A comparative study of the quality and outcomes of Environmental Impact Assessment reports from the Free State and Northern Cape provinces

by

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Opsomming

`n Omgewingsimpak studie stel die beraamde ekonomiese, sosiale en omgewingsimpakte vas van `n voorgestelde ontwikkeling. Omgewingsimpak verslae word saamgestel deur onafhandlike konsultante om sodoende die owerhede te voorsien van inligting oor voorspelde impakte wat veroorsaak word deur ontwikkelinge en aktiwiteite. Die owerhede baseer hulle besluite grootliks op die omgewingsimpak verslae en vertrou dat die inligting wat daarin voorsien word akkuraat is. Die owerhede vertrou ook dat die voorkomings en versagtingsmaatrëels wat gestaaf is in die besluitnemingsdokumente en omgewingsbestuursplanne, geïmplementeer word gedurende die konstruksie en operasionele fase van projekte. Na-besluitnemings aktiwiteite, soos monitering en ouditering, is die enigste terugvoeringsmeganisme om die owerhede te voorsien met inligting in verband met die implementeering van voorgestelde versagtingsmaatrëels en die omvang van voorspelde impakte.

Die akkuraatheid van voorspelde impakte en die hoeveelheid van geïmplementeerde versagtingsmaatrëels in Suid Afrika is onbekend, omdat die Omgewings Impak Regulasies wat gepromulgeer is in September 1997 in terme van die Omgewings Bewarings Wet 107 van 1987, nagelaat het om ouditering verpligtend te maak.

Die doel van hierdie studie is om vas te stel wat die akkuraatheid van voorspelde impakte is en die aantal versagtingsmaatrëels wat geïmplementeer is, van goedgekeurde projekte, in die Vrystaat en Noord Kaap provinsies. Die doelwit van die studie is om te verseker dat owerhede hulle besluite baseer op korrekte inligting, deur vas te stel of enige verbeteringe aangebring moet word, aan omgewingsimpak verslae. Nog `n mikpunt van die studie is om te verseker dat besluitnemers maatrëels voorstel wat suksesvol en voldoende sal wees om impakte te versag of te voorkom.

Die navorsingsvraag in die studie is tweeledig. Eerstens moes die vraag oor die akkuraatheid van voorspelde impakte en die aantal versagtingsmaatrëels wat geïmplementeer is in die Vrystaat en Noord Kaap beantwoord word. Die vraag se antwoord was verkry deur die metode genaam “backwards auditing” te implementer. Tweedens moes bepaal word of die twee provinsies se resultate dieselde was in terme van die akkuraatheid van voorspelde impakte en geïmplementeerde versagtingsmaatrëels. Die vergelyking van resultate tussen die twee provinsies was bekom deur veskeie “ Pearson chi-square ” toetse op gebeurlikheidstabelle toe te pas.

Die gevolgtrekking van die studie was dat daar geen noemenswaardige statistiese verskille voorgekom het tussen die twee Provinsies nie, in ooreenstemming met die uitslag van die voorspelde impakte en versagtings maatrëels. Voorspelde impakte was meestal akkuraat en die meerderheid vesagtingsmaatrëels was grootendeels suksesvol geïmplementeer om die impakte te versag.

Key terms: Environmental impact assessment, EIA, auditing, monitoring, accuracy of impacts, implementation of mitigation measures, Record of decision, ROD, public participation, chi-square tests.

Abstract

An Environmental Impact Assessment (EIA) determines the economic, social and environmental impacts of proposed developments. Environmental Impact Assessment reports are complied by independent consultants in order to provide the authorities with information on the anticipated impacts on the environment caused by a proposed activity or development. The authorities therefore base their decision largely on the EIA document and trust that the information about forecasted impacts are to a large extent accurate. Authorities also trust that the mitigation measures proposed in the Record of Decisions (RODs) and Environmental Management Plans (EMP`s), in order to minimize impacts on the environment, are implemented during the construction and operational phases of a project. Post-authorization activities such as monitoring and auditing are the only feedback mechanisms to provide authorities with information on the extent to which predicted impacts materialised and whether mitigation measures were implemented.

Post authorization activities, especially auditing is to a large extend neglected because it was not mandatory in South Africa under the Environmental Impact Assessment regulations promulgated on September 1997 in terms of Environment Conservation Act 107 of 1989. Therefore the accuracy of predicted impacts and the implementation rate of mitigation measures in South Africa are to a large extent unknown.

The aim of the study is to assess the accuracy of predicted impacts and the implementation rate of mitigation measures of activities that received authorization from the Departments of Environmental Affairs in the Free State and Northern Cape provinces, in South Africa. The objective of the study is to determine if any improvements are necessary to EIA reports, to establish whether authorities base their decisions on correct information. The adequacy or success of proposed mitigation measures will also aid decision makers in suggesting preventative measures.

The research problem posed in this study was two-fold. First the question relating to the accuracy of predicted impacts and implementation of mitigation measures in the Free State and Northern Cape had to be answered. This was done through a method called impact-backwards auditing. Secondly the question whether the two provinces had similar outcomes in terms of predicted impact accuracy and implementation of mitigation measures, had to be assessed. The comparison between the two provinces was conducted through a series of Pearson chi-square tests on contingency tables to assess if statistically significant differences occurred in the outcome of predicted impacts and mitigation measures between the Free State and Northern Cape provinces.

This study concluded that no statistically significant differences occurred between the two provinces in relation to the outcome of predicted impacts and mitigation measures. Predicted impacts were to a large extent accurately predicted and the majority of mitigation measures were to a large extent implemented successfully to prevent or minimize an impact.

1. Introduction

The main purpose of an Environmental Impact Assessment (EIA) is to provide comprehensive information about the impacts a development will have on the environment. The authorities trust that the information in the environmental impact reports on which they base their decisions on are to a large extent accurate and that all the possible impacts, which were predicted, are reliable. The only way to determine if the information about predicted impacts in environmental impact reports were accurate and if mitigation measures were implemented, is through monitoring and auditing.

Auditing can help the EIA process to be dynamic instead of a static linear exercise by providing information about the actual outcome of predictions and the success of mitigation measures, in order to improve future practices. Auditing and monitoring practices are however largely neglected because it is not mandatory in many countries.

This research study is based on the Environmental Impact Assessment regulations promulgated in September 1997 in terms of the Environment Conservation Act (ECA) 107 of 1989. This research study is a follow-up study on previous research done by the author in 2004 for an honours degree (Freemantle, 2004). The previous qualitative study was based on 6 case studies in the Free State province and was an explorative type of study in order to provide information about the quality of environmental impact reports in terms of the accuracy of predictions. This study indicated to the author that the subject matter of EIA auditing needed further exploration, on a larger scale, to determine the accuracy of predicted impacts and the outcome of mitigation measures in more than one province in South Africa. Data from more than one province would be useful because comparisons can be made between the results of provinces to determine if trends or similarities occur in the outcome of predicted impacts and proposed mitigation measures.

This research study is a comparative study that focuses on the quality and the outcomes of predicted impacts and mitigation measures that are stated in Environmental Impact Assessments (EIAs) and Record of Decisions (RODs) in the Free State and Northern Cape provinces. The accuracy of predicted impacts and the implementation and success rate of mitigation measures are determined in both provinces and then compared to determine if the outcomes are similar or not. The literature review provides background information about environmental impact assessment and auditing. The methodology utilized in the study will be discussed in terms of obtaining and analysing data and by conducting a quantitative comparison on the outcome of predicted impacts and mitigation measures between the two provinces. The results and observations of the research study and recommendations for improvement and future studies are also discussed.

2. Background information on Environmental Impact Assessments (EIAs) and auditing

In 1980 the White Paper on national policy regarding environmental conservation was published in South Africa. A direct outcome of this white paper was the Environment Conservation Act (ECA) 100 of 1982 (Rabie, 1999). This act made provision for the co-ordination of all actions that would have an influence on the environment. The ECA of 1982 was replaced by the Environment Conservation Act (ECA) 107 of 1989, which provided for effective protection and controlled utilization of the environment (South Africa, 1989). ECA 107 of 1989 also made provision for the legal enforcement of Integrated Environmental Management (IEM) procedures (Rabie, 1999; Rogerson & McCarthy, 1992). South Africa adopted the Constitution of the Republic of South Africa 108 of 1996, of which in section 24, the environmental rights of the people are described. Hence to ensure that these constitutional rights are not affected; proper environmental impacts management through uniform control of developments had to be ensured. Thus the listed activities and Environmental Impact Assessment (EIA) regulations were promulgated in September 1997 in terms sections 21, 22 and 26 of the Environment Conservation Act of 1989 (Jenks, 1999). These EIA regulations focused exclusively on the role of EIA in decision-making and lacked provision to regulate the implementation phase of developments (Hill, 2000). The National Environmental Management Act (NEMA) 107 of 1998 (South Africa, 1998) followed to provide a fundamental legal framework that ensures the concretisation of the environmental rights in the Constitution. NEMA repeals the greater part of the ECA of 1989 (Van der Linde, 2006). New Environmental Impact Assessment regulations in terms of Chapter 5 of the National Environmental Act of 1998 were published in the Government Gazette no.28753 on 21 April 2006. These new regulations do not only focus on the role of EIA in decision-making, but on also the requirements for post-decision implementation.

2.1 Environmental Impact Assessment (EIA)

The National Environmental Management Act of 1998, describes the national environmental management principles, which aim to promote sustainable development through integrated environmental management (IEM) (Environmental Evaluation Unit, 2002; Oelofse & Scott, 2002, South Africa, 1998b; Wood, 1999).

The goal of IEM is to ensure that South African resources are utilised in a sustainable way and that development takes environmental and social concerns into account without delaying or adding too much cost to projects. The purpose of IEM is to minimise negative impacts on the environment by implementing mitigation measures and to maximise positive impacts on the environment during the development phase of a project (Hugo, Viljoen and Meeuwis, 1997; Quinlan, 1993).

In South Africa the IEM provides a conceptual framework for the implementation of environmental impact assessments (EIAs) (Hamann, Booth and O`Riordan, 2000). EIA is defined, by Hansen and Jorgensen (1991:367), as a …*systematic examination of the likely environmental consequences of [proposed] projects, programmes, plans and policies.* Hugo et al. (1997:213), define EIA as a … *administrative or regulatory process by which the environmental impact of a project is determined.*

According to Mayhew and Penny (1992:76), Environmental impact assessment statements should provide …*information about the technology and location of the development, an appraisal of the likely environmental effects, both positive and negative, an outline of possible alternatives, and an estimate of any irreversible commitment of scarce resources* … in order to provide enough information for decision-makers to be able to make informed decisions.

Please note that the IEM provides a conceptual framework for both the EIA regulations promulgated in terms of ECA in 1997 and the new EIA regulations promulgated in terms of NEMA in 2006 (South Africa, 2006). The new EIA regulations of 2006 replaced the old EIA regulations of 1997. However this literature review will focus on the old EIA regulations promulgated in September 1997 in terms sections 21, 22 and 26 of the Environment Conservation Act of 1989, due to the fact that the research for this study started prior to the promulgation of the new EIA regulations and because the case studies used obtained authorization based on the old EIA regulations.

According to Preston, Robins and Fuggle (1999), the procedure of EIA in the conceptual framework of IEM can be divided into three stages namely: development and assessment of proposals, decision stage and implementation stage.

In the development and assessment stage of the proposed development, the legal and administrative requirements of a proposed project must be established (Preston et al., 1999). In Section 21 of the Environment Conservation Act (ECA) of 1989, provision is made for the identification of activities by the Minister, which may have detrimental effects on the environment (South Africa, 1989). These activities, that are identified in the EIA regulation, may not be undertaken, according to section 22 without authorisation from the relevant authorities (South Africa, 1989; Environmental Evaluation Unit, 2002). If the proposed development is identified in Section 21 of the Environment Conservation Act (ECA) of 1989, a proposal for the new development has to be submitted to the relevant government department for approval. The proposal undergoes a screening process to determine if the new development would have any impact on the environment (see **Diagram 1**). If the screening process reveals that the proposed development would have no adverse impact on the environment it can be exempted from applying for approval (Hugo et al., 1997). Section 28 of the ECA of 1989 states that a person or local authority can apply for an exemption from an application of approval to the Minister (South Africa, 1989; Environmental Evaluation Unit, 2002). If the screening process reveals that the proposed development will have an impact on the environment, an application needs to be submitted to the Department of Environmental Affairs and Tourism (DEAT) (Hugo et al., 1997). In section 28 of the ECA of 1989, the Department of Environmental Affairs and Tourism was identified as the general regulatory power and lead agent for all matters pertaining to EIAs (Environmental Evaluation Unit, 2002; South Africa, 1989).

A proposed development that was identified during the screening phase, to submit an application for approval to DEAT, has to go through a scoping phase (see **Diagram 1**). A scoping report has to ascertain the expected extent of the impacts on the environment (Curi, 1983; Hugo et al., 1997). The positive and negative impacts of the proposed project should be assessed by an independent consultant firm and mitigation measures should also be suggested by the firm. Interested and affected parties must also be included into the planning processes of the project. Thus the concept of IEM must be utilised from the beginning of the planning processes and not as an “add on” (additional phase) after the project development plan has been completed (Preston et al., 1999; Therivel & Morris, 1995).

Many developments are approved after the scoping report, if all the relevant information about environmental impacts are provided to the satisfaction of the authorities (Preston, et al., 1999). The approval of the project after the scoping report is stated in the Record of Decision (ROD) with the mitigation measures that have to be implemented, but larger projects usually have to undergo a full environmental impact assessment before authorities can come to a decision (Hugo et al., 1997). If the authorities decided that insufficient information about the proposed development and the impact on the environment was supplied in the scoping report, additional information is needed through further assessment (Preston et al., 1999).

An environmental impact assessment would have to be conducted in order to identify the impact a development would have on the environment plus recommendations or alternative proposals and possible mitigation measures (Dipper, Jones, Wood, 1998; Fuggle, 1999a; Hugo et al., 1997; Lloyd, 1995). Section 26 of the Environment Conservation Act of 1989, provides for regulations regarding environmental reports (Environmental Evaluation Unit, 2002; South Africa, 1989).

The authorities should evaluate the environmental impact report and either approve the proposed project or decline it (see **Diagram 1**). If the proposed project was approved the ROD might stipulate relevant procedures that must be followed, such as mitigation measures that reduce impacts to an acceptable level or prevent impacts from occurring on the environment (Preston et al., 1999).

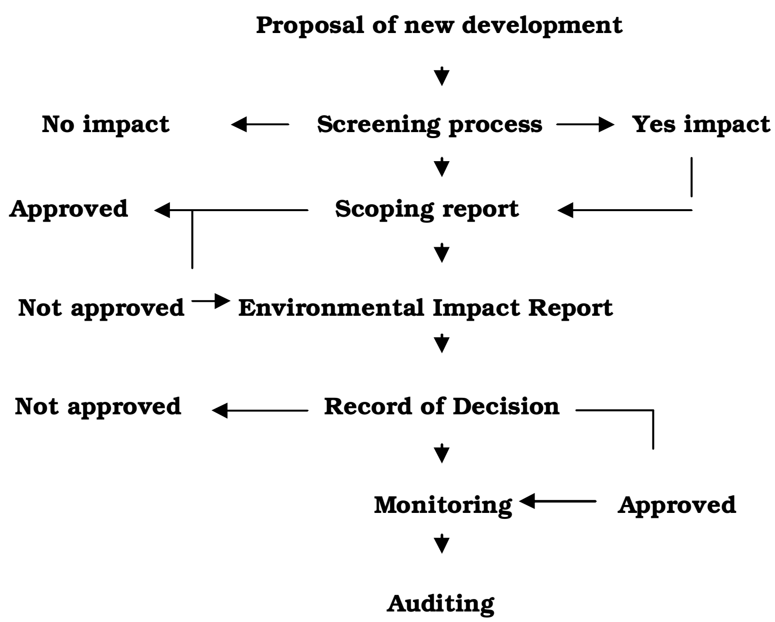


Diagram 1: Environmental impact assessment procedure
(Adapted from source, South Africa, 1998a)

2.2 Monitoring and auditing

The implementation stage occurs after authorisation has been granted for the development to take place (decision stage). The implementation of the project must comply with the mitigation measures mentioned. Monitoring practices can be implemented to ensure that mitigation measures are implemented during construction and that any additional impacts that might occur can be controlled or be prevented (Arts, Caldwell, Morrison-Saunders, 2001; Lawrence, 1997; Preston et al., 1999). Monitoring provides information about the characteristics and magnitude of impacts while development takes place (Antcliffe, 1999). After the project is completed an audit might be conducted to ensure that all mitigation measures were implemented and that all legal requirements were adhered to. The auditing of a project can also measure the accuracy of predicted impacts and is a tool to evaluate and improve the EIA process (Arts et al, 2001; Bailey & Hobbs, 1990; Hugo et al., 1997; Preston et al., 1999).

EIAs provide information to decision-makers on the possible environmental impacts of proposed developments. The authorities trust that the information they base their decision on are unbiased and based on sound and comprehensive data, but uncertainties and knowledge gabs do exist about impact forecasts (Arts et al, 2001; Dipper et al, 1998; Fuggle, 1999b ; Turnbull, 1983).

Some independent consultant firms that are hired by companies to conduct EIAs, may however not be fully independent and can be biased, favouring the interests of the company that hired them above the environmental concerns (Abaza, 2000; Lee & Brown, 1992). Moreover the accuracy of the possible predictions or the margin of error associated with the evaluation techniques used, are not known (Arts et al, 2001; Bisset & Tomlinson, 1983; Tomlinson & Atkinson, 1987). Only post project analysis (monitoring and auditing) can be used to assess the accuracy of predicted impacts and if mitigation measures were implemented after the project implementation stage (Abaza, Bisset, Sadler, 2004; Arts et al, 2001).

Various researchers (Abaza, 2000; Abaza, 2004; Arts et al, 2001; Dipper et al, 1998; Glasson, Therivel and Chadwick, 1994; Sadler, 1988; Wood, 1995) notes that in many countries the post-project approval stage is the weakest phase in the EIA process, because of a lack of monitoring and auditing practices that exist. Abaza (2000) argues that the reason for the lack in monitoring and auditing practises can be contributed to consultants, whose main aim is to finish their job, completing and submitting EIAs for approval.

Consultants do not consider or take into account the inclusion of monitoring and auditing practices in to their reports, because they are usually only hired to do an environmental impact assessment (Arts et al, 2001). This therefore makes the EIA process not an environmental management tool because it lacks the life-cycle approach to environmental management by not focussing on monitoring and auditing (Alex, Ebenzario, Hespina, Tarr, 2003).

Project planners do not consider the need for the inclusion of monitoring and auditing practices into their project plans, because it is considered as too time-consuming and costly. The EIA process is thus considered as a tool to obtain permission to develop instead of a tool to achieve sound environmental management (Arts et al, 2001; Bisset & Tomlinson, 1988,). Authorities that approve EIAs are also to be blamed for not ensuring that monitoring and auditing practices are considered by project planners as an important part for obtaining approval for developments. Another reason why auditing and monitoring practices seldom occur, may be because in many countries it is not part of the formal process of EIAs and is therefore not considered mandatory according to the legislation (Arts et al, 2001; Dipper et al, 1998; Gilpin, 1995).

According to Hugo et al. (1997:213), there was no legislation that required post-project environmental impact assessment audits to be undertaken by any company or developer in South Africa in terms of the EIA regulations promulgated in terms of ECA of 1989. However, the new EIA regulations promulgated in terms of NEMA do provide for the authorities to request an audit from a proponent if non-compliance is suspected (South Africa, 2006). Therefore, there was no mandatory tool in South African EIAs prior to 2006, which required the assessment of the accuracy of predicted impacts and to ascertain if mitigation measures were implemented.

However, uncertainty still exists about the accuracy of predicted impacts and the implementation of mitigation measures in South Africa, due to the fact that the old EIA regulations did not make mandatory provision for it and because the new regulations that make provision for auditing and monitoring have not been implemented fully in the post decision stage due to capacity building problems and staff shortages (Arts et al, 2001; Krynauw, 2007).

It is important that environmental impact assessment audits are conducted because it is a feedback mechanism or evaluation tool for the EIA process (Abaza, 2004; Bisset and Tomlinson, 1988; Gilpin, 1995; Harrop and Nixon, 1999). The EIA process then becomes a static linear exercise without a feedback mechanism, instead of a dynamic interactive process, which ensures sound environmental management over the life-cycle of a project (Sadler, 1988). Audits provide useful information about the accuracy of impact prediction and whether mitigation measures were implemented successfully and correctly (audits are a quality control mechanism) (Arts et al, 2001; Culhane, 1993; Dipper et al 1998; Gilpin, 1995; Leu, Williams and Bark, 1997). Thus audits can provide the authorities and project developers with useful information about the impact predictions and mitigation measures in order to improve future EIA practices and to ensure better-informed decisions and environmental protection (Arts et al, 2001; Harrop and Nixon, 1999).

Audits can also be seen as mechanisms to ensure that acceptable standards of performance are being achieved in environmental management. Moreover, audits can also provide information about the competence of authorities and project developers to prevent and manage environmental impacts caused by project development (Buckley, 1991). The cost-effectiveness of EIA in the project planning stage can also be assessed through audits, determining the accuracy and success of environmental management (Arts et al, 2001; Sadler, 1988), therefore justifying the added cost of EIA studies to the project budgets.

Arts et al. (2001) highlights the fact that most literature and studies are based on the pre-decision stage of the EIA process and that only a few studies or literature is available on the post-decision stage in particular the assessment of the actual impacts that occurred in reality compared against the predicted impacts. He further notes that the notion of the follow-up process or audit is understood properly but the implementation of such an EIA follow-up audit on the predicted impacts and mitigation measures proves to be rather difficult in practice and that only a few studies are available addressing the implementation process of an EIA audit.

The following studies were the only the author could obtain that dealt with EIA audits:

In the United States of America, according to Culhane (1987), environmental impact audits were conducted by using a cross-sectional time-series statistical model. The data that were used were obtained in records of agencies and local government offices and by conducting interviews with knowledgeable informants that were familiar with the various randomly selected developments.

Culhane (1987) notes that the cross-sectional time-series statistical model was inappropriate to deal with the real-world variances in project impacts, data and forecasts. Culhane (1987) also explains another method used in environmental impact auditing namely, the case by case rating scheme. In this method, the accuracy of the predicted impacts are *…evaluated using a case by case rating scheme. The rating scheme contains a total of 39 codes describing the direction of the impacts, the match between forecast conditions and actual impacts…it also allows both primary and secondary ratings.* (Culhane, 1987:224) (see **Chapter 8** for results).

Buckley (1991) conducted environmental impact assessment audits in Australia. His data were obtained from various State and Commonwealth government agencies and from various corporations. Only EIA reports with predictions that could be quantified and which had substantial monitoring programmes, were chosen by him to be audited. The predicted impacts were compared with monitoring results, to determine the degree of accuracy of the predictions. The results were presented in a matrix format (see **Chapter 8** for results).

An environmental impact assessment audit was conducted in the United Kingdom on two case studies using a matrix approach. The accuracy of predicted impacts and additional impacts that occurred were assessed in the study. The assessment of the accuracy of various prediction techniques was found to be difficult because it was either not mentioned in the EIA reports or if it was mentioned, it was not possible to audit (Harrop & Nixon, 1999) (see **Chapter 8** for results).

Lee Wilson and Associates (Harrop & Nixon, 1999), conducted environmental impact audits in the United States of America using an analysis called 'impact-backwards auditing'. This analysis… *relies upon reports of actual, observable impacts after a project has been constructed and checked impacts arising against those predicted in the…*EIAs (Harrop & Nixon, 1999:144) (see **Chapter 8** for results).

3. Problem statement, aims and objectives

It is clear from the literature review in **Chapter 2** that the post-authorisation stage of the EIA process is to a large extended neglected and that only a limited amount of literature is available on the subject, especially the implementation of an EIA audit. Since auditing of EIA outcomes after the authorisation stage was not a legal requirement in South Africa in 1998; no information about the quality of EIA predictions in terms of its accuracy or the number of implemented mitigation measures are available in South Africa. The aim of this research study is to determine the accuracy of predicted impacts and the implementation rate of mitigation measures in South Africa. Due to time constraints this research study only focused on EIAs in the Free State and Northern Cape provinces. It was necessary to compare results of the two provinces with each other in order to determine if similarities or differences occur in the outcomes, to establish if trends in terms of accuracy of predicted impacts or in the implementation of mitigation measures occur. The objective of the study is to use the information obtained through the research to make recommendations that would assist consultants and authorities with identifying areas that need improvement in regard to proposed mitigation measures and predicted impacts that need more attention,

Therefore this research study would firstly focus on the post-authorisation period of the Environmental Impact Assessment (auditing), in order to determine if the impacts on the environment were predicted accurately. The research question posed is the following:

Have Environmental Impact Assessments (EIAs) conducted in the Free State and Northern Cape provinces been successful and accurate in their prediction of environmental impacts?

Secondly, the research study will focus on determining if all the mitigation measures that were stated in the Record of Decision (ROD) and Environmental Management Plans were implemented successfully or correctly, in order to prevent detrimental environmental impacts. The following question is posed:

Have mitigation measures stated in Environmental Management Plans (EMPs) and Records of Decision (RODs) in the Free State and Northern Cape provinces been successfully or adequately implemented?

Thirdly, the following research question will be focused on after the accuracy of predicted impacts and the success and implementation rate of mitigation measures have been established in the Free State and Northern Cape provinces:

Have the outcome of predicted impacts and the outcome of proposed mitigation measures been similar in the Free State and Northern Cape provinces?

The methodology used to answer the above research questions is discussed in **Chapter 4**.

4. Data and Methodology

4.1 Data

Fifty case studies, 25 in each province, were randomly selected from the EIA registers at the Department of Environmental Affairs in the Free State and Northern Cape provinces, in order to determine if Environmental Impact Assessments (EIAs) have made accurate predictions and if appropriate measures were taken to prevent environmental impacts. All 50 of the selected case studies are activities that are identified in Section 21 of the Environmental Conservation Act (ECA) of 1989, as activities that may have an impact on the environment. Only case studies that were conducted and that obtained authorization under the EIA regulations that were promulgated in September 1997 in terms of ECA of 1987 were selected, due to the fact that the study started and the case studies were selected before the new EIA regulations were promulgated in April 2006 in terms of NEMA. The case studies that were selected were all in the operational phase for at least a year. None of the selected case studies had undergone a full environmental impact assessment. The reason why only case studies that underwent a scoping report were selected, is that no case studies that underwent a full environmental impact assessment in the Free State and Northern Cape province were completed or available in the registers of the two provincial Departments of Environmental Affairs.

According to a communication by Mr. Krynuaw (2004), an Officer at the Department of Environmental Affairs and Tourism in the Free State, few applications underwent a full environmental impact assessment and the few that have undergone a full environmental impact report was submitted at national scale and thus would be at the Pretoria / Johannesburg office of the Department of Environmental Affairs in the register. Wood (2000) notes that all activities in South Africa that are identified in Section 21 of ECA of 1989, are required to undergo a scoping report or at least to prepare a plan of study for scoping that can be reviewed by the authorities. Preston et al. (1999) states that not all the applications for proposed projects are required to undergo a full environmental impact assessment. In many cases, a brief investigation such as a plan of study for scoping or a scoping report, will convince the decision makers that the proposed project will not have a significant impact on the environment, or that mitigation measures can be implemented successfully, preventing adverse environmental impacts. The case studies were based on various identified activities in the EIA regulations (South Africa, 1998) and varied from fuel filling station developments to the construction of communication structures.

The case studies that were selected were studied and analysed in depth, in order to determine the predicted environmental impacts that were identified in the scoping reports. The environmental management plans and records of decisions were analysed to determine the mitigation measures that were required for the prevention or minimization of detrimental environmental impacts. The information that was required to determine whether the impacts were correctly predicted and if all mitigation measures were implemented, were obtained through interviews with relevant people and from visual observations at the 50 sites that were visited.

4.2 Methodology

A literature review was embarked on before the study was conducted. The author only found a limited amount of literature that were based on auditing environmental impact assessments and none of these research articles or books were based on South African case studies (see **Chapter 2** for literature review). The literature found in regard to environmental impact audits were based on case studies in the United States of America, United Kingdom and Autralia (Culhane, 1987; Buckley, 1991; Harrop & Nixon, 1999). The methods utilised in these studies to conduct environmental impact audits were a matrix approach, a cross sectional time series statistical model and a case-by-case rating scheme. These methods were not utilized during this research study, because some of the methods were not appropriate to deal with real world variances or the predictions had to be quantifiable and comprehensive monitoring data had to be available.

The method used by Lee Wilson and Associates (Harrop & Nixon, 1999) in the United States of America to conduct environmental impact audits was utilised by the author during this research study. The analysis method is called 'impact-backwards auditing' (see **Chapter 2** for the literature review). This method was implemented and described underneath in step number 1 to 6, in order to compare the actual impacts that occurred against the impacts that were predicted in the EIAs in the Free State and Northern Cape provinces. This same method was utilised to determine if proposed mitigation measures were implemented and whether it were sufficient in the minimization or prevention of impacts in both provinces. The results from the environmental impact audit from both provinces were compared with each other (see step number 7 underneath), in order to determine if differences occurred between the two provinces in terms of predicted impacts outcomes and mitigation measure implementation rates and successes.

The method followed for the ‘impact-backwards auditing’ and comparison of results between the two provinces are described below in the following 7 steps:

1. *Select project EIAs to audit:*

   Sixty scoping reports of projects, 30 in each province, in the Free State and Northern Cape provinces, from 1998 until 2006, were randomly selected from the EIA registers at the two provincial Departments of Environmental Affairs. Scoping reports from 1998 were chosen because legal requirements to conduct an EIA were only promulgated in 1997 (Hamann, Booth and O`Riordan, 2000). Out of the 60 selected scoping reports only 50 (25 from each province) were chosen to conduct audits on. The reason for this is mainly because the scoping reports of projects near or in the Bloemfontein, Kimberley and Upington areas were selected out of the 60, due to time and money constraints to conduct the audits. The case studies were not based on similar types of developments, because this research study focused on determining the actual outcome of an impact compared to the predicted impact and the actual success and implementation rate of a proposed and required mitigation measure, irrespective of the type of impact or mitigation measure.

2. *Identify likely project impacts:*

   The predicted environmental impacts in the scoping reports were identified and categorised into possible impacts during the construction phase, possible impacts during the operational phase of the project and unpredictable impacts (impacts for which no definite prediction could be provided for because of inconclusive evidence). The predicted impacts in the construction and operational phases were further categorized into bio-physical and socio-economic impacts (see **Appendix G** & **H**). The predictions were analysed (see **Appendix A**) in order to determine the predicted probability, intensity and extent of each impact. This proved to be difficult because many of the activities were described in detail, while few predictions were given. When an impact predictions was stated, it was usually vague and in a qualitative form, not directly providing information about the extent and probability or intensity of an impact. It had to be interpreted from descriptions of activities and checklists.

The mitigation measures for the project were obtained in the environmental management plans, records of decision and scoping reports. The mitigation measures were categorized into construction phase, operational phase and unidentifiable mitigation measures (see **Appendix J** & **K**). The mitigation measures that were stated were usually general and not specific to the projects itself.

3. *Prepare approach for field investigation:*

A study plan for each case study was planned, in order to identify knowledgeable informants with whom interviews could be conducted. A checklist for each case study was compiled for site visits, to assess if impacts were predicted correctly and if additional impacts occurred, plus if mitigation measures were implemented. Each case study had a different checklist based on the predicted impacts and mitigation measures of that specific case study. See **Appendix A** for an example of the checklist used for a site visit.

4. *Identify actual project impacts:*

Interviews with knowledgeable informants such as officials, land owners, managers, neighbours and developers were conducted in order to obtain information that revealed the actual impacts of projects. Site visits to the various areas of all the case studies were conducted to determine if changes to the project design plan occurred between the decision stage and the implementation stage. Construction / site plans and locality maps of the projects, which were included in the scoping reports, were compared to the actual construction and site localities of the developments during the site visits.

The various sites of the projects were photographed in order to aid as visual confirmation about findings that were made during the site visit. Conclusions about the impacts and mitigation measures were drawn after site visits; interviews and additional information about various impacts such as endangered and protected species and historical sites were obtained.

5. *Comparison with scoping report:*

Predicted impacts in the scoping report and mitigation measures in the environmental management plans and records of decision were compared to information gathered during site visits and interviews in order to determine if impact predictions were accurate, if additional impacts occurred and if mitigation measures were implemented.

The outcome of predicted impacts were grouped into three categories, namely: accurate, inaccurate and indeterminable. Predicted impacts that were placed in the accurate category exhibited the outcome that was predicted in the scoping reports. However, when the predicted impacts did not exhibit the outcome that was predicted in the scoping reports it was deemed to be inaccurate. Predicted impacts that did not noticeably exhibit an outcome were considered indeterminable. For example, if the scoping report stated that the visual impact of a cell phone mast would be minimal or not significant and it was revealed after site visits, interviews etc., that the visual impact was indeed minimal due to the height, colour and location of the mast, the impact was deemed accurate (see **Diagram 2**).

If a predicted impact was marked inaccurate and information about the predicted extent, intensity, and probability of the impact was available, it was also possible to indicate if the prediction was marked inaccurate due to an over- or underestimation. Thus indicating the cause of the inaccuracy (see **Diagram 2**).

When an impact occurred which was not predicted, it was listed under the additional impact category and the probability, extent and intensity of the impact was listed if information about it could be obtained.

If enough information about a mitigation measure was available to determine its status, it was either marked implemented or not. If the mitigation measure was marked implemented and enough information was available to determine if it was put into practice or applied and was adequate in minimizing or preventing an impact, it was indicated as successfully or unsuccessfully implemented. Mitigation measures were sorted into the sufficiently implemented mitigation measure category when it was adequately implemented and if it was sufficient in the minimization or prevention of an impact. While insufficiently implemented mitigation measures were not adequately implemented and were not successful in the prevention or minimization of an impact (see **Diagram 3**).

When it was not possible to determine if a mitigation measure was implemented or not, due to a lack of information or uncertainty, the mitigation was categorised under indeterminable mitigation measures. If a mitigation measure was indicated as indeterminable, a reason for the indeterminability was provided. The three categories for reasons of indeterminable mitigation measures were the following: no compelling evidence, no evidence of construction activities and no information available. An indeterminable mitigation measure was categorized in the no compelling evidence category when no decisive decision about the implementation (implemented or not implemented) of the mitigation measure could be made. If no monitoring reports and compliant registers could be found or if no information could be recalled during interview about construction activities, the mitigation measure was deemed indeterminable and was sorted into the no evidence of construction activities category. If no information was available during the audit to make a conclusive decision the mitigation measure was considered indeterminable and it was categorised into the no information category (see **Diagram 3**).

6. *Analyse the outcome*

To determine the overall outcome of predicted impacts and implementation of mitigation measures, it was necessary to create a similar data sheet for each case study. The data sheets indicated the various results for the predicted impacts and mitigation measures of each case study. The data sheets divided the predicted impacts into construction and operational phase impacts. The construction phase contains impacts that would occur during the development stage when construction activities occur. The operational phase contains impacts that would occur after the construction phase; during the day-to-day activities of a development. A decommissioning phase was also discussed in some scoping documents, but was not listed on the data sheets because none of the case studies that were audited had reached this stage. Hence predicted impacts that have not yet occurred cannot be audited (see **Diagram 2**).

The predicted impacts in the construction and operational phases were further sub-divided into bio-physical and socio-economic impact categories. The bio-physical impacts included the following impact groups: air quality, water and soil contamination, waste production and associated pollution and ecological impacts on flora and fauna. This category is concerned with impacts dealing with biological and other direct physical impacts on the elements and ecosystems. The socio-economic impact category included the following impacts: archaeological, cultural and historical impacts, noise, traffic and health and safety issues, visual and impacts to aesthetic features, employment issues, surrounding land use and impacts dealing with developments within the 1 in 100 floodline. This category contains impacts mainly dealing with social and cultural issues of developments and economic impacts (see **Diagram 2**).

The mitigation measures were divided into construction phase and operational phase mitigations on the data sheets. Mitigation measures in the construction phase were measures that had to be implemented during the development / construction stage of a project to prevent or minimize impacts. Mitigation measures in the operational phase are measures that are implemented to prevent or minimize an impact cause by the day-to day operations of a project (see **Diagram 3**).

The outcome of the predicted impacts and mitigation measures were coded in order to process the data on a computer in Excel. See **Appendix A** for an example of a data sheet. The total number of accurate, inaccurate and indeterminable predicted impacts were summarised for each province, phase and impact category. The total number of implemented, not implemented and indeterminable mitigation measures were summarised for each province, and phase. Only a few additional impacts occurred and the numbers were not sufficient to be compared.

Diagram 2: Analysis used for predicted impacts

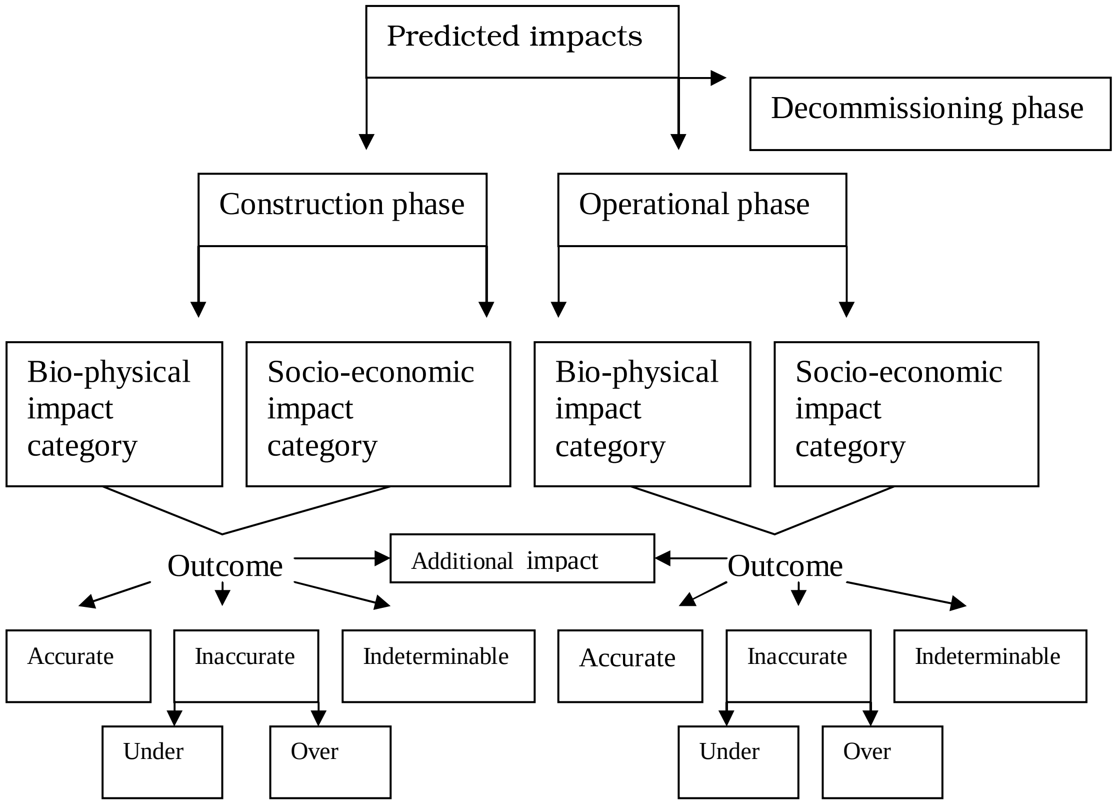
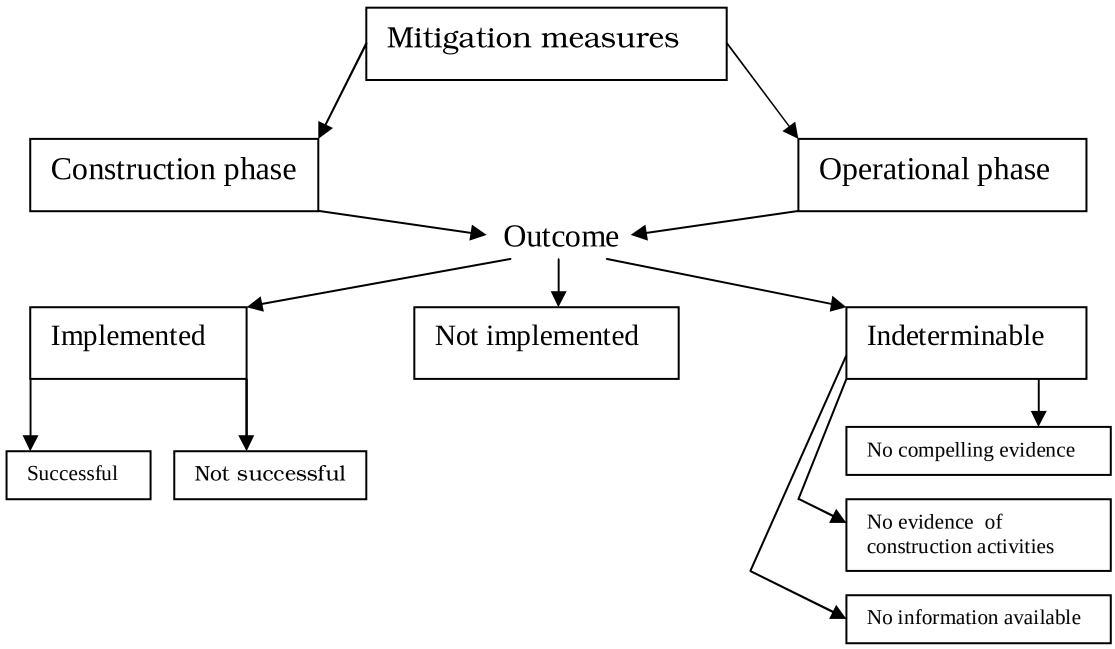


Diagram 3: Analysis used for mitigation measures



7. *Compare the outcomes between the two provinces*

Contingency tables were created with the summarised outcome of predicted impacts and mitigation measures for all 50 case studies for each of the two provinces. Chi-square tests were conducted on the various contingency tables. A chi-square test is a nonparametric statistical test that is employed to test the differences between actual and another hypothetical previously established frequency / distribution which may be expected due to chance or probability. The chi-square test can also be used to test differences between two or more actual samples (Key, 1997). The chi-square test compares observed frequencies (frequencies obtained during data gathering) to expected frequencies (hypothetical frequency if all things were equal and no differences occurred between categories/phases/ provinces) (Williams, 1992). Thus the chi-square test is used to determine if a null hypothesis must be rejected or accepted. The null hypothesis usually states that there is no statistical difference between the groups that are compared, while the alternative hypothesis states that there is a statistical significant difference between the groups that are compared (Ebdon, 1978). See hypotheses for this study in **Table 1** and **Table 2**.

Table 1: Hypotheses for predicted impacts

Table		Hypotheses
		Total predicted impacts:
4	H_o	The **total number of predicted impacts** are **equally** distributed between the accurate, inaccurate and indeterminable categories.
4	H_a	The **total outcome of predicted impacts** are **not equally** distributed between the accurate, inaccurate and indeterminable categories.
		Predicted impacts in the Free State and Northern Cape:
5	H_o	There is **no difference** in the outcome of **predicted impacts** between the **Free State** and **Northern Cape** provinces
5	H_a	There is a **difference** in the outcome of **predicted impacts** between the **Free State** and **Northern Cape** provinces
6	H_o	There is **no difference** in the outcome of **predicted impacts** in the **construction phase** between the Free State and Northern Cape provinces
6	H_a	There is a **difference** in the outcome of **predicted impacts** in the **construction phase** between the Free State and Northern Cape provinces
7	H_o	There is **no difference** in the outcome of **predicted impacts** in the **operational phase** between the Free State and Northern Cape provinces
7	H_a	There is a **difference** in the outcome of **predicted impacts** in the **operational phase** between the Free State and Northern Cape provinces
8	H_o	There is **no difference** in the outcome of predicted **bio-physical** impacts between the Free State and Northern Cape provinces
8	H_a	There is a **difference** in the outcome of predicted **bio-physical** impacts between the Free State and Northern Cape provinces
9	H_o	There is **no difference** in the outcome of predicted **socio-economic** impacts between the Free State and Northern Cape provinces
9	H_a	There is a **difference** in the outcome of predicted **socio-economic** impacts between the Free State and Northern Cape provinces
		Reason for inaccurately predicted impacts:
10	H_o	There is **no difference** between the Free State and Northern Cape provinces in regarding the **reasons of inaccurately** predicted impacts
10	H_a	There is a **difference** between the Free State and Northern Cape provinces in regarding the **reasons of inaccurately** predicted impacts
		Predicted impacts in the Free State:
11	H_o	There is **no difference** in the outcome of predicted impacts in the **Free State** between the **construction** and **operational** phases
11	H_a	There is a **difference** in the outcome of predicted impacts in the **Free State** between the **construction** and **operational** phases
12	H_o	There is **no difference** in the outcome of predicted impacts in the **Free State** between the **bio-physical** impact and **socio-economic** impact categories.
12	H_a	There is a **difference** in the outcome of predicted impacts in the **Free State** between the **bio-physical** impact and **socio-economic** impact categories.
		Predicted impacts in the Northern Cape:
13	H_o	There is **no difference** in the outcome of predicted impacts in the **Northern Cape** province between the **construction** and **operational** phases
13	H_a	There is a **difference** in the outcome of predicted impacts in the **Northern Cape** province between the **construction** and **operational** phases
14	H_o	There is **no difference** in the outcome of predicted impacts in the **Northern Cape** province between the **bio-physical** impact and **socio-economic** impact categories
14	H_a	There is a **difference** in the outcome of predicted impacts in the **Northern Cape** province between the **bio-physical** impact and **socio-economic** impact categories

Table 2: Hypotheses for mitigation measures

Table		Hypotheses
		Total mitigation measures:
15	H_o	The total outcome of **mitigation measures** is **equally** distributed between the implemented, not implemented and indeterminable categories.
15	H_a	The total outcome of **mitigation measures** is **not equally** distributed between the implemented, not implemented and indeterminable categories.
		Mitigation measures in the Free State and Northern Cape:
16	H_o	There is **no difference** in the outcome of **mitigation measures** between the **Free State** and **Northern Cape** provinces
16	H_a	There is a **difference** in the outcome of **mitigation measures** between the **Free State** and Northern Cape provinces
17	H_o	There is **no difference** in the outcome of **construction phase mitigation measures** between the Free State province and Northern Cape province
17	H_a	There is a **difference** in the outcome of **construction phase mitigation measures** between the Free State province and Northern Cape province
18	H_o	There is **no difference** in the outcome of **mitigation measures** in the **operational phase** between the Free State province and Northern Cape province
18	H_a	There is no difference in the outcome of **mitigation measures** in the **operational phase** between the Free State province and Northern Cape province
		Precision of implemented mitigation measures:
19	H_o	There is **no difference** in **precision of implemented mitigation measures** in the Free State and Northern Cape
19	H_a	There is a **difference** in the **precision of implemented mitigation measures** in the Free State and Northern Cape
		Indeterminable mitigation measures:
20	H_o	There is **no difference** between the Free State and Northern Cape in regard to the **reasons for indeterminable mitigation measures**
20	H_a	There is a **difference** between the Free State and Northern Cape in regard to the **reasons for indeterminable mitigation measures**
		Mitigation measures in the Free State:
21	H_o	There is no difference in the outcome of mitigation measures in the Free State between the **construction** and **operational phases**
21	H_a	There is a difference in the outcome of mitigation measures in the Free State between the **construction** and **operational phases**
		Mitigation measures in the Northern Cape:
22	H_o	There is no difference in the outcome of the implementation of mitigation measures in the **Northern Cape** between the **construction** and **operational phases**
22	H_a	There is a difference in the outcome of the implementation of mitigation measures in the **Northern Cape** between the **construction and operational phases**

When the observed frequencies are different from the hypothetically expected frequencies it can be concluded that the null hypothesis of no difference can be rejected and a claim can be made that a statistically significant difference occurs between the compared groups. The chi-square test therefore helps to establish if a statistically significant difference occurs or if the differences that are observed are due merely to chance or sampling error (Garson, 2008). Hence it is important to establish, before conducting the chi-square test, a level of confidence to reject the null hypothesis. An asymptotic significance or predetermined alpha level of significance must be selected to indicate the threshold of tolerance for error that is acceptable when results are generalised (Williams, 1992). When results are generalised it indicates that the outcome are not due to chance alone and that a statistically significant difference does occur. The predetermined alpha level of significance selected for this study was **0.05**, which indicates that there is only a 5% probability that the variance is due to random chance and that a 95% confidence exists in the outcome (see **Appendix B**).

Table 3 is an example to explain how expected frequencies are obtained and how to apply the chi-square test (see **Appendix C**) and interpret the results as described by Ebdon (1978), Garson (2008) and Williams (1992):

Table 3: Contingency table for chi-square test example

	Provinces		
Outcome of predicted impacts	Free State	Northern Cape	**Total**
Accurate	(Observed) 162 (Expected) 158.1 (Percentage) 71.4%	(Observed) 104 (Expected) 107.9 (Percentage) 67.1%	266
Inaccurate	(Observed) 27 (Expected) 30.3 (Percentage) 11.9%	(Observed) 24 (Expected) 20.7 (Percentage) 15.5%	51
Indeterminable	(Observed) 38 (Expected) 38.6 (Percentage) 16.7%	(Observed) 27 (Expected) 26.4 (Percentage) 17.4%	65
Total	227 100%	155 100%	382

Pearson`s X^2 statistic	1.5
Degree of Freedom	2
p	0.5613

The **observed cell frequency** for the Free State (162) in **Table 3** is indicated in red and is obtained through the data collection stage of the study; the frequency is all the counted predicted impacts with an accurate outcome in the Free State.

The **expected cell frequency** (158.1) in **Table 3** is indicated in light blue and is obtained for each cell in the table by taking the row total (266) of this particular cell (indicated in light green) and multiplying it with the column total (227) of the cell in question (indicated in pink) and dividing it with the total number (382) of observed frequencies (indicated in light purple).
(266 X 227) / 382 = 158.1

After all the expected frequencies are obtained for each cell the **conditional percentages** can also be calculated. This will be used in the visual presentation of the contingency table (bar chart) to display the outcome in a more comparable way, because the two provinces did not have an equal number of predictions. Conditional percentage (71.4%, as indicated in grey) is calculated by dividing the cell frequency (162) as indicated in red with the column total (227) as indicated in pink , and by multiplying the ratio by 100.
162/227 = 0.7136
0.7136 X 100 = 71.4 %

The chi-square formula must be applied to every cell in the contingency table. The cell indicating the predicted impacts with an accurate outcome in the Free State would be used as an example. The observed frequency (162, as indicated in red) must be subtracted from the expected frequency (158.1, as indicated in light blue) and the result must be squared and then be divided by the expected frequency.
$(162 – 158.1)^2 / 158.1 = 0.096$
The difference between the observed and expected frequencies is squared to ensure a positive number. The squared difference is divided by the expected frequency to essentially remove the expected frequency from the equation, in order for the remaining measures of the observed/expected difference to be comparable across all cells. The results of all cells are added together to obtain the chi-square value for the contingency table (1.5, indicated in dark purple).

The chi-square value cannot be interpreted directly; it must be compared to the chi-square distribution table (see **Appendix B**). The columns on the table represent the significant levels; the alpha level of 0.05 was selected before the chi-square test was conducted.

The rows in the chi-square distribution represent the degree of freedom. The **degree of freedom** is calculated by the number of columns in Table minus one, times the number of rows in **Table 3**. The row totals and columns are excluded from the equation.

(2 – 1) x (3 – 1) = 2 Degrees of Freedom (indicated in dark blue)

The critical value of the chi-square test is determined by allocating the column representing the significance level of 0.05 on the chi-square distribution table and the row representing 2 degrees of freedom. Where the column and row cross or overlap the critical value is obtained (see **Appendix B**). In this case the critical value is 5.99. In order to determine if the null hypothesis can be rejected and if a statistically significant difference occurs; the obtained Pearson chi-square value must be larger than the critical value of the chi-square distribution table. The obtained Pearson chi-square of 1.5 is smaller than the critical value of 5.99, therefore the null hypothesis cannot be rejected.

The chi-square test can also be conducted on computer by using the SPSS program, which also provides the obtained Pearson chi-square value and the p-value or asymptotic significance obtained for each chi-square test conducted. The obtained p-value (0.5613, indicated in dark green) that was computed by the SPSS program can also be used to determine if the outcome of the chi-square test is statistically significant and if the null hypothesis can be rejected or not. If the obtained p-value is less than the selected alpha level of 0.05, the outcome is statistically significant and the null hypothesis can be rejected. In this case the obtained p-value of 0.5613 was larger than the chosen alpha level of 0.05, hence the null-hypothesis can not be rejected and the results are not statistically significant. Therefore the observations in the contingency table and the outcome can not be generalised to the larger population, but it can be discussed in relation to the sample population.

Requirements that must be adhered to for the chi-square test statistic to be statistically valid as stated by Ebson (1978) and Garson (2008):

- conduct test on contingency tables
- the sample must be randomly drawn from the population, otherwise you can not test for significance.
- raw frequencies (actual counted data) and not percentages must be used, because the chi-square mathematical procedure standardize frequencies /measurements. Therefore if percentages were used the chi-square test would be standardizing already standardized frequencies/ measurements.
- measured variables must be independent, therefore any observation can only appear in one cell. Thus chi-square can not be used to test correlated data.
- nominal or ordinal data must be used
- the sample size must be adequate. Observed frequencies can not be too small, the cell size must be 5 or more in 80% of the cells, and no cells with a zero count. If this requirement is not met or if the contingency table only has one degree of freedom, the Yate`s correction of continuity must be employed. The calculation of the chi-square test is the same, except after the observed and expected frequencies were subtracted from each other and an additional 0.5 must be subtracted from the result. This must occur before the result is squared and divided by the expected frequency of the particular cell (see **Appendix C**).
- the sum of the observed frequencies must equal the sum of the expected frequencies in the created contingency table
- observations must be grouped
- normal distribution is assumed; chi-square is a non-parametric test in the sense that it does not assume the parameter of normal distribution for the data, only for the deviations

Disadvantages and advantages in the utilization of the non-parametric statistical Chi-square test as stated by Williams (1992) and Garson (2008):

Disadvantages:

- test hypotheses that do not require normal distribution or assumptions about the population from which the sample is drawn
- less powerful than parametric tests
- less likely to reject the null hypothesis when it is false
- SPSS program can exaggerate the size of the relationship
- chi-square test can estimate the likelihood that mere chance is causing the observed differences, but it can not prove that chance alone is at work and not some other factors
- no assumptions about the measurability of parameters can be made

Advantages:

- easier to compute
- treat data measured on nominal (classificatory) scales
- chi-square does not inflate or minimize the column or row totals, it works with the provided frequencies

8. *Determine cause of error:*

In Chapter 7 the conclusion about the outcome of the data and the study are discussed. Attention is paid to certain issues such as inaccurately predicted impacts and unimplemented mitigation measures and also other irregularities and problems concerning impact predictions and mitigation measures dealt with in this study.

9. *Apply the lesson learned:*

In Chapter 8 recommendations for future actions and studies are discussed based on the outcome of the study and lessons learned during the research process.

4.3 Constraints and difficulties encountered

The difficulties and constraints encountered by other researcher while conducting studies on EIA qualities and outcomes are discussed, as well as problems encountered by the author during the research process of auditing the outcome of predicted impacts and proposed mitigation measures. The main problems encountered are highlighted and recommendations to address these problems are discussed in the **Chapter 8**.

4.3.1 Constraints and difficulties encountered by other researchers

The problems that were encountered when audits were conducted by other researchers were mistrust from the decision-makers because they fear that their judgement and rationale might be questioned (Bisset and Tomlinson, 1988). Thus auditing might be seen as a tool to criticise the decisions rather than the quality of the materials decisions are based on. Bisset and Tomlinson (1988) found that access to data files could be difficult due to issues pertaining to confidential information, while Buckley (1991) and Wood (1995) notes that many project designs are changed between the approval and implementation stage, which result in many impact predictions of projects not being applicable or inadequate in the end.

Matters that further contribute to the difficulties of auditing impact predictions are vague prediction statements that lack information such as the magnitude, spatial distribution, probability and significance of possible impacts on the environment (Barrow, 1997; Culhane, 1987; McCallum, 1987; Wathern, 1988). According to Sadler (1988) and Bird and Therivel (1996), most EIA statements are descriptive of the project actions rather than predicting possible impacts, which make few EIA statements possible to audit. Moreover, Barrow (1997) notes that most EIA prediction statements are written in a summaritive, non-technical type of way, with expert judgements that are subjective and difficult to scrutinise, which makes it difficult to verify the accuracy of predictions. Thus many predictions are stated in a qualitative style, which makes auditing such predictions in a quantitative way impossible.

The lack of monitoring data or the biased nature of monitoring data plus the lack of quantifiable predictions pose another obstacle in the auditing process of EIAs (Buckley, 1991).

4.3.2 Constraints and difficulties encountered by the author

Problems and difficulties encountered when the author conducted the research was the time consuming process of obtaining permission from the Department of Environmental Affairs, in the Free State and Northern Cape provinces, to access public registers where the EIA files were stored (see **Appendix D** for letter). It took roughly 6 months before the author obtained permission from each of the two departments in the Free State and Northern Cape provinces. However, it must be mentioned that the staff at the two departments, which assisted the author, were very helpful and friendly.

Another time-consuming process was copying all the randomly selected EIA files and analysing the data to determine the predicted impacts and mitigation measures. It was rather difficult to determine the predicted impacts, because as stated by other researchers (Barrow, 1997; Bird and Therivel, 1996; Culhane, 1987; McCallum, 1987; Wathern, 1988) the predictions were mostly stated in a vague manner, which tend to be more descriptive of the actions or processes, rather than stating probabilities, intensities of the foreseen impacts. Mitigation measures were predominantly stated very generally in the environmental management plans and records of decision, and it was difficult to ascertain what specific measures were suggested to curb or minimize foreseen impacts.

Difficulties were encountered in obtaining access to some of the premises of the developments and to obtain interviews with informed people. The interviews also revealed some biased information especially if the interviewee benefited financially from the development. Some information could not be obtained from the interviewed people due to the difficulty of recalling certain events or actions that took place a few years ago. Certain constraints in terms of obtaining useful information from households surrounding a development were encountered due to the lack of knowledge to provide meaningful input and opinions. For instance, a concept such as visual impacts caused by developments, was not clearly understood and therefore in most cases no opinion or comment about such concepts could be obtained.

The author also encountered a lack of monitoring data as mentioned before by Buckley (1991), which made it difficult to ascertain which, construction activities took place. The lack of availability of formal monitoring data forces this research study to only have a snap shot view of the outcomes of impacts and mitigation measures.

5. Predicted impacts

5.1 Total number of predicted impacts of the Free State and Northern Cape provinces

The 50 selected case studies contained various types of predicted impacts, although several addressed roughly similar impacts. Therefore it was necessary to combine the impacts that were similar into groups, in order to obtain fewer groups with more meaningful numbers (see **Figure 1**). For instance, impacts such as Archaeological artefacts, cultural or historical areas or objects were clustered together, because it addressed issues from related study fields. Fifthteen impact groups remained after similar impacts were clustered together. **Figure 1** illustrates the 15 predicted impact groups and the percentage each represent out of the 382 identifiable predicted impacts from the 50 case studies in both the Free State province and Northern Cape province. **Appendix E** contains a table with the frequencies of the 15 predicted impact groups for both the Free State and Northern Cape provinces.

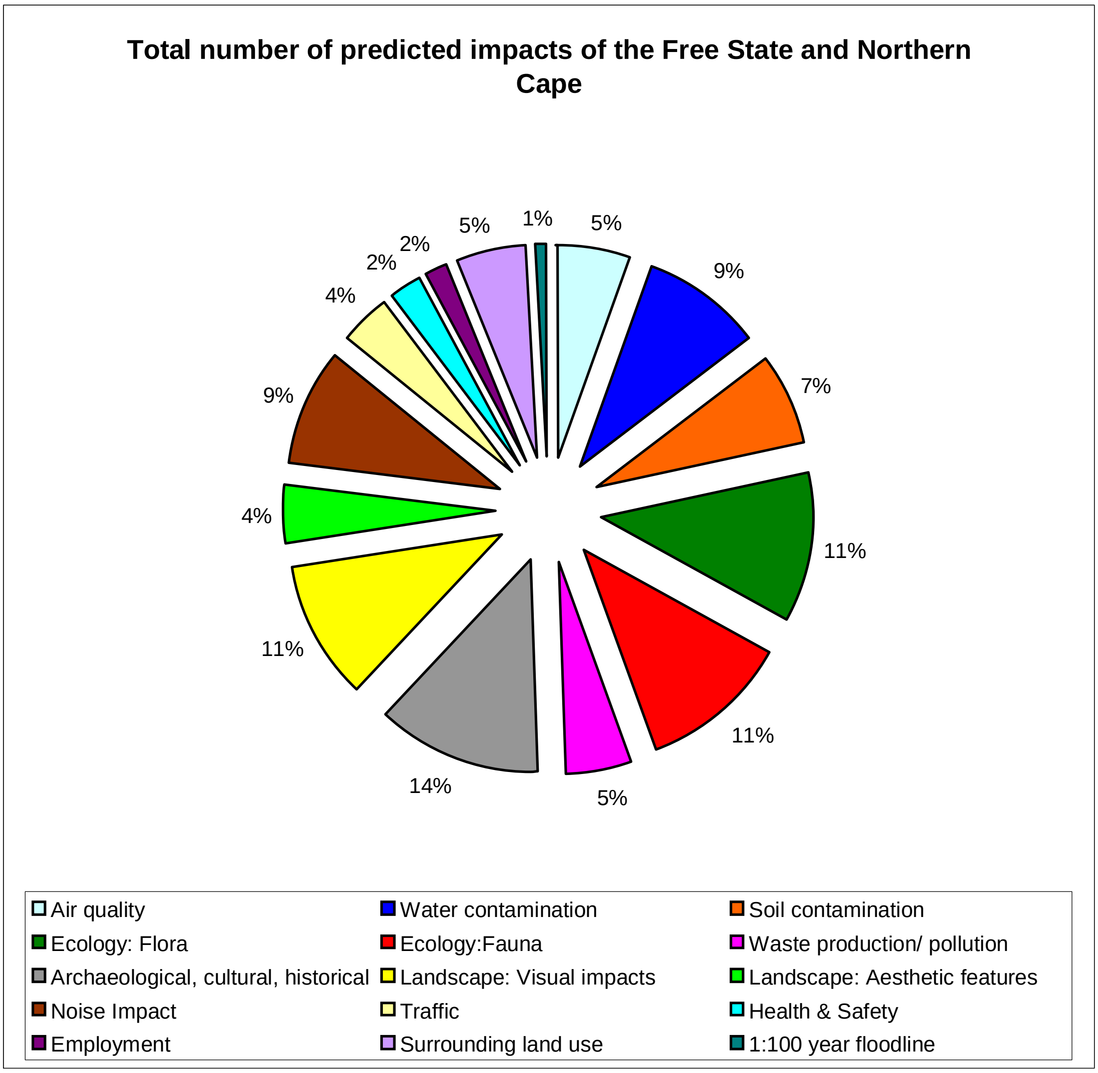


Figure 1: Total number of predicted impacts of the Free State and Northern Cape provinces

Figure 1 illustrates that 14% of the total number of predicted impacts were related to the Archaeological, cultural or historical study field. In the scoping reports these impacts were frequently determined by the presence of archaeological objects, buildings or areas with historical or cultural value on the proposed site or nearby. The predicted impacts were frequently based on findings from reports written by archaeological and cultural specialists. Forty-two of the 48 predicted archaeological, cultural or historical impacts had an accurate outcome (see **Appendix E**).

Furthermore, 22% of the total number of predicted impacts were ecologically related (fauna 11% and flora 11%). The scoping reports indicated ecological impacts to fauna and flora in relation to the occurrence of protected or red data species on site and whether such species had to be cleared or relocated. The occurrence of common species (not protected or red data species), on site that had to be cleared or relocated were deemed as insignificant impacts.

No consideration was given to very old indigenous trees that might be removed during the construction phase. The studies were frequently desktop studies and based on observations in the field. Very few of the predicted impacts in the scoping reports were based on findings from specialist reports. Thirty-seven of the 42 predicted flora impacts and 41 of the 43 predicted fauna impacts had an accurate outcome (see **Appendix E**).

Predicted visual impacts to the landscape represented 11% and impacts on aesthetic features represented 4% of the total number of predicted impacts in the Free State and Northern Cape provinces. In the scoping reports visual impacts were determined by considering the height, colour, texture, form and scale of a development, as well as the distance from the nearest roads and houses. All these features were taken into consideration to determine if the landscape would be able to visually absorb the development. For instance, if a landscape had a low acceptance or accommodation rate for a new development, the visual absorption would be low and the visual impact would be deemed high. Thirty-one of the 41 predicted visual impacts had an accurate outcome. Aesthetic features are the psychological value or sense of place that are ascribed to an area. Impacts on aesthetic features in the scoping reports were determined by the occurrence of nature reserve areas, other natural features such as waterfalls and tourist attractions on the proposed sites or nearby. Fifthteen of the 17 predicted impacts on aesthetic features had an accurate outcome (see **Appendix E**).

Moreover predicted impacts with regard to water and soil quality deterioration due to contamination represented 9% and 7% respectively of the total number of predicted impacts. These impacts were determined in the scoping report by considering the type of construction and operational activities that might cause soil and water contamination due to spillages; seepages or leakages form hazardous substances or waste. Additionally, soil erosion was also taken into consideration. A small number of the impacts in the scoping reports were determined by geo-technical and geo-hydrological studies, which focused on soil permeability and the ground water table of an area. The possibility of soil erosion was mainly determined during the construction phase when top soil is removed.

Moreover, possible erosion during the operational phase of a development was mostly neglected. Sixteen of the 35 predicted water quality impacts were accurately predicted whereas another 16 of 35 predicted impact had an indeterminable outcome. The outcome of predicted impacts for soil quality varied between 11 accurate, 10 inaccurate and 6 indeterminable outcomes (see **Appendix E**).

Impacts regarding air quality deterioration represented 5% of the total number of predicted impacts. The scoping reports usually determined air quality impacts based on possible dust due to construction and operational activities. No specialist reports were used to determine possible air quality impacts. Third teen of the 21 predicted air quality impacts were accurately predicted while 8 were indeterminable.

A further 9% of the total number of predicted impacts were in regard to noise and it was mostly determined in the scoping reports by taking into account the duration of construction activities. Few operational activities were considered. 23 of the 43 predicted impacts had an accurate outcome.

Traffic impacts only represented 4% of the total number of predicted impacts and were only considered in larger developments such as fuel filling stations and township establishments. These predictions were frequently based on traffic impact studies that were conducted by specialists in the field. Eleven of the 15 predicted traffic impacts had an accurate outcome.

Moreover, only 5% of the total number of predicted impacts were in regard to waste production and related pollution. The scoping reports commonly focused on the production of waste during the construction phase of the development and rarely considered waste produced during the operational phase. Six of the 9 predicted impacts had an accurate outcome (see **Appendix E**).

The impact on surrounding land use represented 5% of the total number of predicted impacts and mainly focused on the already existing usage of land in the proposed areas and suitability of the new development. For instance, it is not advisable to locate a factory next to a townhouse complex, but rather a filling station or a clinic. Sixteen of the 20 predicted impacts had an accurate outcome.

Only 2% each of the total number of predicted impacts focused on the employment of local labourers and on health and safety issues. A possible explanation for the lack of health and safety impacts in scoping reports might be due to the fact that the Occupational Health and Safety Act and the Department of Labour deals with these issues and it is mostly outside of the scope of the environmental impact reports. Both predicted employment impacts and health and safety impacts had largely an indeterminable outcome.

The predictions dealing with the 1 in 100 year floodline were only considered when a proposed development was situated near a waterbody, river or stream area, and only comprised out of 1% of the total number of predicted impacts of which most were accurately predicted (see **Appendix E**).

5.1.1 Outcome of the total number of predicted impacts of the Free State and Northern Cape provinces

In order to determine the outcome of the total number of predicted impacts all the outcomes of the 15 groups, or 382 predicted impacts, were arranged into three categories, namely: accurate, inaccurate and indeterminable (see 5.1). **Table 4** and **Figure 2** provide an overall view of the outcome of all predicted impacts in both provinces.

Table 4: Total outcome of predicted impacts of the Free State and Northern Cape

Outcome of Predicted impacts		
Accurate	(Observed)	266
	(Percentage)	69.6%
Inaccurate	(Observed)	51
	(Percentage)	13.4%
Indeterminable	(Observed)	65
	(Percentage)	17%
Total		**382**

Pearson`s X^2 statistic	227.28
Degree of Freedom	2
p	0

The hypothesis tested in **Table 4**:

H_o: The **total outcome of predicted impacts** are equally distributed between the accurate, inaccurate and indeterminable categories.

H_a: The **total outcome of predicted impacts** are not equally distributed between the accurate, inaccurate and indeterminable categories.

The Pearson chi-square test statistic of **Table 4** is 227.28 with an associated p-value of 0. Therefore the chi-square test statistic is larger than the critical value of the chi-square distribution table of 5.99, and the p-value is smaller than the chosen alpha level of 0.05 (see **Appendix B**). This means that the null hypothesis can be rejected with a 95% confidence level and that only 5% of the outcome is due to chance. Hence it can be accepted that the distribution of predicted impacts are not equal between the categories. The result is statistically significant and can be generalised to the larger population in the two provinces (Free State and Northern Cape provinces).

Figures 2 illustrates, in percentages, the total outcome of the predicted impacts from both provinces.

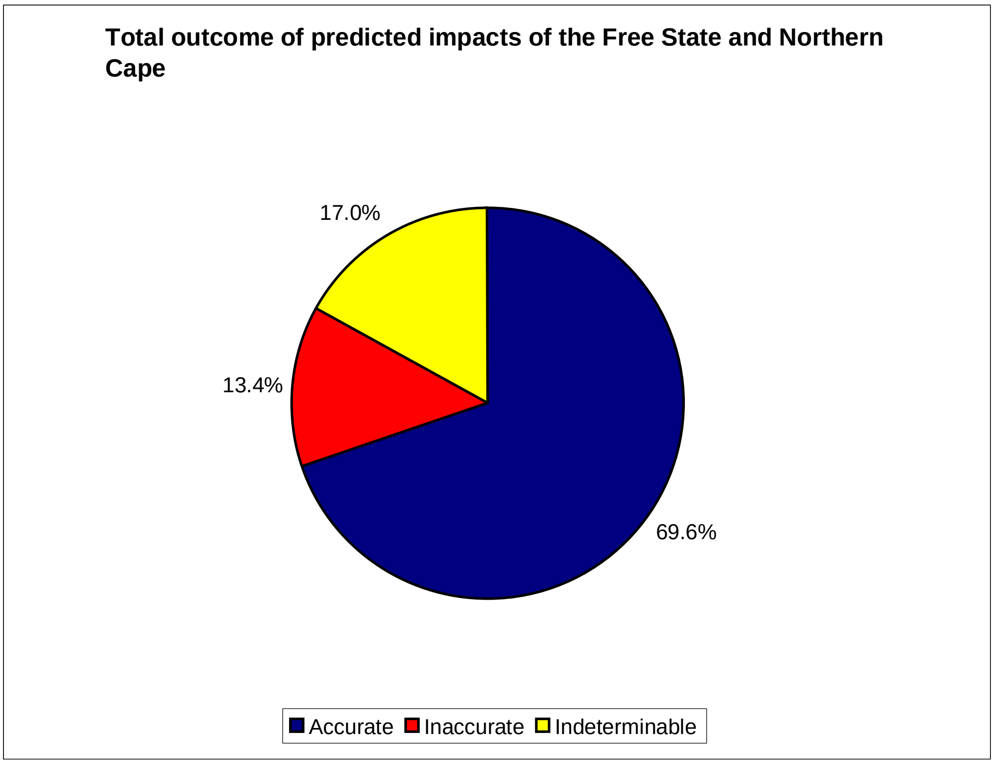


Figure 2: Total outcome of predicted impacts of the Free State and Northern Cape

Figure 2 illustrates that 69.6% of the predicted impacts were accurately predicted, while 13.4% were inaccurately predicted and 17% of predicted impacts were indeterminable. The null hypothesis was rejected and the outcome of **Table 4** is significant. Therefore it can be assumed that the majority of predicted impacts might have an accurate outcome.

5.2 Predicted impacts in the Free State and Northern Cape provinces

The 15 impact groups in **5.1** were comprised out of 382 predicted impacts from both provinces. Two hundred and twenty-seven predicted impacts were derived from 25 case studies in the Free State province and 155 predicted impacts from 25 case studies in the Northern Cape province. The predicted impacts of the Free State and Northern Cape were sorted separately into the same 15 impact groups (see 5.1), the reason for this was to determine the amount of predicted impacts each province represented in the impact groups (see **Appendix F**). Since the Northern Cape and Free State did not have an equal number of predicted impacts, the frequencies were converted to percentages to present a clearer comparison between the two provinces in **Figure 3**.

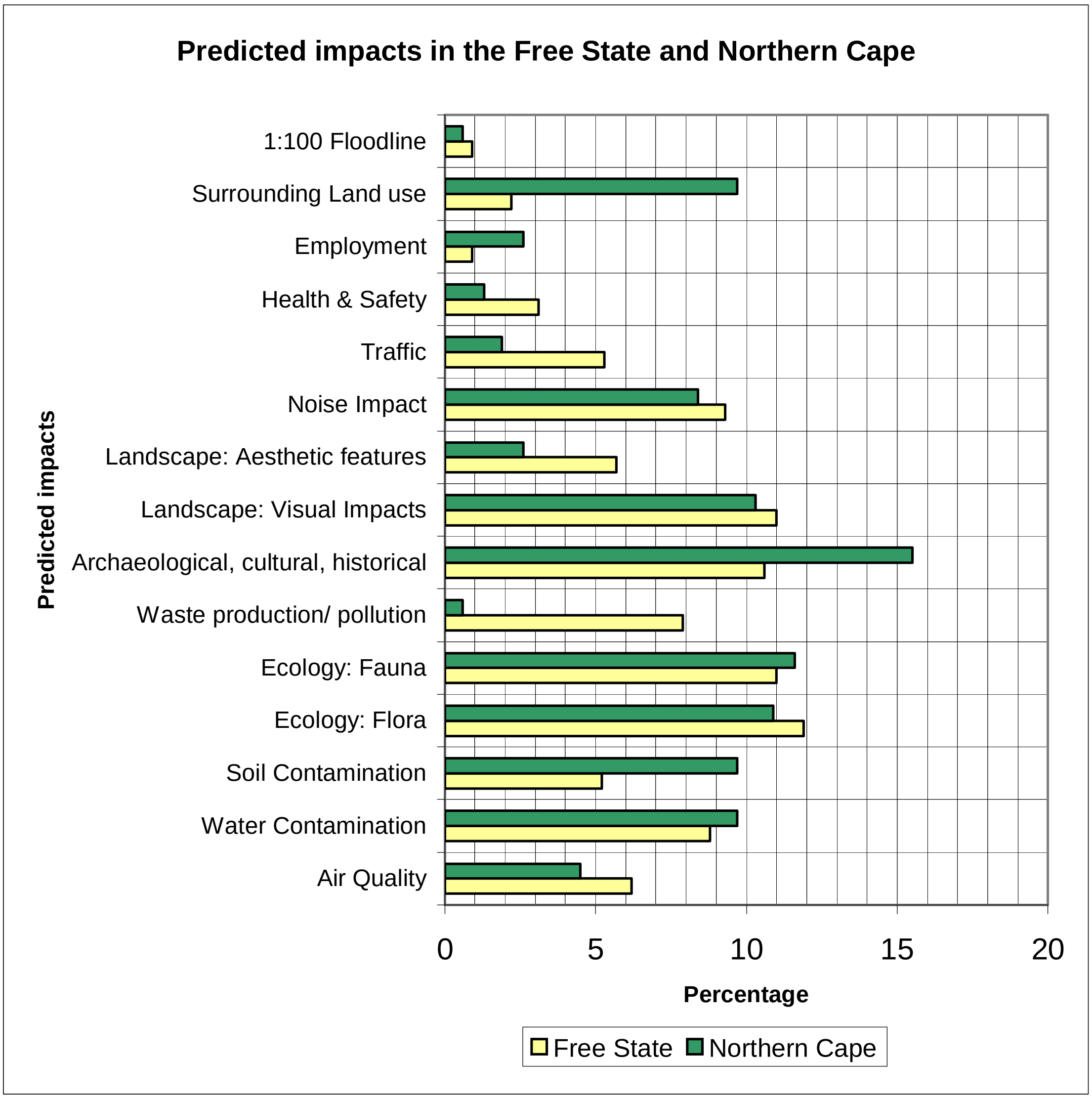


Figure 3: Predicted impacts in the Free State and Northern Cape

Figure 3 illustrates the difference in the distribution of predicted impacts in the 15 impact groups between the Free State and Northern Cape. In the Free State more attention was paid to impacts related to possible waste production and associated pollution (8%) in the scoping reports in contrast to the Northern Cape (1%). Moreover scoping reports in the Free State also paid more attention to health and safety aspects (3%), traffic impacts (5%), air quality deterioration (6%) and impacts on aesthetic features (5%), than in comparison to impacts the Northern Cape. Although in the Northern Cape, scoping reports focused more on impacts such as archaeological, cultural and historical impacts (15%), issues concerning employment of local people (3%), soil contamination and erosion (10%) in comparison to the Free State province. However the percentage of predicted impacts concerned with water contamination, fauna and flora, visual aspects, noise disturbances and development within the 1 in 100 year floodline were very closely associated between the two provinces.

It must be noted that the largest percentage of predicted impacts in the Northern Cape were with regard to archaeological, cultural and historical impacts (15%), while in the Free State a larger percentage of predicted impacts were concerned about impacts to the ecology, especially flora (12%).

5.2.1 Outcome of predicted impacts in the Free State and Northern Cape provinces

In each of the two provinces the overall outcome of predicted impacts were determined by sorting the outcomes into three categories: accurate, inaccurate and indeterminable (see **Appendices G** and **H**). A chi-square test was conducted on the frequencies in **Table 5** in order to establish if predicted impacts had the same distribution pattern between the categories in both provinces. The outcome would indicate if predicted impacts in both provinces are of the same quality in terms of accurately predicting the future impacts of developments.

Table 5: Comparing the outcome of predicted impacts between the Free State and Northern Cape

	Provinces		
Outcome of predicted impacts	Free State	Northern Cape	**Total**
Accurate	(Observed) 162 (Expected) 158.1 (Percentage) 71.4%	(Observed) 104 (Expected) 107.9 (Percentage) 67.1%	266
Inaccurate	(Observed) 27 (Expected) 30.3 (Percentage) 11.9%	(Observed) 24 (Expected) 20.7 (Percentage) 15.5%	51
Indeterminable	(Observed) 38 (Expected) 38.6 (Percentage) 16.7%	(Observed) 27 (Expected) 26.4 (Percentage) 17.4%	65
Total	227 100%	155 100%	382

Pearson`s X^2 statistic	1.5
Degree of Freedom	2
p	0.5613

The hypothesis tested in **Table 5**:

H_o: There is no difference in the outcome of predicted impacts between the **Free State** and **Northern Cape** provinces

H_a: There is a difference in the outcome of predicted impacts between the **Free State** and **Northern Cape** provinces

The chi-square test statistic is 1.5 with an associated p-value of 0.5613. Therefore the obtained chi-squared test statistic is smaller than the critical value of the chi-square distribution table of 5.99, and the p-value is larger than the chosen alpha level of 0.05. Thus the null hypothesis cannot be rejected and this implies that there is no difference in the outcome of the predicted impacts between the Free State and Northern Cape provinces. The results are not statistically significant and the results cannot be generalised to the larger population in the two provinces, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 4** illustrates, in percentages, the outcome of predicted impacts in the Free State and Northern Cape provinces. Percentages are used in **Figure 4** in order to present a clearer comparison between the two provinces, since the two provinces did not have an equal amount of predicted impacts.

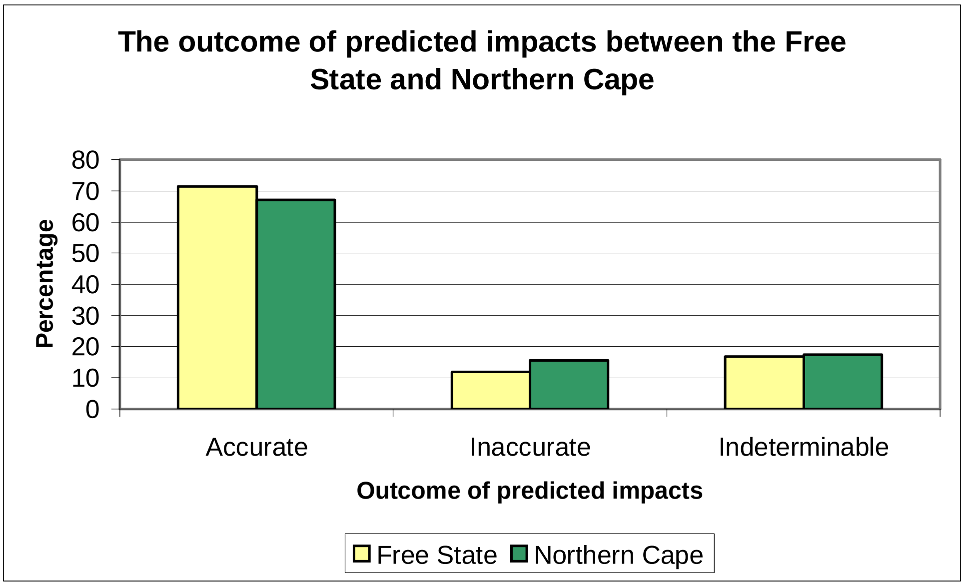


Figure 4: The outcome of predicted impacts in the Free State and Northern Cape

Figure 4 illustrates that the majority of predicted impacts had an accurate outcome both in the Free State (71.4%) and the Northern Cape (67.1%). Furthermore the predicted impacts with an indeterminable outcome were higher in both provinces (Free State 16.7%, Northern Cape 17.4%), compared to the predicted impacts that had an inaccurate outcome (Free State 11.9%, Northern Cape 15.5%). The results support the findings of **Table 4**, which indicates that the majority (about 69.6%) of all predicted impacts would be accurately predicted. However it must be noted that the results of **Table 5** can only be discussed in relation to the outcome of predicted impacts in the sample population of the Free State and Northern Cape provinces because the outcome was not significant.

The null hypothesis was accepted and it was determined that there was no significant difference between the outcome of predicted impacts in the two provinces. It can therefore be interpreted that both provinces have similar trends in terms of impact outcomes and that both provinces have predicted impacts that are of good quality because the majority of impacts were accurately predicted.

5.2.2 Predicted impacts in the construction and operational phases in the Free State and Northern Cape provinces

The predicted impacts were divided into the construction phase and operational phase. The construction phase had a total of 149 predicted impacts, from which 91 predicted impacts were from case studies in the Free State and 58 from case studies in the Northern Cape. Two hundred and twenty-three predicted impacts formed part of the operational phase and 156 of these impacts were from case studies in the Free State, while 73 were from case studies in the Northern Cape. The predicted impacts in the two phases were sorted into the 15 previously identified impact groups (see **Appendices G** and **H**). The overall outcome of the predicted impacts in the construction and operational phase were sorted into the following categories: accurate, inaccurate and indeterminable.

Chi-square tests were conducted in **table 6** and **7** to determine if the outcome of predicted impacts in the construction and operational phases are similar between the Free State and Northern Cape provinces. The results of the chi-square tests will also help to determine if the outcomes of predicted impact are different depending on the phases it occurs in.

5.2.2.1 The outcome of predicted impacts in the construction phase in the Free State and Northern Cape provinces

A chi-square test was conducted to determine if there is a difference in the outcome of predicted impacts in the **construction phase** between the **Free State** and **Northern Cape** provinces (see **Table 6**).

Table 6: Comparing the outcome of predicted impacts in the construction phase between the Free State and Northern Cape

	Provinces		
Outcome of predicted impacts	Free State	Northern Cape	**Total**
Accurate	(Observed) 53 (Expected) 55.6 (Percentage) 58.2%	(Observed) 38 (Expected) 35.4 (Percentage) 65.6%	91
Inaccurate	(Observed) 11 (Expected) 10.4 (Percentage) 12.1%	(Observed) 6 (Expected) 6.6 (Percentage) 10.3%	17
Indeterminable	(Observed) 27 (Expected) 25.0 (Percentage) 29.7%	(Observed) 14 (Expected) 16.0 (Percentage) 24.1%	41
Total	91 100%	58 100%	149

Pearson`s X^2 statistic	0.8
Degree of Freedom	2
p	0.6719

The hypothesis tested in **Table 6**:

H_o: There is no difference in the outcome of predicted impacts in the **construction phase** between the Free State and Northern Cape provinces

H_a: There is a difference in the outcome of predicted impacts in the **construction phase** between the Free State and Northern Cape provinces

The chi-square test statistic is 0.8 with an associated p-value of 0.6719. Therefore the chi-square test statistic is smaller than the critical value on the chi-square table of 5.99, and the p-value is larger than the chosen alpha level of 0.05. Therefore the null hypothesis can not be rejected and hence it can be interpreted that there is no difference in the outcome of the predicted impacts in the construction phase between the Free State and Northern Cape provinces.

The results are not statistically significant and the results can not be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 5** illustrates, in percentages, the outcome of predicted impacts in the **construction phase** for both provinces.

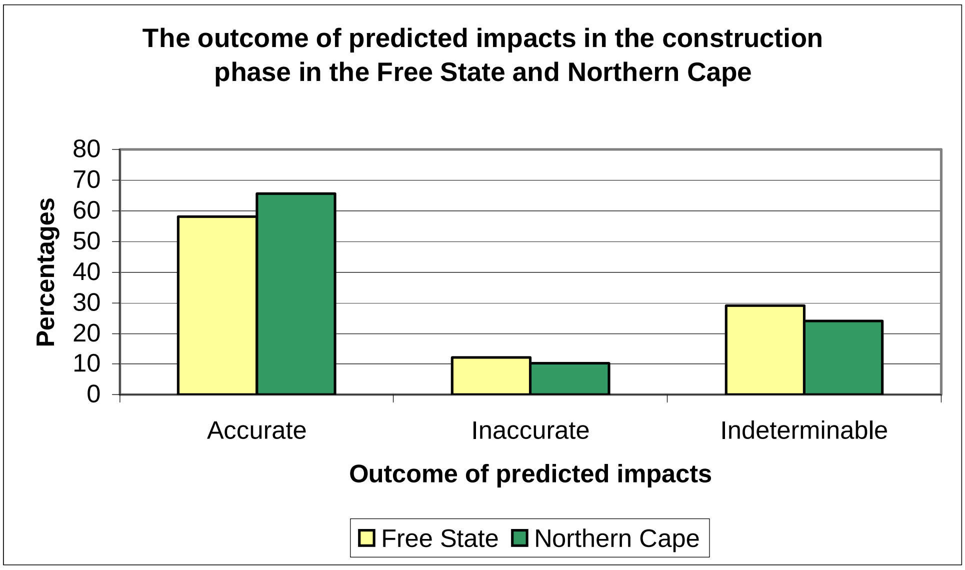


Figure 5: The outcome of predicted impacts in the construction phase in the Free State and Northern Cape

Figure 5 illustrates that the majority of predicted impacts in the construction phase in both the provinces had an accurate outcome (Free State58.2%, Northern Cape 65.6%). Furthermore predicted impacts in the construction phase had a higher indeterminable outcome (Free State 29.7%, Northern Cape 24.1%) compared to an inaccurate outcome (Free State 12.1%, Northern Cape 10.3%). These findings support the findings in **Table 4**, that the majority of predicted impacts would have an accurate outcome. It must be noted that the outcome of the chi-square test applied on **Table 6** was not significant and that **Figure 5** can only be discussed in term of the sample population of the Free State and Northern Cape and not the larger population. In both the Free State and Northern Cape the impacts were more prone to an indeterminable outcome than an inaccurate outcome.

5.2.2.2 The outcome of predicted impacts in the operational phase in the Free State and Northern Cape provinces

A chi-square test was conducted on the outcome of predicted impacts in the **operational phase** of the Free State and Northern Cape provinces, to determine if differences occur between the two provinces in relation to the outcome of predicted impacts in the operational phase (see **Table 7**).

Table 7: Comparing the outcome of predicted impacts in the operational phase between the Free State and Northern Cape

	Provinces		
Outcome of predicted impacts	Free State	Northern Cape	**Total**
Accurate	(Observed) 109 (Expected) 102.1 (Percentage) 80.1%	(Observed) 66 (Expected) 72.9 (Percentage) 68.1%	175
Inaccurate	(Observed) 16 (Expected) 19.8 (Percentage) 11.8%	(Observed) 18 (Expected) 14.2 (Percentage) 18.5%	34
Indeterminable	(Observed) 11 (Expected) 14.0 (Percentage) 8.1%	(Observed) 13 (Expected) 10.0 (Percentage) 13.4%	24
Total	136 100%	97 100%	233

Pearson`s X^2 statistic	4.45
Degree of Freedom	2
p	0.1082

The hypothesis tested in **Table 7**:

H_o: There is no difference in the outcome of predicted impacts in the **operational phase** between the Free State and Northern Cape provinces

H_a: There is a difference in the outcome of predicted impacts in the **operational phase** between the Free State and Northern Cape provinces

The chi-square test statistic is 4.45 with an associated p-value of 0.1082. Therefore the chi-square test statistic is smaller than the critical value of the chi-square distribution table of 5.99, and the p-value is larger than the chosen alpha level of 0.05. Hence the null hypothesis cannot be rejected and therefore it can be assumed that there is no statistically significant difference in the outcome of the predicted impacts in the operational phase between the Free State and Northern Cape provinces.

The results are not statistically significant and the results cannot be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 6** illustrates, in percentages, the outcome of predicted impacts in the **operational phase** between the two provinces.

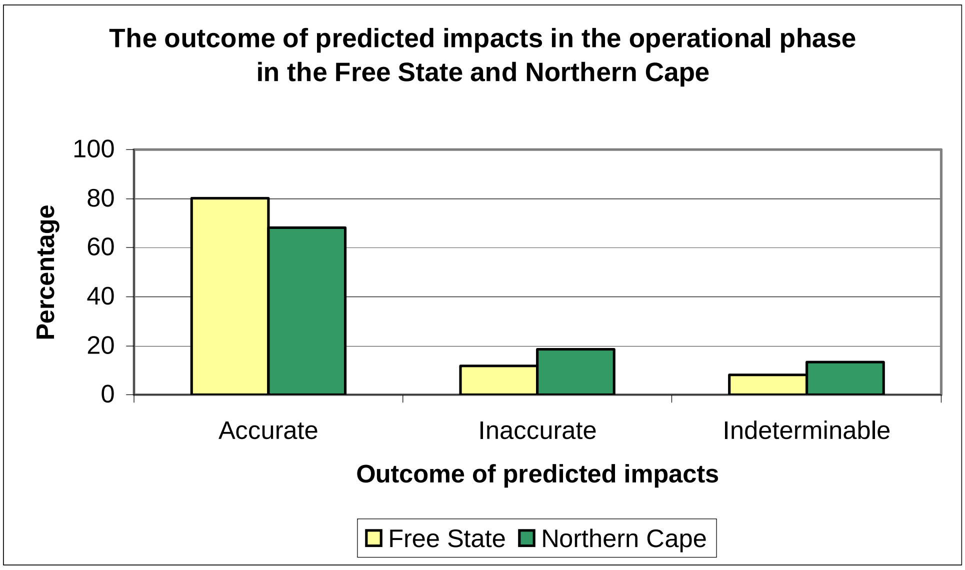


Figure 6: The outcome of predicted impacts in the operational phase in the Free State and Northern Cape

Figure 6 illustrates that the majority of predicted impacts in the **operational phase** had an accurate outcome in both provinces (Free State 80.1%, Northern Cape 68.1%). The results support the findings of **Table 4** that the majority of predicted impacts will have an accurate outcome. The null hypothesis is not rejected and the outcome of **Table 7** is not statistically significant. Therefore the outcome illustrated in **Figure 6** can only be discussed in terms of the sample population in the Free State and Northern Cape provinces and cannot be generalised. It is evident in **Figure 6** that more predicted impacts had an inaccurate (Free State 11.8%, Northern Cape 18.5%) outcome compared to an indeterminable (Free State 8.1%, Northern Cape 13.4%) outcome in both provinces.

The majority of predicted impacts in the construction and operational phases had an accurate outcome in both the Free State and Northern Cape provinces, therefore indicating that the majority of predictions were of a good quality in terms of accurately predicting the future. Differences in the outcome of predicted impacts did occur between the operational phase and construction phase in both provinces. The outcome of predicted impacts in the construction phase had a higher tendency to be indeterminable than inaccurate.

The opposite occurred in the operational phase were the outcome of predicted impacts were more prone to be inaccurate than indeterminable. It can therefore be assumed that it is more difficult to determine the outcome of predicted impacts in the construction phase due to the lack of information and evidence of construction activities to draw a conclusion from.

5.2.3 The outcome of predicted bio-physical and socio-economic impacts in the Free State and Northern Cape provinces

The 15 impact groups (see 5.1) were further divided into a **bio-physical** and a **socio-economic** category (see **Appendices G** and **H**). These categories include impacts in both the construction and operational phases in order to provide meaningful numbers that can be used for analysis. Chi-square tests were conducted to establish if there is a statistically significant difference between the outcome of bio-physical and socio- economic impacts in the Free State and Northern Cape (see **Table 8** and **9**). The results of the chi-square tests would help to determine if differences or similarities in the outcome of predicted impacts occur between the bio-physical and socio-economic impact categories in the two provinces.

5.2.3.1 The outcome of predicted bio-physical impacts in the Free State and Northern Cape provinces

Table 8: Comparing the outcome of predicted bio-physical impacts between the Free State and Northern Cape

	Provinces		
Outcome of predicted impacts	Free State	Northern Cape	**Total**
Accurate	(Observed) 78 (Expected) 74.9 (Percentage) 67.2%	(Observed) 44 (Expected) 47.1 (Percentage) 60.3%	122
Inaccurate	(Observed) 11 (Expected) 15.3 (Percentage) 9.5%	(Observed) 14 (Expected) 9.7 (Percentage) 19.2%	25
Indeterminable	(Observed) 27 (Expected) 25.8 (Percentage) 23.3%	(Observed) 15 (Expected) 16.2 (Percentage) 20.5%	42
Total	116 100%	73 100%	189

Pearson`s X^2 statistic	3.67
Degree of Freedom	2
p	0.159

The hypothesis tested in **Table 8**:

H_o: There is no difference in the outcome of predicted **bio-physical** impacts between the Free State and Northern Cape provinces

H_a: There is a difference in the outcome of predicted **bio-physical** impacts between the Free State and Northern Cape provinces

The chi-square test statistic is 3.67 with an associated p-value of 0.159. Therefore the chi-square test statistic is smaller than the critical value of the chi-square distribution table of 5.99, and the p-value is larger than the chosen alpha level of 0.05. This means that the null hypothesis can not be rejected and that there is no difference in the outcome of the predicted bio-physical impacts between the Free State and Northern Cape provinces. The results are not statistically significant and the results can not be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 7**, illustrates in percentages, the outcome of predicted bio-physical impacts in the two provinces.

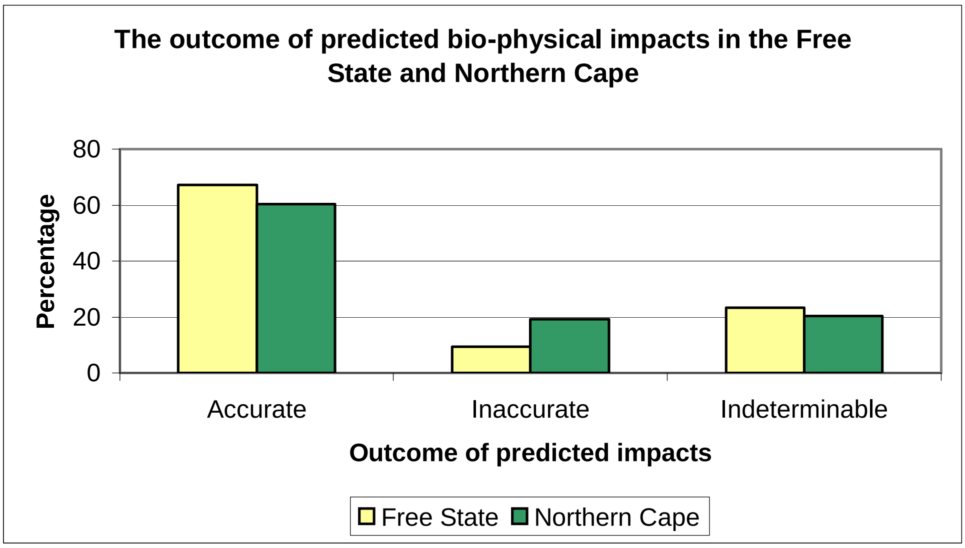


Figure 7: The outcome of predicted bio-physical impacts in the Free State and Northern Cape

Figure 7 illustrates that the majority of predicted **bio-physical** impacts had an accurate outcome (Free State 67.2%, Northern Cape 60.3%) in both provinces. This support the outcome of **Table 4,** that the majority of predicted impacts would have an accurate outcome. However it must be noted that the findings in **Table 8** can only be related to the sample population in the Free State and Northern Cape and can not be generalised because the outcome was not statistically significant. The predicted bio-physical impacts were more likely to have an indeterminable outcome (Free State 23.3%, Northern Cape 20.5%) compared to an inaccurate outcome (Free State 9.5%, Northern Cape 19.2%) in both provinces.

5.2.3.2 The outcome of predicted socio-economic impacts in the Free State and Northern Cape provinces

Table 9: Comparing the outcome of predicted socio-economic impacts between the Free State and Northern Cape

	Provinces		
Outcome of predicted impacts	Free State	Northern Cape	**Total**
Accurate	(Observed) 84 (Expected) 82.8 (Percentage) 75.7%	(Observed) 60 (Expected) 61.2 (Percentage) 73.2%	144
Inaccurate	(Observed) 16 (Expected) 15.0 (Percentage) 14.4%	(Observed) 10 (Expected) 11.0 (Percentage) 12.2%	26
Indeterminable	(Observed) 11 (Expected) 13.2 (Percentage) 9.9%	(Observed) 12 (Expected) 9.8 (Percentage) 14.6%	23
Total	111 100%	82 100%	193

Pearson`s X^2 statistic	1.09
Degree of Freedom	2
p	0.58

The hypothesis tested in **Table 9**:

H_o: There is no difference in the outcome of predicted **socio-economic** impacts between the Free State and Northern Cape provinces

H_a: There is a difference in the outcome of predicted **socio-economic** impacts between the Free State and Northern Cape provinces

The chi-square test statistic is 1.09 with an associated p-value of 0.58. Therefore the chi-square test statistic is smaller than the critical value on the chi-square table of 5.99, and the p-value is larger than the chosen alpha level of 0.05. Thus the null hypothesis can not be rejected and it can be alleged that there is no difference in the outcome of the predicted socio-economic impacts between the Free State and Northern Cape provinces. The results are not statistically significant and the results can not be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 8** illustrates, in percentages, the outcome of predicted **socio-economic** impacts in both provinces.

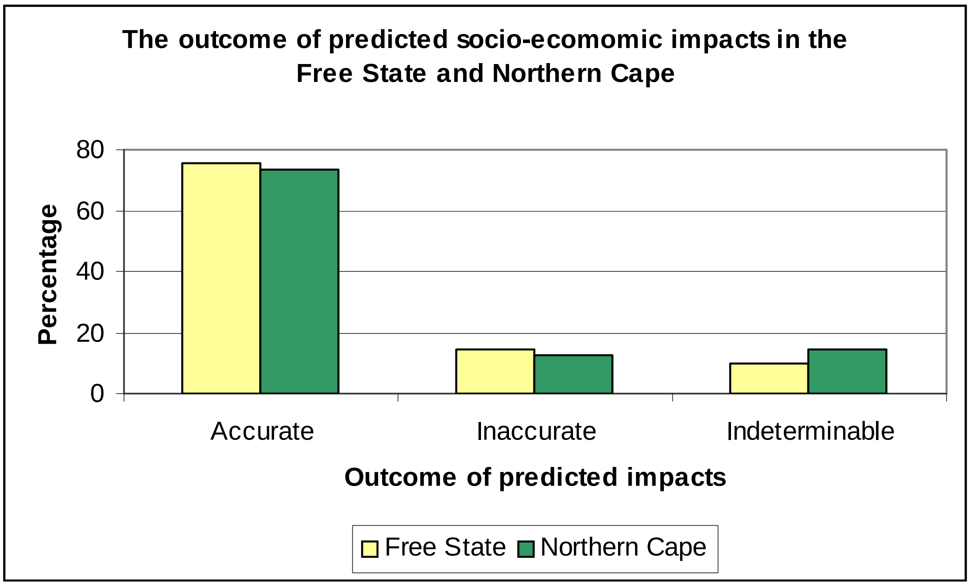


Figure 8: The outcome of predicted socio-economic impacts in the Free State and Northern Cape

Figure 8 illustrates that in both provinces the majority of predicted socio-economic impacts had an accurate outcome (Free State 75.7%, Northern Cape 73.2%). The Free State has a higher percentage of predicted impacts with an inaccurate outcome compared to an indeterminable outcome, and vice versa for the Northern Cape. This does not mean that the hypothesis was incorrectly accepted, because none of the expected values in the contingency table were less than five and a 0.05 significance level was used to accept or reject the null hypothesis. The outcome in **Table 9** indicates that there are similarities between the two provinces but it does not mean that differences do not occur. The majority of predicted impacts had an accurate outcome in both provinces, while the differences that occurred between the inaccurate and indeterminable categories were not statistically significant.

The majority of predicted impacts had an accurate outcome in both the bio-physical and socio-economic impact categories, therefore it can be assumed that both impact categories had a good quality of predictions in terms of predicting the future.

5.3. The reasons for predicted impacts with inaccurate outcomes

It is important to establish the reason for inaccurately predicted impacts, and to compare the outcome between the two provinces, in order to establish if the reason for inaccuracy is similar or different in both the provinces. A chi-square test was conducted on **Table 10** to determine if there are differences between the Free State and Northern Cape provinces for reasons of inaccurately predicted impacts (see **Appendices G** and **H**). Inaccurately predicted impacts were divided in to the following category: under or over estimated. When an impact was not correctly predicted the under and over estimated categories were used as criteria to determine the reason for the inaccurately stated forecast. Therefore the prediction was deemed inaccurate because the forecast in the EIA was less or more than the actual outcome of the impact.

Table 10: Comparing reasons for predicted impacts with inaccurate outcomes between the Free State and Northern Cape

	Provinces		
Reason for inaccurate outcome	Free State	Northern Cape	**Total**
Under predicted	(Observed) 21 (Expected) 19.6 (Percentage) 77.8%	(Observed) 16 (Expected) 17.4 (Percentage) 66.7%	37
Over predicted	(Observed) 6 (Expected) 7.4 (Percentage) 22.2%	Observed) 8 (Expected) 6.6 (Percentage) 33.3%	14
Total	27 100%	24 100%	51

Pearson`s X^2 statistic	0.78
Degree of Freedom	1
p	0.37

The hypothesis tested in **Table 10:**

H_o: There is no difference between the Free State and Northern Cape provinces in regard to the **reason** for the **inaccuracy of predicted impacts**.

H_a: There is a difference between the Free State and Northern Cape provinces in regard to the **reason** for the **inaccuracy of predicted impacts**.

The chi-square test statistic is 0.78 with an associated p-value of 0.37. Therefore the chi-square test statistic is smaller than the critical value on the chi-square table of 3.84, and the p-value is larger than the chosen alpha level of 0.05. This means that the null hypothesis cannot be rejected and that there is no difference for the reasons of inaccurately predicted impacts between the Free State and Northern Cape provinces. The results are not statistically significant and the results cannot be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 9** illustrates, in percentages, the outcome for the reasons of inaccurately predicted impacts in the Free State and Northern Cape provinces.

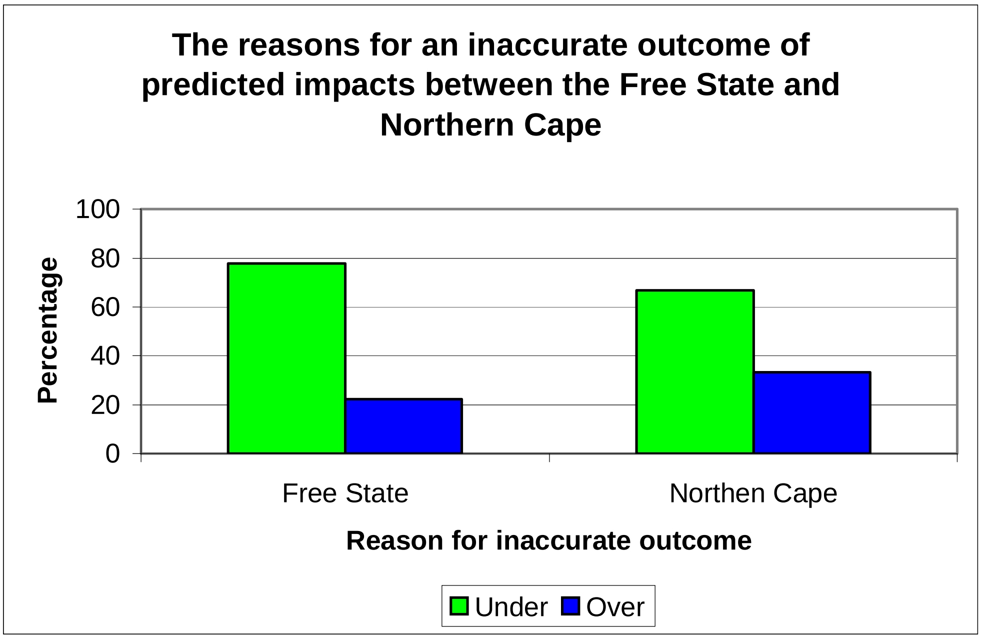


Figure 9: The reasons for inaccurately predicted impacts in the Free State and Northern Cape

Figure 9 illustrates that the major reason for an inaccurately predicted impacts in the two provinces (Free State 77.8%, Northern Cape 66.7%) were because of under estimated impacts. The impact was far greater than expected or predicted. Only 22.2% of inaccurately predicted impacts in the Free State were overestimated and 33.3% in the Northern Cape.

An explanation for the majority of under estimated impacts could be the outcome of cumulative impacts that were overlooked or consultants might state impacts as less sever that anticipated in order to obtain approval for a development more easily from the authorities.

5.4 Predicted impacts in the Free State province

The two provinces have been compared to each other to determine if any differences occurred between them in the outcome of predicted impacts. However it is also important to estimate whether any differences occur within the two provinces itself concerning the construction and operational phase and bio-physical and socio-economic categories (see **Appendix G**) in order to establish if impacts tend to have different outcomes based on the category or phase it occurs in.

5.4.1 Predicted impacts in construction and operational phases in the Free State province

The difference in the outcome of predicted impacts in the Free State province between the construction and operational phases must be determined in order to establish if the two phases have similar outcomes or if differences might occur, due to the different time periods the impacts manifest in. A chi-square test was conducted on **Table 11** to determine if there is a difference in the outcome of predicted impacts in the Free State province between the construction and operational phases.

Table 11: Comparing the outcome of predicted impacts in the Free State between the construction and operational phases

	Phases		
Outcome of predicted impacts	Construction	Operational	**Total**
Accurate	(Observed) 53 (Expected) 64.9 (Percentage) 58.2%	(Observed) 109 (Expected) 97.1 (Percentage) 80.1%	162
Inaccurate	(Observed) 11 (Expected) 10.8 (Percentage) 12.1%	(Observed) 16 (Expected) 16.2 (Percentage) 11.8%	27
Indeterminable	(Observed) 27 (Expected) 15.2 (Percentage) 29.7%	(Observed) 11 (Expected) 22.8 (Percentage) 8.1%	38
Total	91 100%	136 100%	227

Pearson`s X^2 statistic	18.84
Degree of Freedom	2
p	0.0001

The hypothesis tested in **Table 11:**

H_o: There is no difference in the outcome of predicted impacts in the **Free State** between the **construction** and **operational** phases

H_a: There is a difference in the outcome of predicted impacts in the **Free State** between the **construction** and **operational** phases

The chi-square test statistic is 18.84 with an associated p-value of 0.0001. Therefore the chi-square test statistic is larger than the critical value on the Chi-square table of 5.99, and the p-value is smaller than the chosen alpha level of 0.05. Therefore the null hypothesis can be rejected and it can be interpreted that there is a difference in the outcome of the predicted impacts in the Free State between the construction and operational phases. The results are statistically significant and the results can be generalised to the larger population in the Free State. **Figure 10** illustrates, in percentages, the outcome of predicted impacts in the Free State between the two phases.

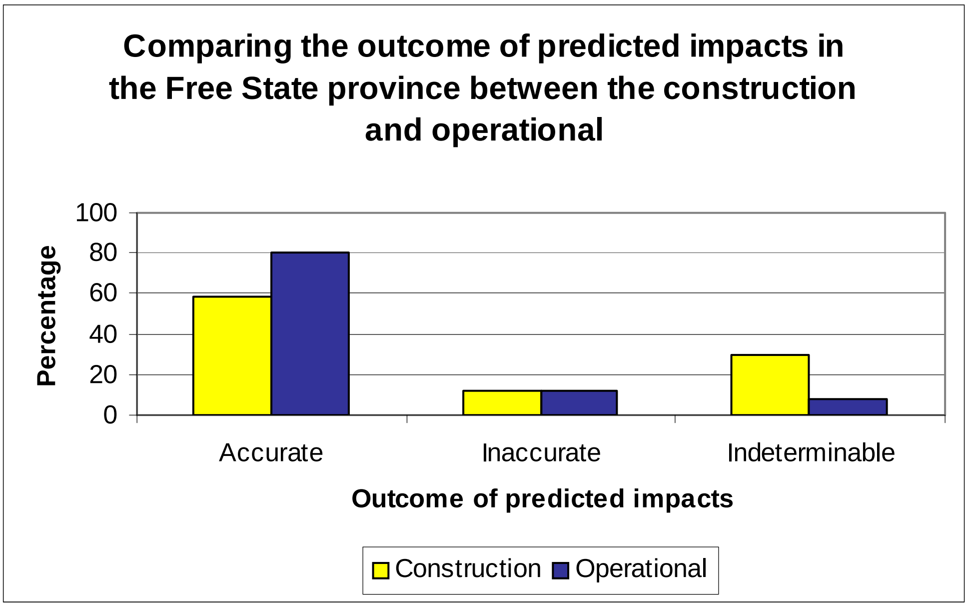


Figure 10: The outcome of predicted impacts in the Free State province in the construction and operational phases

Figure 10 illustrates that the majority of predicted impacts in the construction phase (58.2%) and operational phase (80.1%) have an accurate outcome. This supports the outcome of **Table 4** that the majority of predicted impacts will have an accurate outcome. However, the chi-square test in **Table 11** revealed that the outcome was statically significant and that the null hypothesis was rejected. Therefore a statistically significant difference between the outcome of predicted impacts in the Free State in the construction and operational phases exist.

It must be noted that the differences might only occur in some of the categories. In the construction phase a larger amount of predicted impacts had an indeterminable outcome (29%) compared to an inaccurate outcome (12.1%). The opposite occurred in the outcome of predicted impacts in the operational phase and 11.8% of predicted impacts had an inaccurate outcome compared to the 8.1%, which had an indeterminable outcome.

It can be assumed that there is a difference in the outcome of predicted impacts, which is based on the time periods (phase) the impacts manifest in. Predicted impacts in the construction phase tends to have a higher indeterminable outcome than an inaccurate outcome and the opposite outcome occurred in the operational phase. A reason for this result might be because information needed to make a conclusion about the outcome of an impact more easily obtained during the operational phase than the construction phase of a development due to the lack of monitoring data.

5.4.2 Predicted bio-physical and socio-economic impacts in the Free State province

The outcome of predicted impacts between the construction and operational phases was determined. However it is also necessary to establish whether a difference occur between the bio-physical and socio-economic categories, to establish if different kinds of impacts are easier to predict than others (see **Appendix G**). A chi-square test was conducted on **Table 12,** to determine if there is a difference in the outcome of predicted impacts in the Free State between the bio-physical and socio-economic impacts.

Table 12: Comparing the outcome of predicted impacts in the Free State between the bio-physical and socio-economic impacts

	Impact categories		
Outcome of predicted impacts	Bio-physical	Socio-economic	**Total**
Accurate	(Observed) 78 (Expected) 40.3 (Percentage) 67.2%	(Observed) 84 (Expected) 37.7 (Percentage) 75.7%	162
Inaccurate	(Observed) 11 (Expected) 5.7 (Percentage) 9.5%	(Observed) 16 (Expected) 5.3 (Percentage) 14.4%	27
Indeterminable	(Observed) 27 (Expected) 14.0 (Percentage) 23.3%	(Observed) 11 (Expected) 13.0 (Percentage) 9.9%	38
Total	116 100%	111 100%	227

Pearson`s X^2 statistic	7.7
Degree of Freedom	2
p	0.02

The hypothesis tested in **Table 12:**

H_o: There is no difference in the outcome of predicted impacts in the **Free State** between the **bio-physical** impact and **socio-economic** impact categories.

H_a: There is a difference in the outcome of predicted impacts in the **Free State** between the **bio-physical** impact and **socio-economic** impact categories.

The chi-square test statistic is 7.7 with an associated p-value of 0.02. Therefore the chi-squared test statistic is larger than the critical value on the chi-square table of 5.99, and the p-value is smaller than the chosen alpha level of 0.05. This means that the null hypothesis can be rejected with a 95 % confidence, and that there is a difference in the outcome of the predicted impacts in the Free State between the bio-physical impact and socio-economic impact categories. The result is statistically significant and the result can be generalised to the larger population in the two provinces. **Figure 11** illustrates, in percentages, the outcome of predicted impacts in the Free State between the bio-physical and socio-economic impacts.

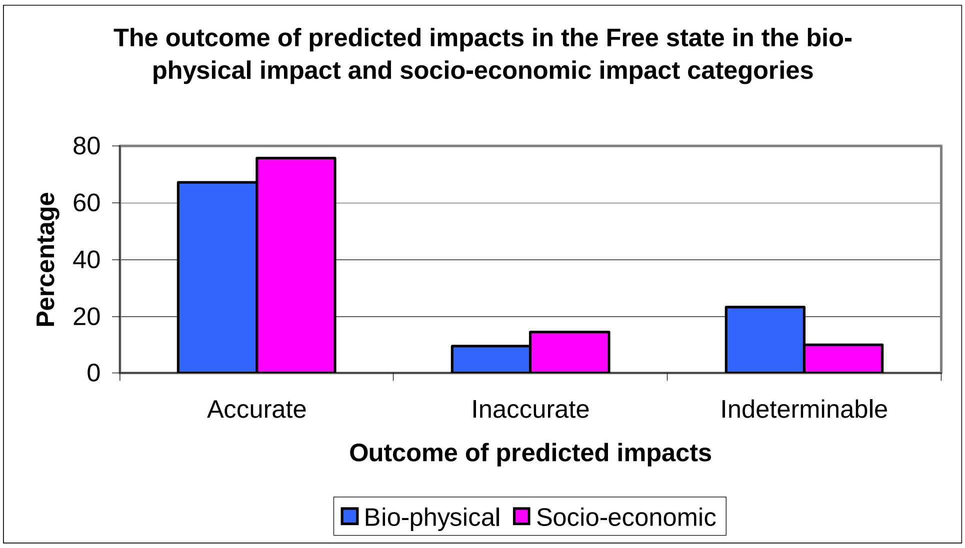


Figure 11: The outcome of predicted bio-physical and socio-economic impacts in the Free State

Figure 11 illustrates that the majority of predicted impacts had an accurate outcome in both the bio-physical impact category (67.2%) and socio-economic impact category (75.7%). This supports the outcome of **Table 4** that the majority of predicted impacts will have an accurate outcome. However the null hypothesis was rejected, hence there is a statistically significant difference in the outcome of predicted impacts between the bio-physical impact and socio-economic impact categories. **Figure 11** also illustrates that there is a difference between the two categories in relation to the percentage of predicted impacts with an inaccurate and indeterminable outcome. In the bio-physical impact category a higher percentage of predicted impacts have an indeterminable outcome (23.3%) compared to the inaccurate outcome (9.5%), whereas the socio-economic impact category has a higher percentage of predicted impacts with an inaccurate outcome (14.4%) compared to the predicted impacts that had an indeterminable outcome (9.9%).

It can be assumed that bio-physical impacts might be more difficult to determine because parameters for the baseline data are usually not provided in the EIAs and therefore it is difficult to determine changes for example in water or air quality. It can also be assumed that socio-economic impacts are easier to determine because the outcomes can mostly be determined in a qualitative format through interviews and questionnaires.

5.5 Predicted impacts in the Northern Cape province

5.5.1 Predicted impacts in the construction and operational phases in the Northern Cape province

In order to establish if a difference occurs in the outcome of predicted impacts in the Northern Cape between the construction and operational phases (see **Appendix H**), it is necessary to conduct a chi-square test (see **Table 13**).

Table 13: Comparing the outcome of predicted impacts in the Northern Cape between the construction and operational phases

	Phases				
Outcome of predicted impacts	Construction		Operational		**Total**
Accurate	(Observed)	38	(Observed)	66	104
	(Expected)	38.9	(Expected)	65.1	
	(Percentage)	65.5%	(Percentage)	68.1%	
Inaccurate	(Observed)	6	(Observed)	18	24
	(Expected)	9.0	(Expected)	15.0	
	(Percentage)	10.3%	(Percentage)	18.5%	
Indeterminable	(Observed)	14	(Observed)	13	27
	(Expected)	10.1	(Expected)	16.9	
	(Percentage)	24.2%	(Percentage)	13.4%	
Total		58 100%		97 100%	155

Pearson`s X^2 statistic	4.02
Degree of Freedom	2
p	0.1342

The hypothesis tested in **Table 13**:

H_o: There is no difference in the outcome of predicted impacts in the **Northern Cape** province between the **construction** and **operational** phases

H_a: There is a difference in the outcome of predicted impacts in the **Northern Cape** province between the **construction** and **operational** phases

The chi-square test statistic is 4.02 with an associated p-value of 0.1342. Therefore the chi-square test statistic is smaller than the critical value on the chi-square table of 5.99, and the p-value is larger than the chosen alpha level of 0.05.

Hence the null hypothesis can not be rejected and therefore no difference exists in the outcome of the predicted impacts in the Northern Cape province between the construction and operational phases. The results are not statistically significant and the results can not be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 12** illustrates, in percentages, the outcome of predicted impacts in the Northern Cape between the construction and operational phases.

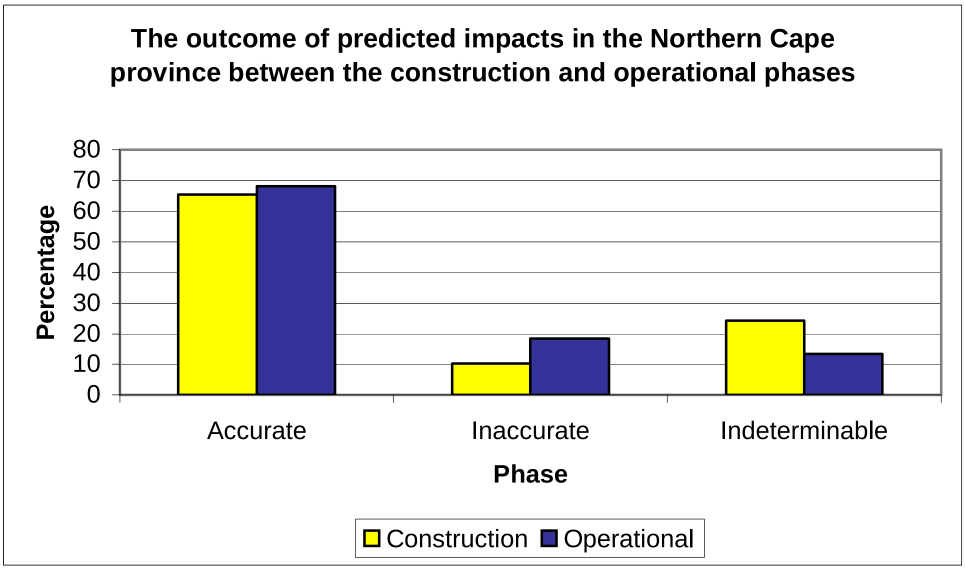


Figure 12: The outcome of predicted impacts in the Northern Cape in the construction and operational phases

Figure 12 illustrates that the majority of predicted impacts had an accurate outcome in both the construction (65.5%) and the operational phase (68.1%). However the construction phase have a higher percentage of predicted impacts with an indeterminable outcome (24.2%) compared to an inaccurate outcome (10.3%), while the opposite occur in the operational phase, 18.5% of predicted impacts had an inaccurate outcome compared to an indeterminable outcome (13.4%). Although there appears to be a difference it is not statistically significant and the difference can only be discussed in relation to the sample population in the Northern Cape. It must also be remembered that the outcome of the chi-square test indicated that there is no difference between the construction and operational phase but it does not mean that all the categories are the same. The differences can occur is one or two categories even though it is not statistically significant. The construction phase has a higher percentage of predicted impacts with an indeterminable outcome compared to the operational phase that has a higher percentage of predicted impacts with an inaccurate outcome.

Therefore it can be assumed that it is more difficult to determine the outcome of predicted impacts in the construction phase due the lack of monitoring data and information regarding construction activities.

5.5.2 Predicted bio-physical impact and socio-economic impact in the Northern Cape province

The outcome of predicted impacts between the construction and operational phases were determined. However, it is also necessary to establish if a difference occurs between the bio-physical and socio-economic categories (see **Appendix H**), to establish whether different kinds of impacts are easier to predict than others.
A chi-square test was conducted on **Table 14,** to determine whether a difference occur in the outcome of predicted impacts in the Northern Cape between the bio-physical impact and socio-economic impact categories.

Table 14: Comparing the outcome of predicted impacts in the Northern Cape between the bio-physical and socio-economic impacts

	Impact categories		
Outcome of predicted impacts	Bio-physical	Socio-economic	**Total**
Accurate	(Observed) 44 (Expected) 49.0 (Percentage) 60.3%	(Observed) 60 (Expected) 55.0 (Percentage) 73.2%	104
Inaccurate	(Observed) 14 (Expected) 11.3 (Percentage) 19.2%	(Observed) 10 (Expected) 12.7 (Percentage) 12.2%	24
Indeterminable	(Observed) 15 (Expected) 12.7 (Percentage) 20.5%	(Observed) 12 (Expected) 14.3 (Percentage) 14.6%	27
Total	73 100%	82 100%	155

Pearson\`s X^2 statistic	2.9
Degree of Freedom	2
p	0.22

Hypothesis tested in **Table 14**:

H_o: There is no difference in the outcome of predicted impacts in the **Northern Cape** province between the **bio-physical** impact and **socio-economic** impact categories

H_a: There is a difference in the outcome of predicted impacts in the **Northern Cape** province between the **bio-physical** impact and **socio-economic** impact categories

The chi-square test statistic is 2.9 with an associated p-value of 0.22. Therefore the chi-square test statistic is smaller than the critical value on the chi-square table of 5.99, and the p-value is larger than the chosen alpha level of 0.05.This means that the null hypothesis can not be rejected and that there is no difference in the outcome of the predicted impacts in the Northern Cape province between the bio-physical impact and socio-economic impact categories. The results are not statistically significant and the results can not be generalised to the larger population , but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 13** illustrates, in percentages, the outcome of predicted impacts in the Northern Cape between the bio-physical impact and socio-economic impact categories.

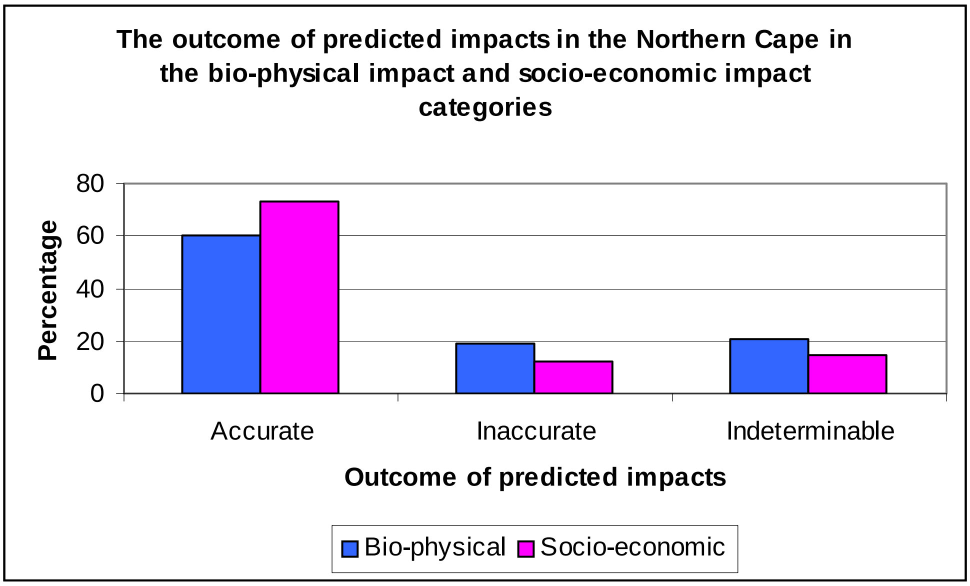


Figure 13: The outcome of predicted bio-physical and socio-economic impacts in the Northern Cape

Figure 13 illustrates that the majority of predicted impacts had an accurate outcome in both the bio-physical impact category (60.3%) and the socio-economic impact category (73.2%).

Furthermore, predicted bio-physical impacts (20.5%) and socio-economic impacts (14.6%) both had a higher percentage of impacts with an indeterminable outcome compared to impacts with an inaccurate outcome (bio-physical 19.2%, socio-economic 12.2%).

A summary of the hypothesises tested and the results for predicted are in **Chapter 7** and the outcome of mitigation measures in EIAs and RODs are discussed in **Chapter 6**.

6. Mitigation measures

6.1 Total number of mitigation measures in the Free State and Northern Cape provinces

In the 50 case studies 233 mitigation measures were identified. Many of the mitigation measures were in relation to the prevention of similar impacts. These mitigation measures were grouped together in order to have fewer mitigation measures but with more meaningful numbers (see **Appendix I**). For example the removal of top soil and proper storage of it during the construction phase and the construction of erosion berms are both mitigation measures for the prevention of soil erosion. Thus these two mitigation measures were grouped together because they address the same type of impact during the same phase of the development. The different mitigation measures and the percentage each represent out of the total of 233 mitigation measures can be seen in **Figure 14**.

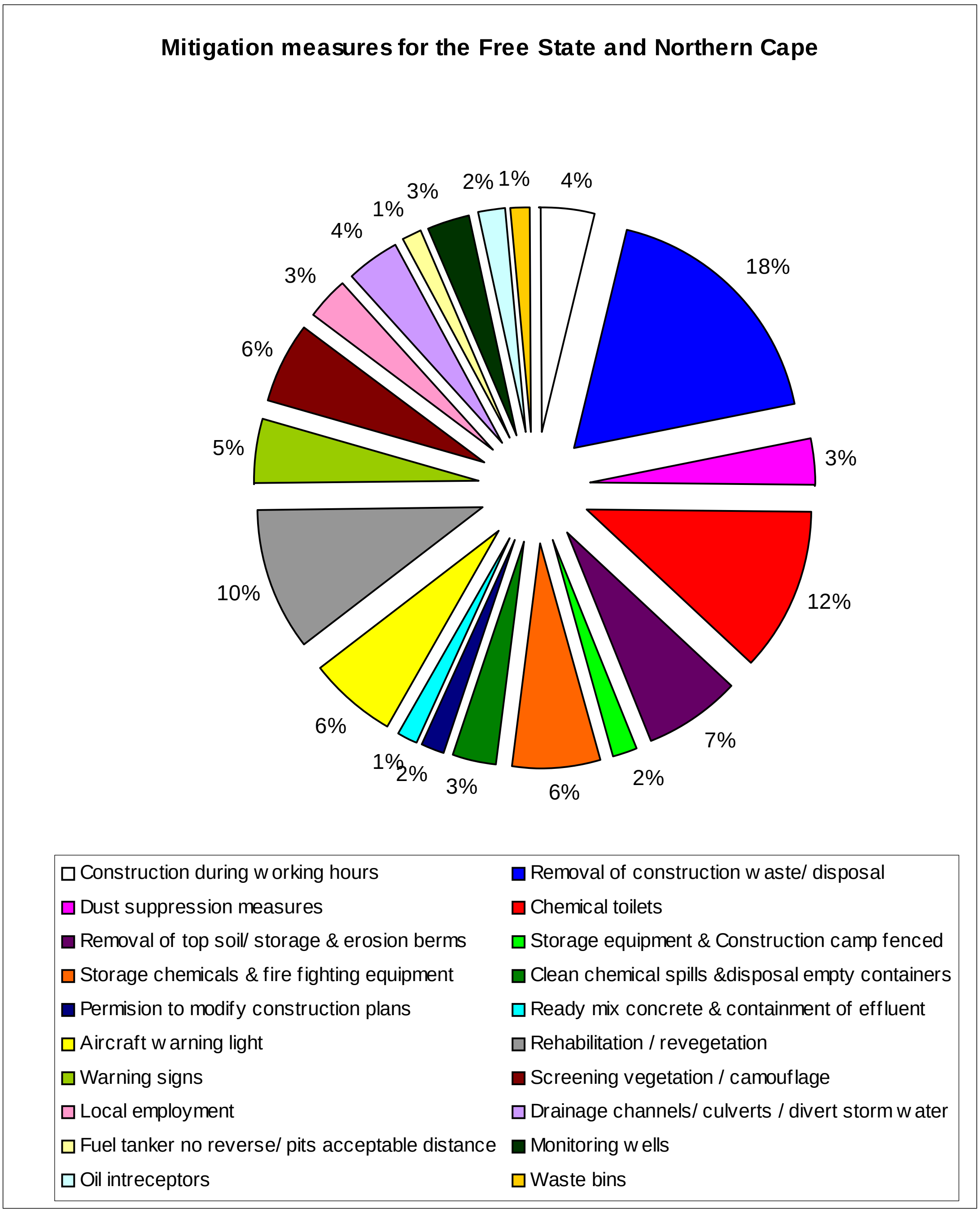


Figure 14: Total number of mitigation measures for the Free State and Northern Cape

Figure 14 illustrates that 18% of the mitigation measures were concerned with the removal of construction waste after the construction activities and the proper disposal of it at a registered landfill site. This mitigation measure aims to prevent illegal dumping of building rubble on open spaces and proper disposal of harmful building rubble such as asbestos, cement, empty oil drums etc. Thirty-three of the 42 mitigation measures concerned with the removal and proper disposal of construction waste were implemented, while 6 were not implemented and 3 were indeterminable (see **Photo 1**).

Photo 1: Example of construction waste not removed

Photo 1 illustrates building rubble that was not removed after the construction of a fuel filling station on the adjacent portion of land.

Furthermore, 12% of the total number mitigation measures were in relation to the supply of chemical toilets during the construction phase in order to provide construction workers with sanitation facilities and to prevent urination in adjacent field areas (see **Figure 14**). Nine of the 27 mitigation measures related to chemical toilets were not implemented because permanent bathroom facilities already existed at the construction areas. Eighteen of the 27 chemical toilet mitigation measures were indeterminable since enough information was not available to determine if it was implemented or not during the construction phase.

The rehabilitation and revegetation of an area after construction activities represented 10% of the total number of mitigation measures (see **Figure 14**). This mitigation measure aims to restore an area to its original state after construction by remediation of contaminated soil and replanting of natural vegetation or ornamental indigenous vegetation. Revegetation of an area also assists in the prevention of erosion. See **Photo 2.1** for an example of vegetation planted on steep areas of a storm water channel to prevent soil erosion. Sixteen of the 24 mitigation measures concerned with rehabilitation and revegetation were implemented while 6 were not implemented (see **Photo 2.2**) and 2 were indeterminable.

Photo 2.1: Example of revegetation at storm water channel

Photo 2.1 illustrates that vegetation was planted on the steep slopes of this storm water channel to prevent soil erosion.

Photo 2.2: Example of an area that was not revegetated

Photo 2.2 illustrates that vegetation was removed during the construction phase and no vegetation was replanted afterward, causing erosion.

A further 7% of mitigation measures were related to the removal of top soil and the proper storage of it during the construction phase and the construction of erosion berms (see **Figure 14**). These mitigation measures were for the prevention of soil erosion and degradation of valuable top soil during the construction and operational phases (see **Photo 3**, for an example). Eight of the 16 mitigation measures aimed at preventing soil erosion and degradation, were indeterminable and the other 8 were not implemented.

Photo 3: Example of a mitigation measure to prevent soil erosion

Photo 3 illustrates a small wall that was constructed at a cell phone mast as a preventative measure for soil erosion.

Mitigation measures concerned with adequate storage of chemicals and the availability of fire fighting equipment during the construction phase represented 6% of the total number of mitigation measures (see **Figure 14**). These mitigation measure aim to prevent chemical spills or leakages that can cause soil or water contamination, by ensuring that chemical products, oil, diesel etc. are stored in a bunded area. Fire fighting equipment near storage areas of flammable chemicals are necessary in order to quickly extinguish a fire. Thirteen of the 15 mitigation measures were indeterminable and 2 were not implemented.

The reason for the large amount of mitigation measures being indeterminable is the lack of information about the construction phase.

Figure 14 illustrates that 6% of the mitigation measures were with regard to the placement of aircraft warning lights on cell phone masts for aviation safety measures. Twelve of the 15 mitigation measures for aircraft warning lights were implemented and 3 were not implemented. Five percent of mitigation measures were in regard to the placement of warning signs on telecommunication base stations as a safety measure warning the public of possible danger when entering the base station. Eight of the 11 mitigation measures for warning signs were implemented while 2 were not implemented and 1 was indeterminable. See **Photos 4.1**, **4.2** & **4.3**, for an example of a warning sign,an aircraft warning light and day markings.

Photo 4.1: Example of a warning sign

Photo 4.1 illustrates a warning sign to warn of possible dangers when entering the fenced area of the base station.

Photo 4.2: Example of an aircraft warning light

Photo 4.2 illustrates an aircraft warning light that is used as a warning sign or location indicator of a high structure for airplanes during the night. The aircraft warning light.

Photo 4.3: Example of day markings on structures for aircrafts

Photo 4.3 illustrates the red and white markings on the cell phone mast that serves as a visual indicator of a high structure for aircraft.

The screening of structures with vegetation or camouflaging it with other measures such as colour, comprised 6% of the total number of mitigation measures (see **Figure 14**). The aim of screening is to minimize visual impact of a development and to make it more visually absorbable into the surrounding landscape. Eight of the 14 mitigation measures for screening or camouflaging were implemented while 5 were not implemented and 1 was indeterminable. See **Photos 5.1**, **5.2**, **5.3**, **5.4**, **5.5**, **5.6**, **5.7** and **5.8** for a few good examples of screening with vegetation and camouflaging with colours and structures.

Photo 5.1: Example of screening with vegetation

Photo 5.1 illustrates that the high trees act as screening mechanisms and reduce the visual impacts of the masts.

Photo 5.2: Example of visual impacts from similar shaped structures

Photo 5.2 illustrates that the visual impact of a structure is reduced if structures of similar height or form occur in the same area (Hopkinson, 1971). The visual impact of the solid green cell phone mast is reduced due to the presence of the concrete tower with a similar shape in the background.

Photo 5.3: Example of the visual impact of a non-solid structure

Photo 5.3 illustrates that a non-solid structure compared to a solid structure as in **Photo 5.2**, have a lower visual impact, because a person can see through a non-solid object (Hopkinson, 1971).

Photo 5.4: Example of a Signpost used as camouflage

Photo 5.4 illustrates that various types of structures can be used to camouflage cell phone masts such as this example where the signpost of a shopping centre was designed to accommodate a cell phone antenna and a container.

Photo 5.5: Example of a floodlight used as a cell phone mast

Photo 5.5 illustrates a reinforced floodlight which doubles as a cell phone mast at a sports field, thereby minimizing the visual impact of the cell phone structure.

Photo 5.6: Example of Camouflaged masts

Photo 5.6 illustrates cell phone structures that are camouflaged by imitating a natural objects such a palm and pine trees and rocks.

Photo 5.7: Example of a container camouflaged as a brick house

Photo 5.7 illustrates that a structure such as a cell phone container can be built to blend in with the image of nearby buildings and is therefore less visually intrusive.

Photo 5.8: Example of rooftop antennas

Photo 5.8 illustrates two rooftop antennas that are mounted on a buildings to reduce the visual impact by blending in with the building.

Four percent of the total number of mitigation measures were concerned with the construction of drainage channels and culverts in order to channel and divert storm water and prevent soil erosion (see **Figure 14**). Four of the 9 mitigation measures were implemented, a further 4 were not implemented and only 1 was indeterminable. This mitigation measure was easier to determine because it was observable during the operational phase when storm water is diverted through channels and culverts.

A further 4% of mitigation measures were concerned with the time restriction of construction activities in order to minimize noise impacts on the surrounding residential areas (see **Figure 14**). The time period construction activities were restricted to was mostly from 8`o clock in the mornings to 5 `o clock in the evenings, which are considered normal working hours. Two of the 9 mitigation measures were implemented while 7 were deemed indeterminable due to the lack of information about activities during the construction phase.

Dust suppression measures represented 3% of the total number of mitigation measures (see **Figure 14**). This mitigation measure aims at improving air quality during the construction phase by keeping areas wet where soil was exposed after vegetation was removed. Stockpiled soil must also be kept wet and covered to prevent excessive amounts of dust in the air during a windy day. All 8 of the mitigation measures were deemed indeterminable, because enough information was not available to determine if the mitigation measures were implemented or not (see **Photo 6**).

Photo 6: Example of earthworks

Photo 6 illustrated that dust suppression measures are important to implement, especially in an arid area.

Three percent of the mitigation measures were concerned with the employment of local labourers (see **Figure 14**). This mitigation measure is suggested in order to ensure that the local community also benefits socially and economically from developments in their area. Two of the 7 mitigation measures concerned with the employment of local labourers were not implemented and 5 were deemed indeterminable, due to a lack of information.

The cleaning of chemical spills and adequate disposal of empty containers that were contaminated represented 3% of the total number of mitigation measures in **Figure 14**. This mitigation measure aims to ensure that chemical spills are cleaned by the removal of contaminated soil through licensed service providers and that the soil and empty containers are disposed of at licensed hazardous landfill sites. Two of the 7 mitigation measures were implemented, while 5 were indeterminable due to a lack of information about construction activities and certificates of proof for contaminated soil removal.

Moreover 3% of mitigation measures focused on the presence of monitoring wells and 2% about the presence of oil interceptors at fuel filling stations (see **Figure 14**). The monitoring well mitigation measure is intended to prevent soil contamination through the monitoring of leakages from underground diesel and petrol storage tanks.

All of the mitigation measures for the monitoring wells and oil interceptors were implemented. See **Photos 7.1** & **7.2**, for examples of oil interceptors and monitoring wells.

Photo 7.1: Example of monitoring wells

Photo 7.1 illustrates monitoring wells (indicated by an arrow) at the fuel filling stations. Monitoring wells are used to detect leakages from underground fuel storage tanks.

Photo 7.2: Example of oil interceptors

Photo 7.2 illustrates oil interceptors at a car wash and a fuel pump. Oil interceptors are used to remove oil and soap residue from runoff water before it is released into the municipal drain/storm water system.

Two percent (see **Figure 14**) of the mitigation measures were focused on fenced off construction camps and the storage of all equipment in a fenced area in order to ensure safety and orderliness on site (see **Photo 8**). Two of the 4 mitigation measures were implemented and the other 2 were indeterminable due to a lack of information about the construction activities.

Photo 8: Example of a construction camp

Photo 8 illustrates a construction camp that is not fenced of and poses a safety risk due to the close proximity of an informal township.

A further 2% of the mitigation measures dealt with the changes to construction plans without authorisation from the Department of Environmental Affairs (see **Figure 14**). Changes to the construction plan on which an environmental impact report and authorisation was based, can have serious consequences. The impacts on the environment can change and be more severe than expected. For instance, if a fuel filling station alone was authorised but a car wash is also built during the construction, additional impacts could occur for which no mitigation measures would be required.

The car wash will cause storm water pollution if oil interceptors are not installed and the fuel filling station might be situated next to a spruit area that can also be polluted from oil and soap runoff from the car wash. One of the 4 mitigation measures was implemented while 2 were not implemented and 1 was indeterminable. See **Photos 9.1**, **9.2.1**, **9.2.2**, **9.3.1**, **9.3.2**, **9.3.3**, **9.3.4**, **9.3.5** and **9.3.6** for examples of 3 developments for which the mitigation measure of authorisation for changes to the construction plans were not implemented.

Photo 9.1: Example 1 of an unauthorised change to construction plans

Photo 9.1 illustrates a project where the construction plans were changed without authorisation and a car wash was constructed without adequate mitigation measures such as oil interceptors.

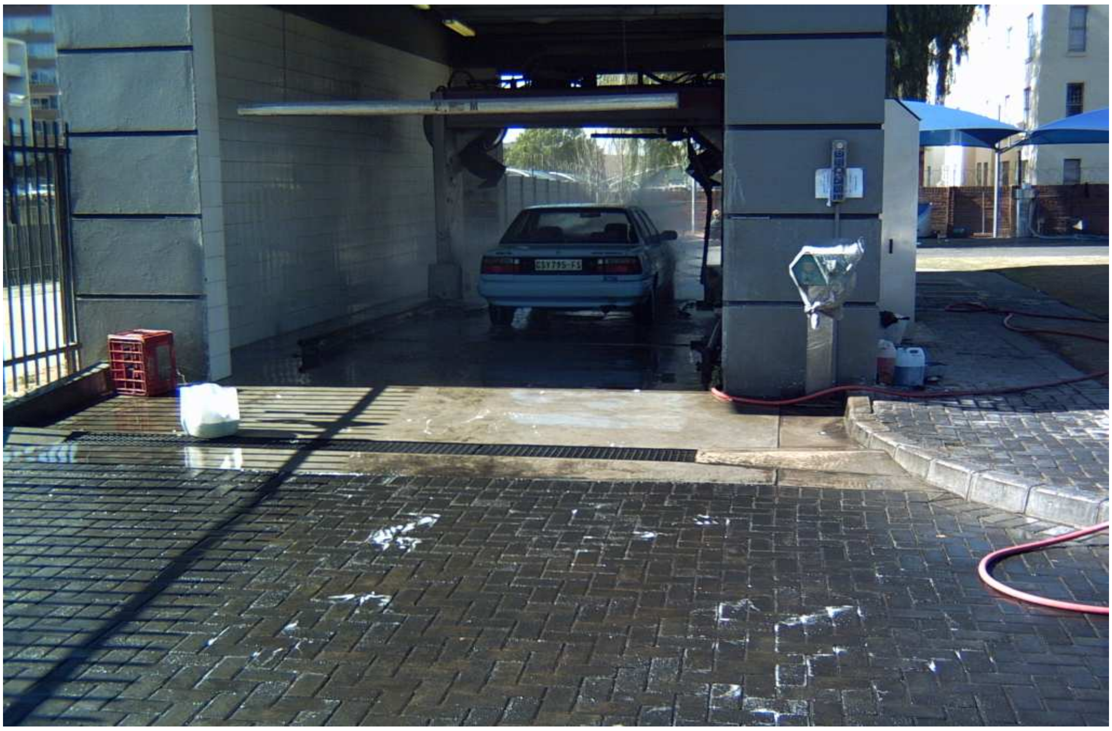


Photo 9.2.1: Example 2 of an unauthorised change to construction plans

Photo 9.2.1 illustrates an unauthorised change to construction plans in order to include a car wash next to a spruit area.

Photo 9.2.2: Runoff from car wash

Photo 9.2.2 illustrates the runoff from the car wash directly into the spruit, as indicated by the arrows.

Photo 9.3.1: Example 3 of an unauthorised change to construction plans

Photo 9.3.1 illustrates an authorised change to construction plans by adding a car wash. No oil interceptors are located near the car wash.

Photo 9.3.2: Filling station at car wash

Photo 9.3.2 illustrates that there are no oil interceptors at the petrol pumps. Oil interceptors were not a mitigation measure that was required by the Record of Decision or that was mentioned in the EMP. Therefore it cannot be seen as a mitigation measure that was not implemented. The arrows indicate the runoff from the filling station towards the storm water drain, indicated by a circle.

Photo 9.3.3: Runoff from filling station and car wash

Photo 9.3.3 illustrates the runoff from the fuel filling station (indicated by an arrow) to a storm water drain (indicated by a circle).

Photo 9.3.4: Storm water drain at filling station

Photo 9.3.4 illustrates the storm water drain (indicated by an arrow) to which the runoff flows to in **Photo 9.3.3**.

Photo 9.3.5: Flow from storm water drain

The arrows in **Photo 9.3.5** indicates the flow of the runoff from the fuel filling station to the storm water drain (indicated by a circle), and into the channel.

Photo 9.3.6: Storm water channel

Photo 9.3.6 illustrates the storm water channel where the runoff from the fuel filling station ends up. Note that the water is very polluted and probably contain high levels of oil, diesel, petrol and soap residue. The impact on this water could have been minimized if oil interceptors were installed at the fuel filling station (was not a required mitigation measure in the ROD or EMP) and if construction plans were not altered adding a car wash as another source of pollution. This clearly illustrates the additional impacts that can occur due to construction plan changes and mitigation measures that are omitted from EMPs.

Only 1% (see **Figure 14**) of mitigation measures were concerned with the provision of waste bins for trash during the operational phase and for the use of ready mix concrete during construction phase in order to minimize the impact on soil when it is mixed on site (see **Photo 10** for an example). A further 1% of the mitigation measures were in regard to fuel tankers that are not allowed to reverse at a fuel filling station to prevent unforeseen accidents and the acceptable distance of refilling points/pits from building (see **Photo 11**).

Photo 10: Example of concrete residue on soil

Photo 10 illustrates that concrete residue was left behind in a nature reserve area, after the construction of a building. Evidence was found to suggest that the cement was mixed on site and that ready mixed cement was not used.

Photo 11: Example of the layout of a filling station

Photo 11 illustrates a fuel filling station with an acceptable entrance and exist layout. Fuel tankers are not allowed to reverse at a fuel filling station. All fuel filling stations must have easy access and departure paths for the tankers.

6.1.1 Outcome of the total number of mitigation measures in the Free State and Northern Cape provinces

All of the various kinds of mitigation measures from both provinces had certain outcomes during the audit process. The outcomes of the 233 mitigation measures were divided into the following categories: implemented, not implemented and indeterminable (See **Appendix I**). A chi-square test was conducted on **Table 15**, to estimate whether the outcome of the total amount of mitigation measures from both provinces were equally distributed across the three categories (implemented, not implemented and indeterminable).

Table 15: Outcome of the total number of mitigation measures of the Free State and Northern Cape

Outcome of mitigation measures		
Implemented	(Observed)	105
	(Percentage)	46%
Not implemented	(Observed)	50
	(Percentage)	21%
Indeterminable	(Observed)	78
	(Percentage)	33%
Total		233

Pearson`s X^2 statistic	19.47
Degree of Freedom	2
p	0.000059

The hypothesis tested in **Table 15**:

H_o: The outcome of **the total number of mitigation measures** is equally distributed between the implemented, not implemented and indeterminable categories.

H_a: There is a difference in the distribution of **the total number of mitigation measures** outcomes between the implemented, not implemented and indeterminable categories.

The chi-square test statistic of **Table 15** is 19.47 with an associated p-value of 0.000059. Therefore the chi-square test statistic is larger than the critical value of the chi-square distribution table of 5.99, and the p-value is smaller than the chosen alpha level of 0.05 (see **Appendices C** and **B**).

This means that the null hypothesis can be rejected with a 95% confidence level and that only 5% of the outcome is due to chance. Hence it can be accepted that the distribution of mitigation measures are not equal between the categories. **Figure 15** illustrates, in percentages, the outcome of the total amount of mitigation measures from the two provinces.

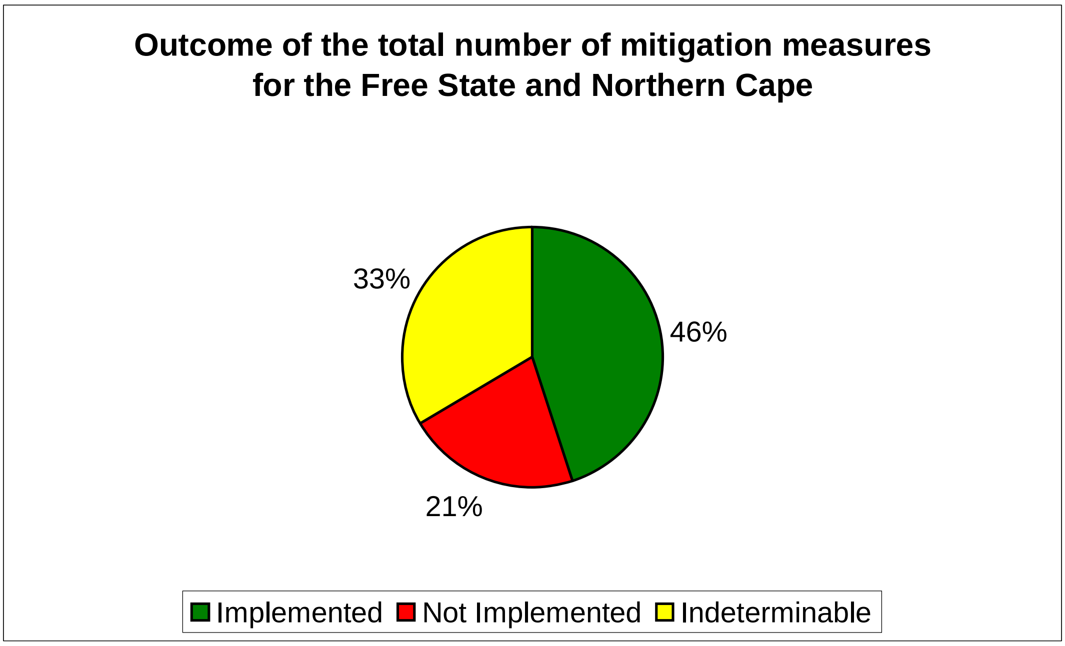


Figure15: Outcome of the total number of mitigation measures in the Free State and Northern Cape

Figure 15 illustrates that 45.1% of mitigation measures were implemented, while 33.5% were not implemented and 21.4% of mitigation measures were indeterminable. The result is statistically significant and can be generalised to the larger population. Therefore it can be implied that the majority of mitigation measures might be implemented in the two provinces, and that more mitigation measures would be deemed indeterminable compared to being considered not implemented.

6.2 Mitigation measures in the Free State and Northern Cape provinces

In the 50 case studies, 25 from each of the two provinces, a total of 233 mitigation measures were identified of which 126 mitigation measures were from the Free State province and 107 from the Northern Cape province (see **Appendices J** and **K**). **Figure 16** illustrates, in percentages, the various kinds of mitigation measures in each of the two provinces. Percentages were used to depict a more comparative picture of the mitigation measures between the two provinces, because the provinces did not have an equal amount of mitigation measures.

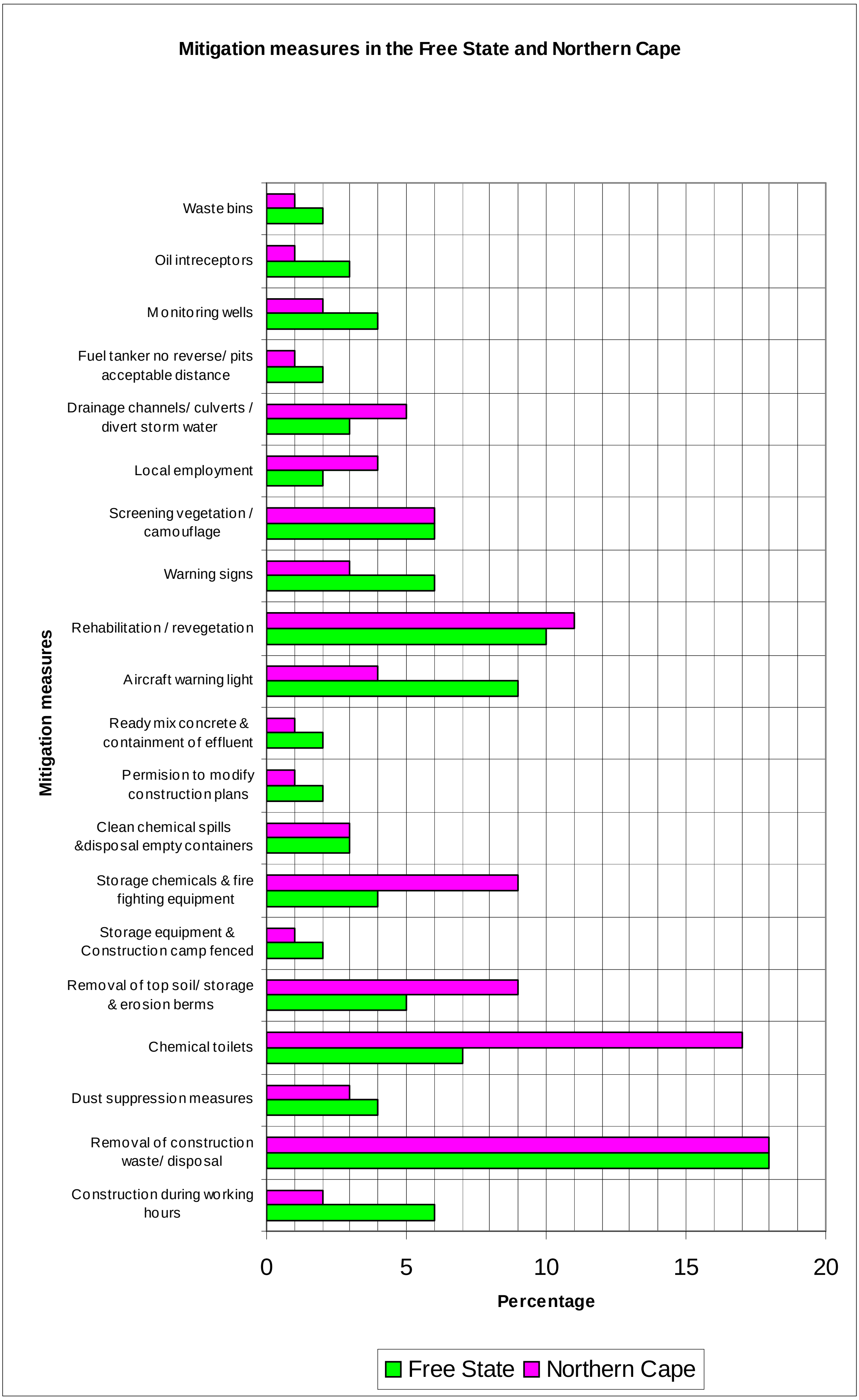


Figure 16: Mitigation measures in the Free State and Northern Cape

Figure 16 illustrates the different mitigation measures in the Free State and Northern Cape provinces. Removal of construction waste and proper disposal of such waste was the foremost mentioned mitigation measure in the case studies in both the Free State (18%) and in the Northern Cape (18%). In both the provinces 6% of the mitigation measures were related to the planting of screening vegetation and 3% were related to proper cleaning of chemical spills. However, in the Northern Cape more attention was paid in the case studies to mitigation measures such as the provision of chemical toilets (17%), removal of top soil and proper storage of the soil (9%), and the storage of chemicals and the availability of fire fighting equipment (9%), in comparison to mitigation measures in the Free State province. Mitigation measures concerned with the provision of drainage channels for storm water diversion (5%) and the employment of local labourers (4%) were also mentioned more times in the Northern Cape case studies, than in the Free State case studies.

In the Free State mitigation measures were more concerned with construction during working hours (6%), the presence of aircraft warning lights (9%), warning signs (6%), monitoring wells (4%) and oil interceptors (3%), than compared to the mitigation measures in the Northern Cape.

In both provinces the following mitigation measures were almost equally mentioned in the case studies: presence of waste bins, the utilization of dust suppression measures and ready mix concrete, the storage of equipment in a fenced off construction camp, the provision of enough space in order for a fuel tanker not to reverse when it provides fuel at a refilling point and prior authorisation for modifications to construction plans.

6.2.1 Outcome of mitigation measures in the Free State and Northern Cape province

The outcome of the various mitigation measures in **Figure 16** was divided into the following categories: implemented, not implemented and indeterminable (see **Appendices J** and **K**). A chi–square test was conducted on **Table 16**, to establish if there is a statistical significant difference between the outcomes of mitigation measures between the two provinces or if similar outcomes occurred.

Table 16: Comparing the outcome of mitigation measures between the Free State and Northern Cape

	Provinces		
Outcome of mitigation measures	Free State	Northern Cape	**Total**
Implemented	(Observed) 64 (Expected) 56.8 (Percentage) 50.7%	(Observed) 38 (Expected) 48.2 (Percentage) 38.3%	105
Not Implemented	(Observed) 22 (Expected) 27.0 (Percentage) 17.5%	(Observed) 28 (Expected) 23.0 (Percentage) 26.2%	50
Indeterminable	(Observed) 40 (Expected) 42.2 (Percentage) 31.8%	(Observed) 38 (Expected) 35.8 (Percentage) 35.5%	78
Total	126 100%	107 100%	233

Pearson`s X^2 statistic	4.29
Degree of Freedom	2
p	0.1172

The hypothesis tested in **Table 16:**

H_o: There is no difference in the outcome of **mitigation measures** between the **Free State** and **Northern Cape** provinces

H_a: There is a difference in the outcome of **mitigation measures** between the **Free State** and Northern Cape provinces

The chi-square test statistic is 4.29 with an associated p-value of 0.1172. Therefore the chi-square test statistic is smaller than the critical value of the chi-square distribution table of 5.99, and the p-value is larger than the chosen alpha level of 0.05. Hence the null hypothesis cannot be rejected and therefore no statistically significant difference exists in the outcome of mitigation measures between the Free State and Northern Cape provinces. The results are not statistically significant and the results cannot be generalised to the larger population, but assumptions about the outcome of mitigation measures in the sample population can be made. **Figure 17** illustrates, in percentages, the outcome of mitigation measures between the two provinces.

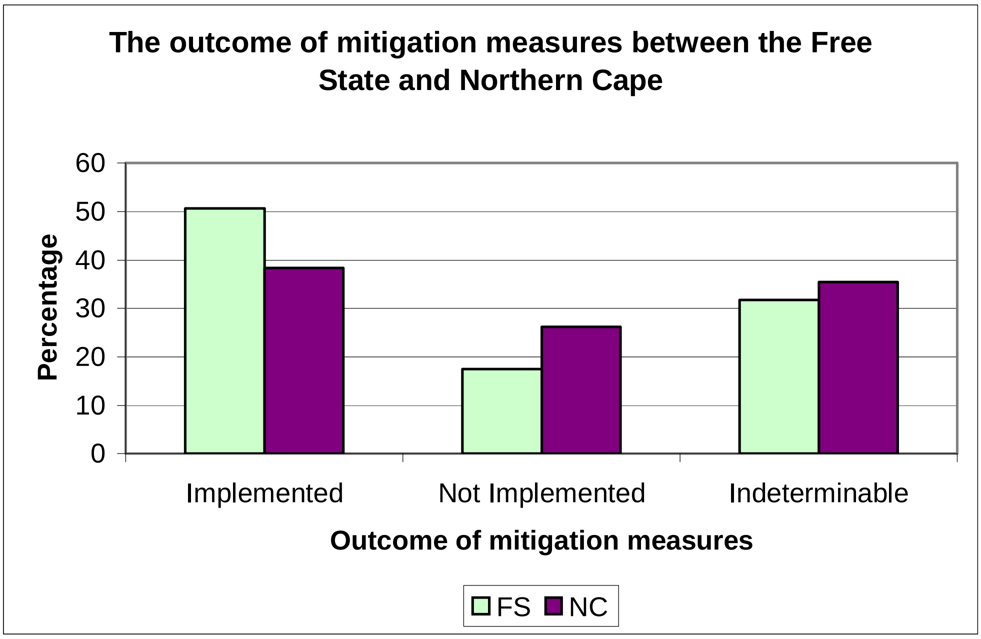


Figure 17: The outcome of mitigation measures between the Free State and Northern Cape

Figure 17 illustrates that the majority of mitigation measures were implemented in both the Free State (50.7%) and in the Northern Cape (38.3%). A larger percentage of mitigation measures in the two provinces were indeterminable (Free State 31.8%, Northern Cape 35.5%) than not implemented (Free State 17.5%, Northern Cape 26.2%). The outcome support the results of **Table 15**, that the majority of mitigation measures would be implemented. However it must be noted that the outcome of **Table 16** was not statistically significant and that **Figure 17** only represents the outcome of the sample population and cannot be generalised.

6.3 Outcome of mitigation measures in the construction and operational phases in the Free State and Northern Cape provinces

The mitigation measures from the Free State and Northern Cape were further subdivided into mitigation measures that should have been implemented during the construction phase and the operational phase (see **Appendices J** and **K**). Hundred and thirty-five of the 233 mitigation measures were construction phase mitigation measures, of which 67 were from Free State case studies and 68 was from Northern Cape case studies. Ninety-eight of the 233 mitigation measures were operational phase mitigation measures of which 59 were Free State mitigation measures and 39 were Northern Cape mitigation measures.

The outcome of the mitigation measures was sorted into the following categories: implemented, not implemented and indeterminable. A chi-square test was conducted on **Table 17** and **18** to determine if differences respectively occur between the outcome of construction phase and operational phase mitigation measures between the Free State and Northern Cape provinces, in order to establish if mitigation measures have different outcomes based on the phase it must be implemented in.

6.3.1 Outcome of construction phase mitigation measures in the Free State and Northern Cape provinces

Table 17: Comparing the outcome of construction phase mitigation measures between the Free State and the Northern Cape

	Provinces		
Outcome of mitigation measures	Free State	Northern Cape	**Total**
Implemented	(Observed) 24 (Expected) 20.3 (Percentage) 35.8%	(Observed) 17 (Expected) 20.7 (Percentage) 25%	41
Not Implemented	(Observed) 9 (Expected) 13.4 (Percentage) 13.4%	(Observed) 18 (Expected) 13.6 (Percentage) 26.5%	27
Indeterminable	(Observed) 34 (Expected) 33.3 (Percentage) 50.7%	(Observed) 33 (Expected) 33.7 (Percentage) 48.5%	67
Total	67 100%	68 100%	135

Pearson`s X^2 statistic	4.20
Degree of Freedom	2
p	0.1223

The hypothesis tested in **Table 17:**

H_o: There is no difference in the outcome of **construction phase mitigation measures** between the Free State province and Northern Cape province

H_a: There is a difference in the outcome of **construction phase mitigation measures** between the Free State province and Northern Cape province

The chi-square test statistic is 4.2 with an associated p-value of 0.1223. Therefore the chi-square test statistic is smaller than the critical value on the chi-square table of 5.99, and the p-value is larger than the chosen alpha level of 0.05.This means that the null hypothesis can not be rejected and that there is no difference in the outcome of mitigation measures in the construction phase between the Free State and Northern Cape provinces. The results are not statistically significant and the results cannot be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 18** illustrates, in percentages, the outcome of mitigation measures in the construction phase between the two provinces.

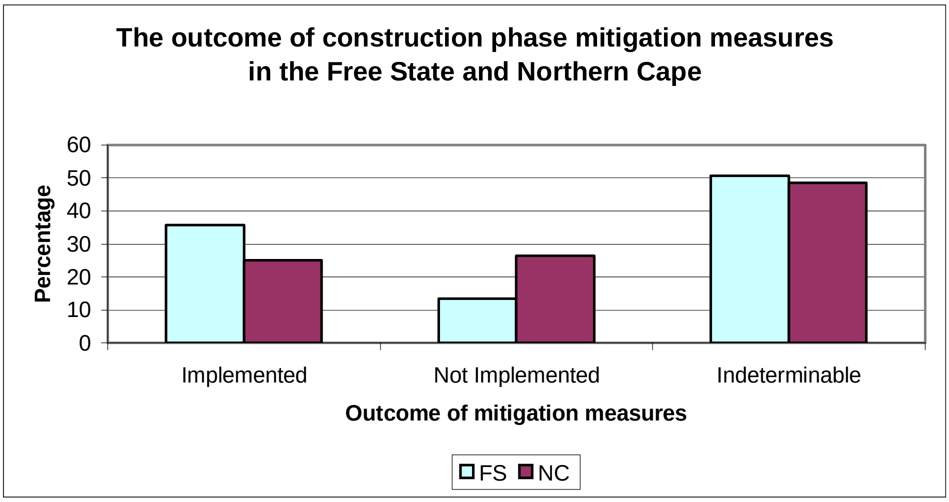


Figure 18: The outcome of construction phase mitigation measures in the Free State and Northern Cape

Figure 18 illustrates that the majority of mitigation measures had an indeterminable outcome in both provinces (Free State 50.7%, Northern Cape 48.5%). However the Free State has a higher percentage of implemented mitigation measures than not implemented mitigation measures and vice versa for the Northern Cape. Thus there is a difference between the outcome of mitigation measures in the Free State and Northern Cape, but it is not statistically significant. It must be noted that it was indicated that there are similarities between the two provinces, but it does not mean that all the categories are similar.

6.3.2 Outcome of operational phase mitigation measures in the Free State and Northern Cape provinces

Table 18: Comparing the outcome of operational phase mitigation measures between the Free State and Northern Cape

	Provinces		
Outcome of mitigation measures	Free State	Northern Cape	**Total**
Implemented	(Observed) 40 (Expected) 38.5 (Percentage) 67.8%	(Observed) 24 (Expected) 25.5 (Percentage) 61.5%	64
Not Implemented	(Observed) 13 (Expected) 13.8 (Percentage) 22%	(Observed) 10 (Expected) 9.2 (Percentage) 25.6%	23
Indeterminable	(Observed) 6 (Expected) 6.6 (Percentage) 10.2%	(Observed) 5 (Expected) 4.4 (Percentage) 12.9%	11
Total	59 100%	39 100%	98

Pearson`s X^2 statistic	0.42
Degree of Freedom	2
p	0.8114
Yate`s chi-square value	0.080
Yate`s p-value	0.956

The hypothesis tested in **Table 18**:

H_o: There is no difference in the outcome of mitigation measures in the **operational phase** between the Free State province and Northern Cape province

H_a: There is no difference in the outcome of mitigation measures in the **operational phase** between the Free State province and Northern Cape province

The chi-squared test statistic is 0.42 with an associated p-value of 0.8114. However one of the expected values was less than 5 and the Yate`s correction was implemented in order to make the results more acceptable (see **Appendix C**). The chi-square value with the Yate`s correction is 0.08 with an associated p-value of 0.956. Therefore the chi-square test statistic is smaller than the critical value on the chi-square table of 5.99, and the p-value is larger than the chosen alpha level of 0.05. This means that the null hypothesis cannot be rejected and that there is no difference in the outcome of mitigation measures in the operational phase between the Free State and Northern Cape provinces.

The results are not statistically significant and the results cannot be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 19** illustrates, in percentages, the outcome of operational phase mitigation measures between the two provinces.

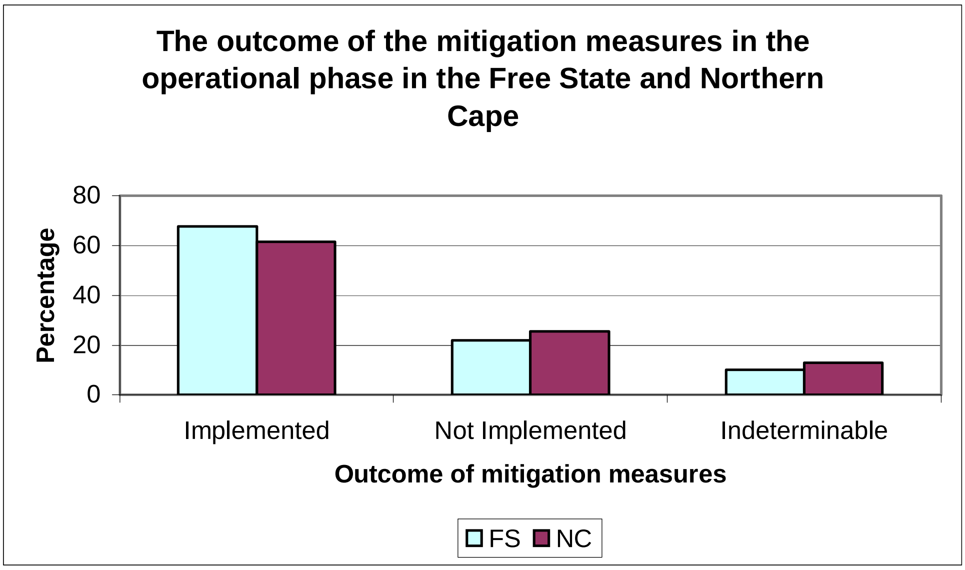


Figure 19: The outcome of operational phase mitigation measures in the Free State and Northern Cape

Figure 19 illustrates that the majority of mitigation measures were implemented in both provinces (Free State 67.8%, Northern Cape 61.5%). A higher percentage of mitigation were not implemented in the Free State (22%) and the Northern Cape (25.6%), compared to the mitigation measures that had an indeterminable outcome (Free State 10.2%, Northern Cape 12.9%). The outcome supports the findings of **Table 15,** that the majority of mitigation measures would be implemented, even though **Table 18** cannot be generalised because the outcome is not statistically significant.

It can be assumed that the majority of mitigation measures could have an indeterminable outcome in the construction phase due to the lack of monitoring data and information of construction activities to make a decisive decision on the implementation of mitigation measures. The majority of mitigation measures in the operational phase tend to be implemented, this might be because more information are available during the operational phase of a project, in order to make a judgement on the implementation of mitigation measures.

6.4 Adequacy of implemented mitigation measures in the Free State and Northern Cape provinces

In both provinces a total of 105 mitigation measures was implemented, of which 64 were from the Free State and 41 from the Northern Cape. The implemented mitigation measures were sorted into two categories namely: sufficiently implemented and insufficiently implemented mitigation measures (see **Appendices J** and **K**). The outcome of implemented mitigation measures were compared between the Free State and Northern Cape to determine if differences occur between the two provinces (see **Table 19**).

Table 19: The adequacy of implemented mitigation measures in the Free State and Northern Cape

	Provinces		
Precision of implemented mitigation measures	Free State	Northern Cape	**Total**
Sufficient	(Observed) 49 (Expected) 50.6 (Percentage) 76.6%	(Observed) 34 (Expected) 32.4 (Percentage) 82.9%	83
Insufficient	(Observed) 15 (Expected) 13.4 (Percentage) 23.4%	(Observed) 7 (Expected) 8.6 (Percentage) 17.1%	22
Total	64 100%	41 100%	105

Pearson\`s X^2 statistic	0.611
Degree of Freedom	1
p	0.43

The Hypothesis tested in **Table 19**:

H_0: There is no difference in **adequacy of implemented mitigation measures** in the Free State and Northern Cape

H_a: There is a difference in the **adequacy of implemented mitigation measures** in the Free State and Northern Cape

The chi-square test statistic is 0.611 with an associated p-value of 0.43. Therefore the chi-squared test statistic is larger than the critical value on the chi-square table of 5.99, and the p-value is smaller than the chosen alpha level of 0.05.

Hence the null hypothesis cannot be rejected and thus there is no difference in the adequacy of implemented mitigation measures in the Free State and the Northern Cape. The results are not statistically significant and the results cannot be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 20** illustrates, in percentages, the precision of implemented mitigation measures in the two provinces.

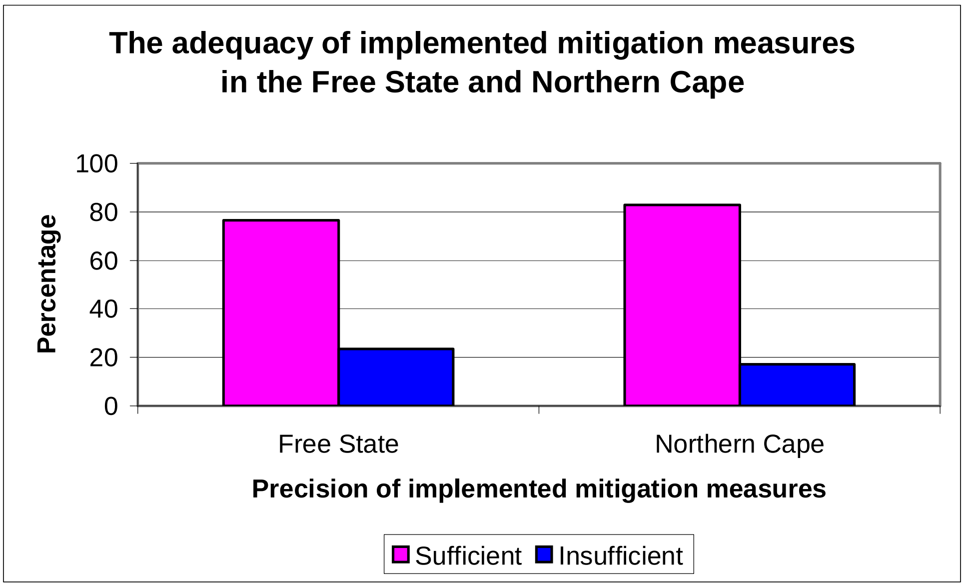


Figure 20: The adequacy of implemented mitigation measures in Free State and Northern Cape

Figure 20 illustrates that the majority of implemented mitigation measures were sufficiently or adequately implemented in the Free State (76.6%) and in the Northern Cape (82.9%) compared to mitigation measures that were insufficiently or inadequately implemented. See **Photo 12** for an example of an insufficiently implemented mitigation measure. Therefore it can be implied that the majority of implemented mitigation measures were successful or adequate in the prevention or minimization of impacts.

Photo 12: Example of inadequately implemented mitigation measures

Photo 12 illustrates the implementation of the revegetation mitigation measure. However, it was not successfully implemented because signs of erosion are present. The above photo indicates that grass was planted to prevent erosion, but the sidewalk area was not fully revegetated and this caused soil erosion. Thus the mitigation measure was implemented, but not sufficiently, because not all the areas were covered by grass and this resulted in the occurrence of soil erosion.

6.5 Reasons for indeterminable mitigation measures in the Free State and Northern Cape provinces

A total of 78 mitigation measures were indeterminable. 40 of the 78 indeterminable mitigation measures were from case studies in the Free State and 38 were from case studies in the Northern Cape. The reasons for indeterminable mitigation measures were recorded and three categories were formed after similar reasons were combined (see **Appendices H** and **I**). The three categories were the following: no compelling evidence, no evidence of construction activities and no information available. A chi-square test was conducted to determine if differences occur between the Free State and Northern Cape with regard to the **reasons for indeterminable mitigation measures** (see **Table 20**).

Table 20: Reasons for indeterminable mitigation measures in the Free State and Northern Cape

	Provinces				
Reason for indeterminable mitigation measures	Free State		Northern Cape		**Total**
No concurrent evidence	(Observed)	10	(Observed)	6	16
	(Expected)	8.2	(Expected)	7.8	
	(Percentage)	25%	(Percentage)	15.8%	
No evidence construction activities	(Observed)	18	(Observed)	25	43
	(Expected)	22.1	(Expected)	20.9	
	(Percentage)	45%	(Percentage)	65.8%	
No information available	(Observed)	12	(Observed)	7	19
	(Expected)	9.7	(Expected)	9.3	
	(Percentage)	30%	(Percentage)	18.4%	
Total		40 100%		38 100%	78

Pearson`s X^2 statistic	3.4
Degree of Freedom	2
p	0.18

The hypothesis tested in **Table 20**:

H_0: There is no difference between the Free State and Northern Cape regarding the **reasons for indeterminable mitigation measures**.

H_a: There is a difference between the Free State and Northern Cape regarding the **reasons for indeterminable mitigation measures**.

The chi-square test statistic is 3.4 with an associated p-value of 0.18. Therefore the chi-squared test statistic is larger than the critical value on the chi-square table of 5.99, and the p-value is smaller than the chosen alpha level of 0.05. This means that the null hypothesis can not be rejected and that there is no difference in the distribution of reasons for indeterminable mitigation measures between the Free State and the Northern Cape. The results are not statistically significant and the results can not be generalised to the larger population, but assumptions about the outcome of predicted impacts in the sample population can be made. **Figure 21** illustrates, in percentages, the reasons for indeterminable mitigation measures in the two provinces.

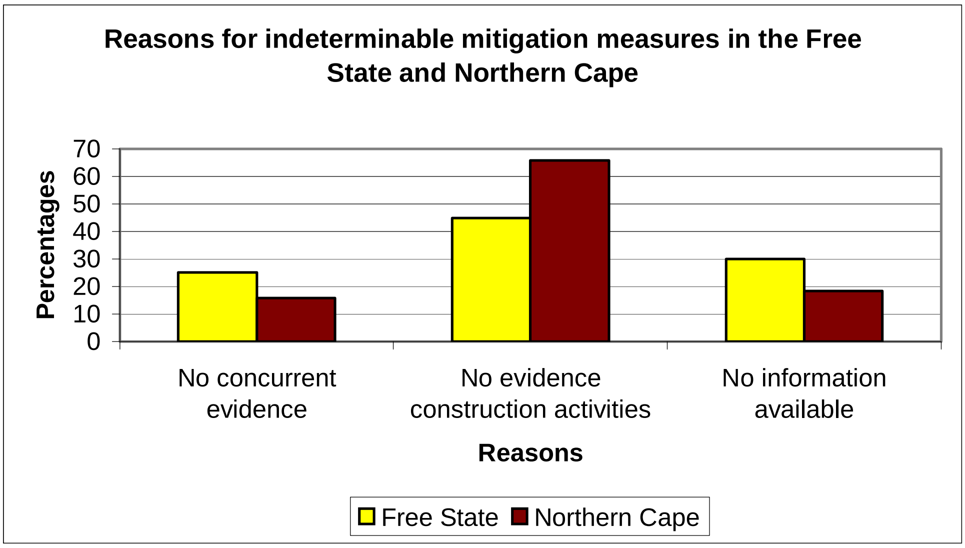


Figure 21: Reasons for indeterminable mitigation measures in the Free State and Northern Cape

Figure 21 illustrates the major reason for not determining if mitigation measures were implemented was because no evidence was available for activities during the construction phase in both the Free State (45%) and the Northern Cape provinces (65.8%). The reason for this might be because construction activities happened fairly long ago. People also tend to forget what happened during past activities and because of no administrative record of construction activities (monitoring records or public compliant registers during the construction phase) it is difficult to determine if a mitigation measure was implemented or not. In both the Free State and Northern Cape higher percentages of indeterminable mitigation measures were due to no information being available (Free State 30%, Northern Cape 18.4%) than compared to no compelling evidence (Free State25%, Northern Cape 15.8%).

6.6 Outcome of mitigation measures in the Free State province in the construction and operational phases

It is important also to determine if differences occur between **construction and operational phases** in the **Free State**, in order to establish whether the implementation of mitigation measures are affected by the phase it have to be implemented in.(See **Appendix J**). A chi-square test was conducted on **Table 21** to determine if there is a difference between outcome of mitigation measures in the operational and construction phases in the Free State province.

Table 21: Comparing the outcome of mitigation measures in the Free State between the construction and operational phases

	Phases		
Outcome of mitigation measures	Construction	Operational	**Total**
Implemented	(Observed) 24 (Expected) 34.0 (Percentage) 38.8%	(Observed) 40 (Expected) 30.0 (Percentage) 67.8%	64
Not Implemented	(Observed) 9 (Expected) 11.7 (Percentage) 13.4%	(Observed) 13 (Expected) 10.3 (Percentage) 22%	22
Indeterminable	(Observed) 34 (Expected) 21.3 (Percentage) 50.7%	(Observed) 6 (Expected) 18.7 (Percentage) 10.2%	40
Total	67 100%	59 100%	126

Pearson`s X^2 statistic	23.92
Degree of Freedom	2
p	0.0001

The hypothesis tested in **Table 21**:

H_o: There is no difference in the outcome of mitigation measures in the Free State between the **construction** and **operational phases**

H_a: There is a difference in the outcome of mitigation measures in the Free State between the **construction** and **operational phases**

The chi-square test statistic is 23.92 with an associated p-value of 0.0001. Therefore the Chi-square test statistic is larger than the critical value on the chi-square table of 5.99, and the p-value is smaller than the chosen alpha level of 0.05.

Hence the null hypothesis can be rejected and it can be assumed that there is a statistically significant difference in the outcome of mitigation measures in the Free State between the construction and operational phase. The results are statistically significant and the results can be generalised to the larger population. **Figure 22** illustrates, in percentages, the outcome of mitigation measures between the two phases in the Free State.

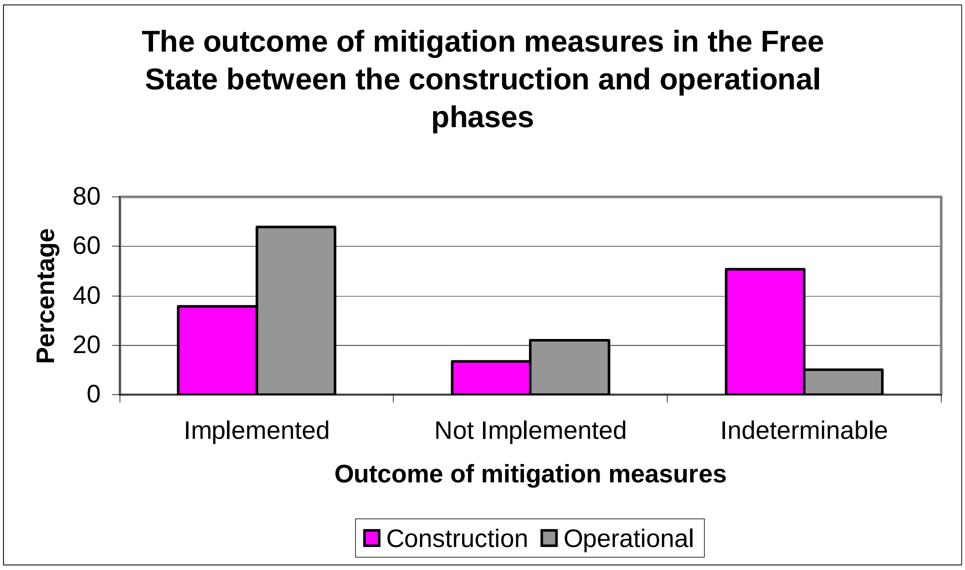


Figure 22: The outcome of mitigation measures in the Free State in the construction and operational phases

Figure 22 illustrates that the majority (50.7%) of mitigation measures were indeterminable in the construction phase, while the majority (67.8) of mitigation measures were implemented in the operational phase. The difference is statistically significant can it be suggested that mitigation measures in the construction phase are more prone to have an indeterminable outcome. Mitigation measures in the operational phase are more likely to be implemented than not. This outcome might be due to the lack of information available for construction activities which prevents judgement about the implementation of mitigation measures.

6.7 Outcome of mitigation measures in the Northern Cape province in the construction and operational phases

A chi square test was conducted on **Table 22** to determine if differences occur between **construction and operational phases** in the **Northern Cape** (See **Appendix K**). It is important to establish if the different time period of each phase has an influence on the outcome of the mitigation measures.

Table 22: Comparing the outcome of mitigation measures in the Northern Cape between the construction and operational phases

	Phases		
Outcome of mitigation measures	Construction	Operational	**Total**
Implemented	(Observed) 17 (Expected) 26.1 (Percentage) 25%	(Observed) 24 (Expected) 14.9 (Percentage) 61.5%	41
Not Implemented	(Observed) 18 (Expected) 17.8 (Percentage) 26.5%	(Observed) 10 (Expected) 10.2 (Percentage) 25.6%	28
Indeterminable	(Observed) 33 (Expected) 24.1 (Percentage) 48.5%	(Observed) 5 (Expected) 13.9 (Percentage) 12.8%	38
Total	68 100%	39 100%	107

Pearson`s X^2 statistic	17.54
Degree of Freedom	2
p	0.0002

The hypothesis tested in **Table 22:**

H_o: There is no difference in the outcome of the implementation of mitigation measures in the **Northern Cape** between the **construction** and **operational phases**

H_a: There is a difference in the outcome of the implementation of mitigation measures in the **Northern Cape** between the **construction and operational phases**

The chi-square test statistic is 17.54 with an associated p-value of 0.0002. Therefore, the chi-square test statistic is larger than the critical value on the chi-square table of 5.99, and the p-value is smaller than the chosen alpha level of 0.05. This means that the null hypothesis can be rejected and that there is a statistically significant difference in the outcome of mitigation measures in the Northern Cape between the construction and operational phase. The results are statistically significant and the results can be generalised to the larger population. **Figure 23** illustrates, in percentages, the outcome of mitigation measures in the Northern Cape in the two phases.

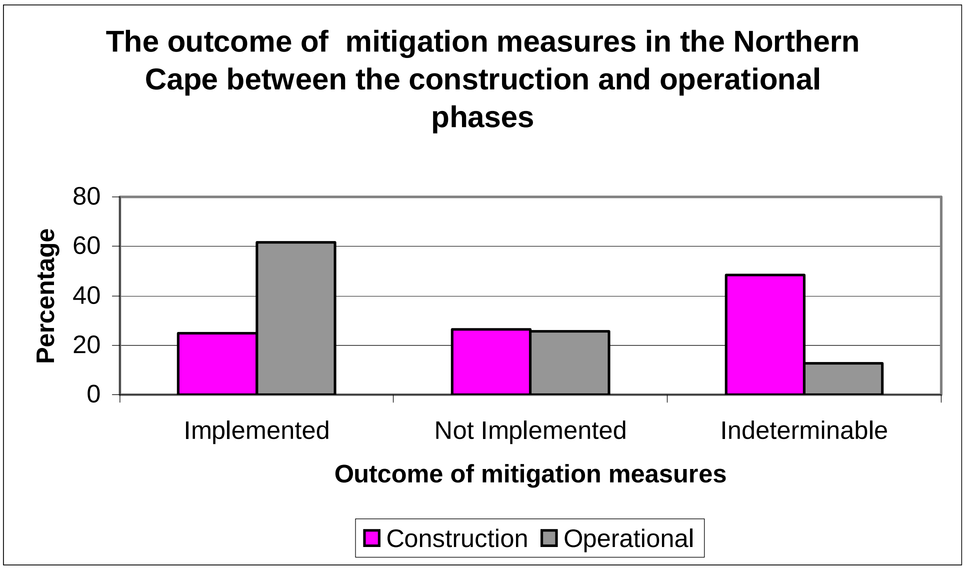


Figure 23: The outcome of mitigation measures in the Northern Cape in the construction and operational phases

Figure 23 illustrates that the majority of mitigation measures in the operational phase (61.5%) were implemented while the majority of mitigation measures in the construction phase (48.5%) were indeterminable. The difference is statistically significant and it can be implied that mitigation measures tend to be more indeterminable in the construction phase, while mitigation measures in the operational phase are more likely to be implemented than not. This outcome supports the results of **Table 21**.

7. Summary of hypotheses tested and reasons for observed differences

The results of **Chapter 5** and **Chapter 6** is summarised below in **Table 23** and **Table 24** and discussed under **7.1** and **7.2**.

Table 23: Summary of hypotheses tested for predicted impacts

Table		Hypotheses	Results
		Total number of predicted impacts:	
4	H_o	The **total outcome of predicted impacts** are **equally** distributed between the accurate, inaccurate and indeterminable categories.	Reject
4	H_a	The **total outcome of predicted impacts** are **not equally** distributed between the accurate, inaccurate and indeterminable categories.	Accept
		Predicted impacts in the Free State and Northern Cape:	
5	H_o	There is **no difference** in the outcome of **predicted impacts** between the **Free State** and **Northern Cape** provinces	Accept
5	H_a	There is a **difference** in the outcome of **predicted impacts** between the **Free State** and **Northern Cape** provinces	Reject
6	H_o	There is **no difference** in the outcome of **predicted impacts** in the **construction phase** between the Free State and Northern Cape provinces	Accept
6	H_a	There is a **difference** in the outcome of **predicted impacts** in the **construction phase** between the Free State and Northern Cape provinces	Reject
7	H_o	There is **no difference** in the outcome of **predicted impacts** in the **operational phase** between the Free State and Northern Cape provinces	Accept
7	H_a	There is a **difference** in the outcome of **predicted impacts** in the **operational phase** between the Free State and Northern Cape provinces	Reject
8	H_o	There is **no difference** in the outcome of predicted **bio-physical** impacts between the Free State and Northern Cape provinces	Accept
8	H_a	There is a **difference** in the outcome of predicted **bio-physical** impacts between the Free State and Northern Cape provinces	Reject
9	H_o	There is **no difference** in the outcome of predicted **socio-economic** impacts between the Free State and Northern Cape provinces	Accept
9	H_a	There is a **difference** in the outcome of predicted **socio-economic** impacts between the Free State and Northern Cape provinces	Reject
		Reason inaccurately predicted impacts:	
10	H_o	There is **no difference** for the **reason of inaccurately** predicted impacts between the Free State and Northern Cape provinces	Accept
10	H_a	There is a **difference** for the **reason of inaccurately** predicted impact between the Free State and Northern Cape provinces	Reject
		Predicted impacts in the Free State:	
11	H_o	There is **no difference** in the outcome of predicted impacts in the **Free State** between the **construction** and **operational** phases	Reject
11	H_a	There is a **difference** in the outcome of predicted impacts in the **Free State** between the **construction** and **operational** phases	Accept
12	H_o	There is **no difference** in the outcome of predicted impacts in the **Free State** between the **bio-physical** impact and **socio-economic** impact categories.	Reject
12	H_a	There is a **difference** in the outcome of predicted impacts in the **Free State** between the **bio-physical** impact and **socio-economic** impact categories.	Accept
		Predicted impacts in the Northern Cape:	
13	H_o	There is **no difference** in the outcome of predicted impacts in the **Northern Cape** province between the **construction** and **operational** phases	Accept
13	H_a	There is a **difference** in the outcome of predicted impacts in the **Northern Cape** province between the **construction** and **operational** phases	Reject
14	H_o	There is **no difference** in the outcome of predicted impacts in the **Northern Cape** province between the **bio-physical** impact and **socio-economic** impact categories	Accept
14	H_a	There is a **difference** in the outcome of predicted impacts in the **Northern Cape** province between the **bio-physical** impact and **socio-economic** impact categories	Reject

Table 24: Summary of hypotheses tested for mitigation measures

Table		Hypotheses	Results
		Total number of mitigation measures:	
15	H_o	The total outcome of **mitigation measures** is **equally** distributed between the implemented, not implemented and indeterminable categories.	Reject
15	H_a	There is a **difference** in the distribution of **total number of mitigation measures** outcomes between the implemented, not implemented and indeterminable categories.	Accept
		Mitigation measures in the Free State and Northern Cape:	
16	H_o	There is **no difference** in the outcome of **mitigation measures** between the **Free State** and **Northern Cape** provinces	Accept
16	H_a	There is a **difference** in the outcome of **mitigation measures** between the **Free State** and Northern Cape provinces	Reject
17	H_o	There is **no difference** in the outcome of **construction phase mitigation measures** between the Free State province and Northern Cape province	Accept
17	H_a	There is a **difference** in the outcome of **construction phase mitigation measures** between the Free State province and Northern Cape province	Reject
18	H_o	There is **no difference** in the outcome of **mitigation measures** in the **operational phase** between the Free State province and Northern Cape province	Accept
18	H_a	There is no difference in the outcome of **mitigation measures** in the **operational phase** between the Free State province and Northern Cape province	Reject
		Adequacy of implemented mitigation measures:	
19	H_o	There is **no difference** in **adequacy of implemented mitigation measures** in the Free State and Northern Cape	Accept
19	H_a	There is a **difference** in the **adequacy of implemented mitigation measures** in the Free State and Northern Cape	Reject
		Indeterminable mitigation measures:	
20	H_o	There is **no difference** in the distribution of **reasons for indeterminable mitigation measures** between the Free State and Northern Cape	Accept
20	H_a	There is a **difference** in the distribution off **reasons for indeterminable mitigation measures** between the Free State and Northern Cape	Reject
		Mitigation measures in the Free State:	
21	H_o	There is no difference in the outcome of mitigation measures in the Free State between the **construction** and **operational phases**	Reject
21	H_a	There is a difference in the outcome of mitigation measures in the Free State between the **construction** and **operational phases**	Accept
		Mitigation measures in the Northern Cape:	
22	H_o	There is no difference in the outcome of the implementation of mitigation measures in the **Northern Cape** between the **construction** and **operational phases**	Reject
22	H_a	There is a difference in the outcome of the implementation of mitigation measures in the **Northern Cape** between the **construction and operational phases**	Accept

7.1 Outcome of hypotheses tested for predicted impacts

The null-hypothesis was rejected in **Table 4** (as indicated in **Table 23)**, in favour of the alternative hypothesis that stated that the combined outcome of predicted impacts (all the impacts in the two provinces added together) are not equally distributed between the accurate, inaccurate and indeterminable categories. Hence a statistically significant difference occurs between the impact categories. The interpretation of this contingency table revealed that the majority of predicted impacts would have an accurate outcome. This statement was found to be true in the majority of the other hypotheses that were tested in this study.

None of the null hypotheses tested in **Tables 5, 6, 7, 8, 9** (as indicated in **Table 23**) were rejected, therefore the interpretation of these contingency tables could not be generalised to the larger population, because the outcomes were not statistically significant. However the observations made from these contingency tables could be discussed in terms of the sample population only. The null-hypotheses in **Tables 5** to **9** (as indicated in **Table 23)** that were not rejected stated that there is no difference in the overall outcome of predicted impacts in the Free State and Northern Cape. Furthermore it also revealed that there is no difference in the outcome of predicted impacts between the two provinces in the construction or operational phases and bio-physical impact and socio-economic impact categories. The majority of predicted impacts had an accurate outcome in the construction and operational phases and bio-physical impact and socio-economic impact categories in the Free State and Northern Cape provinces. However more predicted impacts had an indeterminable outcome compared to an inaccurate outcome in the construction phases and bio-physical impact categories of both provinces. Whereas more predicted impacts had an inaccurate outcome compared to an indeterminable outcome in the operational phases of both the provinces.

The comparison in **Table 11** (as indicated in **Table 23**) between the construction and operational phases in the Free State revealed that there is a statistical significant difference between the two phases in some of the categories. The majority of impacts had an accurate outcome in both the phases but the construction phase had a higher number of predicted impacts with an indeterminable outcome compared to an inaccurate outcome and the opposite outcome occurred in the operational phase, whereas the comparison between the two phases in the Northern Cape in **Table 13** (as indicated in **Table 23**) revealed that there is no difference in the outcome of predicted impacts between the two phases. However, it must be noted that the majority of predicted impacts in both phases had an accurate outcome and that differences did occur between the two phases even though it was not statistically significant.

In **Table 12** (as indicated in **Table 23**) the bio-physical impact and socio-economic impact categories were compared in the Free State province and it was revealed that there is a statistically significant difference between the two impact categories. The majority of predicted impacts in the bio-physical impact and socio-economic impact categories had an accurate outcome. However a statistically significant difference occurred in the bio-physical impact category; there were more impacts with an indeterminable outcome compared to an inaccurate outcome, and visa versa occurred in the socio-economic impact category. In **Table 14** (as indicated in **Table 23**) a comparison between the two impact categories was made in the Northern Cape province and it was revealed that no statistically significant difference occurred between the two impact categories. The majority of predicted impacts had an accurate outcome in both the impact categories.

Differences between the construction and operational phases were observed, some statistically significant and others not. However, the main differences occurred between the observed frequencies and percentages of indeterminable and inaccurately predicted impacts. The construction phase tends to have more impacts with an indeterminable outcome than an inaccurate outcome and the operational phase tends to have more impacts with an inaccurate outcome compared to an indeterminable outcome. The reason for this might be because it is difficult to determine whether an impact was predicted accurately or inaccurately in the construction phase, due to the fact that the survey (audit) on the case studies was conducted after the construction phase was completed and little or no monitoring information of activities and impacts that occurred were available. In the operational phase (when the audit was conducted) it was easier to determine the accuracy of predicted impacts because it takes place in the present time; information is more obtainable and impacts can mostly be observed.

A few statistically significant differences between the bio-physical and socio-economic impact categories occurred. The majority of the differences between the two impact categories occurred in terms of the observed frequencies and percentages of indeterminable and inaccurately predicted impacts. The bio-physical impact category tends to have more impacts with an indeterminable outcome than an inaccurate outcome and the socio-economic impact category tends to have more impacts with an inaccurate outcome compared to an indeterminable outcome.

This might be due to the fact that it is difficult to determine whether air pollution or contamination of soil or water took place without scientific parameters in the baseline studies (environmental reports) and monitoring reports.

For instance, to determine if the quality of surface water will deteriorate or become polluted after a development, it is necessary to take a sample of the water before the development and analyse it. A sample must then be taken at the same position after the development has been completed. The two samples can then be compared to determine if pollutants entered the water before or after the development. If scientific information is not available, it is almost impossible to determine if a biophysical impact occurred or not. Socio-economic impacts are easier to determine due to the fact that most impacts can be observed or information can be obtained through interviews because it has a more direct effect on humans and their perceived concepts or ideas and values or moral systems compared to the bio-physical impacts, which directly affect the physical environment and indirectly affect the human race through secondary impacts.

The null hypothesis in **Table 10** (as indicated in **Table 23**) was not rejected and therefore, it can be concluded that there is no difference for the reasons of inaccurately predicted impacts in the two provinces. The major reason for inaccurately predicted impacts in the Free State and Northern Cape provinces was the underestimations of impacts, hence the impacts that occurred were far greater than expected.

It can be concluded that the outcome of predicted impacts are similar for both provinces and that the majority of predicted impacts tend to be accurately predicted. Predicted impacts in the construction phase tends to be more indeterminable than inaccurate and predicted impacts in the operational phase tends to be more inaccurate than indeterminable in the two provinces. The bio-physical impact category tends to have more impacts with an indeterminable outcome than an inaccurate outcome and the socio-economic impact category tends to have more impacts with an inaccurate outcome compared to an indeterminable outcome in the two provinces.

7.2 Outcome of hypotheses tested for mitigation measures

The null hypothesis in **Table 15** (as indicated on **Table 24**) was rejected, therefore it could be suggested that a statistically significant difference exist between the implemented, not implemented and indeterminable outcome categories. The interpretation of **Table 15** revealed that the majority of mitigation measures tend to be implemented.

The comparison in **Table 16** (as indicated on **Table 24**) between the overall (all phases included) outcome of mitigation measures in the Free State and Northern Cape provinces proved that there was no statistically significant difference between the two provinces. The majority of mitigation measures were implemented while more mitigation measures were indeterminable than inaccurate.

The comparison between the mitigation measures in the construction phase of both provinces suggested that there was no statistically significant difference between the two provinces (**Table 17** as indicated in **Table 24**). The majority of mitigation measures had an indeterminable outcome, while more were implemented than not in the two provinces.

The comparison between the outcome of operational phase mitigation measures in the two provinces revealed that no statistically significant difference occurred between the two provinces (**Table 18** as indicated in **Table 24**). The majority of mitigation measures were implemented, while more were not implemented compared to indeterminable mitigation measures in both provinces.

The comparison in the Free State province between the outcome of construction phase and operational phase mitigation measures revealed that statistically significant differences occurred between these two phases (**Table 21** as indicated in **Table 24**). The majority of mitigation measures in the construction phase were indeterminable, while the majority of mitigation measures in the operational phase were implemented. The outcome of the comparison between the two phases in the Northern Cape province (**Table 22** as indicated in **Table 24**) was the same as in the Free State province. The results can be generalized to the larger population and it can be suggested that majority of mitigation measures in the operational phase tend to be implemented and the majority of mitigation measures in the construction phase tend to be indeterminable.

The null-hypothesis was not rejected in **Table 20** (as indicated in **Table 24**) and it stated that there is no statistically significant difference in the distribution of reasons for indeterminable mitigation measures between the Free State and Northern Cape. The main reason for indeterminable mitigation measures in both provinces was the lack of evidence for construction activities. Therefore it can be suggested that more indeterminable mitigation measures occurred in the construction phase due to the lack of information available to determine the outcome of mitigation measures. Whereas mitigation measures in the operational phase are more likely to be implemented than not, this might be due to the fact that it is easier to obtain information about current operational activities than past construction activities.

In **Table 19** (as indicated in **Table 24**) it was concluded that there is no statistically significant difference between the precision of implemented mitigation measures in the Free State and Northern Cape provinces. The majority of implemented mitigation measures were sufficiently, successfully or adequately implemented to avoid or minimize an expected impact.

8. General outcome of study, correlation to international studies and recommendations

The results of this research study are compared to the outcome of other international studies that were mentioned in **Chapter 3**. The results of the predicted impacts are first discussed in relation to other international studies in **8.1** and then the results of the mitigation measures are compared to other studies in **8.2**. Recommendations is also discussed in light of problems and difficulties that were highlighted in this research study and other international studies such as public participation and auditing, as mentioned in **Chapter 4**.

8.1 Predicted impacts

The findings of this study that was conducted in the Free State and Northern Cape provinces correlates with the authors previous qualitative study conducted in the Free State province in 2004 and with the outcomes of various other auditing studies that were conducted by other researchers (Barrow, 1997; Buckley, 1991; Culhane, 1987) in various countries (USA, Australia, UK). Most assessments of prediction in scoping or environmental impact reports revealed the tendency of predicted impacts to be accurate and few unanticipated impacts to occur (Barrow, 1997; Buckley, 1991; Culhane, 1987). Only a few additional impacts were identified during this study, but were not analysed and compared between the two provinces, because the audit was only conducted on predicted impacts mentioned in the environmental impact reports. The additional impacts that occurred, were usually secondary impacts, which resulted due to an activity that was not anticipated, alterations to construction plans or due to mitigation measures which were not implemented correctly.

It was difficult during the analysis of the scoping/environmental impact reports in this study to identify possible impacts that were predicted, because the majority of reports only described construction and operational activities, but did not state the possible impacts that the described actions might cause. When predicted impacts were provided they were presented in a vague, imprecise manner, not stating directly the environmental parameters such as the probability, intensity or extent of a possible impact. For example, various scoping reports only had checklists with possible impacts, simply revealing an answer such as a yes or no that a certain impact might occur. Some of the predictions that were stated in an unclear manner provided for uncertainty and doubt about the meaning and outcome of an impact, therefore some predictions were open for more than one interpretation.

Culhane (1987), Bisset and Tomlinson (1983) and Buckley (1991) all argues that the accuracy of most of the predicted impacts could be due to the fact that these impacts were described in a vague manner. Therefore, the more unclear the possibility, extent and intensity of a prediction, the more likely the possibility that the prediction would be deemed accurate and the more unlikely that the prediction would be falsified. De Jongh (1988:67) noted that in *...general, the more precise the information required, the more difficult it is to obtain highly accurate information. Thus it seems to be possible to give accurate information only when the statement of the likely impact is conducted in very imprecise terms.*

A reason why the predictions are described in a vague manner, might be because most impact reports (scoping reports or environmental impact reports) are written in a manner as to clarify and simplify possible predictions (in a non-scientific, summurative form) for decision makers. Harrop and Nixon (1999) noted that an environmental report is a public document and that it must be written in a style that will be understood by interested and affected parties with various interests and backgrounds.

Therefore most of the information about possible impacts is conveyed in a qualitative form instead of in a quantitative form. This proves to create difficulties when the accuracy of certain impacts that can only be assessed quantitatively is to be established (such as the degree of air pollution or quantity of soil moisture).

A large number of predictions in environmental reports are based on expert opinions instead of empirical research, and these opinions are seldom checked, because it is difficult to scrutinize such subjective judgements of experts (Wood,1995). This might also explain why it is rarely mentioned in a scoping/environmental report what predictive or research techniques were utilised to obtain information and to formulate a conclusion about a future impact. Environmental reports are therefore descriptively strong but analytically weak (Lee, 2000; Smith, 1993).

Tomlinson and Atkinson (1987) stated that the environmental impact process tends to focus more on project authorization than environmental impact management. Therefore most consultants only focus on identifying possible impacts and stating such impacts in laymans terms in order to clarify possible impacts a project might have on the environment to obtain authorization, without taking into consideration post authorisation and implementation activities such as monitoring and auditing. This were found to be the true for this research study, the emphases tend to be on obtaining authorization instead of managing environmental impacts.

A few researchers (Tomlinson & Atkinson,1987; Beanlands, 1988) suggest that environmental impact forecasts should be stated as falsifiable hypotheses in environmental impact reports in order to be able to test the accuracy of such predictions. However, Wood (1995) argues that precision of predicted impacts is important but the main focus of impacts predicted in the EIA report is to enable appropriate minimization of foreseen impacts through mitigation measures and not the auditability of such foreseen impacts. Tomlinson & Atkinson (1987) stated that the main concern for decision makers is the reliability and accuracy of information they base their decisions upon and how well it corresponds to the situation that will actually occur in the future.

The author suggests that a possible solution to satisfy both the auditors and decision makers is to compile environmental impact reports which contain:

- baseline studies that indicate scientific parameters
- state the predictive and research techniques used
- descriptions in laymans terms of the current environmental status and future envisaged changes or impacts
- predicted impacts stated in a qualitative, descriptive manner indicating possibility, and significance

An environmental impact report that contains a baseline study with scientific parameters and research techniques can be audited to establish the precision of predicted impacts. However a predicted impact can be stated in a qualitative or descriptive manner (often described as vague by scientists) because it only has to give an indication of a possible negative impact that might occur and if it will be significant and what mitigation measures will be needed to minimize or prevent such an impact. Hence the accuracy of forecasts which are important for decision makers will be retained and also the auditability of prediction. Furthermore, descriptions in laymans terms will make concepts and conclusions in the document more understandable to decision makers and interested and affected parties.

8.2 Mitigation measures

The study found that the majority of mitigation measures was implemented and that construction phase mitigation measures tend to be indeterminable due to the lack of information about construction activities (monitoring data). The study also found that the majority of implemented mitigation measures tends to be successfully or adequately implemented to minimize or prevent an impact.

The findings of this study support the results of other studies regarding mitigation measures. Culhane (1987) stated that a general tendency to implement promised or mandatory mitigation measures exist in the United States. Other studies conducted in the Unites States, Australia and the United Kingdom (Culhane:1987; Buckley:1991; Harrop & Nixon: 1999) also found that the lack of monitoring data made it difficult to assess the outcome or implementation of mitigation measures.

It was found that the majority of mitigation measures were stated in very general term and therefore could be interpreted in various ways. This made it difficult for developers and contractors to understand their duties and to implement mitigation measures. Harrop & Nixon (1999) and Sadler (1998) suggested that mitigation measures should not be stated in general terms and must be project specific. Therefore the Environmental Management Plan (EMP) should state specific mitigation measures, and allocate the responsibility of implementation to a specific role player. According to George (2000), an EMP sets out the developer`s actions and appropriate provisions to manage a project/ development throughout it's life-cycle (descriptions of proposed monitoring and auditing actions must be included). The proper management of a development is important because most environmental impacts occur mostly not due to poor project design or implementation, but due to improper management (George, 2000). Environmental management plans must be made mandatory and must evolve through the planning to the final stage; it must also receive authorization and must be seen as a legally binding document.

Developers may intend to implement certain mitigation measures, but contractors may not implement mitigation measures especially during the construction phase. George (2000) suggests that contractors sign legally binding documents with the developers to adhere to the requirements in the Record of Decision and Environmental Management Plan during the construction phase. Hence mitigation measures may be implemented more strictly because the contractor will be held legally responsible for requirements that were not followed or implemented. A copy of such a contract must be included in the case file of each project that received authorization and which commenced with construction activities, in order to assist auditing later on. The author of this study noted that it was very difficult to obtain the name and contact details of construction companies in the majority of case studies and therefore was unable to obtain information about several construction phase activities, since monitoring data were absent.

The EMP in terms of the new EIA regulations that were promulgated on 21 April 2006, address the issue of stating who will be responsible for the implementation of mitigation measures, and the time frame of implementation, plus monitoring plans for compliance of the requirements in the EMP and report back mechanisms. However, the issue of project specific mitigation measures is not addressed and mitigation measures can still be stated in general terms and would not aid contractors with implementation. Furthermore, EMPs are only mandatory when a project or development is going the full EIA route; therefore projects that follow the Basic Assessment route are not required in terms of legislation to submit an EMP. The EMP in terms of the new regulations only addresses compliance monitoring of projects and not auditing (DEAT, 2006).

8.3 Public participation

While the study for the research project was conducted, it was noticed that participation of the public is limited. Although many consultants published the proposal of new developments in local newspapers and notice boards were placed at the proposed site, not many people reacted to these notices. During site visits, interviews were attempted with people living near the development, but this proved to be unproductive and unsuccessful. The reason why the public was not helpful was because most of them did not want to state their opinion and most of them were unable to understand concepts such as visual impact and noise impact, regardless of how simple the terms in which these were described. Many of the people in the surrounding area might have had objections to the developments, but did not notice the published proposals in the newspapers or the notice boards.

The public might only have become aware of the new development once construction started. A few biased responses from the public were received, especially if they gained financially from the development (landowners or managers where developments took place, might receive rent from various cell phone companies), this problem was also encountered by other researchers (Lee, Walsh and Reeder, 1994).

The observations made in this study regarding the public participation correlate with the experiences of other researchers. Erickson (1994) noted that public involvement in the EIA process has remained to a large extent an unfulfilled ideal. The reason for this might be that the public is not always aware of their right to complain and object to proposed developments (Harrop & Nixon, 1999). Thus it is important that the public should be made aware of their right to participate in EIAs. Glasson et al. (1994) highlighted the fact that people that live in the surrounding areas of proposed developments often lack the technical resources, financial resources and familiarity with procedures to effectively represent their point of view. This is a problem because the people living in the surrounding area of a proposed project are usually the ones that are most directly affected by developments. Therefore the public should be educated so that they can understand the issues involved in developments well enough to participate in the EIA process. Khan (1998) argues that the public do not have an equal ability to articulate their interests and voice their concerns due to social disadvantages and that the existing procedures for public participation lack the sensitivity to address such problems (lack of transport, illiteracy, language barriers etc.). Hence, different techniques should be used to involve all the categories of the public but special emphasis should be put on involving disadvantaged groups, especially if they are directly affected by a development. The new regulations provide ample opportunity for interested and affected parties to participate and review documents. However, the issue of raising awareness and educating the public in their rights to participate meaningfully is lacking in the new regulations and also the attention that should be given to alternative forms of participation in disadvantaged communities.

It is very important to have meaningful public participation, because the concerns of communities are different from those of experts (Kruger, Van Wilgen, Weaver and Greyling, 1997; Vanclay, 2000). They might also be able to suggest mitigation measures that might be acceptable to the community at large.

8.4 Auditing

Environmental impact assessment auditing is a very important part of the EIA process because it is the only phase, together with monitoring, that can provide feedback about the accuracy of predicted impacts and whether or not mitigation measures were implemented. Auditing can help the EIA process to be dynamic instead of a static linear exercise by providing information to consultants and authorities about the actual outcome of their actions. Thus auditing will provide an opportunity to improve the EIA process by improving the accuracy of predictions and the success of proposed mitigation measures

Auditing is to a large extent neglected, because it has not been mandatory in South Africa under the Environmental Impact Assessment regulations promulgated in terms of ECA, and in many other countries. Thus most of the EIA processes are static linear exercises, which replicate mistakes done in the past over and over again, because of the lack of information about the accuracy of predictions and success of mitigation measures. This problem could be solved if auditing is taken into account when environmental impact reports are compiled. Therefore, consultants should not only be concerned with obtaining approval for a proposed development, but also the environmental management of a development throughout its life cycle. Consultants should realise the financial gain, if they could also conduct environmental control work through monitoring on a regular basis and by conducting audits for projects and developments. Hence the consultant could be part of the whole life cycle of a development or project until it is decommissioned and the area rehabilitated. Gilpin (1995) suggested, that such an objective may be reached if a preliminary post-project assessment plan (monitoring and auditing) is developed during the EIA process and thus when a project is approved to be implemented, a plan for auditing and monitoring will already be developed.

Environmental impact assessment audits should be made mandatory in order to ensure that the EIA process is evolving. The problem with internal audits (audits carried out by the companies themselves to evaluate its performances in-house) is that sensitive information may not be made public. The problem with external audits are that the authorities lack the manpower and funds to conduct the audits (Hill, 2000). Therefore authorities usually only inspect developments when complaints are received from the public (Hill, 2000; Krynauw, 2004 and 2007).

The new EIA regulations in South Africa that were published on 21 April 2008 followed the example that Chile adopted. Chile implemented an intermediate approach, in which the government requires an independent environmental audit at the expense of the developer to be conducted, and the results have to be submitted to authorities for review (George, 2000). Spot checks at the request of authorities can also aid in the assessment of the accuracy of predictions and to determine whether mitigation measures were implemented and if the measures were successful.

Audit results should be published so that it can be available to the public (Wood, 1995; Barrow 1997), this will increase public participation in the EIA process and it will also display the capabilities of the authorities and companies to practice sound environmental management.

Canter (1977) remarks that most audit and operational feedback links exist but are extremely weak in practice. The new regulations provide for Environmental Management Inspectors (EMI), of which the author also underwent training, to do compliance monitoring and investigations if non-compliance is suspected. Therefore, only time will tell if the new regulations in South Africa will address the problems raised in this chapter.

It can be concluded from this research study that there is no significant difference between the outcome of predicted impacts and the implementation rate of mitigation measures in the Free State and Northern Cape provinces. It can therefore be implied that the Department of Environmental Affairs in both provinces enforce the EIA regulations in an equal manner and that Consultants in both provinces interpret and apply the EIA regulations in the same manner, because similar features arose from scoping reports, environmental management plans and RODs, in both provinces.

9. Conclusion

It can be assumed based on the outcome of the data collected (see **Chapter 7**) that consultants in both the Free State and Northern Cape provinces have made predictions that are mostly accurate and have suggested mitigation measures that were fairly successful in the minimization or prevention of impacts. Therefore the authorities based their decisions on information that are relatively correct.

Negative aspects regarding EIA documents in both provinces were the vagueness of predictions and mitigation measures that makes it very difficult to audit the outcome of the impacts or mitigation measures. Therefore consultants in both provinces should not neglect to remember that the EIA documents must be written in such a way that the predictions and mitigation measures are auditable. Predictions must include the intensity, extent and duration of an impact and mitigation measures must be more specific and descriptive. It is the responsibility of the authorities to also ensure that consultants do not write their EIA documents in a vague manner, because various interpretations can be made form unclear statements / predictions.

A large number of mitigation measures had an indeterminable outcome due to the lack of information to assist the author to make a decisive decision about the accuracy of an impact or the implementation of a mitigation measure. The information that was mostly not available was the monitoring data during the construction activities and to a lesser extend the monitoring data for operational activities. The authorities should insist that independent environmental control officer monitor construction activities and submit their reports on a monthly basis. Hence consultants must write their EMPs to specifically outline all the mitigation measures that must be undertaken and the role and responsibility and report mechanism for each stakeholder onsite.

During the research it became apparent that a large majority of the public lack knowledge about environmental impacts and their role in the EIA process. Environmental education is needed to inform the public of how the EIA process work and what rights they have and how they can participate and assist. It is the responsibility of the consultants to inform the public of their rights and it is the responsibility of the authorities to ensure that public participation is conducted in a manner that is suitable for communities of various advantages and disadvantages.

10. Future studies

Future research may concentrate on assessing the accuracy of various impact prediction methods. Further research on the accuracy of impact predictions can be performed, and a study could be conducted nation wide, a comparison could be made between the EIAs conducted under the new and old EIA regulations. Research can also be conducted to assess the compliance of the Department of Environmental Affairs to adhere to the processing time frameworks of EIA as stated in the new EIA regulations. Studies can also be conducted to determine how public involvement and awareness can be improved in order to assist in the EIA process.

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12.Glossary

Audit- a term used to describe the process of comparing the impacts predicted in an EIA with those which actually occur after implementation, in order to assess whether the impact prediction process performs satisfactorily (Bisset & Tomlinson, 1988: 117).

Baseline data- data obtained from initial investigation of the characteristics of an area (environment) in the pre- project state (Beanlands, 1988).

Ecology- the relationship of an organism to its environment; mankind's relationship with their environment (Rosen, 1976: 63).

Environment- the total surroundings in which an organism lives. It includes land, water and air as well as more aesthetic concepts such as landscape, whether natural or not (Geddes & Grosset, 2001: 56).

Environmental impact assessment (EIA)- a planning tool which encompasses methodologies and techniques for identifying, predicting and evaluating the environmental impacts associated with project developments and actions. It is a procedure for facilitating informed decision making (Hugo *et al.*,1997: 213).

Environmental Management plan- a description of all actions that will be taken by the developer, which include the monitoring of impacts and ongoing management, during the implementation stage of a project, up until the de-commissioning phase.

Impact- consists of a spatial and temporal component that can be described as the change in an environmental parameter, over a specific period and within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initiated (Wathern, 1988: 7)

Significant impact- impact that reached the threshold of importance (Rogers, 1976: 39).

Social impact assessment- a process to identify and assess the social impact of a proposed project, programme or policy on individuals and social groups within a community (Barrow, 1997: 227).

Visual impact assessment- extent to which a proposed development is visible rather than with any quantification of human reaction to, or perception of, the visual intrusion of a development. Visual characteristics can include size of landscape, materials, colour and form (Harop & Nixon, 1999: 45)

Appendix A:

Checklists and data sheets

Example of Checklist

Number: 5

Application number: EM1/1g/03/68

Activities that are identified in section 21: Construction of structures associated with communication networks

Location: *Province: Free State

*City/Town/ nearest town: Bfn

*Suburb: General de Wet

*Address: Three Services sports club , Curie avenue

*Latitude/Longitude: 28 12' 04" S 29 08' 20" E

LOCATION: Correct X | Incorrect | Reason:

Proposed construction: Construction of an MTN 21m lattice mast

Construction details: 21m high lattice mast, isobody + generator, mast will be painted grey and palisade fence surround equipment, Existing access road, 10x12m site size, Area already disturbed, Construction complete after 4 weeks

CONSTRUCTION DETAILS: Correct | Incorrect X | Reason: mast is painted olive green

Impacts:

Predicted impacts:	Probability	Intensity	Extent	Accurate	Inaccurate	Indeterminable	Under	Over	WHY
Construction:									
Noise impact	low	minor	immediate			X			House near by might have caused
Waste production pollution	improbable					X			Wash [illegible] vice bride(?) not known from this or other construction
Ecology Fauna	improbable			X					
Flora	improbable				X				Had to clear vegetation
Operational:									
Landscape Visual impact	medium	moderate	immediate		X		X		Visible from Curie Avenue without screen
Aesthetic	improbable			X					
Air quality	improbable			X					
water contamination	improbable			X					
Surrounding Landscape	improbable			X					
Cultural, historical impact	improbable			X					

Additional :

erosion

Mitigation measures						
Waste disposal proper way	Implemented	TRUE	FALSE	Indeterminable X	REASON:	Brick wo laying around do not know if from this or other construction
		Correct	Uncorrect	Reason		
	Successful	Unsuccessful		Reason		
Cause additional impact	No	Yes	Specify			
Prevent additional impact	No	Yes	Specify			
Paint mast grey or heritage green screening	Implemented	TRUE X	FALSE	Indeterminable	REASON:	
		Correct X	Uncorrect	Reason		
	Successful	Unsuccessful X		Reason		clearly visible from curie avenue and on hill
Cause additional impact	No X	Yes	Specify			
Prevent additional impact	No	Yes	Specify			
Replace trees, vegetation	Implemented	TRUE	FALSE X	Indeterminable	REASON:	Do not rep grass or trees
		Correct	Uncorrect	Reason		
	Successful	Unsuccessful		Reason		
Cause additional impact	No	Yes	Specify	cause erosion		
Prevent additional impact	No	Yes	Specify			
Warning sign	Implemented	TRUE X	FALSE	Indeterminable	REASON:	
		Correct X	Uncorrect	Reason		
	Successful X	Unsuccessful		Reason		
Cause additional impact	No X	Yes	Specify			
Prevent additional impact	No	Yes	Specify			
Aircraft warning light	Implemented	TRUE X	FALSE	Indeterminable	REASON:	
		Correct X	Uncorrect	Reason		
	Successful X	Unsuccessful		Reason		
Cause additional impact	No X	Yes	Specify			
Prevent additional impact	No	Yes				
Paint red and white	Implemented	TRUE	FALSE X	Indeterminable	REASON:	green
		Correct	Uncorrect	Reason		
	Successful	Unsuccessful		Reason		
Cause additional impact	No		Specify			
Prevent additional impact	No	Yes	Specify			
Chemical toilets	Implemented	TRUE	FALSE X	Indeterminable	REASON:	clubhouse have toilets
		Correct	Uncorrect	Reason		

Case study specific checklists were used during the field study. The predicted impacts and mitigation measures of each case study were indicated on the checklist and during the audit process the outcome was assessed.

Example of datasheet

Number	2
Province	1
Predicted impacts during construction phase	
Bio-physical impacts	
Air quality	
Why impact is inaccurate	
Water contamination	
Why impact is inaccurate	
Soil contamination	
Why impact is inaccurate	
Ecology:Flora	2
Why impact is inaccurate	1
Ecology:Fauna	1
Why impact is inaccurate	
Waste production/ pollution	3
Why impact is inaccurate	

Sosio-economic impacts	
Archaeological, cultural,historical	
Why impact is inaccurate	
Landscape: Visual impact	
Why impact is inaccurate	
Landscape:Aesthetic features	
Why impact is inaccurate	
Noise impact	1
Why impact is inaccurate	
Traffic impact	
Why impact is inaccurate	
Health and safety	
Why impact is inaccurate	

Predicted impacts during operational phase	
Bio-physical impacts	
Air quality	
Why impact is inaccurate	
Water contamination	
Why impact is inaccurate	
Soil contamination	
Why impact is inaccurate	
Ecology:Flora	
Why impact is inaccurate	
Ecology:Fauna	
Why impact is inaccurate	
Waste production/ pollution	
Why impact is inaccurate	

Sosio-economic impacts	
Archaeological, cultural,historical	1
Why impact is inaccurate	
Landscape: Visual impact	2
Why impact is inaccurate	2
Landscape:Aesthetic features	1
Why impact is inaccurate	
Noise impact	
Why impact is inaccurate	
Traffic impact	
Why impact is inaccurate	
Health and safety	3
Why impact is inaccurate	
Employment	
Why impact is inaccurate	
Surrounding landuse	1
Why impact is inaccurate	
1:00 floodline	
Why impact is inaccurate	

Mitigation measures	
Construction phase mitigation measures	
Construction during work hours	
Precision of mitigation implementation	
Removal construction waste/ proper disposal	1
Precision of mitigation implementation	1
Dust suppresion	
Precision of mitigation implementation	
Chemical toilets	2
Precision of mitigation implementation	
Removal of top soil and proper storage	
Precision of mitigation implementation	
Fenced off construction camp/ equiptment properly stored	
Precision of mitigation implementation	
Chemicals properly stored/ fire fighting equiptment	
Precision of mitigation implementation	
Clean chemical spills/ disposal of empty containers	
Precision of mitigation implementation	
Permission to modify construction plans	
Precision of mitigation implementation	
Ready mix concrete/ containment of concrete	
Precision of mitigation implementation	

Operational phase mitigation measures	
Aircraft warning light	
Precision of mitigation implementation	
Rehabilitation/ restriction/ revegetation/	
Precision of mitigation implementation	
Warning sign	
Precision of mitigation implementation	
Screening/ camouflage	2
Precision of mitigation implementation	
Local employment	
Precision of mitigation implementation	
Drainage channels, culverts under road/ channeling water	
Precision of mitigation implementation	
Fuel tanker not allowed to reverse/ pits acceptable distance	
Precision of mitigation implementation	
Monitoring wells	
Precision of mitigation implementation	
Oil intreceptors	
Precision of mitigation implementation	
Waste bins	
Precision of mitigation implementation	

Reasons for indeterminable mitigation measures:

A datasheet indicating all predicted impacts and mitigation measures that were assessed was created. The results of each case study were coded and entered into a datasheet in order to process the information on a computer.

An example of an answer sheet

Answer sheet

Number: 1-50 *(number of case studies)*

Province: 1- Free State 2- Northern Cape

Predicted impacts:
(all impacts in construction and operational phases)

1- Accurate 2- Inaccurate 3- Indeterminable

Why impact is inaccurate:
(only if impact was inaccurate)

1- Under predicted 2- Over predicted

Mitigation measures:
(all measures in construction and operational phases)

1- Implemented 2- Not implemented 3- Indeterminable

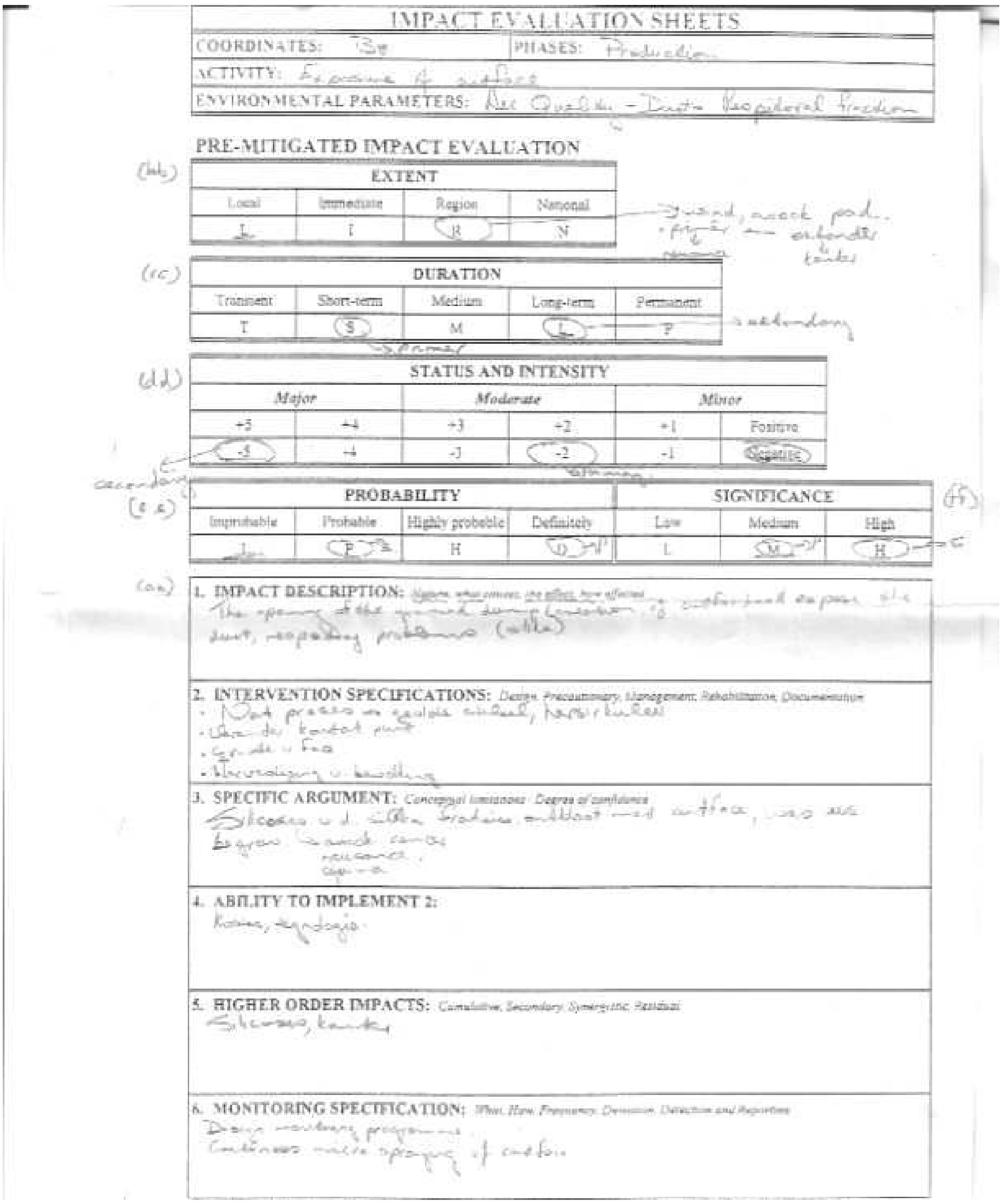
Precision of mitigation implementation:
(only if measure was implemented)

1- Successful/adequate   2- Unsuccessful/inadequate

Reason for indeterminable mitigation measure:
(only if outcome of measure could not be determined/ open question which was coded later)

An example of the answer sheet used for coding the outcome op predicted impacts and mitigation measures.

Example of evaluation sheet



IMPACT EVALUATION SHEETS

COORDINATES:

PHASES:

ACTIVITY:

ENVIRONMENTAL PARAMETERS:

PRE-MITIGATED IMPACT EVALUATION

EXTENT			
Local	Immediate	Region	National
L	I	R	N

DURATION				
Transient	Short-term	Medium	Long-term	Permanent
T	S	M	L	P

STATUS AND INTENSITY					
Major		*Moderate*		*Minor*	
+5	+4	+3	+2	+1	Positive
-5	-4	-3	-2	-1	Negative

PROBABILITY				SIGNIFICANCE		
Improbable	Probable	Highly probable	Definitely	Low	Medium	High
I	P	H	D	L	M	H

1. IMPACT DESCRIPTION: *Nature, what causes the effect, how affected*

2. INTERVENTION SPECIFICATIONS: *Design, Precautionary, Management, Rehabilitation, Documentation*

3. SPECIFIC ARGUMENT: *Conceptual limitations, Degree of confidence*

4. ABILITY TO IMPLEMENT 2:

5. HIGHER ORDER IMPACTS: *Cumulative, Secondary, Synergistic, Residual*

6. MONITORING SPECIFICATION: *What, How, Frequency, Duration, Detection and Reporting*

An example of an evaluation sheet to assess impacts.

Appendix B:

Chi-square distribution table

Degrees of Freedom (*df*)	**Probability** (*p*)										
	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.01	0.001
1	0.004	0.02	0.06	0.15	0.46	1.07	1.64	2.71	3.84	6.64	10.83
2	0.10	0.21	0.45	0.71	1.39	2.41	3.22	4.60	5.99	9.21	13.82
3	0.35	0.58	1.01	1.42	2.37	3.66	4.64	6.25	7.82	11.34	16.27
4	0.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	13.28	18.47
5	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	15.09	20.52
6	1.63	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	16.81	22.46
7	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	18.48	24.32
8	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	20.09	26.12
9	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	21.67	27.88
10	3.94	4.86	6.18	7.27	9.34	11.78	13.44	15.99	18.31	23.21	29.59
	Not significant								Significant		

Source: Fischer & Yates 1938

Appendix C:

Examples of chi-square calculations

	Provinces		
Outcome of predicted impacts	Free State	Northern Cape	**Total**
Accurate	(Observed) 32 (Expected) 36.8	(Observed) 38 (Expected) 33.2	70
Inaccurate	(Observed) 6 (Expected) 6.3	(Observed) 6 (Expected) 5.6	12
Indeterminable	(Observed) 22 (Expected) 16.8	(Observed) 10 (Expected) 15.2	27
Total	60	54	114

Pearson`s X^2 statistic	4.72
Degree of Freedom	2
p	0.095

- To calculate expected frequencies = $\dfrac{\text{column total X row total}}{\text{grand total}}$

  For example the expected frequency for the observed frequency of 32:
  60 x 70 / 114 = 36.8

- To calculate chi-square = (Observed – Expected) ^{2} / Expected

$$x^2 = \frac{(32 - 36.8)^2}{36.8} + \frac{(38 - 33.2)^2}{33.2} + \frac{(6 - 6.32)^2}{6.32} + \frac{(6 - 5.6)^2}{5.6} + \frac{(22 - 16.8)^2}{16.8} + \frac{(10 - 15.2)^2}{15.2}$$

$$= 4.72$$

Source: Ebdon, 1977:65

Example of Chi square test with Yate`s correction applied:

n = 51

	Province		
Reason for inaccurate outcome	Free State	Northern Cape	**Total**
Under predicted	(Observed) 21 (Expected) 19.6 **A**	(Observed) 16 (Expected) 17.4 **B**	37
Over predicted	(Observed) 6 (Expected) 7.4 **C**	Observed) 8 (Expected) 6.6 **D**	14
Total	27	24	51

Pearson`s X^2 statistic	0.32
Degree of Freedom	1
p	0.32

$$x^2 = \frac{n([\ AD - BC\ ] - n/2)^2}{(A+B)(C+D)(A+C)(B+D)}$$

$$= \frac{51(\ [\ 21 \times 8 - 16 \times 6] - 51/2\ )^2}{(21+16)\ (6+8)\ (21+6)\ (16+8)}$$

$$= 0.32$$

Source: Ebdon, 1977:64

Appendix D:

Letter

13.Jul. 2005 13:12 GEOGRAFIE No.5230 P. 2

DEPARTMENT OF TOURISM
ENVIRONMENT AND CONSERVATION

ISEBE LEZOKHENKETHO, INDALO
NOLONDOLOZO

LEFAPHA LA BOJANALA,TIKOLOGO
LE TSHOMARELO

DEPARTEMENT VAN TOERISME
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Enquiries / Dipatlisiso / Navrae / Imibuzo : JJ Mutyorauta

Date / Letsatsi / Datum / Umhla : 4 July 2005

Reference / Tshupelo / Verwysing / Isalathiso : NNO 25/19

Ms E Kruger
Dept of Geography
University of the Free State
P.O. Box 339
BLOEMFONTEIN
9300

Dear Madam

RE : PERMISSION TO OBTAIN INFORMATION ON EIAs FOR MSc STUDIES RESEARCH

We acknowledge receiving your letter of the 25th May 2005 in which you were asking for permission to have access to our EIA records (historical) for your MSc research studies.

We are excited and happy to inform you that the HoD of the Northern Cape Department of Tourism, Environment and Conservation (DTEC) has granted permission for you to conduct part of your research from our EIA records with immediate effect.

Please get in touch with my office for a meeting in Kimberley at which we will put in place the practical arrangements and logistics for your research and access to our EIA records.

We wish you all the best in your post graduate studies.

Yours sincerely

JJ MUTYORAUTA
DIRECTOR : ENVIRONMENTAL MANAGEMENT

oj/letters/E Kruger

A letter from the Environmental Department in the Northern Cape granting the author permission to access EIA files to select case studies.

Note: that the Free State Department of Environmental Affairs telephonically informed the author that permission was granted to access EIA files and assigned an official to assist the author while working with the files.

Appendix E:

Total number of predicted impacts

Total number of predicted impacts for the Free State and Northern Cape				
Predicted Impacts	**Accurate**	**Inaccurate**	**Indeterminable**	**Total**
Construction and Operational phases				
Air Quality	13	0	8	***21***
Water Contamination	16	3	16	***35***
Soil Contamination	11	10	6	***27***
Ecology: Flora	35	9	0	***44***
Ecology: Fauna	41	1	1	***43***
Waste production/ pollution	6	2	11	***19***
Archaeological, cultural, historical	42	3	3	***48***
Landscape: Visual Impacts	31	10	0	***41***
Landscape: Aesthetic features	15	2	0	***17***
Noise Impact	23	5	6	***34***
Traffic	11	2	2	***15***
Health & Safety	2	0	7	***9***
Employment	2	0	4	***6***
Surrounding Land use	16	4	0	***20***
1:100 Floodline	2	0	1	***3***
Total	***266***	***51***	***65***	**382**

Appendix F:

Predicted impacts in the Free State and Northern Cape

Predicted impacts for the Free State and Northern Cape			
Predicted Impacts	**Free State**	**Northern Cape**	**Total**
Construction and Operational phases			
Air Quality	14	7	21
Water Contamination	20	15	35
Soil Contamination	12	15	27
Ecology: Flora	27	17	44
Ecology: Fauna	25	18	43
Waste production/ pollution	18	1	19
Archaeological, cultural, historical	24	24	48
Landscape: Visual Impacts	25	16	41
Landscape: Aesthetic features	13	4	17
Noise Impact	21	13	34
Traffic	12	3	15
Health & Safety	7	2	9
Employment	2	4	6
Surrounding Land use	5	15	20
1:100 Floodline	2	1	3
Total	**227**	**155**	**382**

Appendix G:

Predicted impacts in the Free State

Predicted impacts

Predicted impacts in the Free State province			
Predicted Impacts	**Accurate**	**Inaccurate**	**Indeterminable**
Construction Phase			
Bio-physical Impacts			
Air Quality	3	0	2
Water Contamination	0	0	6
Soil Contamination	1	1	4
Ecology: Flora	10	4	0
Ecology: Fauna	14	0	0
Waste production/ pollution	4	1	10
Sub-total	*32*	*6*	*22*
Socio-economic Impacts			
Archaeological, cultural, historical	5	0	1
Landscape: Visual Impacts	3	2	0
Landscape: Aesthetic features	0	0	0
Noise Impact	10	2	1
Traffic	3	1	1
Health & Safety	0	0	2
Sub-total	*21*	*5*	*5*
Operational Phase			
Bio-physical Impacts			
Air quality	8	0	1
Water Contamination	10	2	2
Soil Contamination	4	2	0
Ecology: Flora	12	1	0
Ecology: Fauna	10	0	1
Waste production/ pollution	2	0	1
Sub-total	*46*	*5*	*5*
Socio-economic			
Archaeological, cultural, historical	16	1	1
Landscape: Visual Impacts	14	6	0
Landscape: Aesthetic features	12	1	0
Noise Impact	6	2	0
Traffic	6	1	0
Health & Safety	2	0	3
Employment	1	0	1
Surrounding Land use	5	0	0
1:100 Floodline	1	0	1
Sub-total	*63*	*11*	*6*
Total	**162**	**27**	**38**

Collapsed columns:

Predicted impacts for Free State province			
Predicted Impacts	**Accurate**	**Inaccurate**	**Indeterminable**
Construction Phase			
Bio-physical Impacts	32	6	22
Socio-economic Impacts	21	5	5
Sub-total	*53*	*11*	*27*
Operational Phase			
Bio-physical Impacts	46	5	5
Socio-economic	63	11	6
Sub-total	*109*	*16*	*11*
Total	**162**	**27**	**38**

Inaccurately predicted impacts

Inaccuratly predicted impacts in the Free State province			
Predicted Impacts			
Construction Phase	**Under**	**Over**	**Total**
Bio-physical Impacts			
Air Quality	0	0	0
Water Contamination	0	0	0
Soil Contamination	1	0	1
Ecology: Flora	3	2	4
Ecology: Fauna	0	0	0
Waste production/ pollution	1	0	1
Sub-total	*4*	*2*	*6*
Socio-economic Impacts			
Archaeological, cultural, historical	0	0	0
Landscape: Visual Impacts	1	1	2
Landscape: Aesthetic features	0	0	0
Noise Impact	2	0	2
Traffic	1	0	1
Health & Safety	0	0	0
Sub-total	*4*	*1*	*5*
Operational Phase			
Bio-physical Impacts			
Air quality	0	0	0
Water Contamination	2	0	2
Soil Contamination	2	0	2
Ecology: Flora	0	1	1
Ecology: Fauna	0	0	0
Waste production/ pollution	0	0	0
Sub-total	*4*	*1*	*5*
Socio-economic			
Archaeological, cultural, historical	1	0	1
Landscape: Visual Impacts	4	2	6
Landscape: Aesthetic features	1	0	1
Noise Impact	2	0	2
Traffic	1	0	1
Health & Safety	0	0	0
Employment	0	0	0
Surrounding Land use	0	0	0
1:100 Floodline	0	0	0
Sub-total	*9*	*2*	*11*
Total	**21**	**6**	**27**

Appendix H:

Predicted impacts in the Northern Cape

Predicted impacts

Predicted impacts in Northern Cape province			
Predicted Impacts	**Accurate**	**Inaccurate**	**Indeterminable**
Construction Phase			
Bio-physical Impacts			
Air Quality	2	0	4
Water Contamination	2	0	4
Soil Contamination	4	2	2
Ecology: Flora	13	4	0
Ecology: Fauna	17	0	0
Waste production/ pollution	0	0	0
Sub-total	*38*	*6*	*10*
Socio-economic Impacts			
Archaeological, cultural, historical	0	0	0
Landscape: Visual Impacts	0	0	0
Landscape: Aesthetic features	0	0	0
Noise Impact	0	0	4
Traffic	0	0	0
Health & Safety	0	0	0
Sub-total	*0*	*0*	*4*
Operational Phase			
Bio-physical Impacts			
Air quality	0	0	1
Water Contamination	4	1	4
Soil Contamination	2	5	0
Ecology: Flora	0	0	0
Ecology: Fauna	0	1	0
Waste production/ pollution	0	1	0
Sub-total	*6*	*8*	*5*
Socio-economic			
Archaeological, cultural, historical	21	2	0
Landscape: Visual Impacts	14	2	0
Landscape: Aesthetic features	3	1	0
Noise Impact	7	1	1
Traffic	2	0	1
Health & Safety	0	0	2
Employment	1	0	4
Surrounding Land use	11	4	0
1:100 Floodline	1	0	0
Sub-total	*60*	*10*	*8*
Total	**104**	**24**	**27**

Collapsed columns:

Predicted impacts for Northern Cape province			
Predicted Impacts	**Accurate**	**Inaccurate**	**Indeterminable**
Construction Phase			
Bio-physical Impacts	38	6	10
Socio-economic Impacts	0	0	4
Sub-total	*38*	*6*	*14*
Operational Phase			
Bio-physical Impacts	6	8	5
Socio-economic	60	10	8
Sub-total	*66*	*18*	*13*
Total	**104**	**24**	**27**

Inaccurately predicted impacts

Inaccurate predicted impacts in the Northern Cape Province			
Predicted Impacts			
Construction Phase	**Under**	**Over**	**Total**
Bio-physical Impacts			
Air Quality	0	0	0
Water Contamination	0	0	0
Soil Contamination	2	0	2
Ecology: Flora	2	2	4
Ecology: Fauna	0	0	0
Waste production/ pollution	0	0	0
Sub-total	*4*	*2*	*6*
Socio-economic Impacts			
Archaeological, cultural, historical	0	0	0
Landscape: Visual Impacts	0	0	0
Landscape: Aesthetic features	0	0	0
Noise Impact	0	0	0
Traffic	0	0	0
Health & Safety	0	0	0
Sub-total	*0*	*0*	*0*
Operational Phase			
Bio-physical Impacts			
Air quality	0	0	0
Water Contamination	0	1	1
Soil Contamination	3	2	5
Ecology: Flora	0	0	0
Ecology: Fauna	0	1	1
Waste production/ pollution	1	0	1
Sub-total	*4*	*4*	*8*
Socio-economic			
Archaeological, cultural, historical	2	0	2
Landscape: Visual Impacts	2	0	2
Landscape: Aesthetic features	0	1	1
Noise Impact	1	0	1
Traffic	0	0	0
Health & Safety	0	0	0
Employment	0	0	0
Surrounding Land use	3	1	4
1:100 Floodline	0	0	0
Sub-total	*8*	*2*	*10*
Total	**16**	**8**	**24**

Appendix I:

Total number of mitigation measures of the Free State and Northern Cape

Total number of Mitigation Measures in the Free State and Northern Cape				
Construction phase	**Implemented**	**Not Implemented**	**Indeterminable**	**Total**
Construction during working hours	2	0	7	**9**
Removal of construction waste/ disposal	33	6	3	**42**
Dust suppression measures	0	0	8	**8**
Chemical toilets	0	9	18	**27**
Removal of top soil/ storage & erosion berms	0	8	8	**16**
Storage equipment & Construction camp fenced	2	0	2	**4**
Storage chemicals & fire fighting equipment	0	2	13	**15**
Clean chemical spills &disposal empty containers	2	0	5	**7**
Permision to modify construction plans	1	2	1	**4**
Ready mix concrete & containment of effluent	1	0	2	**3**
Sub-total	*41*	*27*	*67*	***135***
Operational phase				
Aircraft warning light	12	3	0	**15**
Rehabilitation / revegetation	16	6	2	**24**
Warning signs	8	2	1	**11**
Screening vegetation / camouflage	8	5	1	**14**
Local employment	0	2	5	**7**
Drainage channels/ culverts / divert storm water	4	4	1	**9**
Fuel tanker no reverse/ pits acceptable distance	2	1	0	**3**
Monitoring wells	7	0	0	**7**
Oil intreceptors	5	0	0	**5**
Waste bins	2	0	1	**3**
Sub-total	*64*	*23*	*11*	***39***
Total	**105**	**50**	**78**	**233**

Appendix J:

Mitigation measures in the Free State

Mitigation measures

Free State Province Mitigation Measures				
Construction phase	**Implemented**	**Not Implemented**	**Indeterminable**	**Total**
Construction during working hours	2	0	5	*7*
Removal of construction waste/ disposal	17	3	3	*23*
Dust suppression measures	0	0	5	*5*
Chemical toilets	0	3	6	*9*
Removal of top soil/ storage & erosion berms	0	1	5	*6*
Storage equipment & Construction camp fenced	2	0	1	*3*
Storage chemicals & fire fighting equipment	0	0	5	*5*
Clean chemical spills &disposal empty containers	2	0	2	*4*
Permision to modify construction plans	1	2	0	*3*
Ready mix concrete & containment of effluent	0	0	2	*2*
Sub-total	*24*	*9*	*34*	***67***
Operational phase				
Aircraft warning light	8	3	0	*11*
Rehabilitation / revegetation	6	5	1	*12*
Warning signs	5	2	1	*8*
Screening vegetation / camouflage	5	3	0	*8*
Local employment	0	0	3	*3*
Drainage channels/ culverts / divert storm water	3	0	1	*4*
Fuel tanker no reverse/ pits acceptable distance	2	0	0	*2*
Monitoring wells	5	0	0	*5*
Oil intreceptors	4	0	0	*4*
Waste bins	2	0	0	*2*
Sub-total	*40*	*13*	*6*	***59***
Total	**64**	**22**	**40**	***126***

Precision of mitigation measures

Precision of Mitigation Implementation in the Free State Province			
Construction phase	**Sufficient**	**Insufficient**	**Total**
Construction during working hours	2	0	*2*
Removal of construction waste/ disposal	15	2	*17*
Dust suppression measures	0	0	*0*
Chemical toilets	0	0	*0*
Removal of top soil/ storage & erosion berms	0	0	*0*
Storage equipment & Construction camp fenced	2	0	*2*
Storage chemicals & fire fighting equipment	0	0	*0*
Clean chemical spills &disposal empty containers	2	0	*2*
Permision to modify construction plans	1	0	*1*
Ready mix concrete & containment of effluent	0	0	*0*
Sub-total	*22*	*2*	***24***
Operational phase			
Aircraft warning light	8	0	*8*
Rehabilitation / revegetation	0	5	*6*
Warning signs	5	0	*5*
Screening vegetation / camouflage	2	3	*5*
Local employment	0	0	*0*
Drainage channels/ culverts / divert storm water	2	1	*3*
Fuel tanker no reverse/ pits acceptable distance	2	0	*2*
Monitoring wells	5	0	*5*
Oil intreceptors	1	2	*4*
Waste bins	1	0	*2*
Sub-total	*27*	*13*	***40***
Total	**49**	**15**	**64**

Reasons for indeterminable mitigation measures

Reason for Indeterminable Mitigation Measures in the Free State Province				
Construction phase	No concurrent evidence	No evidence of construction activity	No information available	**Total**
Construction during working hours	1	1	3	5
Removal of construction waste/ disposal	1	1	1	3
Dust suppression measures	0	4	1	5
Chemical toilets	2	3	1	6
Removal of top soil/ storage & erosion berms	2	3	0	5
Storage equipment & Construction camp fenced	0	0	1	1
Storage chemicals & fire fighting equipment	1	3	1	5
Clean chemical spills &disposal empty containers	0	1	1	2
Permision to modify construction plans	0	0	0	0
Ready mix concrete & containment of effluent	1	1	0	2
Sub-total	*8*	*17*	*9*	*34*
Operational phase				
Aircraft warning light	0	0	0	0
Rehabilitation / revegetation	1	0	0	1
Warning signs	0	0	1	1
Screening vegetation / camouflage	0	0	0	0
Local employment	2	0	1	3
Drainage channels/ culverts / divert storm water	0	1	0	1
Fuel tanker no reverse/ pits acceptable distance	0	0	0	0
Monitoring wells	0	0	0	0
Oil intreceptors	0	0	0	0
Waste bins	0	0	0	0
Sub-total	*3*	*1*	*2*	*6*
Total	**11**	**18**	**11**	**40**

Appendix K:

Mitigation measures in the Northern Cape

Mitigation measures

Northern Cape Province Mitigation Measures				
Construction phase	**Implemented**	**Not Implemented**	**Indeterminable**	**Total**
Construction during working hours	0	0	2	*2*
Removal of construction waste/ disposal	16	3	0	*19*
Dust suppression measures	0	0	3	*3*
Chemical toilets	0	6	12	*18*
Removal of top soil/ storage & erosion berms	0	7	3	*10*
Storage equipment & Construction camp fenced	0	0	1	*1*
Storage chemicals & fire fighting equipment	0	2	8	*10*
Clean chemical spills &disposal empty containers	0	0	3	*3*
Permision to modify construction plans	0	0	1	*1*
Ready mix concrete & containment of effluent	1	0	0	*1*
Sub-total	*17*	*18*	*33*	***68***
Operational phase				
Aircraft warning light	4	0	0	*4*
Rehabilitation / revegetation	10	1	1	*12*
Warning signs	3	0	0	*3*
Screening vegetation / camouflage	3	2	1	*6*
Local employment	0	2	2	*4*
Drainage channels/ culverts / divert storm water	1	4	0	*5*
Fuel tanker no reverse/ pits acceptable distance	0	1	0	*1*
Monitoring wells	2	0	0	*2*
Oil intreceptors	1	0	0	*1*
Waste bins	0	0	1	*1*
Sub-total	*24*	*10*	*5*	***39***
Total	**41**	**28**	**38**	**107**

Precision of mitigation measures

Precision of Mitigation Implementation in the Northern Cape Province			
Construction phase	**Sufficient**	**Insufficient**	**Total**
Construction during working hours	0	0	0
Removal of construction waste/ disposal	16	0	16
Dust suppression measures	0	0	0
Chemical toilets	0	0	0
Removal of top soil/ storage & erosion berms	0	0	0
Storage equipment & Construction camp fenced	0	0	0
Storage chemicals & fire fighting equipment	0	0	0
Clean chemical spills &disposal empty containers	0	0	0
Permision to modify construction plans	0	0	0
Ready mix concrete & containment of effluent	1	0	1
Sub-total	*17*	*0*	*17*
Operational phase			
Aircraft warning light	4	0	4
Rehabilitation / revegetation	4	6	10
Warning signs	2	1	3
Screening vegetation / camouflage	2	1	3
Local employment	0	0	0
Drainage channels/ culverts / divert storm water	1	0	1
Fuel tanker no reverse/ pits acceptable distance	0	0	0
Monitoring wells	2	0	2
Oil intreceptors	1	0	1
Waste bins	0	0	0
Sub-total	*16*	*8*	*24*
Total	**34**	**7**	**41**

Reasons for indeterminable mitigation measures

Reason for Indeterminable Mitigation Measures in the Northern Cape Province				
Construction phase	No concurrent evidence	No evidence of construction activity	No information available	**Total**
Construction during working hours	0	2	0	2
Removal of construction waste/ disposal	0	0	0	0
Dust suppression measures	0	3	0	3
Chemical toilets	2	8	2	12
Removal of top soil/ storage & erosion berms	0	3	0	3
Storage equipment & Construction camp fenced	0	1	0	1
Storage chemicals & fire fighting equipment	0	8	0	8
Clean chemical spills &disposal empty containers	0	3	0	3
Permision to modify construction plans	1	0	0	1
Ready mix concrete & containment of effluent	0	0	0	0
Sub-total	*3*	*30*	*2*	*33*
Operational phase				
Aircraft warning light	0	0	0	0
Rehabilitation / revegetation	1	0	0	1
Warning signs	0	0	0	0
Screening vegetation / camouflage	0	0	1	1
Local employment	1	0	1	2
Drainage channels/ culverts / divert storm water	0	0	0	0
Fuel tanker no reverse/ pits acceptable distance	0	0	0	0
Monitoring wells	0	0	0	0
Oil intreceptors	0	0	0	0
Waste bins	0	0	1	1
Sub-total	*2*	*0*	*3*	*5*
Total	**5**	**28**	**5**	**38**