African impoundment and abstraction developments. Some examples include: The Inanda Dam has resulted in the retention of sediment behind the dam wall which had led to the reduction in available downstream sediment (Garland & Moleko, 2000). Dams in Limpopo have been noted to lead to a downstream reduction in riparian vegetation and increase in terrestrial vegetation (Mokgoebo *et al.*, 2018). Abstraction from the Sabie River has also been linked to downstream changes in vegetation composition alongside the river in the Kruger National Park (Brown & King, 2002).

In SA, the manipulation of river flow regimes and the quality thereof, through abstraction and storage and / or uncontrolled releases from upstream dams has also been reported to result in the deterioration of biodiversity in riparian and aquatic ecosystems and overall health of the country's rivers (King & Louw, 1998; Mokgoebo, *et al*., 2018). However, by implementing environmental flow assessments as part of the design and operation of water resource developments, it may act to mitigate the negative impacts of river regulation and protect or restore aquatic ecosystems (Owusu, *et al*., 2021).

Internationally, an Environmental Impact Assessment (EIA) is one of the most important regulatory instruments to evaluate impacts of development activities on water resources (IUCN ELC, 2003; Tortajada, 2000). Many developments affecting water resources in SA trigger an

Environmental Impact Assessment (EIA). The aim of an EIA is to consider and predict the consequences of development activities on the environment to inform authorities, as well as the public, of these potential impacts prior to decision-making (IAIA, 1999); Wood, 2008). Since the EIA for a development forms the basis for decision-making (Sandham, *et al*., 2020), the quality of the EIA report is critical if sound authorisations are to be made. The review of EIAs is therefore essential, as it ensures that the information submitted for decision-making is convincing and adequate (Sarmah, *et al*., 2020).

In the case of EIAs for water resource development projects, the quality of EIAs may exert an influence on the protection of aquatic ecosystems and the statutory obligation of realising the Ecological Reserve. One could also argue that EIAs conducted for water resource development projects requires the inclusion of specific information or assessments such as environmental flow assessments to ensure the protection of water resources.

The review of EIA quality has been the subject of several research studies internationally as well as in SA. In SA, these studies investigate the quality of EIA reports conducted for, amongst others, mining, wetlands, energy, and protected areas (Sandham, *et al*., 2008; Boshoff, 2019; Sandham *et al*., 2020). However, there has been little research regarding the quality of EIA reports specifically with regards to the quality of Ecological Reserve inputs for water resource development projects in SA.

1.2 Research aim and objectives

Based on the problem statement above, the following aim has been established for this study: To determine the quality the Ecological Reserve inputs in EIAs for water resource development projects in South Africa.

To achieve the aim of the research the following objectives have been identified:

1. To develop a review package to determine the quality of Ecological Reserve inputs to EIAs for water resource development projects.
2. To apply the developed review package to selected EIAs for water resource development projects.
3. To provide recommendations to improve the quality of Ecological Reserve inputs to EIAs for water resource development projects.

1.3 Assumptions and limitations

The assumptions and limitations noted for this study are as follows:

- EIAs for water resource development projects are in the public domain and easily accessible;
- The documentation evaluated will mostly focus on the Environmental Impact Report and the associated specialist studies. Environmental Management Programmes (EMPRs) and Environmental Authorisations (EAs) could also have been considered as documentation for quality evaluation:
- The quality of EIAs for water resource development projects with particular reference to the quality Ecological Reserve inputs will be evaluated in this study and not the effectiveness of the EIA in addressing the Reserve.
- Only 1 reviewer undertook the majority of the EIA reviews, with an inter-comparison approach only applied to 1 of the selected EIAs.

1.4 Structure and outline of the dissertation

Table 1-1 provides an overview of the overall structure of the dissertation.

Table 1-1: Research Dissertation Outline

Chapter 1	• Key concepts – Ecological Reserve and water resource development • Problem Statement • Research Aim and Objectives • Assumptions and Limitations • Structure of the dissertation
Chapter 2	• Literature Review o The Ecological Reserve ▪ Concept of the Ecological Reserve o Methods to Determine the Ecological Reserve ▪ Content and Status of Reserve Determinations in South Africa o Incorporating the Ecological Reserve into EIAs o Guidelines and Legislation in SA for consideration of the Ecological Reserve in EIAs o EIA – Purpose of Quality Review ▪ EIA quality Review – International trends

	▪ EIA quality Review – South African trends ▪ Summary on EIA Quality Review o Chapter Summary
Chapter 3	• Research Design • Report Selection • Data Analysis o Review methodology • Ethical Considerations
Chapter 4	• Overall quality of consideration of the Ecological Reserve in EIAs o Results of different review criteria o Summary of Results
Chapter 5	• Conclusions and Recommendations o Concluding Remarks ▪ Identified strengths and weaknesses o Recommendations o Areas of Further Research

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

In this chapter existing literature related to the research aim is explored. To determine criteria for the review of the Ecological Reserve inputs to EIAs, content discussed includes an overview of the incorporation of the Ecological Reserve into EIAs both internationally and locally and the methods used to determine the Ecological Reserve. An overview on the development of EIA review packages is also discussed, as this will aid in the development of a review package to determine the consideration of the reserve in EIAs for water resource development projects.

2.2 The Ecological Reserve

The following sections provide an overview on the concept of the Ecological Reserve from both an international and local viewpoint. The impacts associated with water resource developments and its implications on the Ecological Reserve are also briefly discussed.

2.2.1 Concept of the Ecological Reserve

Several terms and definitions have been developed related to the provision of water to the environment (Katz, 2006). There are many definitions, and to some extent, interchangeable terminology for the concept of the Ecological Reserve which includes amongst others Instream Flow Requirement, environmental flows, or Ecological Water Requirements. 'Environmental flows' is a term often referred to internationally (Dube *et al*., 2015). It is defined as the water requirements of aquatic ecosystems to maintain its physical and chemical structure, biodiversity, ecosystem processes, and function that gives its specific characteristics (Arthington *et al*., 2006). The Brisbane Declaration (2007: 4) also provided a widely recognised definition of environmental flows as *"the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems*." In South Africa, this concept is generally referred to as the Ecological Reserve. The Ecological Reserve is defined in the National Water Act (Act 36 of 1998) and represents the quantity and quality of water required to maintain long-term ecological functioning of an aquatic ecosystem.

Ecological Reserve for water resources has been regarded by stakeholders in certain catchments to be in direct competition with human needs (van Wyk, *et al*., 2006). However, the water reserved and allocated for the protection of aquatic ecosystems also indirectly contribute to the livelihoods of people through the provisions of ecosystem services (Acreman, 1998). The Ecological Reserve

is therefore regarded as a key element of integrated water resource management (Dyson, *et al*., 2008).

2.3 Methods to Determine the Ecological Reserve

Several environmental flow assessment methodologies, which accommodate different project timeframes and scales; and constraints, such as data availability, budgets, specialist inputs, and human resources (Brown & King, 2002); are currently available. The main method categories of environmental flow assessments are namely, hydrological, hydraulic rating, habitat rating, and holistic assessments (King, *et al*., 1999).

To broadly summarise the flow assessment method categories stated above, hydrological methods primarily make use of historical flow records for environmental flows with scant reflection on ecological criteria. Hydraulic rating methods make use of hydraulic variables, such as water depth or velocity, and discharge, to develop environmental flow recommendations. Habitat simulation methodologies make use of hydraulic variables, but also link these with flows required to meet habitat requirements of selected river species. Holistic methods are considered to be the most comprehensive form of environmental flow assessments. Table 2-1 below provides a summary of the commonly used flow assessment methods.

Table 2-1: Summary of commonly used environmental flow assessment methods (Tharme, 2003)

Category and/or Methods	Description
Hydrological	Summary statistics from hydrological data sets, such as a percentile from the annual flow duration curve, or the lowest recorded flow, to set what is often called a “minimum flow” for the river.
Hydraulic Rating	Uses hydraulic variables, such as depth, as substitutes for ecological data on habitat and predict how these will change with variations in discharge.
Habitat-Simulation	Measures the most-often used hydraulic habitat of indicator species (fish, vegetation, invertebrates etc.) and then model how much

	of this habitat would be available over a range of water flows.
Holistic	Addresses the condition of the whole river ecosystem. These methodologies are often connected to resource, and socioeconomic issues.

Although the application of holistic methodologies has been noted to only form part of eight percent (8%) of the global application of environmental flow assessments, these methods continue to contribute greatly to the field of environmental flow assessments (Tharme, 2003: 407). By using holistic methods, the predicted basin-wide ecological and social outcomes linked to scenarios of different water management options, can be described (King & Brown, 2018). The Building Block Methodology (BBM) (King & Louw, 1998; King, et al., 2008), and the Downstream Response to Imposed Flow Transformations (DRIFT) (King, *et al*., 2004) are both holistic methods that have been developed and are most frequently used in South Africa.

Both the BBM and DRIFT methodologies share a conceptual basis by means of analysing the biophysical and hydraulic conditions of a river to determine the required environmental flows, and both methodologies can link well with public participation processes. The DRIFT methodology however, has more explicit socio-economic components and can assess more alternative scenarios relative to the BBM (Tharme, 2003).

Holistic methodologies are generally demanding in terms of data requirements and human resources (Tegos, *et al*., 2018). Specialist inputs into flow-related requirements of each ecosystem component (geomorphology, hydrology, water chemistry, fish, macro-invertebrates) with as much supporting data as possible, as well as socio-economic cost and benefits, are required to implement these methods.

In addition, challenges that have been noted for environmental flow assessments in general include, amongst others (Seaman, *et al*., 2010):

- Establishing of reference conditions, which is one of the early stages of an environmental flow assessment. This is mainly due to a lack of present and historical data of a water resource.
- Hydrological modelling due to a lack of sufficient and reliable rainfall and runoff data.

Despite these challenges, environmental flow assessments allow estimates to be made regarding the amount of water required for the protection of resources and the amount of water available for future development (Brown and King, 2002).

2.3.1 Content and Status of Reserve Determinations in South Africa

In South Africa, the Minister of Water Affairs is required to determine the Reserve, which considers both basic human needs and the ecological reserve, for each significant water resource or part thereof. The objective of a reserve determination study is to determine the Ecological Reserve for a water resource to ensure resource protection while considering the legal, socio-economic and sustainability needs of the resource. The Reserve is the only right to water in the NWA. It therefore has priority over all other water use, and the amount of water required for the Reserve must be met before water resources can be allocated to other water users (Dennis, 2015).

As part of the protection of water resources, the classification of a water resource must also be undertaken as defined in Chapter 3 of the NWA. The main objective of the classification process is to define the class in which a resource can be sustainably utilised without significantly altering the natural characteristics of the resource (Kleynhans & Louw, 2008). Areas for assessment or resource units are determined as the initial step in classification process. Ultimately the Ecological Reserve is set for each of these units within a water resource. The key content and components of a Classification and Ecological Reserve determination is detailed in the table (Table 2-2) below.

Table 2-2: Key components for Ecological Reserve Determinations (Louw & Hughes, 2002; Kleynhans & Louw, 2008)

Component	Description
Areas of assessment / resource units	Areas within a water resource are defined based on levels of sustainable use, stress indexes, hydrological, and ecological characteristic.
Reference conditions	Defining natural conditions of assessment area prior to anthropogenic impacts.

Present Ecological State (PES)	Determining the current state of the resource by modelling driver components (geomorphology, hydrology, water quality) and biological response components (fish, macro-invertebrates, vegetation). This is then used to determine the overall health of the resource.
Ecological Importance and Sensitivity (EI & ES)	Modelling the water resource's ability to maintain ecological diversity, as well as its ability to recover from disturbance.
Habitat Integrity	Evaluation of both the instream and riparian components.
Management Class and Recommended ecological category (REC)	The management class for a water resource is based on observed anthropogenic impacts. It ranges from Minimally Used (I) to Heavily Used (III). Present ecological category and Ecological importance and sensitivity, are also used to determine the Recommended Ecological Category for a water resource unit. The management class and REC are based on the water resources' ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services.
Ecological Water Requirements (EWR)	Determining the quantity of water needed to maintain the Recommended Ecological Category. Environmental flow assessment methods are utilised. A range of operational scenarios are also developed to assess the impact of incorporating the Ecological water requirements on ecology, system yield, goods and services and economic activities.
Ecological Reserve	The percentage of time that defined flows, should equal or exceed the flow regime to satisfy the ecological reserve.

A map published by the Directorate of Resource Directed Measures, Department of Water Affairs in 2010 (refer to Figure 2-1), provides an overview of the status of reserve determinations across

the previous sixteen (16) water management areas in South Africa (currently there are only nine (9) water management areas). A water management area is an area established as a management unit in which the protection, use, development, conservation, management and control of water resources will be conducted (NWA, 1998).

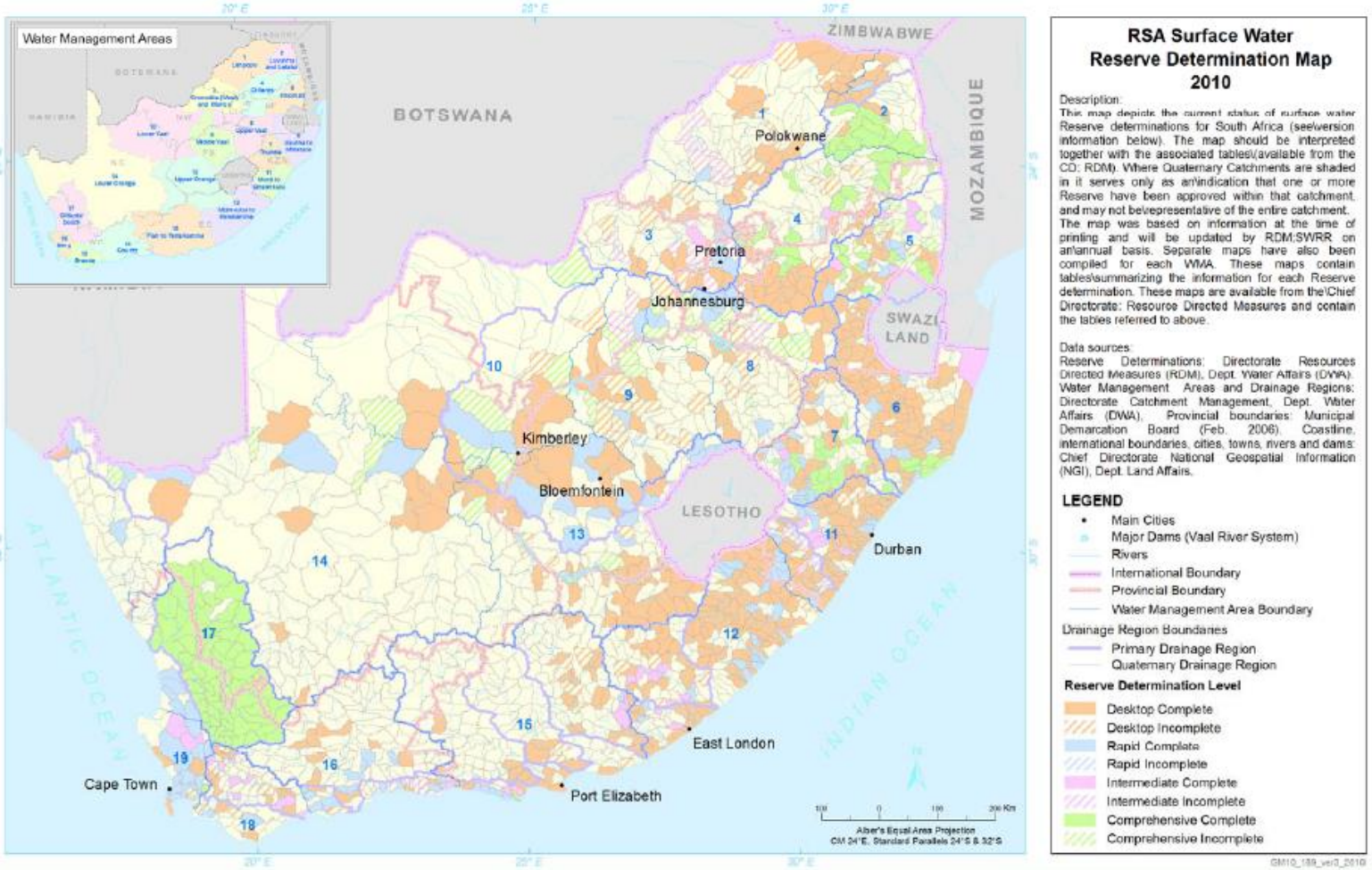

Figure 2-1: Map of Reserve Determinations across quaternary catchment in South Africa.

Reserve determination studies can be carried out at different levels of effort and information requirements (e.g., desktop, rapid, intermediate or comprehensive). From Figure 2-1 above, it can be seen that the majority of the reserve determinations have been undertaken at desktop-level, which is shown by the solid orange areas. Although a number of comprehensive reserve determinations have been undertaken and subsequently gazetted, it has been restricted to larger catchments with greater abstraction schemes (e.g., Vaal catchment, Inkomati catchment, Breede-Gouritz catchment etc.). Where a desktop reserve determination study has been undertaken, it is mostly due to a lack of long-term monitoring data, and budgetary and time constraints (Adams, *et al*., 2016). Also, where catchments are completely lacking reserve determinations, preliminary reserves may have to be undertaken to determine the reserve applicable to a specific development, which is often a time-consuming process, and may delay authorisation processes.

2.4 Incorporating the Ecological Reserve into EIAs

Releasing water from impoundments or restricting the volume of water abstracted from a water resource, are both instances in which water can be supplied for the Ecological Reserve. Methods have been developed since the mid-1970s to determine the Ecological Reserve for a given water resource (Acreman & Dunbar, 2004). The methods for determination of the Ecological Reserve are commonly referred to as environmental flow assessments (King, *et al*., 2008).

Environmental flow assessments are recognised by the World Bank as an intrinsic part of integrated water resource management (World Bank, 2009). Brown and King (2002) have noted that to achieve sustainable use of water resources, the environmental impact assessments (EIAs) for water resource developments need to ensure that environmental flow assessments are integrated into the EIAs.

Internationally, EIAs have been used as tools to identify and assess environmental impacts of developments prior to commencement (UNEP, 2018). Information obtained and captured during an EIA is also used to inform the competent authorities (i.e. decision-makers) on the acceptability of a project to proceed as from an environmental and social perspective (IAIA, 1999). The need to integrate an environmental flow assessment as a component of an EIA for a water resource development, is motivated on the basis that it makes provision for maintaining the integrity of aquatic ecosystems by establishing the release of water to the environment and anticipates the impact of hydrologic modifications on downstream environments (Flint, et al., 1996). Therefore, conducting environmental flow assessments as part of EIAs may act as a mitigation to the several negative impacts downstream of the development (Adgolign & Srinivasa, 2014). For instance,

Yang, *et al*., (2016) have found that the implementation of environmetal flows increased regulating services, such as sedimentation, and maintained biodiversity and ecosystem services.

According to the World Bank's *Good Practice Handbook: Environmental Flows for Hydropower Projects* (2018), aligning the EIA with findings of the environmental flow assessment ensures that impacts are properly assessed. In addition, environmental flow assessments support several fundamental principles of EIAs (refer to Table 2-3).

Table 2-3: Fundamental Principles of EIAs supported by Environmental Flow Assessments (adapted from World Bank, 2018)

Principles of EIA	Environmental Flow Assessment Activities
Assessing Alternatives	Scenarios relating to different project locations, designs and release regimes are analysed to assess the risks to the environment; to determine the extent of deviation from the ecological and social baseline; and to optimise design and operation of the development.
Mitigation Hierarchy	Impacts may be avoided by considering implications of alternative project locations. Impacts may be minimised by considering different operational flow scenarios. By incorporating restoration methods into flow scenarios impacts may also be offset.
Area of Influence	Predication of impacts are provided for the full upstream and downstream extent related to the alternation of the aquatic environment.
Stakeholder Engagement	Inputs should be obtained from stakeholders on ecosystem uses, livelihood dependence, conservation priorities, possible water resource developments, and other aspects of concern to them that should be included in the investigation of flow scenarios.

Specific project level case studies which included the integration of environmental flow assessments into the EIAs include, amongst others, the development of the Berg River Dam in South Africa, and to some extent the Lesotho Highlands project (Hirji & Davis, 2009). According to Hirji and Davis (2009), the environmental flow assessment for the Berg River Dam was fully integrated with the EIA during the project planning phase and was influential in determining the initial operational rules and further adaptations for the impoundment. The data collected as part of the baseline monitoring programme, were used to develop a conceptual model to determine and manage changes in flow regime and the physical, chemical and biological characteristics brought about by the dam.

Although the case studies above are examples that environmental flow assessments, with their in-depth insights into river functioning, are being mainstreamed into EIAs for water resource development projects, the integration between these two assessments remains yet to be fully adopted (Hirji & Davis, 2009). This was illustrated in an assessment undertaken by the World Bank, where only 1 of the 8 water resource development case studies combined the environmental flow assessment with the project EIA (Hirji & Davis, 2009). Given this lack of integration, it has further been noted that the substantial changes to aquatic ecosystems and its dependent social environment are not being made clear during EIAs where dams are involved (King & Brown, 2018).

2.5 Guidelines and Legislation in SA for consideration of the Ecological Reserve in EIAs

According to Lee and Colley (1999:31) the criteria for review of an EIA should, where necessary, be adapted to the local regulatory context of the country in which the EIA review is undertaken. In this section the legislation applicable to the Ecological Reserve and EIAs for water resource developments are discussed, which will inform the development of criteria.

There are several Acts and Regulations in South Africa relevant to the environmental management field. Those directly relevant to the environment and specifically to the Ecological Reserve are namely the National Water Act (Act 36 of 1998) (NWA) and the National Environmental Management Act (Act 107 of 1998) (NEMA).

The concept of the Ecological Reserve is enshrined in South African legislation as part of Chapter 3 of the NWA.

> *"Part 3 deals with the Reserve … The ecological reserve relates to the water required to protect the aquatic ecosystems of the water resource."*

The NWA is therefore the main Act relevant to the Ecological Reserve. However, the sustainable use of the environment (including the aquatic environment) and protection of ecosystems is essentially governed by the NEMA. The principles found in section 2 of the NEMA provide a framework for environmental management and serves as guideline in which environmental decisions must be taken. Couzens and Dent (2006) have highlighted the link between the Ecological Reserve and the principles of NEMA in the case of the De Hoop Dam. It was stated that although no ecological reserve determinations have been determined for the catchment in which the De Hoop Dam is located at the time of authorisation, the ecological reserve could not be disregarded, as the principles of NEMA require that environmental management be integrated and considered in the effects of decisions on all aspects of the environment and all people in the environment.

The NEMA also has jurisdiction over environmental assessment and governs the requirements of the studies which need to be undertaken prior to authorisation. In addition, in terms of section 4(b)(vii) of the NEMA where an environmental assessment is undertaken, every application for an environmental authorisation should make provision for the adherence to requirements that are prescribed in a specific environmental management Act relevant to the listed activity triggered. Therefore, the requirements of the NWA, such as protection of water resources (Part 3 of the NWA), and water use (Part 4 of the NWA) should also be adhered to for water resource development projects.

Regulations under NEMA have been promulgated in 2006, 2010, 2014, and 2017, and are referred to as the EIA Regulations. The 2006 EIA Regulations provide thresholds for listed activities in Regulation 386 and Regulation 387. A Basic Assessment was required for activities listed in Regulation 386, and a full Environmental Assessment was required for activities listed in Regulation 387. The subsequent EIA Regulations also followed a similar approach in terms of listed activities and assessments but have become more detailed, inclusive, and well-defined (Huysamen, 2019). The development of a dam, as well as the construction of weirs, triggers the need for an environmental authorisation in terms of the EIA Regulations 2010, 2014, and 2017.

Currently, there are no specific regulations in South Africa detailing the requirement and assessment of the Ecological Reserve in EIAs. However, recent regulations on the procedures for the assessment and minimum criteria for reporting on identified environmental themes for activities requiring environmental authorisation (GN 320 of March 2020), refer to Aquatic Biodiversity Assessments. Where such assessments are undertaken, several components related to the Ecological Reserve require consideration. For instance, the specialist input on aquatic biodiversity must report on how the proposed development will impact on the functioning

of the aquatic features, which must further include an assessment of the impact on base flows, change in hydrological regime, and water quality. To include legal requirements prescribed in terms of South African EIA regulations, the prescribed requirements for the content of an Environmental Impact Assessment Report and Basic Assessment Report, as contained in Appendix 1 and 3 of EIA Regulations in terms of the NEMA are also considered.

2.6 EIA – Purpose of Quality Review

Evaluating the quality of an EIA is of particular importance to determine the adequacy of information available for decision-making regarding environmental and social impacts (Sandham & Pretorius, 2008). Review packages and checklists, such as those proposed by Elkin and Smith (1988) and Lee *et al.* (1999) are mainly used to determine EIA quality. During a quality review the content of the EIA, or specific reports contained in the EIA, are scrutinised against predetermined review criteria. A rating scale is used to evaluate the extent to which the EIA content conforms to the selected review criteria. Since the key components of the Ecological Reserve (as discussed in the sections above) are used to inform the EIA review package for this study, EIA quality review, as well as the evaluation methods related to it, and a summary of previous international and national EIA quality review studies are discussed in the sections below.

2.6.1 Quality of EIA Reports

The quality of EIA documentation is widely evaluated through the use of quality review packages. A package typically consists of different report quality review criteria against which the quality of EIA reports can be evaluated (Sandham, *et al.,* 2020).

Another aspect of EIA quality that may also be considered, is the improvement of EIA quality over time. From an international perspective, in a study undertaken by Barker and Wood (1999) on the quality of EIAs in European Union countries, it was determined that with experience of environmental assessment practitioners (EAP) EIA quality tends to improve over time. Similarly, Kamijo and Huang (2016) investigated the quality of EIAs undertaken in Japan during 2001 and 2021, using an adapted Lee and Colley review package. It was determined in the study that there was an improvement in EIA quality after in the introduction of regulatory guidelines.

EIA quality review - International trends

Various studies have been conducted internationally regarding the quality of EIAs across various sectors. A summary of the quality review results from randomly selected international studies

which made us of the Lee and Colley Review Package is provided below. The evaluation of the below studies is of relevance as it provides insight into which review areas of the Lee and Colley Review Package are commonly identified as strengths and weaknesses.

- **Environmental Impact Statements in Egypt**

Badr *et al.* (2011) have evaluated the quality of forty-five (45) environmental impact statements in Egypt between 2000 and 2007. It was found that sixty-nine percent (69%) of the environmental impact statements were found to be of statisfactory quality. Review categories of weaknesses included impact prediction, significance evaluation, scoping, and consideration of alternatives.

- **Environmental Impact Assessment for the industrial sector in Bahrain**

Yaqoob *et al.* (2019) have investigated the quality of EIA reports with respect to energy conservation and gas emissions. The results obtained from the study have indicated that aspects of gas emissions received more attention than energy conservation. The considertation of air quality was reflected as good (75%) and satisfactory (25%) in the reports. The reports were assessed as satisfactory (25%), borderline (50%) and poor (25%) quality with regards to the coniseration of the efficiency and energy consumption aspects,. Weaknesses noted in the EIA reports included descriptions of the project, the baseline environment, prediction of impacts, and monitoring of residual impacts.

From a water resource development perspective, quality reviews studies include the reviews of EIAs for small-scale hydropower projects in Portugal (Pinho, *et al*., 2007), and the review of the EIA for the Myitsone Dam in Myanmar (Aung, *et al*., 2019). Both of these EIA reviews have made use of the Lee and Colley review package (1999). A summary of the quality review results for international water resource development studies is provided below.

- **Portugese Small Hydropower Projects**

The EIA quality for thirteen (13) small-scale hydropower projects has been investigated in Portugal. From this study Phino *et al.* (2007) have determined that the EIA quality of small-scale hydropower projects were overall satisfactory (fair). Poorly adressed review criteria included: public particpation, scoping, alternatives, and monitoring, whereas baseline conditions, identification of impacts, and projects description were well preformed. Phino *et al.* (2007) have also concluded that the type and size of the project influenced the quality of the EIAs produced, as the larger projects delivered better quality EIA reports.

- **Chinese EIA in Myanmar: Myitsone Dam**

The overall quality of the Myitsone Hydropwer Dam EIA was found to be statisfactory (Aung, *et al*., 2019), with alternatives and mitigation, and public participation being poorly preformed review areas. Based on the results of the study it was recommeded that project proponents need to stengthen their EIAs by improving transparency and stakeholder engagement, and to make practical contributions to local development. The study has proved useful to identify strengths and weaknesess of mega developments such as the Myitsone Dam, and to help manage sustainable development.

EIA quality review - South African trends

The Lee and Colley review package has also been used to conduct several EIA report quality review studies in South Africa as well (Sandham, *et al*., 2008; Sandham, *et al*., 2008; Boshoff, 2019; Sandham *et al*., 2020). Van Heerden (2010) has created a generic review package suitable to the South African EIA system by adapting the Lee and Colley review.

One previous EIA study incorporating water resources, although not the Ecological Reserve, has been undertaken in South Africa. This EIA quality review considered projects affecting wetlands in South Africa (Sandham *et al.*, 2008). The study stated that the information available in the EIA for decision-making is a major determining factor in the outcome of wetland protection and / or destruction (Sandham *et al.*, 2008:156). Four EIA reports were evaluated using an EIA report quality checklist. The reports were found to be “generally satisfactory” or “just satisfactory”. The areas of greatest weakness are related to impact identification, magnitude and significance of impacts, site descriptions and wastes.

Huysamen (2019) has concluded that based on evaluation of previous research, EIAs in South Africa are generally satisfactory, with the main weaknesses being analytical components such as identification and analysis of impacts, alternatives, and impact magnitude and significance.

Summary on EIA Quality Review

The international and local studies discussed above show that the Lee and Colley review package is well-known and widely used, as well as easily adaptable to determine report quality across different EIA sectors. Review categories of weaknesses noted in the EIA reports, generally included descriptions of the project, the baseline environment, prediction of impacts, and monitoring of residual impacts, whereas baseline conditions, identification of impacts, and projects description were generally well preformed review categories. Lastly, it is assumed that

EIA quality improves over time as regulations and / or guidelines are implemented or experience is gained.

A detailed description of this review package is provided in Chapter 3.

2.7 Chapter summary

Given that water and other environmental resources are linked, it is important to address issues related to water holistically with other environmental resources. EIAs are vital tools to ensure that negative environmental impacts are avoided and mitigated and are vital for sound decision-making. Aligning the environmental flow assessment with the EIA for a water resource development project is an intrinsic part of integrated water resource management and vital for sustainable development of water resources. aligning the EIA with findings of the environmental flow assessment ensures that impacts are properly assessed. In addition, environmental flow assessments support several fundamental principles of EIAs

Although the integration of environmental flows with EIAs are improving (World Bank, 2018), the assessment of environmental flows has yet to be properly integrated into many EIAs. This disconnectedness between the environmental and water resources sectors may be counterproductive in promoting environmentally responsible development (World Bank, 2009).

The Ecological Reserve plays a key role in protection of aquatic ecosystems which also indirectly contributes to the livelihoods of people through the provisions of ecosystem services. The development of water resources however threatens the statutory obligation for protection of the Ecological Reserve. The Ecological Reserve is given effect to by means of environmental flow assessments, which assess several abiotic and biotic components of aquatic ecosystems. These key components ought to be included in EIAs conducted for water resource development projects to ensure the protection of water resources.

Several methods have been developed to quantify the Ecological Reserve. If a holistic method is applied for the environmental flow assessment, the various ecological and social components related to a water resource ought to be considered. Undertaking environmental flow assessments for water resource development are crucial to determine the impact of the development on the Ecological Reserve.

Certain criteria are required in an EIA for a water resource development, as this may influence the protection of the Ecological Reserve. The quality of EIA documentation is widely evaluated by quality review packages. Based on the literature review of EIA review quality studies, review

categories of weaknesses noted in the EIA reports, generally included descriptions of the project, the baseline environment, prediction of impacts, and monitoring of residual impacts, whereas baseline conditions, identification of impacts and projects description were generally well preformed review categories. The development of an adapted review package based on the literature discussed above, has been undertaken in Chapter 3 of this dissertation.

CHAPTER 3 METHODOLOGY

Throughout this chapter the research design and methodology used to address the aim and objectives for this study is described.

3.1 Research design

Case study research has become widely accepted as a valid approach to quality review (Eisenhardt, 2002; Robson, 2002). This type of research has been shown to be an effective methodology to investigate and understand complex issues in real world settings (Harrison *et al.*, 2017). Creswell *et al*. (2007) defined case study research as a qualitative research approach during which the investigator evaluates a case or multiple cases, through in-depth data collection from multiple sources (e.g., documents and reports).

The main stages of the of case study research are as follows; define the case, which is based on the research aim and objectives; select the case(s); collect and analyse the data; interpret data; and report on findings (Crowe, *et al*., 2011). A similar approach has been followed throughout this research, specific EIAs related to water resource developments in SA were collected; the selected EIAs were analysed against a set of criteria to determine the quality of the Ecological Reserve inputs; and data were interpreted to determine the quality of Ecological Reserve inputs considered in EIAs for water resource development projects. The analysis of the quality of Ecological Reserve inputs is quantitative in nature.

3.2 Data collection methods

The sections below detail how data (EIAs) were obtained and the criteria that were used for the selection of reports for this research.

3.2.1 Report selection

Eisenhart (2002) has indicated that between four and ten (4 and 10) cases can work well for case study research. This research has also relied on replication logic (Yin, 2014) in that reports were chosen on the assumption that they would produce similar and comparable findings.

EIAs were sourced based on the focus of this research, which is the Ecological Reserve and its consideration in EIAs for water resource development projects. The EIAs were either sourced by contacting consulting firms, using consulting firm websites, or the Department of Water and

Sanitation's Integrated Water Resource Planning project page.[1] The Environmental Impact Report (EIR) as well as specialist reports, such as aquatic, and surface water assessment, are considered as part of the report selection sample.

The selection was limited to large-scale dam, abstraction, and hydro-power developments. The reason for their selection is that these types of developments are relatively recent large-scale developments of national importance with the potential to influence the Ecological Reserve. The selected reports also fall under the ambit of the EIA Regulations (2006, 2010, 2014, and 2017) including environmental impact reports and basic assessment reports. The seven (7) case studies were therefore selected for this research and are detailed in Table 3-1 below.

Table 3-1: Table of EIAs selected for this research and their respective water resource development type and specialist inputs.

Report	Development type	Specialist Study			
		Aquatic Ecology	**Water Quality**	**Hydrology**	**Water Resource Assessment**
1	Dam Mpumalanga (De Hoop 2005)	**X**	**X**		
2	Dam Limpopo (Nwamitwa 2008)	**X**			
3	Storage Dam (Ncwabeni 2013)	**X**	**X**		
4	Hydropower Groblershoop (Boegoeberg 2014)	**X**		**X**	
5	Dam Eastern Cape (Foxwood 2015)	**X**		**X**	
6	Hydropower Ash River (Kruisvallei 2018)	**X**		**X**	
7	Abstraction weir (Umkhomazi 2018)				**X**

In instances where reports were sourced via contacts at consulting firms, some specialists and environmental assessment practitioners who provided reports have requested to remain anonymous, therefore consultancy details will not be mentioned in this dissertation.

3.3 Data Analysis

The methods used to analyse data, in order to determine the extent of consideration of the Ecological Reserve in the selected case studies, are described in this section.

[1] Integrated water resource planning website: Projects & Programmes (https://www.dws.gov.za/iwrp/projects.aspx)

3.3.1 Review Methodology

Data analysis for this study consists of reviewing the selected EIA reports against the determined review criteria.

Numerous EIA review packages do exist, with the Lee and Colley EIA review package (Lee, *et al*., 1999) likely to be the most widely applied (Sandham, *et al*., 2020). The Lee and Colley review package was developed to evaluate the quality of Environmental Impact Statements, using a four-level hierarchical design (Lee, et al., 1999). The wide application of the Lee and Colley review package may be due to its practical and systematic approach to evaluating EIA quality (Sandham, *et al*., 2013).

An overall grade was given to each of the selected EIAs using a hierarchal structure to evaluate the tiers of review criteria (see Figure 3-1). The review follows a bottom-up approach and starts at the lowest level of the hierarchy, namely the subcategories, which contain simple criteria relating to specific tasks and procedures. Following the review of the subcategories, are the review categories, and lastly review areas, which are more complex criteria and broader tasks and procedures. A reviewer collation sheet was used to record the results attributed to each of the reviews of each of the EIAs.

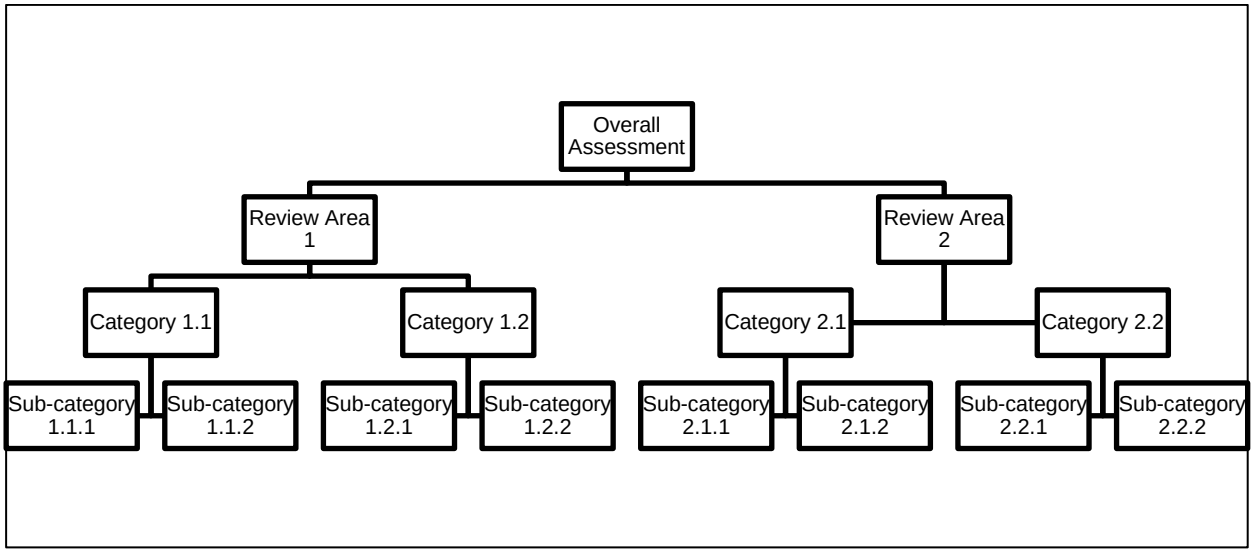

Figure 3-1: Schematic of representation of review category hierarchy as per Lee and Colley Review Framework (Lee *et al.,* 1999).

These review areas, under which categories and subcategories are defined, are as follows (Lee, et al., 1999):

- Review Area 1: Description of the development, the affected environment and the baseline conditions
- Review Area 2: Identification and evaluation of key impacts
- Review Area 3: Alternatives, mitigation measures, monitoring and recommendations
- Review Area 4: Communication of results

A rating scale, as proposed by the Lee and Colley package, has been used. Each of the review criteria in the hierarchical structure was assessed and attributed with a symbol to determine the overall grade of each of the selected EIAs. Seeing that this will be a qualitative assessment, symbols ranging from A (well done) to F (poorly performed) were used for the rating scale. The use of numbers in the rating scale would have resulted in a numerical evaluation (Sandham *et al.*, 2008).

Table 3-2: Rating scale symbols and descriptions (Lee *et al.,* 1999)

Symbol	Description
A	Completed and well preformed
B	Satisfactory, with minor inadequacies / omissions
C	Just satisfactory, with inadequacies / omissions
D	Just unsatisfactory due to inadequacies / omissions although some part may be satisfactory
E	Not satisfactory – major inadequacies / omissions
F	Incomplete and poorly preformed

.

When carrying out the review of the selected EIAs and assigning a rating symbol to a review category, the reviewer should base their assessment on the level of detail and precision the review category was addressed in the EIA. Therefore, a review criterion should be considered satisfactory if there is sufficient information to allow a decision-maker or affected party to make an informed decision without having to seek further advice (Sandham & Pretorius , 2008).

The Lee and Colley review package as adapted for the South African regulatory and procedural context has been developed by van Heerden (2010). However, for the purpose of this study additions had to be made to the adapted review package to review the EIAs for water resource developments, and more specifically, content related to the Ecological Reserve. Additions were made for the purpose of this study at the subcategory level to include specific Ecological Reserve components. These components were based on the aspects related to the Ecological Reserve

highlighted in Chapter 2 which is defined by the key components of Louw & Hughes (2002) and Kleynhans & Louw (2008). The review package developed as part of this study, is introduced in Table 3-3. The following review criteria related to the assessment of the Ecological Reserve were added to the adapted Lee and Colley Review package: specialist inputs regarding water resource components; hydrology & flow of resource; Present Ecological State (PES) of water resource; ecosystem goods and services; socio-economic benefits; Ecological Importance and Sensitivity (EIS) of water resource; habitat integrity; Resource Management Class & Recommended Ecological Category; and current state of the Ecological Reserve - refer to criteria highlighted in grey in **Table 3-3**).

Table 3-3: Adapted review criteria for consideration of the Ecological Reserve in EIAs for Water Resource Development Projects

	Review Area 1: Description of the development, the affected environment and the baseline conditions		***Review Area 2: Identification and evaluation of key impacts***
1.1	**Description of development**	**2.1**	**Scoping**
1.1.1	Identification of applicant	2.1.1	Identifying interested and affected parties
1.1.2	Purpose and objective of development	2.1.2	Public participation
1.1.3	Description of activity	2.1.3	List of issues identified
1.1.4	Description of site	2.1.4	Key impacts for further investigation
1.1.5	Proposed location	**2.2**	**Definition of Potential Impacts**
1.1.7	Need & Desirability (EIA Regulations 2010)	2.2.1	All possible effects on the environment (indirect, direct, cumulative)
1.1.8	Details of EAP and specialists	2.2.2	Interaction of effects (analysis of project effect on aquatic environment)
1.2	**Site Description**	2.2.3	Impacts from non-standard operating conditions (impacts due to incidents)
1.2.1	Area for development site and activities (locality map)	2.2.4	Impacts from deviation from baseline
1.2.2	Description of surrounding land use	**2.3**	**Identification of Impacts**
1.2.3	Duration of development phases	2.3.1	Assess impacts in all phases
1.2.4	Infrastructure required	2.3.2	All possible impacts identified
1.3	**Description of the Environment**	**2.4**	**Assessment of Impacts**
1.4.1	Area likely to be affected (map)	2.4.1	Impact magnitude (quantitative or qualitative)
1.4.2	Location of basin / catchment	2.4.2	Significance to affected community
1.4.3	Geographical aspects of the environment	2.4.3	Method of assessing significance
1.4.4	Biophysical description of environment		***Review Area 4: Communication of Results***
1.4.5	Socio / cultural characteristics	**4.1**	**Layout of Report**
1.4.6	Current cumulative impacts	4.1.1	Introduction (project description, aims of EIA)
1.4	**Baseline Conditions**	4.1.2	Information logically arranges
1.5.1	Important components of affected environment (methods and uncertainties)	4.1.3	Summary of long chapters
1.5.2	Interaction and effect of project on environment	4.1.4	Acknowledgement of external sources

	Review Area 1: Description of the development, the affected environment and the baseline conditions		***Review Area 2: Identification and evaluation of key impacts***
1.5.3	Specialists inputs (Hydrology, Aquatic, Wetland)	**4.2**	**Presentation**
1.5.4	Data sources mentioned	4.2.1	Comprehensible presentation of information (avoiding obscure language)
	Hydrology & flow of resource	4.2.2	Technical terms, acronyms, initials defined
1.5.5	Present Ecological State (PES) of water resource	4.2.3	Presentation of the report as an integrated whole
1.5.6	Ecosystem goods and services	**4.3**	**Emphasis**
1.5.7	Socio-economic benefits	4.3.1	Emphasis on adverse / beneficial impacts
1.5.8	Ecological Importance and Sensitivity (EIS) of water resource	4.3.2	Statement must be unbiased
1.5.9	Habitat integrity	4.3.3	Conditions for authorisation
1.5.10	Resource Management Class & Recommended Ecological Category	4.3.4	Opinion as to whether development should / should not be authorised
1.5.11	Current state of the Ecological Reserve	**4.4**	**Non-technical summary**
1.5.12	Local Plans / policies / guidelines	4.4.1	Non-technical summary of main findings and conclusions
1.5.13	Summary of specialist reports	4.4.2	Summary covers all main issues
	Review Area 3: Alternatives, Mitigation Measures, Monitoring and Recommendations		
3.1	**Alternatives**		
3.1.1	Description of methods used to identify alternatives		
3.1.2	Description of alternative site (advantages / disadvantages)		
3.1.3	Description of alternative process, designs, and operating conditions (flow scenarios)		
3.1.4	Rejected alternative identified		
3.1.5	Comparative assessment of alternatives and reason for preferred alternative		
3.2	**Mitigation Measures**		
3.2.1	Mitigation of all significant adverse impacts considered		
3.2.2	Mitigation measures proposed to prevent or offset adverse impacts		
3.2.3	Mitigation measures clearly defined		
3.2.4	Anticipated effectiveness of proposed mitigation		
3.3	**Monitoring and Review**		
3.3.1	Monitoring arrangements		
3.3.2	Commitment and responsibilities for monitoring stated		
3.3.3	Financial provisions for rehabilitation / closure		

To start the review process an inter-comparison approach was followed (Poder & Lukki, 2011; Canelas, *et al*., 2005), as opposed to a double-reviewer approach as recommend by Lee and Colley (1999). The inter-comparison approach is less time consuming and can ensure consistency in understanding of review criteria when subsequently applied (Canelas, *et al.*, 2005).

One of the water resource development EIA reports, were independently reviewed by two reviewers. Therefore, the researcher of this study and an independent professional assessed and recorded grades for the EIA report separately. Following their separate reviews, the recorded results of the independent reviews recorded compared. This allowed differences and discrepancies to be identified and to identify an appropriate scoring based on a discussion between the two reviewers.

3.4 Ethical considerations

Ethical standards have been followed in this dissertation for research without direct animal or human contact. The risk category for this research (NWU-00480-21-A9) was determined to be of No Risk. Therefore, ethics approval has been granted to conduct research in such a manner as part of this study.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Introduction

In Chapter 4 the results obtained from the review of the selected reports against predetermined criteria to gauge the quality of Ecological Reserve inputs to EIAs for water resource development projects are discussed.

In terms of the inter-comparison approach, as recommended by Poder and Lukki (2011) and Canelas *et al.* (2005), the EIA for the Hydropower Project – Kruisvallei (2018) was reviewed by two reviewers. The results from both reviewers were tabled (see Appendix B) and compared to determine the final score. Overall, the results from both reviewers were found to be similar. Any discrepancies that had occurred were clarified to determine results for the selected report. The remainder of the reports were reviewed by one reviewer.

The sections discussed throughout this chapter include the overall quality of the EIAs, quality of review areas, and lastly the key findings of the results of the quality review.

4.2 Overall quality of the EIAs

As a starting point for discussion, a summary of the scores of the Review Areas and Categories are indicted in **Table 4-1** to **Table 4-2.**

Table 4-1: Review scores for the review category, review area, and overall score for reports

	Summary of review areas, categories, and subcategories	De Hoop Dam (2005)	(Nwamitwa Dam (2008)	Ncwabeni Storage Dam (2013)	Hydropower - Boegoeberg (2014)	Foxwood Dam (2015)	Hydropower Kruisvallei (2018)	Abstraction weir (Umkhomazi 2018)
	OVERALL SCORE	**D**	**C**	**B**	**B**	**A**	**B**	**B**
	Review Area 1: Description of the development, the affected environment and the baseline conditions	**D**	**B**	**B**	**B**	**A**	**B**	**B**
1.1	**Description of development**	**C**	**A**	**A**	**B**	**A**	**A**	**B**
1.2	**Site Description**	**C**	**B**	**A**	**B**	**A**	**B**	**A**
1.3	**Description of the Environment**	**C**	**B**	**B**	**B**	**B**	**B**	**B**
1.4	**Baseline Conditions**	**D**	**C**	**C**	**C**	**B**	**B**	**C**
	Review Area 2: Identification and evaluation of key impacts	**D**	**C**	**B**	**C**	**C**	**B**	**B**
2.1	**Scoping**	**C**	**B**	**A**	**A**	**B**	**A**	**B**

	Summary of review areas, categories, and subcategories	De Hoop Dam (2005)	(Nwamitwa Dam (2008)	Ncwabeni Storage Dam (2013)	Hydropower - Boegoeberg (2014)	Foxwood Dam (2015)	Hydropower Kruisvallei (2018)	Abstraction weir (Umkhomazi 2018)
	OVERALL SCORE	**D**	**C**	**B**	**B**	**A**	**B**	**B**
2.2	**Definition of Potential Impacts**	C	B	B	B	B	B	B
2.3	**Identification of Impacts**	B	C	B	A	B	B	B
2.4	**Assessment of Impacts**	D	B	A	D	C	B	C
	Review Area 3: Alternatives, Mitigation Measures, Monitoring, and Recommendations	C	B	B	B	C	B	C
3.1	**Alternatives**	C	B	A	A	A	B	A
3.2	**Mitigation Measures**	C	B	B	C	C	B	B
3.3	**Monitoring and Review**	B	B	C	C	D	A	D
	Review Area 4: Communication of Results	D	B	A	B	B	B	B
4.1	**Layout of Report**	B	A	B	B	A	B	B
4.2	**Presentation**	B	B	B	B	B	B	A
4.3	**Emphasis**	E	A	A	B	A	B	A
4.4	**Non-technical summary**	B	B	A	B	B	B	B

As indicated in **Table 4-1**, four (4) of the reports were rated satisfactory despite omissions and / or inadequacies with a B score. A just satisfactory or borderline score (C) was attributed to the Nwamitwa Dam EIA, and a D score was attributed to the De Hoop Dam EIA. More than seventy percent (70%) of the selected EIAs were graded as satisfactory, indicating that good quality information was presented for decision making. Similar findings have been reported by Sandham *et al*. (2008) and Lee *et al*. (1999). It was however important to investiage the qaulity of information reflected by the different aspects of the EIAs, to determine the quality of consideration of the Ecological Reserve. This was achieved by focusing on the results for the lower tiers (i.e. review categories), grouped by review areas. **Table 4-2** presents the percentage scores of the review categories related to the different review areas. Scores were grouped as A - B being satisfactory, C as just or borderline satisfactory, and groups D - E and E - F as unsatisfactory. A similar approach has been used Sandam and Pretorius (2008), since it assists with interpretation of the critical boundary for satisfactory performance of a task. The information provided suggests that review categories Baseline Conditions, Assessment of Impacts, and Monitoring and Review, have delivered the lowest results with more than 50% being borderline just satisfactory or just unsatisfactory.

Review categories that performed mostly well (Score A) and / or satisfactory (Score B) include Description of the Development, Definition of Potential Impacts, Alternatives, and review categories related to communication of results.

Table 4-2: Analysis of Review Areas and Categories

	Summary of review areas, categories and subcategories	A-B	C	D-E	E-F
		%	%	%	%
	Review Area 1: Description of the development, the affected environment and the baseline conditions	86	0	14	0
1.1	**Description of development**	86	14	0	0
1.2	**Site Description**	86	14	0	0
1.3	**Description of the Environment**	86	14	0	0
1.4	**Baseline Conditions**	29	57	14	0
	Review Area 2: Identification and evaluation of key impacts	43	43	14	0
2.1	**Scoping**	86	14	0	0
2.2	**Definition of Potential Impacts**	86	14	0	0
2.3	**Identification of Impacts**	86	14	0	0
2.4	**Assessment of Impacts**	43	29	29	0
	Review Area 3: Alternatives, Mitigation Measures, Monitoring and Recommendations	57	43	0	0
3.1	**Alternatives**	86	14	0	0
3.2	**Mitigation Measures**	57	43	0	0
3.3	**Monitoring and Review**	43	29	29	0
	Review Area 4: Communication of Results	86	0	14	0
4.1	**Layout of Report**	100	0	0	0
4.2	**Presentation**	100	0	0	0
4.3	**Emphasis**	86	0	14	14
4.4	**Non-technical summary**	100	0	0	0

4.3 Results related to the quality of Review Areas

The following discussion will be structured around key criteria (Sub-Categories) underpinning the Review Areas. This discussion aims to investigate the reasoning behind the scoring of the sub-category and how this reflects on the quality of the Ecological Reserve inputs to EIAs.

4.3.1 Review Area 1 – Description of the development, the affected environment, and the baseline conditions

This review area generally scored well, with seventy-one percent (71%) of the selected EIAs graded satisfactory (B) overall (refer to **Table 4-3**). The description of the environment and

baselines conditions category is considered to be important as it sets the level of sensitivity of the project area and / or the level of protection that a project area may require.

Table 4-3: Analysis of review categories and subcategories for Review Area 1

	Summary of review areas, categories and subcategories	A-B	C	D-E	E-F
		%	%	%	%
	Review Area 1: Description of the development, the affected environment and the baseline conditions	86	0	14	0
1.1	**Description of development**	86	14	0	0
1.1.1	Identification of applicant	86	14	0	0
1.1.2	Purpose and objective of development	100	0	0	0
1.1.3	Description of activity	100	0	0	0
1.1.4	Description of site	86	14	0	0
1.1.5	Proposed location	86	14	0	0
1.1.7	Need & Desirability (EIA Regulations 2010)	71	0	0	0
1.1.8	Details of EAP and specialists	86	14	0	0
1.2	**Site Description**	86	14	0	0
1.2.1	Area for development site and activities (locality map)	86	14	0	0
1.2.2	Description of surrounding land use	43	57	0	0
1.2.3	Duration of development phases	86	14	0	0
1.2.4	Infrastructure required	100	0	0	0
1.3	**Description of the Environment**	86	14	0	0
1.3.1	Area likely to be affected (map)	71	29	0	0
1.3.2	Location of basin / catchment	100	0	0	0
1.3.3	Geographical aspects of the environment	100	0	0	0
1.3.4	Biophysical description of environment	100	0	0	0
1.3.5	Socio / cultural characteristics	86	14	0	0
1.3.6	Current cumulative impacts	29	57	14	0
1.4	**Baseline Conditions**	29	57	14	0
1.4.1	Important components of affected environment (methods and uncertainties)	100	0	0	0
1.4.2	Interaction and effect of project on environment	100	0	0	0
1.4.3	Specialists inputs (Hydrology, Aquatic, Wetland)	100	0	0	0
1.4.4	Data sources mentioned	100	0	0	0
1.4.5	Hydrology & flow of resource	0	86	14	0
1.4.6	Present Ecological State (PES) of water resource	100	0	0	0
1.4.7	Ecosystem goods and services	14	14	14	57
1.4.8	Socio-economic benefits	86	14	0	0
1.4.9	Ecological Importance and Sensitivity (EIS) of water resource	100	0	0	0
1.4.10	Habitat integrity	71	0	14	29
1.4.11	Resource Management Class & Recommended Ecological Category	86	0	0	14
1.4.12	Current state of the Ecological Reserve	86	0	14	14
1.4.13	Local Plans / policies / guidelines	86	0	14	0
1.4.14	Summary of specialist reports	71	14	14	0

The Review Category, Description of the Environment, has overall scored satisfactory results (86% of the case studies scored a B). The best preforming sub-category was the location of the basin / catchment in which the development is located (SC 1.3.2). All of the EIAs provided an adequate qualitative description of the water management area, quaternary catchment, and water resources in which the development would be located. It is important that this sub-category be well described, as it defines the area in which further analysis will be undertaken for the proposed development.

For the Review Category, Baseline Conditions, although there were well preforming sub-categories, the majority of the case scores for the Baseline Conditions category was C (57%) or D (14%). The Present Ecological State (SC 1.4.6) was determined in all of the EIAs and was particularly well done for the 2018 Hydropower project in Ash River. Also in the EIA for the Ash River Hydropower project, the Present Ecological State (PES) was determined for fish, macro-invertebrates, and riparian vegetation. The Ecological Importance of Sensitivity (EIS) of the impacted water resources were taken into account in all the selected EIAs, however in the case of the De Hoop Dam the standard DWS River EcoClassification and EcoStatus Models (Kleynhans & Louw, 2008) was most likely not applied.

Further detailed results of the specific lower preforming review subcategories of Review Area 1 are discussed below:

- SC 1.3.6 – Current cumulative impacts

Current cumulative impacts (SC 1.3.6) was a lower preforming subcategory, with seventy-one percent (71%) of the EIAs scoring just satisfactory (score C) or unsatisfactory (D). Although the reports provided a description of the general land use and use of the water resource proposed for the development, an overall description of the condition of the water resource as a result of the current and potential future activities and in the catchment, was deficient.

- SC 1.4.5 – Hydrology & flow of water resource

The majority of the EIAs scored a just satisfactory score (86% C) with the remaining (14%) being unsatisfactory (D). In the EIA for the De Hoop Dam (2005), although indicated as a limitation, the only flow gauge in the vicinity of the proposed dam consisted of observed data, which may not reflect the longer-term natural wet and dry cycles. It was also noted that the

weir was found to be damaged and would appear to be currently inaccurate at low-flows. The available flow data for the river, particularly for low flows, were therefore considered unreliable. Furthermore, there was limited metered records of the actual quantities of water that are currently abstracted for irrigation purposes, which means that the simulated present-day flows may not accurately reflect the actual flows. The data on water availability and water use should therefore be treated with caution. Despite these limitations to hydrology and flow data and the lack of real time monitoring data the EIA included statements suggesting that the Ecological Reserve would not be impacted by the development of the De Hoop dam. Similar findings were observed for the other case studies.

- SC 1.4.8 – Ecosystem goods and services

A particular weakness identified in the Baseline Conditions category was the inclusion of ecosystem goods & services (SC 1.4.7), with fifty-seven percent (57%) the EIAs scoring an F. The Ecological Reserve is directly aligned with options for human use arising from rivers to deliver ecosystem goods and services to the surrounding area. Doing an evaluation of ecosystem goods and services, is therefore and important component to assess the impact of a water resource development on the Ecological Reserve.

4.3.2 Review Area 2 - Identification and evaluation of key impacts

This review area is related to the identification and assessment of impacts related to the proposed development. This review area, and its related criteria, is important as it ensures that the potential significant impacts of a development are identified and evaluated to prevent environmental degradation. For the purpose of this study, the score attributed to each review category and sub-category was largely focused on the extent to which impacts considered the Ecological Reserve. This Review Area was largely satisfactory (86%) (refer to **Table 4-4**).

Table 4-4: Analysis of review categories and subcategories for Review Area 2

	Summary of review areas, categories and subcategories	**A-B**	**C**	**D-E**	**E-F**
		%	**%**	**%**	**%**
	Review Area 2: Identification and evaluation of key impacts	43	43	14	0
2.1	**Scoping**	86	14	0	0
2.1.1	Identifying interested and affected parties	86	14	0	0
2.1.2	Public participation	0	71	29	0
2.1.3	List of issues identified	100	0	0	0

	Summary of review areas, categories and subcategories	A-B	C	D-E	E-F
		%	%	%	%
2.1.4	Key impacts for further investigation	43	57	0	0
2.2	**Definition of Potential Impacts**	86	14	0	0
2.2.1	All possible effects on the environment (indirect, direct, cumulative)	86	14	0	0
2.2.2	Interaction of effects (analysis of project effect impacts on aquatic environment)	0	86	14	0
2.2.3	Impacts from non-standard operating conditions (impacts due to incidents)	57	43	0	0
2.2.4	Impacts from deviation from baseline	100	0	0	0
2.3	**Identification of Impacts**	86	14	0	0
2.3.1	Assess impacts in all phases	86	0	14	0
2.3.2	All possible impacts identified	86	14	0	0
2.4	**Assessment of Impacts**	43	29	29	0
2.4.1	Impact magnitude (quantitative or qualitative)	100	0	0	0
2.4.2	Significance to affected community	29	29	43	29
2.4.3	Method of assessing significance	100	0	0	0

A strength of Review Area 2 under the Scoping Review Category is SC 2.1.4 (key impacts for further investigation). SC 2.1.4 was graded 43% completed and well-performed. For instance, the EIA for the Foxwood Dam (2015) provided comprehensive tables of the construction and operational phase impacts of the dam. The potential impacts identified were also specific to the Ecological Reserve and discussed issues such as changes to seasonal flows, impacts to downstream water user requirements, impacts to water quality etc. However, it should be noted that most of the reports did not specifically categorise the impacts as direct and indirect impacts.

The following sub-categories are considered to be poorly addressed:

- SC 2.1.2 – Public Participation

Borderline results (71% C score) were assigned to the majority of the EIAs. Although public participation was undertaken as per the statutory requirements of NEMA, and public input was obtained from stakeholders and also referenced as part of specialist reports, it was found that comments were not always specifically addressed as part of the impact assessment. For instance, in the case of the Nwamitwa Dam, stakeholders have specifically enquired why existing ecological reserves of water are not being maintained and they have been asked to consider the impact of the development on the downstream water users. However, the impact was not assessed in either the EIA or the specialist report and the concluding statement from the specialist regarding the public comment was as follows:

"*Mitigations measures as mentioned in this report may reduce or alleviate these impacts to some degree."*

- SC 2.2.2 – Interaction of effects (analysis of project effect impacts on aquatic environment)

This subcategory was mostly just satisfactory (86% scored C). Overall, the EIAs investigated the interaction of the impacts of the development, particularly those regarding water quality and quantity related to other biophysical aspects (e.g., aquatic biota). However the consideration of the ecosystem goods and service the water resource provides, was inadequate.

- SC 2.4.2 – Significance to the affected community

Just satisfactory © and unsatisfactory scores (D and E) were determined for seventy-one percent (71%) of the EIAs. Besides two of the reports, both of which are dam developments, that mentioned the impacts to reallocation of affected communities and the calculation of agricultural resources, there was barely any mention of the water resource development that would impact the affected community.

4.3.3 Review Area–3 - Alternatives, Mitigation Measures, Monitoring and Recommendations

This review area was generally satisfactory (57%) (refer to **Table 4-5**). In terms of the Alternatives, most of the EIAs evaluated alternatives and provided descriptions of how the preferred alternatives were selected, and as a result the review category was scored eighty-six percent (86%) satisfactory. It was also interesting to note that in some cases, specifically the Off-channel Storage Dam EIA, the alternatives have formed part of the impacts which were assessed in the impact assessment tables. This is considered to be a reflection of good understanding of the project description (Review Area 1), which led to a good result in another, in this case, Review Area 3.

Table 4-5: Analysis of review categories and subcategories for Review Area 3

	Summary of review areas, categories and subcategories	**A-B**	**C**	**D-E**	**E-F**
		%	**%**	**%**	**%**
	Review Area 3: Alternatives, Mitigation Measures, Monitoring and Recommendations	57	43	0	0
3.1	**Alternatives**	86	14	0	0

	Summary of review areas, categories and subcategories	A-B	C	D-E	E-F
		%	%	%	%
3.1.1	Description of methods used to identify alternatives	71	29	0	0
3.1.2	Description of alternative site (advantages / disadvantages)	86	14	0	0
3.1.3	Description of alternative processes, designs, and operating conditions (flow scenarios)	86	14	0	0
3.1.4	Rejected alternative identified	86	14	0	0
3.1.5	Comparative assessment of alternatives and reason for preferred alternative	86	14	0	0
3.2	**Mitigation Measures**	57	43	0	0
3.2.1	Mitigation of all significant adverse impacts considered	71	29	0	0
3.2.2	Mitigation measures proposed to prevent or offset adverse impacts	57	43	0	0
3.2.3	Mitigation measures clearly defined	57	43	0	0
3.2.4	Anticipated effectiveness of proposed mitigation	86	14	0	0
3.3	**Monitoring and Review**	43	29	29	0
3.3.1	Monitoring arrangements	14	71	14	0
3.3.2	Commitment and responsibilities for monitoring stated	0	0	0	0
3.3.3	Financial provisions for rehabilitation / closure	0	0	0	0

Despite the overall satisfactory performance of this Review Area, the following review subcategories are considered to be inadequately addressed:

- SC 3.3.1 – Monitoring arrangements

  Monitoring arrangements should be proposed to check the environmental impacts resulting from the implementation of the project and their conformity with the predictions within the EIA. Although EMPRs were not evaluated as part of this research (refer to Section 1.4), the EIAs only vaguely mentioned baseline and environmental monitoring arrangements such as river flows, water quality, aquatic invertebrates, fish and riparian vegetation.

4.3.4 Review Area 4 – Communication of Results

The presentation and communication of results are presented as part of this review area. The performance of this review area is important given that communication and presentation of results the EIA may impact on the evaluations of stakeholders and decision-making authorities. The Review Area largely scored satisfactory, with seventy-one percent (71%) of the reports scoring a B. Besides some instances where summaries for longer chapters in the EIAs required, were omitted, the EIAs have overall been professionally compiled.

Table 4-6: Analysis of review categories and subcategories for Review Area 4

	Summary of review areas, categories and subcategories	A-B	C	D-E	E-F
		%	%	%	%
	Review Area 4: Communication of Results	86	0	14	0
4.1	**Layout of Report**	100	0	0	0
4.1.1	Introduction (project description, aims of EIA)	100	0	0	0
4.1.2	Information logically arranges	100	0	0	0
4.1.3	Summary of long chapters	43	57	0	0
4.1.4	Acknowledgement of external sources	100	0	0	0
4.2	**Presentation**	100	0	0	0
4.2.1	Comprehensible presentation of information (avoiding obscure language)	100	0	0	0
4.2.2	Technical terms, acronyms, initials defined	100	0	0	0
4.2.3	Presentation of the report as an integrated whole	86	14	0	0
4.3	**Emphasis**	86	0	14	14
4.3.1	Emphasis on adverse / beneficial impacts	100	0	0	0
4.3.2	Statement must be unbiased	86	14	0	0
4.3.3	Conditions for authorisation (EIA Regulations, 2014)	14	14	14	0
4.3.4	Opinion as to whether development should / should not be authorised	86	0	0	14
4.4	**Non-technical summary**	100	0	0	0
4.4.1	Non-technical summary of main findings and conclusions	100	0	0	0
4.4.2	Summary covers all main issues	100	0	0	0

The following review sub-categories are however highlighted for discussion, as they may potentially have influence on the decision-making process:

- SC 4.3.3 – Conditions of Environmental Authorisation

Although this sub-category was not applicable to the EIAs undertaken prior to 2014, where a score could be determined, it was found that the criteria was inadequately addressed, with the exception of one (1) EIA. This is an important aspect that should be included in EIAs, as it provides the opportunity for Environmental Assessment Practitioners (EAPs) to ensure that decision-making authority is informed regarding the minimum requirements to ensure that a development is undertaken in an environmentally sound manner. For instance, the EIA for the Kruisvallei Hydropower Project (2018) has recommended the release of mitigation flows to ensure river continuum.

- SC 4.3.4 – Opinion as to whether development should / should not be authorised

Only one of the EIAs failed to address this criterion although it is important that these criteria are addressed in EIAs, as it provides the decision-making authority with insight into the project if it can be reasonably authorised, based on the evaluation of an independent EAP.

4.4 Report quality over time

An improvement in quality can be seen over time for the EIAs from 2005 to 2018 (refer to **Table 4-7**). It can be seen that just satisfactory (C rating) and just unsatisfactory (D rating) ratings were found for the first EIAs in the study.

Table 4-7: Results of EIA quality over time (2005 to 2018)

Dam Mpumalanga (De Hoop 2005)	Dam Limpopo (Nwamitwa 2008)	Storage Dam (Ncwabeni 2013)	Hydropower Groblershoop (Boegoeberg 2014)	Dam Eastern Cape (Foxwood 2015)	Hydropower Ash River (Kruisvallei 2018)	Abstraction weir (Umkhomazi 2018)
D	C	B	B	A	B	B

Table 4-7 above indicates that the improvement in EIA quality coincides with the implementation of the EIA Regulations from 2006 to 2017. The improvement in EIA quality may also be related to the improvement of knowledge and skills. This is supported by the research undertaken by Badr *et al.* (2011), which indicated that the quality of an EIS quality might be affected, to some extent, by the experience of the consultant(s) who had conducted the EIA study.

4.5 Key Findings & Chapter Summary

By scoring the review areas, categories, and sub-categories, strengths and weaknesses of EIAs could be determined. In the case of this research, by evaluating strengths and weaknesses, the quality of the Ecological Reserve inputs considered in EIAs could be determined. The key findings of quality of Ecological Reserve inputs into EIAs for water resource developments are:

- The EIAs reviewed were found to be satisfactory overall.
- There was also an improvement in the quality of EIA reports over time as the trend in overall scores improved from the EIA of 2005 to the EIA of 2018. This may be indicative

of improvement of the knowledge and skills of water resources developers and Environmental Assessment Practitioners.

- The review categories of greatest weaknesses were identified during the quality review related to Baseline Conditions, Assessment of Impacts, and Monitoring and Review, all which are vital areas of an effective EIA (Aung, *et al*., 2019).
- Strengths identified within the review categories include Scoping, Alternatives, Layout and Emphasis of the EIA.
- Subcategory criteria specific to Ecological Reserve inputs were generally well preformed with the exception of hydrological and flow, and ecosystem goods and services.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

This research has aimed to critically assess the quality of Ecological Reserve inputs into EIAs for water resource developments in South Africa. The research approach combined EIA quality reviews conducted according to an adapted Lee and Colley Review Package. This chapter will cover what could be concluded from the earlier chapters and will provide recommendations to improve the quality of Ecological Reserve inputs and methods how to develop our knowledge on this topic are also included.

5.1 Conclusions

The EIA process has been accepted as the cornerstone of decision-making processes in environmental regulation and the information provided to the public and decision makers regarding the consequences of a proposed project and mitigation measures is influence to a great extent by the quality of the EIA (Peterson, 2010).

Given the scope and scale of water resource developments and the adverse impacts associated with such developments of water resources, and moreover the statutory requirement of meeting the Ecological Reserve, the evaluation of the quality of these EIAs and its Ecological Reserve inputs is vital. The Ecological Reserve is given effect to by means of environmental flow assessments, which assess several abiotic and biotic components of aquatic ecosystems. These key components ought to be included in EIAs conducted for water resource development projects to ensure the protection and sustainable use of water resources.

As part of this study a review package was developed in order to determine the quality of Ecological Reserve inputs. Similar to previous studies (Sandham & Pretorius , 2008; Badr, *et al*., 2011) the Lee and Colley review package was adapted. Key criteria related to the Ecological Reserve were added to the Lee and Colley Review package and applied to 7 water resource development EIAs (refer to Objective 1 in Chapter 1).

Based on the discussion below, Objective 2 of this study was demonstrated. This quality review of Ecological Reserve inputs into EIAs for water resource developments in South Africa shows that seventy-one percent (71%) of the selected EIAs were satisfactory. This demonstrates a relatively good overall quality of the EIAs in the water resource development sector. Review areas of strengths include descriptive and presentational areas (i.e., Review Area 1 and Review Area 4), with strengths of review subcategories under Scoping, Alternatives, Layout and Emphasis of

the EIA. Other international and South African studies have also found similar results (Pinho, *et al*., 2007; Sandham, *et al*., 2008).

However, several omissions and inadequacies, specifically at subcategory level, were shown in all the EIAs despite the overall satisfactory results. The following weaknesses have been identified during the quality review of Ecological Reserve inputs for water resource development projects:

- Hydrology and flow inputs: This inadequacy was mostly related to the lack of real time monitoring data, however EIAs still included statements suggesting that the Ecological Reserve would not be impacted by the development of the water resource.
- Ecosystem goods and services: Determining the values and uses of a water resource is an important aspect of the Ecological Reserve and ought to be considered as part of an impact assessment for water resource developments.
- Significance to the affected community: Water resource developments can have extensive environmental and social implications; it is therefore important that the EIA quantifies or qualifies the significance of the affected community regarding displacement, loss of agricultural land, effects on water quality, etc.
- Public participation: Inputs should be obtained from stakeholders on ecosystem uses, dependence of the system for their livelihood, conservation imporatance, possible water resource developments, and other aspects of concern to them that ought to be part of an EIA.

5.2 Recommendations and areas of future research

Recommendations from Sandham *et al.* (2008) included the use of a quality review checklist to ensure that all key aspects are addressed prior to submitting to the competent authority for decision making. Therefore, to ensure provision of high quality EIAs and to mitigate substantial changes to aquatic ecosystems and its dependent social environment as a result of water resource developments, the following recommendations are suggested based on the results of this study as well as existing literature:

- The use of a quality review checklist by EIA practitioners and authorities as an additional tool to the EIA regulations and protocols, can further improve the quality of Ecological Reserve inputs for water resource development projects.
- The use by EIA practitioners of a review checklist will assist in ensuring that all key aspects relating to the Ecological Reserve are addressed before submission to the relevant authority.

- When undertaking EIAs for water resource development projects, review subcategories related to the Ecological Reserve should be brought to the attention of the Environmental Assessment Practitioner as well as specialists associated with the project. By doing so these review subcategories may improve the potential for protection of the Ecological Reserve as legally required.

This dissertation has focused on the quality of Ecological Reserve inputs to EIAs as reflected in the environmental assessment reports and associated specialist studies on a sample of seven (7) EIAs for water resource developments. Further research could be undertaken on a larger EIA sample regarding the quality of the Ecological Reserve inputs to Environmental Management Programmes as well as Environmental Authorisations issued for water resource developments.

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ANNEXURE A

	Summary of review areas, categories and subcategories	Dam Mpumalanga (De Hoop 2005)	Dam Limpopo (Nwamitwa 2008)	Storage Dam (Ncwabeni 2013)	Hydropower Groblershoop (Boegoeberg 2014)	Dam Eastern Cape (Foxwood 2015)	Hydropower Ash River (Kruisvallei 2018)	Abstraction weir (Umkhomazi 2018)
	OVERALL SCORE	**D**	**C**	**B**	**B**	**A**	**B**	**B**
	Review Area 1: Description of the development, the affected environment and the baseline conditions	**D**	**B**	**B**	**B**	**A**	**B**	**B**
1.1	**Description of development**	**C**	**A**	**A**	**B**	**A**	**A**	**B**
1.1.1	Identification of applicant	B	A	A	A	A	B	C
1.1.2	Purpose and objective of development	B	A	A	B	A	A	B
1.1.3	Description of activity	B	A	A	A	A	A	A
1.1.4	Description of site	C	A	A	B	B	A	B
1.1.5	Proposed location	C	A	A	A	A	A	B
1.1.7	Need & Desirability (EIA Regulations 2010)	N/A	N/A	A	B	B	B	A
1.1.8	Details of EAP and specialists	C	A	A	B	A	A	B
1.2	**Site Description**	**C**	**B**	**A**	**B**	**A**	**B**	**A**
1.2.1	Area for development site and activities (locality map)	C	B	A	A	B	B	B
1.2.2	Description of surrounding land use	C	C	B	C	A	C	A
1.2.3	Duration of development phases	C	A	B	A	A	A	A
1.2.4	Infrastructure required	B	A	A	A	A	A	A
1.3	**Description of the Environment**	**C**	**B**	**B**	**B**	**B**	**B**	**B**
1.3.1	Area likely to be affected (map)	C	B	B	B	B	B	C
1.3.2	Location of basin / catchment	A	A	A	A	A	A	A
1.3.3	Geographical aspects of the environment	B	A	A	A	A	A	A
1.3.4	Biophysical description of environment	B	B	B	A	A	B	A

1.3.5	Socio / cultural characteristics	C	B	B	B	A	B	A
1.3.6	Current cumulative impacts	D	C	C	B	C	C	B
1.4	**Baseline Conditions**	**D**	**C**	**C**	**C**	**B**	**B**	**C**
1.4.1	Important components of affected environment (methods and uncertainties)	B	B	A	A	A	B	A
1.4.2	Interaction and effect of project on environment	B	B	A	A	B	A	A
1.4.3	Specialists inputs (Hydrology, Aquatic, Wetland)	B	B	A	A	B	B	B
1.4.4	Data sources mentioned	B	B	B	A	A	B	B
1.4.5	Hydrology & flow of resource	D	C	C	C	C	C	C
1.4.6	Present Ecological State (PES) of water resource	B	B	B	B	B	A	B
1.4.7	Ecosystem goods and services	F	F	F	F	B	C	D
1.4.8	Socio-economic benefits	B	A	A	A	B	C	B
1.4.9	Ecological Importance and Sensitivity (EIS) of water resource	B	A	A	A	A	A	A
1.4.10	Habitat integrity	A	B	A	F	A	B	E
1.4.11	Resource Management Class & Recommended Ecological Category	F	B	A	A	A	B	A
1.4.12	Current state of the Ecological Reserve	E	B	A	A	A	A	A
1.4.13	Local Plans / policies / guidelines	D	A	A	B	A	A	B
1.4.14	Summary of specialist reports	D	B	B	B	B	B	C
	Review Area 2: Identification and evaluation of key impacts	**D**	**C**	**B**	**C**	**C**	**B**	**B**
2.1	**Scoping**	**C**	**B**	**A**	**A**	**B**	**A**	**B**
2.1.1	Identifying interested and affected parties	C	B	A	B	B	A	B
2.1.2	Public participation	D	D	C	C	C	C	C
2.1.3	List of issues identified	B	B	A	A	A	A	B
2.1.4	Key impacts for further investigation	C	C	B	B	C	C	B
2.2	**Definition of Potential Impacts**	**C**	**B**	**B**	**B**	**B**	**B**	**B**
2.2.1	All possible effects on the environment (indirect, direct, cumulative)	B	C	B	B	B	B	B
2.2.2	Interaction of effects (analysis of project effect impacts on aquatic environment)	D	C	C	C	C	C	C
2.2.3	Impacts from non-standard operating conditions (impacts due to incidents)	C	B	B	C	C	B	B

2.2.4	Impacts from deviation from baseline	B	B	A	A	A	B	A
2.3	**Identification of Impacts**	**B**	**C**	**B**	**A**	**B**	**B**	**B**
2.3.1	Assess impacts in all phases	B	D	A	A	B	B	A
2.3.2	All possible impacts identified	C	B	B	A	B	B	B
2.4	**Assessment of Impacts**	**D**	**B**	**A**	**D**	**C**	**B**	**C**
2.4.1	Impact magnitude (quantitative or qualitative)	A	A	A	A	A	A	A
2.4.2	Significance to affected community	E	C	B	E	B	C	D
2.4.3	Method of assessing significance	A	A	A	A	A	A	A
	Review Area 3: Alternatives, Mitigation Measures, Monitoring and Recommendations	**C**	**B**	**B**	**B**	**C**	**B**	**C**
3.1	**Alternatives**	**C**	**B**	**A**	**A**	**A**	**B**	**A**
3.1.1	Description of methods used to identify alternatives	C	C	A	A	A	A	A
3.1.2	Description of alternative site (advantages / disadvantages)	C	B	B	B	A	B	B
3.1.3	Description of alternative process, designs, and operating conditions (flow scenarios)	C	B	A	B	A	B	B
3.1.4	Rejected alternative identified	C	B	A	A	A	A	A
3.1.5	Comparative assessment of alternatives and reason for preferred alternative	C	B	A	A	A	B	A
3.2	**Mitigation Measures**	**C**	**B**	**B**	**C**	**C**	**B**	**B**
3.2.1	Mitigation of all significant adverse impacts considered	C	C	A	B	B	A	B
3.2.2	Mitigation measures proposed to prevent or offset adverse impacts	C	B	B	C	C	A	B
3.2.3	Mitigation measures clearly defined	C	B	A	C	C	B	B
3.2.4	Anticipated effectiveness of proposed mitigation	C	B	B	B	B	B	B
3.3	**Monitoring and Review**	**B**	**B**	**C**	**C**	**D**	**A**	**D**
3.3.1	Monitoring arrangements	C	C	C	C	B	C	D
3.3.2	Commitment and responsibilities for monitoring stated	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.3	Financial provisions for rehabilitation / closure	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Review Area 4: Communication of Results	**D**	**B**	**A**	**B**	**B**	**B**	**B**
4.1	**Layout of Report**	**B**	**A**	**B**	**B**	**A**	**B**	**B**
4.1.1	Introduction (project description, aims of EIA)	B	A	A	A	A	A	B

4.1.2	Information logically arranged	A	A	A	A	A	A	B
4.1.3	Summary of long chapters	C	B	C	C	B	C	B
4.1.4	Acknowledgement of external sources	A	A	A	A	A	A	A
4.2	**Presentation**	**B**	**B**	**B**	**B**	**B**	**B**	**A**
4.2.1	Comprehensible presentation of information (avoiding obscure language)	B	B	B	B	B	B	B
4.2.2	Technical terms, acronyms, initials defined	A	A	A	A	A	A	A
4.2.3	Presentation of the report as an integrated whole	C	B	B	B	A	B	A
4.3	**Emphasis**	**E**	**A**	**A**	**B**	**A**	**B**	**A**
4.3.1	Emphasis on adverse / beneficial impacts	B	B	A	A	A	B	A
4.3.2	Statement must be unbiased	C	A	A	A	A	A	A
4.3.3	Conditions for authorisation (EIA Regulations, 2014)	N/A	N/A	N/A	N/A	D	B	C
4.3.4	Opinion as to whether development should / should not be authorised	F	A	A	A	A	A	A
4.4	**Non-technical summary**	**B**	**B**	**A**	**B**	**B**	**B**	**B**
4.4.1	Non-technical summary of main findings and conclusions	B	B	A	B	B	B	B
4.4.2	Summary covers all main issues	B	A	A	A	A	A	A

ANNEXURE B

	Ash River - Hydropower **OVERALL SCORE**	Reviewer 1 - J de Jager	Reviewer 1 - notes	Reviewer 2 -	Reviewer 1 - notes	Final Result - based on Reviewer 1&2
	Review Area 1: Description of the development, the affected environment and the baseline conditions					
1.1	**Description of development**	**A**		**A**		**A**
1.1.1	Identification of applicant	A		B	could use more background of make-up of applying bussiness	B
1.1.2	Purpose and objective of development	A	described well in introduction of report - clear why project is being developed	A	clear discription	A
1.1.3	Description of activity	A	good description of activity - table of detailed description & infrastructure required	A	clear background and description	A
1.1.4	Description of site	A	good descriprion of site & site feasibility	A	receiving environment well described	A
1.1.5	Proposed location	A		A	clear indication of where the project will be	A
1.1.7	Need & Desireabilty (EIA Regulations)	B	Well described section on policy/socio-economic need for project & receptiveness of sight. However, tie in of diserability aspect in terms of impact assessment lacking	B	description is good but assumed that hydro-electrical generation trumps all concerns	B

1.1.8	Details of EAP and specialsits	A			A		fully provided	A	
1.2	**Site Description**		**B**			**B**			**B**
1.2.1	Area for development site and activities (locality map)	A		Good description & maps of development site	B		locality maps could be better and use of arial imagery would improve	B	
1.2.2	Description of surrounding land use	C		Land uses broadly described for the region & no map provided of the directly adjacent land uses and activities	C		not a clear description of surrounding land use	C	
1.2.3	Duration of development phases	A		Expected construction & operation timeframes provided	A		clearly shown	A	
1.2.4	Infrastructure required	A		Good description & detailed infrastructure table	A		clearly shown	A	
1.4	**Description of the Environment**		**B**			**B**			**B**
1.4.1	Area likely to be affected (map)	B		Locality of project site well described however, delineated extent of area to be affected by the development is lacking	A		well described	B	
1.4.2	Location of basin/ catchment	A		Good description in aquatics report and description of the environment section in assessment report	A		clearly described	A	
1.4.3	Geographical aspects of the environment	A			A			A	
1.4.4	Biophysical description of environment	B			B			B	
1.4.5	Socio/cultural characteristics	B			B		text book details with lack of "on the ground" insight	B	

1.4.6	Current cumulative impacts	C		Cumulative developments described in terms of similar hydropower developments however given inadequacies with land use description these may be not fully evaluated	B		lacking specifics to the addining the impacts of the project to the impacts of the site, e.g. add hydropower station to already degraded watercourse?	C		
1.5	**Baseline Conditions**		**B**			**B**				**B**
1.5.1	Important components of affected environment (methods and uncertainties)	B		Comprehensive description of the environmental in EIA report	A		good description	B		
	Interaction and effect of project on environment	A			A			A		
1.5.2	Specialists (Hydrology, Aquatic, Wetland)	A		Complete suite of aquatic specialist studies formed part of the assessment	C		minor inaccuracy in fish species and feel there is a lack in specialist visual assessment	B		
1.5.3	Data sources mentioned	B		Although not specifically mentioned in the EIA report mentions were made in the specialist reports	B		adequate sources	B		
	Hydrology & flow of water resource	C		Obtained from DWS - no real time monitoring (although noted as a limitation)	C			C		
1.5.4	Present Ecological State (PES),	A		PES, EI, & ES was determined and compared to the DWS 2014 study	A		all included	A		
	Ecological Importance and Sensitivity (EIS) of water resource	A			A			A		
1.5.5	Ecosystem goods and services	C		Only the impact to ecosystem goods and services were described	B			C		
1.5.6	Socio-economic benefits	A			A		slightly generic	A		

1.5.7	Habitat intergrity	B		Habitat integrity was determined in specialist study but was not incorporated into the EIAr specifically	B		assumption that the modified habitat trumps other environmental concerns	B
1.5.8	Recommended Ecological Category	B		REC was determined in specialist study but was not incorporated into the EIAr	B		not carried into EIA report	B
1.5.9	Method to determine Ecological Reserve	A		Mitigation flows were determined	A		determined	A
1.5.10	Local Plans/policies/guidelines	A		Good policy & legislative context chapter	A		strong policy section	A
1.5.11	Summary of specialsit reports	A			A			A
	Review Area 2: Indentification and evaluation of key impacts		**B**			**B**		**B**
2.1	**Scoping**		**A**			**A**		**A**
2.1.1	Identififying interested and affected parties	A		In addition to government and neigbouring landowners local tour operatorators dependent on the river were included as I&Aps	A		well done	A
2.1.2	Public participation	A		Issues of I&Aps were taken into account	A		comprehensive	A
2.1.3	List of issues identified	A			A			A
2.1.4	Key impacts for further investigation	B		Good list of potential impacts	A			B
2.2	**Defintion of Potential Impacts**		**B**			**B**		**B**
2.2.1	All possible effects on the environment (indirect, direct, cumulative)	B		Indirect, direct and cumulative impacts were described however, some inadequcies regarding land use decriptions limit impact descriptions	B		visual impacts considered but felt to be inadequate	B
2.2.2	Interaction of effects	B			B		interaction not always clear	B

2.2.3	Impacts from non-standard operating conditions	B			B		not well described - flow changes from Lesotho?	B	
2.2.4	Impacts from deviation from baseline	B			B			B	
2.3	**Identification of Impacts**								
2.3.1	Assess impacts in all phases	B			A			B	
2.3.2	All possible impacts identified	B			B		some degree of assumption that the modified river is no longer ecologically functional	B	
2.4	**Assessment of Impacts**		**C**			**B**			**C**
2.4.1	Impact magnitude (quantitative or qauliative)	A			A		graded	A	
2.4.2	Significance to affected community	D		Although impacts related to socio-economics were assessed, the sigficance of other impact to the affected community was not mentioned	C		community data was somewhat text book based and lacked on-the-ground insight	C	
2.4.3	Method of assessing significance	A		Qauntitative rating scale	A			A	
	Review Area 3: Alternatives, Mitigation Measures, Monitoring and Recommendations								
3.1	**Alternatives**		**A**			**B**			**A**
3.1.1	Description of methods used to identify alternatives	A			A			A	
3.1.2	Description of alternative site (advantages/disadvantages)	A			C		alternative sites were mentioned but much of the alternative site assessment was done technically outside of the EIA - at least add source of data to this process.	B	
3.1.3	Description of alternative process, designs, and operating conditions (flow scenarios)	B		Mitigation flows described in specialist study	B		final sleection of turbines not done and/or use of waterbearings	B	
3.1.4	Rejected alternative identified	A			A			A	

3.1.5	Comparative assessment of alternatives and reason for preferred alternative	A		Preferred alternatives identified	B		access must be provider to assessmsnts outside the EIA	B	
3.2	**Mitigation Measures**		**A**			**A**			**A**
3.2.1	Mitigation of all signficant adverse impacts considred	A			A			A	
3.2.2	Mitigation measures proposed to prevent or offset adverse impacts	A			A			A	
3.2.3	Mitigation measures clearly defined	B		Most mitigations unambiguous	B		more operation mitigation could be included	B	
3.2.4	Anticipated effectiveness of proposed mitigation	A		comment on residual impacts	B		generic	B	
3.3	**Monitoring and Review**		**A**			**A**			**A**
3.3.1	Monitoring arragements	C			B		good	C	
3.3.2	Commitment and responsibilites for monitoring stated	N/A		mentioned as part of EMPr	N/A			N/A	
3.3.3	Financial provisions for rehabilitation/closure	N/A			N/A			N/A	
	Review Area 4: Communication of Results								
4.1	**Layout of Report**		**A**			**B**			**B**
4.1.1	Introduction (project description, aims of EIA)	A			A		good	A	
4.1.2	Information logically arranges	A			A		good	A	
4.1.3	Summary of long chapters	B			C		executive summary could improve	C	
4.1.4	Acknowledgement of external sources	A			A			A	
4.2	**Presentation**		**B**			**B**			**B**
4.2.1	Comprehensible presentation of information (avoiding obsure language)	B			C		map could improve. None environmental public will find difficult to follow	B	
4.2.2	Technical terms, acronyms, initials defined	A			A			A	
4.2.3	Presentation of the report as an integrated whole	B			B		access difficult for none-environmental person	B	
4.3	**Emphasis**		**A**			**B**			**A**

4.3.1	Emphasis on adverse/beneficial impacts	B			B		assumumtion of impacted watercourse that trumps other matters	B	
4.3.2	Statement must be unbaised	A			A			A	
4.3.3	Conditions for authorisation	B		Overall generic with some specific to mitigation flows. although there was mention of mitigation flows in EIAr recommendations, recommendations were overall generic - competent authority will have to refer to specialist studies for more comprehension	B		more specifics required	B	
4.3.4	Opinion as to whether development should/should not be authorised	A			A			A	
4.4	**Non-technical summary**		**A**			**A**			**A**
4.4.1	Non-technical summary of main findings and conclusions	A			B		layman needs more basics	B	
4.4.2	Summary covers all main issues	A			A			A	