A CRITICAL INVESTIGATION INTO VALUE ADDING PRINCIPLES FOR CONDUCTING AN OPEN PIT CONCEPTUAL STUDY

OCKERT BUYS

Presented in partial fulfilment of the requirements for the degree

M.Eng (Mining Engineering)

IN THE FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

UNIVERSITY OF PRETORIA

MAY 2017

DECLARATION

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Ockert Johannes Buys

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ABSTRACT

A CRITICAL INVESTIGATION INTO VALUE ADDING PRINCIPLES FOR CONDUCTING AN OPEN PIT CONCEPTUAL STUDY

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A conceptual study is regarded as the first phase in the development of a new open pit mine. The phased approach (conceptual, prefeasibility, feasibility) is described as a “stepwise risk reduction” process, whereby each phase progressively reduces risk prior to project implementation. As the first step in the process, the conceptual study could potentially have the largest effect on mine development since investment decisions are based on its content. Carelessly conducted, a conceptual study has the potential to underestimate a viable project or produce an overoptimistic valuation.

In a tough economic climate, mine project developments are scrutinised, prioritising capital to develop assets with the most potential. To prioritise, conceptual studies need to be comparable and therefore based on a similar, structured approach. Comparability is hindered by low confidence geological information and assumptions on which conceptual studies are based. The time it takes to conduct a conceptual study and the associated accuracy are largely dependent on the information available since information is often borrowed from similar projects or developed from first principles. To prevent casual educated guesswork, conceptual studies need to be subject to a scientific, standardised approach with experienced professionals involved.

At the core, a conceptual study can be broken down into a set of activities as is found in a work breakdown structure. Major mining companies have comprehensive internal standards (sets of activities) where the activity determines what needs to be included in a conceptual study and the deliverables that need to be achieved. This dissertation drew activities from industry standards and

eight different case studies for consideration. Essentially, activities add value to a conceptual study by reducing technical and financial risk. For this reason, activities culminated from case studies and industry standards were evaluated by a focus group to determine the risk reduction potential of each activity. From the focus group evaluation, activities were ranked according to value adding potential, and a list of twenty activities was identified as critical to the success of a conceptual study. The top twenty activities were evaluated against the required conceptual study deliverables identified in the literature, and six additional activities were added, ensuring that all critical deliverables are met.

In total, twenty-six activities were identified that, if included in a conceptual study, would ensure that a standardised, scientific approach is followed and that a conceptual study would add value by reducing risk. In addition to the critical activities identified, this dissertation drew from the literature survey, case study results and focus group assistance such value adding principles critical for the success of an open pit conceptual study.

ACKNOWLEDGEMENTS

I wish to express my appreciation to the following organisations and persons who made this project report possible:

1. My colleagues at work who kindly and effortlessly shared their knowledge and experience with me.
2. The following persons are gratefully acknowledged for their assistance during the course of this study:
    a. Professor Ronny Webber-Youngman, my supervisor
    b. Mr Brendan Botha, my co-supervisor
3. VBKOM (Pty) Ltd., for sponsoring my studies.

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LIST OF ABBREVIATIONS

ASX	Australian Stock Exchange
BM&C	Badger Mining & Consulting Services
BCM	Bank Cubic Meters
CAPEX	Capital Expenditure
CIMVAL	Canadian Institute of Mining, Metallurgy and Petroleum on Valuation of Mineral Properties
COG	Centre of Gravity
DC	DRC Copper Study – A Case Study
DRC	Democratic Republic of the Congo
EPCM	Engineering Procurement and Construction Management
GET	Ground Engaging Tools
GI	Guinea Iron Ore Concept Study – A Case Study
GP	Guinea Phosphate Scoping Study – A Case Study
IVS	International Valuation Standards Council
IRR	Internal Rate of Return
IS	Industry Standard
ISMR	Industry Standard for Mineral Resource Management
ISMO	Industry Standard for Mining Operations Considerations
ISSH	Industry Standard for Safety and Health Considerations
ISRM	Industry Standard for Risk Management
ISME	Industry Standard for Mining Economics
ISWP	Industry Standard for Future Work Plan Activities
JORC	Australian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves
LOM	Life of Mine
MCAF	Mining Cost Adjustment Factor
MHS	Malawi Heavy Mineral Sands Scoping Study – A Case Study
MRM	Mineral Resource Management
ND	Namibian Dollar
NC	Namibia Copper Silver Desktop Study – A Case Study

NI 43-101	National Instrument for the Standards of Disclosure for Mineral Projects – Canada
NPV	Net Present Value
OPEX	Operating Expenditure
PB	Pushback
PEA	Preliminary Economic Assessment
PFS	Prefeasibility Study
RBS	Risk Breakdown Structure
ROM	Run of Mine
SAC	South-African Coal Desktop Study – A Case Study
SAM	South African Manganese Conceptual Study – A Case Study
SAMREC	South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves
SAMVAL	South African Code for the Reporting of Mineral Asset Valuation
SHE	Safety Health and Environment
SMU	Smallest Mining Unit
SOW	Scope of Work
Surpac	Mine Design and block modelling open pit software – Geovia
Talpac	Equipment optimisation software for open pit mining – Runge
USA	United States of America
VALMIN	Code for the Technical Assessment and Valuation of Mineral and Petroleum Assets and Securities for Independent Expert Reports
WBS	Work Breakdown Structure
Whittle	Prominent open pit optimisation electronic software – Geovia Whittle 4d
ZC	Zambia Copper Scoping Study – A Case Study

CHAPTER 1

MOTIVATION FOR THIS STUDY

This chapter highlights the need for the investigation and quantifies the importance of the study. It also outlines the objectives of the study, as well as the approach in achieving these objectives with reference to relevant literature.

The term “conceptual study” in the context of mine development generally refers to all such studies that lead up to a prefeasibility study, and for this dissertation the wording will include in its definition:

1. Scoping study
2. Desktop study
3. Order of magnitude estimation
4. Preliminary economic assessment

1.1 PROJECT BACKGROUND AND GENERAL INFORMATION

A conceptual study is the first step in the phased approach of mine development (conceptual, prefeasibility and feasibility operations). The phased approach to mine development is a stepwise risk reduction process whereby more capital is invested over time to reduce uncertainty and financial risk. At the end of each stage in the phased approach, a “continue”, “postpone” or “abandon” decision is made on the basis of existing information. A guiding framework for the development of mining projects is shown in Figure 1.1 (Botin, 2009).

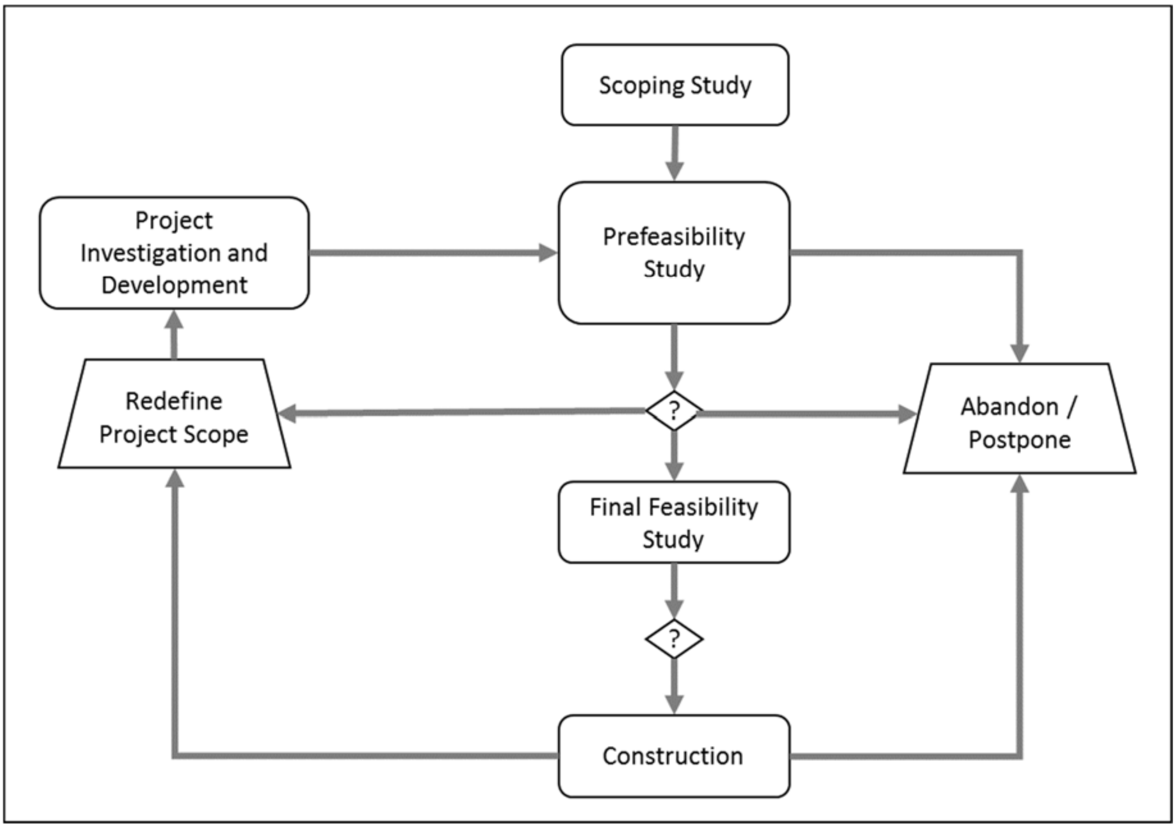

Figure 1.1: Guiding framework for mining projects (Botin, 2009)

1.1.1 Value adding potential of a conceptual study

The conceptual study has the highest potential impact in a value improvement process, compared with the other study phases (White, 2001). This is illustrated in Figure 1.1.1. The graph shows that value is added iteratively from "scoping study" through to an optimised design or plan ("definitive feasibility study"). Whereas a feasibility study would be based on scientific data and detailed engineering design, a conceptual study would rely on reasonable assumptions made by experts. It is argued that the more "reasonable" the original assumptions, the more value can be added at the beginning of the project, while it is possible to make changes at a relatively low cost (Griesel, 2008).

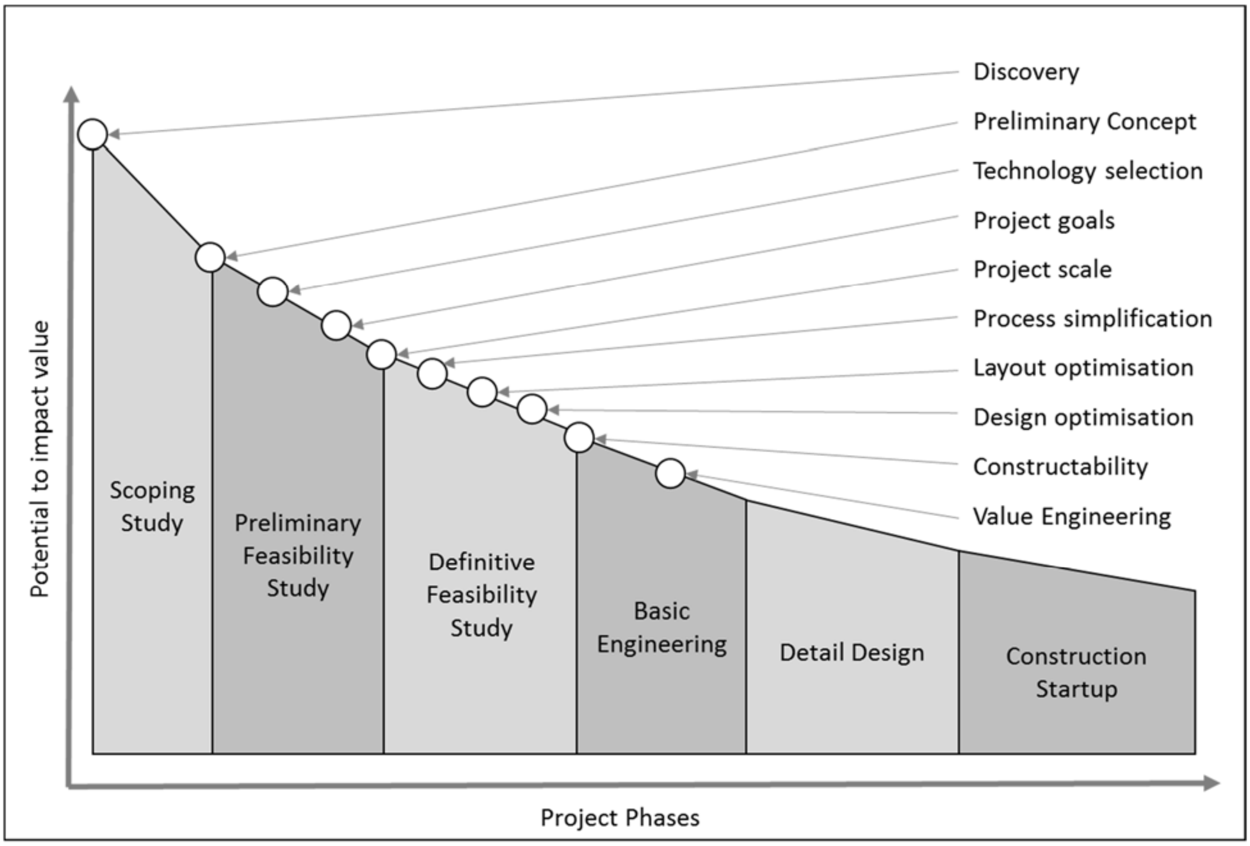

Figure 1.1.1: Project phase potential impact on value of a project (White, 2001)

A conceptual study is intended primarily to highlight the principal investment aspects of a possible mining proposition. It is defined as the transformation of a project into an investment proposition. By using comparative methods for scope definition and cost estimating techniques, investment opportunities can be ranked (Hustrulid & Kuchta, 2006).

One of the pitfalls associated with the three-phased approach, according to Bullock (2011), is that it is non-uniform, non-systematic and constituting a non-standardised approach to feasibility. It is emphasised that with all types of valuation studies within a company, the methodology should be similar to ensure a decision is based on comparable economics. A need is identified for conceptual studies internationally to follow a standardised approach, stating that investment houses would benefit from studies that are comparable.

1.1.2 Value reduction potential of a conceptual study

At a recent Association of Mining and Exploration Companies' annual conference held in Western Australia, it was stated that 83% of scoping studies presented to the Australian Stock Exchange (ASX) were of poor quality. Stavely Minerals facilitated potential solutions to the controversy over disclosure standards which were identified as the main reason for poor quality scoping studies at the conference (Beyer, 2016).

Reports on Rothschild Denver's experience with sixteen feasibility projects indicates the capital cost deviation from study to project implementation ranged from 1% to 57% overrun. On a weighted average the overrun was nearly 30%. The stated reason for the overruns is changes in scope as the projects progressed, highlighting the importance of setting scope as early as the conceptual level. It was stated that no project, even when designs were supposedly duplicated from a previous example, is ever built exactly as defined by the initial cost estimate. The estimate's range of accuracy can only be defined for the design case which exists at the time that the study is produced (Burks & Nell, 1999).

Various authors (Burks & Nell, 1999; Bullock, 2011; White, 2001) recommend the inclusion of contingency assumptions on which the accuracy is based. Contingency is not intended to be an allowance to cover the effect of future unknown changes. By definition, the effect of these is unpredictable, and estimates should be revised and, if necessary, re-evaluated whenever scope changes are made. Different estimations are provided by the various authors shown in Table 1.1.2. From the estimations, it is clear that a conceptual study can be between 30% and 50% inaccurate.

Table 1.1.2: Various estimations of scoping study level accuracy

Author	% Accuracy
Burks and Nell (1999)	+- 30% to 50%
White (2001)	+- 30%
Ruprecht (2004)	+- 30% to 50%
West (2006)	+- 30% to 40%
Bullock (2011)	+- 45%
Haldar (2013)	+- 40% to 50%

According to Ruprecht (2004), mining has a high financial risk potential, and a carelessly conducted conceptual study may turn down a viable project due to an inadequate assessment. Ruprecht (2004) cautions that the conceptual study is never overstated beyond its engineering basis since it ultimately includes assumptions and not detailed engineering. A conceptual study has the potential to be very misleading. Nearly every exploration project that is even slightly sub-marginal can be shown to be worthy of further development based on casual educated guesses and optimistic, simplified or even biased evaluations (Bullock, 2011).

1.1.3 Industry standards for conceptual studies

Banks see codes such as the South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (SAMREC) as a framework for technical studies. The SAMREC Code delineates that the evaluation and reporting of mineral projects and forward-looking mine plans (as contained in a conceptual study) are expressions of judgement predicated on knowledge and experience. It states that such evaluations and reports are more than arbitrary determinations and that it should seek to facilitate valuations as a consequence of method. It states that methods employed should be scientifically valid; tested, using scientific definitions of terms and procedures; and best suited to the making of reliable estimates for the project in question (SAMREC, 2016).

Large international mining companies, such as BHP and Anglo American, have in-house standards for each of the phased studies. These standards contain detailed work breakdown structures showing the activities required for the studies. Such standards are thorough and all-inclusive. Companies which would evaluate and rank multiple conceptual studies annually would benefit from such standards since it ensures comparable economics in deciding which project to develop.

Bullock (2011) states that the average cost of a conceptual study is around 0.3% of the capital spent on a project. With typical mine capital in excess of $600 million, conceptual studies could be rather costly. Griesel (2008) emphasises the importance of focusing the costly and scarce skills of competent professionals on items and issues that have a material impact, reducing efforts on the unessential (Griesel, 2008).

1.1.4 The need for value adding conceptual studies

In summary, Section 1.1 identified the need for the study by the following:

1. The conceptual study is the first phase in a stepwise risk reduction process which has the largest effect on the value improvement of the project (Botin, 2009).
2. The conceptual study could be subject to a non-systematic, non-uniform and non-standardised approach (Bullock, 2011) which makes comparing projects difficult.
3. A conceptual study should not only be based on expressions of judgement predicated on knowledge and experience but should also be substantiated by scientifically valid, tested, procedures and methods (SAMREC, 2016).
4. The main reason for capital overruns in projects is due to poorly defined scope in technical studies which necessitates proper scope definition within a conceptual study (Burks & Nell, 1999).
5. With the high costs associated with a typical conceptual study (0.3% of the capital spent according to Bullock (2011)) it is emphasised that costly and scarce competent professionals

should focus on items and issues that have a material impact, reducing efforts on the unessential (Griesel, 2008).

6. Without proper structure and outcomes defined a conceptual study can be prone to two extremes: either an overoptimistic valuation or the turning down of a viable project (Rupprecht, 2004).

1.2 PROBLEM STATEMENT

Poorly conducted conceptual studies can result in an overoptimistic valuation or the turning down of a viable project. As the first phase in mine development, the conceptual study could have the largest effect on the value improvement or value reduction of a project. Conceptual studies are often associated with a non-systematic, non-uniform and non-standardised approach to mine development. As a result, international mining codes increasingly emphasise that technical studies need to include scientifically valid procedures and methods. A critical investigation into value adding principles for conducting an open pit conceptual study is required to reduce inherent project risk in early mine development.

1.3 OBJECTIVES

The main objective of this study was to investigate value adding principles for conducting an open pit mine conceptual study. A principle is a comprehensive and fundamental truth, doctrine, or assumption (Merriam-Webster, 2016). Since the main purpose of a conceptual study is to reduce financial and technical risk, a value adding principle in the context of this dissertation will aim to reduce technical and financial risk in early mine development.

The following sub-objectives were set for the study:

1. To establish a fact base for guiding principles from industry standards and case studies for conducting a conceptual study.
2. To emphasise such principles that would ensure that conceptual studies are based on comparable economics.
3. To identify principles that would promote scientific methodology and sound logic for the conducting of conceptual studies.
4. To validate literature study and case study results through a focus group of industry professionals in terms of its potential to add value.

1.4 METHODOLOGY

The research methodology is depicted by the flow chart shown in Figure 1.4.

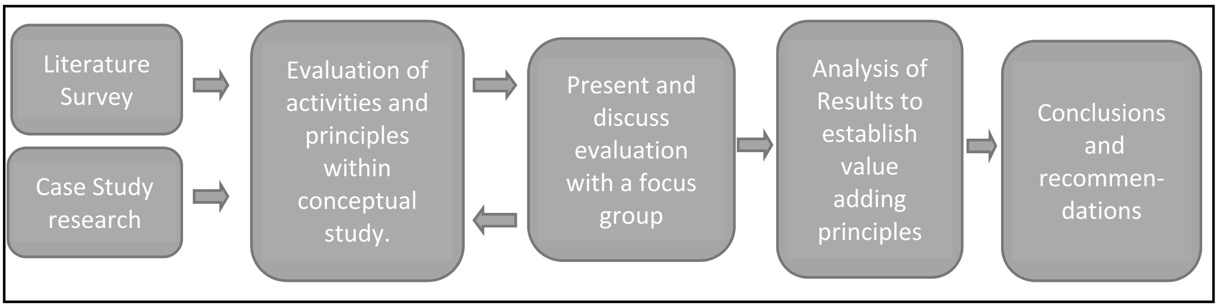

Figure 1.4: Methodology flowchart

Literature Survey

A literature review was done to identify value adding principles from articles and peer-reviewed publications on conceptual studies. The literature study also included an evaluation of industry standards for conceptual studies. Industry standards are comprised of various activities contained in a work breakdown structure that are required to conduct a conceptual study which formed a baseline for evaluation of value adding principles.

Case Study Research

A descriptive study was conducted by considering case study documents of conceptual studies. A descriptive study, according to Meyer and Page (2006), sets out an event as it exists, without manipulation or control of the elements of the event. For this dissertation, a conceptual study report was described as it was written without manipulation or control of the document but with a specific focus as the aim of a descriptive study is to reveal elements most relevant to the issue of interest. The case study report documents were attained from various sources, and care was taken not to disclose any confidential information.

Focus Group Involvement

Case studies and literature review findings were presented to a focus group consisting of mining engineers, project managers and industrial engineers with experience in conducting conceptual studies. The aim of establishing a focus group, according to Meyer and Page (2006), is to reveal the issues relevant to the research where little knowledge exists. Activities identified from the literature review and case studies were presented to focus group participants in an online survey. The survey participants were required to evaluate each activity according to its risk reduction potential and the potential consequence if the activity was excluded from a conceptual study (Table 1.4a). Similarly, themed activities which occurred in multiple case studies were grouped together for the online survey.

Table 1.4a: Evaluation criteria for value adding principles

Activity No	**Activity occurrence**	**Risk reduction potential** **1 = low;** **9 = high**	**Potential consequence if not included** **1 = no consequence;** **9 = catastrophic**	**Overall value adding potential of activity** **(score out of 100)**
Reference to each activity	Some activities occurred in more than one case study. The activity occurrence was included for evaluation.	The risk (financial or technical) reduction potential was evaluated on a scale of 1 to 9.	The potential consequences if an activity is not included in the study were rated on a scale of 1 to 9.	An overall score of the value adding potential of each activity will be provided out of 100 – similar to a risk rating approach.

Evaluation of Results

Focus group survey results, findings from the literature review and activities from the case studies were evaluated in the analysis of results chapter (Chapter 4). An activity numbering framework was used to reference activities in the literature survey and case studies as shown in Table 1.4b.

Since all participants of the initial survey were employed at VBKOM at the time of the study, it was recommended that outside experts be involved to ensure the study was not subject to company bias. The resultant evaluation from the focus group was therefore tested with an external group of experts and the correlation discussed in Chapter 4.

Table 1.4b: Activity numbering for the evaluation of results

Activity No	Category		Activity
Reference to the case study in which an activity occurred as well as the category code.	Code.	Mining Engineering Discipline	Description of the activity and the principle on which the activity could add value.
	MR	Mineral Resource Management	
	M	Mining Operational considerations	
	S	Safety Health and Environment	
	R	Risk Management	
	E	Mining Economic considerations	
	W	Study Work Plan: PFS	
	G	General	

1.5 SCOPE OF THE STUDY

Although the principles for conceptual studies might be applicable to other mining methods, the focus of this dissertation was on open pit mining. A conceptual study would typically comprise of chapters compiled by various disciplines (Engineering, Infrastructure, Mining, Environmental, Labour, Finance, etc.); this dissertation only considered such activities requiring mining engineering involvement.

The project management (PM) principles for mine development studies have been studied and documented extensively. Literature of detailed work breakdown structures (WBS) was available for phased mine development studies for all disciplines. This dissertation did not focus on the project management principles for conducting a conceptual study intrinsically, but per implication could ensure that mine development projects can be better managed.

1.6 STUDY OUTLINE

This dissertation report is composed of five chapters:

Chapter 1: Introduces and provides the background to this report, presents the problem statement, clarifies the objectives, defines the scope of the study and outlines the methodology.

Chapter 2: Introduces and discusses the existing literature on the topic of open pit conceptual studies.

Chapter 3: Relays the results stemming from the knowledge gained in the descriptive study (case studies). Each case study is described according to its value adding potential, and a summary of value adding activities is provided.

Chapter 4: Provides an analysis and evaluation of results of the literature study, case study results and focus group sessions.

Chapter 5: Presents the conclusions from the study.

Chapter 6: Presents the recommendations.

Chapter 7: Presents the suggestions for further work.

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CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

The literature study focused on information that would add value to the conducting of an open pit conceptual study. It was included in the study with the aim of establishing an information baseline for the evaluation of value adding principles and was organised according to the sub-headings summarised in Table 2.1.

Table 2.1: Literature survey study outline

Sub-Section	Title	Description
2.2	The phased approach to mine development	As background information, this section describes where the conceptual study slots into open pit mine development.
2.3	The purposes of a conceptual study	The various purposes of a conceptual study are discussed, emphasising the importance of a value adding conceptual study.
2.4	Critical deliverables within a conceptual study	A summary is provided of various authors' expected deliverables from a conceptual study, providing context for a value adding conceptual study.
2.5	Standards for conceptual studies	Large international mining companies' in-house standards for conceptual studies are summarised as a baseline to further evaluate value adding principles for conceptual studies.
2.6	Disciplines involved in a conceptual study	Various authors comment on which professionals should be involved in conducting a conceptual study.
2.7	The duration of a conceptual study	In this section, the expected duration for the conducting of a conceptual study is summarised.
2.8	Risk analysis within a conceptual study	Assessing the financial risk within a study is imperative. Therefore, this section highlights the important principles for conducting a risk analysis within a conceptual study.
2.9	Significance of information from the literature survey	This section summarises important principles from the literature survey.

2.2 THE PHASED APPROACH TO MINE PROJECT DEVELOPMENT

White (2001) states that typical mine development projects consist of four major functional phases, namely:

1. Opportunity development
2. Project development
3. Operations
4. Asset disposal and final restoration

According to White (2001), the conceptual study is seen as the first step of the project development function, post exploration. The progression of resource projects is shown in a timeline in Table 2.2. For each of the functions, typical activities, milestones and estimate types are shown. Whilst still conceptual in nature, such studies' purpose is to define the design basis or assumptions on which further project development is justified. At this point, the conceptual study could include an order of magnitude or a preliminary valuation estimate of the orebody. The timeline shows the strategic importance of the conceptual study as a design basis for decision making at the start of the project post exploration (White, 2001).

Table 2.2: Progression of resource projects (White, 2001)

<table>
<tr><th>Functions</th><th>Opportunity Development</th><th colspan="8">Project Development</th><th>Operations</th><th>Asset Disposal</th></tr>
<tr><td rowspan="3">Activities</td><td rowspan="3">Exploration research and development</td><td colspan="2" rowspan="2">Scoping and prelim feasibility</td><td colspan="2" rowspan="2">Definitive feasibility</td><td rowspan="2">Basic design</td><td>Detailed eng.</td><td>Construction</td><td>Commission</td><td rowspan="3">Production</td><td rowspan="3">Shutdown and final rehabilitation</td></tr>
<tr><td colspan="3">Procurement</td></tr>
<tr><td colspan="4">UG Projects/test mines/bulk samples</td><td colspan="3">Initial development</td><td>Startup</td></tr>
<tr><td>Milestones</td><td>Discovery</td><td colspan="4">Design basis</td><td colspan="3">Design and construction specification</td><td>Mechanically complete</td><td>Full production</td><td></td></tr>
<tr><td>Estimate Types</td><td colspan="2">Order of magnitude</td><td colspan="2">Preliminary</td><td colspan="2">Definitive</td><td>Basic engineering</td><td colspan="4"></td></tr>
<tr><td colspan="5">Conceptual studies</td><td colspan="7"></td></tr>
</table>

A simplified, widely accepted approach to the project development is the three-phased approach namely:

Phase 1: Conceptual (scoping, preliminary valuation or desktop)

Phase 2: Preliminary or prefeasibility study

Phase 3: Feasibility study

The third-phase feasibility study is often changed to a “definitive feasibility study” (West, 2009). The term “definitive feasibility” and “bankable feasibility study” is also used interchangeably as an extension to the feasibility study, incorporating considerations from the bank’s perspective. This step will be required when the bank needs to be approached for a loan (Amos, 2001).

The phased approach, as mentioned in Chapter 1, is a widely-accepted practice for project development. The conceptual study carries importance since it facilitates the basis on which all further phases in mine development can be justified. The conceptual study’s importance hinges on the fact that it can be used to motivate continuing with or expanding an exploration campaign, set the scope for future development, motivate a prefeasibility study and, ultimately, serve as a basis to motivate further investment into mine project development (White, 2001).

2.3 COMPETENCE REQUIREMENTS FOR DISCIPLINES INVOLVED IN A CONCEPTUAL STUDY

The bulk of the information used in a conceptual study is obtained by professionals involved in the project. These professionals would select production rates, estimate plant and equipment sizes, assess costs and structure the project to cover investment, return borrowed funds and provide funds for resource replacement (West, 2006).

Various authors (Bullock, 2009; Hustrulid & Kuchta, 2006; Ruprecht, 2004; White, 2001) note that in a conceptual study, a number of mining and processing alternatives will be examined as a screening process. It is recommended therefore that experienced mining engineers and metallurgists be involved in this process.

Non-geological disciplines should be involved at an early stage of the estimating process to ensure that the approach to resource modelling and estimation is consistent with the likely mining method. Data relating to contaminants, by-products or mineralogical variations need to be modelled as it can cause significant variations in metallurgical performance. Many projects have suffered because it did not realise until late that more representative metallurgical information should have been collected at the beginning of the assessment (Appleyard, 2003).

Appleyard (2003) states that "*Common sense is fundamental to estimating resources and reserves so that an estimation should not lean too far towards optimism from realism*" (p.7). Where all the disciplines and experience may not be available, outside experts may be required to confirm confidence in the data and its interpretation. In such a case, a senior manager must be appointed to be aware of all the related developments in the different phases. The estimating practice has to be standardised, and exposure of practitioners to liability for poor, incomplete or misleading estimations is increasing (Appleyard, 2003).

The Australian VALMIN code for the disclosure of reserves and resources was the first to insist that material information on a property be reviewed by independent, competent professionals. Transparency and reasonableness of assumptions were the main tenants of the code (VALMIN, 2015).

The Canadian Institute for Mining Metallurgy and Petroleum Valuation (CIMVAL) emphasises transparency by requiring the inclusion of a statement that a conceptual study is preliminary in nature. It requires the inclusion of a statement that an "inferred" mineral resource is considered too speculative geologically to have the economic considerations applied to be categorised as mineral reserves. (Mineral valuation codes would classify geological material in increasing confidence levels from "inferred", "indicated" to "measured"). In the event of a preliminary assessment, the CIMVAL requires a statement that there is no certainty that the preliminary assessment will be realised. The CIMVAL code's guiding philosophy is also such that all the information relevant to the property must be disclosed and the valuation carried out by a qualified valuator (QV), a member of a professional organisation with extensive experience in the valuation field (CIMVAL, 2003).

The South African Mineral Valuation (SAMVAL) standard specifies that the valuator must be a member of a recognised national valuation body and follow the code of conduct established by the International Valuation Standards Council (IVSC), but does not necessarily have to be independent (SAMVAL, 2016). Such a valuator has flexibility in selecting approaches and methods. The preparation of reports subject to the jurisdiction of the Johannesburg Stock Exchange must adhere to the code. Although due diligence is required towards the guiding principles of the code, there is no guidance specifically about how the assessment should be done (Heffetnan, 2004).

2.4 THE PURPOSES OF A CONCEPTUAL STUDY

The specific purpose of a conceptual study, according to Bullock (2011), is to consider the logical mining and processing methods (and other project elements) in sufficient detail to:

1. Determine in an option analysis what will work together to meet the company's objectives
2. Estimate the capital and operating costs for the project based on information from the engineering work that has been done.

A conceptual study is mostly based on assumptions to decide on further detailed exploration or project continuation. According to Haldar (2013), an optimistic view is required in estimating a mineable resource and grades, mining and milling recoveries, costs and revenues, rather than expecting exact figures. As has been stated previously, information on engineering design, method of mining and beneficiation, operating and capital costs are taken from experience, reports, case studies and published literature on similar types of deposits.

In light of an optimistic mineable resource, Burks and Nell (1999) cautions against the validity of a conceptual study for economic decision making. Optimistic geological data is often associated with low confidence levels. It is stated that the only time when a conceptual study can be used for economic decision making is when a project is proven not viable with the most optimistic financial inputs.

White (2001) describes the main uses of conceptual studies as follows:

- Developing long-term corporate strategies
- Asset valuations for stock analysis
- Evaluating acquisitions
- Assessing the transfer of exploration finds to a pre-development stage
- Deciding whether a particular mineralised resource is worth further exploration
- Determining exploration and opportunity development goals

Although the most commonly analysed document for a loan application is the feasibility study, it is imperative that discussions with the financial institutions start in the early phases of the project (Figure 2.4). In many cases, the project or study provides the sole security for the loan. Due to the stand-alone nature of the security, all the phases of the project must therefore be thoroughly examined to identify and understand the risks in financing a mining project (Amos, 2001).

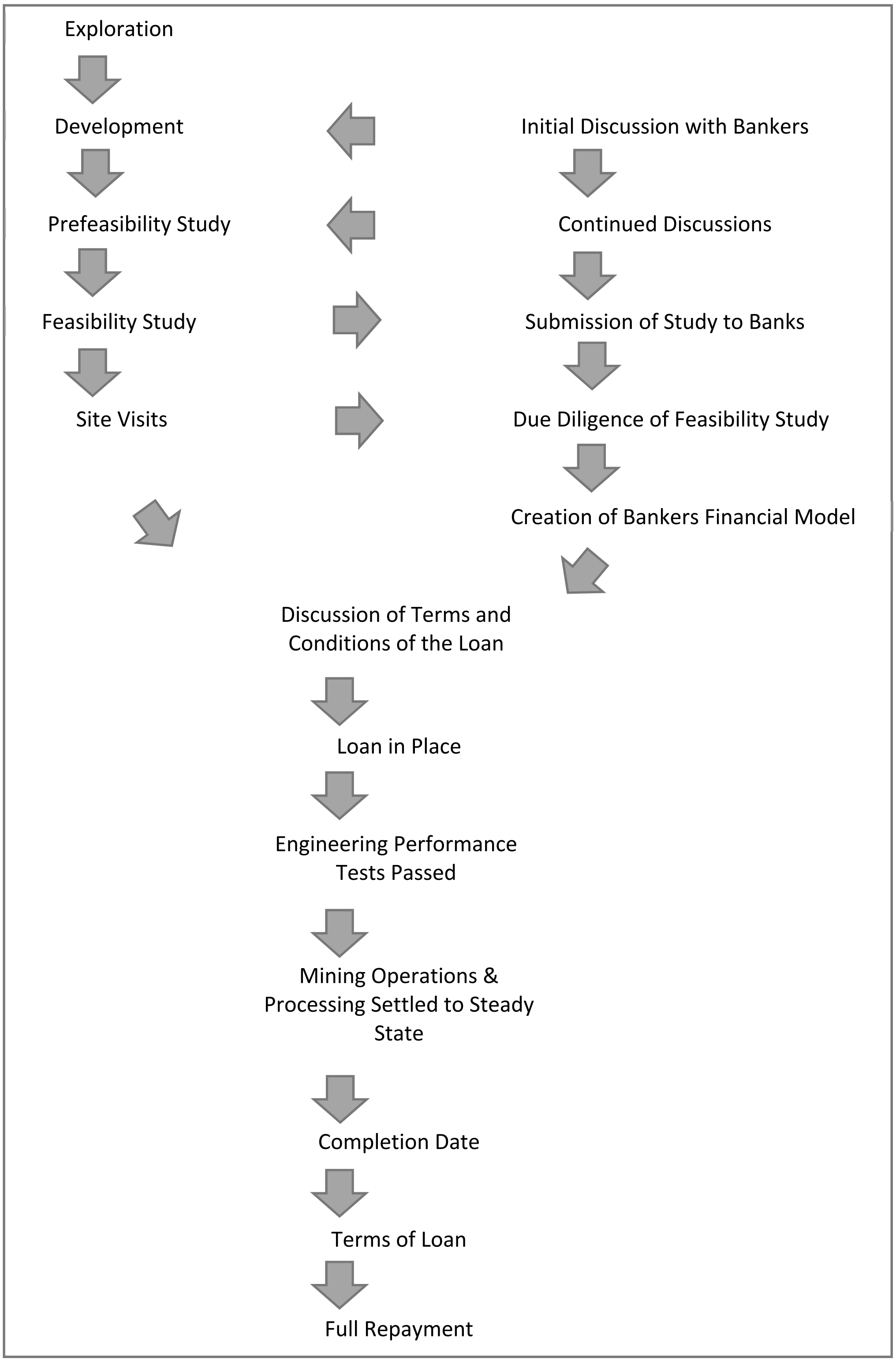

Figure 2.4: The path of loan progression (Amos, 2001)

2.5 CRITICAL DELIVERABLES REQUIRED FOR A CONCEPTUAL STUDY

Deliverables required for a conceptual study are shown in Table 2.5 along with an indication of which of the five different authors it was sourced from. The required deliverables of the SAMREC code for the declaration of exploration results were also included as a sixth source since a conceptual study is often used to motivate the extension of an exploration drilling campaign as mentioned in 2.4. Deliverables aim to ensure that all the objectives of a project are met. When planning a conceptual study, activities will aim to achieve these deliverables. Deliverables from disciplines other than the mining engineering discipline were included in the table for thoroughness. The deliverables collected in Table 2.5 were used in Chapter 4 to ensure that value adding principles would achieve the critical deliverables required by a conceptual study.

Table 2.5: Deliverables required for a conceptual study

Grouping	Deliverables Required	J.V. Thompson (1993) in White (2001)	Northcote (1998) in White (2001)	Richard West (2006)	SAMREC Code for the declaration of exploration results (2009)	Richard Bullock (2011)	University of Pretoria Mineral Valuation study notes (2014)
Admin and General	Legal tenure such as the nature of the permit (mining or exploration) application and overview of the agencies or governmental parties involved					x	
	Permit application specifications scope of work (SOW)					x	
	Location, topography and climate overview	x	x		x		x
	Site visit	x					
	Overview of the basis on which estimates were done		x		x		
	Statement of the purpose of the report				x		
	Project history				x		
Geology	Exploration drilling, sampling and assays review report				x	x	x
	Predevelopment drilling programme and budget					x	x
	Geotechnical overview					x	
	Geological map	x			x		x
	Geological data management programme detail and Geological data				x		
	Spatial and three-dimensional data (surveys, cross sections, etc.)				x		
	Specific gravity and bulk tonnage data				x		
	Geological model description and overview				x		
	Cut-off grades or cut-off points estimation			x			

Table 2.5. Continued

Grouping	Deliverables Required	J.V. Thompson (1993)	Northcote (1998)	Richard West (2006)	SAMREC Code for the declaration of exploration results (2009)	Richard Bullock (2011)	University of Pretoria Mineral Valuation study notes (2014)
Mining	Mine work specifications			x		x	
	Mining literature search					x	
	Alternative mining methods evaluations			x		x	x
	Mining equipment specifications, vendor quotations and equipment lists	x	x			x	x
	Contractor or subcontractor selection		x				
	Mining factors that could pose a risk to the project				x		
	Mining production schedule estimate		x				x
Infrastructure	Surface civil facilities work specifications, work design (SOW) or sketches	x				x	x
	Tentative surface building requirements and mechanical erection estimates	x				x	x
	Tentative surface utilities requirements and electrical work estimates	x				x	x
	Tentative surface transportation requirements and piping estimates	x				x	x
	General surface facilities arrangement and infrastructure list		x			x	x
	Surface mobile and miscellaneous equipment requirements					x	
	Tentative siting preferences	x				x	
	Structural design and estimates	x					x

Table 2.5. Continued

Grouping	Deliverables Required	J.V. Thompson (1993)	Northcote (1998)	Richard West (2006)	SAMREC Code for the declaration of exploration results (2009)	Richard Bullock (2011)	University of Pretoria Mineral Valuation study notes (2014)
Metallurgy	Process work specifications, design parameters and description (SOW)	x	x			x	x
	Process flow sheet, capacity and block flow diagram	x	x			x	x
	Process alternatives evaluation			x		x	
	Preliminary process functional analysis (labour operating cycles etc.)					x	
	Process equipment list	x	x				x
	Metallurgical testing programme			x			
	Processing risks				x		
Environmental	Environmental overview and compliance estimates			x	x	x	x
	Land and water status evaluation			x		x	
	Environmental work specifications (SOW)					x	
Labour	Preliminary functional analysis (labour operational cycles)					x	
	General personnel requirements	x				x	
	Miscellaneous labour-related cost factors					x	

Table 2.5. Continued

Grouping	Deliverables Required	J.V. Thompson (1993) in White (2004)	Northcote (1998) in White (2004)	Richard West (2006)	SAMREC Code for the declaration of exploration results (2009)	Richard Bullock (2011)	University of Pretoria Mineral Valuation study notes (2014)
Economic	Process capital and operating cost estimates	x	x	x		x	x
	Preliminary market study			x	x	x	
	Tax overview study, royalties and insurance		x			x	
	Financial analysis			x		x	x
	Approximate administrative costs, indirect cost estimates and contingencies (% of totals)	x	x			x	x
	Preliminary study plan and budget, development schedule and professional services		x			x	x
	Value engineering and risk analysis			x			x
	Surface and ancillary facilities and infrastructure capital and operating cost			x		x	x
	Import-export and logistics estimation		x				

2.6 STANDARDS FOR CONCEPTUAL STUDIES

Large international mining companies have adopted internal standards for technical studies to ensure comparability. Such internal standards contain detailed work breakdown structures showing the activities required to conduct technical studies. As stated in Chapter 1, large companies evaluating multiple conceptual studies would benefit from a standardised approach since it improves comparability. Comparability subsequently aids the decision on which projects to develop further.

Most large companies have adopted a risk reduction approach (gated approach) to technical studies whereby each major step (gate) in a technical study is followed by a decision to progress to the next step. If any of the gates makes it clear that a project is not viable, a decision to discontinue further developmental work can be made (Griesel, 2008).

Three large international mining company standards were made available to VBKOM (Pty) Ltd to conduct technical studies in the past. Due to confidentiality, these companies will be known as Company A, B and C. Companies A and B are under the top 10 largest mining companies in the world, and Company C is one of the largest companies in South Africa. Company A's standards, which was the most elaborate, were used as a baseline and supplemented by company B and C.

For ease of reference in Chapter 4 (analysis of results), each activity was grouped under the different mining engineering sub-disciplines as shown in Table 2.6. This grouping also forms the sub-sections for this chapter. Each activity was numbered according to a code. For example the activity number "ISMR01" comprised – Industry Standard "IS" + Mineral Resource Management "MR" + activity number "01". The same methodology was applied to evaluate case study activities.

Table 2.6: Activity groupings per mining engineering sub-disciplines

Sub-Section	Mining Engineering Discipline	Code	Description
2.6.1	Mineral Resource Management	ISMR	Geological and geotechnical considerations, pit optimisation, mine design and production schedule
2.6.2	Mining Operation	ISMO	Equipment optimisation, selection, mining method selection and labour complement
2.6.3	Safety Health and Environment	ISSH	Safety health and environmental
2.6.4	Risk Management	ISRM	Financial and technical risk considerations
2.6.5	Mining Economics	ISME	CAPEX, OPEX, NPV, IRR
2.6.6	Study Work Plan: PFS	ISWP	Scope of work for the next project phase

2.6.1 Mineral resource management

The Mineral Resource Management (MRM) section of the international standards considers activities that would typically be managed by the MRM department of an open pit mine. The MRM activities are stated under the following headings:

- Geotechnical considerations (Table 2.6.1a)
- Geology (Table 2.6.1b)
- Pit economic optimisation (Table 2.6.1c)
- Pit design (Table 2.6.1d)
- Production scheduling (Table 2.6.1e)
- General considerations (Table 2.6.1f)

Geotechnical considerations

The activities conducted under the geotechnical category (Table 2.6.1a) focus on providing the mining engineering discipline with inputs which would subsequently be used in the pit optimisation and pit design process. The inclusion of preliminary geotechnical considerations in a conceptual study aims to set the scope for future studies by defining which areas would require additional information to determine safe slope angles. Such activities require the assistance of a geotechnical engineer or would make reference a preliminary geotechnical report.

Table 2.6.1a: Geotechnical activities

Geotechnical Activities	**Specification/Criteria**
ISMR01: Obtain the regional and onsite geology	All relevant data available from preliminary studies, literature surveys, geophysical surveys and past experience in the area must be included and summarised.
	The plan must show all major lithological units.
	The plan must show at least regional scale geological structures.
	The proposed mining area must be clearly delineated on the plan.
ISMR02: Collect available geotechnical and geohydrological data	All boreholes and mapping traverses in the exploration programme must be logged and sampled to obtain representative geotechnical data.
	The exploration data must be supplemented by index tests on core intact samples where available.
	All groundwater intersections must be recorded during drilling and mapping.
	A database with UCS, Poisson's ratio, rock moduli, cohesion, friction and shear strength must be made available.
	A database with locations and estimated flow rates of groundwater intersections must be made available.
	There must be plans or models showing geological, geohydrological and geotechnical domains with a description of how they were determined.

Table 2.6.1a Continued

Geotechnical Activities	Specification/Criteria
ISMR03: Determine basic lithological, geohydrological and structural domains.	All geological, geohydrological and geotechnical data have to be considered to determine such domains.
	There has to be a documented description of the choice of rock mass rating systems used.
ISMR04: Determine geotechnical or rock mass characterisation.	There must be a plan showing rock mass characterisation over the project area.
	A recognised rock mass rating system must be used.
	The rock mass rating systems used must be suited to the site characteristics and potential mining methodology.
	A basic excavation stability design must be supplied to mine planning - giving key mine planning parameters as required.
ISMR05: Conduct empirical analysis to determine geotechnical design parameters.	The key value driving and safety parameters for mine planning purposes must be analysed and justified.
	The following parameters must be considered as a minimum requirement: - Slope angles for pits - Dewatering requirements - A benchmarked regional stress estimate must be available.
	If not available, regional stress estimates must be determined and the methodology explained.
	This report must include the data and geotechnical design assumptions made with a justification for each.
	Mine design parameters must be provided in a format suitable for mine planning purposes.
ISMR06: Undertake benchmarking study to determine in-situ stress estimates.	Slope angles, recommended bench heights, berm widths, face and batter angles defined.
	Mineable resource divided into geotechnical zones.

Table 2.6.1a Continued

Geotechnical Activities	Specification/Criteria
ISMR07: Provide preliminary Geotechnical Design Report for the proposed project.	
ISMR08: State all geotechnical and geohydrological parameters for use in mine design.	

Geology

Activities under the geology category (Table 2.6.1b) is important for understanding the resource model with all its attributes and translating it into a model suitable for mining engineering work by applying modifying factors. The mineable model will then be used for pit optimisation and subsequent pit design and production scheduling. The geology activities would typically be performed by the geologists involved in the project.

Table 2.6.1b: Geology activities

Geology Activities	Specification/Criteria
ISMR09: State information relevant to a resource model or block model for use in the mine planning process.	Resources defined by measured, indicated and inferred classification if available.
	Resource grades and qualities defined by type and location.
	Resource densities defined by type.
	Dip and plunge values shown.
	Structures indicated.
	Required software (Datamine, Surpac, Vulcan etc.) model available.
	Resource information signed off by competent person.
	Grade-tonnage curves supplied.
	Cut-off criteria described.
	Exclusions and boundaries indicated graphically.
ISMR10: Determine the relevant modifying factors	Criteria validated by competent person.
	Modifying factor descriptions available.
	Benchmarks with similar operations available and used.
ISMR11: Develop mineable resource model	The mineable resource model must be developed from the geological resource model by applying conversion factors e.g. cut-off grade, dilution and recovery.
	The mineral resource tabulation must include a discussion as to the confidence level of the estimate.
	A statement as to the JORC/SAMREC compliance.
	The overall limits of the deposit must be known and overall resource tonnage and grade inferred from the available data.

Pit optimisation

Activities within the pit optimisation category (Table 2.6.1c) focus on input parameters, such as metal price, costs, geotechnical slope angles, metal recoveries, yields and other variables, that influences the economic viability of the project. At this point, the mining engineering discipline will use the parameters in a software simulation package to generate a three-dimensional pit “shell” which would represent the economic limit of the pit. This is a crucial phase in the project since a pit optimisation could show that a project is not economically viable given the financial set of input parameters.

Table 2.6.1c: Pit optimisation activities

Pit Optimisation Activities	Specification/Criteria
ISMR12. Determine the relevant processing parameters for use in the mine planning process	Expected recoveries of all products stated.
	Mass pulls defined.
	Grade, quality recovery curves and yield generated.
	Processing plant start-up volume and quality requirements stated.
ISMR13. Gather relevant market parameters (e.g. product quality, product quantity etc.) impacting on pit optimisation	Market parameters used in pit optimisation defined and documented.
	Source of parameters identified, documented and validated by relevant specialist.
ISMR14. Define economic assumptions for pit optimisation	Economic assumptions utilised documented.
	Source for economic assumptions identified and validated.
ISMR15. Provide a description of the methods used to acquire data and to facilitate the pit optimisation	*The description must include:*
	Methods used to acquire data,
	An assessment of the accuracy and precision of the data acquired.
	The preliminary estimates must include:
	Slope angles,
	Ore dilution,
	Mining recovery,
	Operating costs,
	Cut-off grade,
	Smallest Mining Unit (SMU) based on bench height.
ISMR16. Determine ore and waste quantities	Ore and waste quantities must be determined through preliminary optimisation analysis.
	A description of the criteria used for ore and waste determination.

Pit design

From the pit optimisation process, a three-dimensional pit shell is generated, which does not contain any ramps, infrastructure or environmental considerations. The next phase is to do pit and pushback designs, which would incorporate ramps, geotechnical slope angles and a push-back strategy (Table 2.6.1d). A pit, pushback or waste dump design would establish a preliminary site layout, which would be used in subsequent studies. The pit design process, often a lengthy process, is important to give a better estimation for waste tons due to the inclusion of ramps.

Table 2.6.1d: Pit design activities

Pit Design Activities	Specification/Criteria
ISMR17. Establish the final mining limits – revenue factor 2 pit.	The final mining limits have been established from the mineable resource model, based on the ultimate pit shells generated in the optimisation process on a double revenue (revenue factor 2 pit) basis.
	All relevant surface infrastructure must be considered in the ultimate pit limits i.e. dams, rivers, cultural sites, villages, power, rail infrastructure etc.
	Design recommendations must be in line with the outcome of the geotechnical analysis and corporate risk management requirements.
ISMR18. Determine preliminary mine layout	The preliminary mine layout and mining plan must include sections and plans showing the proposed positioning of mine excavations, waste dumps, ore stockpiles, ore processing plant and mining infrastructure.

Production scheduling

Utilising strategic directives, determined from the pit optimisation, and physical limitations, as determined in the pit push-back designs, a production schedule can be generated (Table 2.6.1e). A production schedule incorporates a production feed into a process along with waste and ore movement over time. With advancements in mining software technology, a production schedule can also be accompanied by three-dimensional animations of conceptual pit face positions over time. Such technical production simulations can be done with relative ease promoting transparency in the exploitation strategy.

Table 2.6.1e: Pit production scheduling activities

Production Scheduling Activities	Specification/Criteria
ISMR19. Determine production rates	Benchmark data for mine capacity.
	Production rates which may be applicable to the deposit must be factored from existing operations of similar magnitude and nature and empirical formula.
	The range of mine production rates and methods described have been based on site information and type of knowledge, methods previously applied and existing mine rates.
ISMR20. Determine the preliminary production sequence and schedules	Determine the preliminary production sequence and schedules by incorporating site-specific environmental regulations into the mine design.
	Determine if the idealised sequence and annual extraction schedule for mining operations can be shown, including ore production and feed to process, ore and waste excavation and waste disposal movement.
	Benchmark the production schedule and build up to steady state against a similar design and scope project.
	Determine if the planned production build-up is aligned with that achieved in like benchmarked projects.
ISMR21. Simulate a conceptual mine production schedule	Provide a production schedule in spreadsheet format showing production figures per month, quarter and year for each scenario under comparison.
	Provide a three-dimensional animation of conceptual pit face positions over time.

General MRM considerations

Various "general" activities also need to be included in a conceptual study in order to understand the tenure and strategic directive of the mine (Table 2.6.1f). These activities focus on such strategic considerations which would limit or prohibit mine development.

Table 2.6.1f: General MRM activities

General Activities:	Specification/Criteria
ISMR22. Determine mine plan strategic considerations	Project objectives defined.
	Business expectations described.
	Production schedule - resource extraction sequence indicated.
	Production rates stated.
	Mining methods described.
	Mining constraints defined.
	Mine strategic operating life defined.
	Optimisation opportunities identified.
ISMR23. Document site description	Correct contour accuracy used.
	Important boundaries shown and described.
	Rights areas and claims shown and described.
	Utilities and servitudes shown and described.
	Existing infrastructure shown and described.
	Flood lines shown and described.
	Rivers and streams shown and described.
	Local communities shown and described.
	Climatic conditions etc. described with potential impact on operations.

2.6.2 Mining Operation

Activities specific to the mining operation are listed in Table 2.6.2. The mining considerations include mechanised machinery to be utilised, labour considerations, environmental considerations pertaining to mining and all activities that a mining production department at a mine would typically be responsible for. Information required for such activities would typically be retrieved from similar operations or recent feasibility studies done on mines with a similar tenure. Mining operational considerations also set the scope for further development of mining support functions and infrastructure.

Table 2.6.2: Mining operation related activities

Activity	Specification/Criteria
ISMO01. Determine general overburden and waste disposal sites and methods	*Has the following been used in determining the waste disposal site:*
	Waste disposal design criteria,
	Environmental and cultural considerations related to disposal sites,
	Mining activities for waste disposal,
	Site preparation requirements,
	Topsoil storage,
	Dump construction or dumping strategy,
	Rehabilitation and decommissioning.
ISMO02. Determine preliminary mine equipment requirements	Statement of what the preliminary mine equipment requirements have been based on (assumed size and type).
	The list and description of the size and type of equipment assumed must include:
	Assumed operating cost estimate for primary and secondary equipment,
	Benchmarks for the operating cost estimates,
	Capital cost estimates for assumed equipment,
	Benchmarks for the capital cost estimates.
ISMO03. Determine mining labour requirements	The manning numbers must be based on high-level benchmarks covering all disciplines and functions, including contractors.
ISMO04. Preliminary determination of infrastructure and utility requirements	The preliminary determination of infrastructure and utility requirements relevant to mining equipment must be based on operations of similar magnitude and scope.
ISMO05. Assume operational management requirements	This must be based on high-level benchmarks.

Table 2.6.2 Continued

Activity	Specification/Criteria
ISMO06. Determine the relevant mining equipment power calculation factors.	Power consumers and unit consumption levels defined.
	Diversity factors by consumer type available.
	Peak demand periods identified.
	Supply constraints and permits available.
	Key infrastructure and power supply availability with dates defined.
	Relevant benchmark of similar operation identified and used.
	Considerations of energy efficient technologies.
ISMO07. Determine potential mining methods	*The potential mining methods to be applied to the project has to be based on:*
	Available site information,
	Regional or deposit type knowledge,
	Methods previously applied,
	Existing mine operation of similar magnitude and nature elsewhere.

2.6.3 Safety, health and environment (SHE)

This section considers activities which affect the mining operation and the economics of a mine as pertaining to safety, health and the environment (Table 2.6.3). The considerations are included to ensure due diligence to protect the environment, health and safety of employees as early as the conceptual phase of mine development. Such activities would usually require the assistance of the environmental engineering discipline.

Table 2.6.3: SHE related activities

Activity	Specification/Criteria
ISSH01. Determine the relevant water requirement calculation parameters for use in mining	Water consumers and unit consumption levels defined.
	Diversity factors by consumer type defined.
	Peak demand periods determined.
	Supply constraints and permits available.
	Key water supply infrastructure availability dates defined.
ISSH02. Determine estimated natural water inflow rates	Natural water inflow rates by area defined.
	Quality of the natural water inflows stated.
ISSH03. Gather environmental, community and cultural information that may impact on mining operations	Environmental, community and cultural issues impacting on mine planning defined and documented.
	Source of parameters identified, documented and validated by relevant specialist.

2.6.4 Risk management

In a conceptual study, technical and financial risks need to be clearly defined especially relating to its impact on the mining operation and the mineral resource (Table 2.6.4). Clear identification of risks at an early stage in the mine project development would assist in subsequent studies to clearly develop risk mitigation strategies.

Table 2.6.4: Risk management related activities

Activity	Specification/Criteria
ISRM01. Determine technical risks associated with mining aspects	All technical, legal and financial risks pertaining to mining assessed and mitigation methods defined.
	Preliminary risk register for mining alternatives and possible risk mitigation methods.
	Outcomes of risk assessments and impacts on mining reserves, production risk, mining method, schedule, operating and capital estimates must be documented.
	Risk assessment done on community and cultural issues.
	Risk mitigation measures must be clearly documented and feasible.

2.6.5 Mine economics

In order to motivate further mine development, the economics of the mine must prove profitable. Such economic considerations include all costs (capital and operating) estimates and revenue. As per the nature of the study, the origin of all such information must be clearly indicated. Activities to determine the mine economics is shown in Table 2.6.5.

Table 2.6.5: Mine economics activities

Activity	Specification/Criteria
ISME01. Develop mining capital cost estimate from benchmarks	Capital cost estimate based on scaled or industry history for the size and type of potential operations contemplated.
	Detail of benchmarks must be used to determine capital cost estimate.
	Benchmarks must be validated for appropriateness to be used in determining capital cost estimate.
	Capital cost estimates for assumed equipment and infrastructure must be included.
	Full scope for capital cost estimate must be covered.
	Battery limits must be catered for in capital cost estimate and must be well defined.
	Clarity – differentiation between what is included in capital cost estimates and operating cost estimates must be well defined.
ISME02. Determine mining capital estimates based on benchmarks	Tabulation illustrating mine benchmarked capital expenditure over LOM.
	Validation of benchmarks for proposed operation.
ISME03. Develop mining operating cost estimates from benchmarks	Global operating cost estimates based on scaled or industry history for size and type of potential operations contemplated.
	Detail of benchmarks used to determine operating costs available.
	General and administrative costs must include inflation ore escalation strategy, royalties.
	Benchmarks validated for appropriateness in determining operating cost estimates for the project.
	Fixed cost elements covered (labour cost, fixed consumables, fixed overheads).
	Variable cost elements covered (fuel and petroleum products, operating consumables, product and transport insurance, maintenance, spares etc.)

Table 2.6.5 Continued

Activity	Specification/Criteria
ISME04. Describe outline of contingencies and accuracy expected	Accuracy levels within -25% to +35%.
ISME05. Describe estimation methodology	Factored, parametric models, judgment or analogy.

2.6.6 Study work plan: prefeasibility study (PFS)

Once the conceptual study is completed, the stakeholders might decide to continue to the next step, which would typically be a prefeasibility study. It is common practice to identify and summarise the scope for a prefeasibility study within the conceptual study (Tale 2.6.6).

Table 2.6.6: Future study work plan activities

Activity	Specification/Criteria
ISWP01. Develop future work programme for a mining prefeasibility study.	Detailed work plan for a mining prefeasibility study included.
	Detailed schedule for the mining prefeasibility study work plan included.
	Detailed resource requirements to undertake work plan as scheduled included.
	Mine strategy, associated infrastructure, access options, extraction sequence and mining methods for options analysis in PFS contextualised.
	Work plan includes detailed costing appropriate for the pre-prefeasibility study and taking into account resources and schedule, including contingency.

2.6.7 Significance of industry standards

Industry standards generally adopt an all-inclusive and comprehensive approach to conceptual studies. The aim of such standards is dually to identify what information is not available as well as what basic engineering needs to be done to aid mine development decision making. The engineering work within a conceptual study is intended to be preliminary in nature whereas the comprehensive nature of international standards can be interpreted to require detailed engineering design. This raises contention to the nature of a conceptual study to provide reasonable estimates within a short time. With low confidence geological information, for example, comprehensive industry standards should only serve to expose gaps in the available information for future studies.

2.7 DURATION OF A CONCEPTUAL STUDY

Estimations for the duration of a conceptual study were sourced from various authors. One source (Bullock, 2011) shows the average duration of a conceptual study to be 7.5 months as shown in Table 2.7. Cusworth (1996), in Bullock (2011), states the following durations for project studies in Australia:

- Scoping study: 7 to 9 months
- Prefeasibility study: 9 to 13 months
- Feasibility study: 12 to 17 months

Table 2.7: Estimates for average duration of project evaluations (Bullock, 2011) - USA

Project Evaluation Phase	Time Duration
Preliminary	7.5 months
Intermediate	2 years, 8 months
Final	2 years, 10 months
Total	6 years, 1.5 months

In terms of the management of resources (including engineers), a project team can handle multiple conceptual studies, unlike with feasibility studies - which would require dedicated individuals. This would often aid in reducing the time required for a conceptual study as opposed to feasibility studies (Bullock, 2011).

In some cases, it is stated that a conceptual study can be carried out in less than two weeks following the receipt of the resource data. In such cases, a conceptual study is prepared by the owner’s team and will largely be based on information in the public domain (Burks & Nell, 1999).

Although the completion of a conceptual study in a short period of time could be beneficial to the study owner, the duration of a conceptual study is largely dependent on the level of information available and the objectives of the study.

2.8 RISK ANALYSIS WITHIN A CONCEPTUAL STUDY

As stated by Griesel (2008), it is common practice to conduct a risk analysis after the completion of a conceptual study. Conducting a risk assessment at the start of a new project, however, ensures that a consideration for risk is an integral part of the thinking process of the team. A risk assessment conducted at the start of a project would identify and assist to model key value drivers for the study. Identifying key value drivers (metal/mineral price, CAPEX, OPEX, metal grade, NPV, processing recoveries/yields etc.) would enable project teams to give more attention to the important considerations (Griesel, 2008).

It is recommended that the resultant findings from a conceptual study be used in a Monte Carlo analysis. A stochastic approach to cash flow and costs modelling, for example, would ensure that the decision maker understands potential variability of the project outcomes. Figure 2.8a shows an example of three different probabilistic cost distributions (Griesel, 2008).

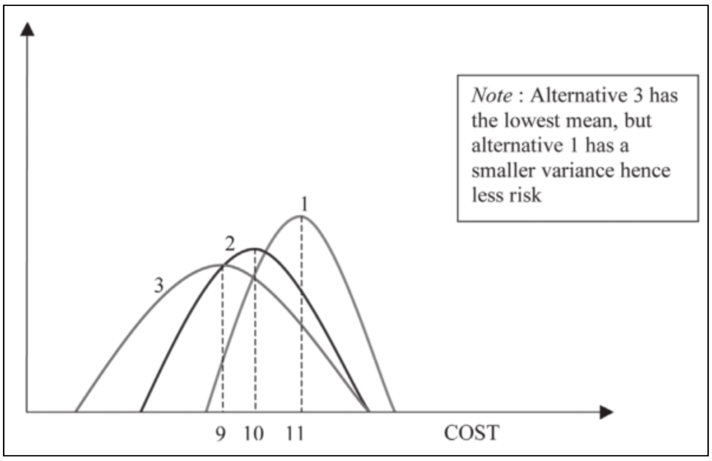

Figure 2.8a: Probabilistic density for cost of three alternatives (Griesel, 2008)

An iterative process for techno-economic evaluation is proposed as shown in Figure 2.8b. Based on the risk analysis, the identified key value drivers form a focus point for the study. The methodology can be used to make an informed decision on the further development of a study (Griesel, 2008).

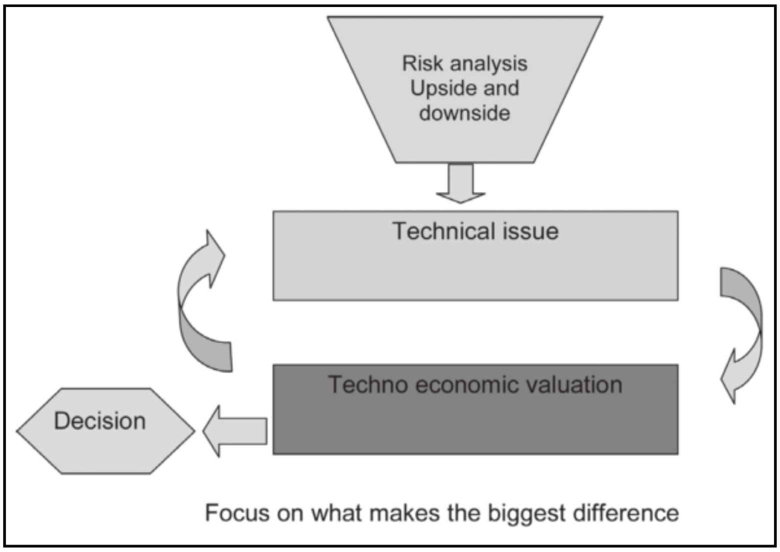

Figure 2.8b: Summarised process of techno-economic evaluations (Griesel, 2008)

2.9 Significance of information from the literature study

In summary, the literature study identified the following principles concerning conceptual studies:

1. A conceptual study is used to: motivate exploration drilling campaigns, set the scope for future mine project development and serve to facilitate investment decisions.
2. Transparency within a conceptual study is important since subsequent investment decisions need to be made on high-level information (assumptions and preliminary exploration results). All assumptions and sources of information must be stated clearly to ensure that the risks within a conceptual study are fully understood.
3. Competent, experienced and independent professionals need to be involved in a conceptual study. Non-geological disciplines should be involved at an early stage of the project development to ensure that resource modelling caters for mining and processing considerations.
4. A set of required deliverables identified at the start of a conceptual study will assist to plan activities required to conduct a conceptual study.
5. Large international mining companies have in-house standards for technical studies which contain detailed work breakdown structures. Detailed activities assist in highlighting the confidence levels of information available, setting the scope for future studies.
6. The duration of a conceptual study can be between two weeks and nine months. The duration of a conceptual study is dependent on the confidence levels of geological information and the objectives which the study want to achieve.

7. The inclusion of a risk assessment done by competent professionals at the start of a conceptual study serves to identify key value drivers. Key value drivers enable project teams to focus on the important aspects for the project.
8. Data within a conceptual study, where applicable, presented in a stochastic manner (such as a Monte Carlo simulation), ensures that the decision-maker not only has probabilistic information but also understands its variability.

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CHAPTER 3

CASE STUDY RESULTS

3.1 INTRODUCTION

In this chapter, the results from the descriptive study which evaluated eight case studies are discussed. Case study descriptions were done with the use of the final report document for the study. All case studies were made available by VBKOM, with two case studies conducted by VBKOM. Sensitive details were omitted to protect the confidentiality of each case study. Case study research investigated:

- Four “conceptual” studies
- Two “scoping” studies
- One “desktop” study

All case studies available for evaluation were based African continent for various minerals and metals. A list of the case studies is included in Table 3.1.

Table 3.1: Case studies overview

Section	Case Study	Abbreviation for reference
3.2	The Copper Silver Desktop Study in Namibia	NC
3.3	The Phosphate Scoping Study in Guinea-Bissau	GP
3.4	The Zambia Copper Scoping Study	ZC
3.5	The Guinea Iron Ore Conceptual Study	GI
3.6	The DRC Copper Mining Conceptual Study	DC
3.7	The South-African Coal Mining Conceptual Study	SAC
3.8	The South-African Manganese Conceptual Study	SAM
3.9	The Malawi Heavy Mineral Sands Study	MHS

The purpose of each case study was to describe the study as it was documented (descriptive study) and extract activities which would promote value adding principles from the study. Details from the descriptive study are included in Appendix A. Each case study started off with an introductory chapter, followed by the value adding activities summarised from the case study.

Each case study was described under the following headings (abbreviations for activity reference):

1. General considerations (G)
2. Mineral resource management considerations (MR)
3. Mining operational considerations (MO)
4. Mining economic considerations (ME)
5. Safety, health and environmental considerations (SH)
6. Risk management considerations (RM)
7. Study work plan (WP)

Value adding activities in each chapter were referenced by the study abbreviations and headings above. For example, the first activity in the Namibia Copper Silver Desktop Study (NC) under the sub-heading General considerations (G) was numbered NCG01 ("NC"+"G"+"01"). A similar methodology was followed as per the international standards, explained in 2.6 (see table 2.6). This was done for easy referencing in the analysis of results in Chapter 4.

In the case studies, similar principles were noted and described. For consistency, such activities were stated repeatedly for each case study as it occurred. The occurrence of repetitive activities in the eight different case studies was used in the evaluation of results in Chapter 4.

3.2 THE COPPER SILVER DESKTOP STUDY IN NAMIBIA – A CASE STUDY

The Namibia Copper Silver Desktop Study (hereafter referred to as the NC study), located in the central parts of Namibia, is considered a shallow oxide deposit of copper with silver as a by-product. The NC study included considerations for an optimal surface mining operation, a geological resource estimation and a conceptual processing plant design. The geological resource model was classified according to measured, indicated and inferred (according to the SAMREC reporting code), with 90% of the material in the inferred category.

The study included an option analysis between three processing and transporting scenarios performed as options within the software used for a pit optimisation study. From the pit optimisation study, pit designs and a high-level production schedule were done with the use of relevant mining software. The NC study included an equipment study based on equipment simulations. Where information was unavailable, the NC study relied on calculations from first principles for mine technical work. The NC study also included a cost-estimation for capital and operating expenditures (CAPEX and OPEX).

Capital and operating costs were sourced from an operation of similar size, supplemented by the original equipment manufacturers' quotes. The NC study included a risk evaluation in a risk matrix which highlighted areas of concern within the study. Value adding activities from the NC study is shown in Table 3.2.

Table 3.2: Value adding activities from the NC study

Activity No	Category	Activity
NCG01	General considerations	A table with all the project assumptions and economic input parameters was presented in the introductory section of the study. This provided a sense of transparency to the reader. It is assumed that the typical reader of the document would be techno-financially inclined and would want to get down to the bottom-line of what the project report is stating.
NCG02	General considerations	It was stated that the financials, such as the mining, processing and equipment costs, were based on a recent technical study that was done for a mine nearby.
NCMR01	Mineral resource management considerations	Overall geotechnical slope angles for weathered and fresh material were sourced from a neighbouring operation with similar geotechnical parameters.
NCMR02	Mineral resource management considerations	Generic modifying factors were stated for the study Dilution – 5% Geological loss – 5%
NCMR03	Mineral resource management considerations	A pit design was done from the selected pit shell. The pit design included 16% more waste than the three-dimensional pit optimisation shell which was produced. The pit design also included 0.4% less ore than the optimisation shell.
NCMR04	Mineral resource management considerations	An option analysis was conducted between various scenarios considering the processing and transporting of ore. This was done within the pit optimisation software and was compared on the basis of tonnage, relative NPV and strategic objectives.

Table 3.2 Continued

Activity No	Category	Activity
NCMR04	Mineral resource management considerations	A sensitivity analysis was done within the pit optimisation software, considering +-20% increases and decreases in OPEX, CAPEX and tax. This was done in 5% increments. The sensitivity study provided areas of focus for future work.
NCMR05	Mineral resource management considerations	An exploitation strategy and subsequent production schedule were developed from the pit optimisation results. Such a methodology ensured a balance between maximising grade in the early years, deferring waste stripping and maximising cash-flow according to the strategic initiative of the mine.
NCMO01	Mining operation	Smaller sized equipment was motivated due to its flexibility and low-risk capital expenditure up-front. Such practical considerations provided information for future studies.
NCMO02	Mining operational considerations	A mining equipment study was done using equipment simulation software. This provided results such as cycle times, periodical hauling distances and amount of equipment totals required.
NCME01	Mining economic considerations	The cash flow model allowed a deferred product sale of 5 months - a practice which closely matches reality.
NCME02	Mining economic considerations	The NC study author stated that future exploration cost estimates and future technical study costs were not included in the cost estimation. Including such costs sets the scope for future work to be performed.
NCME03	Mining economic considerations	Capital cost estimations were done according to the financial modelling policy of the study's owners. Such a systematic approach provided comparability and transparency.
NCME04	Mining economic considerations	Operating costs for mining were split into fixed and variable costs. Equipment related operating costs were deducted from first principles using quotes from original equipment manufacturers (OEM).
NCME05	Mining economic considerations	It was stated that an order of magnitude estimation was targeted to be +-25% to 30% accurate. A capital contingency of 30% was included in the cash flow model as a result.
NCRM01	Risk management considerations	A 5 x 5 financial risk matrix was included in the NC study. Each item was quantified with a risk rating in the matrix.

3.3 THE PHOSPHATE SCOPING STUDY IN GUINEA-BISSAU – A CASE STUDY

The Guinea Phosphate Scoping Study (hereafter referred to as the GP study) is located in the northern part of Guinea-Bissau. The GP study consisted of a high-grade sedimentary phosphate deposit of one continuous phosphate bed, extending over a large area. A preliminary economic assessment (PEA) was done prior to the GP study and was used to motivate a scoping study.

The GP study included considerations for:

1. Additional mining methods (dredging) not covered in the PEA
2. Processing plant considerations
3. A suitable location for waste dumping and tailings disposal facilities
4. A slurry pipeline of 80 km linking the mine site to a proposed port facility.

The study was conducted by a European-based consultant, who made use of an expert mining consultant from Colorado, USA, specialising in phosphate deposits. The GP study report did not include a financial appraisal of the project but made reference to a preliminary economic assessment (PEA) done prior to the study. Multiple mining and dredging methods were considered during the PEA. Since dredging is somewhat of a niche methodology for surface mining, the GP study incorporated the assistance of a dredging expert consultant from the United States.

The GP study, though somewhat unique as a case study, was included for its emphasis on developing the scope of subsequent studies. Only a few activities were highlighted from the case study for consideration as value adding activities (see Table 3.3).

Table 3.3: Value adding activities from the GP study

Activity No	Category	Activity
GPG01	General considerations	The GP study showed that a scoping study can be defined solely as a study which investigates gaps in the information for the next level of study. Per implication, the GP case study defines a scoping study solely as an evaluation of existing historical information with a strong emphasis on the gaps in information for a future conceptual design. The GP study showed that a gap analysis evaluation provides a structured approach for setting the scope for future studies.
GPG02	General considerations	A multi-disciplinary site-visit, with specialists relevant to the proposed mining method, identified critical considerations to be included in a conceptual design phase. During the site visit, external specialists pointed out significant risks to the project which would need to form part of the scope for future studies.
GPG03	General considerations	A checklist was provided for future work requirements. The checklist included: required information, a proposed method for information gathering as well as an estimated time for information gathering. A checklist will ensure a structured approach for future studies.

3.4 THE ZAMBIA COPPER SCOPING STUDY - A CASE STUDY

The Zambia Copper Scoping Study (hereafter referred to as the ZC study), is located in the central parts of Zambia. The study was done by a prominent international mining consulting firm. The main intention of the scoping study was to provide an overall opinion of the technical and financial merits for the project in order to aid the decision making for further investments in the project. The ZC study included a review of historical information and a gap analysis to identify what needed to be done to get the mineral resource up to standard for reporting under the JORC code.

Potential mineral processing options were identified and evaluated in an option analysis. The processing options were based on operations with similar mineral resources. A pit optimisation study was conducted for the two processing alternatives in an option analysis. A production schedule was done within the pit optimisation software, which provided a high-level schedule. The study assumed that contractor mining would be done and made use of contractor mining rates. High-level capital costs were used with contingencies. Value adding activities identified from the ZC study are included in Table 3.4.

Table 3.4: Activities considered for best practices for the ZC study

Activity No	Category	Activity
ZCG01	General considerations	A site visit by experienced professionals was conducted which assisted in addressing issues of significant risk to the project.
ZCG02	General considerations	A statement of independence from the external consultant who conducted the ZC study ensured the reader that the consultant did not have any conflict of interest in the project.
ZCG03	General considerations	In general, the ZC study took great care to ensure that the reader clearly understands that the report does not comply with the relevant mineral valuation codes to prove feasibility. The statement emphasised that such speculative geology is often overstated and that the study cannot be used to prove feasibility. This promoted a sense of transparency and objectivity to the financial appraisal of the project.
ZCMR01	Mineral resource management considerations	A description of the selected mineral processing options was included and was merited from the available resources (sulphides and oxides).

Table 3.4. Continued

Activity No	Category	Activity
ZCMR02	Mineral resource management considerations	A description of the geology as it relates to mining was included. This included a brief description of the exploration drilling campaigns with reference to borehole spacing and the logic behind it. The weathering of strata was discussed, which is an important consideration for drilling and blasting practices.
ZCMR03	Mineral resource management considerations	Modifying factors were applied in the ZC study: geological losses of 15% were applied along with mining losses of 10% and dilution of 7.5%.
ZCMR04	Mineral resource management considerations	Included in the pit optimisation portion of the ZC study was a description of how the pit limit was deducted for the infrastructure and permanent structure positioning. A revenue 2 factor pit was chosen, which provided for sufficient space next to the pit to ensure that permanent infrastructure would not potentially sterilise future ore if the metal price increased.
ZCMR05	Mineral resource management considerations	Scheduling was done with the use of the pit optimisation software. The pit optimisation software provided high-level schedules which usually takes less time to complete than conventional scheduling packages.
ZCMO01	Mining operational considerations	An equipment list was provided which showed that the purchasing of mining equipment would be spread over two years. For the ZC study, it was assumed that contractor mining would be done with equipment owned by the mine.
ZCME01	Mining economic considerations	A 40% accuracy level is stated overall for the study.
ZCME02	Mining economic considerations	The ZC study cost estimation included an operating cost summary table which showed the costs of all the major components of the study expressed as unit costs ($/BCM, $/ton treated, $/ROM). This promoted a sense of transparency within the cost estimation.
ZCME03	Mining economic considerations	A sensitivity analysis on NPV was included for the ZC study. The analysis showed percentage changes in capital, revenue and production cost. In addition, an NPV to discount rate sensitivity was also included which showed the effect on NPV for the different rates at which capital can be borrowed for the project. This approach set the scope for areas of focus for the next level of study.
ZCME04	Mining economic considerations	A capital cost contingency of 15% was included for the study to cater for potential price escalations, since most costs were based on a study of similar tenure.

Table 3.4. Continued

ZCRM01	Risk management considerations	A chapter summarising predominant project risks was included in the ZC study. A relative risk rating (low, moderate or high) was included for each of the identified risks. This approach highlighted specific areas of concern, directing scope for future work.

3.5 THE GUINEA IRON ORE CONCEPT STUDY - A CASE STUDY

The Guinea Iron Ore Scoping Study (hereafter referred to as the GI study) investigated a Greenfields deposit located in Guinea, West Africa. Various ore beneficiation, ore transport and ore production scenarios were considered by the study in an option analysis. The study report was less than 50 pages and was based on very high-level estimations and assumptions. Overall, the study provided an optimistic estimation based on limited data available.

The mineral resource considered for the scoping study was based on less than 10% of the target resource for exploration. It was stated that the ore under consideration represented the shallow portion of the resource. The main objective of the study was to aid the decision on whether the current drilling campaign should continue.

Two ore beneficiation options were investigated for the GI study. The beneficiation options assumed respective mass yields, capital and operating costs from a neighbouring mine. In addition to the two beneficiation options, the transporting of the ore to a nearby harbour evaluated road and rail transport systems.

A production schedule was done in Microsoft Excel (bench by bench schedule) on the inferred portion of the resource. Potential mining production rates were recommended by the study owner to fit into a predetermined corporate strategy and rail capacity available. Three different mining rates were considered in an option analyses.

Contractor mining unit cost rates were sourced from an external consultant to which a 20% margin was added. All costs were expressed as unit costs ($/t and $/BCM). A metal price per ton product was based on marketing studies undertaken by an external consultant. Capital costs were estimated based on consultant databases. Value adding activities are included in Table 3.5.

Table 3.5: Activities to be considered for best practices from the GI study

Activity No	Category	Activity
GIMR01	Mineral resource management considerations	The mineral resource was based on less than 10% of the exploration target consisting of shallow ore. The ore was extrapolated and it was assumed that exploration would discover at least 5 times more ore of similar nature.
GIMR02	Mineral resource management considerations	Two processing options along with three ore transport options and three production capacity scenarios were considered for the study in an option analysis – showing the purpose of a conceptual study as a place to do high-level option analysis.
GIMR03	Mineral resource management considerations	A bench by bench Excel production schedule was done based on an extrapolated inferred mineral resource. Excel production schedules take less time than conventional production scheduling software.
GIMO01	Mining operational considerations	For mining, contractor rates were sourced from an external consultant to which a 20% margin was added.
GIME01	Mining economic considerations	An external consultant was used to source indicative costs for the processing plant for the three production scenarios as well as price per ton product.
GIME02	Mining economic considerations	A table with a detailed breakdown of the transport cost - to deliver ore to the market - was included since the transportation of material is often the highest cost associated with a project in developing countries.
GIME03	Mining economic considerations	An indicative cost accuracy of 50% was stated for the GI study

3.6 THE DRC COPPER MINING CONCEPT STUDY - A CASE STUDY

The Democratic Republic of the Congo (DRC) Copper Study (hereafter referred to as the "DC study") is located in the Katanga Province north-west of Lubumbashi. The deposit forms part of the Katanga Copperbelt - a large region of 300 km long by 50 km wide, stretching all the way to the Zambian border.

The DC study investigated the potential benefits of expanding the current operation to a multiple open pit operation with its own central ore processing facility. The main objectives that were addressed within the study were:

- Determining the optimum location of a processing plant to minimise ore hauling
- Conceptual design of the open pit areas and determining the sequence for mining ore resources to maximise NPV
- Determining specifications of an optimum contract mining fleet

The resource model included measured, indicated and inferred mineralised material which was included for the pit optimisation. A pit optimisation was done with multiple resource areas feeding into one ore processing facility. Five different scenarios were compared within the pit optimisation in an option analysis. The scenario with the highest NPV was selected for an annual production schedule which was done with the pit optimisation software. No pit designs were done for the DC study. Pit optimisation shells were used for production scheduling.

A truck and loader trade-off study was done within the DC study which investigated different truck and loader equipment combinations. Based on the high-level production schedule totals, primary and secondary equipment numbers were calculated from first principles.

Capital and operating cost estimates were based on nearby quoted costs of a similar operation. An additional 15% was included in the estimate for unmeasured items. The plant capacity used in the production schedule was based on a previous study done by a prominent metallurgical consultant. The DC study related the foreseen metal tons produced to the market size for the supply of the metal in question. The value adding activities from the DC study is included in Table 3.6.

Table 3.6: Activities to be considered for value adding principles from the DC study

Activity No	Category	Activity
DCMR01	Mineral resource management considerations	Block model dimensions were 10 x 10 x 5 m, according to a smallest mining unit (SMU) approach for the DC study. The involvement of mining engineers at a geological modelling phase is of critical importance to arrive at a relevant mining model.
DCMR02	Mineral resource management considerations	Ore classification based on metallurgical test work was done for the DC study, which implied the early involvement of metallurgical engineers in the geological modelling.
DCMR03	Mineral resource management considerations	Mining losses of 10% and dilution of 10% were assumed for the study. Dilution was included in addition to the dilution implicated by the smallest mining unit modelling approach.
DCMR04	Mineral resource management considerations	In the DC study, the planned output metal tons were related to the market supply and demand stating that an oversupply of the metal could reduce metal demand and price. This gave scope for future study work to determine optimal plant output size according to the market size.
DCMR05	Mineral resource management considerations	The pit optimisation for the DC study made use of specialist pit optimisation software catering for a multiple resource pit optimisation with a centralised ore processing facility. The specialised mining software was also used for production scheduling. This software module approach provided flexibility in scenario comparisons and provided a structured approach for comparability.
DCMR06	Mineral resource management considerations	The inclusion of a Mining Cost Adjustment Factor (MCAF) within a pit optimisation catered for increases in mining cost with depth and variations in distances to transport ore. This inclusion implied that the economic limit of the pit took cognisance of varying the costs of transporting ore for the particular pit.
DCMR07	Mineral resource management considerations	Five different scenarios were considered for the DC study. A base case was compared with two ore hauling scenarios and two processing scenarios. Each option was included in the pit optimiser as a scenario for optimisation. The scenario comparisons within the pit optimisation lent itself to structured means to provide comparability within scenarios.
DCMR08	Mineral resource management considerations	The pit optimisation pit shells were used for pit scheduling within the pit optimiser. Pit optimisation software schedules, though somewhat optimistic, can provide a production schedule within a relatively short turn-around time, considered applicable to a conceptual study.

Table 3.6 Continued

Activity No	Category	Activity
DCMR09	Mineral resource management considerations	To determine the optimal location for the centralised processing facility, a centre of gravity calculation was done. In determining an ideal location involved, mining engineers and metallurgists worked together.
DCMO01	Mining operational considerations	A detailed equipment optimisation from first principles with the use of specialist equipment simulation software was included in the DC study. Subsequent studies would benefit from such detailed equipment calculations.
DCMO02	Mining operational considerations	The DC study considered 27 km of haul road construction. Haul road construction costs of a nearby operation, sourced from a consultant, were used. A 15% contingency was added to the cost due to various uncertainties.
DCMO03	Mining operational considerations	Costs to remove permanent infrastructure – a power line – were based on information from a consulting firm in South Africa and converted to US dollars.
DCMO04	Mining operational considerations	Mining infrastructure costs, such as truck workshops, diesel fuel storage, dispensing and pit shelters and lunch room costs, were based on a study that was done for a nearby mine based in Sub-Saharan Africa.
DCME01	Mining economic considerations	A key profitability metric was used as an alternative to NPV, which was the profit to investment ratio for each scenario. This was expressed as a ratio of 0.37.
DCME02	Mining economic considerations	An accuracy of 30% to 40% for capital costs were stated for the DC study.
DCME03	Mining economic considerations	Mining costs were shown in detail per activity as well as per cost type. The costs were provided as total costs per annum and unit costs. This provided transparency regarding the magnitude of the costs.
DCSH01	Safety, health and environmental considerations	A consideration and calculation of water requirements for mining and processing in relation to water sources outlined in a preliminary hydrogeological study ensured the sourcing of adequate water for the study, setting the scope for future hydrogeological studies.
DCWP01	Study work plan	The DC study's final "Conclusions and Recommendations" chapter included a list of areas of focus on for future subsequent studies.

3.7 THE SOUTH AFRICAN COAL MINING CONCEPT STUDY - A CASE STUDY

The South African Coal Desktop Study (hereafter referred to as the “SAC study”) is located in the northern parts of South Africa, in the Limpopo Province. The SAC study location formed part of the Soutpansberg Coalfields, which is situated close to the border of South Africa and Zimbabwe.

The study was based on the following information:

1. Resource data which was completed just prior to the study commencement
2. Preliminary metallurgical test work and process designs
3. A competent person’s report done by independent consultants.

The study sponsor is an exploration company which is owned by a consortium of smaller coal mining companies. The SAC study was therefore based on data that was more conclusive than the other case studies thus far mentioned.

The study assumed that a mining contractor would be used throughout the life of the operation. The mining costs were partially calculated from first principles (loading, hauling, drilling and blasting) whereas some costs were based on the costs of a similar operation. Included in the capital cost estimations were detailed cost estimations for future exploration (drilling and sampling) work. A contingency of 10% was included for the operating cost estimations since most of the operating costs were sourced from other operations.

A pit optimisation study was done for the SAC study. From the pit optimisation, nested pit shells were used to target shallow high-quality material to sequence the production schedule. The initial pit optimisations showed that the study would not be profitable even in the most optimistic market projections. The study proceeded to investigate a coal price where the project will be sufficiently profitable for consideration.

A detailed market study was done for the SAC study. A summary section which considered the marketability of the coal according to its inherent qualities was included. All financial and project risks were modelled and presented in a risk breakdown structure (RBS). Activities with value adding potential from the SAC study are shown in Table 3.7.

Table 3.7: Activities to be considered for value adding principles from the SAC study

Activity No	Category	Activity
SACG01	General considerations	Included in the executive summary, an overview of the strategic objectives of the project was provided. It was stated that the main strategic objective was to determine the production and processing scenario which would, in order of priority, provide: 1) the best NPV, 2) maximise the life of mine, and 3) provide earliest payback.
SACG02	General considerations	A statement was made that the study as presented did not comply with the guidelines as defined by the JORC standards of disclosure for Mineral Projects for a preliminary economic assessment (PEA). This is a requirement of the JORC code and promoted transparency.
SACMR01	Mineral resource management considerations	A detailed overview of the project prospecting and mining licenses was provided. This provided scope for the timeframe available under the current licenses for further development of the project.
SACMR02	Mineral resource management considerations	A summary of the cut-off parameters used in the mineral resource classification was described under: yield, ash content, geological structure limits, metallurgical factors and relative density considerations. Such data is relevant for future mineral resource classification work to be done.
SACMR03	Mineral resource management considerations	Losses were modelled per resource category, with inferred category at 20% and indicated category at 10%. Detailed modelling of losses per category added a methodical logic in assigning risk to a specific area.
SACMR04	Mineral resource management considerations	Geotechnical slope angles were based on typical slope angles of open pits in the area and did not constitute a preliminary geotechnical investigation.
SACMR05	Mineral resource management considerations	Six different logically derived scenarios were considered for the pit optimisation. The scenarios varied in primary and secondary products, calorific values and ash content. Each of the scenarios was considered with the appropriate costs and prices identified from the detailed market study. Logically derived scenarios could potentially eliminate less profitable strategic options at an early stage.
SACMR06	Mineral resource management considerations	For the production schedule, the pit optimisation software was utilised to select interim pit pushbacks. Most pit optimisation software packages create nested pit shells increasing in revenue factors. Smaller pit shells, which target shallow high-grade material at the start of the project, reduced financial risk and capital payback.

Table 3.7 Continued

Activity No	Category	Activity
SACMR07	Mineral resource management considerations	The strategic directive for the production scheduling was stated, and a production schedule was done using the pit optimisation software. The scheduling considered the blending of ore types and the balancing of stockpiles. This would add value to developing future exploitation strategies.
SACMR08	Mineral resource management considerations	The schedule included stockpile balance levels at 25% of the required ROM monthly feed. This implied that 25% of the ore would be re-handled.
SACMR09	Mineral resource management considerations	No pit designs were done. Instead, pit optimisation shells were used for pit scheduling. Pit shells take less time to generate compared to pit designs and can be considered appropriate for a conceptual study.
SACMR10	Mineral resource management considerations	The waste dump design was done in such a way as to aim for an optimal balance between vertical lift and horizontal distance hauled. The location was also selected to be as close to the pit as possible to minimise hauling cost and not sterilise potential future ore below.
SACMR11	Mineral resource management considerations	Three-dimensional images depicting mine depletion showed that geospatial mining progression was considered and assure the reader that sound scientific methodology was implemented for the study.
SACMR12	Mineral resource management considerations	A declaration of a mineable resource was included in the study report as a waterfall chart. This was done in a similar fashion to a reserve statement for a feasibility study. The chart showed graphically the effect of each of the different modifying factors applied to the mineral resource and provided the reader with an idea of the future potential reserves for the area.
SACMO01	Mining operational considerations	The mining cost and strategy was partially based on contractor rates and supplemented by costs developed from first principles. The SAC study showed that, where relevant, data for mining cost calculations at similar mines were not available, yet calculations from first principles can be used as a substitute. Such first principle calculations can then be revisited in subsequent studies.
SACMO02	Mining considerations	A depth cost adjustment factor was used along with the mining cost, simulating an increase in mining cost for every 10 m below surface. Cost increments were based on contractor costs borrowed from a similar project.

Table 3.7 Continued

Activity No	Category	Activity
SACME01	Mining economic considerations	At the start of the project, the pit optimisation runs indicated that the project will not be feasible. A coal price was back-calculated where the economics would render the project profitable. Such a price would enable the strategic inclusion of the study at a point when prices would be more favourable.
SACME02	Mining economic considerations	A contingency of 10% was included in the OPEX calculations to cater for potential increases, since most costs were sourced from other operations.
SACME03	Mining economic considerations	A detailed market study was done for the SAC study which assisted to set the scope for the strategic directive which the study would investigate.
SACME04	Mining economic considerations	A rule of thumb was stated that contractor mining would typically be considered if an open mine has a life of less than 5 to 7 years, which is more or less the life of the equipment.
SACME05	Mining economic considerations	Cost details were presented in a graphical format, and the rises and falls were discussed accordingly. Each rise and fall in cost and revenue were related to technical, strategic and mining related factors.
SACSH01	Safety, health and environmental considerations	A summary paragraph of safety and health related matters that would affect mining was included. Areas of concern were highlighted. This sets the scope for future work considerations.
SACRM01	Risk management considerations	Study risks were modelled in a risk breakdown structure. Each risk was rated in terms of the potential consequence and likelihood of occurrence. A qualitative risk rating was assigned to each risk item. Qualitative ratings provided emphasis for future study work.
SACSW01	Study work plan (PFS)	Recommendations for the next study level were based on the risk breakdown structure. It was stated that further work would specifically aim to reduce and manage risks associated with the study.

3.8 THE SOUTH AFRICAN MANGANESE CONCEPTUAL STUDY - A CASE STUDY

The South African Manganese Conceptual Study (hereafter referred to as the SAM study) investigated a manganese resource located in the Northern Cape Province of South Africa. The study is located in a semi-arid area with high daytime temperatures of up to 40 degrees Celsius, low annual rainfall and sub-zero temperatures during winter months.

The SAM study included a mine design, production schedule, equipment optimisation and a risk management strategy. The SAM study was prepared to fit into a detailed financial model which would consider the strategic development of multiple mining projects. It considered four production schedule scenarios with various dilution, modifying factors and ore products in an option analysis.

Mining equipment selection was based on suitability and equipment at similar operations. A detailed mining equipment study was included to set the scope for future studies. A high-level risk table was included in the SAM study, depicting the cause, impact, likelihood, risk rating and risk priority of the risks identified by the project. Activities to be considered for value adding principles from the SAM study are included in Table 3.8.

Table 3.8: Activities to be considered for value adding principles from the SAM study

Activity No	Category	Activity
SAMG01	General considerations	With simplistic geology, as with the SAC study, experienced engineers targeted an area with high-grade shallow ore, and a high-level pit design and production schedule were developed. The exclusion of a pit optimisation study required less engineering work and subsequently less time to complete.
SAMMR01	Mineral resource management considerations	An overview of the project mining right area was provided along with the proposed location for mine dumps, stockpile areas and pit areas on a map of the area. The map showed the orebody in such a way as to confirm that the waste dump locations did not sterilise potential future ore.
SAMMR02	Mineral resource management considerations	Pit, bench and ramp designs were based on preliminary geotechnical work as performed by an external consultant.

Table 3.8 Continued

Activity No	Category	Activity
SAMMR03	Mineral resource management considerations	A material bulking and compaction factor of 10% was used to calculate the waste dump capacity. Such considerations are important where limited dumping area is available.
SAMMR04	Mineral resource management considerations	A period progress plot was shown as an output from the production schedule, promoting a sense of geospatial transparency in the mining progression.
SAMMR05	Mineral resource management considerations	The effect of modifying factors (mining losses = 4% and dilution = 3%) on the resource was shown graphically in a waterfall chart. The chart showed graphically the effect of each of the different modifying factors applied to the mineral resource and provided the reader with an idea of the future potential reserves for the area.
SAMMO01	Mining operational considerations	An equipment optimisation took cognisance of blast delays, equipment inspection, meal breaks, weather interruptions, public holidays and weather delays. Equipment optimisation software provided a structured approach to determine equipment requirements per month.
SAMMO02	Mining considerations	Contractor mining was assumed, and results from the equipment optimisation study were used to provide scope for contractor mining budget quotes.
SAMRM01	Risk management considerations	Study risks were modelled in a risk breakdown structure. Each risk was rated in terms of the potential consequence and likelihood of occurrence. A qualitative risk rating was assigned to each risk item providing areas of focus for future studies.

3.9 THE MALAWI HEAVY MINERAL SANDS SCOPING STUDY - A CASE STUDY

The Malawi Heavy Mineral Sands Scoping Study (hereafter referred to as the MHS study) was a "brownfields" study with the main purpose of setting the scope for a potential drilling campaign to expand the existing orebody. The mineral sands industry mainly consists of titanium dioxide minerals in the form of rutile, ilmenite, leucoxene and zircon. The study was conducted in parallel with metallurgical test work that would confirm the validity of historical data. Costs and revenue information was sourced from a neighbouring operation owned by the study initiator for the evaluation of the economics of the study.

The MHS study was based on geological data that was not yet at an inferred level. A resource model was compiled based on a basic interpolation of assays from drill-hole data and Auger samples. Large drill-hole spacing provided data with a low level of confidence (less than inferred). Metallurgical test work on drill samples and bulk samples provided recoveries for the economic model.

Three different production scheduling scenarios were governed by predetermined ideal slurry pumping rates in the processing plant. Within these rates, the deposits were scheduled according to four strategic approaches based on different product specifications. In total, 12 different schedule scenarios were evaluated according to NPV. In the MHS study, six different mining methods were considered in an option analysis.

A predefined NPV was selected from which an average grade was back calculated. In a similar fashion, a break-even average grade was also calculated, which was subsequently used to determine grade targets for the drilling campaign. Activities for consideration as value adding principles are included in Table 3.9.

Table 3.9: Activities to be considered for value adding principles from the MHS study

Activity No	Category	Activity
MHSG01	General considerations	The inclusion of a statement in the introduction of the report stating that the data used was too speculative for a feasibility study was included for the MHS study, promoting transparency.
MHSMR01	Mineral resource management considerations	A summary of historical data provided relevance for the MHS investigation.
MHSMR02	Mineral resource management considerations	In the absence of a topography for the area, borehole collar elevations were used in conjunction with contours extracted from Google Maps in order to estimate the elevations for a topography.
MHSMR03	Mineral resource management considerations	A mineral resource model was based on a basic interpolation of assays from drill-hole data and Auger samples which was associated with a low level of confidence (less than inferred). This was used effectively to draw attention to the investment potential for a project. The investment potential in turn was used to motivate a future drilling campaign.
MHSMR05	Mineral resource management considerations	In total, 12 different schedule scenarios were evaluated as strategic alternatives to determine the scenario with the highest NPV in an option analysis.
MHSMO01	Mining operational considerations	A consideration of six different mining methods along with a quantitative evaluation of each (pros and cons) eliminated alternatives for subsequent detailed studies. One of the mining methods was selected for further consideration.
MHSME01	Mining economic considerations	EPCM costs were assumed as a percentage (2%) of the total capital spent on the project. Freight costs were also assumed at a percentage (6%) of total capital spent. Such factored costs provide scope for future study cost estimations.
MHSME02	Mining economic considerations	One of the strategic objectives of the project was to search for value. A predefined NPV was selected from which an average grade was back-calculated. In a similar fashion, a break-even average grade was also calculated which served as a grade target for the proposed drilling campaign.
MHSME03	Mining economic considerations	The expected study accuracy is stated to be between 25% and 50% for the MHS study. Based on this, a sensitivity study of +-25% was done for OPEX, CAPEX and product price.
MHSSH04	Safety, health and environmental considerations	The MHS study assumed a social and labour plan, environmental impact analysis and port infrastructure similar to the neighbouring operation owned by the study initiator.

3.10 SIGNIFICANCE OF CASE STUDY RESULTS

The activities identified for each case study revealed information about the nature of conceptual studies. All activities mentioned in Chapter 3 were used in the analysis of results in Chapter 4. In addition to value adding activities identified, recurring themes within the case studies are summarised in Table 3.10.

Table 3.10: Case study trends

Case Study	Study Accuracy	Geological Losses	Dilution	Software used for Production Scheduling	Option Analysis Included	Equipment Study Included
DC	40%	10%	10%	Pit optimisation software	Yes	Yes
GI	50%			Excel	Yes	
GP						
MHS	25-50%				Yes	
NC	30%	5%	5%	Scheduling software	Yes	Yes
SAC		10% (Indicated) 20% (Inferred)		Pit optimisation software	Yes	Yes
SAM		4%	3%	Scheduling software	Yes	Yes
ZC	40%	15%	7%	Pit optimisation software	Yes	Yes

The case studies stated accuracies in the range of 25 to 50% which is fairly consistent with the literature study accuracies of 30% to 50%. In most cases, study accuracy was used as a contingency when calculating capital expenditure, ensuring that the study is not undervalued.

Geological losses of 4% to 15% and dilution of 3% to 10% were stated for the different case studies as modifying factors. The usage of modifying factors, although dependant on the type of orebody, ensures that uncertainties associated with the resource model are dealt with in a logical manner. In one case study, higher geological losses were associated with ore in the inferred category, compared to the indicated category.

In three out of the eight case studies, production scheduling was done within the pit optimisation software. Pit optimisation software can be effectively used as a tool to provide a high-level production schedule. Such production schedules, though somewhat rudimentary and optimistic, are not as time-consuming as detailed schedules simulated in specialised mine scheduling software packages. However, in two out of eight case studies, a production schedule was developed using specialist scheduling software.

All but one of the case studies included an option analysis. This confirms findings from literature as to the important purpose of a conceptual study, namely to consider various mining, ore transportation and ore beneficiation options in a screening process.

Since the purchase of a large mining equipment fleet would typically comprise the largest capital contribution from the mine technical function to start an open pit mine, five out of eight case studies included an equipment study. In most cases, equipment simulations were done to determine relevant equipment totals required over time. Such calculations are justified in proportion to the capital required and would set the scope for equipment simulations in future studies.

CHAPTER 4

ANALYSIS AND EVALUATION OF RESULTS

4.1 INTRODUCTION

This section will provide an analysis of all the results obtained from the literature and case study research. Activities identified from the case studies and industry standards collectively resulted in 153 activities in total. Within the 153 activities, similar activities were grouped together to arrive at 72 activities, which formed the basis for the evaluation of results. The detailed list of activities is included in Appendix B. The purpose of this section is to identify and discuss such activities that are critical to the success of a conceptual study.

4.2 SURVEY RESULTS

Professionals experienced in conceptual studies at a consulting firm, VBKOM consulting engineers, were presented with background information for conceptual studies and were invited to take part in an online focus group discussion. Willing participants were given an online survey to complete, presenting 72 activities culminated from industry standards (Section 2.6) and case study results (Chapter 3). As discussed in Section 1.4, participants were requested to evaluate each activity according to its “risk reduction potential” and “potential consequence if not included”. Participants were also requested to provide comments for each of the activities.

4.2.1 Survey participants

The list of survey participants is shown in Table 4.2.1 along with each participant’s designation and years of experience in conceptual studies. The SAMREC code specifies that a professional with five years’ commodity specific experience is considered competent for reserve sign-off. A similar measure was applied for survey participants in five-year intervals. More experienced participants’ inputs were given a higher weighting. From the participants’ inputs, the weighted average ratings (1-9) were used to calculate the overall value adding potential for each activity. The survey participants were asked to provide comments along with the evaluation of an activity. The detailed list of activities presented to the survey participants are shown in Appendix B.

Table 4.2.1: Electronic survey participants (focus group study)

Designation	Abbreviation	Years' Experience
Principal Mining Engineer, CEO	MK	10+
Principal Geologist	BB	10+
Principal Industrial Engineer	SO	5+
Senior Mining Engineer	BS	< 5
Principal Mining Engineer, Director	GO	10+
Mining Engineer	TM	< 5
Industrial Engineer	TA	
Industrial Engineer	ML	< 5
Senior Mining Engineer	WH	< 5
Manager – Project Support	JJ	5+
Mining Engineer	NL	< 5

4.2.2 Survey results – ranked according to value adding potential

From the survey results, the activities were ranked according to "value adding potential", calculated by the methodology described in Section 1.4. Ranked activities were plotted against the overall value adding potential scores in Figure 4.2.2a.

If assumed that the 72 activities would achieve a 100% of the potential value to be added to a conceptual study, then the top 20 activities would relatively add 50% of the overall value for a conceptual study. The top 20 activities are shown in Table 4.2.2, ranked according to value adding potential and showing comments from the survey participants. The full list of activities (72) are included in Appendix B.

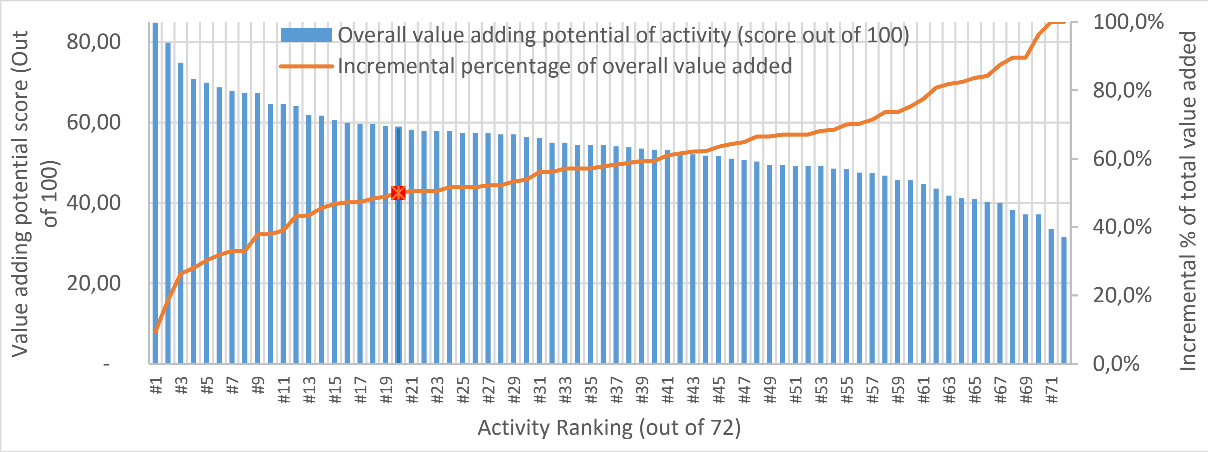

Figure 4.2.2a: Incremental value added per activity

Table 4.2.2: Top 20 activities identified from the survey

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#1	ISMR23	MRM General	Provide a site description for the intended project with boundaries, rights, existing infrastructure and local communities highlighting all socio-economic risks.	7.42	7.84	MK: Fundamental! BB: Understanding the socio-economic risk of the project is very important especially in our current operating climate. SO: It is important that the project scope and stakeholders are clearly defined to ensure that all user requirements are considered.	84.80 (#1)
#2	ISMR13	MRM Pit optimisation	Determine relevant marketing parameters (e.g. product quality, product quantity, product price, potential off-take agreements etc.) for use in the pit optimisation process.	6.95	7.42	MK: Projects more sensitive to revenue assumptions. BB: The more information is presented, the better the decision to continue with the project will be. SO: Must understand product specs to achieve. BS: Markets change. Especially in the 5-10 years from scoping to start-up	79.82 (#2)

Table 4.2.2 Continued

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#3	ISMR12	MRM Pit optimisation	Determine the relevant processing parameters for use in the mine planning process.	6.84	6.63	MK: Need to get this fairly close to get order of magnitude right. BB: Processing of the material contributes a great deal to overall costs that influences conversion from resource to reserve estimates. SO: Important to understand ROM tons requirement. BS: Get the benchmark right.	74.85 (#3)
#4	ISMR14, ISMR15	MRM Pit optimisation	Summarise all input parameters and assumptions used for the pit optimisation process and clearly state how data was obtained.	6.26	6.47	MK: Economics are more sensitive for Revenue assumptions - more so than costs. SO: The parameters may have [a] huge effect on the results, and this must be understood if the study results are queried. BS: It's closer to "guesswork" in this level of study. The projections are beyond 5 years into the future. All relevant assumptions must be stated.	70.76 (#4)

Table 4.2.2 Continued

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#5	SACMR02	MRM Geology	Include a summary of all cut-off parameters used for the mineral resource estimation.	5.84	6.74	MK: This has a direct bearing on revenue and would therefore have a greater impact than expenditures. BB: If the cut-off grade is opinion based it should be clearly stated and justified. SO: Data can be incorrectly interpreted if cut-off grade is not understood. BS: It will change in future studies. It is good to see though.	69.88 (#5)
#6	GIMR01	MRM Geology	Include a statement of the expected confidence of geological information relative to a drilling campaign (measured, indicated, inferred).	6.58	5.79	BB: The confidence determines the amount of resource definition work required and the confidence of the scoping study. SO: If this is not understood, the conceptual business case may be over or under stated.	68.71 (#6)
#7	ISSH03	Safety, health and environmental considerations	Gather environmental, community and cultural information that may impact on mining operations.	5.74	6.47	BS: As much as required for a scoping study e.g. relevant.	67.84 (#7)
#8	GPG01,	General	Conduct a GAP analysis to show what information is required and what work needs to be done before feasibility can be proved.	5.95	6.16	BS: Yes.	67.25 (#8)

Table 4.2.2 Continued

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#9	MHSSH04	Safety, health and environmental considerations	Conduct a scope of work for a social and labour plan and an environmental impact analysis, based on that of a neighbouring operation or benchmark data.	6.37	5.74	BS: Include your major risks and clearly state them.	67.25 (#9)
#10	ISMR19, ISMR20, ZCMR05, GIMR03, DCMR09, SACMR10	MRM Production Schedule	Determine the preliminary production sequence and schedule, including the reasoning for “build-up” and “steady-state” rates.	5.68	5.95	SO: Could have an impact for a large mine - business case. GO: Big driver of NPV.	64.62 (#10)
#11	ISMR21, SAMMR04	MRM Production Schedule	Simulate a conceptual mine production schedule in a spreadsheet format and a “three-dimensional animation” or “end of period” plots.	5.68	5.95		64.62 (#11)
#12	MHSMR03	MRM Geology	If unclassified resource material is used for the study, include an explanation of material used related to its suitability for doing a financial appraisal.	6.05	5.47	BB: Stakeholders must fully understand the underlying risk of the project. SO: If this is not understood, the conceptual business case may be over or under stated. BS: Financial appraisals for not classified minerals should only be a one liner.	64.04 (#12)

Table 4.2.2 Continued

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#13	DCWP01, SACSW01, ISWP01	Study work plan	Outline a study work plan based on each item as defined in a project risk breakdown structure.	5.58	4.95		61.81 (#13)
#14	NCMR05, SACMR06	MRM Pit optimisation	Include a sensitivity analysis on processing recovery and yields, metal or mineral price, mining cost and processing and crushing cost for the project.	5.58	5.53	MK: Revenue! Projects are more sensitive on these assumptions. BB: Monte Carlo will indicate biggest contributors to project success. SO: Maybe somewhat pre-mature for conceptual study. GO: I have seldom seen huge value in these sensitivities.	61.70 (#14)
#15	NCMR02, ZCMR03, DCMR03, SACMR03, SAMMR05, ISMR10	MRM Geotechnical	State the modifying factors (dilution, geological loss and mining loss) in reference to a logical explanation (geological occurrences, equipment size). Where relevant, categorise losses per geological or geotechnical zone.	5.00	5.89	MK: Need to get this fairly close to get order of magnitude right. BB: Especially in thin seam orebodies, which will be mined by open pit mining. GO: Material and beneficiation process specific.	60.53 (#15)
#16	NCE03, DCMO02, DCMO04, ISMO04	Economic - Cash flow modelling	Source unknown capital costs, such as mining infrastructure, rehabilitation and mine closure costs, from benchmark data or relevant experts.	5.32	5.47		59.94 (#16)

Table 4.2.2 Continued

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#17	ISMR17, ZCMR04, ISMR18, SACMR01, SAMMR01, SACMR09	MRM Pit optimisation	Establish the final mining limits from the "revenue 2 factor pit" and ensure all infrastructure is located outside the final mining limit.	5.21	5.53	MK: Good practice but not crucial at this level. BB: Infrastructure placement can be confirmed in later project stages. SO: Future sterilisation of resource if not done, but must still be economically feasible. BS: Start with the end (future prices) in mind. The plant location might sterilise the best ore.	59.65 (#17)
#18	ZCMR02	MRM Geology	Describe the geology as it relates to mining. Include a description of the stratigraphy as it relates to mining practices referring to attributes such as "degree of weathering".	5.47	5.26	MK: Only has bearing on part of mining opex. BB: Understanding the geological dates as well as the amount and type of data collected is vital for project success. SO: Important for equipment selection, but this level of detail may be too much detail at conceptual level. BS: Very important - especially in areas where "free dig" (at a lower cost) or oxidised ore is to be mined. GO: Important for its effect on slope angles	59.65 (#18)

Table 4.2.2 Continued

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#19	SACSH01	Safety, health and environmental considerations	Include a summary paragraph on any potential safety, health and environmental matters that would affect or prevent mining.	5.21	5.42	BS: As much as required for a scoping study e.g. relevant. ML: Environmental factors, such as water sources or wetlands may deem the project infeasible. It would be preferable to identify such factors before expensive further study work is continued.	59.06 (#19)
#20	ISME05	Economic - cash flow modelling	Describe the cost estimation methodology, stating all assumptions and data sources.	5.42	5.16		58.77 (#20)

The occurrence of value adding activities in the case studies

As mentioned, similar activities were grouped for the evaluation within the survey. The original activity reference was included in the first column in Table 4.2.2. The activity occurrence was plotted against the value adding potential in Figure 4.2.2b. It was expected that the activities that would add more value would occur in more case studies. The graph, however, shows a poor correlation between activity occurrence and the value-adding potential. A poor correlation could potentially confirm the need for industry to better understand such value adding activities critical to the success of a conceptual study.

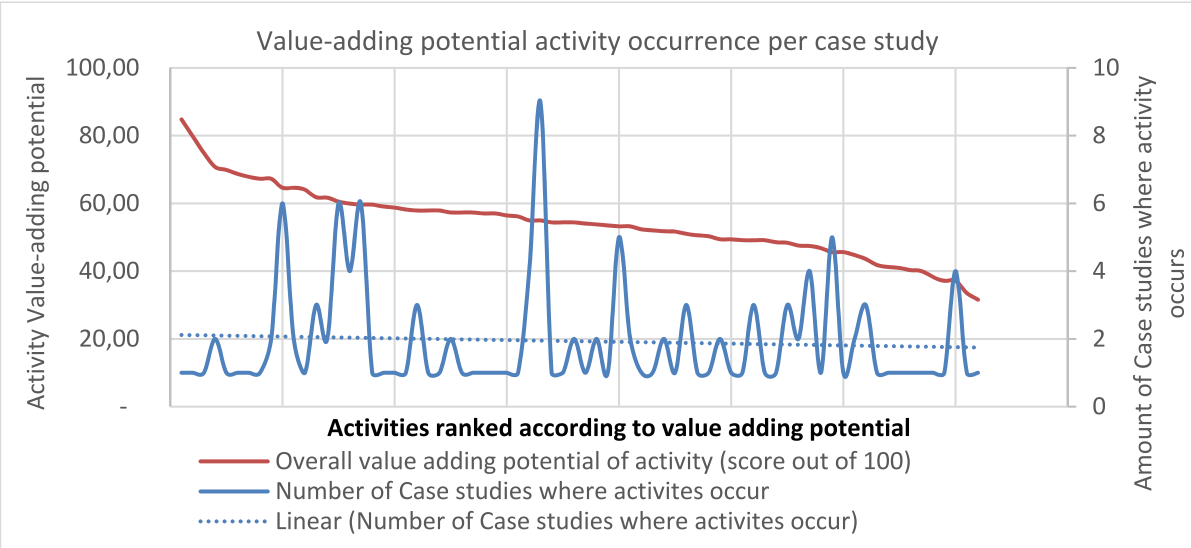

Figure 4.2.2b: Value adding activity occurrence in the case studies

Pit optimisation

From the top 20 activities identified from the survey, five activities describe the pit optimisation process to be followed for a conceptual study. The inclusion of a pit optimisation, as determined in the literature survey, provides a structured, repeatable process for determining the economic limit and profitability of a mining operation. A repeatable process allows comparability between conceptual studies.

Pit optimisation software also incorporates a scientific approach to calculating profitability, cognisant of the geospatial dynamics of an orebody when determining the economic pit limit. As implied in the #2, #3 and #4 activities (Table 4.2.2), a clear understanding of the origin of input parameters (metal price, recovery, processing cost, etc.) is to be provided, so as to ensure transparency. It is also important that the sensitivity of the project is understood in terms of the relevant input parameters (activity #14). A sensitivity analysis is important to understand the effect on the variability of data. Most pit optimisation software provides for such a sensitivity analysis with relative ease.

Environmental and socio-economic impacts

Activity #1, #7, #9 and #19 imply that a clear understanding of the potential environmental and socio-economic impacts is imperative in adding value at a conceptual phase. To identify wetland areas, water sources or potential village relocations are important in considering whether to proceed with mine development.

Geology

Since the geology of a mining project is probably the most important source of information on which the project is based, it must be clearly understood at a conceptual phase (activity #5, #6, #12, #15, #18). The confidence levels of the geology (measured, indicated, inferred) would determine the scope for further exploration and provide an understanding of the potential variability of geological information. From the activities, it is stated that all modifying factors applied to the geological model must be clearly understood (dilution, losses, cut-off etc.) Furthermore, the data relevant to mining (degree of weathering) and geotechnical characteristics of the rock, where available, need to be understood for mine development.

Future work plan

Activities #8 and #13 highlight the importance of a conceptual study to determine the scope for future mine development work. Value is added by determining the gaps in information in a “gap analysis” approach. The quantum of future work could be a major determinant in deciding future mine development.

Production Schedule

The production schedule for a conceptual study is the main source of information in estimating the value (NPV) of the project (activities #10 and #11). Simulating mining production with relevant scheduling software provides a scientific approach cognisant of geospatial data.

Transparency in cash-flow modelling

The importance of stating the source of costs used for cash flow modelling is emphasised by activities #16 and #20. Stating the source of information ensures accountability as the study estimator has to make use of relevant information.

4.2.3 Survey results and deliverables required

As identified in the literature survey (Section 2.5), 53 critical deliverables are required to successfully complete a conceptual study (Table 2.5). An evaluation of the top 20 activities (4.2.2) against the critical deliverables determined that 34 of the 53 deliverables would be satisfied. The ranked activity reference is shown with the deliverables in Table 4.2.3a. From the 53 deliverables, 6 were considered not applicable to the scope of this dissertation. Therefore, it can be said that 34 of the 47 deliverables (72%) are met by the top 20 activities.

Table 4.2.3a: Top 20 activities addressing deliverables required

Grouping	Deliverables Required	Addressed by activity (Ranked activity reference – Table 4.2.2)
Admin and General	Legal tenure such as the nature of the permit (mining or exploration) application and overview of the agencies or governmental parties involved.	(#1)
	Permit Application Specifications Scope of Work (SOW)	(#1)
	Location, topography and climate overview	(#1)
	Site visit	
	Overview of the basis on which estimates were done	(#4) (#20)
	Statement of the purpose of the report	
	Project history	(#1) (#4)
Geology	Exploration drilling, sampling and assays review report	
	Predevelopment drilling programme and budget	
	Geotechnical overview	(#15)
	Geological map	
	Geological data management programme detail or geological data	N/A *
	Spatial and three-dimensional data (surveys, cross sections, etc.)	
	Specific gravity and bulk tonnage data	
	Geological model description and overview	(#6) (#12) (#18)
	Cut-off grades and cut-off points estimation	(#5) (#15)

Table 4.2.3a Continued

Grouping	Deliverables Required	Addressed by activity (Ranked activity reference – Table 4.2.2)
Mining	Mine work specifications	(#8) (#13)
	Mining literature search	
	Alternative mining methods evaluations	
	Mining equipment specifications, vendor quotations and equipment list	
	Contractor and subcontractor selection	
	Mining factors that could pose a risk to the project	(#13)
	Mining production schedule estimate	(#10) (#11)
Infrastructure	Surface civil facilities work specifications, work design (SOW) and sketches	(#13)
	Tentative surface building requirements and mechanical erection estimates	(#16)
	Tentative surface utilities requirements and electrical work estimates	(#16)
	Tentative surface transportation requirements and piping estimates	(#16)
	General surface facilities arrangement and infrastructure list	(#16) (#17)
	Surface mobile and miscellaneous equipment requirements	N/A *
	Tentative siting preferences	(#17)
	Structural design and estimates	(#16)
Metallurgy	Process work specifications, design parameters and description (SOW)	(#13)
	Process flow sheet, capacity or block flow diagram	(#3)
	Process alternatives evaluation	
	Preliminary process functional analysis (labour operating cycles etc.)	N/A *
	Process equipment list	N/A *
	Metallurgical testing programme	
	Processing risks	(#13)
Environmental	Environmental overview and compliance estimates	(#7)
	Land and water status evaluation	(#19)
	Environmental work specifications (SOW)	(#7) (#8)
Labour	Preliminary functional analysis (labour operational cycles)	(#9)
	General personnel requirements	(#9)
	Miscellaneous labour-related cost factors	(#9)
Economic	Process capital and operating cost estimates	(#16)
	Preliminary market study	(#2)
	Tax overview study, royalties and insurance	(#16)

Table 4.2.3a Continued

Grouping	Deliverables Required	Addressed by activity (Ranked activity reference – Table 4.2.2)
	Financial analysis	(#14)
	Approximate administrative costs, indirect cost estimates and contingencies (% of totals)	(#16)
	Preliminary study plan and budget, development schedule and professional services	(#13)
	Value engineering and risk analysis	(#13)
	Surface and ancillary facilities and infrastructure capital and operating cost	(#16)
	Import or export and logistics estimation	(#16)

** These deliverables are not part of the scope of this dissertation*

It was found that the inclusion of six additional activities from the 72 activities list increases the number of deliverables satisfied from 34 to 45 (out of the 47 deliverables - 96% will be achieved). The deliverables achieved by the additional activities are shown in Table 4.2.3b. The additional activities are shown in Table 4.2.3c. Concurrently, by performing these 26 activities – more than half (+50%) of the relative value adding potential will be realised, and 45 of the 47 deliverables (95%) will be provided in a conceptual study.

Table 4.2.3b: Remaining deliverables addressed

Grouping	Deliverables Required	Sources (See table 2.5a)	Addressed by activity (Ranked activity reference as per appendix B)
Admin and General	Site visit	1	(#52)
	Statement of the purpose of the report	1	(#23)
Geology	Exploration drilling, sampling and assays review report	3	(#21)
	Predevelopment drilling programme and budget	2	(#21)
	Geological map	3	(#21)
	Spatial and three-dimensional data (surveys, cross sections, etc.)	1	(#21)
	Specific gravity and bulk tonnage data	1	(#21)
Mining	Mining literature search	1	
	Alternative mining methods evaluations	3	(#59)
	Mining equipment specifications, vendor quotations and equipment list	4	(#57)
	Contractor or subcontractor selection	1	
Metallurgy	Process alternatives evaluation	2	(#36)
	Metallurgical testing programme	1	(#36)

Table 4.2.3c: Additional value adding activities included for consideration

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#21	ISMR09	MRM Geology	State all information relevant to the resource model as well as the origin thereof.	5.42	5.05	MK: Very nice if at good level at early stage - more important at feasibility study. BB: Understanding of the origin of information populated and accuracy is more important. SO: Declaration of resource model confidence levels and summary of where and how the data was sourced should be sufficient. BS: It is the basis for the mining technical study.	58.18 (#21)
#22	SACG01, ISMR17, NCG01	General	State all the strategic objectives of the study.	5.37	5.05	MK: Nice to have a baseline, but may change as information and accuracy increase. BS: All requirements for the Code required. GO: Important for follow on studies to understand where focus was.	57.9 (#22)

Table 4.2.3c Continued.

Ranking	Activity No	Category	Activity (Condensed)	Risk reduction potential 1 = low; 9 = high	Potential consequence if not included 1 = no consequence; 9 = catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#36	ZCMR01, DCMR02	MRM Pit optimisation	State all mineral processing options considered for the study - referencing preliminary metallurgical testing where applicable.	5.05	4.74	BB: The recovery assumptions for each processing stream [are] important. SO: This may be more applicable to the prefeasibility phase. BS: Not relevant for a scoping study.	54.39 (#36)
#52	GPG02, ZCG01, ISMR18	General	Conduct a multi-disciplinary site visit with specialists relevant to the commodity type, and state all findings from the site visit.	4.89	3.95		49.13 (#52)
#57	NCMO02, DCMO01, SACMO01, ISMO02	Mining Considerations	Conduct an equipment simulation to provide preliminary equipment numbers per period.	3.79	3.95	MK: A good place to get these numbers within 30% accuracy. SO: Maybe pre-mature for concept study.	47.42 (#57)
#59	NCMR04, DCMR07, GIMR02, SACMR05, MHSMR05	MRM Pit optimisation	Where relevant, include an option analysis (ore hauling, processing alternatives, production alternatives, sale-able products) as scenarios in the pit optimisation.	4.32	3.89	MK: A good study phase to consider options but really more relevant in PFS. BB: The aim of the scoping is not an option analyses. The option presented should be based on realistic assumptions and scenario analyses in later project phases should add to the NPV. SO: Maybe pre-mature for concept study. BS: No, not at this level of study.	45.61 (#59)

4.2.4 External survey

Since all of the survey participants were employed by the same company (VBKOM Consulting Engineers), the survey analysis could potentially be subject to company bias. It was, therefore, recommended that a second survey be requested from external professionals outside of VBKOM. Although the activities were deducted from industry standards and case studies outside of VBKOM and only the evaluation could be subject to bias, to be certain, an external evaluation was done. A list of the external survey participants is shown in Table 4.2.4a. The external evaluation correlates within 10% of the focus group evaluation as shown in Figure 4.2.4. The difference in the valuation could be ascribed to the external evaluation participants being more experienced than the initial survey. The comments made by external survey participants also largely validated the significance of the activities and are included in Table 4.2.4b.

Table 4.2.4a: External survey participants

Abbreviation	Designation	Experience
DM	Practice Manager - Minerals and Metals	10+
RV	Head of Technical Management	10+
HB	Director Mining and Valuations	10+
DC	Projects: Mining Engineer	10+
PL	Partner	10+
SA	Manager, Strategic Mine Planning and Design	10+
	Director	10+
DL	Principle Engineer	10+
MD	Consultant	5+
CL	Mining Engineer	5+
JV	Mining Manager	5+
SM	Director	5+

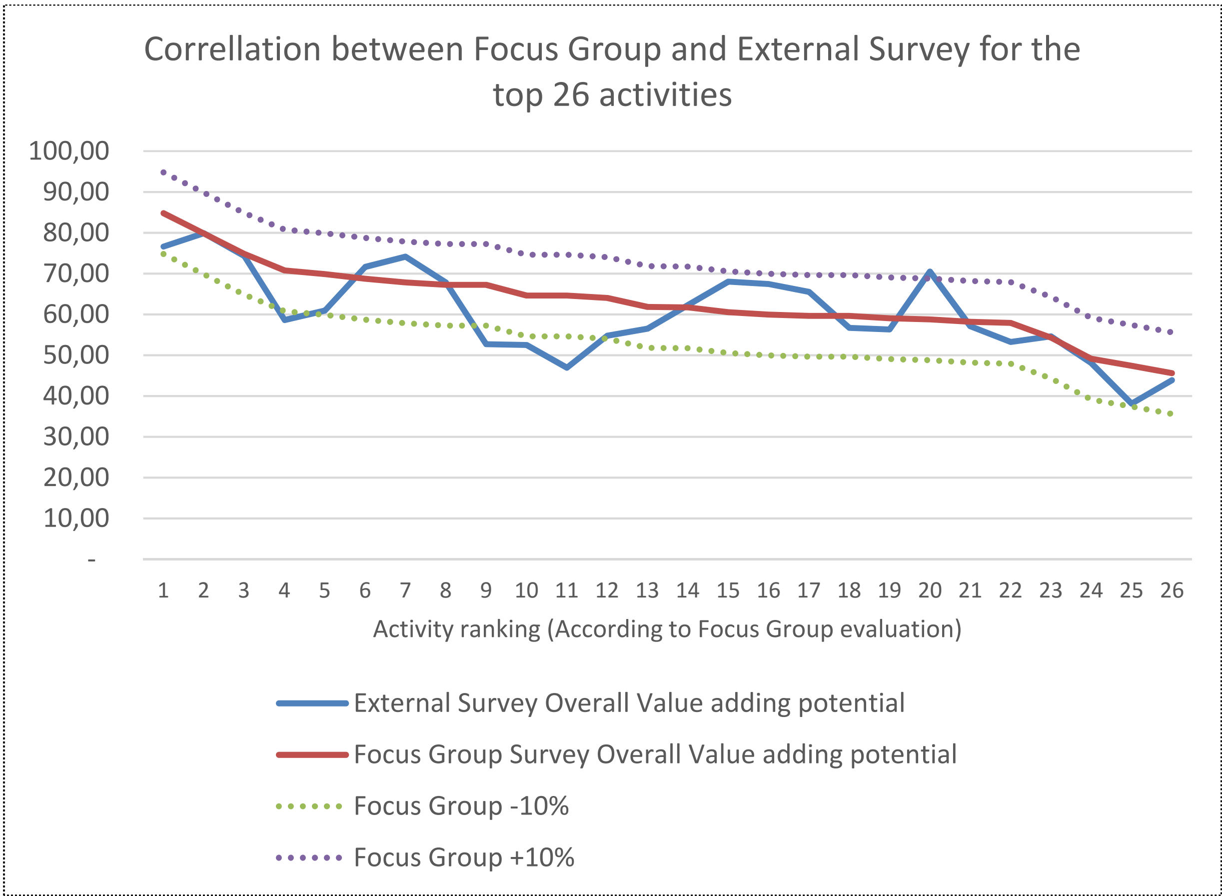

Figure 4.2.4 Correlation between Focus Group and External Experts

Table 4.2.4b: External survey participants' comments on the 26 critical activities

Activity	Survey Comment
1. Provide a site description for the intended project with boundaries, rights, existing infrastructure and local communities highlighting all socio-economic risks.	JV: While I rated the potential and consequence at a medium scale, it is dependent on the specific area in question. Consideration should always be given to all the aspects above as it impacts decisions in terms of resource, mining method, infrastructure costs but also whether the project is executable based on the socio-economic aspects and the environment. All the above items if taken into consideration will guide associated designs and costs. RV: Knowing where you operate and who the stakeholders are/may be is critical. PL: This is highly dependent on the jurisdictions you are operating in. The friendlier the jurisdiction is to open-pit mining, the less of an impact this step would have. SA: Example many projects in central Africa, where many big companies lost a lot of money. SM: The major proportion of the above-mentioned items (which is not exhaustive) have the potential to prevent the project from proceeding.
2. Determine the relevant marketing parameters (e.g. product quality, product quantity, product price, potential off-take agreements etc.) for use in the pit optimisation process.	JV: Without understanding the market, wrong decisions may be taken which ultimately leads to the wrong choice being exercised. Most projects are extremely revenue sensitive - understand the product and the market. PL: Dependent on commodity type SM: Incorrect initial assumptions (including probability ranges) may exclude viable options, incorrectly indicating the project is "no-go".

Table 4.2.4b Continued

Activity	**Survey Comment**
3. Determine the relevant processing input parameters for use in the mine planning process (recoveries, yield, mass pull, plant capacity)	JV: The aspects impact revenue and drive the viability of the project. RV: Part of delivering to a specific market for revenue calculations. SM: Is processing required at all? What is the market requirement for the product (quality, volume, price, revenue)?
4. Summarise all input parameters and assumptions used for the pit optimisation process and clearly state how data was obtained.	JV: It makes auditing easier and to reconcile changes. RV: All inputs especially revenue drivers and how they were applied are critical. SA: Referring to conceptual study. SM: Pit optimisation is less important in concept - business case is critical.
5. State all "cut-off" grade parameters used for the mineral resource estimation along with the approach to determining the cut-off.	JV: It is for auditing and reconciliation purposes. SA: Referring to conceptual study. SM: Important for understanding inputs into the concept. Needs to be aligned with a viable business case.
6. Include a statement of the expected confidence of geological information relative to a drilling campaign (measured, indicated, inferred or unclassified).	JV: Each confidence level infers risk reduction and that a CP has considered risk, if not included it will be risky to utilise the data or place reliance on it. SA: As far as conceptual study is concerned... SM: Appropriate geological confidence needs to be demonstrated to support a concept level of study.
7. Gather environmental, community and cultural information that may impact on mining operations.	Look for the fatal flaws and then look at those aspects that may cost money to mitigate as it has the potential to erode huge value Highly dependent on the jurisdiction you are operating in Conceptual study! Insufficient understanding of these factors may stop implementation or severely delay implementation (increased cost, delayed cashflow and ultimately failure).

Table 4.2.4b Continued

Activity	Survey Comment
8. Conduct a GAP analysis to show what information is required and what work needs to be done before feasibility can be proved.	JV: GAP analysis will show the unknowns to be considered and which would reduce risk in the future study, but which could also be considered as risk in the current study. RV: Study cost may be at risk. PL: If done right, this is probably the most important step in setting up for an effective feasibility study. SM: Without a holistic plan (based on appropriate norms, standards and guidelines) a feasibility will not be conducted successfully.
9. Conduct a scope of work for a social and labour plan and an environmental impact analysis - based on that of a neighbouring operation or benchmark data.	JV: It has no immediate consequence, but should be done, it is suggested that a fatal flaw analysis be done in the conceptual phase. PL: Dependent on jurisdiction. SM: Although generally useful, a formal baseline risk assessment, conducted by specialists, is required as a first step in the legislated Environmental approval processes (including WULA).
10. Determine the preliminary production sequence and schedule including the reasoning for “build-up” and “steady-state” rates.	JV: It is more a case of being realistic as this impacts revenue generation and disregarding it will make the project look better. RV: Needed for business case. SA: Only mining sequence is important at this level of study. SM: Some preliminary estimate is required to inform the overall cashflow, but is not critical for a concept study (the danger of no estimate is that the business case may assume a close-to instantaneous build up which will incorrectly predict early positive cashflows)
11. Simulate a conceptual mine production schedule in a spreadsheet format and a “three-dimensional animation” or “end of period” plots.	JV: This assumes more detailed work than at conceptual level. SM: Useful for business case modelling and visual conceptualisation. Numerous variations are required to inform potential options to be studied in prefeasibility.

Table 4.2.4b Continued

Activity	Survey Comment
12. If unclassified resource material is used for the study, include an explanation of material used related to its suitability for doing a financial appraisal.	JV: Important to note it, but to use this material already implies a high level of risk and potential value impact. PL: Impact will be greater for marginal projects.
13. Outline a study work plan (Prefeasibility or Feasibility) based on each item as defined in a project risk breakdown structure.	JV: This item highlights future work requirements but is not necessarily a value creator or destroyer. PL: Dependent on how marginality. SM: If the identified risk is not addressed, incorrect results will be obtained.
14. Include a sensitivity analysis on processing recovery, yields, the metal or mineral price, mining cost and processing and crushing cost for the project.	JV: Potential to reduce risk is high, but to not do it is not at this stage of study of consequence as detail is little and it only acts as guidance on areas to focus on. SM: Critical for understanding variability in business case due to lack of detailed study information (only obtained in PFS and FS).
15. State the modifying factors (dilution, geological loss and mining loss) in reference to a logical explanation (geological occurrences, equipment size). Where relevant, categorise losses per geological or geotechnical zone.	JV: It highlights those aspects that reduce resources and the ability to translate it into value, identifies areas for consideration in modifying or improving further upon. PL: Dependent on geological/geotechnical complexity of the project. SM: As the mining method may not be frozen, these may change in future study stages (especially PFS).
16. Source unknown capital costs, such as mining infrastructure, rehabilitation and mine closure costs, from benchmark data or relevant experts.	JV: For initial work this is deemed appropriate. PL: This can be a bit hit and miss... SM: These are significant components of the business case model and if under estimated, or omitted, could materially contribute to incorrect decisions.

Table 4.2.4b Continued

Activity	Survey Comment
17. Establish the final mining limits from the "revenue 2 factor pit" and ensure all infrastructure is located outside the final mining limit.	JV: For the level of study the impacts would not be that great, but is worth considering. RV: We use 1.8 - this depends on potential life of the deposit. PL: Getting it wrong is value destroying, but does not necessarily impacts on feasibility. SM: Layout (plan view) is important to concept, but may be changed during PFS without significant costs.
18. Describe the geological stratigraphy as it relates to mining practices - referring to attributes such as "degree of weathering" and digability.	JV: Not important at this stage depending on the impact it may have on processing. PL: Highly dependent on commodity type. SA: Not so important on this level of study. SM: Important input into mining component of concept options (and business case), important input into decision making required during PFS.
19. Include a summary paragraph on any potential safety, health and environmental matters that would affect or prevent mining.	RV: These more often than not result in show stoppers. PL: Dependent on jurisdiction. SM: Dependent on mining technology selection (usually during PFS); so less important for concept.
20. Describe the cost estimation methodology, stating all assumptions and data sources.	JV: The level of study is such that it does not reduce risk, but is important to understand the assumptions. SM: Concept studies are about business case - financial model assumptions are important.
21. State all information relevant to the resource model as well as the origin thereof.	JV: Suspect data creates a high degree of risk, the more reliable the data and resource the lower the risk. SA: The origin is important! SM: The resource model is a significant input into the business case.

Table 4.2.4b Continued

Activity	Survey Comment
22. State all the strategic objectives of the study.	JV: It defines the study and likely outcomes and would drive some of the risk, but ultimately the outcome is dependent on the study approach and reliability of data.
23. State all mineral processing options considered for the study - referencing preliminary metallurgical testing where applicable.	JV: It will reduce the risk of inappropriate conclusions or technologies being proposed. RV: Should be based on most likely option in concept studies SM: Generally, a concept is the first phase - a processing option (dictating metallurgical testing) may not be chosen until the next phase (PFS).
24. Conduct a multi-disciplinary site visit with specialists relevant to the commodity type and state all findings from the site visit.	JV: Site visit assists with visual clues, but ultimately technology is available that could provide the same.
25. Conduct an equipment simulation to provide preliminary equipment numbers per period.	RV: Benchmark rates should be good. SA: Not on this level of study.
26. Where relevant, include an option analysis (ore hauling, processing alternatives, production alternatives, sale-able products) as scenarios in the pit optimisation.	JV: It assist already in reducing or eliminating options that are not viable earlier in the process. RV: Part of PFS scope.

During correspondence with some of the participants of the external survey, a recommendation was made to present the 26 activities in a logical sequence. It would make sense, for example, to first perform all activities related to the geology, prior to performing a pit optimisation. A logical sequence for activities is shown in Table 4.2.4c.

Table 4.2.4c: Logical Sequence for the 26 critical activities

1. Site Visit:	**2 Safety, Health and the Environment:**			**3. Strategic Considerations:**		
Conduct a multi disciplinary site visit with specialists relevant to the commodity type and state all findings from the site visit.	Gather environmental, community and cultural information that may impact on mining operations	Conduct a scope of work for a social and labour plan and an environmental impact analysis - based on that of a neighboring operation / benchmark data.	Include a summary paragraph on any potential safety, health and environmental matters that would affect/prevent mining.	Sate all the strategic objectives of the study.	Provide a site description for the intended project with boundaries, rights, existing infrastructure and local communities highlighting all socio-economic risks.	
4. Geology:						
Describe the expected confidence of geological information relative to a drilling campaign (Measured, Indicated, Inferred, unclassified).	State all "cut-off" grade parameters used for the mineral resource estimation along with the approach to determining the cut-off.	If unclassified resource material is used for the study, include an explanation of material used related to its suitability for doing a financial appraisal.	State the modifying factors (dilution, geological loss and mining loss) in reference to a logical explanation. (geological occurrences, equipment size). Where relevant - categorise losses per geological / geo-technical zone.	Describe the geological stratigraphy as it relates to mining practices - referring to attributes such as "degree of weathering" / digability.	State all information relevant to the resource model as well as the origin there-of.	
5. Pit Optimisation:						
Determine the relevant marketing parameters (e.g. product quality, product quantity, product price, potential off-take agreements etc.) for use in the pit optimisation process.	Determine the relevant processing input parameters for use in the mine planning process (Recoveries, Yield, Mass pull, Plant capacity)	Summarise all input parameters and assumptions used for the pit optimisation process and clearly state how data was obtained.	Where relevant - include an option analysis (ore hauling, processing alternatives, production alternatives, sale-able products) as scenarios in the pit optimisation.	Establish the final mining limits from the "revenue 2 factor pit" and ensure all infrastructure is located outside the final mining limit.	Include a sensitivity analysis on processing recovery / yields, metal/mineral price, mining cost and processing/crushing cost for the project.	State all mineral processing options considered for the study - referencing preliminary metallurgical testing where applicable.
6. Production Scheduling:		**7. GAP analysis and Future work plan:**		**8. Equipment Study:**	**9. Cost Estimation:**	
Determine the preliminary production sequence and schedule including the reasoning for "build-up" and "steady-state" rates.	Simulate a conceptual mine production schedule in a spreadsheet format and a "3D animation" / "end of period" plots.	Conduct a GAP analysis - to show what information is required and what work needs to be done before feasibility can be proved.	Outline a study work plan (Pre-feasibility / Feasibility) based on each item as defined in a project risk breakdown structure	Conduct an equipment simulation to provide preliminary equipment numbers per period	Source unknown capital costs such as mining infrastructure, rehabilitation and mine closure costs from benchmark data or relevant experts.	Describe the cost estimation methodology, stating all assumptions and data sources.

4.2.5 Significance of the analysis of results

The survey assisted to deduct critical activities for a conceptual study. Although conceptual studies may vary according to the purposes thereof and the relevance of and confidence in information available, such critical activities can be used as a minimum criterion for conceptual studies. The nature of the activities is such that, where information is lacking, the activity would serve to reveal such gaps in the information. The analysis of results determined that the success of a conceptual can be improved by the inclusion of 26 critical activities and that such activities would ensure the following:

1. Repeatability – stressed by the importance of the inclusion of a pit optimisation study.
2. Transparency – as determined by an emphasis of the activities on disclosing the origin of information available.
3. Technical methodology – by the inclusion of technical methodology such as pit designs, geospatial production schedules and an equipment simulation.
4. Relevance of information – as determined by the activities that stress a clear understanding of the confidence levels associated with geological information.
5. Understanding risk – the importance of understanding risk is emphasised by the activities that highlight socio-economic and environmental risks.
6. Setting scope – where inadequate information is available to perform an activity, the role of an activity would automatically become to set the scope for future work.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the main findings of the dissertation are discussed in relation to the objectives set for the study. The main objective of this study was to investigate value adding principles for conducting an open pit conceptual study.

The following principles were established for each of the sub-objectives that were set:

Sub-objective 1: The following value-adding principles were established from the literature review:

1. It was established that a conceptual study can have multiple purposes, such as to:
    a. Motivate exploration drilling campaigns;
    b. Set scope for future mine project development; and
    c. Serve to facilitate investment decisions.
2. Identifying risks within a conceptual study is of utmost importance to ensure informed investment decisions.
3. Competent, experienced and independent professionals should be involved in a conceptual study to ensure that critical risks are identified. Non-geological disciplines should be involved at an early stage of the project development to ensure that resource modelling caters for all mining and processing considerations.
4. A set of critical deliverables were identified for a conceptual study from literature. Establishing the required deliverables at the start of a conceptual study will assist in planning value adding activities.
5. Large international mining companies have comprehensive in-house standards for technical studies. A detailed work breakdown structure will ensure that all activities add value by reducing technical and financial risk.
6. The duration of a conceptual study is dependent on the confidence levels of geological information and the multiple purposes which the study wants to achieve. A conceptual study can therefore take between two weeks and nine months to complete.
7. The valuation accuracy within a conceptual study is largely dependent on the confidence levels of information used and can range between 30% to 50% accuracy. Logically derived expected levels of accuracy can be used as a contingency in capital cost estimation.

Sub-objective 2: The following value adding principles would ensure that conceptual studies are based on comparable economics.

1. For an open pit mine, a pit optimisation study provides a structured, repeatable process for determining the optimal economic limit of a pit. Combined with subsequent production scheduling and cash-flow modelling, a pit optimisation will ensure comparable economics.
2. For comparability, transparency in the origin of information used is of critical importance.
3. The inclusion of the 26 critical activities identified in this dissertation would promote a standardised approach, permitting comparability.

Sub-objective 3: The following value adding principles were identified that would promote scientific methodology and sound logic for the conducting of conceptual studies.

1. The inclusion of a risk assessment done by competent professionals at the start of a conceptual study will identify key value drivers for the study. Key value drivers enable project teams to focus on the important aspects of the project.
2. Results from a conceptual study presented in a stochastic manner will ensure that decision makers understand its variability.
3. The inclusion of mining technical work (pit optimisation, pit designs, production schedules and equipment simulations) ensures that preliminary data are interpreted in a scientific manner.
4. An emphasis on the clear understanding of confidence levels associated with geological information (measured, indicated, inferred) ensures accountability in resource modelling.

Sub-objective 4: Industry standards and case study activities were presented to a focus group of industry professionals to evaluate its potential to add value.

1. A poor correlation between the activities that add value and the occurrence of such activities within the case studies potentially indicate that value adding activities are not understood by industry.
2. From the focus group assistance, the activities were ranked in terms of value adding potential, and it was determined that the top 20 out of 72 activities will be responsible for half of the total value added.
3. The top 20 activities will also provide 34 of the 47 critical deliverables required from a conceptual study. By including six additional activities to the top 20 list, 45 of the 47 critical deliverables will be provided.

4. Based on the findings of the focus group, an electronic survey with external experts validated the importance of the 26 critical activities identified.
5. It can therefore be reasoned that 26 activities could prove invaluable to the success of a conceptual study.

The following is recommended based on the conclusions from this dissertation:

1. To ensure informed investment decisions, a conceptual study must adequately address all technical and financial risks associated with early mine development. It is recommended that a project team kick-off meeting commences with a risk assessment that would identify key value drivers for the study.
2. It is recommended that a conceptual study be conducted by competent, experienced professionals (engineers) in a teamwork approach, and that such a team be involved as early as the geological resource modelling phase.
3. The compilation of a detailed work breakdown structure (WBS) at the start of a conceptual study is recommended to ensure that a conceptual study provides all strategic deliverables required.
4. It is recommended that all open pit conceptual studies include the twenty-six activities identified in this dissertation (see Table 4.3.4c).
5. It is recommended that the conceptual study accuracy range be between 30% and 50% and that the expected accuracy be substantiated by a logical explanation. It is recommended that such a logically-derived study accuracy be used as a contingency for capital cost estimations.
6. It is recommended that all open pit conceptual studies include a pit optimisation study to ensure a structured, repeatable process for determining the economic pit limit.
7. Transparency in the origin of information is recommended as an important principle for conducting a conceptual study. Where information is unavailable, assumptions should be clearly stated or calculated from first principles.
8. It is recommended that all confidence levels associated with geological information (measured, indicated, inferred) are clearly understood and clearly stated in a conceptual study.
9. For all estimations within a conceptual study, it is recommended that a scientific methodology be followed and implemented by competent professionals.
10. It is recommended that all estimations stated from a conceptual study be presented in a stochastic manner to ensure that the stakeholders understand the potential variability of information.

11. It is recommended that all conceptual studies include a future work plan which would set the scope for future studies and identify critical areas requiring additional engineering work.

CHAPTER 6

SUGGESTIONS FOR FURTHER WORK

1. The findings from this dissertation can be used to supplement and prioritise industry standard activities for conducting a conceptual study.
2. It is suggested that the principle of prioritising attention to such activities that would reduce risk is applied to other disciplines involved in a conceptual study (metallurgy, infrastructure, electrical engineering, underground mining etc).
3. It is suggested that an online system be developed to assist study initiators to plan the activities required for a conceptual study.
    a. A consultant would sit with a study initiator and use such a system in a "tick box" approach to determine what information is available, what will be addressed by this study and what scope will be set for subsequent studies.
    b. Such a system could be used in a gap analysis study to evaluate an existing conceptual study.
    c. Activities within the system can automatically be prioritised in terms of value adding potential.
    d. The system can be tailored to suit the strategic requirements of each study.
    e. A consulting firm could attach typical billing costs to perform an activity. This would enable the system to provide instant budget costs to conduct a conceptual study.
    f. An estimated time duration for each activity could be used to estimate the overall time needed to conduct a conceptual study.
4. It is suggested that further research be conducted in a PhD on early mine development studies, evaluating work breakdown structures for all disciplines involved in a conceptual study and designing a system that would ensure the successful completion of conceptual studies.
    a. Such a system should incorporate suggestions stated in point 3 above.
    b. It is suggested that such research would furthermore identify the strategic nature and importance of various study types: desktop study, order of magnitude estimate, conceptual study and scoping studies.

APPENDIX A – DETAILED CASE STUDY RESULTS

A.1 The Malawi heavy mineral sands scoping study - a case study.

The Malawi heavy mineral sands scoping study (hereon referred to as the MHS study) was a "brownfields" study with the main purpose of setting the scope for a potential drilling campaign to expand the existing orebody. The mineral sands industry mainly consists of titanium dioxide minerals in the form of rutile, ilmenite, leucoxene and zircon. The study was conducted in parallel with metallurgical test work that would confirm the validity of historical data. Historical data of a neighboring operation owned by the study initiator was used to evaluate the economics of the study.

A.1.1 General considerations

A statement was included in the introduction of the report stating that the data used for the study was too speculative to be used to prove feasibility, and that it should be seen as an order of magnitude estimate only. Such statements of clarification promote transparency and ensures that a conceptual study is not mistaken for proof of feasibility.

In the executive summary of the MHS study document - a summary of the historical data, assumptions of the block model, interpolation methodology, production scheduling scenarios and NPV for each scenario were included. The summary provided historical relevance for what the MHS study investigated.

A.1.2 Mineral Resource Management considerations

The MHS study was based on geological data that was not yet at an inferred level. In the absence of a topography of the area, borehole collar co-ordinates was used with a Google maps contour extract to estimate the elevations for a topography.

A resource model was compiled based on a basic interpolation of assays from drill-hole data and Auger samples. Large drill hole spacing provided data with a low level of confidence (less than inferred). In the MHS study, low confidence geological data was used effectively to draw attention to the investment potential of a project. The investment potential in turn was used to motivate a future drilling campaign.

Metallurgical test work on drill samples and bulk samples provided recoveries for the economic model. Metallurgical test work also searched for sub-elements, which could potentially affect the profitability of the product stream.

Three different production scheduling scenarios were governed by predetermined ideal slurry pumping rates in the processing plant. Within these rates, the deposits were scheduled according to 4 strategic approaches based on different product specifications. In total, 12 different schedule scenarios were evaluated according to NPV. The production schedules ROM feed was in turn used by Metallurgists to estimate process flow cost and recoveries. The MHS study showed evidence in strategic considerations that was considered in a multi-disciplinary involvement of geologists, metallurgists and mining engineers.

A.1.3 Mining operational considerations

In the MHS study, 6 different mining methods were considered:

1. Truck and Shovel
2. Shovel and conveying
3. Hydraulic monitoring and pumping
4. Track Dozers and pumping
5. Bucket Wheel excavators and conveying
6. Dredging and pumping.

A consideration for each mining method included the pros and cons of each with a relative weighting. From the considerations, a conventional truck and shovel operation were selected as the optimal mining method. The MHS study provided a systematic methodology for the evaluation of a relevant equipment choice, showing high level assumptions supplemented by logical methodology.

A.1.4 Economic considerations

Cost revenue and technical parameters were stated as between 25% and 50% accurate. Economic model input parameters were converted into unit costs and were based on historical data. A sensitivity study of +25% and -25% was done on the Capex, Opex and price which was based on the estimated accuracy.

Engineering, Procurement and Construction Management (EPCM) costs were assumed as a percentage (2%) of the total capital spent on the project. Freight costs were also assumed at a percentage (6%) of the total capital spent and was based on unit costs from similar operations. Factored costs provided scope and a quantum for future detailed calculations.

The MHS study document included considerations for the marketing of the final products. The final uses of the various products were explained in relation to product price. Product pricing for NPV calculations were provided by the MHS study owner. Maximum and minimum prices were modelled based on impurity levels and freight differential savings. An economic model was developed with all the input parameters.

The strategic objective defined by the project was to search for value. A predefined NPV was selected from which an average grade was back calculated. In a similar fashion, a break-even average grade was also calculated. Grade targets for the drilling campaign in turn was determined from the break-even average grade.

A.1.5 Safety, health and environmental considerations

The MHS study assumed a social and labour plan, environmental impact analysis, and port infrastructure similar to the neighboring operation of the client.

A.1.6 Risk considerations

Although it might be implied, no considerations for risk management were included in the MHS study document report.

A.1.7 Study work plan

As is the nature of a scoping study, future work was highlighted by various considerations within the MHS study. Although it might be implied, a detailed study work plan was not included in the MHS study.

A.1.8 Activities to be considered for value adding principles from the MHS study

Table A.1.8: Activities to be considered for value adding principles from the MHS study

Activity No	Category	Activity
MHSG01	General	The inclusion of a statement in the introduction of the report stating that the data used was too speculative for a feasibility study was included for the MHS study, promoting transparency.
MHSMR01	Mineral resource management	A summary of historical provided relevance for the MHS investigation.
MHSMR02	Mineral resource management	In the absence of a topography for the area, borehole collar elevations was used in conjunction with contours extracted from Google maps in order to estimate the elevations for a topography.
MHSMR03	Mineral resource management	A mineral resource model was based on basic interpolation of assays from drill-hole data and Auger samples which was associated with a low level of confidence (less than inferred). This was used effectively to draw attention to the investment potential **for** a project. The investment potential in turn was used to motivate a future drilling campaign.
MHSMR05	Mineral resource management	In total, 12 different schedule scenarios was evaluated as strategic alternatives to determine the scenario with the highest NPV in an option analysis.
MHSM01	Mining Considerations	A consideration of 6 different mining methods along with a quantitative evaluation of each (Pros and Cons), eliminated alternatives for subsequent detailed studies. One of the mining methods were selected for further considerations.
MHSE01	Economic considerations	EPCM costs was assumed as a percentage (2%) of the total capital spent on the project. Freight costs were also assumed at a percentage (6%) of total capital spent. Such factored costs provide scope for future study cost estimations.
MHSE02	Economic considerations	One of the strategic objectives of the project was to search for value. A predefined NPV was selected from which an average grade was back calculated. In a similar fashion, a break-even average grade was also calculated which served as a grade target for the proposed drilling campaign.
MHSE03	Economic considerations	The expected study accuracy is stated to be between 25% and 50% for the MHS study. Based on this a sensitivity study of +-25% was done for OPEX, CAPEX and product price.

Table A.1.8 Continued

Activity No	Category	Activity
MHSEH04	Environmental, Safety and health considerations	The MHS study assumed a social and labour plan, environmental impact analysis and port infrastructure similar to the neighboring operation owned by the study initiator.

A.2 The Copper Silver Desktop study in Namibia – a case study.

The Namibia Copper Silver desktop study (hereon referred to as the NC study), located in the central parts of Namibia, considered a shallow oxide deposit of copper with silver as a by-product. The NC study included considerations for an optimal surface mining operation, a geological resource estimation and a conceptual processing plant design.

A.2.1 General considerations

In the executive summary of the document, all economic parameters considered in the study were presented for each scenario. All the inputs and assumptions for the NC study were tabled (Table A.2a) in the executive summary. The table also included technical parameters used for the conceptual design of the pit, dimensions of the resource block model and modifying factors. In the table, the data used for each option is shown for the option analysis. Presenting important data in the executive summary promoted a sense of transparency for the reader.

Table A.2a: Economic input parameters for the NC study

Parameter	Unit	Option 1a	Option 1b	Option 2
Base Currency		USD	USD	USD
Exchange Rate	ND:USD	10	10	10
Discount Rate (real)	(%)	10 %	10 %	10 %
Commodity Price				
Copper (Cu) Metal	(USD/t)	$7 373	$7 373	
Copper (Cu) Concentrated filter cake w/w % of 27 %	(USD/t)	$-	$-	$7 118
Silver (Ag) Metal	(USD/oz)	$-	$-	$24.00
Government Royalty	(%)	4 %	4 %	4 %
Inland Freight Rate	(USD/tkm) metal	0.09	0.09	0.09
Distance from mine to port	km	400	-	-

Table 3.2a continued

Parameter	Unit	Option 1a	Option 1b	Option 2
Selling Cost - Transport - Inland Freight	(USD/t) metal	$36.53	$136.75	$194.44
Selling Cost - Transport - Port Charges	(USD/t) metal	$42.84	$42.84	$-
Selling Cost - Transport - Sea Freight	(USD/t) metal	$37.14	$37.14	$-
Selling Cost - Transport - Marine Insurance	(%)	0.35 %	0.35 %	$-
Selling Cost - Smelting & Refinery	(USD/t) metal	$-	$-	$2 548.6
Diesel Cost	(USD/L)	$1.10	$1.10	$1.10
Power Cost	(USD/kWhr)	$0.12	$0.12	$0.12
Mining Block Model Dimensions:				
Block Model Name				
Origin	X(m), Y(m), Z(m)	787 250, 7 402 550, 1 200		
Extent	X(m), Y(m), Z(m)	788 250, 7 403 250, 1 350		
Block Size	X(m)xY(m)xZ(m)	12.5x12.5x5		
Geotechnical Design Parameters				
Weathered strata				
Slope 1	(deg)	35	35	35
Fresh strata				
Slope 2	(deg)	45	45	45
Ramp Width:				
Two-way	(m)	15	15	15
One Way	(m)	11	11	11
Ramp Gradient	(1:)	10	10	10
Mining Modifying Factors				
Dilution	(%)	5 %	5 %	5 %
Moisture in ore:	(%)	2 %	2 %	2 %
Ore Loss	(%)	5 %	5 %	5 %

A.2.2 Mineral Resource Management considerations

The NC study mineral resource estimation included ore classes: inferred, indicated and measured material. Only 10% of the total resource consisted of measured and indicated material. A clear classification (Measured, Indicated and Inferred) of the confidence levels associated with resource material helped to understand the risks associated. Block modelling work (Re-blocking) was done according to an appropriate practical block size of 12.5 x 12.5 x 5m, a block size which would typically be mined with smaller sized equipment.

The overall geotechnical slope angles for weathered and fresh material were stated from a neighbouring operation. High level modifying factors were used for the NC study:

- 5% for dilution with a 0% diluted grade.
- Moisture in the ore were incorporated in the calculations.
- A geological ore loss of 5% was used.

The inclusion of high level modifying factors tested the robustness of the economic viability of the orebody.

Pit optimisation

This section describes the pit optimisation practices highlighted by the NC study.

The NC study pit optimisation input parameter sheet contained a detailed breakdown of processing costs, which can often be one of the highest operating costs for a mine. All economic input parameters were presented for approval and sign-off to the NC study project owner prior to commencing with the pit optimisation.

Three processing and transporting scenarios were considered in an option analysis for the NC study:

1. Direct selling and transporting of ore from the mine to the harbour
2. Treat the ore and transport of a "concentrate" to the harbour
3. Transport of the ore to a nearby processing facility owned by NC study stakeholders.

The Run of Mine (ROM) processing tonnage was determined by the NC study owner to slot into a strategic long term plan for the company. The ROM tonnes was the main strategic limitation for the project size.

The option analysis for the scenarios was done by using pit optimisation software which incorporated the economic input parameters for the three different scenarios. Using the Lerch-grossman algorithm, the software created "nested" pit shells and calculated a revenue for each pit shell. (See addendum for explanation) The revenue of each pit is presented as a factor of the Metal price. A "0.8 factor revenue pit", for example, would represent the optimal economic limit at 80% of the current metal price. Often, a smaller size pit (with a lower revenue factor pit) would yield a higher NPV due to the dynamic nature of the orebody. From these scenarios, a revenue 1 pit was selected for comparative purposes, which is common industry practice. A smaller revenue factor would typically target high grade shallow material. The revenue factor pit with the highest relative Net Pesent Value (NPV) at 10% discount rate was selected as the optimal scenario for the NC study. Pit optimisation software provided a standardised approach to high level option analysis, ensuring comparability in scenarios.

A Sensitivity study was done using the pit optimisation software, which showed the effect on NPV with of +20% and -20% incremental changes in Price, CAPEX, Tax and OPEX in 5% increments. The sensitivity study showed that the project was most sensitive to metal price changes, which provided emphasis for future marketing studies.

Capital expenditure was excluded in the pit optimisation, and it was stated that optimisation results would be used for value comparison purposes only. Project profitability would be evaluated by the project financial model, which would include tax, rehabilitation, capital replacement and sensitivities. Such pit optimisation comparison methodology affirmed that a conceptual study is useful to evaluate strategic company objectives in a structured manner.

Production Scheduling

From the pit optimisation shells, a pit design was done using design software. Since the pit design incorporated ramps and a bench configuration (as opposed to the pit shell), it contained 16% more waste, with 0.4% less ore. The pit designs ensured that waste amounts was not underestimated for calculation purposes in the scheduling process. The difference between a pit shell and a pit design is shown in Figure A.2.2.

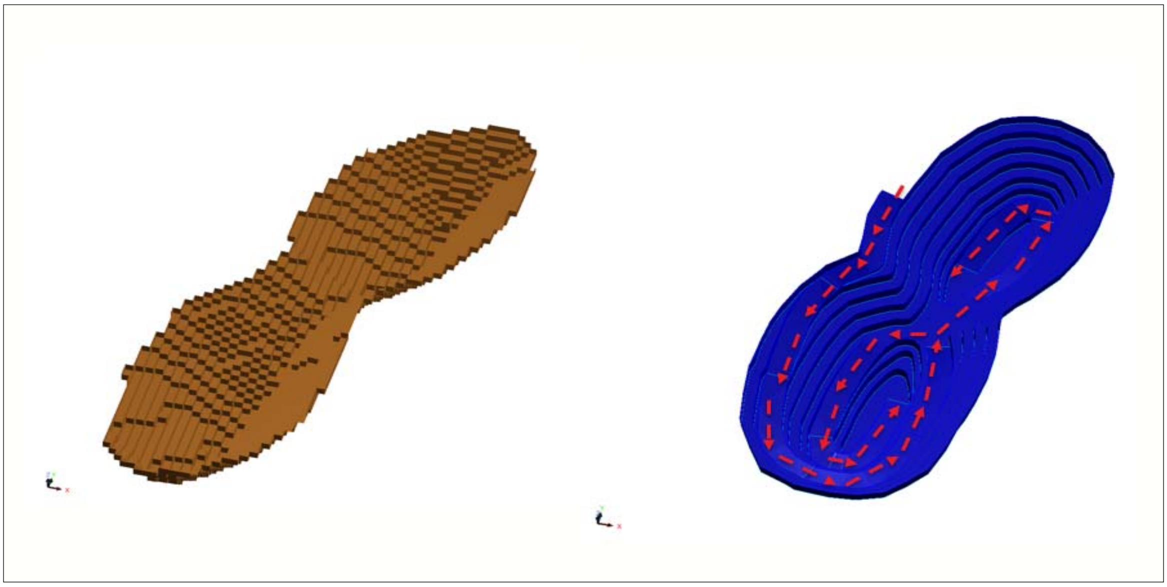

Figure A.2.2: Pit optimisation shell vs Pit design with ramps

It was stated that the mining exploitation strategy was governed by three principles:

1. Maximising grade to the mill in the early years
2. Deferring waste stripping into the future
3. Ensuring design criteria such as overall and batter slope angles were achieved.

To achieve this, lower revenue factor pits from the pit optimisation was selected for the initial pushbacks. This methodology enabled the deferring of waste stripping to reach higher grade ore at the start of the project. An annual mining production schedule was shown with the different pushbacks. Production scheduling software was used to determine an optimised mining rate based on the processing capacity of the plant, required metal tonnes and required grades. Such methodical approach to open pit mine scheduling set scope for future studies to ensure an optimised exploitation strategy.

A.2.3 Mining operational considerations

Smaller sized tipper trucks were considered for mining due to its flexibility and low risk capital expenditure up-front. The production tonnes were less than 800ktpa which was considered suitable for smaller sized equipment, which allows selective mining. The mining strategy assumes in-pit back filling to be done, with only the remaining waste to be stored on an existing nearby waste dump with sufficient remaining capacity. Such practical considerations provided information for future studies in developing a detailed backfilling strategy.

A mining equipment study was also done from first principles. For each year, an average hauling distance from the centre of gravity of mining to the dumping/stockpiling area was used to calculate truck cycle times. The equipment simulation assumed that 25% of all ore will be sent to a Run-of-mine stockpile to be re-handled. The simulations provided tonnes/hour rates for trucks and hydraulic loaders which was used to determine the amount of trucks and shovels required. The inclusion of a mining equipment study delineated the scientific methodology followed to determine equipment totals.

For blasting calculations, a powder factor was calculated based on the hardness of the rock. The blasting considerations also included a proposed pre-split design. Average drill hole spacing and hole diameters for the different materials / rock types along with powder factors for ore and waste material was calculated from first principles. From these parameters a unit cost ($/t) was calculated for usage in the OPEX model. The NC study showed that – in the absence of good assumptions, calculations from first principles can be used as a substitute.

A.2.4 Economic considerations

A deferred product sale of 5 months was shown in the cash flow models which reflected lower revenue for the 1st production year. This implied that the first year's higher grade ore was deferred to the 2nd year's sales. 80% of the CAPEX for the processing plant was allocated to the pre-production year, with the remaining 20% allocated to the 1st year of production. Such practical considerations based on sound methodology instils confidence in the estimation techniques utilised.

Capital cost estimations detailed processing plant capital costs per sector since it constituted the highest capital cost. It was stated that future exploration cost estimates and future technical study costs was not included in the cost estimation. A factor of 10% of the capital costs was allocated to mining infrastructure requirements. Since the life of the operation is relatively short (less than 6 years), no regard for equipment replacement capital was made. Capital costs were subdivided into initial, sustaining and replacement, and Mine closure CAPEX. Mine closure CAPEX were included at the end of the operation life and calculated as a percentage of the total CAPEX. Cost estimations was done according to the study owner's financial modelling policy and provided a systematic approach for comparability and transparency.

A contingency cost was included in the first year of production – expressed as a percentage of total capital spent (30%). In the study document it was emphasized that the cost estimation was at an order of magnitude level estimate which implies that cost-revenue and technical parameters were targeted to be +- 25 to 30% accurate.

Operating costs were split into fixed and variable costs. Equipment OPEX calculations were done from first principles using original equipment manufacturers (OEM) hourly life cycle cost estimates. For equipment operating cost calculations for primary, secondary and tertiary equipment - an hourly rate was calculated ($/hr) which incorporated fuel consumptions, lubricant costs, tires, drill bits, drill steel, ground engaging tools (GET) and wear parts. OEM provided tonnes per hour rates (t/hr) along with production tonnes from the production schedule was used to calculate OPEX unit costs. Estimated labour amounts based on industry standards and equipment / shift requirements were multiplied by typical "cost to company" salary rates relevant to Namibia. This accounted for the labour OPEX portion.

Such high level cost estimations based on OEM data is an example of combining scientific calculations with budget quote data to provide scope for future detailed cost estimations.

A.2.5 Safety, health and environmental considerations

Mention was made in the NC study document of safety, dust suppression, noise, vibration, landform and waste products management as pertaining to the potential effects it would have on mining in the area. The NC report stated that "In-pit" water management and haul road dust suppression would have to be calculated in more detail in subsequent studies. Such considerations provided scope for future studies.

A.2.6 Risk considerations

Capital projects risk was considered under a 5 x 5 risk matrix, whereby the potential consequences and likelihood of each heading under a conceptual study was considered. For each item, a risk rating was allocated according to a low, medium, significant and high risk level (see Table A.2.6). A multiple variable impact sensitivity analysis was done based on the risk matrix which compared all the main variables selected. Project risks highlighted areas of concern which would require attention in developing future risk management strategies.

Table A.2.6: Project Financial risks matrix of the NC study

RBS - Item	Name	Description	Consequence	Likelihood	RR	RL
Geoscience	Resource Estimation	Likelihood of Inferred material becoming reserve	High	Unlikely	14	Significant
Mining & Geology	Primary equipment matching	Choice of equipment and ability to do job	Moderate	Unlikely	9	Medium
	In-Pit waste dump design	Capacity management over LoM	Minor	Likely	12	Medium
Plant & Process	Processing recovery	Chances 80 % is not achieved	High	Possible	18	Significant
	Availability of water	Water not available from BH	High	Possible	18	Significant
Engineering, Maintenance & Procurement	Skilled labour	Difficulty finding skilled labour	Moderate	Likely	17	Significant
Infrastructure	Terrain	Challenges erecting infrastructure	Insignificant	Unlikely	2	Low
Marketing & Off-take	Price	Sensitivity	High	Likely	21	High
	Selling cost	Transport cost accuracy	Moderate	Likely	17	Significant
Business & Financial	OPEX	Accuracy	Minor	Likely	12	Medium
	CAPEX	Accuracy	Moderate	Likely	17	Significant
Environment	Contamination	Heap Leach	Major	Possible	22	High

A.2.7 Study work plan

A chapter was included with recommendations for further work which outlined some of the areas of focus for a prefeasibility study. The NC study did not include a detailed study work plan. Per implication, many of the considerations in the report did however set scope for further studies.

A.2.8 Value adding activities from the NC desktop study

The activities evaluated for the NC study is shown in Table A.2.8.

Table A.2.8: Value adding activities from the NC study

Activity No	Category	Activity
NCG01	General	A table with all the project assumptions and economic input parameters were presented in the introductory section of the study. This provided a sense of transparency to the reader. It is assumed that the typical reader of the document would be techno-financially inclined, and would want to get down to the bottom-line of what the project report is stating.
NCG02	General	Most of the financials such as the mining, processing unit costs and equipment costs were based on a recent technical study that was done for a mine nearby.
NCMR01	Mineral resource management	Overall geotechnical slope angles for weathered and fresh material were sourced from a neighbouring operation with similar geotechnical parameters.
NCMR02	Mineral resource management.	Generic modifying factors were stated for the study Dilution – 5% Geological loss – 5%
NCMR03	Mineral resource management.	A pit design was done from the selected pit shell. The pit design included 16% more waste than the 3D pit optimisation shell which was produced. The pit design also included 0.4% less ore than the optimisation shell.
NCMR04	Mineral resource management.	An option analysis was conducted between various scenarios considering the processing and transporting of ore. This was done within the pit optimisation software and was compared on the basis of tonnage, relative NPV and strategic objectives.

Table A.2.8 continued

Activity No	Category	Activity
NCMR04	Mineral resource management.	A sensitivity analysis was done within the pit optimisation software, considering +- 20% increases / decreases in OPEX, CAPEX and tax. This was done in 5 % increments. The sensitivity study provided areas of focus for future work.
NCMR05	Mineral resource management.	An exploitation strategy and subsequent production schedule was developed from the pit optimisation results. Such methodology ensured a balance between – maximizing grade in the early years, deferring waste stripping, and thereby maximising cash-flow according to the strategic initiative of the mine.
NCM01	Mining Operation	Smaller sized equipment were motivated due to its flexibility and low risk capital expenditure up-front. Such practical considerations provided information for future studies in developing a detailed backfilling strategy
NCM02	Mining Operation	A mining equipment study was done using equipment simulation software. This provided results such as cycle times, periodical hauling distances and amount of equipment totals required.
NCE01	Mining Economic considerations	The cash flow model allowed a deferred product sale of 5 months - a practice which closely matches reality.
NCE02	Mining Economic considerations	The NC study author stated that future exploration cost estimates and future technical study costs was not included in the cost estimation. Including such costs sets scope for future work to be performed.
NCE03	Mining Economic considerations	Capital cost estimations done was according to the study owner's financial modelling policy. Such a systematic approach provided comparability and transparency.

Table A.2.8 continued

Activity No	Category	Activity
NCE04	Mining Economic considerations	Operating costs for mining was split into fixed and variable costs. Equipment related operating cost was deducted from first principles using quotes from original equipment manufacturers (OEM).
NCE05	Mining Economic considerations	It was stated that an order of magnitude estimation was targeted to be +- 25% to 30% accurate. A capital contingency of 30% was included in the cash flow model as a result.
NCRM01	Risk Management considerations	A 5 x 5 financial risk matrix was included in the NC study. Each item was quantified with a risk rating in the matrix.

A.3 The Phosphate scoping study in Guinea-Bissau – a case study.

The Guinea Phosphate scoping study (hereon referred to as the GP study) is located in the Northern central part of Guinea-Bissau. The GP study consisted of a high grade sedimentary phosphate deposit of one continuous phosphate bed, extending over a large area. A preliminary economic assessment (PEA) was done prior to the GP study and was used to motivate a scoping study.

The GP study included considerations for:

5. Additional mining methods (Dredging) not covered in the PEA
6. Processing plant considerations
7. Suitable location for waste dumping and tailings disposal facilities
8. A slurry pipeline of 80km linking the mine site to a proposed port facility.

The study was conducted by a European based consultant, who made use of an expert mining consultant on phosphate deposits from Colorado, USA.

A.3.1 General considerations

Scoping study report principles

The main focus of the GP study was to set the scope for critical work that would be required for the next study phase. The GP study report did not include a financial appraisal of the project, but made reference to a preliminary economic assessment (PEA) done prior to the study. The GP study report – focused mainly on gaps in the available information. The first chapter of the GP study consisted of an overview of existing work, revisiting historical information relevant to the study.

Site visit

Although not necessarily required, a site visit was done prior to commencement of the GP study. The site visit was accompanied by a multi-disciplinary team consisting of: 2x Environmental specialists, 2x Mining Engineers, and a Civil/Geotechnical Engineer.

During the site visit, interviews were held with local contractors to determine available capacities for mining. The site visit included meetings with local authorities to identify potential government department's roles and involvement. An attempt was also made to access topographical maps from the director general of topography in Guinea-Bissau. Meetings were held with port authorities and the director general of hydrology. These meetings were aimed at identifying potential pitfalls of the project early on.

During the site visit it was discovered that the area considered for waste dumping by PEA study, was a swampy wetland, unsuitable for the building of a waste dump. From the site visit, a suitable area was identified for waste dumping / tailings facility building. The GP study showed therefore that a site visit conducted within a scoping study is crucial in identifying potential risks to the project.

A.3.2 Mineral Resource Management considerations

Since a mineral resource PEA was done just prior to the study commencement, the GP study did not include any pit optimisation, pit designs or production scheduling.

A.3.3 Mining operational considerations

Multiple mining / dredging methods were considered during the PEA. Since dredging is somewhat of a niche methodology for surface mining, the GP study incorporated the assistance of a dredging expert consultant from the United States. The dredging expert assisted in identifying gaps in the information. Such information gaps included the absence of: a dredge mining layout, mining lifts, water balance and production rates. The dredging expert also pointed out the potential environmental impact that dredging would have on the community concerning the effects on groundwater levels. The GP study is a good example of critical information sharing within a multi-disciplinary approach to conceptual studies, assisting to further understand the risks associated. The inclusion of external experts also assisted in pointing out significant risks to the project which might have been overlooked.

A.3.4 Economic considerations

The GP study made reference to a PEA which was done according to the Canadian National Instruments - NI 43-101 – code for reporting of preliminary mineral resource results. The details for the PEA were not available for inclusion in this dissertation.

It was stated that the PEA was done with a cost accuracy of 25% and that a conceptual design (the next proposed phase of the project) would take in excess of 18 months.

A.3.5 Safety, health and environmental considerations

As mentioned, the external dredging expert pointed out concerns in maintaining groundwater levels as an environmental concern. The environmental specialists delineated all natural resources and wetlands during the site visit, which was used to find a suitable location for waste dumps and tailings dams. It was mentioned that future studies will have to address the health and safety of locals in the villages situated close to the mine.

A.3.6 Risk considerations

Although it might be implied, no specific mention was made to risk management considerations within the GP study.

A.3.7 Study work plan

A gap analysis was carried out for mining engineering, waste disposal management and geotechnical engineering. The approach was to firstly create a list of critical requirements for the next study phase and then discuss the gaps in the information. The main headings in the list included:

- Potential mineral reserve estimates
- Generalised mining and ore processing methods
- Mine and mill production rates
- Environmental issues and permitting requirements
- Preproduction period and mine life
- Mine and plant recovery rates
- Product(s) marketability
- Approximate range of project capital costs
- Approximate range of project operating costs
- Preliminary economic analysis with an assessment of its sensitivity to variation in the input parameters
- A list of long lead-time procurement items.

For the GP study, a paragraph was included for each of the items listed above which described the gaps in the information. From this information, a checklist was drawn up for the mining engineering work required to proceed to the next study phase (Table A.3.7). Within the checklist, the current availability and the proposed method of information gathering was shown, along with the estimated time for information gathering. Some of the data within the table were omitted for confidentiality reasons. The inclusion of a checklist provided a structured approach for future work to be done.

Table A.3.7: GP study conceptual design phase checklist

Required Information	Current Availability	Proposed Method of Information Gathering	Estimated Time for Information Gathering
Confirmation of extent of mining areas, preliminary infrastructure layout and design parameters			2 weeks
Establish block model values to determine relative revenues for use in mining costs			2 weeks
Determine preliminary cut-off grades for the Project			2 months
Mining equipment selection			2 months
Estimate mine capital and operating costs			2 months
Develop pit shells for mine planning			1 month
Mining legislation for Guinea Bissau			2 weeks (may take longer if translation isrequired)
Clear delineation of ore body and overburden			1 month (if required)
Topography of the mining areas			2 months
Surface lithology on the mining areas			9 week
Material parameters			3 months
Groundwater data			12 months (6 weeks for installation of boreholes)

A.3.8 Value adding activities from the GP desktop study

The GP study, though somewhat unique as a case study, was included for its emphasis on developing the scope of subsequent studies. Only a few activities were highlighted from the case study for consideration as value adding activities (See Table A.3.8).

Table A.3.8: Value adding activities from the GP study

Activity No	Category	Activity
GPG01	General	The GP study showed that a scoping study can be defined solely as a study which investigates gaps in the information for the next level of study. Per implication – the GP case study defines a scoping study solely as an evaluation of existing historical information with a strong emphasis on the gaps in information for a future conceptual design. The GP study showed that a Gap analysis evaluation provides a structured approach for setting scope for future studies.
GPG02	General	A multi-disciplinary site visit with specialists relevant to the proposed mining method identified critical considerations to be included in a conceptual design phase. During the site visit, external specialists pointed out significant risks to the project, which would need to form part of the scope for future studies.
GPG03	General	A checklist was provided for future work requirements. The checklist included: required information, a proposed method for information gathering as well as an estimated time for information gathering. A checklist will ensure a structured approach for future studies.

A.4 The Zambia Copper scoping study - a case study.

The Zambia copper scoping study (hereon referred to as the ZC study), is located in the Central parts of Zambia. The study was done by a prominent international mining consulting firm. The main intention of the scoping study was to provide an overall opinion of the technical and financial merits for the project in order to aid the decision making for further investments in the project.

A.4.1 General considerations

The executive summary of the ZC study highlighted areas of major concern for the project in terms of the Geology, Processing and Mining. Reference was made to an environmental site visit report which considered future vegetation removal and village relocation potential as major risks for the project. It was also clearly stated that the ore body dissects a floodplain which may hold regulatory and environmental impacts going forward. In the executive summary, it was stated that the following should be further investigated in a hydrology study:

- 1 in 100 year and 1 in 50 year flood-line positions
- Groundwater levels during dry and wet season
- Potential river diversion options and water inflows

Highlighting the major risks and concerns within the executive summary of the document provided the reader with an overview of the important issues investigated within the ZC study.

A statement of independence was included in the introductory chapter, stating that none of the key personnel involved in the project had any vested interest in the project, and that work done was done strictly for professional fees. It was also clearly stated that the mineral inventory tabulated is not SAMREC or JORC compliant. A statement of independence ensured the reader that the study compiler was independent and unbiased in the estimation.

A.4.2 Mineral Resource Management considerations

Geology

The ZC study included a review of historical information and a gap analysis to identify what needed to be done to get a resource up to standard for reporting under the JORC code. Included was a statement that resource models did not comply with a JORC, SAMREC or NI43-101 code’s standards for resource declarations, and might be overstated in tonnages. Such statements is a requirement by most mineral valuation codes and ensures that the relevance and nature of mineral resources is clearly understood.

The ore mineralisation was described according to likely processes which would suite its characteristics. Two possible mineral processing options was identified and evaluated in an option analysis. The processing options were based on operations with similar mineral resources (Oxides and Sulphides).

A chapter describing the geological history relevant to mining was included. A description of each of the drilling campaigns included the types of holes drilled, hole spacing and the logic behind it. The stratigraphy was described in detail, with reference to rock weathering and at what depth the weathering occurs. The depth of weathering is an important consideration for quantifying the amount of drilling and blasting which would be required for future studies. A description of the geology – relative to likely mining and processing methods promoted multi-disciplinary involvement early on in mine project development.

Pit Optimisation

A pit optimisation study was conducted for the two processing alternatives in an option analysis. The pit optimisation considered economic input parameters from similar processes. The following modifying factors were used for the study:

- Geological losses of 15%
- Mining losses of 10%
- Dilution of 7.5% dilution.

For each option, optimistic, realistic and pessimistic input parameters were evaluated, and the pit shell with the highest NPV was selected as the final pit for the option analysis. Performing an option analysis with a range of possible input parameters, helped in understanding the variability associated with the project.

A revenue factor 2 pit was used as an outline for infrastructure positioning. A revenue factor 2 pit represents the economic limit of the mine if the metal price would be doubled. Using a revenue factor 2 pit for pit infrastructure delineation is a conservative approach to limit potential future sterilisation of ore.

Production schedule

Nested pit shells were selected as pushbacks for scheduling within the pit optimisation software. Pit optimisation software can usually provide a production schedule in much less time than conventional scheduling packages. It was therefore possible to provide a high-level production schedule for each of the alternatives in the option analysis.

The production schedule contained a variable waste ton schedule which of which the outputs from the software was smoothed in excel. Waste smoothing was done to reduce year on year variations in equipment requirements. It was stated that although the smoothing of a waste schedule could be detrimental to the NPV of the project, it is more practical for equipment planning.

A.4.3 Mining operational considerations

A start-up and steady state equipment list was provided for the ZC study. This assumed that not all equipment will be purchased in the first year of production, spreading the capital spent over two years. The study furthermore assumed that the mine would purchase a fleet of equipment which will be operated and managed by a contractor. A contractor mining cost was therefore used for OPEX calculations - based on an operation of similar tenure. By selecting and quantifying such an assumed mining method along with the equipment selected – value is added by setting scope for further detailed mining work in subsequent studies.

A.4.4 Economic considerations

For the ZC study, a 40% Accuracy level is stated and assumed. It was stated that the study cannot be used to prove financial feasibility, and that it is only provided as a techno-economic basis on which an investment house may proceed with further investigations and/or development of the project. Such a clear statement is prescribed by major mining valuation codes. High level capital and operating costs were assumed along with contractor mining. Steady state operating costs were presented per mining activity.

The ZC study included a structure for presenting operating costs for the project. Costs were adjusted for confidentiality. Summarising unit costs as displayed in the table provided the reader with a good structure for reference.

Table A.4.4a: ZC Operating cost summary

Activity	Unit	US$
Direct Mining cost	USD/bcm	5.00
Mining Overhead cost	USD/bcm	3.00
Rehabilitation costs	USD/bcm	1.00
Processing Plant – Oxide & Mixed	USD/t treated	15.00
Processing Plant – Oxide, Mixed and Sulphide	USD/t treated	25.00
Bulk Services	USD/ROM	0.30
Roads - maintenance	USD/ROM	0.50
Processing Plant Area - maintenance	USD/ROM	0.15
Building Structures - maintenance	USD/ROM	0.05
Vehicles and Mobile Equipment for plant	USD/ROM	1.05
Transport Cost of product	USD/tonne.km	0.20

For the ZC study, a sensitivity analysis on NPV was included in 5% increments. The sensitivity analysis showed that the NPV is most sensitive to Revenue (Figure A.4.4), and that the project is still profitable even if the revenue is reduced by 20%, providing an indication of the "robust" nature of the project.

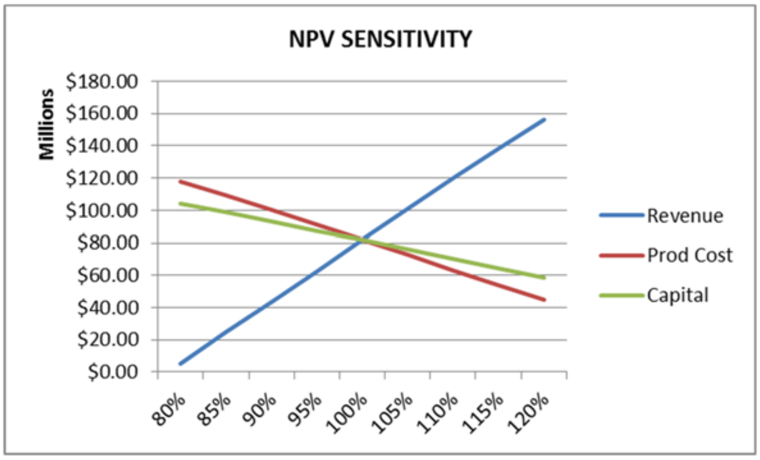

Figure A.4.4: NPV sensitivity example for the ZC study

Capital costs for the ZC study were broken down into the categories shown in Table A.4.4b. (Values were omitted for confidentiality). The ZC study considered pre-stripping as a capital expenditure. Survey equipment & planning software was also included as CAPEX, which is often an underestimated expenditure. A contingency of 15% was included in the CAPEX estimation.

Table A.4.4b: Capital cost breakdown for the ZC study

AREA	Option 1	Option 2
Mining		
Pre-stripping		
Survey Equipment & Planning Software		
In-pit infrastructure (pumps, piping)		
Site Establishment/ De-Establishment		
Engineering		
Bulk Services		
Roads		
Processing Plant Civils		
Building Structures		
Office Equipment and Furniture		
Stores Inventory		
Maintenance Tools and Equipment		
Vehicles and Mobile Equipment		
Treatment Plant		
Treatment Plant Capital		
Contingency (15%)		
Closure Costs		
TOTAL		

A brief explanation of the expected future market value of the commodity was included. An overview of current market trends at the time were provided. The ZC study also included a NPV to discount rate sensitivity analysis providing scope for investors to determine at what discount rate money can be borrowed.

A.4.5 Safety, health and environmental considerations

A reference to monthly average Rainfall graph was included, which considered scope for potential pit dewatering calculations that would be required for the area.

A.4.6 Risk considerations

A chapter was included to summarise all the predominant risks under the different headings. Each risk was rated as a Low, Moderate or High risk (Table A.4.6.) From the risk summary, it was clear that future work will have to focus on developing the mineral resource, which posted the highest risk.

Table A.4.6: Project Risk summary for the ZC Study

Item	Relative Risk
Geology and Mineral Resources	Moderate to High
Mining	Moderate
General Engineering and Site Infrastructure	Low to Moderate
Metallurgy and Processing	Moderate
Capital and Operating Cost Estimates	Low to Moderate
Project Economics	Moderate

A.4.7 Study work plan

A chapter was included which discussed foreseen risks and opportunities for further work. Although it might be implied by the ZC study (A scoping study), no specific mention was made to a study work plan for future work.

A.4.8 Value adding activities to from the ZC desktop study

Table A.4.8: Value adding activities from the ZC study

Activity No	Category	Activity
ZCG01	General	A site visit was undertaken prior to the study. A site visit conducted by experienced professionals assisted in addressing issues of significant risk to the project.
ZCG02	General	A statement of independence from the external consultant who conducted the ZC study ensured the reader that the consultant did not have any conflict of interest in the project.
ZCG03	General	In general, the the ZC study took great care to ensure that the reader clearly understand that the report does not comply with the relevant mineral valuation codes to prove feasibility. The statement emphasised that such speculative geology are often over stated and that the study cannot be used to prove feasibility. This promotes a sense of transparency and objectivity to the financial appraisal of the project.
ZCMR01	Mineral resource management	A description of the selected mineral processing options were included and merited from the available resources (Sulphides and Oxides).
ZCMR02	Mineral resource management.	A description of the geology as it relates to mining was included. This included a brief description of the exploration drilling campaigns with reference to borehole spacing and the logic behind it. The weathering of strata was discussed, which is an important consideration for drilling and blasting practices.
ZCMR03	Mineral resource management.	Modifying factors were applied in the ZC study: Geological losses of 15% was applied along with mining losses of 10% and dilution of 7.5%.
ZCMR04	Mineral resource management.	Included in the pit optimisation portion of the ZC study was a description of how the pit limit was deducted for the infrastructure and permanent structure positioning. A revenue 2 factor pit was chosen, which provided for sufficient space next to the pit to ensure that permanent infrastructure would not potentially sterilise future ore if the metal price increased.

Table A.4.8 continued

Activity No	Category	Activity
ZCMR05	Mineral resource management.	Scheduling was done with the use of the pit optimisation software. The pit optimisation software provided high level schedules which usually takes less time to complete than conventional scheduling packages.
ZCM01	Mining Operation	An equipment list was provided which showed that the purchasing of mining equipment would be spread over two years. It is assumed that contractor mining would be done with equipment owned by the mine.
ZCE01	Mining Economics	A 40% accuracy level is stated overall for the study.
ZCE02	Mining Economics	The ZC study cost estimation included an operating cost summary table which showed the unit costs of all the major components of the study expressed as unit costs ($/BCM, $/tonne treated, $/ROM). This promoted a sense of transparency within the cost estimation.
ZCE03	Mining Economics	A sensitivity analysis on NPV was included for the ZC study. The analysis showed % changes in Capital, Revenue and production cost. In addition - a NPV to discount rate sensitivity was also included which showing the effect on NPV for the different rates at which capital can be borrowed for the project. This approach set scope for areas of focus for the next level of study.
ZCE04	Mining Economics	A capital cost contingency of 15 % was included for the study to cater for potential price escalations, since most costs was based on a study of similar tenure.
ZCR01	Risk Management	A chapter summarising predominant project risks was included in the ZC study. A relative risk rating (low, Moderate, high) for each of the chapters were included. This approach highlighted specific areas of concern – directing scope for future work.

A.5 The Guinea Iron ore Concept study - a case study.

The Guinea Iron ore scoping study (hereon referred to as the GI study) investigated a Greenfields deposit located in Guinea, West Africa. Various ore beneficiation, ore transport and ore production scenarios were considered by the study.

A.5.1 General considerations

The study report was less than 50 pages and was based on very high level estimations and assumptions. Overall, the study provided an optimistic estimation based on limited data available, showing that a conceptual study can be based on high level optimistic data.

A.5.2 Mineral Resource Management considerations

The mineral resource considered for the scoping study was based on less than 10% of the target resource for exploration. As a base case the economics were determined on less than 10% of the existing information available. It was stated that the ore under consideration represented the shallow portion of the resource. The main objective of the study was to provide inputs for the consideration on whether the current drilling campaign should be allowed to continue.

The GI study supposed that at least 5 x more ore than was quantified thus far in the exploration would be realised. The ore body was therefore crudely extrapolated accordingly. A production scheduling scenario considered extrapolated tonnes mined per annum, on which an economic estimation (Cash flow & NPV) was done. This high-level approach set scope to evaluate a potential size of the resource for future exploration targets and drilling campaigns.

Two ore beneficiation options were investigated for the GI study. The beneficiation options assumed respective mass yields, capital and operating costs from a neighbouring mine. In addition to the two beneficiation options, the transporting of the ore to a nearby harbour evaluated road and rail transport systems – which for developing countries is often the highest unit cost in the mining cycle. Ore transport distances estimations were done using “Google earth” – with a 40% contingency allowance for terrain variations. The GI study therefore considered multiple processing and ore transporting options which would set scope for future studies.

A simple production schedule was done in Microsoft Excel (bench by bench schedule) on the inferred portion of the resource. The schedule implied that mining will take place from top to bottom in benches which would increase the stripping ratio over time. Since input data was based on broad assumptions and speculative geology, an excel schedule is appropriate since it would take less time to complete than production scheduling software.

A.5.3 Mining operational considerations

Potential mining production rates were recommended by the study owner to fit in to a predetermined corporate strategy and rail capacity available. Three different mining rates were considered in an option analyses. Contractor mining unit cost rates were sourced from an external consultant to which a 20% margin was added.

A.5.4 Economic considerations

Indicative costs for a processing plant was sourced from an external consultant. All costs were expressed in unit costs ($/t and $/BCM). A metal price per tonne product was based on marketing studies undertaken by an external consultant. Since the transporting of ore to the market is often the highest cost associated with iron ore, a detailed breakdown for the transport unit costs was included in the report. Included in the estimation were typical costs associated with port re-handle, barging costs and trans-shipping costs.

Capital costs were estimated based on consultant databases. Capital costs included the potential purchase of locomotives and wagons for rail transport, port construction, ship loading equipment and associated infrastructure. It is stated in the GI study that beneficiation costs were based on verbal communication from a reputable consultant. An indicative cost accuracy of 50% were stated as provided by the external consultant. The use of external consultants proved a useful source for information for the GI study. The GI study is a good example of how reasonable, logical assumptions was combined with indicative costs and speculative geology to provide a high-level project valuation.

A.5.5 Safety, health and environmental considerations

Although it might have been implied, no mention was made of safety, health and environmental considerations.

A.5.6 Risk considerations

Although it might have been implied, no mention was made of Risk considerations.

A.5.7 Study work plan

Although it might have been implied, no mention was made of a future study work plan.

A.5.8 Value adding activities from the GI study

Table A.5.8: Value adding activities from the GI study

Activity No	Category	Activity
GIMR01	Mineral resource management	The mineral resource was based on less than 10% of the exploration target consisting of shallow ore. The ore was crudely extrapolated and assumed that exploration would discover at least 5 times more ore of similar nature.
GIMR02	Mineral resource management	2x processing options along with 3x ore transport options and 3x production capacities scenarios were considered for the study in an option analysis – showing the purpose of a conceptual study a place to do high level option analysis.
GIMR03	Mineral resource management	A bench by bench excel production schedule was done based on an extrapolated inferred mineral resource. Excel production schedules take less time than conventional production scheduling software.
GIM01	Mining operation	For mining - contractor rates were sourced from an external consultant to which a 20% margin was added.
GIME01	Mining Economic considerations	An external consultant was used to source indicative costs for the processing plant for the three production scenarios as well as price per tonne product.

Table A.5.8 continued

Activity No	Category	Activity
GIME02	Mining Economic considerations	A table with a detailed breakdown for the transport cost - to deliver ore to the market - was included since the transport of material are often the highest cost associated with a project in developing countries.
GIME03	Mining Economic considerations	An indicative cost accuracy of 50% was stated for the GI study

A.6 The DRC Copper mining concept study - a case study.

The Democratic Republic of the Congo (DRC) copper study (hereon referred to as the "DC study") is located in the Katanga province North West of Lubumbashi. The deposit forms part of the Katanga "copperbelt" - a large region of 300 km long by 50 km wide, stretching all the way to the Zambian border. The DC study investigated the potential benefits of expanding the current operation to a multiple open pit operation with its own central ore processing facility.

A.6.1 General considerations

Within the executive summary of the DC study document, the main issues that were addressed within the study were summarised in a bullet format:

- Determining the optimum location of a processing plant to minimise ore hauling
- Conceptual design of the open pit areas and determining the sequence for mining ore resources to Maximise NPV
- Determining specifications of an optimum contract mining fleet

Providing such a summary within the introductory chapter provided with a clear understanding of the specific purposes that the DC study wanted to address.

A.6.2 Mineral Resource Management considerations

For the DC study, the format of the mineral resource model took cognisance of the likely mining method, and the block sizes were modelled accordingly. The mineral resource consisted of a regular sized 10 x 10 x 5m block model, modelled to fit smaller sized equipment according to a Smallest Mining Unit (SMU) – methodology. Mining losses of 10% and dilution of 10% were used. Measured, indicated and inferred mineralised material were included for the pit optimisation. The SMU methodology renders the DC study as a good example of the early involvement of mining engineers in the geological modelling, ensuring that data prepared is relevant for mining.

Within the block model, ore was classified according metallurgical done in previous studies. The occurrence of high amounts of calcium were flagged since it would increase the gangue acid consumption in the processing facility. Production scheduling attempted to blend in the calcium rich ore so as to limit costly gangue acid consumption in the processing facility. It is evident that within the

DC study, the early involvement of Metallurgists, Mining Engineers and Geologist served to add value to the study evaluation.

The plant capacity used in the production schedule was based on a previous study done by a prominent metallurgical consultant. The DC study related the foreseen metal tonnes produced to the market size for supply of the metal in question. It was stated that production of the plant in question might lead to a potential oversupply of copper and a subsequent decrease in metal prices. This provided scope for a detailed market study to investigate optimal plant capacity.

Pit optimisation

To facilitate the pit optimisation, a high level process flow was included (see example in Figure A.2.6)

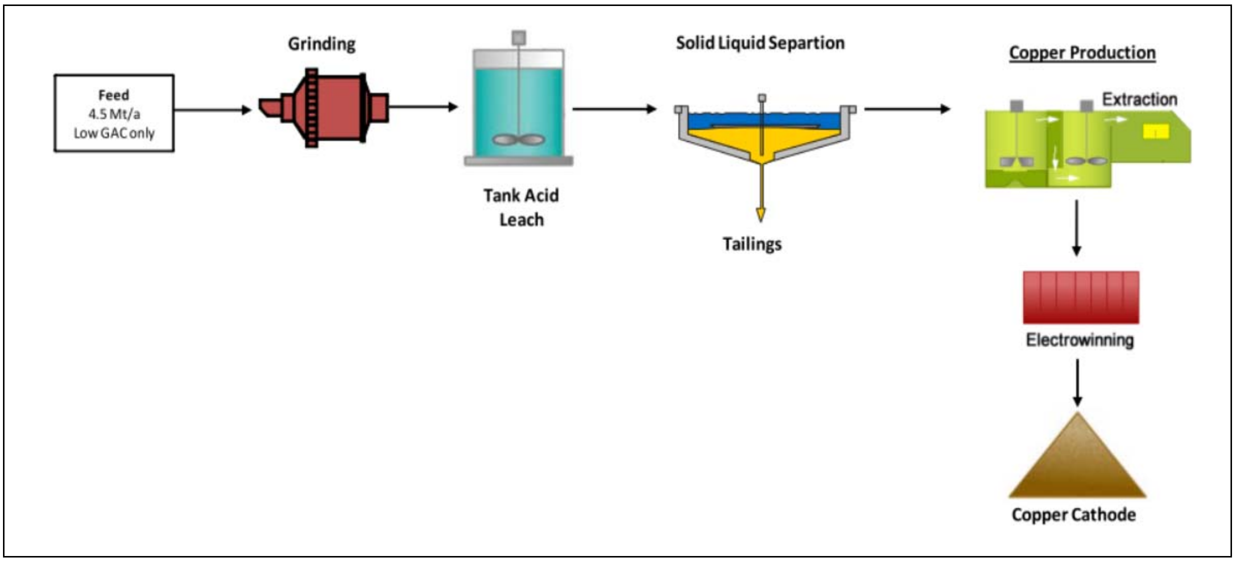

Figure A.2.6: Basic process flow for the DC study

A pit optimisation was done with multiple resource areas and one ore processing facility. Multiple mineral resource areas required specialist pit optimisation software ("Whittle Multi-mine" expansion module) for the pit optimisation. The pit optimisation was done to find the theoretical maximum NPV for the various scenarios.

The DC study considered the optimisation of multiple resource areas, the furthest located 18km from the processing facility. The optimisation included a factored ore hauling cost from the suggested plant location to the resource area. A cost adjustment factor based on the depth of mining was also included for the pit optimisation. Each block within the block model was given a cost relative to the bench elevation and its distance from the processing facility. A block of ore in a resource far from the ore processing plant would accordingly have a higher cost. Such variable mining cost inputs assisted to determine the optimum mining sequence for the various resource areas.

The usage of specialist pit optimisation software enabled the ranking the mineral resource areas in terms of its profitability. Such information would be used to focus future efforts on areas with higher profitability to increase confidence levels from inferred to indicated ore. The usage of specialised mining software within a conceptual study was warranted by the confidence levels associated with a classified mineral resource (measured, indicated and inferred). The DC study involved pit optimisation experts and specialist consultants.

In total, five different scenarios were compared within the pit optimisation in an option analysis. Once the logical setup is done, pit optimisation software lends itself to run various scenarios with relative ease. In each scenario, the base case was compared with two ore hauling alternatives and two processing options. The structure provided by pit optimisation software proved ideal for option analysis since it ensured comparability within the conceptual study.

From the five scenarios, the scenario with the highest NPV was selected by the study owner, and an annual production schedule was done within the pit optimisation software. The schedule was smoothed to minimise variations in equipment requirements. Since most pit optimisation software determines NPV by simulating a high-level production schedule – the usage of pit optimisation software to this extent provided an added advantage, reducing time required to do scheduling.

No pit designs were done for the DC study. Pit optimisation “shells” were used for production scheduling. Using pit shells could imply that waste mining is underestimated as mentioned in previous case studies. Pit shells provide an easy means to determine the economic limit of mineral resource areas, but are often optimistic in terms of waste mining and stripping ratio estimations.

The pit shells were used to find the centre of gravity (COG) of the mine as a whole, since some of the deposits were more than 18km from the existing workings. The COG was then used in conferring with the metallurgical consultants to determine the optimal location of the processing facility. The optimal location was then confirmed by a site visit to the area, further promoting a team work approach to problem solving within a conceptual study.

A.6.3 Mining operational considerations

A trade-off study was done within the DC study which investigated different truck and loader equipment combinations. Such equipment considerations would be used to supplement the existing operations and had to be compatible with the existing fleet. Based on the high-level production schedule totals, primary and secondary equipment numbers were calculated from first principles. The equipment totals calculated took cognisance of OEM provided availabilities, utilisations and efficiencies (Table 3.6a). The equipment optimisation included the following:

- Drill rig detailed design and drill rig costs along with detailed calculations on blasting agents required.
- Four loaders with varying bucket capacities were considered for the study – to find an optimum pairing.
- Equipment usage rates of consumables for all equipment types were included under the headings: Lubricants, GET/Wear-parts, Under-carriage, Tyre life, Tyre Cost.
- Varying maintenance rates (Cost US $/hr) according to operating hours of the machine.
- Average fuel consumption was modelled for Machine idling and average fuel burning.

Detailed equipment calculations included in a conceptual study was a specific requirement from the DC study owner and was merited by detailed information available from the existing operational area. Subsequent studies would benefit from such detailed equipment calculations.

A.6.4 Economic considerations

Due to some of the remote mineral resource areas, the DC study hat to cater for estimates of 27km of haul road construction for the project. Such cost estimates were based on nearby quoted costs of a similar operation. An additional 15% were included in the estimate for unmeasured items. One of the pit areas implied the potential diverting of a power line. Costs to remove the powerline was based on a study that was done by a consulting firm for a South-African mine a few years prior to the study. Such costs were then escalated by South-African inflation rates and converted to $US. It was stated that mining related infrastructure such as truck workshops, diesel fuel storage, dispensing and pit shelters / lunch room costs were based on a study that was done for a nearby mine based in Sub-Saharan Africa. For the DC study, unknown cost items were based on historical costs typical of a country on the same continent, escalated with inflation and a 15% contingency to cater for the unknown. In the absence of relevant cost assumptions, the estimations erred towards the conservative.

For the DC study, a key profitability metric reported (as an alternative to NPV) was the profit to investment ratio for each scenario (Profit: Investment). This was expressed as a ratio - for example 0.37. Such profitability metrics serves to highlight investment decisions for a conceptual study. An accuracy of +-30 to 40% for capital costs were stated as an estimation.

Mining costs were broken down in detail firstly per activity level (Drilling, blasting, Loading, hauling, etc.) as well as per cost type (Ancillary, GET, Labour, Fuel, lubricants, explosives, maintenance etc.) showing total cost per annum and unit cost. Reporting costs into different formats promoted transparency in the study document.

A.6.5 Safety, health and environmental considerations

A calculation was included in the DC study – which considered the amount of water which would be required for mining. The calculation was compared with the results of a hydrogeological study which outlined the supply of water to the mining operation and processing plant, which would be a significant consideration for mining to take place. A consideration for water requirements at a conceptual level is of critical importance, since the cost to supply sufficient water for a process could be considerable.

A.6.6 Risk considerations

Although this might have been implied, no specific items with regards to risk considerations were stated for the DC study.

A.6.7 Study work plan

The final chapter of the DC study included a conclusions and recommendations chapter showing a list of specific areas of focus for future subsequent studies. No specific mention was made to a study work plan.

A.6.8 Activities to be considered for value adding principles from the DC study

Table A.6.8: Activities to be considered for value adding principles from the DC study

Activity No	Category	Activity
DCMR01	Mineral resource management	Block model dimensions were 10x10x5m according to a smallest mining unit (SMU) approach for the DC study. The involvement of mining engineers at a geological modelling phase is of critical importance to arrive at a relevant mining model.
DCMR02	Mineral resource management	Ore classification based on Metallurgical test work was done for the DC study, which implied the early involvement of Metallurgical engineers in the geological modelling.
DCMR03	Mineral resource management	Mining losses of 10% and dilution of 10% were assumed for the study. Dilution were included in addition to the dilution implicated by the smallest mining unit modelling approach.
DCMR04	Mineral resource management	In the DC study, the planned output metal tonnes were related to the market supply and demand stating that an oversupply of the metal could reduce metal demand and price. This gave scope for future study work to determine optimal plant output size according to the Market size.
DCMR05	Mineral resource management	The pit optimisation for the DC study made use of a specialist software module catering for a multiple resource pit optimisation with a centralised ore processing facility. The specialised mining software was also used for production scheduling. This software module approach provided flexibility in scenario comparisons and provided a structured approach for comparability.
DCMR06	Mineral resource management	The inclusion of a Mining Cost Adjustment Factor (MCAF) within a pit optimisation catered for increases in mining cost with depth and variations in distances to transport ore. This inclusion implied that the economic limit of the pit took cognisance of varying the costs of transporting ore for the particular pit.

Table continued

Activity No	Category	Activity
DCMR07	Mineral resource management	Five different scenarios were considered for the DC study. A base case was compared with two ore hauling scenarios and two processing scenarios. Each option was included in the pit optimiser as a scenario for optimisation. The scenario comparisons within the pit optimisation lent itself to structured means to provide comparability within scenarios.
DCMR08	Mineral resource management	The pit optimisation pit shells were used for pit scheduling within the pit optimiser. Pit optimisation software schedules, though somewhat optimistic, can provide production within relatively short turn-around times.
DCMR09	Mineral resource management	To determine the optimal location for the centralised processing facility, a centre of gravity calculation was done. This involved a multidisciplinary problem solving approach which required mining engineers and metallurgists working together.
DCM01	Mining Considerations	A detailed equipment optimisation from first principles with the use of specialist equipment simulation software was included in the DC study. Subsequent studies would benefit from such detailed equipment calculations
DCM02	Mining Considerations	The DC study considered 27km of haul road construction. Haul road construction costs of a nearby operation – sourced from a consultant - was used. A 15% contingency was added to the cost due to various uncertainties.
DCM03	Mining Considerations	Costs to remove permanent infrastructure – a power line – were based on information from a consulting firm in South-Africa and converted to US dollars.
DCM04	Mining Considerations	Mining infrastructure costs such as truck workshops, diesel fuel storage, dispensing and pit shelters and lunch room costs were based on a study that was done for a nearby mine based in Sub-Saharan Africa.

Table A.6.8 continued

Activity No	Category	
DCE01	Economic considerations	A key profitability metric was used as an alternative to NPV – which was the profit to investment ratio for each scenario. This was expressed as a ratio – 0.37.
DCE02	Economic considerations	An accuracy of 30% to 40% for capital costs were stated for the DC study.
DCE03	Economic considerations	Mining costs were shown in detail: Per activity as well as per cost type. The costs were provided as total costs per annum and unit costs. This provided transparency over the order of magnitude of the costs.
DCSH01	Safety, health and environmental considerations	A consideration and calculation of water requirements for mining and processing in relation to water sources outlined in a preliminary hydrogeological study ensured the sourcing of adequate water for the study, setting scope for future hydrogeological studies.
DCWP01	Study work plan	The DC study final "Conclusions and Recommendations" chapter included a list of areas of focus for future subsequent studies.

A.7 The South-African Coal mining concept study - a case study.

The South-African coal desktop study (hereon referred to as the "SAC study") is located in the Northern parts of South-Africa in the Limpopo province. The SAC study location formed part of the Soutpansberg Coalfields which is situated close to the border of South-Africa and Zimbabwe.

The study is based on resource data which was completed just prior to the study commencement; preliminary metallurgical test work & process designs; and a competent person's report done by independent consultants. The study sponsor is an exploration company which is owned by a consortium of smaller coal mining companies. The SAC study was therefore based on data that was more conclusive than the other case studies thus far mentioned.

A.7.1 General considerations

Included in the executive summary of the SAC study was a table giving an overview of the prioritised strategic objectives as required by the study promotor, highlighting one of the specific purposes of a conceptual study. The strategic objectives were:

1. Best NPV
2. Maximum life of mine
3. 5-year payback.

Included in the SAC study document was a statement that the study will not comply with the guidelines as defined by the joint Ore Reserves Committee (JORC) standards of disclosure for Mineral Projects for a preliminary economic assessment (PEA). To promote transparency, this is a requirement of the JORC code when conducting a PEA.

A.7.2 Mineral Resource Management considerations

A section in the SAC study document was dedicated to a detailed explanation of the project prospecting and mining licenses. A summary was tabled which showed an overview of project exploration owners. Within the geology section, the main "cut-off" parameters for the resource was summarised, which included yield, ash content, geological structure limits, metallurgical factors and relative density considerations. The anticipated geological losses of the orebody was modelled per geological zone, and was largely based on the occurrence of faults within the area. Losses of 10% were assigned in the block model to zones with "indicated" ore. Zones with inferred content were assigned with a 20% ore loss. Zones with a lower level of confidence in the quality of the coal were therefore penalised accordingly. The SAC study is an example of methodical logic applied to zones/areas where low certainty ore is expected.

Geotechnical slope angles for the SAC study were based on typical slope angles for the area, and did not constitute a preliminary geotechnical investigation. It was assumed that neighbouring mines might have similar strata with similar overall geotechnical slope angles.

Pit and dump designs

In determining waste dump design characteristics, the waste dump was designed in such a way as to aim for an optimal balance between vertical lift and horizontal distance hauled. The Waste dump location was also selected close to the pit at a location that doesn't sterilise any ore. Such considerations for **t**he placement of permanent infrastructure will have a material impact on the economics of a mine and need to be considered as early as the conceptual study.

Pit optimisation

For the pit optimisation, the SAC study considered six different scenarios in an option analysis. Various primary- and secondary- products, calorific values and ash contents were explored. Each scenario was costed and prices were sourced from a detailed market study document.

The pit optimisation software created a range of nested pit shells with an increasing ore price (revenue factor). A lower revenue factor pit targeted shallow high grade material. Interim pit pushback shells were selected which provided early access to high grade material whilst maintaining a low stripping ratio. Using these lower revenue factor pits as the first pushbacks during scheduling served to improve the early cash flow of the study whilst increasing NPV. An example of push back selection using nested pit shells is shown in Figure A.7.2a. The pit optimisation approach aimed to reduce economic risks by first mining shallow high grade ore, ensuring early capital payback.

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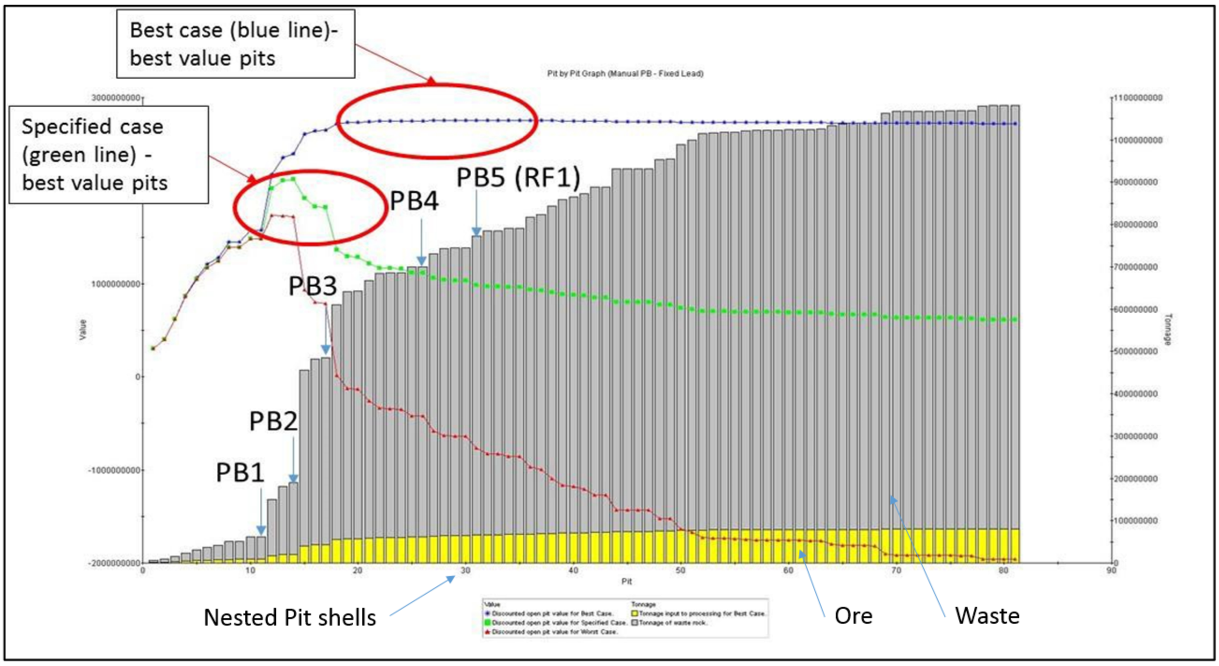

Figure A.7.2a: Nested pit shells pushback selection

Production scheduling

The strategic directive for production scheduling was stated:

1. Maximised overall NPV for the project
2. Select push-backs to improve NPV
3. Achieve plant feed tonnages and grade
4. Minimise waste tonnes and total material mined
5. Limited amount of active benches and vertical advance

The production schedule was done using the pit optimisation software. The first year of production (year 0) was used for pre-stripping of waste. Within the production schedule, ore zones in the resource model were targeted in such a way to achieve a uniform blend over the life of mine. The pit optimisation software was also used to simulate stockpiling. For the schedule, a stockpile of up to 25% of the monthly required ROM feed was allowed for, assuming 25% of the ore would be re-handled. Reliable geological information available to the ZAC study meant the inclusion of detailed considerations such as stockpiling simulations, advanced ore targeting and re-handle calculations which added value for future studies.

The production schedule was smoothed and was based on computer generated pit shells rather than detailed pit designs. A smoothed production schedule is considered more practical for equipment planning.

Included in the SAC study document - as an output from the production schedule - were period progress plots, which depicted periodical 3D images of the pit progression. 3D images depicting mine depletion showed that geospatial mining progression was considered and confirms sound scientific methodology implemented for the study.

Declaration of mineable resource

Included in the SAC study was a declaration of “mineable resource” in a waterfall chart (Figure A.7.2b). Similar to a reserve declaration, the graph summarised the effect of modifying factors such as geological losses, pit optimisation, design and scheduling, to arrive at a mineable resource. The term “mineable resource” is often used when data is insufficient to declare a mineable reserve. Providing data in such a manner provided an idea of the future potential reserves for the area.

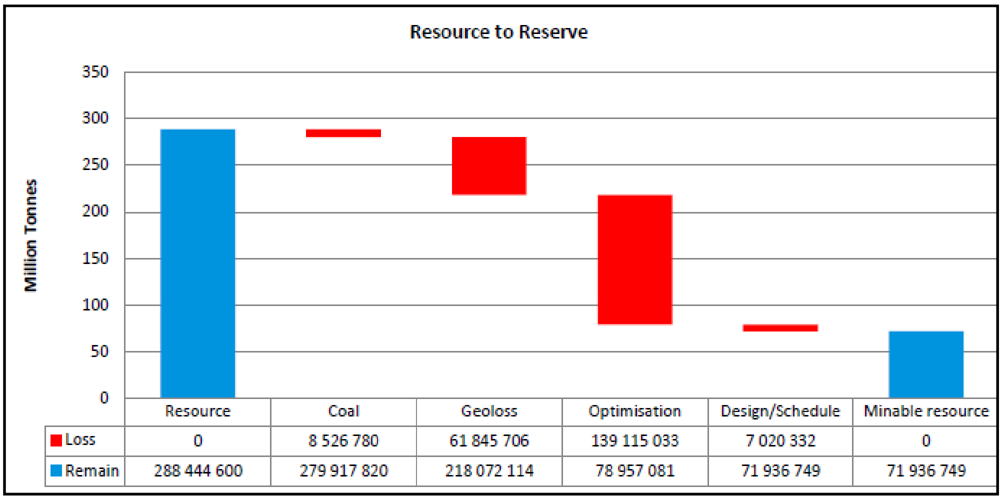

Figure A.7.2b: SAC study resource to mineable resource example

A.7.3 Mining operational considerations

A detailed explanation of the logic for selecting a mining contractor vs. owner operated costing was explained. To remain conservative, it was assumed that contractor mining would be done throughout the life of the mine. It was stated however that one would typically consider owner operated mining if the life of mine is more than the typical life of the equipment (5-7 years).

The mining cost, however was partially based on cost calculations from first principles. The drilling, blasting, loading, hauling and secondary equipment costs were determined from first principles, whereas the infrastructure costs, day rates, labour and other fixed costs were based on South-African mining contractor costs for a mine of similar tenure. The SAC study showed that where relevant data for mining cost calculations at similar mines is not available, calculations from first principles can be used as a substitute. Such first principle calculations can then be revisited in subsequent studies.

A depth cost adjustment factor was used for the mining cost, which assumed that the mining cost would increase as mining deepens. Mining cost would increase for every 10m in depth below surface. Such varying costs were used as an input to the pit optimisation software, taking cognisance that additional vertical lift would increase hauling costs. This furthermore promoted sound methodology used in conjunction with high level cost assumptions.

A.7.4 Economic considerations

For the SAC desktop study, the initial pit optimisations showed that the study would not be profitable even in the most optimistic market projections. The study proceeded to investigate a coal price where the project will be sufficiently profitable for consideration. The SAC study is unique therefore in that it investigated future conditions at which an orebody would be profitable. With the cyclical nature of commodities, such an investigation could enable the strategic inclusion of the study at a point in the future when prices are more favourable.

Included in the capital cost estimations were detailed cost estimations for future exploration (drilling and sampling) work. A contingency of 10% were included for the operating cost estimations since most of the operating costs were sourced from other operations.

A detailed market study was done for the SAC study. A summary section which considered the marketability of the ore according to its inherent qualities was included. The detailed market study assisted to set scope for the strategic directive which the study would investigate.

The cash-flow (revenue and costs) profile were determined along with commentaries on the rises and falls in the profile. Changes over time in revenue and costs were attributed to technical, strategic and mining related issues foreseen over the course of the lifetime of the project. The commentaries provided a clear overview of the various external effects which impacted the cash-flow as determined by logical methodology in the SAC study.

A.7.5 Safety, health and environmental considerations

A brief summary of the environmental, safety and health related matters were included as it relates to mining. It regarded critical areas of concern such as waste (spillage) management, dust suppression, noise, vibration, landform, personal protective equipment, occupational hygiene and employee welfare. The SAC study emphasised such areas where further work and investigation would be required, so as to set scope for future studies.

A.7.6 Risk considerations

The study included risks as modelled in a risk breakdown structure (RBS) shown in Table A.7.6. Each risk was rated in terms of the potential consequence and the likelihood of occurrence. A qualitative risk rating was also assigned to each risk item. Such qualitative ratings provided a clear understanding of the strategic areas of focus that would have to be addressed in the next level of study. The risk table identified the mineral resource estimation as well as the project sensitivity to coal price as major risks to the project viability.

Table A.7.6: Risk breakdown structure for the SAC study

RBS - Item	Name	Description	Consequence	Likelihood	RR	RL
Geoscience	Resource Estimation	Washability curves based on RC data, potential increase in yield with large diameter core assays	Major	Possible	22	High
Geoscience	Geotechnical	Slope angles too shallow	High	Possible	18	Significant
Mining & Geology	In-Pit waste dump design	Capacity management over LoM	Moderate	Unlikely	9	Medium
Mining & Geology	UG Longwall mining	Ability to maintain production requirement	Minor	Possible	8	Medium
Plant & Process	Processing recovery	Chances 90% efficiency is not achieved	Minor	Unlikely	5	Low
Engineering, Maintenance & Procurement	Skilled labour	Difficulty finding skilled labour	Moderate	Likely	17	Significant
Infrastructure	Terrain	Challenges erecting infrastructure	Insignificant	Unlikely	2	Low
Marketing & Off-take	Price	Sensitivity	Major	Almost certain	25	High
	Selling cost	Transport cost accuracy	Moderate	Unlikely	9	Medium
Business & Financial	OPEX	Accuracy	Minor	Likely	12	Medium
	CAPEX	Accuracy	Minor	Likely	12	Medium
Environment	Subsidence	Subsidence of land above UG Longwall mining sections	High	Possible	18	Significant

A.7.7 Study work plan

Recommendations for the next study level were included in high level. The RBS shown in the previous Table 3.7a was used as a reference to highlight specific areas for future work. It included detailed recommendations such as specifying areas of focus for further pit optimisations, developing capital and operating costs and outlines for a market study. It was stated that further work would specifically aim to reduce and manage risks associated with the study.

A.7.8 Activities to be considered for value adding principles from the SAC study

Table A.7.8: Activities to be considered for value adding principles from the SAC study

Activity No	Category	Activity
SACG01	General	Included in the executive summary, an overview of the strategic objectives of the project was provided. It is stated that the main strategic objective was to determine the production / processing scenario which would in order of priority provide: 1. The best NPV, 2. Maximise the life of mine, 3. Provide earliest payback.
SACG02	General	A statement that the study as presented did not comply with the guidelines as defined by the JORC standards of disclosure for Mineral Projects for a preliminary economic assessment (PEA). This is a requirement of the JORC code and promoted transparency.
SACMR01	Mineral resource management	A detailed overview of the project prospecting and mining licenses were provided. This provided scope for the timeframe available under the current licenses for further development of the project.
SACMR02	Mineral resource management	A summary of the cut-off parameters used in the mineral resource classification was described under: yield, ash content, geological structure limits, metallurgical factors and relative density considerations. Such data is relevant for future mineral resource classification work to be done.
SACMR03	Mineral resource management	Mining losses were modelled per zone – where Inferred zones – 20% were used and Indicated zones – 10% were used. Detailed modelling of losses per zone added methodical logic in assigning risk to a specific area.
SACMR04	Mineral resource management	Geotechnical slope angles were based on typical slope angles of open pits in the area, and did not constitute a preliminary geotechnical investigation.
SACMR05	Mineral resource management	Six different logically derived scenarios were considered for the pit optimisation. The scenarios varied in primary and secondary products calorific values and ash content. Each of the scenarios were considered with the appropriate costs and prices identified form the detailed market study. Logically derived scenarios could potentially eliminate less profitable strategic options at an early stage.

Table A.7.8 Continued

Activity No	Category	Activity
SACMR06	Mineral resource management	For the production schedule, the pit optimisation software was utilised to select interim pit pushbacks. Most pit optimisation software packages create nested pit shells increasing in revenue factors. Smaller pit shells which targets shallow high grade material at the start of the project reduced financial risk and capital payback.
SACMR07	Mineral resource management	The strategic directive for the production scheduling was stated and a production schedule was done using the pit optimisation software. The scheduling considered the blending of ore types and the balancing of stockpiles. This would add value to the developing future exploitation strategies.
SACMR08	Mineral resource management	The schedule included stockpile balance levels at 25% of the required ROM monthly feed. This implied that 25% of the ore would be re-handled.
SACMR09	Mineral resource management	No pit designs were done, pit optimisation shells were used for pit scheduling. Pit shells take less time to generate compared to pit designs and can be considered appropriate for a conceptual study.
SACMR10	Mineral resource management	The waste dump design was done in such a way as to aim for an optimal balance between vertical lift and horizontal distance hauled. The location was also selected to be as close to the pit as possible to minimise hauling cost and not sterilise potential future ore below.
SACMR11	Mineral resource management	3D images depicting mine depletion showed that geospatial mining progression was considered and assures the reader that sound scientific methodology was implemented for the study.
SACMR12	Mineral resource management	A declaration of a mineable resource was included in the study report as a waterfall chart. This was done in a similar fashion as a reserve statement for a feasibility study. The chart showed graphically the effect of each of the different modifying factors applied to the mineral resource and provided the reader with an idea of the future potential reserves for the area.
SACM01	Mining Considerations	The mining cost and strategy was partially based on contractor rates and supplemented by costs developed from first principles. The SAC study showed that where relevant data for mining cost calculations at similar mines were not available, calculations from first principles can be used as a substitute. Such first principle calculations can then be revisited in subsequent studies.

Table A.7.8 Continued

Activity No	Category	Activity
SACM02	Mining Considerations	A depth cost adjustment factor was used along with the mining cost, simulating an increase in mining cost for every 10m below surface. Cost increments were based on contractor costs borrowed from a similar project.
SACE01	Economic considerations	At the start of the project, the pit optimisation runs indicated that the project will not be feasible. A coal price was back calculated where the economics would render the project profitable. Such a price would enable the strategic inclusion of the study at a point when prices would be more favourable.
SACE02	Economic considerations	A contingency of 10% was included in the OPEX calculations to cater for potential increases since most costs were sourced from other operations.
SACE03	Economic considerations	A detailed market study was done for the SAC study which assisted to set scope for the strategic directive which the study would investigate.
SACE04	Economic considerations	A rule of thumb was stated that contractor mining would typically be considered if an open mine has a life of less than 5-7 years, which is more or less the life of the equipment.
SACE05	Economic considerations	Cost details were presented in a graphical format and the rises and falls were discussed accordingly. Each rise and fall in cost and revenue was related to technical, strategic and mining related factors.
SACSH01	Safety, health and environmental considerations	A summary paragraph of safety and health related matters that would affect mining was included. Areas of concern were highlighted. This set scope for future work considerations.
SACR01	Risk management	Study risks were modelled in a risk breakdown structure. Each risk was rated in terms of the potential consequence and likelihood of occurrence. A qualitative risk rating was assigned to each risk item. Qualitative ratings provided emphasis for future study work.
SACSW01	Future study work plan (PFS)	Recommendations for the next study level were based on the risk breakdown structure. It was stated that further work would specifically aim to reduce and manage risks associated with the study.

A.8 The The South-African Manganese Conceptual study - a case study.

The South-African Manganese conceptual study (hereon referred to as the SAM study) investigated a Manganese resource located in the Northern Cape province of South-Africa. The study is located in a semi-arid area with high daytime temperatures of up to 40 degrees Celsius, low annual rainfall and sub-zero temperatures during winter months.

The SAM study included a mine design, production schedule, an equipment optimisation and a risk management strategy. The SAM study was prepared to fit into a detailed financial model which would consider the strategic development of multiple mining projects.

A.8.1 General considerations

For the SAM study - only the mining technical portion was described and considered - with the production schedule and equipment totals as a main output. With uniform continuous strata such as Manganese, the SAM study only included a high level design and schedule and did not contain a pit optimisation. With simplistic geology, experienced engineers can often predict what pit optimisation software would typically do, namely target high grade shallow ore. This was imitated with a simple design and production schedule which required less engineering and subsequently less time to complete.

A.8.2 Mineral Resource Management considerations

The local mineralisation was discussed along with a map depicting the boreholes and stratigraphic layout of the area as it relates to the mine technical work. A block model with 50m x 50m x 100m blocks was converted into a mining model with 5m x 5m x 2m blocks according to SMU methodology for scheduling.

A plan view of the proposed mine design showing the mining right delineation, proposed mine dumps and stockpile areas was shown. The overview depicted the area of the waste dump location in such a way showing that the dip of the orebody does not sterilise any ore.

A conceptual geotechnical study were performed by an external consultant, and made recommendations for bench heights, berm widths and overall slope angles. Bench heights, flitches, haul road widths and draining channels were designed within the conceptual geotechnical parameters, taking cognisance of similar operations design parameters.

For waste dump design, a material bulking factor of 10% was used to calculate a waste dump capacity. For the waste dump design, the natural angle of repose of the softest rock were used for the waste dump designs. Limited dumping space emphasised the importance of such seemingly ominous considerations.

The SAM study considered four production schedule scenarios with various dilution, modifying factors and grades of the ore products in an option analysis. The mine production schedule aimed at opening up high grade shallow ore up front, delaying stripping to later in the life of the operation, so as to improve project NPV. Fixed plant / transport parameters from the study owner was used as targets for the production profile.

A period progress plot of the pit was provided to show the face positions at the end of each year of the production schedule.

A mining loss of 4% was applied to in-situ tonnes and a dilution of 3% was applied at a zero grade percentage on the remainder of the ore. The effect of the modifying factors were presented in a waterfall chart. (Figure A.8a) This was done in a similar fashion as a reserve statement for a feasibility study. The chart shows graphically the effect of each of the different modifying factors applied to the mineral resource and provided the reader with an idea of the future potential reserves for the area.

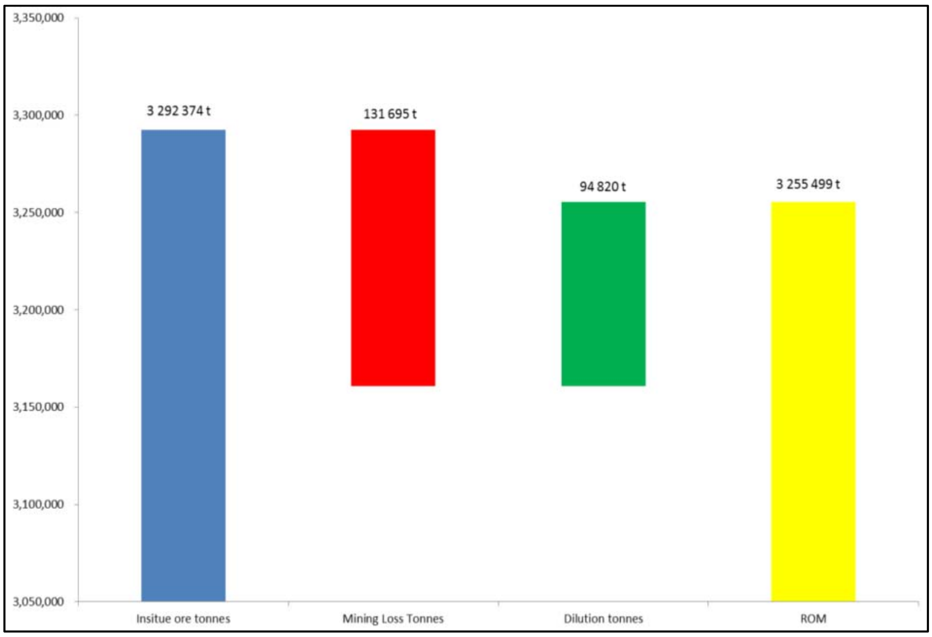

Figure A.8a: Modifying factors for the SAM study

A.8.3 Mining operational considerations

Mining equipment selection was based on suitability and equipment at similar operations. A detailed overview of uptime and downtime configurations were included for the equipment optimisation portion of the study. The equipment optimisation took cognisance of blast delays, equipment inspection, meal breaks, weather interruptions and public holidays. Equipment optimisation software usually include such considerations in a structured approach to determine equipment requirements per month.

It was assumed that contractor mining would be undertaken - at the conceptual phase, it was stated that owner operated mining costs must be considered in the studies following. Results from the equipment optimisation study was used to provide scope for contractor mining budget quotes.

A.8.4 Economic considerations

The SAM study only consisted of the mine technical portion of a larger conceptual study document which included a detailed financial model, not available for this dissertation. It is understood that economic considerations were detailed in the financial model.

A.8.5 Safety, health and environmental considerations

Although it might be implied, no specific environmental, safety and health considerations were stated for the study.

A.8.6 Risk considerations

A high-level risk table were included in the SAM study, depicting the cause, impact, likelihood, risk rating and risk priority of the risks identified by the project. (Table A.8.6) Such a qualitative risk rating provided areas of focus for future studies.

Table A.8.6: Project risk matrix identified in the SAM study

ID	Risk Breakdown Category	Risk Type	Risk Name	Risk Description	Cause	Impact	Uncontrolled/Inherent Risk (i.e. not considering current controls)				
							Likelihood	Consequence	Risk Rating	Risk Priority	Rationale / Comments
001	Mining	Threat	**Geotechnical**	Geotech and design criteria differ from surrounding mines	Preliminary geotechnical work by Midindi, our in-house geotech design not corresponding	if needed to change then there could be a reduction in footprint and tonnes	Likely	Moderate	17	3	It is recommended that the geotechnical study be revised and neighbouring mines criteria taken in consideration
002	Mining	Threat	**Mining width**	width of pit constraining the amount of equipment inside the pit at one time	width of the mining lease area	could reduce the rate of mining and hence the production of product, safety impact on congestion of pit with large equipment	Almost Certain	Major	23	1	Need to pre-strip enough top benches with enough lead and lag applied to be able to continues mine on top and bottom benches
003	Mining	Threat	**Waste dump**	waste dump space and position	original waste dump position; mining carried on as is	current waste dump could potentially sterilize reserves	Almost Certain	Major	23	2	verify information about resource within the current waste dump position, if possible avoid dumping there
004	Mining	Opportunity	**Inpit backfill**	inpit backfill strategy	lack of space and increase of productivity	could potentially increase productivity, reduce cost on hauling and rehabilitation	Possible	Major	18	4	inpit backfill can be done as soon as the resource at the waste dump area have been verified
005	Mining	Threat	**Product stockpile**	ROM and product stockpile area and space	offices and lack of planning	reduce possibility to blend properly	Likely	Moderate	17	5	currently in progress do expand the product stockpile area

A.8.7 Study work plan

Although implied by the study document, no future study work plan were included for the SAM study.

A.8.8 Value adding activities from the SAM study

Table A.8.8: Value adding activities from the SAM study

Activity No	Category	Activity
SACG01	General	With simplistic geology as with the SAC study, experienced engineers targeted an area with high grade shallow ore and developing a high level pit design and production schedule. The exclusion of a pit optimisation study required less engineering work and subsequently less time to complete.
SACMR01	Mineral resource management	An overview of the project mining right were provided along with the proposed location for mine dumps, stockpile areas and pit areas were depicted in a map of the area. The map showed the orebody in such a way as to confirm that the waste dump locations did not sterilise potential future ore.
SACMR02	Mineral resource management	Pit, bench and ramp designs were based on preliminary geotechnical work as performed by an external consultant.
SACMR03	Mineral resource management	A material bulking and compaction factor of 10% were used to calculate the waste dump capacity. Such considerations are important where limited dumping area are available.
SACMR04	Mineral resource management	A period progress plot were shown as an output from the production schedule, promoting a sense of geospatial transparency in the mining progression.
SACMR05	Mineral resource management	The effect of modifying factors (mining losses = 4% and dilution =3%) on the resource is shown graphically in a waterfall chart. The chart showed graphically the effect of each of the different modifying factors applied to the mineral resource and provided the reader with an idea of the future potential reserves for the area.
SACM01	Mining Considerations	An equipment optimisation took cognisance of blast delays, equipment inspection, meal breaks, weather interruptions, public holidays and weather delays. Equipment optimisation software provided a structured approach to determine equipment requirements per month.

Table A.8.8 Continued

SACM02	Mining Considerations	Contractor mining was assumed, and results from the equipment optimisation study was used to provide scope for contractor mining budget quotes.
SACR01	Risk management	Study risks were modelled in a risk breakdown structure. Each risk was rated in terms of the potential consequence and likelihood of occurrence. A qualitative risk rating was assigned to each risk item providing areas of focus for future studies.

APPENDIX B - DETAILED ACTIVITY EVALUATION LIST

This section provides the detailed activity evaluations for all of the 72 activities derived from the case studies and industry standards. The table shows the activities ranked from highest to lowest value adding potential along with all the comments made by professionals at VBKOM.

Table B1: Value adding activities ranked according to value adding potential

Activity Ranked	Activity No	Category	Activity (Condensed)	Number of Case studies where activities occur	Risk reduction potential 1=low; 9=high	Potential consequence if not included 1=no consequence; 9=catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#1	ISMR23	MRM General	State the site description, boundaries, rights, existing infrastructure and local communities highlighting all socio-economic risks.	1	7.42	7.84	MK: Fundamental! BB: Understanding the socio-economic risk of the project is very important especially in our current operating climate SO: It is important that the project scope and stakeholders are clearly defined to ensure that all user requirements are considered.	84.80
#2	ISMR13	MRM Pit optimisation	State all relevant marketing parameters (e.g. product quality, product quantity, product price, potential off-take agreements etc.) used for in the pit optimisation process.	1	6.95	7.42	MK: Projects more sensitive on revenue assumptions BB: The more information is presented the better the decision to continue with the project will be SO: Must understand product specs to achieve. BS: Markets change. Expecially in the 5-10 years from scoping to startup	79.82
#3	ISMR12	MRM Pit optimisation	Determine the relevant processing parameters for use in the mine planning process	1	6.84	6.63	MK: Need to get this fairly close to get order of magnitude right BB: Processing of the material contributes a great deal to overall costs that influences conversion from resource to reserve estimates SO: Important to understand ROM tonnes requirement. BS: Get the benchmark right.	74.85

Table B1 continued

Activity Ranked	Activity No	Category	Activity (Condensed)	Number of Case studies where activities occur	Risk reduction potential 1=low; 9=high	Potential consequence if not included 1=no consequence; 9=catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#4	ISMR14, ISMR15	MRM Pit optimisation	State all economic input parameters and assumptions used for the pit optimisation process, clearly stating how data was obtained.	2	6.26	6.47	MK: Economics are more sensitive for Revenue assumptions - more so than costs. SO: The parameters may have huge effect on result and this must be understood if the study results are queried. BS: It's closer to "guesswork" in this level of study. The projections are beyond 5 years into the future. All relevant assumptions must be stated.	70.76
#5	SACMR02	MRM Geology	Include a summary of all cut-off parameters used for the mineral resource estimation.	1	5.84	6.74	MK: This has a direct bearing on revenue and would therefore have a greater impact than expenditures. BB: If the cut-off grade is opinion based it should be clearly stated and justified. SO: Data can be incorrectly interpreted if cut-off grade is not understood. BS: It will change in future studies. It is good to see though.	69.88

Table B1 continued

Activity Ranked	Activity No	Category	Activity (Condensed)	Number of Case studies where activities occur	Risk reduction potential 1=low; 9=high	Potential consequence if not included 1=no consequence; 9=catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#6	GIMR01	MRM Geology	Include a statement of the expected accuracy of geological information relative to a drilling campaign (Measured, Indicated, Inferred).	1	6.58	5.79	MK: Not crucial at concept level BB: The confidence determines the amount of resource definition work required and the confidence of the scoping study SO: If this is not understood the conceptual business case may be over or under stated.	68.71
#7	ISSH03	Safety, health and environmental considerations	Gather environmental, community and cultural information that may impact on mining operations	1	5.74	6.47	BS: As much as required for a scoping study e.g. relevant	67.84
#8	GPG01, GPG03	General	The Conceptual study must include a GAP analysis - to show what information is required and what work needs to be done before feasibity can be proved.	1	5.95	6.16	BS: Yes	67.25
#9	MHSSH04	Safety, health and environmental considerations	Include a social and labour plan and environmental impact analysis scope of work - based on that of a neighboring operation / benchmark data.	2	6.37	5.74	BS: include your major risks and clearly state them.	67.25

Table B1 continued

Activity Ranked	Activity No	Category	Activity (Condensed)	Number of Case studies where activities occur	Risk reduction potential 1=low; 9=high	Potential consequence if not included 1=no consequence; 9=catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#10	ISMR19, ISMR20, ZCMR05, GIMR03, DCMR09, SACMR10	MRM Production Schedule	Determine the preliminary production sequence and schedule including the reasoning for "build-up" and "steady-state" rates.	6	5.68	5.95	MK: Not all that critical at a concept level SO: Could have an impact for a large mine - business case. BS: You won't know untill you receive your large equipment delivery and training schedule / contractor rampup for greenfields project. GO: Big driver of NPV	64.62
#11	ISMR21, SAMMR04	MRM Production Schedule	Simulate a conceptual mine production schedule in a spreadsheet format and a "3D animation" / "end of period" plots.	2	5.68	5.95	MK: Not all that critical at a concept level SO: Could have an impact for a large mine - business case. BS: You won't know untill you receive your large equipment delivery and training schedule / contractor rampup for greenfields project. GO: Big driver of NPV	64.62
#12	MHSMR03	MRM Geology	If unclassified resource material is used for the study, include an explanation of material used related to its suitability for doing a financial appraisal.	1	6.05	5.47	BB: Stakeholders must fully understand the underlying risk of the project SO: If this is not understood the conceptual business case may be over or under stated. BS: Financial appraisals for not classified minerals should only be a one liner.	64.04

Table B1 continued

Activity Ranked	Activity No	Category	Activity (Condensed)	Number of Case studies where activities occur	Risk reduction potential 1=low; 9=high	Potential consequence if not included 1=no consequence; 9=catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#13	DCWP01, SACSW01, ISWP01	Study work plan	Outline a study work plan based on each item as defined in a project risk breakdown structure	3	5.58	4.95		61.81
#14	NCMR05, SACMR06	MRM Pit optimisation	Include a sensitivity analysis on processing recovery / yields, metal/mineral price, mining cost and processing/crushing cost for the project.	2	5.58	5.53	MK: Revenue! Projects are more sensitive on these assumptions BB: Montecarlo will indicate biggest contributers to project success SO: Maybe pre-mature for concept study. BS: Sure GO: I have seen seldom huge value in these sensitivities	61.70
#15	NCMR02, ZCMR03, DCMR03, SACMR03, SAMMR05, ISMR10	MRM Geotechnical	State the modifying factors (dilution, geological loss and mining loss) in reference to a logical explanation. (geological occurrences, equipment size). Where relevant - categorise losses per geological / geo-technical zone.	6	5.00	5.89	MK: Need to get this fairly close to get order of magnitude right BB: Especially in thin seam orebodies, which will be mined by open pit mining GO: Material and beneficiation process specific	60.53
#16	NCE03, DCM02, DCM04, ISMO04	Economic - Cash flow modelling	Source unknown capital costs such as mining infrastructure, rehabilitation and mine closure costs from benchmark data or relevant experts.	4	5.32	5.47		59.94

Table B1 continued

Activity Ranked	Activity No	Category	Activity (Condensed)	Number of Case studies where activities occur	Risk reduction potential 1=low; 9=high	Potential consequence if not included 1=no consequence; 9=catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#17	ISMR17, ZCMR04, ISMR18, SACMR01, SAMMR01, SACMR09	MRM Pit optimisation	Establish the final mining limits from the "revenue 2 factor pit" and ensure all infrastructure is located outside the final mining limit.	6	5.21	5.53	MK: Good practice but not crucial at this level BB: Infrastructure placement can be confirmed in later project stages SO: Future sterilisation of resources if not done, but must still be economically feasible. BS: Start with the end (future prices) in mind. The plant location might sterilise the best ore.	59.65
#18	ZCMR02	MRM Geology	Describe the geology as it relates to mining. Include a description of the stratigraphy as it relates to mining practices referring to attributes such as "degree of weathering"	1	5.47	5.26	MK: Only has bearing on part of mining opex - which is not that crucial of a consideration. BB: Understanding the geological dates as well as the amount and type of data collected is vital for project success SO: Important for equipment selection, but this level of detail may be too much detail at conceptual level. BS: Very important - especially in areas where "free dig" (at a lower cost) or oxidised ore is to be mined GO: Important for its effect on slope angles	59.65

Table B1 continued

Activity Ranked	Activity No	Category	Activity (Condensed)	Number of Case studies where activities occur	Risk reduction potential 1=low; 9=high	Potential consequence if not included 1=no consequence; 9=catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#19	SACSH01	Safety, health and environmental considerations	Include a summary paragraph on any potential safety, health and environmental matters that would affect/prevent mining.	1	5.21	5.42	BS: As much as required for a scoping study e.g. relevant ML: Environmental factors, such as water sources or wetlands may deem the project infeasible. It would be preferable to identify such factors before expensive further study work is continued.	59.06
#20	ISME05	Economic - Cash flow modelling	Describe the cost estimation methodology, stating all assumptions and data sources.	1	5.42	5.16	BS: Not relevant for scoping study	58.77
#21	ISMR09	MRM Geology	State all information relevant to the resource model as well as the origin there-of.	1	5.42	5.05	MK: Very nice if at good level at early stage - more important at feasibility study. BB: Understanding of the origin of information populated and accuracy is more important SO: Declaration of resource model confidence levels and summary of where and how the data was sourced should be sufficient. BS: It is the basis for the mining technical study	58.19

Table B1 continued

Activity Ranked	Activity No	Category	Activity (Condensed)	Number of Case studies where activities occur	Risk reduction potential 1=low; 9=high	Potential consequence if not included 1=no consequence; 9=catastrophic	Survey Comments	Overall value adding potential of activity (score out of 100)
#22	SACG01, ISMR17, NCG01	General	In the executive summary, include an overview of the strategic objectives of the study.	3	5.37	5.05	MK: Nice to have a baseline, but may change as information and accuracy increase BS: All requirements for the Code required. GO: Important for follow on studies to understand where focus was	57.89
#23	ISMR22	MRM Pit optimisation	Determine mine plan strategic considerations, project schedule, project objectives and strategic optimisation opportunities identified.	1	5.32	5.11	MK: Good to understand strategy early on, but doing the work may change strategy as facts present themselves. BB: If the project s risk is understood and the project is robust, the optimization will only be a positive to the project BS: Will change	57.89
#24	DCMR04	MRM Production Schedule	State product output derived from the schedule relative to the potential effect on market supply and demand.	1	5.26	5.16	BS: Absolute "guesswork", except for very small industry e.g. refractories or rare earth metals GO: Very commodity specific. Very important for something like rare earths	57.89

Table B1 continued

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#25	MHSMR02, ISMR23	MRM General	Validate the relevancy and expected accuracy associated with the topography / Survey available for the project	2	5.21	5.11	MK: Not that critical at a study phase where accuracy is 30%-50% BB: Correctness of data can play a big part in the economic success of a project SO: Areas that does not exist anymore may be assumed to be there and unnecessary costs included for removing or leveling the area. BS: Especially for an opencast operation, the volume of waste to be stripped is the primary mining cost.	57.31
#26	SAMMR03	MRM Pit design	Calculate waste dump volumes required clearly stating swell and compaction factors used.	1	4.63	5.68	MK: Good to have an understanding of the "real estate" requirments BB: Waste dump swell should clearly be stated BS: Waste dump areas to be identified. Waste plan, the specifics not so important. Find the risk, not solve a problem you don't have the data for. GO: Valid if there are area/space constraints for waste dumps.	57.31

Table B1 continued

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#27	DCMR10	MRM General	Where multiple resource areas feed into a centralised plant, determine an optimised plant location.	1	4.84	5.47	BB: Plant location not always driven by center of gravity calculations. Sufficient cost should be provided for for transfer of ROM from pits to plant SO: If not considered the additional operational haulage cost over time can be major.	57.31
#28	ZCE02, NCG02	Economic - Cash flow modelling	Express in the cost model a summary of all operating costs expressed in unit costs. ($/BCM, $/tonne, $/ROM, $/tonne.metal.contained etc.)	1	5.00	5.26	BS: Not relevant for scoping study GO: Good for benchmarking	57.02
#29	DCE01	Economic - Cash flow modelling	Include a summary of key profitability metrics such as IRR, NPV and Profit to investment ratio.	1	5.26	5.00	MK: Important to get these numbers in order to inform the decision to progress to PFS	57.02
#30	SACMR07, NCM03	MRM Production Schedule	Where relevant, state all blending, stockpiling, "rehandling" assumptions.	1	5.00	5.16	MK: Not all that critical at a concept level BB: High level plans should be provided not neccassery to have exact values SO: Key operational considerations BS: Yes, will affect the mining cost.	56.43

Table B1 continued

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#31	DCMR05	MRM Pit optimisation	Where relevant, use specialist software for multiple resource pit and plant optimisations.	1	5.53	4.58	MK: Using the best tools can add lots of value BB: This can be done in detail in later project phases. SO: Manual evaluation may neglect many potential options. BS: It is early days. Use what is appropriate for the level of information	56.14
#32	GPE01, ZCE01, GIME03, DCE02	Economic Accuracy / Contingency considerations	State the associated cost accuracy and substantiate the reasoning for the cost accuracy.	4	5.37	4.53		54.97
#33	NCMR01, SACMR04, SAMMR02, ISMR08, ISMR07, ISMR05, ISMR06, ISMR02, ISMR04	MRM Geotechnical	State all Geo-technical end Geo-hydraulical information and the origin thereof (bench-marked / Preliminary reports / neighboring operations).	9	4.58	5.32	MK: "Nice to have" at concept level BB: Very important for future considerations BS: If available, it must be included.	54.97
#34	NCE02	Economic - Cash flow modelling	Future technical study costs (PFS and BFS) and future exploration costs to be included in the cash flow model under capital costs.	1	4.74	5.05	BS: This is important, and a considerable cost.	54.39

Table B1 continued

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#35	ISME01	Economic - Cash flow modelling	Develop mining capital cost estimate from benchmarks	1	5.05	4.74		54.39
#36	ZCMR01, DCMR02	MRM Pit optimisation	State all mineral processing options considered for the study - referencing preliminary metallurgical testing where applicable.	2	5.05	4.74	BB: The recovery assumptions for each processing stream is important. SO: This may be more applicable to the prefeasibility phase. BS: Not relevant for a scoping study	54.39
#37	ISMO03	Mining Considerations	Determine Mining labour compliment (Equipment operators, support staff) with additional labour for absenteeism.	1	4.58	4.95	SO: Important for OPEX calcs BS: Numbers will change GO: These factors very important for future community and government negotiations	54.04
#38	ZCR01, ISRM01	Risk Management	Include a chapter summarising predominant project technical and financial risks along with a relative risk rating (low, Moderate, high)	2	6.37	5.74	BS: include your major risks and clearly state them.	53.80
#39	ISSH01, DCSH01	Safety, health and environmental considerations	Determine the relevant water requirement calculation parameters for use in mining and processing - referencing a hydrogeological study.	1	4.58	5.05	BS: See if there is water available / excessive. GO: I think requirements more important than hydro study ML: Insufficient availability of water on the mine site may deem the project infeasible or add significant cost	53.51

Table B1 continued

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#40	NCE05, ZCE04, SACE02, MHSE03, ISME04	Economic Accuracy / Contingency considerations	Include capital contingencies relative to the expected accuracy of the study.	5	5.16	4.42		53.22
#41	ISMR11, SACMR11	MRM General	Show the "mineable resource" along with the effect of design losses (Where a pit design was done) and modifying factors in a Waterfall chart.	2	4.79	4.79	MK: Order of magnitude numbers important for concept study - becomes really important at feasibility study level BB: Good indication of conversion rate from resources. Can indicate if project is justified to continue with BS: It is important that the reader understands that "Mineable resource" doesn't mean you can mine.	53.22
#42	SACG01	General	For all conceptual type studies - a financial appraisal - or a reference to a financial appraisal must be included.	1	4.84	4.58	BS: Some assessment to guide a yes/no decision on the future of the project is required.	52.34
#43	MHSE01	Economic - Cash flow modelling	Include engineering, procurement and construction management costs in the Capital cost estimate based on benchmark data (Approximately 2% of total Capital cost estimate)	1	4.47	4.89	0	52.05

Table B1 continued

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#44	NCMR03, ISMR16	MRM Pit design	Where a pit optimisation and a pit design is included, ensure that the pit design does not differ from the pit optimisation shell by more than 10% for waste and 5% for ore.	2	4.68	4.63	MK: Not important at conceptual level, use pit shells only BS: Not possible for all material. Regular shaped material, yes. In thin, tabular or veined deposit, it is not always possible. Dependant on setup of optimisation software block size, slope angle and bench elevations.	51.75
#45	SACR01	Risk management	Model study risks in a risk breakdown structure. Rate each risk in terms of the potential consequence and likelihood of occurrence.	1	6.11	5.53		51.70
#46	ISMO01, MHSM01, ISM007	Mining Considerations	Determine general overburden and waste disposal sites and mining method. (Strip mining, Terrace mining, open pit, back filling) Include a description of each mining method considered for the study.	3	4.32	4.26		50.99
#47	SACE03	Economic Strategic considerations	Provide a summary of all relevant preliminary product / marketing studies done for the project.	1	4.74	4.37	BS: All relevant or preliminary work GO: Commodity specific	50.58

Table B1 continued

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#48	MHSMR01	MRM General	Provide a summary of all historical data and work done relevant to the study - to ensure no rework is done.	1	4.79	4.26	MK: Historic info often good to give context but needs to be validated and often easier to start fresh. BB: If the historic information is noted rework from previous studies can be minimised SO: In many cases new consultants are involved or there may be major time periods between different phases of the study and the new stakeholders may not be aware of work done previously. TA: Rework will not necessarily reduce risk, as the conceptual study will still be completed. It may just take longer to do.	50.29
#49	DCMR08, SACMR08	MRM Pit optimisation	Where pit optimisation "shells" are used for volume and tonnage calculations, additional waste tonnes must be included in the calculation - to cater for the inclusion of ramps.	2	4.79	4.11	MK: Only has bearing on mining cost BB: Assumptions based on cost must be realistic BS: Yes - overall slope angle will be decreased. Dependant on type of mineral and deposit shape & type. GO: Whittle slopes should be reduced to cater for the inclusion of ramps	49.42

Table B1 continued

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#50	SACE01	Economic Strategic considerations	If a project does not prove feasible from the pit optimisation, then the study may (with permission from the stakeholders) calculate at what metal / mineral price the project be feasible.	1	4.37	4.53	BS: Yes, give the owner / client / reader of the document the range where you see this coming back to the market. GO: Good practise	49.42
#51	GIMG01	General	Where data is lacking, external consultants must be sourced and used for the project.	1	4.32	4.53	BS: If no data, no data. Otherwise, let someone else guess or measure.	49.12
#52	GPG02, ZCG01, ISMR18	General	A multi disciplinary site visit with specialists relevant to the commodity must be conducted prior to the study. Document findings from the site visit along with a site description	3	4.89	3.95		49.12
#53	ISSH02	Safety, health and environmental considerations	Determine estimated natural water inflow rates and identify areas where possible inflow might occur.	1	4.53	4.32	BS: If you have the information, do it. A geohydrological model will normally not be available. ML: Possible disturbances to natural water sources due to possible inflow may deem the project infeasible	49.12
#54	ZCE03	Economic Strategic considerations	Include a sensitivity analysis on NPV with step changes in Capital, Revenue, Operating cost, and Discount rate.	1	4.37	4.37	-	48.54

Table B1 continued

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#55	GIM01, SACM01, SACM02	Mining Considerations	Where the LOM of the operation is less than 5 years, assume contractor mining and state benchmarked contractor mining costs.	3	4.00	4.11		48.36
#56	SACM02, DCM06	Mining Considerations	Calculate mining unit costs over time using a mining cost adjustment factor (MCAF) that increases with depth and distance hauled.	2	4.11	4.05	SO: May understate costs if not done. BS: For deep pits & long hauls, yes.	47.54
#57	NCM02, DCM01, SACM01, ISM002	Mining Considerations	Conduct a detailed equipment simulation to provide preliminary equipment numbers per period	4	3.79	3.95	MK: A good place to get these numbers within 30% accuracy SO: Maybe pre-mature for concept study.	47.43
#58	NCE04	Economic - Cash flow modelling	State all costs in the cost model as either fixed or variable costs.	1	3.63	4.79		46.78

Table B1 continued

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#59	NCMR04, DCMR07, GIMR02, SACMR05, MHSMR05	MRM Pit optimisation	Where relevant - include an option analysis (ore hauling, processing alternatives, production alternatives, sale-able products) as scenarios in the pit optimisation.	5	4.32	3.89	MK: A good study phase to consider options but really more relevant in PFS BB: The aim of the scoping is not an option analyses. The option presented should be based on realistic assumptions and scenario analyses in later project phases should add to the NPV SO: Maybe pre-mature for concept study. BS: No, not at this level of study	45.61
#60	NCE01	Economic - Cash flow modelling	Defer product sales in the cash flow model (+-6months) to cater for operational readiness.	1	4.05	4.16	MK: Such detail is more relevant for a feasibility study BS: Good practice if done consistently for all conceptual scoping studies all over the world.	45.61
#61	NCMR06, SACMR06	MRM Pit optimisation	Develop an exploitation strategy and a push-back strategy from the pit optimisation results.	2	3.89	4.16	MK: Not important at concept level BB: This can be done on a high level as it is part of the management of your stripping ratio SO: Maybe pre-mature for concept study. BS: Mining engineer & team to decide, based on geology shape, size & infrastructure existing. GO: Will make a huge difference in NPV	44.74

Table B1 continued

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#62	ZCG03, SACG02, MHSG01, ZCG02	General	Include a statement of transparency - that the report does not comply with the relevant mineral valuation codes and that it cannot be used to prove feasibility.	3	3.95	3.89	GO: Good practise	43.57
#63	NCE06	Economic Strategic considerations	Provide a financial risk matrix for each item in the cost model and provide each item with a risk rating in terms of the potential of the cost to increase.	1	4.63	2.89	BS: The outcome of the risk rating will have a large range in this level of study. +-+35% is fine, otherwise the owner of the mining target areas decides it is a feasibility level study.	41.81
#64	DCMR01	MRM Geology	Where applicable, convert block model sizes to smallest mining units (SMU's) appropriate to the size of equipment / nature of the ore deposit.	1	3.84	3.58	BB: Only of use for mine design and planning. Block sizes will not influence the viability of the project and can be determined in pre- or feasibility study phase. SO: Wrong equipment may be considered if not done. BS: This will change. Mining blocks and benches will change. Equipment will still change.	41.23
#65	SACE05	Economic - Cash flow modelling	The cost model cash flow must be shown as graphical results. Such results must then be discussed and related to major rises and falls in the cash flow.	1	4.11	3.26	BS: Too much detail for a scoping study	40.94

Table B1 continued

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#66	ISMO06	Mining Considerations	Determine the relevant mining equipment power calculation factors (Electricity kW / Diesel consumption)	1	3.47	3.58	SO: Key cost drivers	40.29
#67	ISMO05	Mining Considerations	Determine operational management requirements for the mining operation.	1	3.63	3.37	BB: High level information will be adequate	40.00
#68	NCM01	Mining Considerations	State an explanation for the reasoning for mining equipment selected.	1	3.05	3.63	SO: High level reasoning required.	38.25
#69	GIME02	Economic - Cash flow modelling	Include in a detailed breakdown of all costs pertaining to the transport of - ore / concentrate / ore refined product - in the cash flow model.	1	3.16	3.53	MK: Such detail is more relevant for a feasibility study BS: If a bulk commodity, yes. GO: High level good assumption should suffice	37.13
#70	DCE03, SACE04, NCE04, ISME03	Economic - Cash flow modelling	Operating costs must be expressed per mining activity (Drilling, Blasting, Load and Haul, Haul roads etc.) as well as per cost type (Maintenance, GET, Diesel, Electricity, Lubricants etc.)	4	3.21	3.47	-	37.13
#71	ZCM01	Mining Considerations	For large operations with a life of more than 5 years, list mining equipment capital purchases preferrably spread over two years.	1	3.11	2.74	SO: Depend on capex versus opex strategy	33.57

Table B1 continued

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#72	MHSE02	Economic Strategic considerations	If the purpose of a conceptual study is to set scope for a potential drilling campaign, then a predefined NPV may be selected and an average grade back calculated.	1	3.21	2.47	-	31.58