THE SAFE AND FEASIBLE POSITIONING, DESIGN AND CONSTRUCTION OF THE MERENSKY BOXCUT AT THE BOOYSENDAL COMPLEX

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, 2018

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ABSTRACT

The mining industry is not as favourable investment destination as in the past. It is getting more challenging to raise capital for a mining greenfield project with compared to other investments that have relatively higher returns in shorter time with less risk.

Mining companies need to focus on sustaining or expanding existing operations with additional brownfield projects. The main advantages of a brownfields project are the lower risk in the resource, and the lower capital and operational cost resulting from the synergies with the existing operation.

Establishing another operation within an existing mine, creates new set of challenges. Geological and geotechnical factors have a big impact of placement of infrastructure. There is always the risk that the available areas were not utilised for a reason. A good understanding of the ground conditions of these areas is required. There is also the challenge of establishing the new infrastructure next to or close to existing in of establishing new infrastructure close to existing infrastructure.

This challenge can be alleviated by careful, detailed planning of the position, design and establishment of the new infrastructure.

The most important principle is to gather as much information as possible from all the critical factors that can influence the establishment of the new operation. This information must be studied and understood to create detailed designs. The detailed designs must take into consideration all possible flaws and must be engineered not to fail. A phased approach to implementation is necessary to break processes up into more manageable sections.

Access Positioning ⇔ Access Design ⇔ Access Establishment

To attract shareholders to their mining projects companies need to focus on reducing the required capital, risk, and the return period of invested capital. This can be achieved exploring for brownfields opportunities within their own realm. Even if the resource was thought to be unfeasible the synergies that can be established between the potential project and the existing mine can be of such a big influence on the capital and operation expenses that it can be turned viable.

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GLOSSARY

Term	Definition
anorthosite	A type of igneous rock largely composed of plagioclase feldspar, formed from intrusions of magma within the Earth's crust
Bushveld Complex	A large, layered, saucer-shaped geological formation found in the Bushveld region of the north of South Africa; it contains deposits rich in PGE
chromite	An iron chromium oxide ($FeCr_2O_4$) mineral with traces of magnesium and aluminium
chromitite	A rock type containing a high concentration of chromite
deflection	A secondary borehole drilled at an angle to the vertical
deposit	The total quantity of an ore body contained within a geological formation
dip	The angle of inclination of a reef from the horizontal
fault	A discontinuity in a layered feature resulting from rock fracture and movement, with one section being displaced relative to another
feldspar	An aluminium silicate mineral, containing potassium, sodium, calcium or barium
footwall	The layer of rock beneath a vein or expanse of ore

grade	The specific quantity of an element of interest contained within a unit mass of an ore body; for the PGEs this is most often given in grams per metric tonne
igneous	Rocks formed from the solidification of either magma in the Earth's crust or of lava on the surface
Merensky Reef	A layer of the Bushveld Complex largely composed of pyroxenite that is rich in sulfide minerals; to date it has supplied most of the world's platinum group metals, and also yields significant quantities of copper, nickel, cobalt and gold as by-products. It is mined on both the eastern and western limbs of the Bushveld Complex
mineralised horizon	A layer or stratum in which minerals of interest are preferentially concentrated; this could be distinct and continuous as a reef, or more dispersed and intermittent
outcrop	A section of the reef which intersects the surface of the Earth and may have been subject to weathering
pegmatite	A type of igneous rock characterised by a very coarse grain structure, with crystals several centimetres across usually composed of granite (quartz, feldspar and mica)
PGE	Platinum group elements (platinum, palladium, rhodium, iridium, osmium and ruthenium). This term is used in geology as the elements generally occur in mineral, rather than metallic, form within an ore
plagioclase	An aluminium silicate mineral of the feldspar family, with varying relative proportions of sodium and calcium

pothole	Circular or elliptical sections where the reef has funnelled into the footwall, leading to discontinuity and altered mineralogy
pyroxene	Silicate minerals containing calcium, magnesium and iron
pyroxenite	A rock type containing a high concentration of pyroxenes
reef	A distinct and continuous layer or stratum in which minerals of interest are preferentially concentrated
reserves	Ore bodies which have been quantified to a high degree of confidence and which can be extracted using existing methods
resource	Ore bodies which are known to exist and which can be quantified to some degree of confidence. These can reasonably be expected to be extracted in the future
sedimentary	A type of rock formed from solidified deposits of eroded rock material, which have usually accumulated in bodies of water
strike	The line of intersection of an inclined plane with the horizontal, such as when a reef outcrops on the surface of the Earth
sulfide	Minerals formed from compounds of sulfur, these are a major source of metals such as copper, nickel and lead
UG2 Reef	Upper Group 2; a layer of the Bushveld Complex rich in chromite but lacking sulfide minerals. It possibly has a larger resource of platinum group elements than the Merensky Reef. It lies below the Merensky Reef and is mined on both the eastern and western limbs of the Bushveld Complex

LIST OF ABBREVIATIONS

ARC: Auto-reclose

BIC: Bushveld Igneous Complex

DMR: Department of Mineral Resources

Hz: Hertz

Ja: Joint Alteration Number

Jn: Number of Joint Sets

Jr: Joint Roughness Number

Jw: Joint Water Reduction Number

MAMSL: Metres Above Mean Sea Level

MPa: Mega Pascal

PGE's: Platinum Group Elements

PGM: Platinum Group Metals

RQD: Rock Quality Designation

SRF: Stress Reduction Factor

MPRDA: Minerals and Petroleum Resources Development Act, 2002 (Act 28 of 2002)

PPV: Peak Particle Velocity

SCPE: Sekhukhune Centre of Plant Endemism

SD: Scale Depth of Burial

UCS: Uniaxial Compressive Strengths

1 INTRODUCTION

1.1. Purpose

Mining companies find it more and more difficult to attract investment capital for new exploration or expansion projects. Financial factors that influence a project's feasibility range from the volatile markets, product demand to declining grades and productivity. Environmental, social and shareholder expectations are also mounting and the reporting thereof is proving to be more stringent to “earn” their social licence to operate. Additional challenges include resources that prove to be extremely difficult to access. This can be due to remote geographical locations or in unfavourable countries which increase the risk to the financial outcome of a project.

Commodity cost and demand cycles affect all commodities, which proofs to be more unpredictable than ever before. Very few high quality, long life resources are still available. This forces companies to focus on optimising their assets and spent sustainable capital on current operations or brownfields expansion. Mining companies have to implement strategies which will enable them to expand or sustain current operations at the lowest capital and operational cost. This forces them to be innovative in order to achieve their goal. The result is that growth strategies are no longer about major new capital projects or significant merger and acquisition deals but focused on portfolio optimization through a combination of productivity improvements, strategic acquisitions, brownfield expansions and divestments. (Deloitte, 2017).

The purpose of this research report is to present that a specific company can sustain or expand its operations by implementing a brownfields project at a much lower cost than a greenfields project. The report highlights the challenges that were encountered in this specific project and how it was addressed to reduce the risks.

1.2. Objective

The above mentioned factors motivated this research and aims to discuss the complexity and considering factors when placing, designing and executing a brownfields project. The risk in brownfield exploration is considerably lower than in greenfield exploration as geologists are able to use existing data. The additional capital cost for processing the extra ore is very low as the facilities for mining support infrastructure and processing the ore have already been built and paid for.

The investigation focusses on a phased approach which can be taken to place, design and execution of the access of a mine through the establishment of a Boxcut. Focus is also given to statutory requirements as well as the economic advantages of the shared infrastructure of a brownfields project.

The establishment of a Merensky mine will be one of only a few on the Eastern Limb as the majority of the mines in the area operate the UG2 reef. The initial scope of the project was to create a small scale mine as a trial but to allow for easy increase in production once the Merensky was proven to be feasible. The planned capacity for the trial mining period was 30 000 tonnes per month with the option to ramp up to 75 000 tonnes per month.

During 2014, a concept study was conducted to ascertain the economic extraction of the Merensky reef with the aim to utilise as much as possible synergies between the established UG2 mine and the planned Merensky mine to reduce the capital and operational cost of the new mine. From the commencement this seemed to be a very challenging project due to variable factors that influenced the location, and design of the mine. This project focuses on this specific platinum mine in the Eastern Limb of the Bushveld Complex and all factors are company and site specific.

2 OVERVIEW AND BACKGROUND INFORMATION

The section below discusses the general background information such as location, history and ownership. It also covers information about the factors that influenced the positioning and design of the mine access which include:

- Topography,
- Geology,
- Geotechnical,
- Environmental,
- Socio Economic, and
- Legislation.

2.1. Platinum Mining in South Africa

Platinum mining in South Africa is predominantly mined in the Bushveld Complex that formed some two billion years ago (Grambling, 2008). This igneous body is divided into four limbs: Northern, Southern, Eastern and Western limbs and hosts more than half of the world's platinum group metals (Kinaird, 2005).

Platinum and palladium production from the mines situated within the complex represents approximately 75% and 40% of annual global production respectively (Johnson Matthey, 2016).

2.2. Location of the Mine

The Booysendal project area is located in an area of Mpumalanga and the Limpopo Province. This area is characterised by intense mining operations and mining development. The mining development serves as a stimulus for local social and economic development.

This economic progress is clearly visible in towns such as Burgersfort and Lydenburg. Although the project area lies between Roossenekal (±10km to the west) and Lydenburg (±35km to the east) its remote location makes it relatively inaccessible. There is no direct access to the project area. Current access to the project area is via the northern Stoffberg-Steelpoort R555 onto the Thorncliffe / Mototolo Road and through Anglo Platinum's Der Brochen Project area.

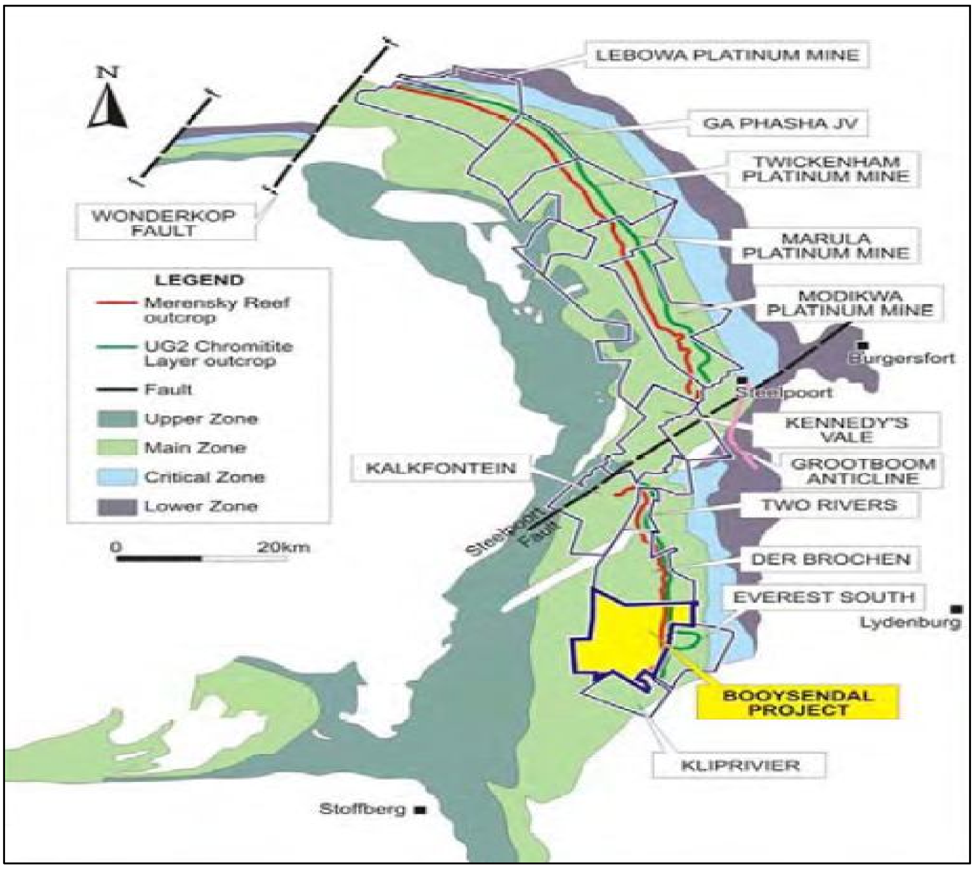

Figure 1: Location of Booysendal and Adjacent Mines (Smith, et al., 2009)

2.3. History of the Operation (Mine)

The Booysendal Platinum mine on the eastern limb was established in 2010 and begun exploiting the UG2 reef horizon with the Booysendal North mine. Extensive exploration programs also focused on the Merensky reef which is proven to be rich in Platinum Group Elements (PGE's). (Cawthorn, et al., 2002)

2.4. Ownership

Northam Platinum Limited purchased the Booysendal part of the Der Brochen Mining operations from Rustenburg Platinum Mines Limited (Anglo Platinum) early in 2008. The property has an existing mining authorisation dating to 2003. Shortly after the purchase in April 2008, Northam Platinum applied to have their old order mining right converted to a new order mining right in terms of the Mineral and Petroleum Resources Development Act (28 of 2002) (MPRDA). The mining right conversion was granted on 18 May 2009.

2.5. Topography

The project area is situated in a very rugged mountainous terrain. Great elevation differences exist between the valleys and the mountain ridges. The prominent north-south trending Steenkamps Mountains extends though the project area. The lowest area in the Booysendal project lies at a height of 1052 metres above mean sea level (mamsl) while the highest point in the proposed project area is 2096 mamsl.

Figure 2: View of the Groot Dwars River Valley (Smith, et al., 2009)

2.6. Geology

The Booysendal Project area is situated in the Bushveld Igneous Complex (BIC). The Bushveld Complex originated from a volcanic intrusion approximately 2 billion years ago and can be divided into a Northern, Southern, Western and an Eastern Limb (Figure 3). The BIC is rich in ore deposits, hence the intense mining development in both the western Rustenburg area and eastern sides of the Bushveld Igneous Complex. The Booysendal Project is located in the Eastern Limb of this complex.

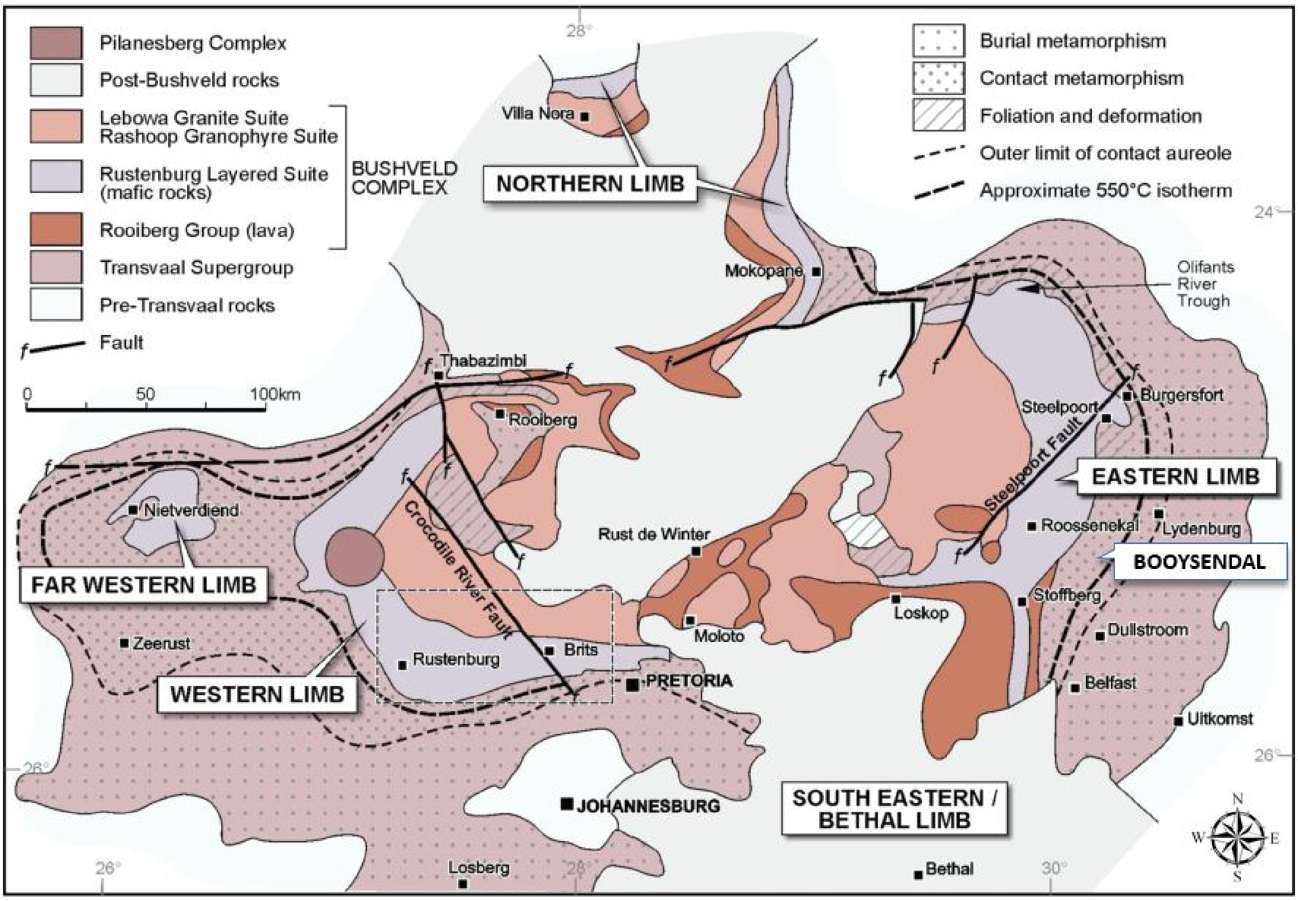

Figure 3: Bushveld Igneous Complex Geology (Smith, et al., 2009)

The Booysendal Project Area is underlain by the Upper Critical and Main Zones of the Bushveld Complex. The main economic horizons in this Southern Upper Critical and Main Zones are the Platinum Group Minerals (PGMs) located in the Merensky Reef and the underlying UG2 Chromitite Reef. The two reefs outcrop in the Groot Dwars River Valley in which the Booysendal Project is located for approximately 12.5km north-south while it dips between 10° and 12° to the west.

Middling between the UG2 and Merensky reefs is variable across the Bushveld, and ranges from 170 m to 400 m on the Eastern Limb. The mineable Merensky resource (over a reef channel) in the area is 23.8 million tonnes at a grade of 5.06 g/t over a channel width of 106 cm, yielding 3.9 million troy ounces. Table 1 below summarises the resource classification and quantities. (Northam Platinum Annual Intergared Report, 2016) Tabled below are the resource quantities in the targeted Merensky project area.

Table 1: Booysendal Merensky Resource Table

Category	Reef Area (m^2)	Width (cm)	Density (t/m	E4 Grade (g/t)	M/tonnes (M/t)	M/ounces (M/oz)
Measured	3 239 550	210	3.25	**3.23**	**22.14**	**1.77**
Indicated	0	0	0	**0**	**0**	**0**
Inferred	0	0	0	**0**	**0**	**0**
Total	**3 239 550**	**210**	**3.25**	**3.23**	**22.14**	**1.77**

Appendix 7.1 illustrates the detailed resource classification table.

2.7. Geotechnical

The geotechnical conditions above the Merensky Reef are competent, with gradational contacts between the rock types. At the base of the Bastard Reef, which occurs between 12 m and 30 m above the Merensky Reef, the first sharp contact (possible parting plane) is evident. The thicknesses of the lithologies differ considerably across the Bushveld, with the base of the Bastard Reef varying between about 10 m and 30 m. Dome structures are often observed in stope hanging walls. Potholes are a frequent phenomenon on the Merensky Reef. These geological structures are generally oval in plan and comprise a sudden drop in the elevation of the reef within the confines of the oval. (Smith, et al., 2009)

2.8. Environmental

The project area is situated within the Dwars River Valley (Figure 2) in the sensitive Sekhukhune Centre of Endemism vegetation biome. The rugged terrain is important in terms of its rich archaeological and heritage finds. The Groot Dwars River valley which is a tributary of the Steelpoort River and of which the water quality in this upper catchment area is still very pristine that it complies with drinking water standards (Arnott, 2012).

2.8.1 Climate

The project area is situated in the Highveld climate region of South Africa, with an annual rainfall of approximately 700mm, summer temperatures are generally greater than 30°C, and winter temperatures can drop to -10°C in the region. Most of the rain in this region occurs during the summer months from December to January. The region is also subject to thunderstorms during these months. (Rocher, 2009)

Summer temperatures are generally hot and winters are moderate. These temperatures are characteristic of typical valley climates where the daily temperatures can be extremely hot. Although the temperature data of Lydenburg weather station is not an exact representation of the climatic conditions at Booysendal, it does present a relative good representation of the local climatic conditions.

2.8.2 Fauna

The Groot Dwars River valley is the habitat of Pycna Sylvia a cicada that is well known for the shrill buzzing sound they produce during summer, which was thought to be extinct for 95 years (Malherbe, et al., 2004).

In addition the project area is host to the Jameson's red rock rabbit, listed as rare/threatened/ vulnerable and the Oribi, listed within the reference of its provincial status as vulnerable. These species may be threatened due to the mining and related activities.

2.8.3 Flora

The project area is mainly located in the Roossenekal sub-centre of the Sekhukhune Centre of Plant Endemism (SCPE). A small northern section is located in the Steelpoort sub-centre; and the SCPE is characterised by endemic/rare/endangered and red data species.

2.9. Socio Economic

The area is characterised by social-economic deprivation including poverty, low levels of education a high dependency rate, and little employment opportunities. Development in the area outside of the mining sector is low and any economic development will be advantageous to the local community to provide employment and business opportunities.

2.10. Legislation

The requirements and provisions of inter alia, the following legislation and relevant regulations promulgated there under have been incorporated into the assessment and authorisation process:

- The Constitution of South Africa (108 of 1996);
- The Mineral and Petroleum Resources Development Act (28 of 2002);
- The National Environmental Management Act (107 of 1998);
- The National Water Act (36 of 1998);

- The Environment Conservation Act (73 of 1989);
- The National Environmental Management: Biodiversity Act (10 of 2004);
- The Conservation of Natural Resources Act (43 of 1983);
- The National Environmental Management: Air Quality Act (59 of 2008);
- Atmospheric Pollution Prevention Act (45 of 1965);
- Hazardous Substance Act (15 of 1973);
- The National Heritage Resources Act (25 of 1999);
- The Occupational Health and Safety Act (85 of 1993);
- The Explosives Act (26 of 1956);
- The Mine Health and Safety Act (29 of 1996);
- Regulation 15 of the Electrical Machinery Regulations Act (85 of 1993); and
- Explosives Act (15 of 2003).

3 MERENSKY BOXCUT

The above mentioned section sets the seen and gives and overview of the high level factors that must be considered when establishing a mine or accessing the resource.
The following section describes the study approach and how various factors would influence the outcome of the study.

3.1. Study Approach

The main advantage of this project is that the resource can be accessed from the outcrop with the establishment of a Boxcut and developing on-reef declines from this to exploit the resource. In order to access a resource, and in this instance the Merensky reef, the ability to mine the resource safely and profitably and the sequence of the mine plan must be considered. Selecting a position on surface, which is best suited to start underground tunnel excavations, is also dependent on the ground surface conditions.

The excavation of a Boxcut through the weathered bedrock and upper soils and provides access to a position where underground tunnelling can commence safely. Determining the correct underground access location is important for project-capital costing as well as operational costing purposes over the life of mine and requires thorough investigation.

The research project follows a phased approach to ensure the optimal and safe position. This approach entails chronological stages that is applied in studies in the mining industry used for determining mine access strategies. These factors are generic for mine access placement when sinking a shaft or establishing a surface mining operation. The process to identify the relevant factors, to positioning and create the final design is an iterative process illustrated in Figure 4 below.

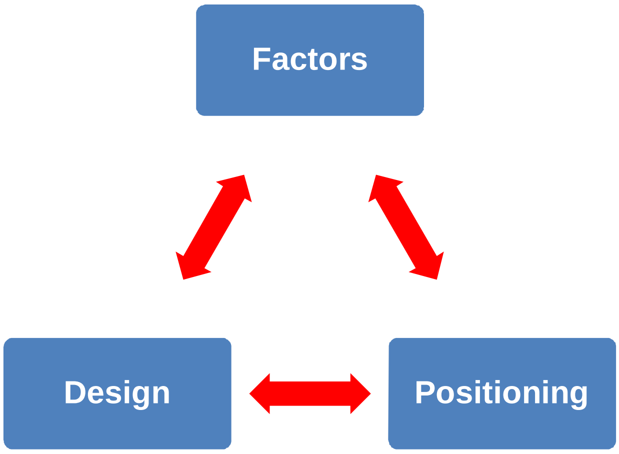

Figure 4: Positioning and Design Process

Phase 1 – Factors Influencing Boxcut Positioning

Phase 2 – Factors Influencing Boxcut Design

Phase 3 – Factors Influencing Boxcut Establishment

Phase 4 – Shared Infrastructure

Figure 5 below illustrates the phased approach as well as elements and factors influencing these phases of the research project.

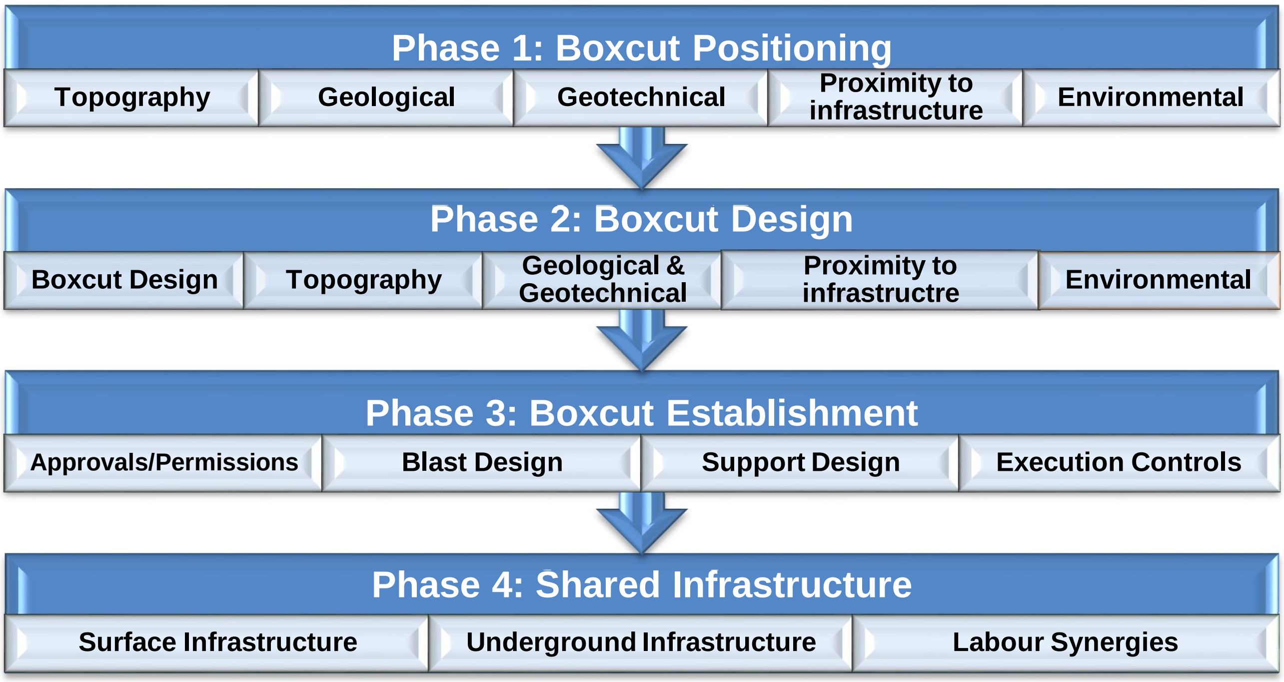

Figure 5: Research Project Approach

3.2. Phase 1: Boxcut Positioning

If the geotechnical conditions are not suited for a safe and cost effective excavation the location of a Boxcut can have far reaching implications. The Boxcut should ideally be positioned in an area where there is reasonably competent rock and the excavation requires minimal support (Puncher, 2009).

In the preliminary phase the drilling of vertical rotary core boreholes were required to confirm the depths of weathering and the likely Boxcut position. From the drill results it was found that the pyroxenitic Merensky reef, which lies within more competent noritic and anorthositic rock layers, is fairly weathered.

Weathering was found to be more pervasive where the mountain slope is less precipitous and based on these findings the size of the Boxcut was reduced. Inclined and orientated core drilling formed part of the detailed investigation to further define the rock mass quality for Boxcut side slope design. The position of the Merensky outcrop and existing infrastructure of the UG2 mine is illustrated in Figure 6 below.

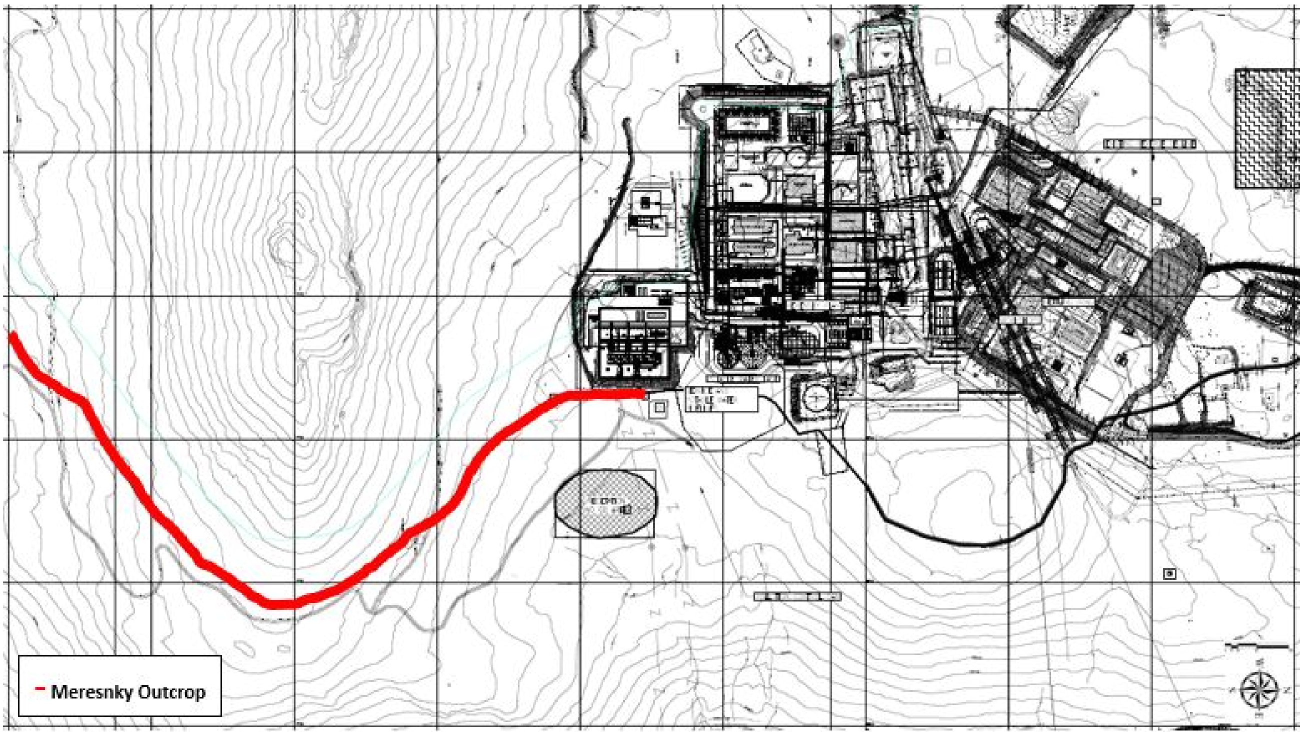

Figure 6: Merensky Outcrop (DRA)

3.2.1 Topography

The first step is to identify potential positions for the placement of the Boxcut taking in consideration the topography where the minimal amount of earthworks will be required. Three options (A, B, C) were identified on the Merensky outcrop against the koppie that is illustrated in Figure 7. The three options against the koppie takes advantage of the contours and reduced the amount of earthworks that is required to cut the Boxcut and fill the back area.

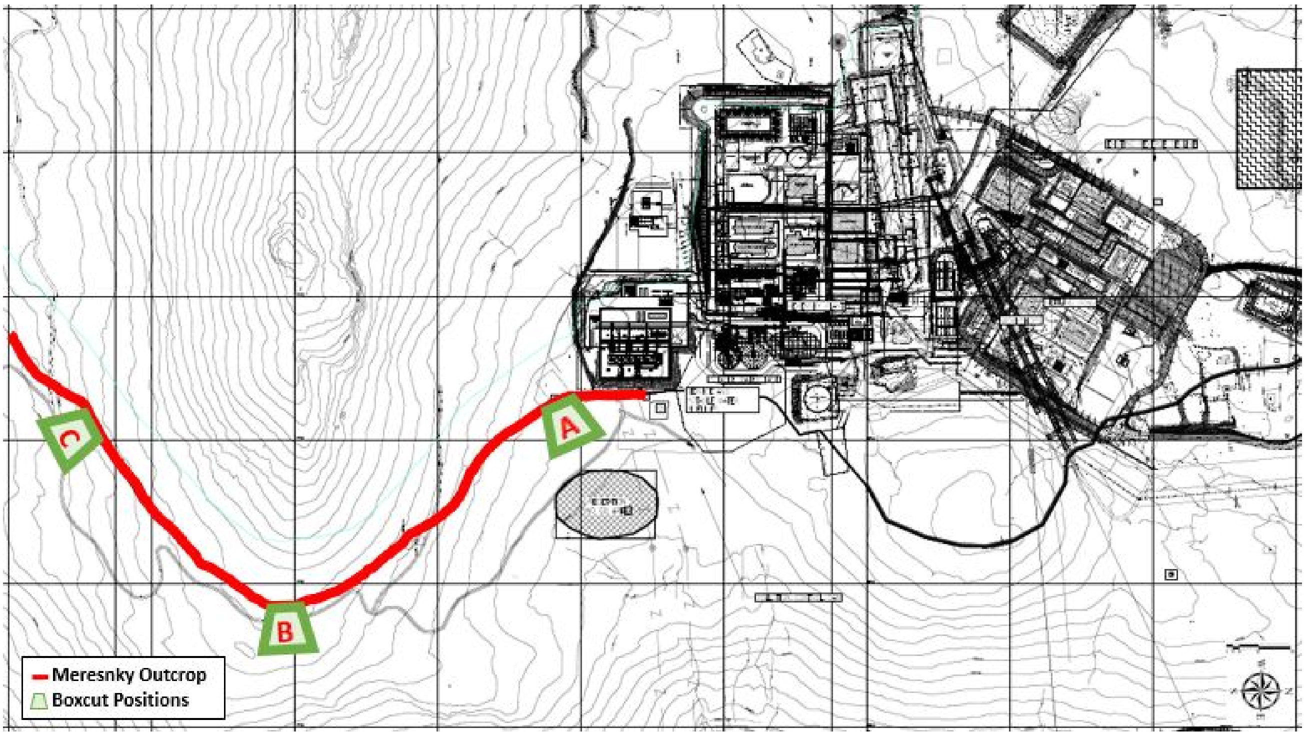

Figure 7: Merensky Boxcut Positions (DRA)

Table 2 tables the various earthworks costs, based on quotes received and calculated quantities, of establishing the Boxcut at the various options.

Table 2: Earthworks Cost Comparison

Option	Terrace	Boxcut	Roads	Total
Option A	R1 636 373	R7 626 585	R1 820 794	**R11 083 753**
Option B	R2 118 875	R7 907 728	R2 161 768	**R12 188 371**
Option C	R2 217 955	R8 006 406	R2 211 800	**R12 436 161**

From Table 2 above the position of option A has the lowest establishment cost due to the topography being more favourable. The position of option B and option C attracts more cost on the roads due to greater distances.

3.2.2 Geological Factors

To determine the positioning of the Boxcut, a clear understanding of the geology is necessary. The following sections describe the resource characteristics that play a role in this.

Channel Characteristics

The Merensky Reef is approximately 12.2 m thick, the base of which is defined by a 2.3 m thick piokilitic feldspathic pyroxenite. The Reef is fairly consistent with a thin chromitite stringer (marker) located approximately 30cm from the top of the Merensky pyroxenite. The Platinum Group Metal (PGM) mineralization of the Merensky Reef occurs in the upper one metre of the Merensky pyroxenite as per Figure 8. This mineralised layer is characterized by an abrupt transition from norite to pyroxenite, a single narrow chromitite stringer, coarser semi-pegmatoidal textures and the presence of visible base metal sulphides. The Merensky Reef hanging wall is geotechnically competent, with gradational contacts between the hanging wall lithologies. Although rare, jointed reef and poorer hanging wall conditions are normally associated with faulting, dykes and potholes (Smith, et al., 2009).

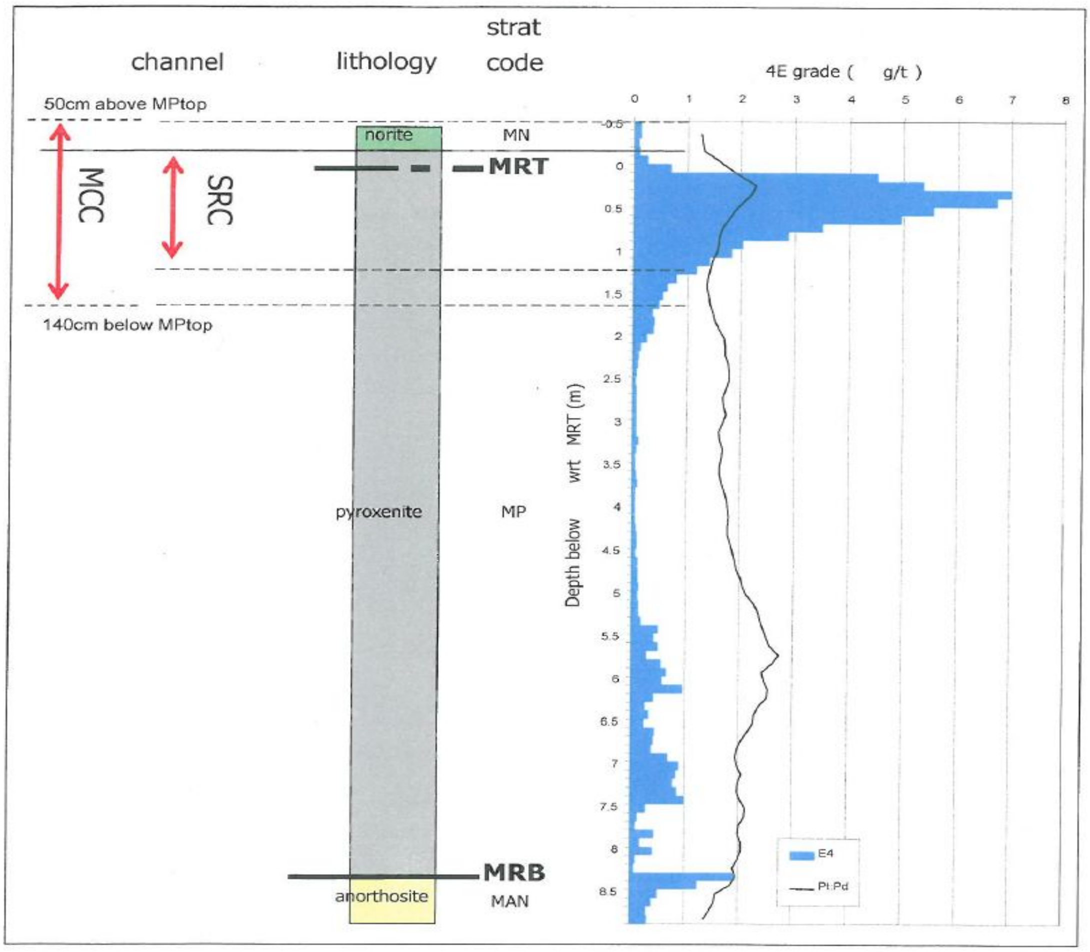

Figure 8: Merensky Reef Stratigraphic Grade Distribution (Smith, et al., 2009)

Grade Distribution

The upper and lower limits of mineralisation are commonly defined by two to four thin chromitite layers between one and two cm in width. The highest grades are associated with these chromitites. (Kinnaird, 2005). The footwall can vary between anorthositic, in most cases, or less commonly feldspathic pyroxenite or harzburgite. Figure 8 above illustrates the variations in the stratigraphy through the Merensky Reef. The hanging wall is largely a norite that changes upwards into anorthosite of the superimposing Bastard Cyclic Unit. This name derived due to the similarity of the Merensky Reef but mineralisation is absent.

The average grade of the Merensky Reef is typically 5-7g/t. The precious metals contained are proportioned as follow:

- 4.82 ppm Pt;
- 2.04 ppm Pd;
- 0.66 ppm Ru;
- 0.24 ppm Rh;
- 0.08 ppm Ir;
- 0.26 ppm Au; and
- Cu:Ni ratio is 0.61.

The reef thickness influences the extent and relatives amount of PGE's and base metal sulphides contained in the channel, where the reef is thinner higher grades are encountered.

The grade of the reef is remarkably constant over great strike distances but the composition of the actual PGE mineralogy is highly variable and can differ from mine to mine. (Cawthorn, et al., 2002). Potholes are developed where the Merensky Reef abruptly transgress footwall rocks that can interrupt the normal mining of the reef.

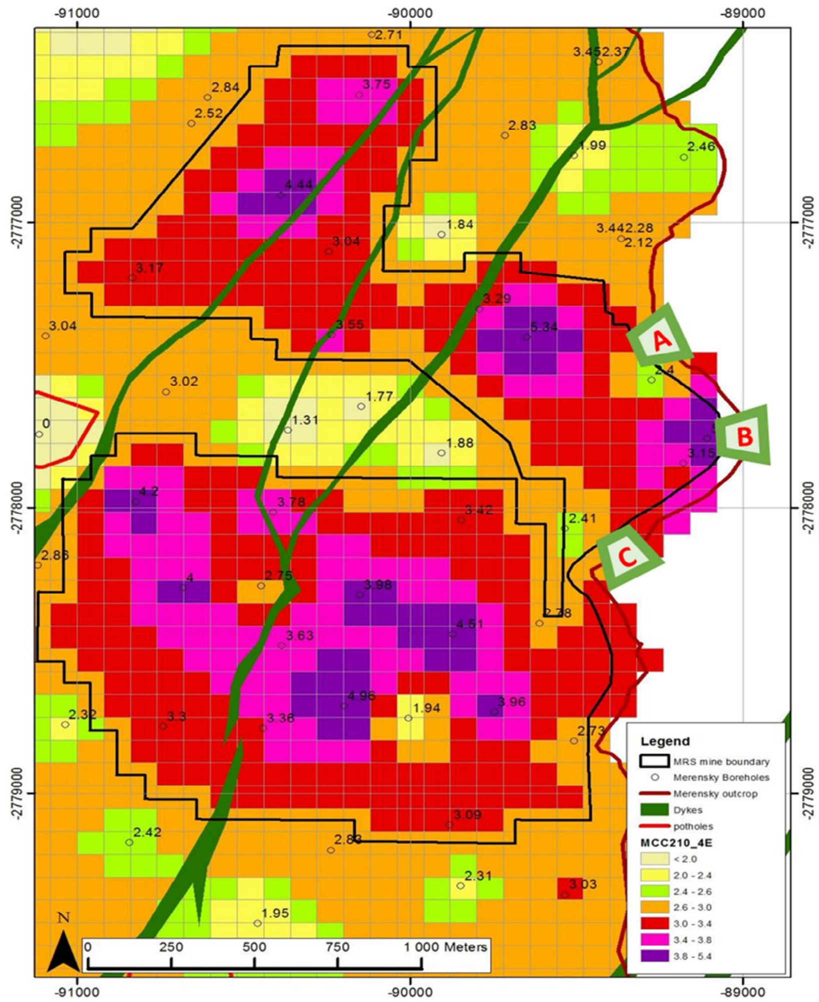

Figure 9: Merensky Target Area Grade Distribution (Northam Platinum)

From the Boxcut access position underground mining takes place in the various areas that have different grade distributions as per Figure 9 above. From each of the three options a detailed mine plan was generated to establish which of the three options, from a mining perspective, results in the best tonnages and content generated.

Table 3 below illustrates the various tonnes mined and content at the grade it is mined at in the first five years.

Table 3: Boxcut Access Options Mining Quantities

Option	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Option A Tonnes (t)	192 017	403 973	326 753	327 743	326 730	**1 577 215**
Option A Content (t)	529	1 206	997	961	953	**4 646**
Option A Grade (g/t)	2.75	2.99	3.05	2.93	2.92	**2.95**
Option B Tonnes (t)	154 757	403 636	326 446	327 437	326 556	**1 538 832**
Option B Content (t)	505	1 205	918	916	902	**4 446**
Option B Grade (g/t)	3.26	2.99	2.81	2.80	2.76	**2.89**
Option C Tonnes (t)	185 696	404 446	326 502	327 415	326 576	**1 570 636**
Option C Content (t)	453	1 143	1 051	996	939	**4 583**
Option C Grade (g/t)	2.44	2.83	3.22	3.04	2.88	**2.92**

From Table 3 above it is illustrated that Option A is the preferred position for the Boxcut as it results in the best return in mining volumes, content and grade over the first five years that will assist with the revenue income. Although Option B has the best mining grade in the first year the lower volumes being mined results in lower content being generated. Figure 10 below illustrates the cumulative content from the various options with option A delivering the highest cumulative content over the first five years.

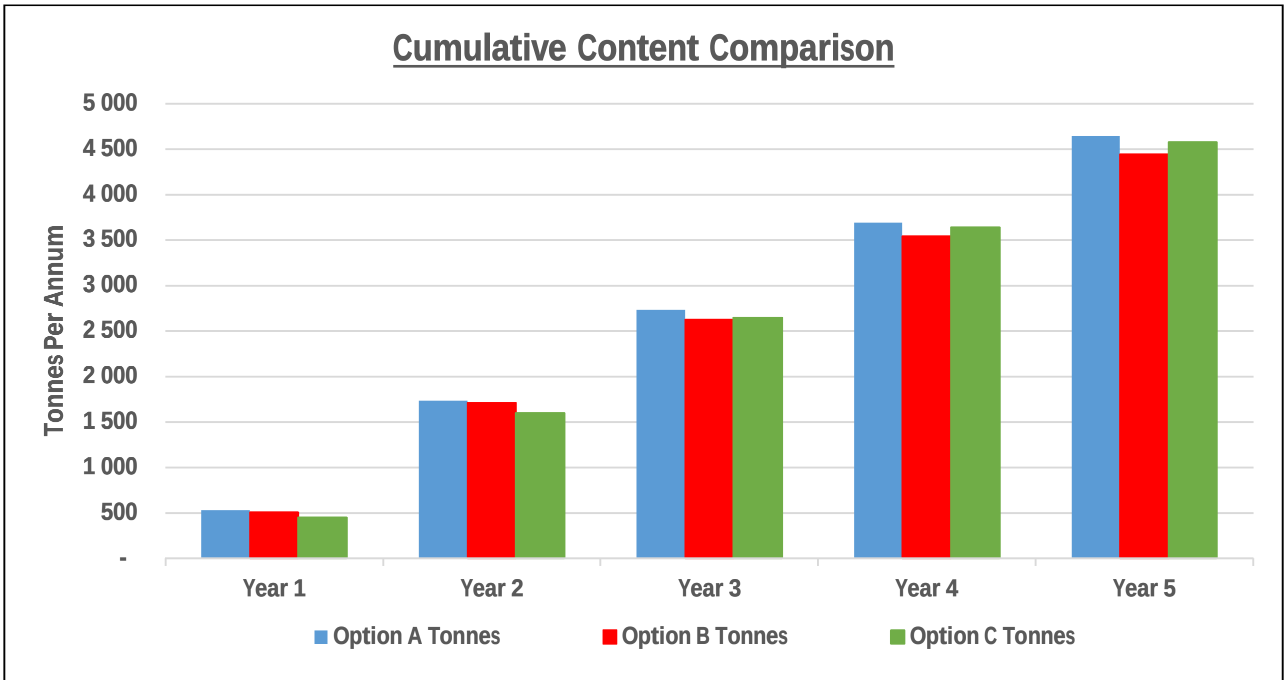

Figure 10: Cumulative Content Comparison

3.2.3 Geotechnical Factors

The typical geotechnical investigation for the positioning of a Boxcut will be carried out in two phases. A preliminary investigation that would determine the ideal location of the Boxcut, while the secondary detailed investigation would deliver information essential for final design and construction (Puncher, 2009).

Rock strength test work and geotechnical logging of hanging wall, reef and footwall samples from numerous Merensky reef borehole intersections was undertaken as part of the Booysendal feasibility work (Spencer, 2014). No significant hanging wall or footwall shears or low angle parting surfaces were identified. The top bounding contact of the Merensky pyroxenite with the overlying Merensky norite is a silicate contact with no parting.

A total of eleven borehole cores were logged. These included MRS1, 2, 3, 3a, 4, 5, 6, 7, 8, 9 and 16 as indicated in Figure 11 below.

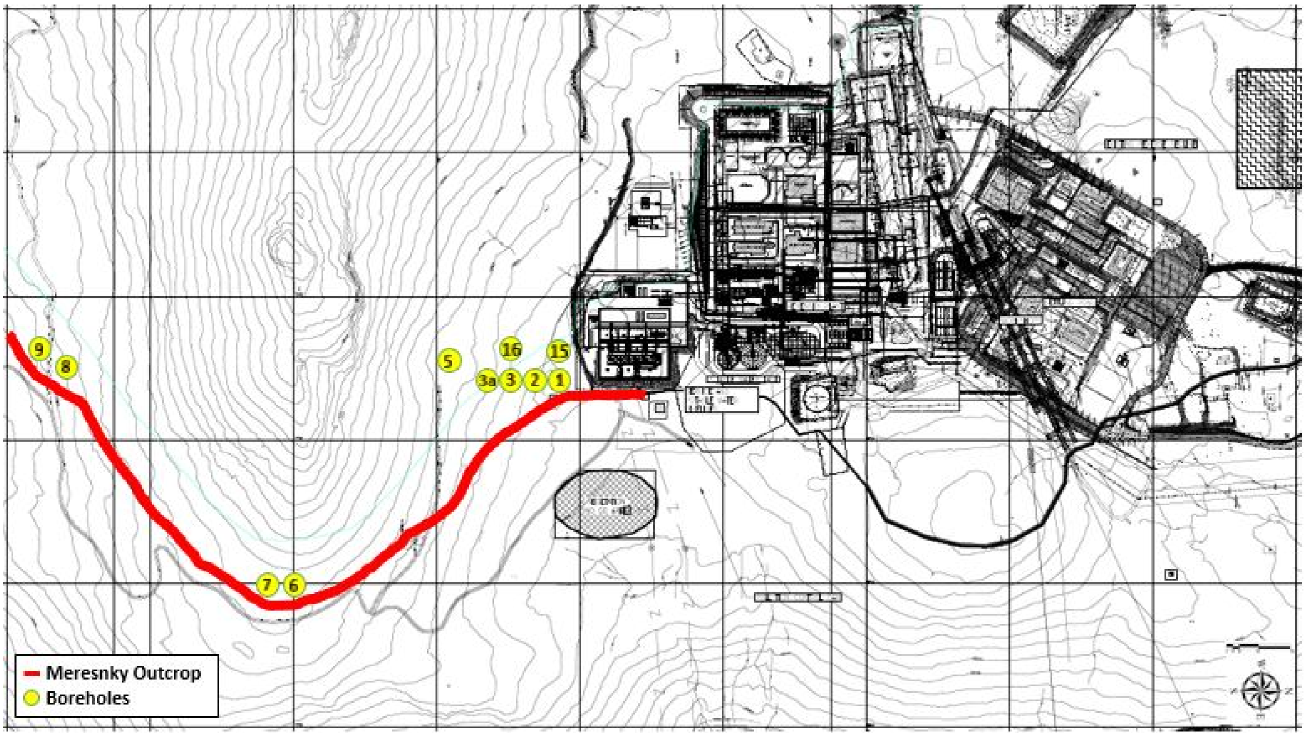

Figure 11: Drilled Boreholes Positions (DRA)

The geotechnical logging was conducted using the Q rating system to determine rock mass ratings that indicate the anticipated ground conditions. The Q rating system was designed to be able to classify rock masses by measuring certain parameters, a total of six, and relating them to excavation stability.

The six parameters are as follows:

- RQD – Rock Quality designation,
- Jn - Number of joint sets,
- Jr - Joint roughness number,
- Ja - Joint alteration number,
- Jw - Joint water reduction number, and
- SRF – Stress reduction factor.

Four of the six parameters are directly related to joints, which make the application of the Q rating system ideal for a shallow mining environment where excavation stability is governed by geological structures such as joints and parting planes.

The following factors were investigated in the geotechnical study done by (Spencer, 2014):

- Q Ratings
- Rock Strength Testing

3.2.4 Q Ratings

A total of 44 boreholes were analysed. Individual Q values varied from a minimum of 0.8 up to a maximum of rating of 20. The average Q ratings for individual boreholes were split between the Merensky immediate hanging wall, reef and immediate footwall.

The Q rating analysis was conducted on borehole core, thus it was not possible to determine whether or not water was present. Table 4 below illustrates the correlation between the Q value and the anticipated ground conditions.

Table 4: Q Values and Expected Ground Conditions

Q value	Description of anticipated ground conditions
<1.0	Very Poor
1.0 to 4.0	Poor
4.0 to 10.0	Fair
10.0 to 40.0	Good
>40.0	Very Good

The Joint set number (Jn) was taken as 15 in all calculations as a result of information from the geologist regarding the number of known regional joint sets which were 4 plus one random set. The average values for the reef and immediate footwall and for the immediate hanging wall correspond to anticipated ground conditions described as fair and good.

The minimum and maximum Q ratings for all rock types are displayed in Table 5 below.

Table 5: Q Ratings

Rock Type	Q Values		
	Minimum	Maximum	Average
Hanging Wall	2.9	20	**11.6**
Reef	1.3	20	**8.7**
Footwall	2.2	20	**8.7**

3.2.5 Rock Strength Testing

The rock strength testing programme consisted of a dual approach by undertaking strength tests using both the point load test and the laboratory test methods.

Sub-vertical structures and the impact thereof are assumed to be analogous in the Merensky reef surface, wherein no severe structural complications have been experienced thus far. The rock mass thereby exhibits high rock strengths, fair to good geotechnical conditions and little or no severe structural complications.

- **Laboratory Test Method**

A total of 91 uniaxial compressive strength tests were conducted on core samples from 10 boreholes on Merensky rock types including immediate hanging wall, reef, and immediate footwall. Table 6 is an overall summary of the average uniaxial compressive strengths (UCS) for the different horizons tested.

Table 6: Laboratory Tests

Merensky Rock Types	UCS (MPa)
Hanging Wall	124.3
Reef	140.9
Footwall	150.0

- **Point Load Test Method**

A total of 755 point load tests were conducted on core samples from the 54 boreholes on Merensky rock types including immediate hanging wall, reef, and immediate footwall. Table 7 below is an overall summary of the average uniaxial compressive strengths (UCS) for the different horizons tested.

Table 7: Point Load Test

Merensky Rock Types	UCS (MPa)
Hanging Wall	196.5
Reef	140.9
Footwall	160.1

3.2.6 Proximity to Existing Infrastructure

Option A of the proposed Boxcut position is the most favourable with regards to proximity of existing surface infrastructure. This includes distances to change houses, workshops and concentrator plant feed area as per Figure 12.

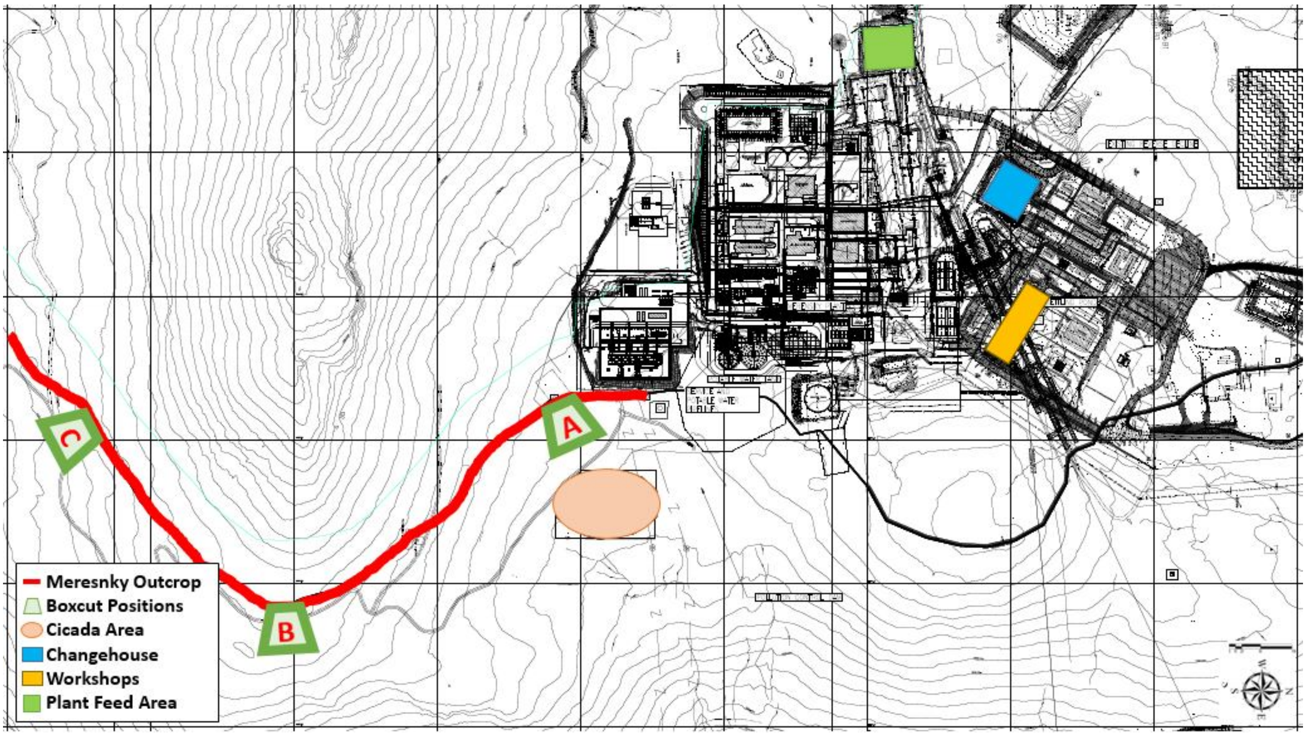

Figure 12: Surface Infrastructure and Environmental Locations (DRA)

Table 8 tables the distances in metres to the existing infrastructure that the employees, rock and machinery needs to travel daily. This distance will have a big impact on the travel time of employees, which influences available underground face time. It is not favourable for underground machinery to travel long distances and transport cost of ore to the plant feed area increases with distance From Table 8 it is evident that Boxcut option A the best position is with regards to existing surface infrastructure.

Table 8: Boxcut Options Distances to Infrastructure

Description	Boxcut A	Boxcut B	Boxcut C
Change house Distance	667m	1 161m	1 319m
Workshops Distance	671m	1 140m	1 338m
Plant Feed Area Distance	631m	1 133m	1 234m

3.2.7 Environmental Factors

As described in section 2.8, the area is known as an environmental sensitive area that is situated within a sensitive biome and the main habitat of the cicada the Pycna Sylvia. To preserve these environmental sensitive areas certain areas, as per Figure 12, have been demarcated as “no go” areas and barricaded off to preserve the habitat of the fauna and flora. These areas had to be taken into consideration when the Boxcut positions were identified.

3.2.8 SWOT Analysis

A SWOT analysis has been done based on the decisive criteria’s used in the placement of the Boxcut. This type of risk evaluation is commonly known and utilised in the mining industry. Table 9 below illustrates the SWOT analysis done on the Boxcut options.

Table 9: Boxcut Option SWOT Analysis

Boxcut Option	Strength	Weakness	Opportunity	Threat
Option A	Location Geotechnical Higher Content	Local Infrastructure	Innovative Designs	Infrastructure Damage
Option B	Infrastructure Distance	Location Geotechnical Lower Content	Innovative Designs	Higher Operating Costs
Option C	Infrastructure Distance	Location Geotechnical Lower Content	Innovative Designs	Higher Operating Costs

From the SWOT analysis in Table 9 above Boxcut option A is the preferred position. The following section focuses on position A as part of Phase 2 – Boxcut Design.

3.3. Phase 2 - Boxcut Design

3.3.1 Boxcut Design - Size of Mine

The main focus was to keep the Boxcut as small as possible with only two declines 6.5m wide by 3.5m high from the high wall position going underground. This is the minimum number of declines to has men and material, and ore transportation separated from each other. The minimum ventilation requirements are also covered by the excavation sizes of the declines. Figure 13 below illustrates the size and shape of a two decline Boxcut.

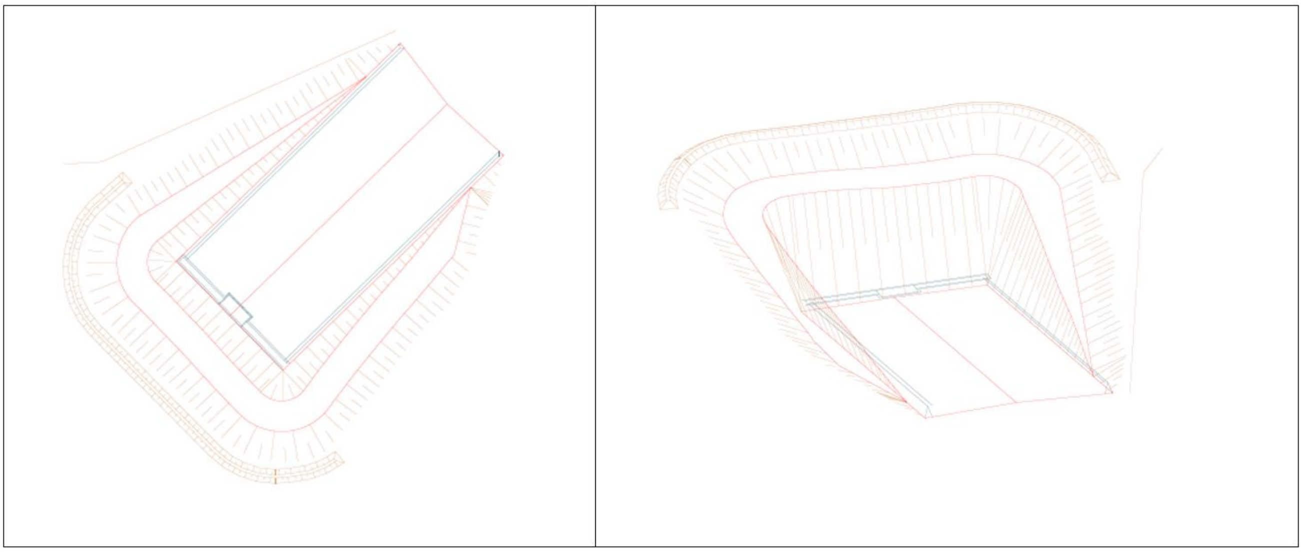

Figure 13: Plan and Isometric View of Boxcut

3.3.2 Topography

Once the general position of the Boxcut have been determined, the precise location, orientation and elevation of the Boxcut needs to be established and co-ordinated. The fact that the Boxcut will be established on the reef outcrop results that the location will be against the koppie and will assist with the amount of earthworks required to get to the required elevation.

3.3.3 Geological Factors Influencing Stability

Jointing

Work done by P Couto et al (Previous Rock Engineer at Booysendal North Mine-2014) indicated the presence of two major joint sets and a third random joint set as per Figure 14.

A shallow dipping (less than 30°) minor joint set was also identified during the development stages of the project. The joint surfaces are described by Couto et al (2014) as planar with a high degree of roughness exhibiting slightly weathered contacts closer to surface. The joints generally do not contain infill, but where infill exists, a calcite / quartz material may be present. Separation along or dilation of joint surfaces is not common but has been known to occur.

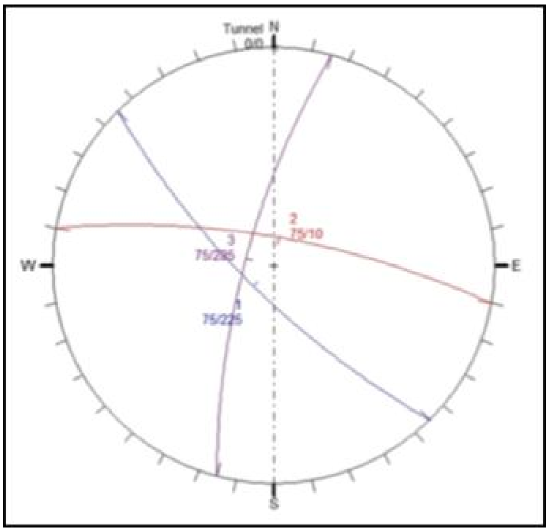

Figure 14: Stereographic Projection of Joints (Spencer, 2014)

The orientation of the major joint sets delineated in the stereonet projection is summarised in Table 10.

Table 10: Major Joint Set Orientation

Joint Set Number	Dip Angle (°)	Dip Direction (°)
1	75	010
2	75	285
3	75	225

Geological Structures

A Geo-physical investigation that was undertaken in 2008. This was to delineate any dykes and major fractures in the study area, through surface geophysical techniques and related data interpretation along and on both sides of the Groot and Klein Dwars Rivers and the tributaries thereof. The findings of the study indicated the definite presence of lineaments; a series of dolerite / diabase dykes as well as minor post dyke faults in the project area. The lineaments represent fractured systems, but some of these lineaments coincide with the presence of dolerite dykes. It must be taken into consideration that the dykes and fractured zones may be potentially water bearing at both shallow and greater depths.

The major structures that intersect the project area, as determined by the GCS study as well as the geological study that formed part of the Feasibility Phase for the existing UG2 mine (Smith, et al., 2009) is indicated in Figure 15. A total of 165 structures over the whole of the project area were identified. The faults identified on the Booysendal Mine area have two prominent strike directions, e.g. north-northwest and north-northeast. The north-northeast faults in this area are normally associated with open fractures and brittle deformation. As such these faults are of a younger age.

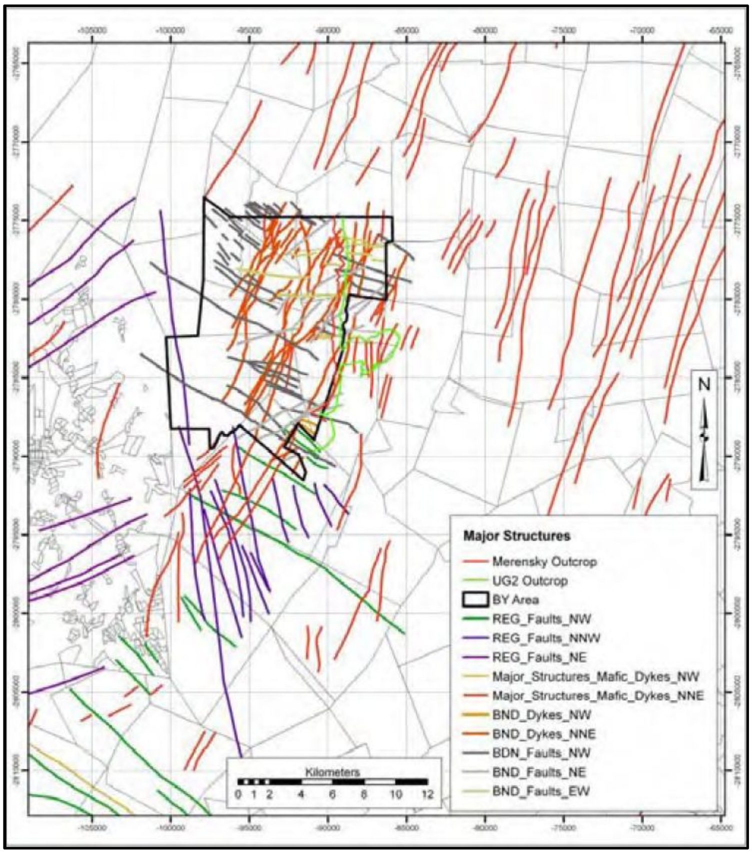

Figure 15: Geological Structures (Smith, et al., 2009)

Based on information contained in the above mentioned investigation the following table details the primary regional structures that will impact on the slope stability in the Boxcut. The information in Table 11 represents the regional dip and direction trends of the structures.

Table 11: Regional Structures Dip and Direction

Primary Structure	Dip Direction (°)	Dip Angle (°)
NNE Trending Dykes	120	85
NW Trending Faults and Dykes	30	80
EW Trending Faults	5	85

Geological Losses

These include any structure that disrupts the ore body such as potholes, rolling reef, intrusions, dykes and faults. For the Merensky reef this loss amounts to approximately 23 percent (Northam Platinum Annual Intergared Report, 2016) of the mining area.

3.3.4 Geotechnical Factors

It is very important to pay close attention to the geological conditions of the wall in order to develop blasts that will limit the damage. The key geological factors are the rock mass structure and the strength. The strength of the rock mass under the shear, tensile and compression loading will also dictate the overall stability of the slope.

The design approach for the Boxcut excavation is as follows:

- Minimise the depth of the Boxcut;
- Locate the portals in competent ground;
- Ensure that there is at least 3 metres of solid un-weathered ground in the high wall immediately above the hanging wall elevation for the portals; and
- Undertake site inspections as the Boxcut is excavated in order to modify the following recommendations.

The criteria used in this report to determine the position at which the decline hanging walls can be undercut is determined by a minimum beam thickness of at least 3 metres located in ground conditions that can be described as Fair to Good. The above results indicate that this criteria is not met in boreholes MRS3, 3a and 5, which are all located on the southern corner of the current Boxcut position where the depth of the Merensky reef top contact is less than approximately 6 metres below surface. In the remaining boreholes the criteria is met, except in MRS2 which is marginal. To meet the design criteria, it is necessary to move the Boxcut position further west, meaning that the depth of the Boxcut footwall and hence the height of the high wall will increase. The distance that the Boxcut must move has been determined using a vertical section through boreholes MRS 3 and 16. These are located along the centre line of the southern decline which, because of its position relative to the outcrop means it has the shallowest depth of Merensky reef intersection, see Figure 16. It has been assumed that the weathering profile, shown in red, is a straight line. However, in reality this is unlikely to be the case.

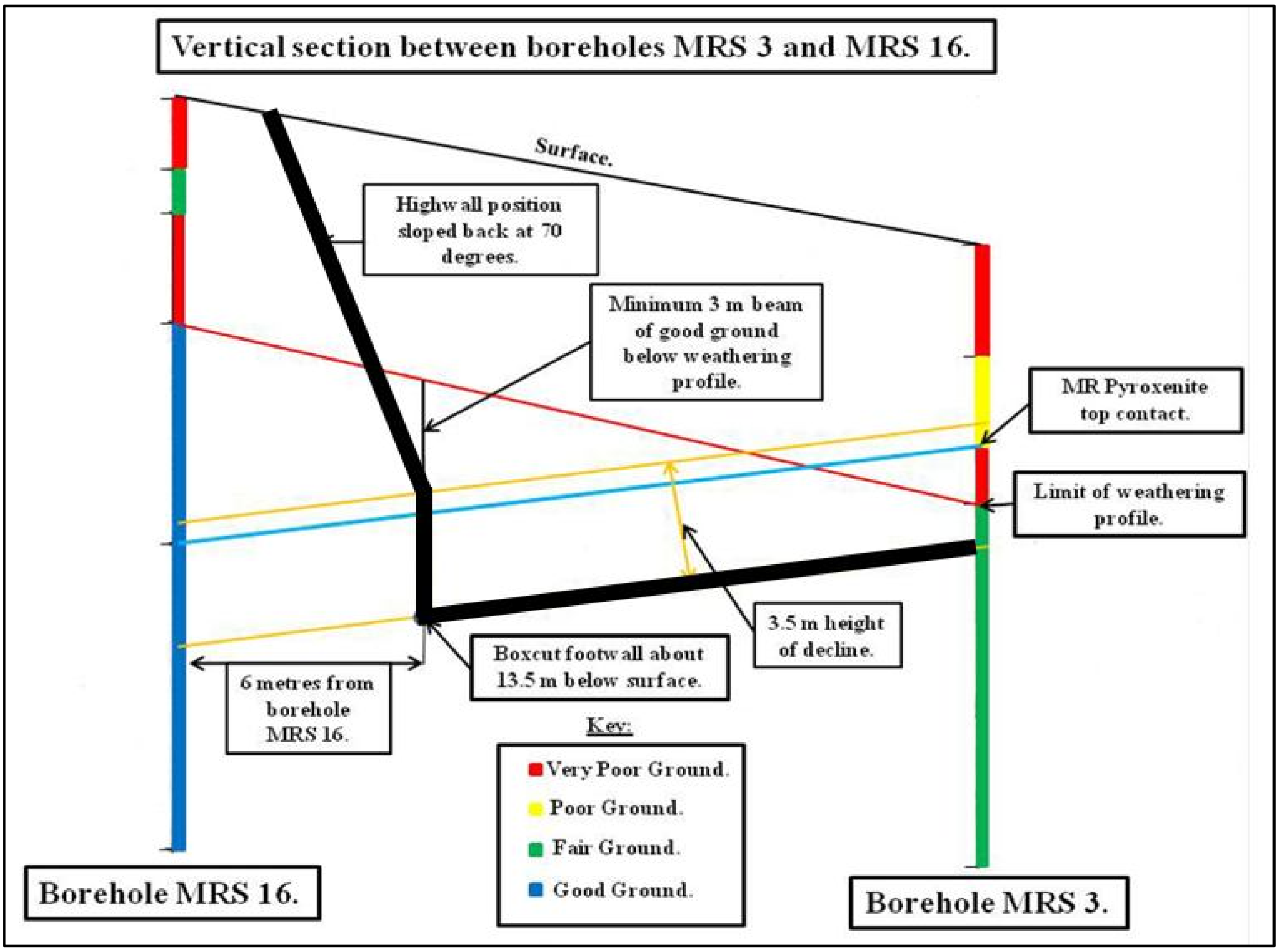

Figure 16: Vertical Borehole Section (Spencer, 2014)

Figure 16 above shows that in order to locate the brow for the southern decline in good ground with a minimum beam thickness of about three metres, the footwall elevation of the Boxcut must be located approximately six metres from borehole MRS 16 in the direction of MRS 3 along the decline centre line. This will result in the footwall elevation of the Boxcut at the southern decline portal position being approximately 13.5 metres below ground level. It has been estimated that the footwall elevation of the northern decline will be approximately 16.5 metres below surface. Figure 17 shows the plan position of the proposed Boxcut at the decline portal positions.

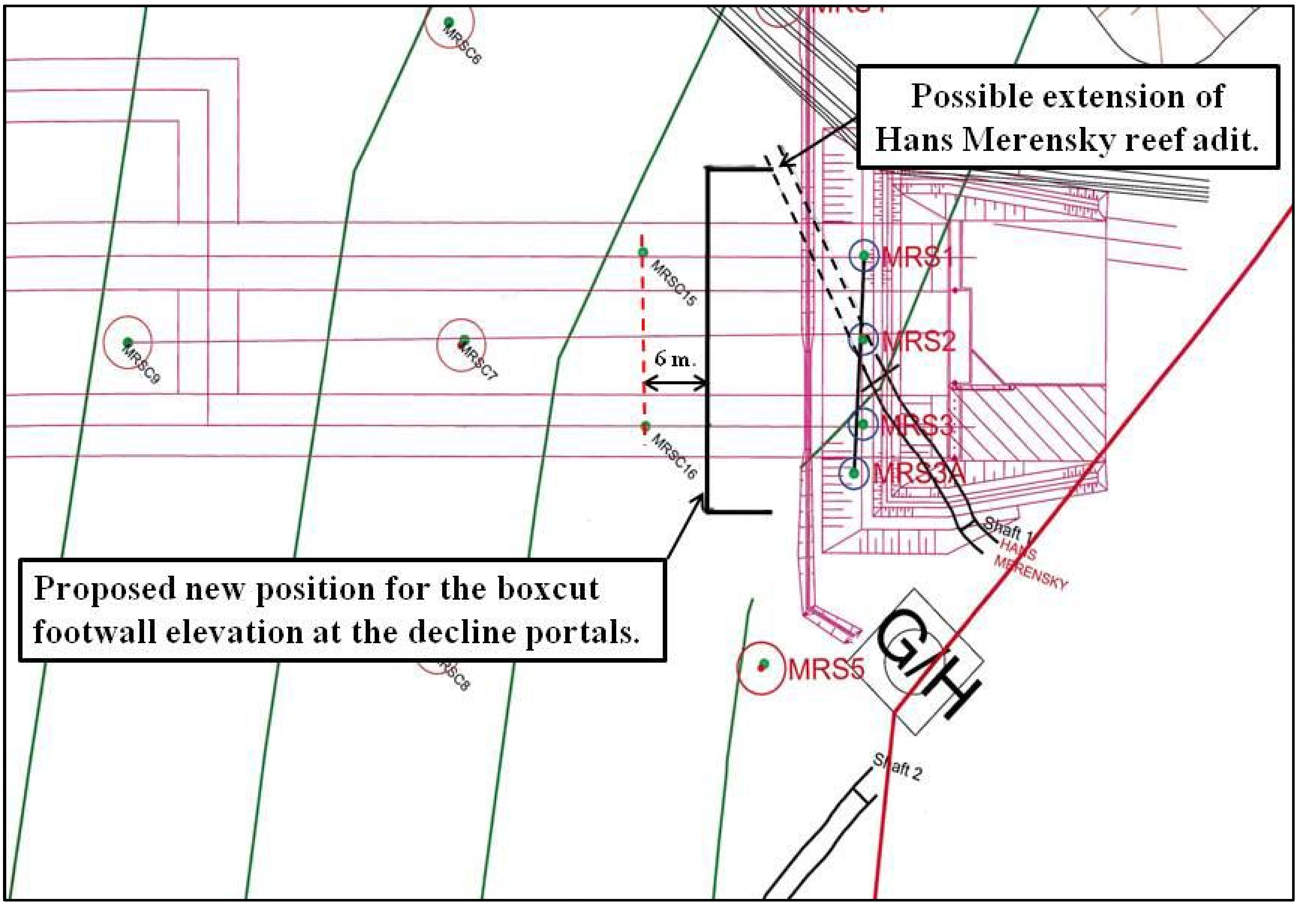

Figure 17: Geotechnical Proposed Boxcut Position (Spencer, 2014)

3.3.5 Proximity to Existing Infrastructure

With Boxcut position A, the proximity to existing infrastructure is the next challenge. The location at position A has limited surface area resulting in another reason to keep the design of the Boxcut footprint as small as possible. The development of the Boxcut will have influence on the following:

3.3.6 Environmental Factors

The design of the Boxcut takes into consideration all the environmental factors and the exact location and orientation is influenced by:

- Fauna and Flora – environmental sensitive areas;
- Storm water Management – design of drains and dams; and
- Geohydrology – eliminate groundwater pollution.

3.4. Phase 3 - Boxcut Establishment

From the previous sections where the location and design of the Boxcut were described, the following section addresses the establishment of the Boxcut and all the approvals required as well as the precautionary steps to ensure a safe design and execution. In Figure 18 below position A of the Boxcut ended up being in close proximity of critical existing infrastructure that if damaged can result in extreme financial expenditure, environmental damage or cause the stoppage of the existing operating mine. The following infrastructure were taken into consideration with the Boxcut establishment:

- ESKOM Power Station
- ESKOM Power Lines
- 10 Mega Litre Water Dam
- Pollution Control Dam
- Water Control Drains
- Historical Trench on Merensky Outcrop
- Environmental Sensitive Areas

Figure 18: Infrastructure Close to Boxcut (DRA)

To ensure the safe and compliant establishment of the Boxcut the following processes needs to be followed as indicated in Figure 19 to make sure all safety compliance matters are covered and is discussed below.

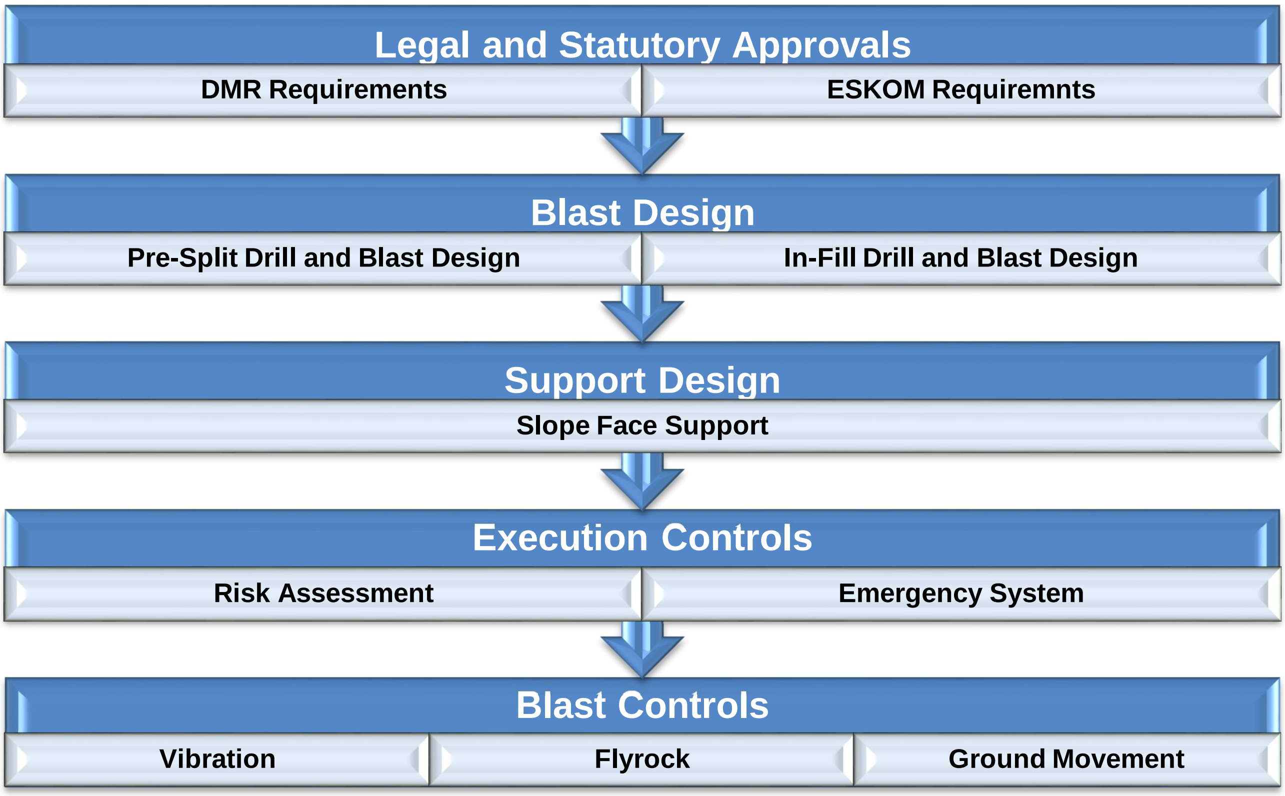

Figure 19: Boxcut Establishment Processes

3.4.1 Legal and Statutory Approvals and Permissions

South African Mining Law is regulated by the Mineral and Petroleum Resources Development Act, 28 of 2002 ("MPRDA"). This is the principal portion of legislation dealing with acquisitions or rights to conduct exploration, prospecting, and mining. On the 1st of May 2004 the MPRDA became effective and replaced the former system that was a mixture of a common law system with statutory interference. Several other pieces of legislation that deals with additional issues such as royalties (the Mineral and Petroleum Resources Royalty Act, 2008), title registration (the Mining Titles Registration Act, 1967), and health and safety (the Mine Health and Safety Act, 1996) are in place.

Anyone that wishes to start mining for minerals, other than petroleum, needs to apply for a mining right in terms of the MPRDA. The application will only be granted if the applicant has submitted an application for an environmental approval and consult with the interested and affected parties, such as communities and land owners. The Minister must grant the mining right if the following is proofed:

- The mining will not result in unacceptable pollution, ecological degradation or damage to the environment;
- The applicant has access to financial resources;
- The mineral can be mined optimally and
- The applicant has the necessary technical ability.

The applicant has to submit a Mine Works Programme accompanied with a detailed social and labour plan. The maximum period a mining right is granted is 30 years. The holder is entitled to apply for renewal for periods not exceeding 30 years. (Stevens, C. I., 2016)

3.4.2 DMR

The mandate of the Department of Mineral Resources (DMR) is to achieve effective governance and transformation in the mining and minerals sector. This is essential for economic growth and development in order to improve the quality of life for all South Africans.

The statutory mandate of the Department of Mineral Resources is to safeguard the health and safety of mine employees and communities affected by mining operations. For this reason the Mine Health and Safety Inspectorate was established, in terms of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996) The DMR strives towards a safe and healthy mining industry. In order to reduce mining related deaths, injuries and ill health the DMR creates national policy and legislation, provides advice, and implements systems that monitor and enforce compliance to the law in the mining sector.

3.4.3 ESKOM

Written permission needs to be obtained from Eskom if blasting is going to take place within 500m from any Eskom infrastructure. Blasting control measures will incorporate vibration and fly-rock control as per Eskom requirements. A document containing the conditions of how the operations must be conducted is attached as 7.3 and covers topics as access to site, work near power lines and requirements during blasting (Eskom Blasting Standards, 2006). Precautionary requirements from Eskom are the following:

- Only minimum charges are used;
- The Peak Particle Velocity (PPV) does not exceed 75 mm/s;
- A seismic controlling device is used to record the above readings; and

- The air blast is controlled by means of adequate matting where the face of the blast is towards Eskom's overhead power lines or substations.
- Only one shot blasting is allowed.
- Eskom representation shall be present.
- Relevant Eskom control centre shall be notified.
- Affected power line(s) shall be taken out of auto-reclose (ARC) or switched off.
- Landowner shall be given a minimum of 7 calendar days' notice of the blast date and time.
- Prior to commencement of work contactor shall compile a risk assessment and risk aversion strategy.
- The contractor shall indemnify Eskom from claims.
- The contractor shall be held responsible for cost.

3.4.4 Blast Design

Due to the sensitivity and close proximity of the Eskom power station, power lines and other infrastructure controlled blasting will be essential. Pressure variances (within close vicinity of blasting) as a result of blast waves may cause nuisance tripping on power transformers located in the Eskom power station.

This nuisance tripping is a result of the Bucholtz relay being inadvertently activated due the force of the blast waves. A Bulcholz relay is a protection relay fitted to each transformer and used to detect dielectric failure within the transformer – e.g. impulse breakdown of the insulating oil, insulation failure of turns etc. Should the Bucholz relay detect dielectric failure then it will trip the feed circuit breaker to the transformer, thus terminating power supply. The Bucholz relay operates by using a mechanical float switch to activate an alarm/trip signal. If there is gas build-up inside the transformer due to breakdown of insulating oil, for example, then accumulation of this gas will change the position of the float switch and thus active a trip/ alarm signal.

Due to the sensitively of the Bucholz float switch to blast waves, caution must be taken when blasting is to be implemented within a close proximity of the transformers (within 1km). As such, the following blasting parameters must be thoroughly considered and assessed before blasting: the strength of charges, number of holes firing, air blast control and vibration control measured by the PPV as listed above.

The burden and spacing selection is critical. Under selection will result in fly rock and air blast. Over selection on the other hand will result in severe back break, stemming ejection, vertical cratering and high ground vibrations. The blast hole size needs to be evaluated. The fragmentation, air blast, fly rock, and ground vibration will have to be assessed.

Blast Design Factors

Knowing the geological formation, the physical distances and the exact placement of an explosive charge in any given rock mass allows to have more confidence in predicting the outcome of a blast. Knowing these conditions also reduce the number of surprises that can arise after the blast. (Kotze & Sellers, 2012) These conditions are used to calculate the following blast design factors:

- Drill pattern – burden and spacing – fragmentation;
- Explosive selection and method of detonation;
- Existing Infrastructure – drill pattern and charge of blast holes;
- Geological structures and geotechnical factors – location of faults and dykes and rock characteristics;
- Eskom requirements – vibration limits, air blast levels, fly rock and single hole firing; and
- Weather conditions – possible rain showers during rainy season.

Pre-Split Drill and Blast Design

The perimeter of the box cut was designed to give a final batter angle of 70 degrees based on geotechnical recommendations and the deepest holes were 17 metres.

The drilling and blasting design is based on empirical formulae and software simulations. The initial design splitting factor for this type of rock and practical experience is selected at 0.6 kg/m2. The holes must be drilled using an 89 mm diameter button bit. The spacing between the holes was 900 mm. The explosives used in the holes are emulsion cartridges, 50mm x 580mm with a unit weight of 1.2 kg. A maximum charge mass of 7.2 kg per hole is recommended for the deepest holes with a charge mass of 2.4 kg per hole in the shallowest holes. Due to the proximity of the Eskom infrastructure the mass charge per delay must not exceed 31kg per delay.

The exact drilling positions according to the design must be marked in the field by the surveyor and the actual completed hole positions and angles must be verified by the surveyor to ensure the accuracy and depth of the holes drilled. The cartridges must be joined to the detonating cord and lowered into the holes. Detonating cord must be used to connect the downlines on surface. During pre-split blasting, to assist with the venting of the gasses generated during the detonation process, and due to the blast hole angle and the close proximity of the sub-station, the holes must be plugged with airbags and stemming material. The airbags must be lowered 1.5 metres from the collar and filled with 13mm aggregate material to the collar of the hole. The majority of the detonating cord on surface must be covered with 150 mm soil to reduce the air blast levels. Delays of 100 milliseconds must be inserted between the 3 legs of the pre-split design to reduce the blast induced vibrations and air blast.

Table 12: Pre-Split Drill and Blast Parameters

Description	Unit
Drill Hole Diameter	89mm
Explosives Diameter	50mm
Hole Spacing	900mm
Maximum/Minimum Charge per Hole	7.8kg/2.4kg
Maximum Charge per Delay	30 x 7.8 = 234kg
Explosives	Emulsion Cartridge (50mm x 580mm)
Initiation System	Detonating Cord
Overall Splitting Factor	0.58kg/m²

In-Fill Drill and Blast Design

The drill and blast design is based on the known geology and geotechnical information of the area, empirical formulae and software simulations. A design powder factor of 0.42kg/m^3 is used for calculating the blast parameter layout.

The stemming length for the blast holes is determined by using the scaled depth of burial guideline, which is a well-accepted standard in the industry. The scaled depth of burial (SD) varies between 1.6m/kg⅓ and 2.5m/kg⅓ for the short and deep holes respectively. The stemming lengths varies between 2.5m and 4.5m depending on the hole depth. The scaled depth of burial calculations is as follow:

- 2.5m stemming – 1.64
- 3.0m stemming – 1.92
- 4.0m stemming – 2.48

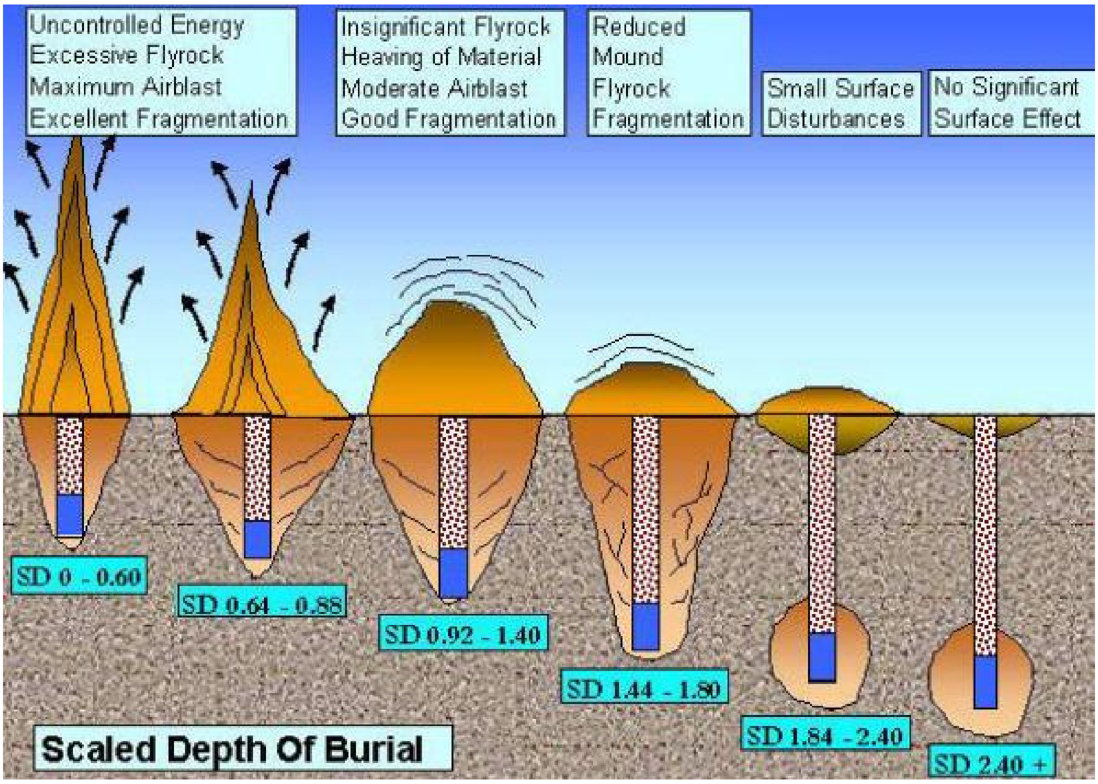

Figure 20: Scaled Depth of Burial (Pretorius, 2015)

The burden and spacing design called for a 2.5m x 2.5m square drilling pattern. To reduce the blast induced vibrations, holes in excess of 9 metres must be decked with 2 separate explosive charges limiting the maximum charge per delay to 29.3kg The decking is a 2.5m solid aggregate deck to reduce the risk of fly rock. The timing delays of the charges is as follows; the bottom charges must be fired first, with an inter hole delay of 8 milliseconds. The initiation point is in the centre of the box cut. The top charges must be initiated 3000 milliseconds after the bottom charges. The drilling contractor must be given clear instruction to keep a detailed drilling log. This will be of utmost interest to the blasting engineer's design, where any abnormalities are experienced during drilling are kept recorded like the soft / hard rock interface. An area on the south western edge of the box cut showed a highly weathered zone. This weathered zone can result collapsing of holes against the high wall.

The drill logs and survey positions must be used in the final timing design. Table 13 below illustrates the in-fill drill and blast parameters.

Table 13: In-Fill Drill and Blast Parameters

Description	Holes: 4m – 9m	Holes: 9m – 15m
Burden	2.5 m	2.5 m
Spacing	2.5 m	2.5 m
Scaled depth	1.6 – 2.5 m/kg1/3	1.6 – 2. 5 m/kg1/3
Stemming length	2.5 – 4.5 m	3.0 – 4.5 m
Stemming material	13.5 mm aggregate	13.5 mm aggregate
Top charge	-	1.5 – 4.5 m
Top charge	-	9.8 – 29.3 kg
Deck length	-	2.5 m
Bottom charge	1.5 – 4.5 m	4.5 m
Bottom charge	9.8 – 29.3 kg	29.3 kg
Initiation System	EDD	EDD
Booster size	150 g	150 g

Figure 21 below shows a section view of charging configuration of various hole lengths.

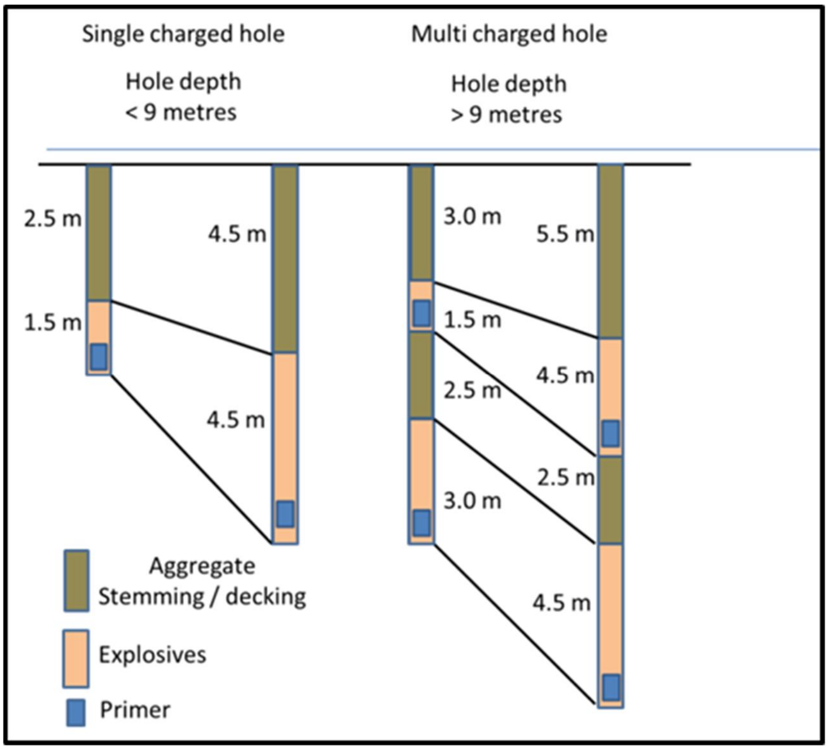

Figure 21: Section View of Charge Configuration

3.4.5 Support Design

The soil layer, which is approximately two metres thick, must be pushed back from the crest of the Boxcut for about five metres. This is to allow space for the contractor to work whilst installing support along the crest of the high wall and both sidewalls. In addition, the water drainage system can be constructed around the Boxcut in this area. The Merensky reef Boxcut must be established using a pre-split blast to create a maximum slope angle of 77 degrees for the high wall and both sidewalls. The pre-split is recommended to minimise the blast damage into the rock that will form the final slopes of the Boxcut. The Boxcut must be excavated in such a manner that permits the slopes to be supported.

A Rock Engineer must inspect all the slopes as the Boxcut is excavated and recommend modifications to the design if and where considered necessary. The timing of these inspections should correspond to the exposure of slopes, possibly following every blast when the broken rock has been cleaned and the slope made safe.

Slope Face Support

Because of the long term nature of the slope, the following support is recommended for the entire slope face to prevent any deterioration of the rock surface.

Support is to consist of the following:

- Diamond wire mesh (5 mm gauge by 100 mm aperture) must be draped over the crest of the slope, extending back from the crest for around 3 metres and extending down the slope for around 4.5 metres where the ground conditions are anticipated as being very poor, see figure 3. The necessity to continue with the diamond wire mesh support for the lower part of the slope, where the anticipated ground conditions are anticipated as being good, will be decided as the ground is excavated and inspected.
- The diamond wire mesh must be pinned to the rock surface using 1.8 metre long by 25 millimetre diameter full column resin bolts. The drill hole diameter should be a maximum of 35 millimetres to ensure proper mixing of the resin whilst the bolts are being installed. The bolts should be installed on a 1.5 metre diamond pattern and tensioned to a minimum of 50kN. The bolting pattern of support should start 3.0 metres beyond the crest of the high wall and sidewall slopes of the box cut and continue down the entire face of the slopes with the bottom row of holes not being further than 1.0 metre from the base of the slope. It is understood that this may result in some rows being closer together than 1.5 metres in order to accommodate the pattern. Additional bolts can be installed where

deemed necessary to ensure stability and to fix the mesh as close as possible to the rock surface for effective shotcreting.

3.4.6 Execution Controls

To ensure compliance to the requirements mentioned above, the following execution controls must be in place to have measurable after blast reviews and analysis.

Risk Assessment

Before any detonation can commence on the Boxcut, a detailed risk assessment needs to be done on the execution of the work and the following areas must be covered for any risks that can negatively influence the project:

- Notification of Blast;
- Preparation of Blast Site;
- Transport of Explosives;
- Priming of Blast Holes;
- Charging of Blast Holes;
- Connecting of Explosive Wires;
- Closing and Clearance of Blast Site;
- After Blast Inspection; and
- Destruction of Excess Explosives.

Emergency Systems

Other precautionary systems that needs to be in place to ensure compliance are:

- Environmental Awareness Plan;
- Emergency Response Plan; and
- Emergency Procedures.

3.4.7 Blast Controls

The following factors can influence the surrounding infrastructure negatively and must be monitored and controlled.

Vibration

In accordance with the Eskom vibration limits, vibration levels should not exceed 75mm/s to avoid structure damage. The two principal and controllable factors, which will affect the vibration levels, are distance and the charge mass of explosives fired at an instant (mass charge per delay). The charge mass per delay has been previously defined as the mass of explosives, which may be detonated within an 8msec. window. Charges firing within 8msec. window will produce greater vibration amplitudes than single holes firing. This vibration monitoring must be monitored with seismographs strategically placed.

No vibration monitoring had been done during previous mining operations at Booysendal, therefore no site specific constants have been modelled for the mine. In the PPV calculation the USBM formula is then used to calculate the allowable charge mass to keep vibration levels below 75mm/s. Any structures, residential or industrial, oscillate naturally. Resonant frequencies for pylons ranging between 1-3 Hz. Blasting vibrations with frequencies within this range can cause damage to structures at low PPV levels. (Pretorius, 2015)

Dominant vibration frequencies can be related to the timing of the blast i.e.:

Frequency   f = 1000/intershot delay (Hz)

Therefore timing should be quickened to ensure higher dominant frequencies. To ensure accurate single hole firing takes place, programmable electronic detonators should be used.

Fly Rock

To prevent damage to the overhead power lines stemming control is critical. It is also very important not to undercharge, as there will be no opportunity for secondary blasting under the overhead lines. To prevent fly rock and ensure breakage in the collar zone a Scaled Depth of Burial (SD) ranging between 1.4 and 1.8 should be used.

- With stemming 2.5m a SD of 1.8 is achieved on the 76mm hole diameter.
- With stemming 1.5m a SD of 1.4 is achieved on the 64mm hole diameter.
- With stemming 1.2m a SD of 1.47 is achieved on the 48mm hole diameter.

The stemming material is as important as the stemming length. Material must be angular with an optimum average diameter size of approximately 0.1 times the blast hole diameter.

- 76mmØ - 8mm angular crushed aggregate
- 64mmØ - 7mm angular crushed aggregate
- 48mmØ - 5mm angular crushed aggregate

It would be recommended to leave a 1.5m to 2.0m soft strip above the solid bench. Prior to blasting any bench it is very important to remove any loose material to prevent projectiles. (Pretorius, 2015)

Ground Movement

The Eskom substation and pylons must be protected from possible ground movement. Through effective pre-splitting, pillar boundaries can be established. These boundaries will assist in minimising the risks, especially where possible, unforeseeable geological discontinuities exist. Where free faces exist extreme caution must be exercised during blasting operations. Blasting towards any free face is very risky and unpredictable. Methods of measuring the effect of the blast consist of the following:

- Face Survey;
- Hole Survey;
- Velocity of Detonation; and
- High Speed Blast Video.

3.5. Phase 4 - Shared Infrastructure

One of the main advantages of the Merensky mine is that there are existing infrastructure that can be utilised to reduce the capital and operating cost of the mine. If these costs were have to be included into the capital estimate the establishment of the mine would not be feasible.

3.5.1 Surface Infrastructure

The following surface infrastructure can be utilised with no or minimal adjustment and the cost savings, based on high level estimates, of building new infrastructure will be reduced under the following areas:

3.5.2 Roads

The existing main access road from the main gate will be utilised. The construction of a road is extremely expensive and the standard of the road must be designed to provincial standard level due to employees that will be transported with busses from the main gate, 11 kilometres from the mine. The cost saving on the capital, based on the going rate of R20 million per kilometre (based on estimates derived from quotes) will be a R220 million. The road that needs to be constructed to transport ore to the concentrator plant area is quoted at R1.8 million.

3.5.3 Concentrator Plant

The existing concentrator will be utilised and the Merensky ore will be batch treated. There will be some additional modifications required to be done to the plant that comes at a cost of R22 294 819. The construction of a new process plant is extremely expensive and the cost saving on the capital will be a considerable estimated amount of R900 000 000.

3.5.4 Change house

The current existing change house that was built for the UG2 mine will need some alterations to accommodate the additional space required by the Merensky employees. The alteration of the change house is less expensive at a cost of R6.6 million than building a new one at a cost of R11.5 million.

3.5.5 Workshop

The current existing workshop that was built for the UG2 mine will need some alterations to accommodate the additional space required by the Merensky underground fleet of machinery. The alteration of the workshop is less expensive at a cost of R8.4 million than building a new one at a cost of R22.9 million.

3.5.6 Offices

The current existing offices that was built for the UG2 mine will need some alterations to accommodate the additional space required by the Merensky employees. The alteration of the offices is less expensive at a cost of R5.4 million than building a new offices at a cost of R25.0 million.

3.5.7 Services Supply

The supply of water and electricity to the Merensky mine would have cost R14.0 million and R23.0 million rand respectively. The current estimate to supply these services are R6.2 million for water handling infrastructure and R4.7 million for power reticulation infrastructure.

3.5.8 Capital Cost Comparison

All the above mentioned areas where major capital cost savings can be achieved are tabled below (Table 14). These are seen as the major capital cost components that make up the bulk of the capital expenses.

Table 14: Capital Cost Comparison

Description	Standalone Capital (R)	Shared Capital (R)	Savings (R)
Roads	R220 0000 000	R1 860 00	R218 140 000
Concentrator Plant	R900 000 000	R22 300 000	R877 700 000
Change house	R11 500 00	R6 600 000	R4 900 000
Workshop	R22 900 000	R8 400 000	R14 500 000
Offices	R25 000 000	R5 400 00	R19 600 000
Water Services Supply	R14 000 000	R6 200 000	R7 800 000
Power Services Supply	R23 000 000	R4 700 00	R18 300 000
Total	**R996 400 000**	**R53 600 000**	**R942 800 000**

3.5.9 Synergies

The geographical position of the two mines lends itself to various synergies that even further contribute to cost savings. The following main areas are described.

Labour

The Merensky mine will consist of six production crews at steady state producing 75 000 tonnes per month. The physical mining crews are required to be at full complement but from management level upwards and other disciplines such as engineering and shared services the duties and the responsibilities can be shared between the two mines. Legal responsibilities can also be shared between the mines. Table 15 below illustrates the labour complements and costs associated with labour based on 2016 company salary scales.

Table 15: Labour Complement and Cost

Discipline/Department	Standalone	Shared	Variance
Top Management	4	0	4
Senior Management	14	5	9
Mining	586	586	0
Engineering	127	123	4
Human Resources	27	20	7
Financial	26	19	7
Safety, Health and Environment	14	10	4
Mine Technical Services	42	42	0

Security	12	12	0
Total Quantity	**852**	**817**	**35**
Total Cost per Month	**R23 205 425**	**R20 624 518**	**R2 580 907**

The saving from this results in R2 580 907 per month that results in a R34.41 per tonne monthly operating cost.

The labour component makes up the largest individual portion of the operational cost.

Underground Infrastructure

The following underground infrastructure can be utilised with no or minimal adjustment and the cost savings of building new infrastructure will be reduced under the following areas as illustrated in Figure 22.

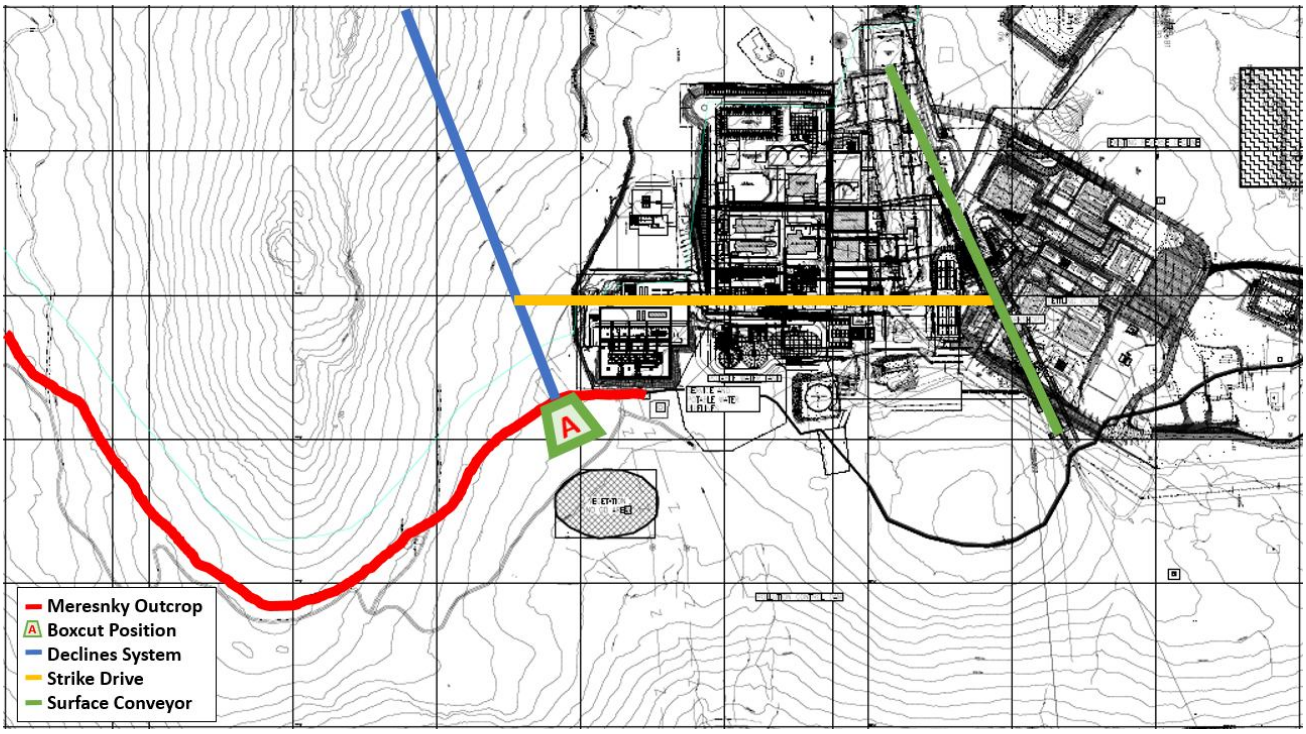

Figure 22: Shared Underground Infrastructure (DRA)

Strike Drives North

From the mine design two underground Strike drives will be developed in a Northern direction to join up with the existing UG2 Reverse decline to transport men, material and ore to the UG2 Reverse decline to create a single ingress and egress point to the concentrator plant and existing surface infrastructure. This option eliminates the necessity of an overland conveyor, surface road and infrastructure for the transport of employees.

Conveyor to Surface

The conveyor that will be installed in the Strike Drive North will discharge onto the existing UG2 Reverse decline conveyor that feeds ore into the concentrator plant. This eliminates the additional cost and surface footprint of a dedicated conveyor from the Merensky Boxcut.

3.5.10 Operational Cost Comparison

The sharing of infrastructure by two mines reduces operational cost in various areas. Where the direct mining cost of the standalone mine and shared infrastructure mine operation will be similar, the real savings arise from the transport of ore on surface, maintenance of surface maintenance, labour and general expenses as these costs would have been there without the new mine. Tabled below are the operational cost comparisons for the standalone mine and the shared infrastructure option based on on-site cost estimates.

Table 16: Operational Cost Comparison

Description	Standalone Cost R/t	Shared Cost R/t	Savings R/t
Reef Development	R15	R15	R0
Stoping	R182	R182	R0
Drilling	R21	R21	R0
Mining Ancillary Equipment	R5	R4	R1
Surface Ore Transport	R26	R17	R9
Underground Ore Transport	R6	R6	R0
Electrical Reticulation	R48	R26	R22
Water	R3	R1	R2
Underground Maintenance	R17	R17	R0
Surface Maintenance	R23	R9	R14
Labour	R281	R247	R34
General Expenses	R12	R4	R8
Indirect Cost	R36	R12	R24
Concentrator Cost	R142	R142	R0
Total	**R817**	**R703**	**R114**

4 CONCLUSION

Mines needs to sustain or expand their production volumes with new or other operations. The two ways they can do this is with greenfield or brownfield projects or merger and acquisition transactions. From these options, the brownfield project option is the best due to the low risk and low cost. Low risk in the geology due to a mine already operating there and low cost due to the option to synergize many processes, resources and functions between the mines.

This entire research project focuses on the phased approach of the positioning, design and establishment of a brownfields project next to an existing mine with all the challenges that was encountered. Although the data and variables are site and company specific and will vary from other sites and companies, the phased approach of establishing a new mine access will be the same with iterations between the phases as new information is received.

Access Positioning ⇔ Access Design ⇔ Access Establishment

Through each of the phases there are common factors that have an influence on the phases and requires as much as possible information to be understood. These factors are:

- Topography,
- Geology,
- Geotechnical,
- Environmental,
- Proximity to Existing Infrastructure, and
- Legal and Statutory Approvals.

The establishment of a mine access can be done safely and in compliance with detail study and understanding of the influencing factors through each phase. The best way to do this is through adequate geological and geotechnical drill holes and performing test work to determine the optimal placement and design. The blast design is one of the most important designs to ensure a safe, durable and long lasting mine access.

Once the access position and designs have been completed the synergies between the mines can be investigated and the result of the shared infrastructure and resources can reduce the capital estimate to only 10% of the required capital for a standalone mine. This is low due to the already existing infrastructure available. The saving on the operational cost, in this case, of 15% compared to a standalone mine. The saving consist of shared infrastructure cost and shared labour cost on the managerial and shared services functions.

5 RECOMMENDATIONS

The mining industry is not the goose that lays the golden eggs anymore. The economics of the world has changed and more lucrative investment opportunities, other than mining projects, are in abundance for investors. These investments are usually less risky, with higher returns, over a shorter period, characteristics that suits the modern day investor. To attract shareholders to their mining projects companies need to focus on reducing the required capital, risk, and the return period of invested capital. This can be achieved exploring for brownfields opportunities within their own realm.

By exploring this avenue the opportunities that arise will have their own risks and challenges. The best way to understand these risks and challenges is to get as much information as possible, analyse the data and create a phased approach to make sure all areas of influence are covered.

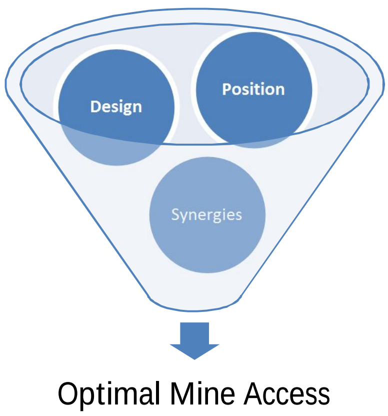

Figure 23: Mine Access Process Funnel

Even if the resource was thought to be highly unfeasible, the synergies that can be established between the potential project and the existing mine can be of such a big influence on the capital and operation expenses that it can be turned viable.

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7 APPENDICES

7.1. Booysendal Merensky North Resource Table

		width	plan area	reef area	ex Geological & oxidised zone losses					total	ex geoloss	
channel	category	(cm)	(m2)	(m2)	E4 grade (g/t)	RD (t/m3)	thick (m)	Moz	Mtonnes	geoloss	Moz	Mtonnes
mcc	measured	210cm	3190334	3239550	3.23	3.25	2.10	2.30	22.14	23.0	1.77	17.05
	indicated											
	inferred											
	total	210cm	3190334	3239550	3.23	3.25	2.10	2.30	22.14	23.0	1.77	17.05
dilution addn (HW)	measured		3190334	3239550	0.00	3.30	0.00	0.00	0.00	23.00	0.00	0.00
	indicated			0								
	inferred			0								
	total		3190334	3239550	0.00	3.30	0.00	0.00	0.00	23.00	0.00	0.00
dilution addn (FW)	measured		3190334	3239550	0.00	3.10	0.00	0.00	0.00	23.00	0.00	0.00
	indicated			0								
	inferred			0								
	total		3190334	3239550	0.00	3.10	0.00	0.00	0.00	23.00	0.00	0.00
combined	measured	210cm	3190334	3239550	3.23	3.25	2.10	2.30	22.14	23.0	1.77	17.05
	indicated						0.00	0.00	0.00			
	inferred						0.00	0.00	0.00			
	total	210cm	3190334	3239550	3.23	3.25	2.10	2.30	22.14	23.0	1.77	17.05

	element grades							
channel	4E	Pt	Pd	Rh	Au	Crinf %	Cu%	Ni%
mcc meas	3.23	1.87	1.00	0.08	0.28	0.2034	0.0957	0.2061
mcc ind								
mcc inf								
combined	3.23	1.87	1.00	0.08	0.28	0.2034	0.0957	0.2061
g/m2	22.07	12.78	6.82	0.54	1.94	13.9	6.5	14.1

prill splits %	Pt	Pd	Rh	Au	Crinf %	Cu%	Ni%
	57.88	30.90	2.45	8.79	0.2	0.0957	0.2061

7.2. Drill Log Information and Ratings

Borehole MRS1.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	1.73	0.02	Very Poor.
Extremely Weathered.	1.9	0.02	Very Poor.
Fresh / Unweathered.	1.34	40.8	Very Good.
Slightly Weathered.	0.78	4.38	Fair.
Fresh Unweathered.	9.75	16.52	Good.
Borehole MRS2.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	1.95	0.02	Very Poor.
Extremely Weathered.	1.42	0.02	Very Poor.
Slightly / Moderately Weathered.	1.65	10.17	Good.
Fresh Unweathered.	10.41	31.90	Good.
Borehole MRS3.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	1.95	0.02	Very Poor.
Extremely Weathered.	1.15	0.02	Very Poor.
Slightly / Moderately Weathered.	2.39	3.33	Fair.
Extremely Weathered (Core Loss).	1.63	0.02	Very Poor.
Fresh Unweathered.	9.77	7.09	Fair.
Borehole MRS3a.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	1.57	0.02	Very Poor.
Extremely Weathered.	1.85	0.02	Very Poor.
Moderately Weathered.	1.35	0.67	Very Poor.
Slightly Weathered.	0.83	3.33	Poor.
Highly Weathered.	1.64	0.15	Very Poor.
Fresh Unweathered.	9.65	7.09	Fair.

Borehole MRS4.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Slightly Weathered, No soil.	1.99	0.95	Very Poor.
Fresh Unweathered.	23.47	16.55	Good.
Borehole MRS5.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	0.8	0.02	Very Poor.
Extremely Weathered.	2.86	0.02	Very Poor.
Slightly Weathered.	0.3	6.65	Fair.
Fresh / Unweathered.	2.04	32.67	Good.
Moderately Weathered.	1.52	0.22	Very Poor.
Fresh Unweathered.	5.78	32.77	Good.
Borehole MRS6.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	0.43	0.02	Very Poor.
Extremely Weathered.	2.09	0.02	Very Poor.
Fresh Unweathered.	27.83	7.29	Fair.
Borehole MRS7.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	1.0	0.02	Very Poor.
Extremely Weathered.	1.42	0.02	Very Poor.
Fresh Unweathered.	22.83	10.93	Good.
Borehole MRS8.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	1.28	0.02	Very Poor.
Slighty Weathered.	2.57	7.36	Fair.
Highly Weathered.	0.41	0.02	Very Poor.
Fresh Unweathered.	17.89	15.93	Good.
Borehole MRS9.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Slightly Weathered, No soil.	1.89	0.02	Very Poor.
Fresh Unweathered.	29.05	33.13	Good.
Borehole MRS16.			
Geotechnical Unit.	**Thickness (m).**	**Q Value.**	**Anticipated Ground.**
Soil	1.95	0.02	Very Poor.
Fresh / Unweathered.	1.05	4.97	Fair.
Moderately Weathered.	3.1	0.37	Very Poor.
Fresh / Unweathered.	14.41	16.45	Good.

7.3. ESKOM Blasting Permission and Conditions

PERMISSION FOR BLASTING OPERATIONS WITHIN 500m FROM ANY ESKOM INFRASTRUCTURE
PROPERTY: The farm Booysendal 43 JT
Our Ref: Myn/01/14

This application for blasting by means of the time delay method and opencast mining operations as indicated in the application nearby the Eskom Distribution Booysensdal substation and powerlines per your submitted plan. Permission for these operations are herewith granted under the following conditions:-

A.1 Access and egress
Eskom shall at all times retain unobstructed access to and egress from its servitudes.

A.2 Approvals (additional)
A.2.1 Eskom's consent does not relieve the applicant from obtaining the necessary statutory, land owner or municipal approvals.

A.2.2 The applicant will adhere to all relevant environmental legislation. Any cost incurred by Eskom as a result of non-compliance will be charged to the applicant.

A.3 Eskom Cables
Eskom's underground cables affected must be placed in sleeves encased in concrete across the width of the servitude, at the applicant's expense. Materials to be used and relevant dimensions shall be determined as required.

A.4 Dimensions
No construction or excavation work shall be executed within 25 metres from any Eskom powerline structure, and/or within 10 metres from any stay wire.

A.5 Earthing
All work within Eskom's servitude areas shall comply with the relevant Eskom standards in force at the time.

A.6 Expenditure
If Eskom has to incur any expenditure in order to comply with statutory clearances or other regulations as a result of the applicant's activities or because of the presence of his equipment or installation within the servitude or wayleave area, the applicant shall pay such costs to Eskom on demand.

A.7 Ground level variations
Changes in ground level may not infringe statutory ground to conductor clearances or statutory visibility clearances. After any changes in ground level, the surface shall be rehabilitated and stabilised so as to prevent erosion. The measures taken shall be to Eskom's requirements.

A.8 Indemnity
Eskom shall not be liable for the death of or injury to any person or for the loss of or damage to any property whether as a result of the encroachment or of the use of the servitude area by the applicant, his/her agent, contractors, employees, successors in title, and assigns. The applicant indemnifies Eskom against loss, claims or damages including claims pertaining to consequential damages by third parties and whether as a result of damage to or interruption of or interference with Eskom's services or apparatus or otherwise. Eskom will not be held responsible for damage to the applicant's equipment. The applicant's attention is drawn to the *Electricity Act, 1987, (Act 41 of 1987, as amended in 1994),* Section 27(3), which stipulates that the applicant can be fined and/or imprisoned as a result of damage to Eskom's apparatus.

A.9 Machinery
No mechanical equipment, including mechanical excavators or high lifting machinery, shall be used in the vicinity of Eskom's apparatus and/or services, without prior written permission having been granted by Eskom. If such permission is granted the applicant must give at least seven working days prior notice of the commencement of work to Mr. Simon Radingoana (Tel. 013 - 230 9106) at Steelpoort Field Service Centre, Eskom Distribution. This allows time for arrangements to be made for supervision and/or precautionary instructions to be issued.

A.10 Permission to do work
A.10.1 No work shall commence unless Eskom has received the applicant's written acceptance of the conditions specified in the letter of consent and/or permit.

A.10.2 Eskom's rights and duties in the servitude shall be accepted as having prior right at all times and shall not be obstructed or interfered with.

Note: Where and electrical outage is required, at least fourteen work days is required to arrange same.

A.11 Remedial action
Under no circumstances shall rubble, earth or other material be dumped within the servitude or Way Leave restriction area. The applicant shall maintain the area concerned to Eskom's satisfaction. The applicant shall be liable to Eskom for the cost of any remedial action which has to be carried out by Eskom.

A.12 Safety
A.12.1 The clearances between Eskom's live electrical equipment and the proposed construction work shall be observed as stipulated by *Regulation 15* of the *Electrical Machinery Regulations of the Occupational Health and Safety Act, 1993 (Act 85 of 1993).*

A.12.2 Equipment shall be regarded electrically live and therefore dangerous at all times.

A. 12.3 In spite of the restrictions stipulated by Regulation 15 of the Electrical Machinery Regulations of the Occupational Health and Safety Act, 1993 (Act 85 of 1993), as additional safety precaution, Eskom will not approve the erection of Houses, or structures occupied or frequented by human beings under the powerlines and only after consideration of all alternatives, within the servitude area.

A. 12.4 Eskom may stipulate any additional requirements to illuminate any possible exposure to Customers or Public to coming into contact or be exposed to any dangers of Eskom plant.

A. 12.5 It is required of the applicant to familiarize him/herself with all safety hazards related to Electrical plant.

B.1 Blasting, opencast mining and undermining

B.1.1 A specific document of permission in respect of the blasting or mining activity as issued by the Inspector of Mines must be submitted to Eskom before commencement of operations.

B.1.2 Blasting in close proximity to Eskom's overhead powerlines or substations is prohibited unless the following precautions are met [refer to the Minerals Act, 1991 (Act 50 of 1991) Regulations 5.31 and 5.32]:

- a blasting plan submitted with the document of permission referred to in B.1.1 above,
- a Peak Particle Velocity (PPV) to be kept below 75 mm/s, for lines and 50 mm/s for buildings,
- a seismic control device is set up to record the readings,
- ensure fly rock and air blast control by means of adequate matting,
- in the interest of air blast control, only single shot blasting shall be allowed.
- Permission for blasting will be strictly as stipulated in the Blasting Design by the Blasting Consultants.

B.1.3 The applicant will be held liable for damage to Eskom's towers or substation equipment, as a result of blasting activities.

B.1.4 Costs incurred by Eskom to comply with statutory requirements in terms of an applicant's (or his contractors) works, equipment or plant in the servitude area, shall be paid to Eskom on demand.

B.1.5 Eskom may charge the applicant appropriately for time on site during blasting operations.

B.1.6 Eskom reserves the right to withdraw its consent if the blasting process becomes hazardous and likely to result in power interruptions.

B.1.7 If permission for the blasting process is granted the applicant must give at least fourteen work days prior notice of the commencement of blasting to Mr. Simon Radingoana (Tel. +27 82 408 5844). This allows time for arrangements to be made for supervision of and/or precautionary instructions to be issued in terms of the blasting operation.

B.1.8 General Conditions

B.1.8.1 Firing near the power lines should be along a free face, facing away from the power lines, as the Mine has suggested.

B.1.8.2 The Mine should prepare a proper analysis of the rock structure and any geological anomalies prior to blasting.

B.1.8.3 The "safe distance of 25m" from Eskom pylons should be verified for the intended plan of blasting (distance; scenario and no of holes) by means of experimental in situ seismic measurements, as proposed. Existing geological faults, decomposed zones and fractured rock structures could have destabilising effects on founding material as a result of the firing, especially when developing an open face next foundations and below founding level. These conditions should be taken into account when deciding on the method and plan of blasting near the Eskom power line pylons.

B.1.8.4 Eskom retains the right to appoint any specialist at any time on behalf of the Mine, to inspect Eskom structures for deformation.

B.1.8.5 The mining depth near Eskom pylons should carefully be controlled for stability and adjustments being made when so instructed by Eskom.

Should the applicant or his contractor damage any of Eskom services during commencement of any work whatsoever, then Eskom's 24 hour Contact Centre Tel: 086 000 1414 must be dialed immediately to report the incident.

We thank you and hope you will find the above in order. Should you have technical queries on the Eskom standards and specifications please feel free to phone our Technology and Quality Department, contact person: Mmedi Motaung Tel: 012-421 3034.

Attached Annexes A (Letter of consent) and B (Indemnity Form) must be completed and returned to this office before commencement of any operations.

Annex A

Letter of consent

PERMISSION FOR BLASTING OPERATIONS WITHIN 500m FROM ANY ESKOM INFRASTRUCTURE
PROPERTY: BOOYSENDAL 43 JT
Our Ref: Myn/01/14

Application to encroach on Eskom's right

With reference to your application dated 08 August 2014 to perform mining operations, permission is hereby granted under the conditions listed on the attached document. Kindly indicate your acceptance of these conditions by initialling each page and signing in the appropriate area on this page and returning this copy to Eskom at the following address:

Eskom Holdings Limited, Distribution Services – Land & Rights, P.O.Box 3499, Polokwane 0700

Should you have any questions, please do not hesitate to contact myself at:

TELEPHONE NUMBER: 015 - 299 0509

Yours sincerely

A B Maudu
LAND DEVELOPMENT MANAGER

I,..(FULL NAMES AND SURNAME)

herewith unconditionally accept the stipulations in the Letter of Consent pertaining to my co-use of an Eskom servitude (building and tree restriction).

SIGNED AT .... THIS .... DAY OF .... (MONTH) (YEAR) ....

....
APPLICANT

WITNESS.. WITNESS ....