## 8.9 Geohydrological Assessment

**SOUTH32 SA COAL HOLDINGS (PTY) LTD**

# VANDYKSDRIFT CENTRAL (VDDC) MINING: INFRASTRUCTURE DEVELOPMENT
# HYDROGEOLOGICAL INVESTIGATION
# FINAL REPORT

Report No.: JW120/19/G535-300

September 2019

Jones & Wagener
Engineering & Environmental Consultants

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## SPECIALIST DECLARATION

This report has been drafted as per the latest requirements for specialist reports as set by the Department of Environmental Affairs and listed in Government Gazette No. 40713, dated 24 March 2017 and Government Gazette No. 40772 dated 07 April 2017 in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA).

I, Altus Huisamen, hereby declare that:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

________________________________________

Altus Huisamen Ph.D., Pr. Sci. Nat.

Senior Hydrogeologist and Numerical Modeller, Jones & Wagener

## SYNOPSIS

### Background

Wolvekrans Colliery which is located in the Witbank Coal Fields. The Vandyksdrift Central (VDDC) area falls within the footprint of the historic underground mining operations referred to as Douglas Colliery.

South32 SA Coal Holdings (Pty) Ltd (South32) is planning to mine the remaining coal seams at VDDC, predominantly by means of bord-and-pillar mining. Since the No. 2 seam workings are flooded with water a dewatering strategy was also developed for this area.

A pre-feasibility investigation has identified the need to develop additional non-production infrastructure to support the proposed opencast mining of the remaining coal seams at VDDC. The proposed infrastructure includes:

- Storm water management structures, pollution control berms and canals;
- Overburden Dumps;
- Mixed ROM coal and slurry stockpile areas;
- Dragline Spoils;
- Proposed Evaporators;
- 5Seam and 4Seam Run of Mine (ROM) Stockpiles;
- Topsoil stockpiles following clearance of vegetation;
- Pipelines for the conveyance of water; and
- Haul roads.

The proposed VDDC opencast pit boundary as determined through the pre-feasibility investigation also differs from the mining area in the 2007 approved EMPR amendment. An area of approximately 196 hectares in the final mine layout was not included in the previous mine layout and is therefore not approved to be opencast mined.

A hydrogeological assessment is required in support of the required regulatory processes to authorise the abovementioned activities and the objective is to determine the potential impact associated with the development of the proposed additional infrastructure and the opencast mining of areas not previously authorised at VDDC.

A risk-based approach was undertaken during the groundwater impact assessment, which also includes the development of a numerical groundwater flow and mass transport model to simulate the potential impacts from these facilities.

### Site conceptualisation

The VDDC area is largely a brownfields area where the natural topography has been dramatically disturbed by mining related activities. The main surface water feature in the study area is the Olifants River, which drains the study area in the south from east to west, and from south to north in the west, until it flows into the Witbank Dam.

There are five coal seams which underlie the weathered Karoo rocks in the study area, namely the No.1 to No.5 coal seams. The No.2 coal seam is the most prominent of the five coal seams and has widely been mined using bord-and-pillar methods. The interburden between the coal seams consist mainly of sandstones and mudstones with carbonaceous shale being present closer to the coal seams. The No.1 seam is also well developed in the study area. It is understood that the No.2 seam will continue to be mined via opencast mining operations.

Based on a review of the previous investigations three aquifers typically underlie the project area:

- A shallow perched aquifer in the lower lying areas or depressions;
- A weathered aquifer, which extends to depths of approximately 20 metre below surface (mbs), depending on the depth of weathering;
- A deeper fractured rock aquifer, which is characterised by fractures, faults and contact zones with dolerite intrusions in the Karoo sediments. This aquifer underlies the weathered aquifer and extends down to the bottom of the No.2 coal seam.

**Study results**

A hydrocensus was undertaken in 2018 by J&W on the entire VDDC footprint to record the local and regional static groundwater levels. This information served as an important step in conceptualising the study area. Being a brownfields area surrounded by mining complexes, no privately used boreholes were identified during the hydrocensus. A total of 35 boreholes were identified and were used in the calibration of the numerical groundwater model. The average depth to groundwater level for the study area was calculated to be 8.4 mbs when the boreholes drilled into the underground workings are not considered. When the underground workings boreholes are included the average depth increases to 25.8 mbs.

Electrical conductivity (EC) profiles were also performed on selected boreholes during the hydrocensus. This data was utilised as part of the hydrochemistry assessment to provide more background on the current extent of mining related contamination plumes (if any). As expected, boreholes that intersect the mine workings and those that are located downstream of the existing PSS Dump had elevated EC levels.

***Model and impact assessment***

A three-dimensional numerical model was employed to simulate stresses to the aquifer system in both a spatial and temporal context. The results obtained during the steady state scenarios were used as initial conditions to simulate dewatering and contaminant transport impacts. The model was setup for three main simulated scenarios i.e. predevelopment phase or baseline scenario, operational phase and post mining or closure phase.

The proposed infrastructure development will take place in an area that has already been impacted by mining activities. The proposed infrastructure development was therefore assessed from a cumulative perspective, taking the existing potential pollution sources into account.

The opencast areas not yet authorised is approximately 196 ha of the total extent of 1146 ha of the proposed final VDDC opencast pit. The opencast mining areas not yet authorised and included in the application for authorisation, was therefore assessed from a cumulative perspective.

The **operational phase** modelling included the following transport and dewatering scenarios:

Transport

- Overburden Dumps.
- Mixed ROM coal and slurry drying areas.
- Final Rejects Dump (cumulative impact – existing authorised facility).
- Dragline Spoils.
- Proposed Evaporators.
- Vleishaft Dam (existing authorised facility to be used for containment of dirty water make from VDDC).
- 5Seam and 4Seam ROM Stockpiles.

Dewatering

- Proposed VDDC Opencast Mine and proposed 2 seam dewatering prior to mine development.

The **closure phase** modelling included the following transport and dewatering scenarios:

Transport

- Backfilled Opencast Mine, Final Rejects Dump

Discharge

- Backfilled Opencast Mine.

***Operational phase impacts***

- VDDC Opencast is expected to receive maximum inflows of 265 $m^3$/d during mining if pre-mining dewatering is performed. The drawdown from this mine is expected to influence water levels in boreholes VD9N, DGMSB124, DGMSB123, DGMUB113, WBH2S7, VD1N, DGMUB110, WBH2S10, VD3NBH1, WBH2S8, DGMUB72, WBH2S6, VD6N, WBH2S5, VD4N as well as the tributary of the Olifants River to the southeast of VDDC. Expected water level decline at these receptors is expected to range between 20-60 m.
- Proposed 2 Seam dewatering prior to mine development is expected to abstract 25000 $m^3$/d. The drawdown from this mine dewatering is expected to influence water levels in borehole UB115. Expected water level decline at this receptor is expected to range between 0-2 m.
- Contamination from the Overburden Dump to the northwest of the opencast pit is expected to affect the Olifants River with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from Mixed ROM coal and slurry stockpile areas. is expected to affect the Old Vleishaft Tributary, which is now part of the dirty water system of the mine, with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from Final Rejects Dump is expected to affect Boreholes DGMSB124, DGMSB123, DGMUB11, DGMUB114, P1, P2, P3, P4, DGMBB34, VD7N, VD8N and the Olifants River to the south of the opencast with expected concentration increases of 200-1000 mg/L with regards to $SO_4$.
- Contamination from Vleishaft Dam is expected to affect the Old Vleishaft Tributary, which is now part of the dirty water system of the mine, with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from the Dragline Spoils is expected to affect Boreholes VD3NBH1, VD4N, VD6N, WBH2S5 with expected concentration increases of 200-1000 mg/L with regards to $SO_4$.

***Decommissioning and closure phase impacts***

Contamination from VDDC Opencast is expected to affect boreholes SB122-124, VD1N, VD7N-9N, WBH2S8, P1 -P4, UB11, UB114 and the Olifants River and its tributaries with expected sulfate concentration increases of 200-2 000 mg/ℓ. Groundwater levels in the VDDC Opencast area are expected to rebound within ±5 years. Decant from this mine is expected to take place at the Olifants River tributary to the south-east of the site via subsurface discharge at approximately 1 530 mamsl and approximately 0.5 ℓ/s.

***Management of identified impacts during mining***

- Clean and dirty water systems should be separated as planned.

- Groundwater monitoring boreholes should be sited at designated positions based on infrastructure layout, to comply with the design requirements of a groundwater monitoring system, as recommended.
- If surface water monitoring shows that the Olifants River or its tributaries are affected by mine dewatering, discharge of clean water into the tributaries should be considered. This could be achieved by discharge of treated water.
- The numerical model should be updated every 5 years during operation of the opencast mine by using the measured inflows, water levels and any potential future drilling and pump test information to re-calibrate and refine the impact prediction.
- Dewatering and groundwater abstraction for mining purposes should be monitored so as to prevent negative impacts on the underlying aquifer.
- Areas in the opencast where the defunct underground is intersected could be sealed with blasted overburden with engineered designs to limit groundwater ingress.
- Since the contamination from the mechanical evaporators is likely to be similar to the geochemical nature of backfill material where the evaporators will be constructed, no impact to sensitive receptors is expected. It is likely that mobilised contamination will move into the VDDC opencast.
- The Mixed ROM coal and Slurry Stockpile areas and proposed overburden dumps must all be provided with a barrier system to prevent any contamination from entering the aquifer system. Groundwater monitoring must be instituted upstream and downstream of these facilities to monitor and intercept any potential contamination timeously. Soil underlying the overburden dumps and the dragline spoils must be, at least, compacted to prevent contamination from entering the aquifer system.

***Management of identified impacts after mining***

- Following mine closure and rehabilitation of the pit, the backfill will form an artificial aquifer which is likely to discharge. The water level in the backfilled opencast should be controlled by pumping to not exceed 1 530 mamsl to prevent decant. Alternatively, an interception trench must be constructed to capture contaminated subsurface seepage for storage in a lined PCD for evaporation or treatment.
- All sulfide containing waste material should be stored at the bottom of the opencast pit and flooded as soon as possible to exclude oxygen. However, flooding should be monitored to flood the pit as quickly as possible but also to control potential decant.
- A mine water discharge management plan must be developed which may include passive or active treatment options.
- Backfilled material should be compacted and surface water flow should be routed around the backfilled opencast mine to reduce recharge to a maximal extent.

It is assumed that the dragline spoils and overburden dumps will be deposited in the VDDC opencast as part of backfill material and that the Mixed ROM coal and slurry stockpile areas will all be removed before opencast mining is undertaken in that area, thereby removing these source terms. It is considered likely that Vleishaft Dam will be decommissioned and rehabilitated after mining has ceased, thereby also removing this source. Groundwater monitoring at the final rejects dump must be maintained and contaminated seepage management implemented. Capping of this facility will also be mandatory.

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***Glossary***

**Abstraction:** The act of removing water from a groundwater resource.

**Act (The):** National Environmental Management Act (Act No. 107 of 1998).

**Alluvial Aquifer:** An aquifer comprising unconsolidated material deposited by water, typically occurring adjacent to rivers and in buried paleochannels.

**Aquifer:** Aquifer means a geological formation which has structures or textures that hold water or permit appreciable water movement through them.

**Aquifer Testing:** Aquifer testing involves the withdrawal of measured quantities of water from or the addition of water to, a borehole(s); and the measurement of resulting changes in head in the aquifer both during and after the period of abstraction or addition.

**Artesian Borehole:** Boreholes that penetrate confined aquifers in which the piezometric surface is above ground level, so that the boreholes spontaneously discharge water without being pumped.

**Baseflow:** Sustained low flow in a river during dry or fair weather conditions, but not necessarily all contributed by groundwater; includes contributions from interflow and groundwater discharge.

**Borehole:** Includes a well, excavation, or any other artificially constructed or improved underground cavity which can be used for the purpose of intercepting, collecting or storing water in or removing water from an aquifer; observing and collecting data and information on water in an aquifer; or recharging an aquifer.

**Borehole Log:** A record of the geological and hydrogeological conditions encountered in the drilling of a borehole and the construction thereof.

**Borehole Yield:** The volume of water that can be abstracted from a borehole.

**Catchment:** Catchment in relation to watercourse or watercourses or part of a watercourse means the area from which any rainfall will drain into the watercourses, or part of a watercourse, through surface flow to a common point or points.

**Conceptual Model:** A conceptual model includes designing and constructing equivalent but simplified conditions for the real world problem.

**Cone of Depression:** The depression of hydraulic head around a pumping borehole caused by the withdrawal of water.

**Contamination:** The introduction of any substance into groundwater systems by the action of man.

**Drawdown:** The distance between the static water level and the surface of the cone of depression.

**Dyke:** A tabular or sheet-like body of igneous rock that cuts through and across the layering of adjacent rocks.

**Electrical Conductivity (EC):** Electrical conductivity is a measure of how well a material accommodates the transport of electric charge. The more salts dissolved in the water, the higher the EC value. It is used to estimate the amount of total dissolved salts, or the total amount of dissolved ions in the water.

**Fault:** A zone of displacement in rock formations resulting from forces of tension or compression in the earth’s crust.

**Fracture:** Any break in a rock including cracks, joints and faults.

**Fracture Flow:** Water movement that occurs predominantly in fractures and fissures.

**Hydraulic Conductivity:** Measure of the ease with which water will pass through the earth's material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (m/d).

**Hydraulic Gradient:** The rate of change in the total hydraulic head per unit distance of flow in a given direction.

**Hydraulic Head:** Hydraulic head is the height above a datum plane such as sea level of the column of water that can be supported by the hydraulic pressure at a given point in a groundwater system.

**Monitoring Borehole:** A borehole used to measure groundwater trends.

**Observation Borehole:** A borehole used to measure the response of the groundwater system to an aquifer test.

**Porosity:** Porosity is the ratio of the volume of void space to the total volume of the rock or earth material.

**Quaternary Catchment:** A fourth order catchment in a hierarchal classification system in which a primary catchment is the major unit.

**Recharge:** The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.

**Remediation:** Reduce the concentrations of contaminants in groundwater to some acceptable level.

**Static Water Level (SWL):** The groundwater level in a borehole not influenced by abstraction or artificial recharge.

**Saturated Zone:** The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.

**Semi-confined Aquifer:** An aquifer that is partly confined by layers of lower permeability material through which recharge and discharge may occur.

**Specific Yield (SY):** The ratio of the volume of water that drains by gravity to that of the total volume of the saturated porous medium.

**Transmissivity (T):** The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.

**Unconfined Aquifer:** An aquifer where the water table is the upper boundary and with no confining layer between the water table and the ground surface. The water table is free to fluctuate up and down.

**Unsaturated Zone:** That part of the geological stratum above the water table where interstices and voids contain a combination of air and water, synonymous with zone of aeration or vadose zone.

**Water table:** The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is equal to that of the atmosphere.

### *Abbreviations*

| | |
|---|---|
| ABA | Acid-base Accounting |
| AMD | Acid Mine Drainage |
| BMK | Boschmanskrans Section |
| DWAF | Department of Water Affairs and Forestry |
| DWS | Department of Water and Sanitation |
| EC | Electrical conductivity |
| ELM | eMalahleni Local Municipality |
| EMPr | Environmental Management Programme Report |
| GQM | Groundwater Quality Management |
| J&W | Jones & Wagener |
| JMA | Jasper Muller Associates (Pty) Ltd |
| K | Hydraulic Conductivity |
| mamsl | Metres above mean sea level |
| mbs | Meters below surface |
| NDM | Nkangala District Municipality |
| NEM:WA | National Environmental Management Waste Act (Act No 59 of 2008) |
| NNP | Net neutralising potential |
| NP | Neutralisation Potential |
| NWA | National Water Act |
| PCD | Pollution control dam |
| SANS | South African National Standards |
| SAWS | South African Weather Service |
| SKS | Steenkoolspruit Section |
| swl | Static water level |
| T | Transmissivity |
| TC | Total Concentration |
| TDS | Total dissolved solids |
| VDDC | Vandyksdrift Central |
| XRD | X-Ray Diffraction |
| XRF | X-Ray Fluorescence |

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**SOUTH32 SA COAL HOLDINGS (PTY) LTD**

VANDYKSDRIFT CENTRAL (VDDC) MINING: INFRASTRUCTURE DEVELOPMENT HYDROGEOLOGICAL INVESTIGATION
FINAL REPORT REPORT NO: JW120/19/G535-300

# 1. INTRODUCTION

## 1.1 Background

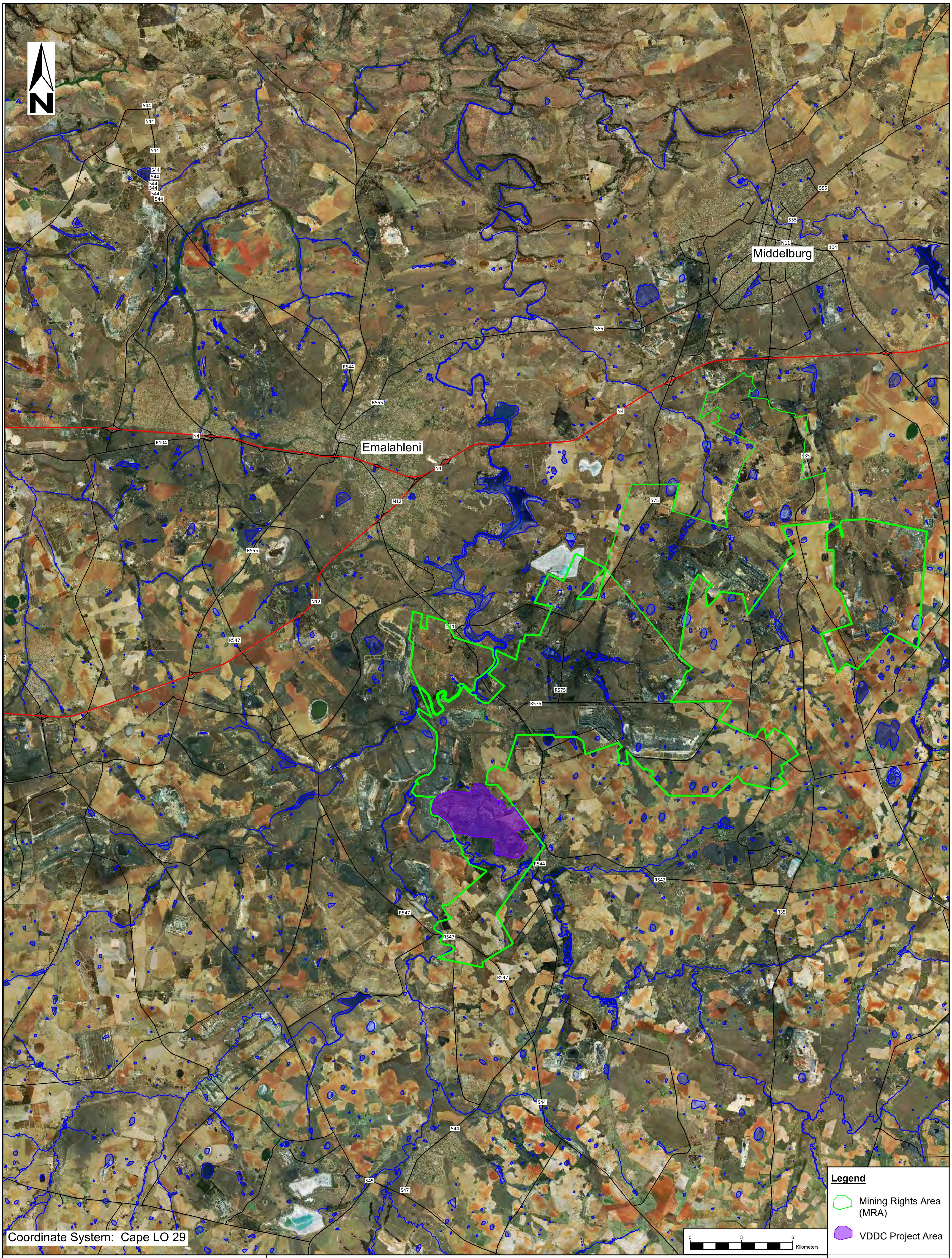
South32 SA Coal Holdings (Pty) Ltd (South32), is the holder of an amended mining right for coal, granted by the Minister of Mineral Resources, in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA) and notarially executed on the 21$^{st}$ of May 2015 under DMR reference MP30/5/1/2/2/379MR, in respect of its Wolvekrans – Ifalethu Colliery. This mining right comprises of the following areas:

- Ifalethu Colliery (previously referred to as Wolvekrans North Section[1]) consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant; and
- Wolvekrans Colliery (previously referred to as the Wolvekrans South Section) consisting of the Wolvekrans, Vlaklaagte (mining ceased), Driefontein, Boschmanskrans, Vandyksdrift, Albion and Steenkoolspruit sections, as well as the South Processing Plants (Eskom and Export). Some of these areas were previously known as Douglas Colliery.

The Vandyksdrift Central (VDDC) area falls within the footprint of the old Douglas Colliery **(Figure 1.1.a)** An amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved in 2007, which entails the opencast mining of the remaining coal seams, primarily through the extraction of the remaining pillars. The No. 2 seam workings are flooded with water and have to be dewatered to enable the open pit development to proceed. A dewatering strategy has therefore been developed.

The 2007 EMPR Amendment did not, however, include any additional infrastructure in support of the opencast mining operations as it was assumed at that stage that existing infrastructure will be used. The need has since been identified to develop additional infrastructure to support the proposed mining. The additional infrastructure relevant to this hydrogeological assessment are illustrated in **Figure 1.1.b** and include storm water management structures, pollution control berms and canals,, overburden sumps, mixed ROM coal and slurry stockpile areas and topsoil stockpiles. Additional to the above infrastructure was the identification of an opencast mining area within the final VDDC mine layout not included in the approved mine layout as per the 2007 approved EMPR Amendment (refer to **Figure 1.1.c)**.

[1] This was previously referred to as Middelburg Colliery

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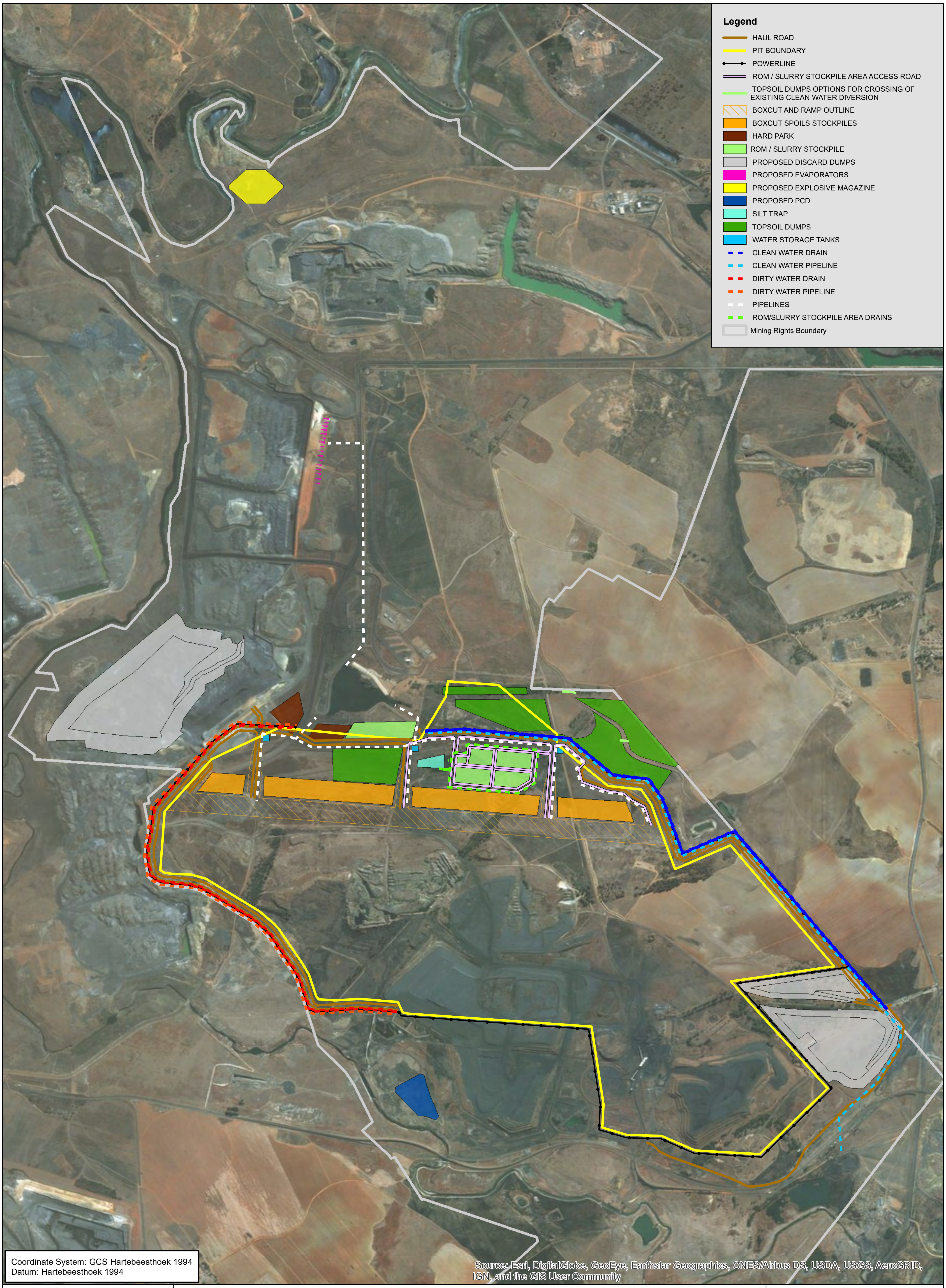
South32
VDDC Project
Regional Locality Plan

Job No G535-04

**Figure 1.1.a**

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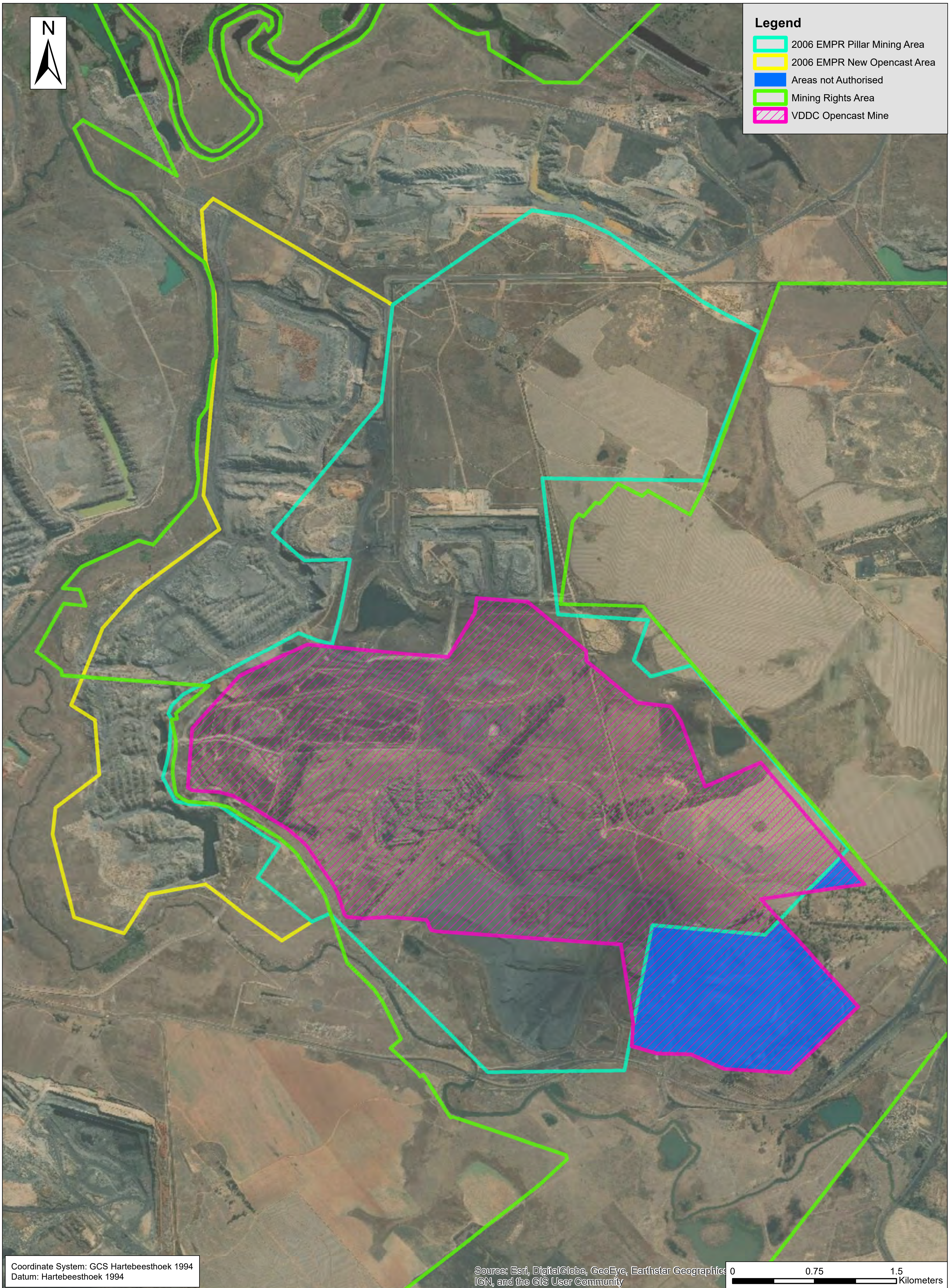
Vandyksdrift Central
Proposed Infrastructure

Job No: G535-04

Figure 1.1.b

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Vandyksdrift Central
Proposed Opencast Extension

Job No: G535-310

Figure 1.1.c

### 1.2 Scope and Purpose

A hydrogeological assessment is required in support of the required regulatory processes and the objective is to determine the potential impact associated with the development of the proposed additional infrastructure and pit layout expansion associated with the opencast mining of the pillars at VDDC.

A risk-based approach was undertaken during the groundwater impact assessment, which also includes the development of a numerical groundwater flow and mass transport model to simulate the potential impacts from these facilities cumulatively as the potential impacts cannot be viewed in isolation. This is due to the likelihood of concurrent and cumulative impacts that could be associated with the proposed infrastructure and pit expansion.

To meet the project objective, the following scope of work was undertaken:

- Review of available information including hydrochemistry and geochemistry;
- Borehole survey; and
- Numerical groundwater flow and transport modelling.

A detailed description of the methodology undertaken for each of the activities listed above is discussed in **Section 3**.

## 2. SITE DESCRIPTION

### 2.1 Site Locality

The VDDC mining and infrastructure development project is a brownfields project within the greater Wolvekrans Colliery mining right area. Wolvekrans Colliery is located between the towns of eMalahleni and Kriel, within the jurisdictional area of the eMalahleni Local Municipality (ELM) and the Nkangala District Municipality (NDM) of the Mpumalanga Province of South Africa. The mine is situated approximately 30 km south-east of the town of eMalahleni (refer to **Figure 1.1.a**). VDDC is located on the western boundary of Wolvekrans Colliery. The Olifants River determine the southern boundary.

### 2.2 Topography and Drainage

The VDDC Section is largely a brownfields area where the natural topography has been dramatically disturbed by mining related activities. As illustrated in **Figure 2.2.a** the greater study area is characterised by a flat, slightly undulating topography at an elevation of between 1 625 and 1 505 mamsl. The study area tends to slope from east to west at an angle of between 1% and 2%.

The main surface water feature in the study area is the Olifants River, which drains the study area in the south from east to west, and from south to north in the west, until it flows into the Witbank Dam. The Olifants River has a surveyed water level of 1 505 mamsl (J&W, 2016).

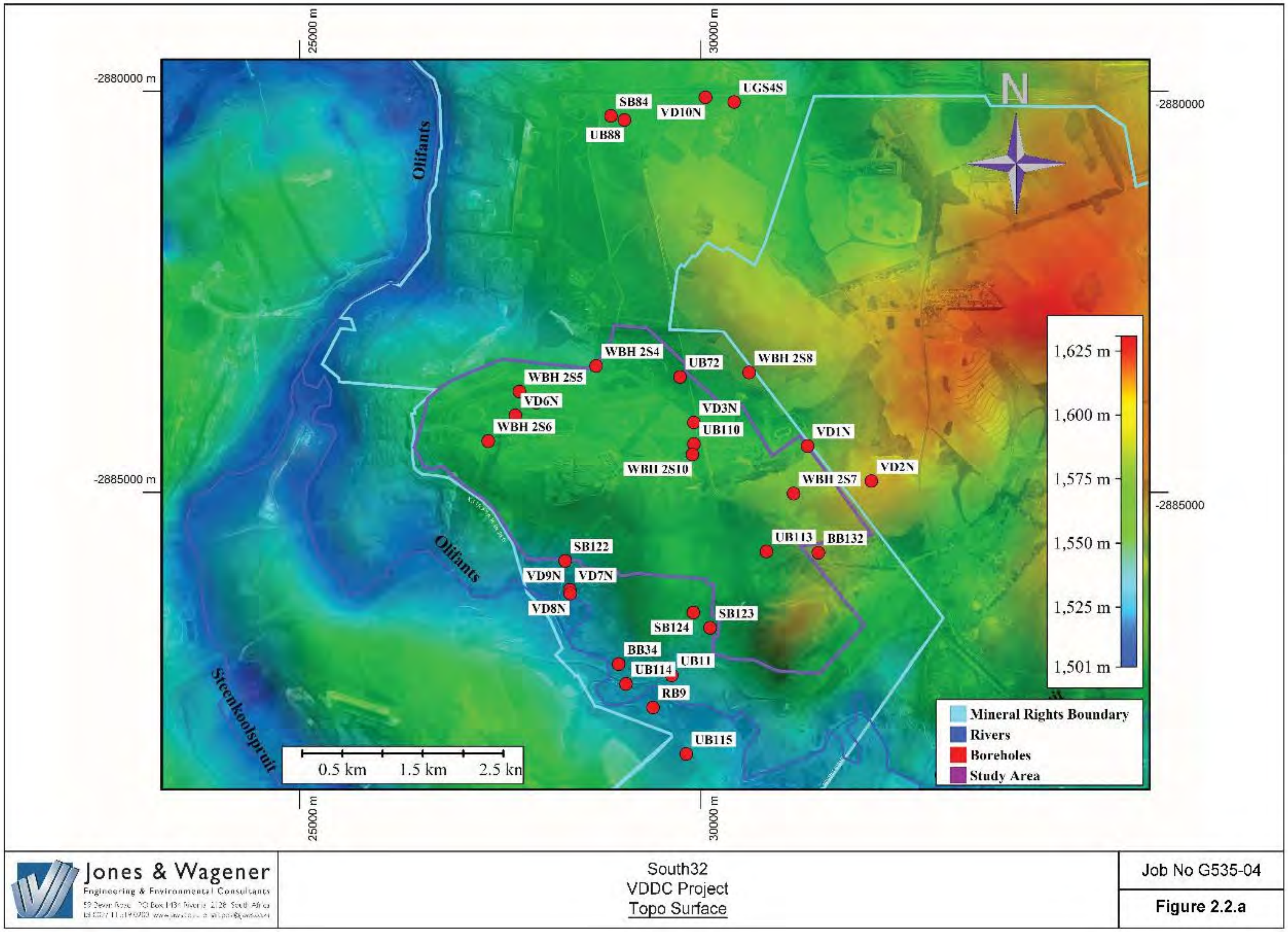


**Figure 2.2.a: Regional topography and drainage**

## 2.3 Climate

### 2.3.1 Regional Climate

The VDDC is situated in the Highveld climatic area of Southern Africa. The area is typically characterised by warm wet summers and cold dry winters. Maximum daily temperatures reaching 27 ºC (with occasional extremes of up to 35 ºC) occur in January, while cold winters with sharp frost and night time temperatures dropping top -2 ºC (with occasional extremes as low as -10 ºC) occur in June and July.

### 2.3.2 Rainfall

The average rainfall per year at the South African Weather Services (SAWS) Vandyksdrift rainfall station (0478546 W) varies between a 988 mm and 368mm, with the mean annual precipitation (MAP) being 705 mm. The higher rainfall months occur from October to March (summer).

The average monthly rainfall at Vandyksdrift is presented in **Figure 2.3.2.a**.

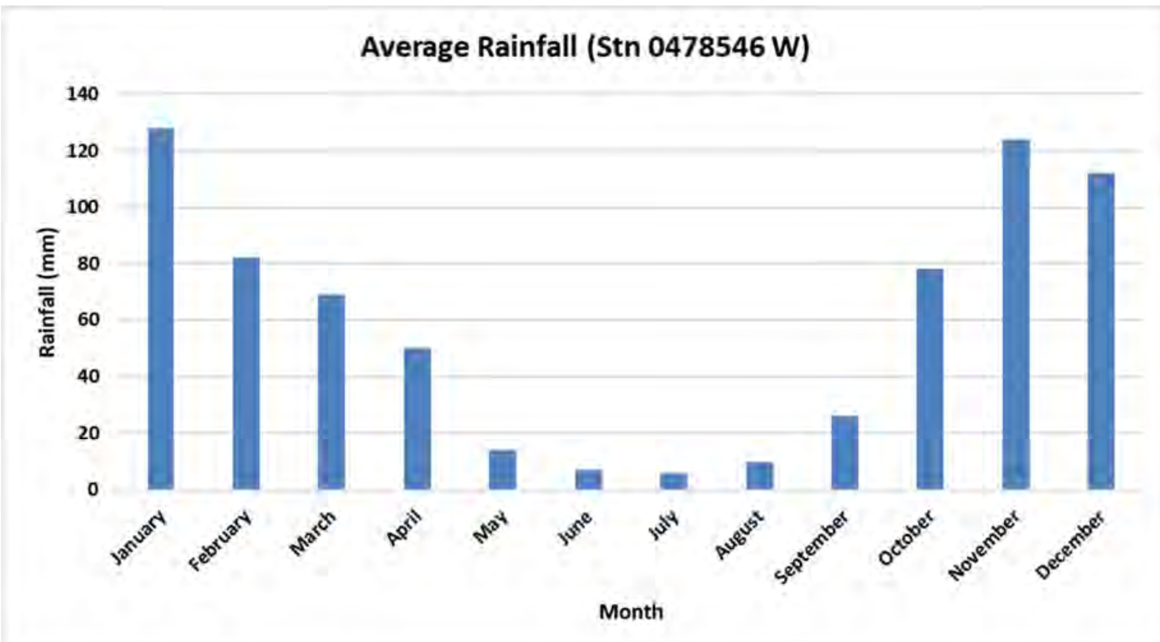


**Figure 2.3.2.a: Mean Monthly Rainfall (Stn 0478546 W)**

### 2.3.3 Evaporation

Monthly Symons Pan evaporation data, obtained from the Department of Water Affairs, for the Witbank Dam station (Stn B1E001) for the period 1964 – 2009 are shown in **Figure 2.3.3.a** below and compared to the annual rainfall. The annual evaporation rates range between 1 211 mm to 1 879 mm with a mean annual evaporation (MAE) of 1 476 mm. Average monthly evaporation rates range between 65 mm (June) to 164 mm (January and December).

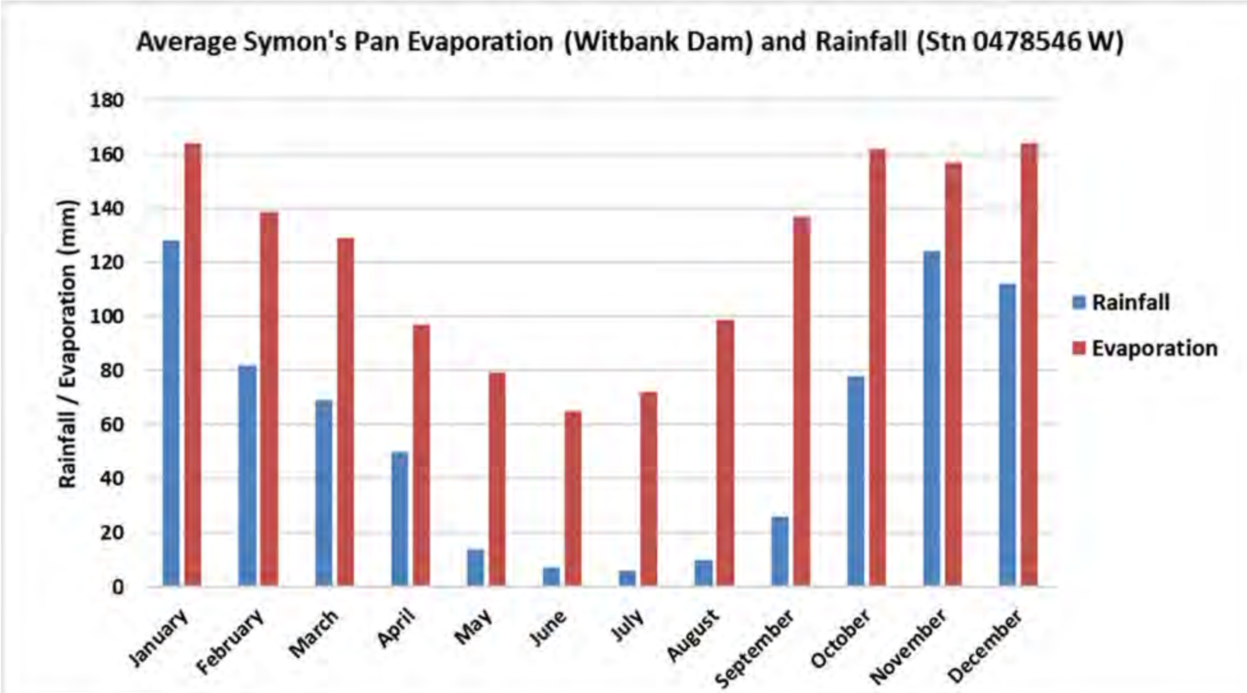


**Figure 2.3.3.a: Mean Monthly Symon's Pan Evaporation (Witbank Dam) and Rainfall (Stn 0478546 W).**

# 3. METHODOLOGY AND FINDINGS

## 3.1 Desk Study

All the available existing groundwater and surface water quality data was collated and evaluated in this assessment. The historical investigations that were used to assist in the compilation of this report included:


- AGES (2012). BHP Billiton Energy Coal South Africa (BECSA) – Middelburg Mines: Water Management Plan. Report No: AS-R-2012-11-22, Lynnwood, Pretoria.
- AGES (2012). BHP Billiton Energy Coal South Africa (BECSA) – Middelburg Mines: Integrated Environmental Site Water Balance. Report No: G12/036-2012-10-30, Lynnwood, Pretoria.
- Brown S., (2011). Summary of Water Make at Middelburg Colliery.
- DHI (2013). Middleburg Mines: Integrated Surface Water and Groundwater Management. Report No: 20111011, Johannesburg North, South Africa.
- DWAF (2009). Integrated Water Resource Management Plan for the Upper and Middle Olifants Catchment. Integrated Water Resource Management Plan. Report No: P WMA 04/000/00/7007, Directorate National Water Resource Planning. Department of Water Affairs and Forestry, South Africa.
- Exigo (2015). South32 CSA – Wolvekrans Hydrochemical and Isotopic Tracing. Report No:ES15/168, Lynnwood, Pretoria.
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- Jones and Wagener Pty Ltd (2016) Steenkoolspruit section of Middelburg mine geohydrological investigation for the storage of water in the Steenkoolspruit pits final report - report no.: JW078/16/E791, Rivonia, South Africa
- Pulles, Howard & de Lange Incorporated (2004) Douglas EMP Amendment, Geochemical Assessment. Auckland Park, South Africa
- SRK Consulting (2013) Surface Water Impact Study for the BECSA Vandyksdrift Central Project. Report no: 449019. Illovo, South Africa

Results from the above referenced studies are summarised below.

In reading this section, it is noted that Douglas Colliery, is now known as Wolvekrans Colliery, and Vandyksdrift and Steenkoolspruit are sections within the Wolvekrans Colliery.

The site geochemistry and hydrochemistry as identified from previous investigations are discussed in more detail in Section 5.

### 3.1.1 Hodgson, Grobbelaar, Cruywagen & de Necker (1999)

***Acid-base Accounting and Long-term Mine Water Chemistry at Douglas Colliery.***

**Study objective**

Core rock and coal samples were tested to investigate the long-term hydro chemical character of the opencast and underground mine water at Douglas Colliery, by performing acid-base accounting and leaching tests on the samples, as well as geochemical modelling.

**Study results**

In terms of future salt load, a sulfate generation rate of 50 tonnes/day was suggested for Douglas Colliery. This was predicted to result in an average sulfate concentration of 1800 mg/ℓ in the seepage water. In areas of low water through flow, the sulfate concentration was expected to rise to saturation levels. At a pH of 6.5 and a calcium concentration of 250 – 380 mg/ℓ, the sulfate concentration was predicted to be in the range of 1825 – 3300 mg/ℓ. At pH-levels below 3.0, sulfate concentrations were assessed to potentially increase to well over 4000 mg/ℓ.

The overall conclusion was that eventual acidification of the opencast water at Douglas Colliery was unavoidable. The scale of mining was seen as simply too large and that mining has progressed too far to make a meaningful and permanent change at that stage. The final fate of the underground water in terms of acidity was concluded to depend on issues such as its interconnectivity to opencast and the surface and the rate of flooding. It was therefore recommended that Douglas Colliery should provide for neutralisation of the mine water in their closure plan. Controlled flood release of treated water or irrigation were seen as the preferred option to dispose of this water. It was considered inevitable that the mine water at Douglas Colliery would eventually acidify to the extent that acid water will be the dominant type.

### 3.1.2 Pulles, Howard & de Lange Incorporated (2004)

***Douglas EMP Amendment, Geochemical Assessment.***

**Study objective**

Douglas Colliery was at the time in the process of expanding their operations to include additional opencast operations at Steenkoolspruit and Kleinkopje, and a pillar mining operation at Vandyksdrift.

The objective was to carry out a screening level geochemical assessment of the long-term water quality impact associated with the proposed new mining development including evaluation of the existing acid base-accounting (ABA) data, salt balance and metal leaching potential and kinetic geochemical modelling for long-term water quality prediction. The modelling was undertaken as a preliminary screening-level study with a number of simplistic assumptions being made.

**Study results**

The study (ABA, mineralogy) showed that, overall, waste rock had less acid generation potential than the coal seams, which all had strong acid potential. Furthermore, equilibrium modelling results indicated that the waste rock material had a moderate Neutralising Potential (NP), but substantial Net Neutralising Potential (NNP) (>20), indicating that the potential for AMD generation from the waste rock material is low.

The kinetic geochemical modelling, using the sparse existing data that could be extrapolated to the site suggested that the ABA results were misleading and that the long-term prognosis for the mine is one of neutral pH with relatively low salinity water at the time of eventual pit discharge.

### 3.1.3 Jasper Muller and Associates (JMA) (2004)

***Douglas EMP Amendment Geology and Geohydrology Assessment.***

**Study objective**

JMA compiled the geology and groundwater related inputs for the EMPR for the Steenkoolspruit strip mine project in 2004. Detailed calculations were performed by JMA to quantify the groundwater components of the total water balance for both the eastern strip mine section and the western pillar mine section. A numerical model was used in the calculation of groundwater influxes from both the aquifer and from the river. JMA also investigated the impact relating to backfilling and flooding of the mined-out pits with unconsolidated material with increased porosity.

**Study results**

The impact assessment results for the construction phase indicated that groundwater flow towards the boxcuts during the construction phase will be limited, due to the depth of operations and due to the relatively small area of construction. JMA rated the impact on groundwater quality during the construction phase as very low.

The operational phase impact assessment indicated that it was highly unlikely that lateral migration of contaminated water will occur from the operational pits as movement of groundwater will be towards the pits. The results further indicated that because the western perimeter of the western strip mine (Steenkoolspruit pits) is situated in close proximity to the Olifants River, the disturbance in piezometric distribution will deplete the groundwater baseflow of the river. This will result in a cone of depression and the groundwater gradient will be reversed so that flow will be induced from the river into the mine workings. The maximum extent of this cone of depression at Steenkoolspruit was estimated to be 400m from the pit perimeter. JMA also concluded that the only adjacent mine workings that will potentially interact with the Steenkoolspruit mine during the operational phase, is the Wolvekrans Opencast section to the north-east at an elevation higher than 1490 mamsl.

The post closure discharge elevation was determined to be 1510 mamsl and the time to reach this level was 100 years. The discharge rate was estimated to be approximately 5000 $m^3$/day. It should be noted that surface water make, influx of water from other mined sections and additional storage of water from other mine workings were not included in this calculation

3.1.4 Institute for Groundwater Studies (IGS) (2006)

Mine Water Balance and inter-mine Flow for Douglas Colliery.

**Study objective**

For this investigation, the IGS obtained all available data for Douglas Colliery and combined it into a model to calculate water balances and investigate the possibility of inter-mine flow, considering the planned dewatering and strip mining operations at the colliery at the time. Their water balance calculations made provision for two standards of rehabilitation, namely *"no rehabilitation at an average recharge rate of 20%"* and *"free draining at 12% recharge"*.

**Study results**

Results from the IGS investigation indicate that up to 47 $Mm^3$ water could be contained in the 2 Seam horizon at Douglas Colliery at the time. IGS projected that the dewatering of the Douglas Section will be a major exercise and that an average of 12 ML/d would have to be removed from the mine workings during 2010 – 2020, thereafter dewatering would have to continue until mine closure in 2035.

The overall estimation for Douglas Colliery was that water influx rates would increase from the then 5 ML/d to 22 ML/d on average during the opencast phase and that through immediate, free-draining rehabilitation, the maximum volume could be brought down to 13 ML/d.

It was also projected that, based on available information at the time, inter-mine flow between Douglas Colliery (Vandyksdrift Section) and Atcom Colliery (Glencore workings) would be negligible.

3.1.5 JMA (2011)

***VDDC Project Geohydrological Study.***

**Study objective**

JMA undertook a geohydrological investigation in 2011 for the Vandyksdrift Central project to determine the groundwater related impact associated with mining of the VDDC pits.

The plan was to re-mine the defunct underground mining sections by new opencast pits and to mine energy coal from the 5, 4, 2 and 1 coal seams. Pillar extraction was planned for the 2 seam.

The existing groundwater model was updated to simulate the loss of base flow towards the Olifants River and induced flow from the Olifants River towards the VDDC Pits. Storage in mined-out pits was not considered at the time.

Two important assumptions that were made in the study was that **the Steenkoolspruit pits was considered to be isolated from the other pits** and that the VDDC project will handle excess water make in isolation from other sections of the mine.

An important aspect to consider is that JMA found that the latest groundwater monitoring data indicated compartmentalisation within these underground workings.

**Study results**

The results indicate that prior to mining, base flow would be towards the Olifants River from the VDDC pits but that reversal in flow was expected after the first six to seven years of mining, albeit only for a section of the pits that was close enough to the river.

It was estimated that prior to mining the base flow towards the Olifants River would have been a maximum of 120 330 $m^3/a$ (329 $m^3/day$). In the final year of mining the total river seepage, which is a reversal in flow, for the entire VDD area would be 19 576 $m^3$/a (16% of original base flow towards the river).

In terms of dewatering of the underground workings, JMA calculated that 20 - 23 $Mm^3$ of water needs to be dewatered from the VDDC workings, excluding the slurry that has been stored in these workings. The Steenkoolspruit pit was a greenfields site at the time and did not require dewatering.

For the entire Vandyksdrift Section, which included the Vandyskdrift North workings, the total water make at 2039 was estimated to be 58 $Mm^3$ while the total dewatering volume was estimated to be approximately 30.6 $Mm^3$.

JMA recommended that the Steenkoolspruit Pit be considered to assist with storage of excess water from 2017.

### 3.1.6 AGES (2012)

***BHP Billiton Energy Coal South Africa (BECSA) – Middelburg Mines: Integrated Environmental Site Water Balance.***

**Study objectives**

As a result of the excess water make at Middelburg Mine, stochastic water balances were developed with the focus on connections between the various components on the mine sections within the entire Middelburg mining complex, as well as the identification of the major drivers in the water balances.

**Study results**

The analytical water balance showed that the rehabilitated areas and spoils are important drivers in the environmental site water balances and that if infiltration from these components can be reduced, the total water make of the mine would also reduce significantly.

AGES (now Exigo Sustainability) indicated that the Steenkoolspruit section was underlain by approximately 41 $km^2$ of underground workings. These underground workings were at the time part of the underground workings on the neighbouring mine property to the west, which belongs to Xstrata (now Glencore). The Glencore underground workings were estimated to cover an area of approximately 9 $km^2$. Exigo implied that inter-mine flow of groundwater occurred between the BECSA (now South32) and Glencore mine properties via the interconnected underground workings.

Using seepage from the area overlying the underground workings and adding seepage from dams, ramps and pits, it was estimated that at the time 3 701 $m^3$/day reported to the South32 underground workings.

It should be noted that the Steenkoolpruit opencast mining has been completed, with extraction of coal down to the No 2 seam.

### 3.1.7 DHI (2013)

***Middelburg Mines: Integrated Surface Water and Groundwater Management.***

**Study objective**

The objective of this study was to develop an understanding of the hydrology at the Middelburg Mine complex. Of particular interest was the spatial - temporal distribution of the water balance, with respect to recharge and evapotranspiration. The goal was to provide a reliable modelling tool to be used to evaluate short-listed engineering alternatives.

**Study results**

Total evaporation was calculated to be 86% of precipitation for the Steenkoolspruit section and 87% for the Vandyksdrift section. Total recharge for the Steenkoolspruit section was calculated to vary between 0.70 and 2.1 ML/day on an annual basis and for the Vandyksdrift section between 7.4 and 17.1 ML/day.

For the Steenkoolspruit section the total surplus water was calculated to be on average 0.70 ML/day. This is the amount of water discharging from groundwater to surface water in mined areas, as well as any water pumped from the mined areas. At the time no pumping or discharging of groundwater occurred from the Vandyksdrift section and it therefore had a zero surplus.

Based on a water balance along the river during the calibration period, the Olifants River network was estimated to be losing about 6.5 ML/day to the groundwater system in the South Complex area. The discharge was estimated to range between 5.9 and 7.8 ML/day. Most of this water was thought to be discharging to the underground workings.

### 3.1.8 Hodgson (2013)

***Update of the Mine-water Balance for Wolvekrans Colliery.***

**Study objective**

This study entailed an update of the existing mine water balance model for Wolvekrans Colliery to incorporate the latest design parameters. New mine plans, surface elevations, coal floor contours and underground mining extraction factors had to be considered in the update of the model.

**Study results**

At the time of the assessment it was expected that the Old Wolvekrans workings to the north east of the Steenkoolspruit section was flooded to a level of 1507 mamsl. The recharge was estimated at the time to be in the order of about 2.0 ML/day, which was believed to be lost either through discharge to the Kleinkopje workings or discharging towards the Olifants River. To prevent seepage towards the Olifants River, water levels in these workings was estimated to be kept below 1502 mamsl.

The results from this assessment also indicate that there was a high in the coal floor at an elevation of 1508 mamsl between the VDD North and Central areas. This was expected to hydraulically separate the two sections. As a result, the VDD North section can be dewatered without impacting on water in the VDDC area.

Another high in the coal floor was indicated to lie at 1502 mamsl to the north of the seals that have been installed underneath the Olifants River. The seals were intended to prevent subsidence of strata and to hydraulically isolate any mining to the north of the river (VDDC) from that in the south (VDD South). Water levels south of the river at the time were at 1501.7 mamsl and it was concluded at the time that mining at VDDC should be able to proceed without influence of water from the south.

It was recommended that the mined out Steenkoolspruit pit (2018) with an estimated capacity at the time of 15 $Mm^3$ be considered for the interim storage of water.

3.1.9 Groundwater Complete (2013)

***Geohydrological Impact Assessment as specialist input to the Environmental Management Programme for BHP Billiton Energy Coal South Africa (Pty) Ltd (BECSA)'s Vandyksdrift Central (VDDC) Project.***

**Study objectives**

Groundwater Complete undertook a desktop evaluation of all available geohydrological and geological data as part of the EIA and EMP for the now South32 VDDC project. A numerical flow and mass transport groundwater model was also constructed to simulate current aquifer conditions and impacts and to provide a tool for evaluation of different management options. The potential sources of groundwater pollution included in the model were the backfilled opencast pits, the water management infrastructure and discard dumps.

**Study results**

In general, this assessment summarised the findings from the previous investigations. Impacts related to the construction and operation of dewatering infrastructure including establishment of dewatering boreholes, a desalination plant, pipelines and a slurry processing facility were also assessed.

Initial findings from the assessment indicated that dewatering will influence the groundwater base-flow to the surface water streams to a very limited extent.

Another general, expected finding was that during the operational mining phase the opencast pits would act as groundwater sinks and groundwater will move radially inwards towards the pits. As a result, poor quality leachate generated by acid mine drainage will move towards the mine voids and will not drain towards the immediate surroundings.

In 2038 at closure, the highest TDS concentration was observed in the opencast pits and the impact in terms of quality from the proposed infrastructure was expected to be less than the proposed pits. The current pollution plume was found to have also moved away from the proposed discard areas and has reached the Olifants River and its tributaries.

The results at 100 years post closure indicated that the pollution concentrations at the majority of the sources started to decrease but the plumes also migrated further away from the potential sources and affected the Olifants River and its tributaries.

3.1.10 SRK Consulting (2013)

***Surface Water Impact Study for the BECSA Vandyksdrift Central Project.***

**Study objectives**

SRK's objective for this study was to quantify the impact from the VDDC project on the flow and salinity of the Olifants River due to the release of treated water. The assessment includes details of the water and mass balance of the water management network, containment of dirty runoff water and treatment of excess runoff, groundwater and pit water.

**Study results**

SRK estimated that discharge from the mine dewatering at the time was 60 ML/day, 20 ML/day during mine operations and at 10 ML/day after closure. The salinity concentration, in TDS, of the groundwater and pit dewatering was assumed to be 2 302 mg/ℓ during operation and 1 576 mg/ℓ at closure.

At the Vandyksdrift section surface water measurements indicated that the average TDS concentration in surface water runoff to be approximately 3 400 mg/ℓ.

Overall results indicated that treatment and discharge of the pit dewatering and underground sources would significantly improve the quality of water in the Olifants River. SRK also projected that the dilution of water in the Olifants River by treated water will be more effective in the winter, low flow months with dilution occurring between 60% and 82% of the time.

They concluded that without treatment of the discharge water, loads to the Olifants River could increase by as much as five-fold, which would result in it consistently exceeding the guideline value for the Witbank dam.

### 3.1.11 Groundwater Complete (2014)

***Geohydrological Study: Glencore and BECSA Steenkoolspruit Barrier Pillar.***

**Study objectives**

The objective of this study was to conduct a geohydrological investigation into the barrier pillar area between the Glencore pit and the South32 pit in the Steenkoolspruit section.

Short-term and long-term water management liabilities associated with selected options to continue mining the Steenkoolspruit pits were investigated.

Groundwater Complete had discussions with both Glencore and South32 and it was confirmed that the barrier pillar had in fact been compromised and that groundwater could flow freely between the two pits.

The water flow dynamics for these two pits, considering the barrier failure was modelled using a numerical groundwater flow and transport model. Stage curves were also generated to indicate time for the pits to fill under different scenarios.

**Study results**

Dewatering rates obtained from South32 and Glencore indicated the average dewatering rate for the Steenkoolspruit pit to be approximately 4 630 $m^3$/day at the time.

The model results for the cone of dewatering indicate that a maximum possible drawdown of approximately 60m can be expected in both Glencore and South32's pit. The maximum extent of the cone of depression was not expected to exceed 800m from the pit boundaries.

In terms of base flow to the Olifants River it was concluded that the Steenkoolspruit pit cause base flow reduction to the Olifants River in the order of 150 $m^3$/d for the South32 portion of the pit and 100 $m^3$/d for the Glencore portion.

At the time, the pits being operational, it was estimated that that the cone of depression causes flow from the river towards the pits in the order of 1 000 $m^3$/d to South32 and 800 - 900 $m^3$/d to the Glencore portion. After closure, it was expected that the flow would reverse again.

With the South32 pit and Glencore pit connected, simulation results indicated that discharge would occur on the western boundary of the South32 pit, approximately 66 years post closure and at an elevation of 1513 mamsl.

It was also estimated that at mine closure the South32 pit would contribute approximately 1020 $m^3$/day (68%) of the water make and the Glencore pit 480 $m^3$/day (32%).

One scenario considered the possibility that the proposed VP pit (see illustration below, from J&W 2016), may intersect the Glencore pit which could lead to the Steenkoolspruit section being connected to the underground workings, which would eventually be mined by opencast methods. For this scenario it was estimated that the entire connected void would fill to discharge elevation (1513 mamsl) in 49 years. The Glencore pit was then estimated to only contribute 6% of the total water in this scenario.

### 3.1.12 Jones & Wagener (2014)

***VDDC project: Mineral Residue Assessment Report***

**Study objective**

With the J&W (2014) investigation the objective was to determine the geochemical properties, including the likelihood to generate AMD, of various coal discard, coal rejects and slurries, and overburden generated and/or disposed of at VDDC.

**Study results**

Based on the Total Concentrations of the various coal waste samples it was noted that the coal discard, coal rejects and slurries contained elevated concentrations of antimony, arsenic, barium, cadmium and lead, while the overburden material contained elevated concentrations of antimony, cadmium, chromium, iron, lead and zinc. An important finding was that the overburden contained the highest total concentrations of cadmium, cobalt, chromium, copper, manganese, nickel, vanadium and zinc of all the residues tested.

It was further noted that the coal discard, coal rejects and slurries contain higher concentrations of total sulfur and sulfide sulfur than the overburden material and that the AMD tests conducted on the samples indicated that it is uncertain as to whether the overburden is likely to generate AMD, while the coal rejects and slurries were found to be potentially acid generating, which may result in AMD generation. The tests conducted could not confirm whether the coal discard on the LAC Dump would be AMD generating, but all the other residues, such as the PSS discard (north and south), the rejects from Discard Processing Plant and coal slurries were found to be potentially acid generating. It was proposed that the option be considered to store AMD generating residues below water level and as such that in-pit disposal should be considered as a management option.

The coal discard, slurries and overburden have been assessed as Type 3 wastes in terms of the National Norms and Standards of the NEM:WA.

Kinetic leach testing was proposed to be undertaken on overburden material. This was addressed by the J&W (2016) investigation - refer to section **5.1.2.**

### 3.1.13 Exigo (2015)

***South32 CSA – Wolvekrans Hydrochemical and Isotopic Tracing.***

**Study objective**

The main objective was to assess the source of water ingress on mining sections falling within Wolwekrans North and South Collieries through hydrochemical and isotopic tracing.

**Study results**

It was assumed that the east west striking Ogies Dyke divides the study area into a northern and southern compartment. Hydrochemical results analysed for groundwater sampling localities situated north and south of the dyke indicate a low correlation and it was assumed that this structure is relatively impermeable.

There also seem to be hydrogeological inter-connectedness between Vlaklaagte Void and Pit 4 facilities (Pit 4D and Pit 4C) respectively. Flooded mined-out sections of both Anglo American Coal and South32 operations are potentially one of the main contributors to water influx at Vlaklaagte Void and Pit 4C, with a preferential flow pathway created by defunct underground seams.

### 3.1.14 Summary of previous information relevant to the current study

From the previous investigations conducted at the old Douglas Colliery and in the greater VDDC study area, the following have direct relevance to the 2018 investigation and has been used in the numerical groundwater model calibration:

**On groundwater flow**

JMA (2004) at the time concluded that the only adjacent mine workings that will potentially interact with the Steenkoolspruit mine was the Wolvekrans Opencast section to the north-east (i.e. the pits to the north of VDDC) at an elevation higher than 1 490 mamsl.

The IGS (2006) projected that, based on available information at the time, inter-mine flow between Douglas Colliery (VDDC) and Atcom Colliery (Glencore workings) would be negligible.

In terms of dewatering of the underground workings, JMA (2011) calculated that 20 - 23 $Mm^3$ of water needs to be dewatered from the VDDC workings, excluding the slurry that has been stored in these workings. A dewatering strategy was subsequently developed.

Exigo implied that inter-mine flow of groundwater occurred between the South32 and Glencore mine properties via the interconnected underground workings. Exigo estimated that at the time 3 701 $m^3$/day reported to the South32 underground workings.

The results from the Hodgson (2013) assessment indicate that there was a high in the coal floor at an elevation of 1 508 mamsl between the VDD North and Central areas. This was expected to hydraulically separate the two sections. Another high in the coal floor was indicated to lie at 1 502 mamsl to the north of the seals that have been installed underneath the Olifants River. The seals were intended to prevent subsidence of strata and to hydraulically isolate any mining to the north of the river (VDD Central) from that in the south (VDD South).

**Groundwater Complete (2015) confirmed that the barrier pillar between the Glencore pit and the South32 pit in the Steenkoolspruit section had been compromised and that groundwater could flow freely between the two pits.**

**On hydrochemistry and geochemistry**

Hodgson, Grobbelaar, Cruywagen & de Necker (1999) for Douglas Colliery estimated a future sulfate generation rate of 50 tonnes/day. This was predicted to result in an average sulfate concentration of 1 800 mg/ℓ in the seepage water. In areas of low water through flow, the sulfate concentration was expected to rise to above 3 000 mg/ℓ.

Surface water measurements taken by SRK (2013) at VDDC indicated that the average TDS concentration in surface water runoff was approximately 3 400 mg/ℓ. They concluded that without treatment of the discharge water, loads to the Olifants River could increase by as much as five fold, which would result in it consistently exceeding the guideline value for the Witbank dam.

From the J&W (2014) geochemical assessment in terms of TC's it was noted that the coal discard, coal rejects and slurries contained elevated concentrations of antimony, arsenic, barium, cadmium and lead, while the overburden material contained elevated concentrations of antimony, cadmium, chromium, iron, lead and zinc.

It was further noted that the coal discard, coal rejects and slurries contain higher concentrations of total sulfur and sulfide sulfur than the overburden material and that the AMD tests conducted on the samples indicated that it is uncertain as to whether the overburden is likely to generate AMD, while the coal rejects and slurries were found to be potentially acid generating which may result in AMD generation.

## 3.2 Hydrocensus

J&W in 2016 had conducted a hydrogeological investigation for the Steenkoolspruit section that included the VDDC workings during which it was found that the Wolvekrans Colliery and more specifically VDDC has been extensively mined in the past. As a result, it was considered of utmost importance that the current baseline conditions on-site be well understood to accurately determine the potential future impacts.

A hydrocensus was therefore undertaken on the entire VDDC footprint to record the local and regional static groundwater levels (SWL's) on 01 and 06 August 2018. This information served as an important step in conceptualising the study area.

Being a brownfields area surrounded by mining complexes, no privately used boreholes were identified during the hydrocensus. In addition, due to access and logistical restrictions at the mine at the time, the hydrocensus did not yield sufficient data on the boreholes in the study area. As South32 already had a groundwater monitoring network in place, the existing borehole database for the VDDC and Steenkoolspruit areas was requested from South32 along with the groundwater qualities and associated water levels.

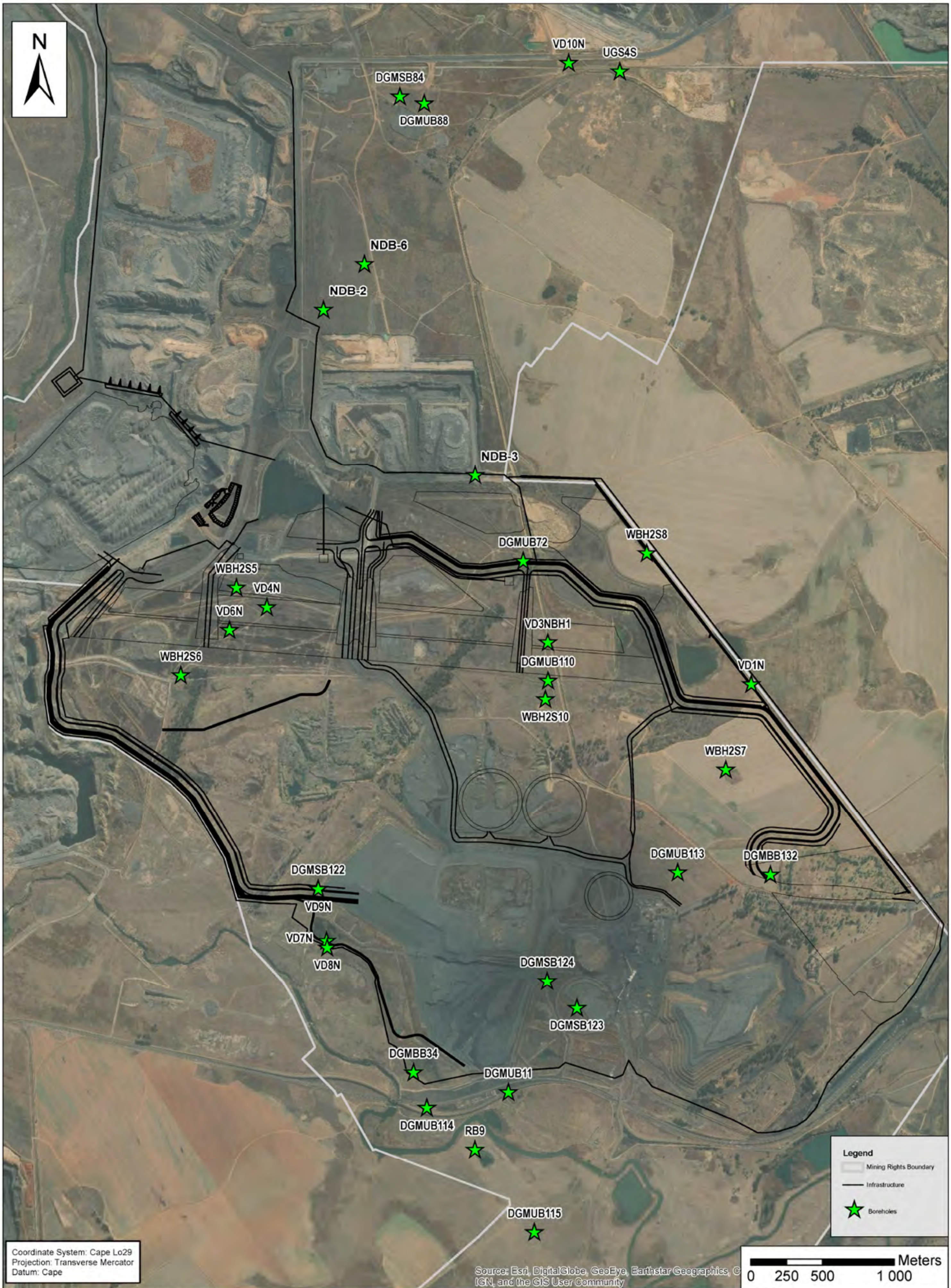
A total of 35 boreholes were identified and were used in the calibration of the numerical groundwater model. The results of the hydrocensus are presented in **Table 3.2.a** below, with the locations of the boreholes shown in **Figure 3.2.a**.

Electrical conductivity (EC) profiles were also performed on selected boreholes during the hydrocensus. This data was utilised as part of the hydrochemistry assessment to provide more background on the current extent of mining related contamination plumes (if any). The results of the hydrocensus and EC profiling are included in **Appendix A.**

**Table 3.2.a: Hydrocensus results**

| BOREHOLE | COORDINATES | | SWL | DEPTH AND SEAM INFORMATION | BOREHOLE ORIGIN INFORMATION |
|---|---|---|---|---|---|
| | X | Y | mbs | | |
| WBH2S4 | 28700.7 | -2883425 | No access | | Boreholes drilled into the underground workings, provides indication of current underground water levels |
| WBH2S5 | 27742.72 | -2883744 | 41.72 | 2 seam roof 52m<br>2 seam floor 55m | |
| WBH2S6 | 27354.51 | -2884360 | 44.11 | BH depth 65m<br>2 seam roof 61.5m<br>2 seam floor 65m | |
| WBH2S7 | 31163.55 | -2885017 | 66.54 | 2 seam roof 74m<br>2 seam floor 78m | |
| WBH2S8 | 30610.12 | -2883505 | 65.3 | 2 seam roof 64m<br>2 seam floor 65m | |
| WBH2S10 | 29902.32 | -2884526 | 50.38 | Slurry from 50m<br>2 seam roof 64m<br>2 seam floor 66m | |
| UB11 | 29644.26 | -2887275 | 15.79 | | |
| UB72 | 29747.76 | -2883560 | 37.59 | BH depth 44m | |
| UB88 | 29054.41 | -2880359 | 21.94 | | |
| UB110 | 29920.96 | -2884397 | 51.68 | | |
| UB113 | 30826.66 | -2885738 | 54.04 | | |
| UB114 | 29073.81 | -2887383 | 17.27 | | |
| UB115 | 29825.42 | -2888254 | 26.1 | | |
| SB84 | 28884.37 | -2880310 | 15.6 | | Boreholes drilled into shallow weathered zone aquifer during Sep 1997 – Feb 1998 and Nov-Dec 2003 |
| SB122 | 28313.52 | -2885852 | 6.66 | BH depth 19m | |
| SB123 | 30122.55 | -2886686 | 11.97 | BH depth 16m | |
| SB124 | 29914.47 | -2886498 | 1.63 | Also known as BB71 | |
| RB9 | 29409.94 | -2887675 | 3.52 | | Unknown |
| UGS4S | 30422.49 | -2880135 | 16.37 | | |
| VD1N | 31341 | -2884422 | 11.62 | | |
| VD2N | 32136 | -2884860 | No access | | |
| VD3N (BH1) | 29920 | -2884130 | 43.63 | Slurry in BH | |
| VD4N | 27955 | -2883881 | 42.23 | Alt name Boorgat 1 | |
| VD5N | 27842 | -2883965 | Damaged | | |
| VD6N | 27694 | -2884040 | 42.57 | Alt name Boorgat 3 | |
| VD7N | 28372 | -2886215 | 9.57 | | |
| VD8N | 28377 | -2886262 | 15.56 | | |
| VD9N | 28315 | -2885854 | 6.66 | BH depth 19m | |

| BOREHOLE | COORDINATES | | SWL | DEPTH AND SEAM INFORMATION | BOREHOLE ORIGIN INFORMATION |
|---|---|---|---|---|---|
| | X | Y | mbs | | |
| VD10N | 30066 | -2880076 | 67.40 | Datalogger installed | |
| P1 | 29101 | -2887131 | 7.01 | BH depth 10m | |
| P2 | 29054 | -2887080 | 1.65 | BH depth 12m | |
| P3 | 29004 | -2887032 | 1.52 | BH depth 10m | |
| P4 | 28943 | -2886975 | 1.54 | BH depth 12m | |

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VDDC Project
Borehole Locality Map

Job No: G535-04

Figure 3.2.a

# 4. SITE CONCEPTUALISATION

## 4.1 Geological Setting

### 4.1.1 Regional Geology

The VDDC is situated in the Great Karoo Basin in South Africa, consisting of the Karoo Supergroup. Geologically, the Karoo Supergroup is the largest stratigraphic unit in Southern Africa covering almost two thirds of the land surface. The basin hosts all the South African coal deposits and was formed in the great Gondwana basin which comprised parts of Southern Africa, India, Antarctica, Australia and South America.

The Karoo Supergroup comprises a sedimentary succession of sandstones, siltstones, shales and coal stratigraphic units. These stratigraphic units (from oldest to youngest) consist of the following:

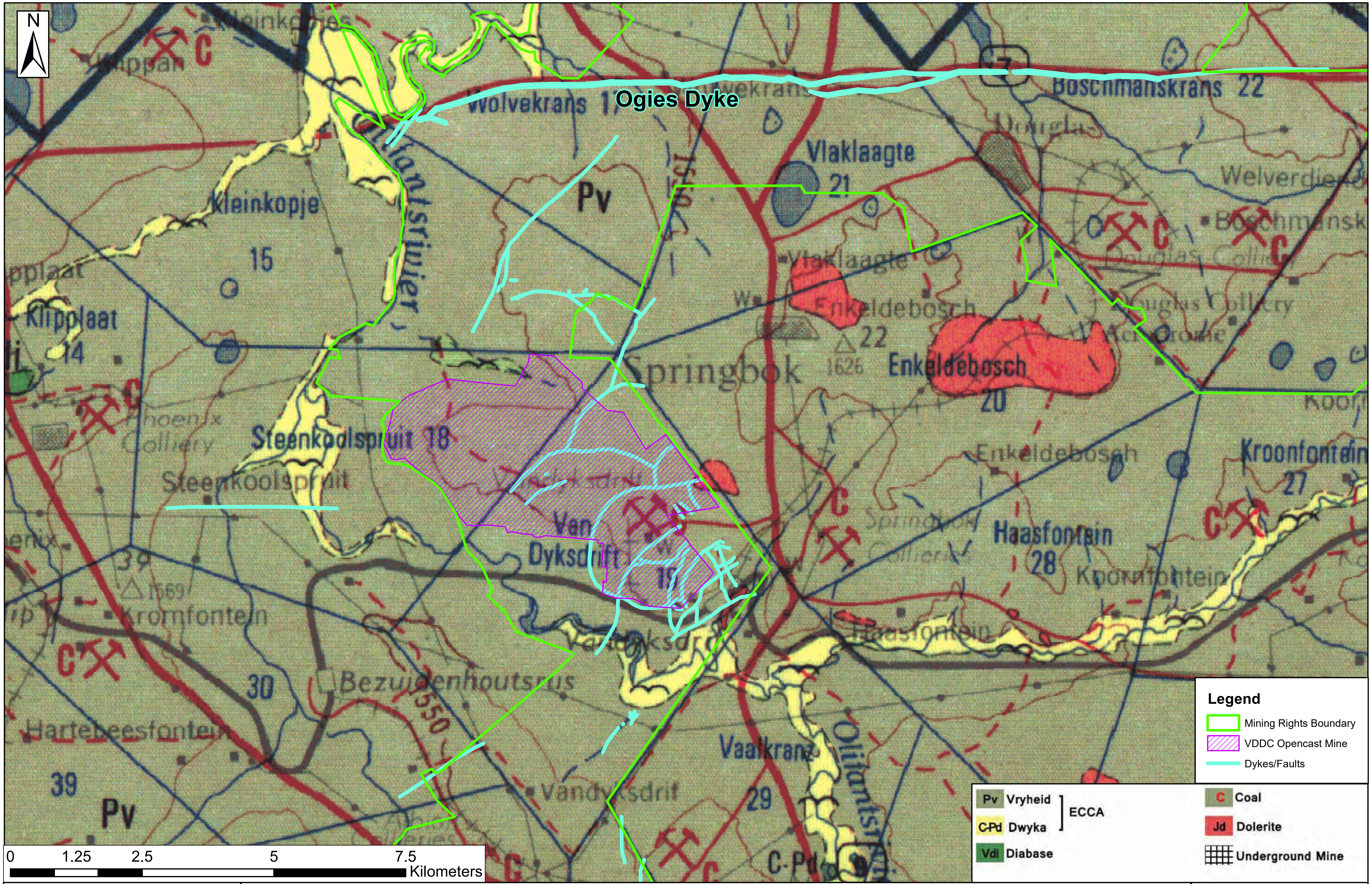
- Dwyka Group – glacial marine deposit (comprising of diamictites and tillites) in the Carboniferous period;
- Ecca Group – fluvial deposition in the Permian period;
- Beaufort Group (terrestrial); and
- Stormberg Group (including basalts).

The first depositional sequence above the pre-Karoo formations comprises a sequence of diamictites, conglomerates and surface sandstones deposited by glacial and glacio-fluvial processes in glacial valleys (Dwyka Group). With the retreat of the ice sheets, lakes formed in the glacial valleys, which in time were transformed into swamps. This resulted in the formation of the lower coal seams. As a result of further shallowing of the valley slopes due to sedimentation within the channels, they began meandering and deltaic deposits were formed in shallow lakes on the flood plains.

The majority of the coal deposits in South Africa are contained in the Vryheid Formation (part of the Ecca Group) of the main basin and are restricted to the north eastern area of terrestrial deposition on a gently subsiding shelf platform. The strata, mostly shale, sandstone and coal seams, formed in fluvial environments.

The strata between the coal seams become finer upward in fluvial sequences, whereas delta and lacustrine sequences coarsen upward. As a general rule, grain size is coarser in shallow water “high energy” environments where waves or currents are present. Waves and currents transport finer sediments offshore into “low energy” environments, generally in deep, quiet water. Fine grain size indicates deposition in a “low energy”, quiet environment.

A 1:250 000 regional geological map, indicating the location of the study area is shown in **Figure 4.1.1.a** below.

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South32
VDDC Project
Regional Geology

Job No: G535-04

**Figure 4.1.1.a**

### 4.1.2 Local Geology

Locally, the study area falls within the Witbank Coalfield, which consists of sedimentary rocks of the coal-bearing Vryheid Formation (denoted by Pv on **Figure 4.1.1.a** of the Ecca Group. The Karoo sediments are underlain by diamictites and tillites of the Dwyka formation (denoted by C-Pd on **Figure 4.1.1.a**) that form the basement of the Karoo Supergroup. Dolerite intrusions (denoted by Jd on **Figure 4.1.1.a**) are common throughout the Karoo formation, the most significant in the study area being the Ogies Dyke which is a near vertical, west-east striking dyke situated to the north of the study area. Based on literature, this dyke is approximately 15 m thick (Digby Wells, 1994). Coal on either side of the dyke has been devolatilised. From historical studies, it is unclear if the Ogies Dyke acts as a hydraulic barrier that prevents the flow of groundwater between the compartments to the south and north of the dyke.

There are five coal seams which underlie the weathered Karoo rocks in the study area, namely the No.1 to No.5 coal seams. The No.2 coal seam is the most prominent of the five coal seams and has widely been mined using bord-and-pillar methods. The interburden between the coal seams consist mainly of sandstones and mudstones with carbonaceous shale being present closer to the coal seams. The No.1 seam is also well developed in the study area. It is understood that the No.2 seam will continue to be mined via opencast mining operations.

The No.5 coal seam has largely been removed by weathering and is mostly present in the topographically higher eastern sections of the mining area. The No.4 seam is split into different upper and lower bands of which only the No.4 L is of economic importance. The No.3 seam, although of high quality, is thin and very irregular.

As previously indicated, numerous investigations have been undertaken in the study area. Based on the results obtained during these investigations, the general lithology of the study area has been summarised in **Table 4.1.2.a**.

**Table 4.1.2.a: General site lithology (JMA, 2004)**

| Lithology | Average depth (mbs) |
|---|---|
| Depth to bottom of soft overburden (m) | 8.5 |
| Depth to bottom of weathered material | 16 |
| Depth to top of No. 5 coal seam | 19 |
| Depth to top of No. 4 coal seam | 27 |
| Depth to top of No. 3 coal seam | 39 |
| Depth to top of No. 2 coal seam | 53 |
| Depth to top of No. 1 coal seam | 62 |
| Depth to Pre-Karoo basement | 72 |

The average weathering depth, as determined from historical borehole logs, across the study area is approximately 16 mbs. The weathering profile for the study area can be summarised as follows:

- Highly weathered (0 – 8.5 mbs);
- Weathered (8.5 – 16 mbs);
- Slightly weathered (18 – 30 mbs).

A generalised geological cross section of the site is presented in **Figure 4.1.2.a** (west – east profile). The original cross section was drawn by JMA (2004) but J&W updated it with the latest topographical survey data.

From the cross section, it is observed that the topography is dipping at an average of 1.5% from a topographical high of between 1 570 – 1 590 mamsl in the east towards the Olifants River in the west at an elevation of 1 505 mamsl.

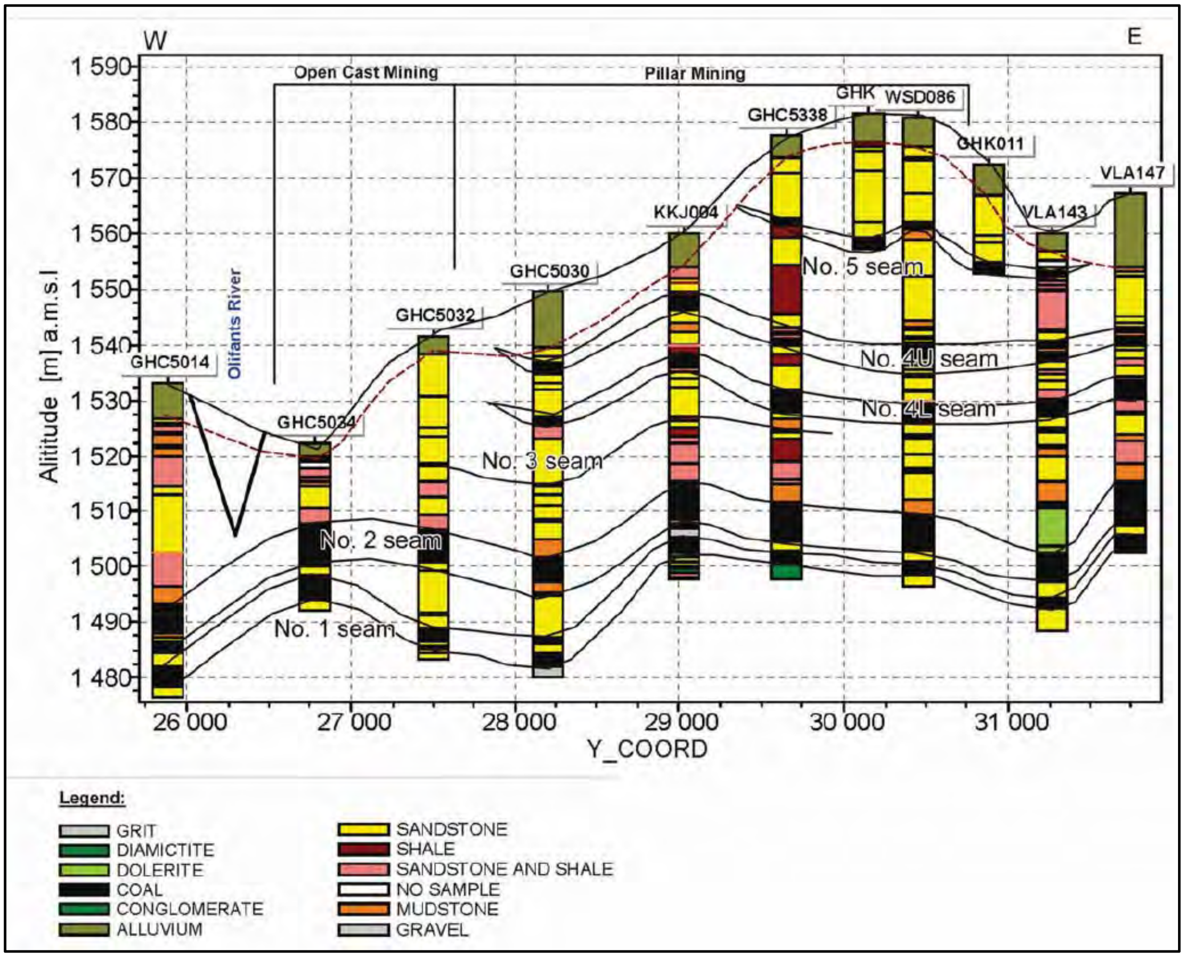



**Figure 4.1.2.a: Geological cross section (west – east) across the study area.**

## 4.2 Hydrogeological Setting

### 4.2.1 Aquifer Type

Based on a review of the previous investigations undertaken in the study area it is evident that three aquifers typically underlie the project are. These are:

- A shallow perched aquifer in the lower lying areas or depressions where a low, permeable, clayey ferricrete layer is overlain by alluvium and transported hillwash material. Wetlands commonly occur in these areas.
- A weathered aquifer, which extends to depths of approximately 20 mbs, depending on the depth of weathering. In the study area, this aquifer is expected to be clay-rich, with comparatively low aquifer parameters. This aquifer is therefore not considered to be a major aquifer, although it does play a role in recharge to the deeper hard-rock aquifer; and
- A deeper fractured rock aquifer, which is characterised by fractures, faults and contact zones with dolerite intrusions in the Karoo sediments. This aquifer underlies the weathered aquifer and extends down to the bottom of the No.2 coal seam.

A summary of the estimated aquifer thickness, based on the existing borehole database, is presented in **Table 4.2.1.a** below.

**Table 4.2.1.a: Estimated aquifer thickness (updated from JMA, 2006)**

| Aquifer | Depth (mbs) | Geology |
|---|---|---|
| Perched | 0 – 8.5 | Sands including Alluvium & transported hillwash underlain by clay / ferricrete |
| Weathered | 8.5 – 16 | Weathered sandstone and siltstone underlain by carbonaceous shale and coal seams |
| Fractured | 16-72 | Slightly weathered to unweathered shale, sandstone and siltstone with coal seams underlain by basement rock |

### 4.2.2 Aquifer Parameters

The calculated mean aquifer parameters for the boreholes tested during historic J&W investigations are presented in **Table 4.2.2.a**.

It is evident from **Table 4.2.2.a** that transmissivity values of less than 1.0 $m^2$/day were obtained from both the weathered and fractured aquifers, which is typically what one would expect from the Karoo rocks where the aquifers are typically double porosity aquifers. Within these aquifers, the groundwater can either be found in fractures or it can exist as inter-granular groundwater.

The average hydraulic conductivity is in the order of 0.030 to 0.0070 m/day. Since T = Kb, where b is aquifer thickness, it is understandable that the hydraulic conductivity is generally an order of magnitude less than the transmissivity.

**Table 4.2.2.a: Mean Aquifer Parameters (J&W, 2016)**

| Estimated Mean Parameter | Transmissivity (T) | Hydraulic Conductivity (K) | Storativity |
|---|---|---|---|
| | ($m^2$/day) | (m/day) | - |
| **Weathered Aquifer** | | | |
| Geometric Mean (2015) | 1.0 | 0.080 | N/A |
| Harmonic Mean (2015) | 0.65 | 0.050 | N/A |
| **Calculated J&W Mean** | **0.83** | **0.070** | N/A |
| JMA Slug Tests (2011) | - | 0.040 | - |
| **Fractured Aquifer** | | | |
| Geometric Mean (2015) | 1.1 | 0.030 | N/A |
| Harmonic Mean (2015) | 0.73 | 0.020 | N/A |
| **Calculated Mean** | **0.92** | **0.030** | N/A |
| JMA Slug Tests (2011) | **-** | 0.0040 | - |

## 4.3 Groundwater Recharge Calculations

Groundwater recharge can be defined as the process by which water is added from outside to the zone of saturation of an aquifer, either directly into a formation, or indirectly by way of another formation. According to literature, the recharge in Karoo aquifers is generally in the range of between 2.0 – 5.0 % of the mean annual precipitation (Vegter, 1995). The groundwater recharge for the study area was also determined using the chloride method (Bredenkamp *et al.,* 1995) and is expressed as a percentage of the Mean Annual Precipitation (MAP). The method is based on the following equation:

$$R = \frac{Chloride\ concentraion\ in\ rainfall\ (mg/\ell)}{Chloride\ concentration\ in\ groundwater\ (mg/\ell)}\ x\ 100$$

As discussed in **Section 2.3.2**, the MAP in the study area is 705 mm/annum. The chloride concentration in the rain water on site is unknown. In the absence of available rainfall chloride values, the method to calculate the rainfall from MAP using the "RECHARGE" spreadsheet (developed by Van Tonder and Xu, 2000) was used. The formula for "inland" areas is as follows:

INLAND: (0.000002 * $MAP^2$) + (0.0003 * MAP) + 0.2207.

The average chloride concentration in rainfall for the study area is therefore approximately 1.43 mg/ℓ. Using a chloride concentration of 6.9 mg/ℓ in the groundwater on site (obtained from the groundwater samples analysed as part of the J&W 2016 study), the groundwater recharge in the study area is estimated to be 3.5 % of the MAP, which is equal to 25 mm/annum.

## 4.4 Groundwater Levels

The first important aspect when evaluating the hydrogeological regime and groundwater flow mechanisms is the groundwater gradients. Groundwater gradients, taking into consideration fluid pressure, are used to determine the hydraulic head which is the driving force behind groundwater flow.

An interpolation technique, using the available data, was used to simulate water levels over the entire model area. The interpolation technique used is referred to as Bayesian interpolation where water levels are correlated with the surface topography. The average depth to groundwater level for the study area was calculated to be 8.4 mbs when the boreholes drilled into the underground workings are not considered. When the underground workings boreholes are included the average depth increases to 25.8 mbs.

Typically, a linear relationship exists between the depth to groundwater and the topography, due to the fact that groundwater normally drains under gravity towards streams and rivers. The boreholes in the study area were evaluated either to prove or disprove if this concept is valid within this study area. All available static water levels (SWL) were plotted against topography as shown in **Figure 4.4.a**. The results indicate a correlation of 93% between the topography and groundwater levels but the correlation is expected to improve to >95% if all the boreholes that were drilled into the underground workings are excluded. However, information on all of the old boreholes could not be obtained to confirm if they intersect the workings and as such only the known underground workings boreholes are excluded from the graph. Another reason for the relatively low correlation is as a result of active dewatering occurring from the underground workings.

As groundwater levels follow topography it can be assumed that groundwater flow takes place under unconfined to semi-confined conditions. It is shown in **Figure 4.4.b** that locally, and in general, groundwater flows from east to west towards the topographically low Olifants River at 1 505 mamsl.

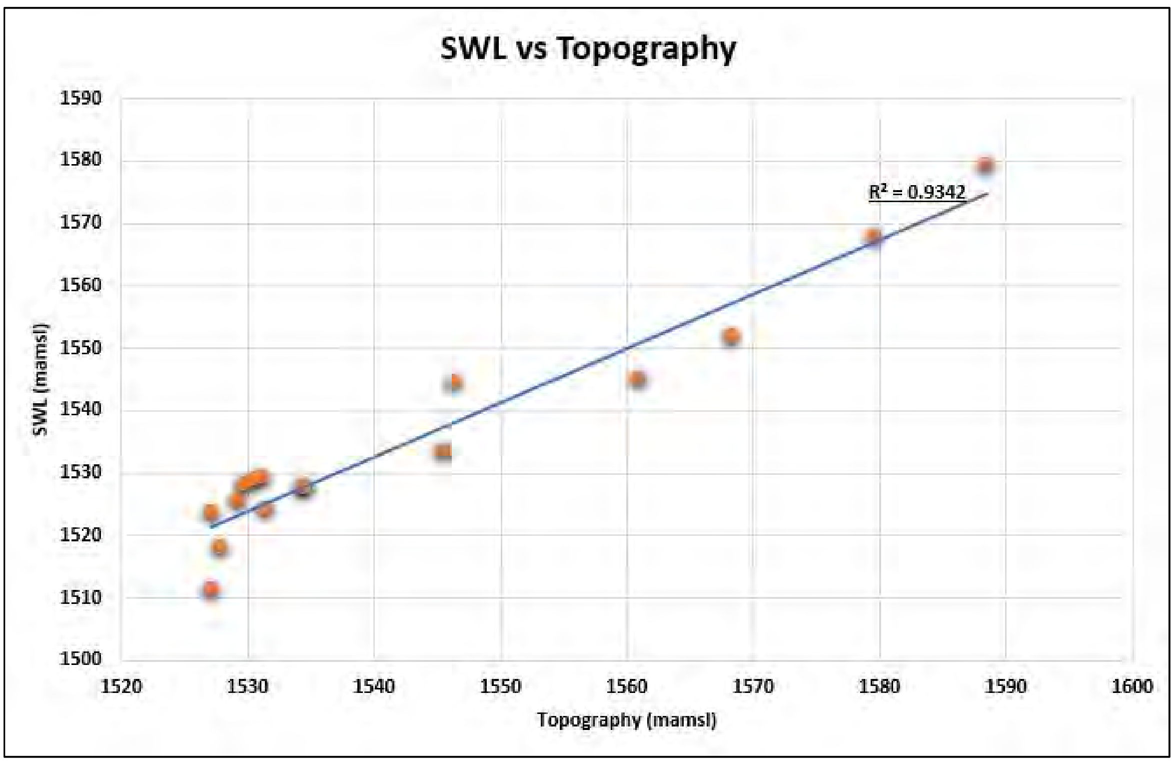
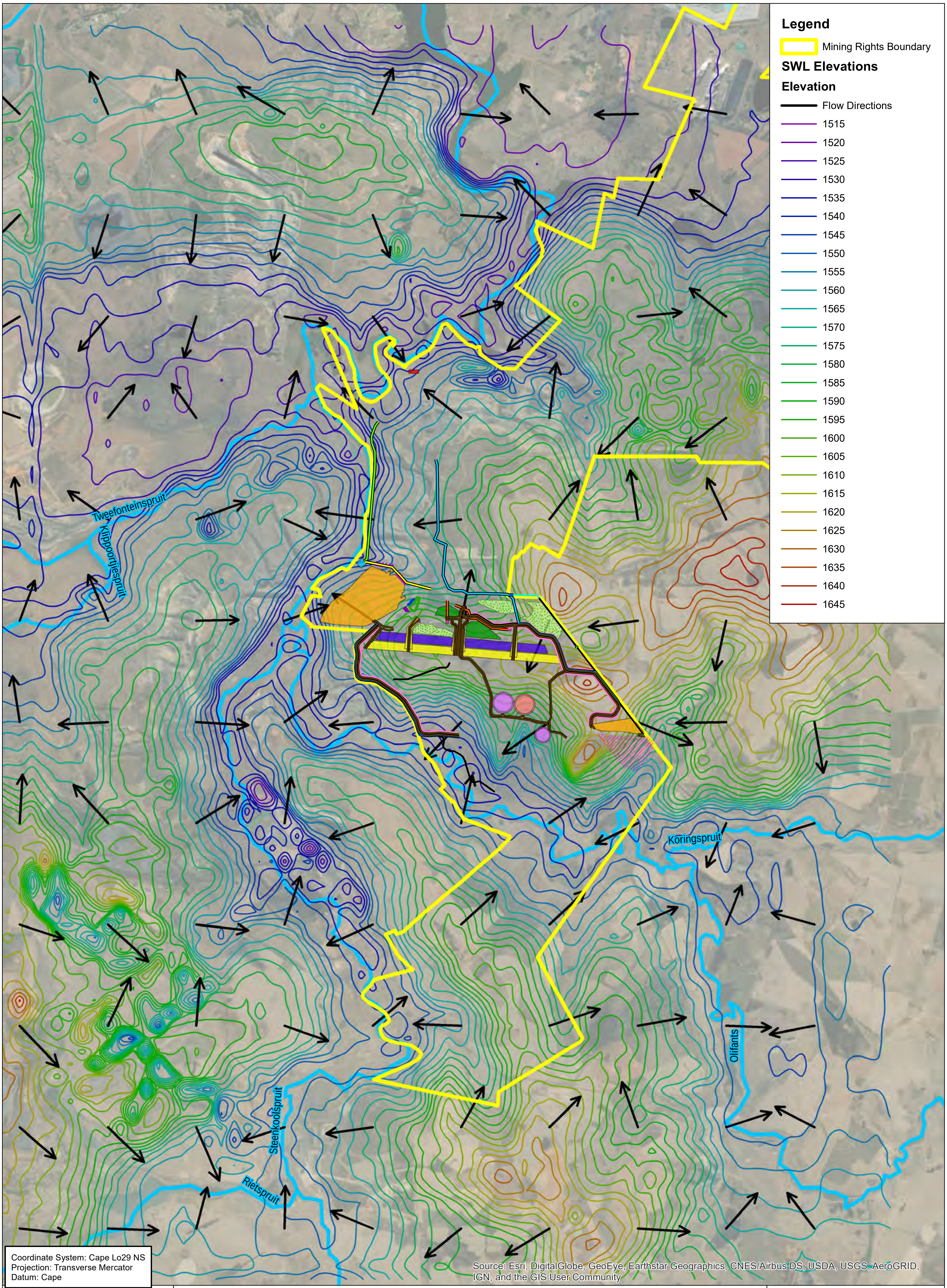



**Figure 4.4.a: Groundwater vs surface topography correlation**

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Vandyksdrift Central
Interpolated Groundwater Table within the Karoo Aquifer

Job No: G535-300

Figure 4.4.b

# 5. SITE GEOCHEMISTRY AND HYDROCHEMISTRY

### 5.1.1 Jones & Wagener (2014)

The objectives of the J&W (2014) VDDC geochemical assessment were to:

- Determine the pollution potential of the residue materials;
- Assess the likelihood of the residue materials generating Acid Mine Drainage (AMD);
- Assess the residues in terms of the Department of Environmental Affairs (DEA's) "National Norms and Standards for the Assessment of Waste for Landfill Disposal" (DEA, 2013).

Samples of the coal discard, coal rejects, slurry and overburden material were collected and sent for leach and static tests including XRD, XRF, NAG, sulfur speciation and ABA.

**Study results**

The major minerals in the coal rejects and coal slurry samples were graphite and kaolinite whereas the overburden sample did not contain any detectable concentrations of graphite. All the samples contained varying percentages of pyrite (FeS), which could result in the generation of Acid Mine Drainage (AMD).

Based on the TCs of the various coal waste samples it was noted that the coal discard, coal rejects and slurries generally contained elevated concentrations of antimony, arsenic, barium, cadmium and lead, while the overburden material contained elevated concentrations of antimony, cadmium, chromium, iron, lead and zinc. The overburden contained the highest total concentrations of cadmium, cobalt, chromium, copper, manganese, nickel, vanadium and zinc of all the residues tested.

The paste pH of most of the coal discard, slurry and overburden samples was acidic with the potential to generate acidic seepage or runoff. The slurry from the discharge into the slimes dam had acidic paste pH and the potential to generate acidic seepage and runoff in the short term.

The coal discard, slurries and overburden have been assessed as Type 3 wastes in terms of the National Norms and Standards of the NEM:WA.

It was noted that the overburden acid base accounting assessment was based on only one composite sample of unknown rock type and may therefore not have been representative of the overburden as a whole. Kinetic testing of representative samples of the overburden was suggested to evaluate its AMD potential. This was addressed by the J&W (2016) investigation (**Section 5.1.2**).

### 5.1.2 Jones & Wagener (2016)

A detailed and comprehensive geochemistry assessment was conducted by J&W as part of the 2016 investigation. It is accepted that the results from the 2016 investigation, as well as from the investigations conducted by Pulles, Howard & de Lange Incorporated (2004) and Hodgson, Grobbelaar, Cruywagen & de Necker (2009) are adequate to fulfil the objectives for the 2018 hydrogeological assessment as well.

The primary objectives of the 2016 geochemistry assessment were as follows:

- To determine the geochemical nature of the material in the backfilled pit;
- To determine the long-term net acid generation potential;

- To identify metals that may be present in drainage from the pit; and
- Perform geochemical modelling in order to predict future discharge water qualities from the pit.

The coal seams, as well as some of the sedimentary host rocks are known to generate acid-mine drainage when exposed through mining. The largest part of the Steenkoolspruit pit is already backfilled with waste rock but some final mining is still taking place and planned on the eastern side of the pit. The Steenkoolspruit pit is also considered for storage of water pumped from underground from nearby opencast mining of old underground pillars at VDDC. In this report the potential and degree of acid-mine drainage that may occur at the Steenkoolspruit Pit was addressed.

The leach test results as well as the geochemical model from the 2016 investigation are considered relevant to this study also especially since these tests were also performed with water sampled from the underground workings at VDDC. These results will be used during the impact assessment to determine source terms for the numerical groundwater flow and transport model once the infrastructure and mine sequence plans are finalised.

**Study results**

- Bi-carbonate is the dominant anion in the infiltrating groundwater into the backfilled pit. Sulfate, however, quickly becomes the dominant anion in interstitial water in the backfill due to sulfide oxidation. Sulfate will be the major indicator of any mine drainage related impact at the Steenkoolspruit Pit. Sulfate is fairly mobile and the first indicator of sulfide oxidation. Alkalinity is still present in the underground mine water, although sulfate is the dominant anion. Alkalinity will also be present in the pit water while it is still near neutral;
- No pumping from underground: Through the modelling it was estimated that if the backfilled Steenkoolspruit pit floods to discharge elevation of 1 505 mamsl, pit water will have a sulfate concentration of up to ±3 500 mg/ℓ (Model A Scenario 1) decreasing to about 3 000 mg/ℓ over the long-term (50 - 200 years). If the backfilled pit floods to the pump elevation of 1 502 mamsl, pit water will have a sulfate of up to ±3 550 mg/ℓ (Model A Scenario 2) decreasing to about 3 000 mg/ℓ over the long-term (75 - 200 years). The 3 meters additional unsaturated zone (1 505 vs 1 502 mamsl) does not result in a significant difference in the pit water quality.
- Pumping from underground: If water is pumped from the underground to the pit and the pit floods to discharge elevation of 1 505 mamsl, the pit water will have an initial sulfate concentration of up to ±4 300 mg/ℓ (Model B Scenario 1) over the short term (0 - 25 years); this will decrease to 3 500 mg/ℓ over the medium term (25 - 50 year) and to 3 000 mg/ℓ over the long-term (50 - 200 year). If the pit floods to 1 502 mamsl, the pit water will have an initial sulfate concentration of up to ±4 500 mg/ℓ (Model B Scenario 2) over the short term (0 - 25 years); this will decrease to 3 500 mg/ℓ over the medium term (25 - 75 year) and to 3 000 mg/ℓ over the long-term (75 - 200 year). Once again, the 3 meters additional unsaturated zone (1 505 vs 1 502 mamsl) does not result in a significant difference in the pit water quality and also the pumping of water from the underground to the pit only results in a short term increase in the sulfate concentrations within the pit;
- Initially, magnesium and calcium are the dominant cations in the neutral pit mine water due to the neutralization reactions of carbonate minerals (i.e. calcite and dolomite). It is important to note that Mg is the dominant cation present in the pumped underground mine water which was classified as a Mg-$SO_4$ water. The still neutral underground mine water was also in equilibrium with calcite and dolomite. The pit water will also be initially in equilibrium with calcite and dolomite. Because of the dominance of Mg with respect to calcium, gypsum may be slightly

undersaturated with the result that sulfate reaches the relatively high concentrations (3 000 - 4 000 mg/ℓ) in the pit water discussed above.

- Where carbonate minerals become depleted (e.g. at the top of the unsaturated zone) acidification will take place. Aluminium, iron and manganese will become the major cations in acidic to slightly acidic seepage from the backfill as not enough basic cations are present. There will be parts of the backfill (hot-spots) in the oxic zone that will acidify (e.g. highly carbonaceous material). This will occur first at the top of the (oxic) unsaturated zone where acidification takes place. In the hot-spot material the pH range was given as pH 3 - 5.
- In *neutral pit water* aluminium and iron will mostly be present at concentrations of below 2 mg/ℓ. Manganese may reach higher concentrations because there is some siderite in the rock that contain manganese in trace amounts and manganese may be persistently present at even neutral conditions;
- After acidification, seepage will have aluminium, iron and manganese concentrations that may reach concentration above 10 mg/ℓ and even up to 500 mg/ℓ. This is typical concentrations also measured in acid mine drainage at other mine sites. The reason that these concentrations are so high under acidic conditions is because not enough basic cations (like calcium and magnesium) are present. Over the long-term aluminium will become dominant as it is released from the silicate mineralogy;
- In acidic drainage, pH 3 - 5; the concentration of trace metals like cobalt and nickel will also become elevated (0.1 - 2 mg/ℓ);
- Metal concentrations under acidic conditions can, however, be expected to be very erratic and will change significantly between each monitoring run;
  - During the first stage, pyrite oxidation takes place but enough carbonate minerals are available to neutralise the acid generated. This results in gypsum precipitation as enough calcium is available. Gypsum will precipitate in favour of Al-Fe-sulfates. Metals are generally not elevated during this phase as the pH remain near neutral. The sulfate is generally below 2 500 mg/ℓ because of the gypsum precipitation if enough calcium is available. However, higher sulfate concentrations may be reached if other cations dominate calcium.
  - During the second stage, pyrite oxidation takes place but carbonate minerals have become depleted. Gypsum does not precipitate anymore as no calcium is generated (from carbonates anymore) and gypsum rather starts to dissolve contributing to the sulfate in solution. Acidic conditions are reached and the sulfate reaches a maximum concentration well above 2 500 mg/ℓ. Aluminium and iron become major cations and Al-Fe-sulfates starts to precipitate;
  - During the third stage, pyrite is depleted in the upper oxidation zone but may still be present deeper in the rock pile. Gypsum is also depleted and sulfate concentrations decreases. Metal concentrations also starts to decrease resulting in a change in the secondary Al-Fe-sulfates. Conditions remain acidic as silicate minerals are usually not able to neutralise the long-term acidity.
  - It is important to notice that all three stages may eventually be present at a mine as different parts of the dump/mine are subjected to different degrees of oxidation. The upper oxic zone of a dump will reach Stage 3 quicker while deeper saturated parts will remain as stage 1 or AMD generation may stop altogether;
- In the backfilled pit AMD Stage 1 will be present for the first 10 - 25 years after closure. Thereafter Stage 2 (acidification) will commence in certain parts of the backfill situated in the oxic part of the unsaturated zone. The maximum sulfate

concentration will be reached about 50 - 75 years after closure where after the sulfate may slightly decrease.

#### 5.1.3 Golder Associates (2018) – Draft Report

A detailed and comprehensive geochemistry assessment was conducted by Golder Associates in early 2018 for the entire Wolvekans Colliery and is currently in draft form. The results of this study were incorporated into this study along with the previous studies discussed above and are adequate to fulfil the objectives for the 2018 hydrogeological assessment with regards to the geochemical component.

**Study results of relevance to VDDC**

***Characteristics of Spoils, Coarse Discard, Slurry and Coal***

- Mineralogy results indicated that pyrite and carbonates were heterogeneously distributed in spoils, coal slurry and discard materials, and Siderite was the most ubiquitous carbonate in spoils and calcite was widespread in the coal materials.
- The sulfide content of was generally low (<0.3%) for spoils, variable for slurry (0.07-0.71%) and high for coarse discard (0.32-3.0%) and coal (0.20-4.8%).
- Acid generation potential of spoils was variable: the spoils are expected to produce near-neutral to saline acid rock drainage in the short term, and metalliferous acid rock drainage in the long term as confirmed by kinetic tests, which indicated that the neutralisation potential will be depleted before sulfides.
- The discard materials are likely to produce near-neutral drainage with low metal content in the short term to acid rock drainage with low to high metal content in the long term as confirmed by both static and kinetic tests.
- The slurry had uncertain to acid generating potential and the drainage is likely to be near-neutral to acid rock drainage with low metal content in the short and long term.
- The coal had low to acid generating potential and the drainage is expected to be near-neutral mine drainage with low metals in the short term.
- Discard from PSS dump and LAC dump and slurry materials from PSS dump are assessed as Type 3 waste.
- Coal samples collected from Steenkoolspruit pit and spoils from SKS main pit are not Type 4 wastes as at least one parameter exceed TCT0, but it does not meet the definition of Type 3 waste due to low risk from leachate.
- Discard is classified as hazardous, while spoils, slurry and coal were classified as non-hazardous in terms of SANS10234.
- The main environmental risks from spoils materials and pit water are saline to acid rock drainage with elevated levels of TDS, EC, sulfate, fluoride, calcium, magnesium, sodium, aluminium, iron, manganese and cobalt.
- The main environmental risk from discard and slurry materials in acid rock drainage with elevated levels of TDS, EC, sulfate, calcium, manganese, aluminium, iron, copper, cobalt and selenium.

***Risk Profile of Pits and Residue Facilities***

- The following relevant sections were modelled as having pits with moderate to high ARD risk:

a. Wolvekrans – some of the pits in this section have acidic outflow;

b. Vandyksdrift;

c. Steenkoolspruit, although circum-neutral seepage with high TDS has been modelled from spoils kinetics.

- The following sections have been modelled as having pits with low to moderate ARD risk:

  a. Boschmanskrans (except for areas of in-pit coarse discard disposal) – circum-neutral seepage with high TDS has been modelled from spoils kinetics;

  b. Vlaklaagte.

- The acid rock drainage from pits exceeded DWAF water quality guidelines and the DWS 2016 Water Quality Planning Limits (WQPL) for pH, TDS, EC, sulfate, fluoride, aluminium, calcium, cobalt, copper, iron, magnesium, manganese, nickel and zinc, while the saline drainage from pits exceeded guidelines and WQPL for TDS, EC, sulfate, fluoride, nitrate, boron, cadmium, cobalt, magnesium, manganese, molybdenum, sodium and SAR.

- Coarse discard has acid rock drainage risk:

  a. LAC Discard Dump: kinetic modelling predicted acidic drainage in the short-term (pH 4-5) and long-term (pH 5-6), with extremely high sulfate levels in the short-term (5 000 – 10 000 mg/ℓ) dropping to high levels in the long-term (2 000 – 2 500 mg/ℓ); and

  b. Wolvekrans Discard Dump west of the Olifants river: the stream draining this dump is acidic (pH 3-4) and has high sulfate levels (2 000 – 3 000 mg/ℓ), despite the dump being rehabilitated and revegetated.

- Slurry has a moderate acid rock drainage risk.

***Impacted water resources***

- Mine-affected surface water is mainly associated with mine residue storage facilities;

- Mine affected groundwater is mainly associated with rehabilitated areas of inactive pits and mine water storage facilities, with TDS levels exceeding 4 000 mg/ℓ and sulfate levels exceeding 2 000 mg/ℓ occur in groundwater around the PSS discard dump;

- Constituents of concern include pH (acidic and alkaline), TDS, sulfate, sodium, calcium, magnesium, alkalinity, ammonia, aluminium, manganese and iron, which each exceeded at least one of the DWAF (1996) guidelines for domestic, livestock and irrigation water quality;

- The water quality in many of the dirty water dams was characterised by elevated sulfate levels with concentrations above 4 000 mg/ℓ being occasionally recorded in water from Vleishaft Dam and extremely high sulfate levels recorded consistently in water from the PSS dump PCD (4 225-19 631 mg/ℓ) - it is noted that these dams form part of a dirty water system, rather than a catchment water resource.

***Based upon the above findings, the following recommendations are made:***

**Further Geochemical Studies**

a) Collection of samples of spoils from pits in the Southern section (e.g. VDD) previously not sampled or where few samples were collected during this study is proposed for geochemical characterisation. Sampling of spoils and coal from active pits is also proposed to improve the understating of spatial distribution of acid generating material in the pits. Collection of slurry and discard material from in pit disposal facilities not previously studied is also proposed.

b) Drilling of more boreholes in rehabilitated spoils is proposed especially on pits where the boreholes do not exist for monitoring pit water quality.

c) Investigation of Wolvekrans Discard Dump west of the Olifants river to characterise the source and major seepage and drainage zones.

Rehabilitation

- Rehabilitation and mitigation measures must be applied for the following potential contaminant relevant sources:

  e) The ROM stockpile areas surfaces should be designed with stilling basins/silt traps to prevent the ponding of water and associated infiltration of storm water.

  f) Rehabilitation of the cover and walls of the Wolvekrans Discard Dump west of the Olifants river.

  h) Wolvekrans Pits 1, 2 and 4, which have acidic outflow.

  k) SKS Pit (saline drainage) rehabilitation.

## 5.2 Groundwater hydrochemistry

Recent water quality records dated from 2015 – 2018, were obtained for 11 boreholes which were deemed relevant to this assessment. In addition, the hydrochemistry results from the J&W (2016) investigation were also used and these results have been summarised below.

### 5.2.1 Jones & Wagener (2016)

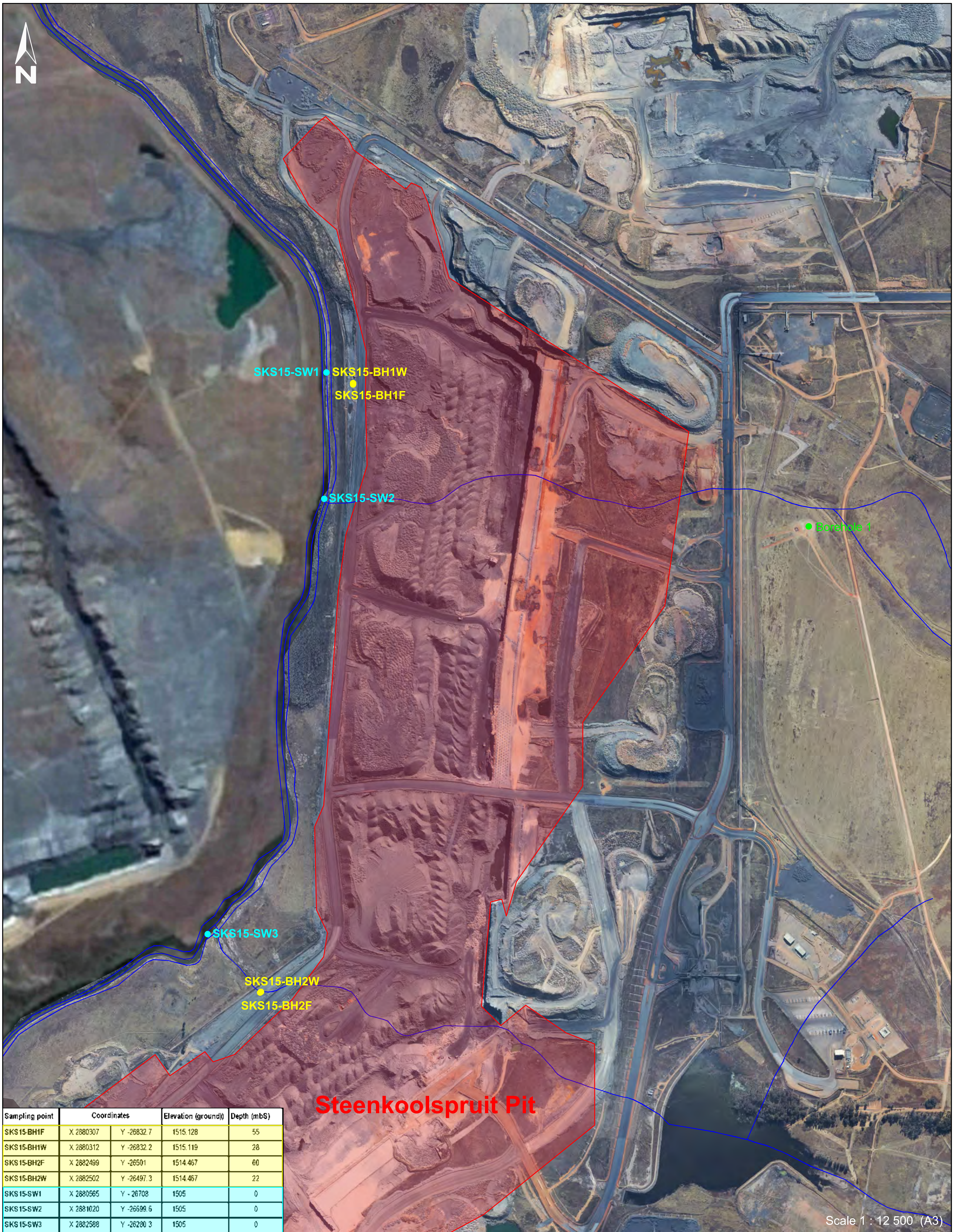
The water quality of the Olifants River has in the past been impacted by irrigated agriculture return flows and by partially treated and untreated effluent from mines, industry and wastewater treatment works. Compounding these impacts are seepages of (acid) mine drainage from abandoned mines, as well as possible consequences from acidic atmospheric deposition from the coal fired power stations in the area. Water quality results from the J&W (2016) investigation are summarised in **Table 5.2.1.a**. The sampling localities are included in **Figure 5.2.1.a**.

The SANS 241-1:2015 Drinking Water Specification is the definitive reference on acceptable limits for drinking water quality parameters in South Africa and provides guidelines for a range of water quality characteristics. The SANS 241-1:2015 Drinking Water Specification effectively summarises the suitability of water for drinking water purposes for lifetime consumption. The limit for the consumption of water is based on the consumption of 2 litres of water per day by a person of mass 60 kg over a period of 70 years.

Since the study area is located within a brownfields area where the natural environment has been impacted upon by mining for many decades, recent background water qualities with specific relevance to VDDC are limited. As such, the SANS 241-1:2015 guidelines have therefore been used for the screening of all inorganic and trace element constituents.

**Table 5.2.1.a: Hydrochemistry results (J&W, 2016)**

| | SANS 241-1: 2015 | BH1 | SKS15-SW1 | SKS15-SW2 | SKS15-SW3 | SKS15-BH1F | SKS15-BH1W | SKS15-BH2F | SKS15-BH2W |
|---|---|---|---|---|---|---|---|---|---|
| **pH** | > 5.0 to < 9.7 | 6.8 | 7.9 | 8.0 | 7.1 | 7.4 | 7.3 | 8.1 | 5.8 |
| **EC (mS/m)** | 170 | 488 | 89.2 | 84.1 | 77.5 | 87.6 | 68.9 | 489 | 269 |
| **TDS** | 1200 | 5 558 | 634 | 614 | 546 | 694 | 528 | 3 852 | 2 790 |
| **Alkalinity as $CaC0_3$** | | 172 | 120 | 120 | 120 | 144 | 116 | 612 | <5.0 |
| **$NO_3$ as N** | 11 | | <0.9 | 0.7 | 1.0 | <0.2 | 0.3 | 2.2 | <0.2 |
| **Cl** | 300 | 26 | 23 | 22 | 22 | 20 | 16 | 58 | 11 |
| **$SO_4$** | 500 | **4 043** | 284 | 275 | 248 | 276 | 230 | **2 192** | **1 981** |
| **F** | 1.5 | 1.1 | 0.4 | 0.4 | 0.4 | 0.7 | 0.5 | 1.0 | 0.30 |
| **Na** | 200 | 97 | 36 | 34 | 34 | 98 | 26 | 1092 | 96 |
| **K** | NG | 29 | 7.7 | 7.3 | 6.6 | 8.4 | 6.7 | 15.8 | 18.9 |
| **Ca** | NG | 477 | 70 | 69 | 58 | 55 | 81 | 61 | 324 |
| **Mg** | NG | 621 | 52 | 51 | 43 | 17 | 18 | 21 | 153 |
| **Al** | 0.30 | <0.100 | 1.2 | 0.37 | 1.4 | 14 | 1.92 | 16 | 0.80 |
| **Fe** | 2.0 | 6.17 | 1.84 | 0.32 | 2.3 | 32 | 0.80 | 41 | 163 |
| **Mn** | 0.40 | 18 | 0.24 | 0.10 | 0.30 | 1.4 | 0.50 | 0.50 | 9.1 |
| **As** | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| **Ba** | 0.70 | <0.025 | 0.10 | 0.08 | 0.10 | 0.18 | 0.15 | 0.06 | 0.05 |
| **Cu** | 2.0 | <0.025 | <0.025 | <0.025 | <0.025 | 0.0500 | <0.025 | 0.03 | <0.025 |
| **Pb** | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.010 | <0.010 | <0.010 | <0.010 |
| **Hg** | 0.0060 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **Zn (total)** | 5.0 | <0.025 | <0.025 | <0.025 | <0.025 | 0.090 | <0.025 | <0.17 | <0.04 |




| Sampling point | Coordinates | | Elevation (ground)) | Depth (mbS) |
|---|---|---|---|---|
| SKS15-BH1F | X 2880307 | Y -26832.7 | 1515.128 | 55 |
| SKS15-BH1W | X 2880312 | Y -26832.2 | 1515.119 | 28 |
| SKS15-BH2F | X 2882499 | Y -26501 | 1514.467 | 60 |
| SKS15-BH2W | X 2882502 | Y -26497.3 | 1514.467 | 22 |
| SKS15-SW1 | X 2880565 | Y - 26708 | 1505 | 0 |
| SKS15-SW2 | X 2881020 | Y -26699.6 | 1505 | 0 |
| SKS15-SW3 | X 2882588 | Y -26280 3 | 1505 | 0 |

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South32
VDDC Project
J&W (2016) Sampling Localities

Job No G535-04

**Figure 5.2.1.a**

The water quality in the section of the Olifants River adjacent to the Steenkoolspruit Section and as represented by samples SKS15-SW1 to SKS15-SW3 have, at the time, had EC values ranging between 77 mS/m and 89 mS/m, with sulfate concentrations ranging between 248 mg/ℓ and 284 mg/ℓ. It was also noted that there has been a deterioration in the river water quality across the study area from south (77.5 mS/m) to north (89.2 mS/m). Considering the size of the Olifants River, this impact is considered significant.

Borehole 1 (BH1), now also known as VD3N, was at the time being used as a dewatering borehole whereby excess groundwater was pumped into Vleishaft Dam from the old Vandyksdrift workings. It was therefore assumed to be the best representative sample of the underground water to be pumped to the backfilled Steenkoolspruit Pit. The hydrochemistry results from this borehole at the time indicated an elevated EC value of 488 mS/m. The historical EC values have been plotted in **Figure 5.2.1.b** and indicated a sudden increase between 08 April 2015 and 21 April 2015. This period coincides with the installation and commencement of pumping of the borehole. The 2018 hydrocensus results indicate that the underground slurry has since then intercepted this borehole as well, most likely due to pumping activities in the vicinity.

This is also seen with sulfate where a highly elevated sulfate concentration of 4 043 mg/ℓ was observed as opposed to pre-2015 as can be seen on **Figure 5.2.1.c**. It was also observed that post April 2015 the sulfate concentrations within this borehole did not show an increasing trend but have remained fairly constant with the concentrations ranging between 3 500 and 4 000 mg/ℓ.

Two of the monitoring boreholes that were drilled by J&W as part of the 2016 investigation, SKS15-BH2F and SKS15-BH2W, are located in a zone where groundwater has been contaminated by mining. The fractured aquifer at the time had a higher EC value (489 mS/m) than the weathered aquifer (269 mS/m), although the sulfate concentrations in both boreholes were similar. This borehole pair has been drilled in the footprint of an old drainage feature which is also one of the topographically lowest areas along the pit perimeter. This may explain the potential groundwater flow path between the mining operations and the Olifants River. When comparing the groundwater elevation in the fractured borehole (1 461 mamsl) against the Steenkoolspruit Pit floor (1 470 mamsl) it seems possible that impacted groundwater from the mining area may well have migrated towards the west.

The EC value of the boreholes SKS15-BH1F and SKS15-BH1W at the time were lower than that of the other pair (88 mS/m and 69 mS/m respectively), and in the same order of magnitude as that of the surface water. The close proximity of these boreholes to the river, as well as their similar chemical signatures (as discussed below) indicate that the water quality in the vicinity of these boreholes has likely been influenced by river water losses to the aquifer.

Total aluminium, iron and manganese concentrations were also found to exceed the screening guidelines in most of the boreholes. Although not undertaken, in a neutral to alkaline environment, these concentrations would be expected to be significantly lower in the dissolved phase.

It is expected that with recovery of groundwater levels at post closure, the water in the pit will be managed below the river level and that the general groundwater gradient will revert towards the Steenkoolspruit Pit.

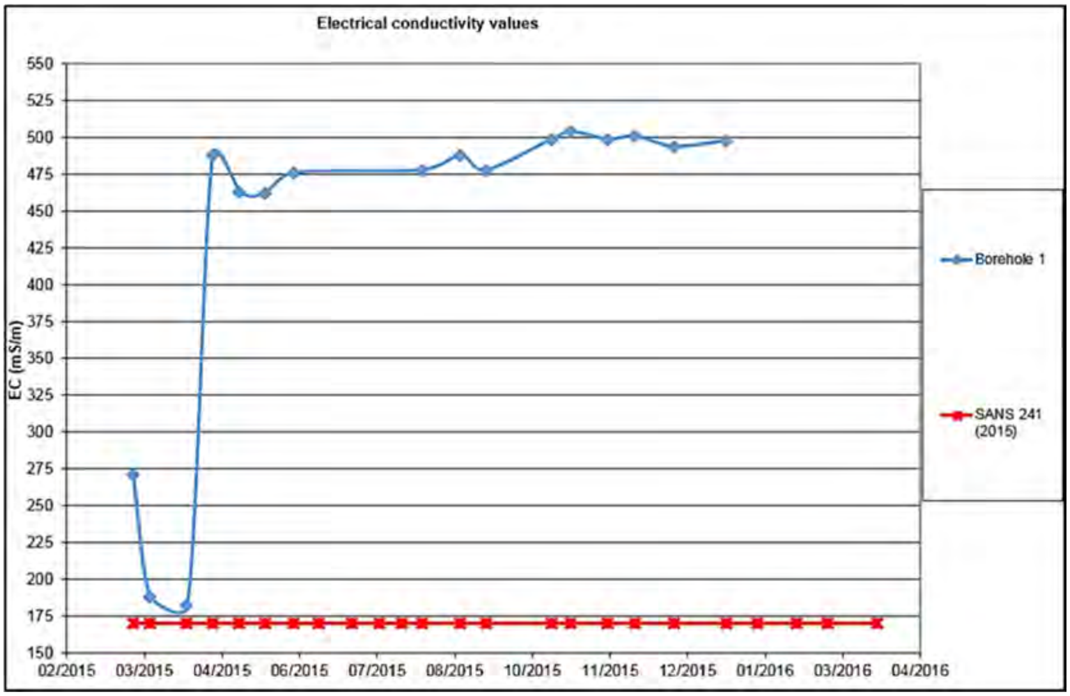



**Figure 5.2.1.b: Electrical conductivity over time for BH1**

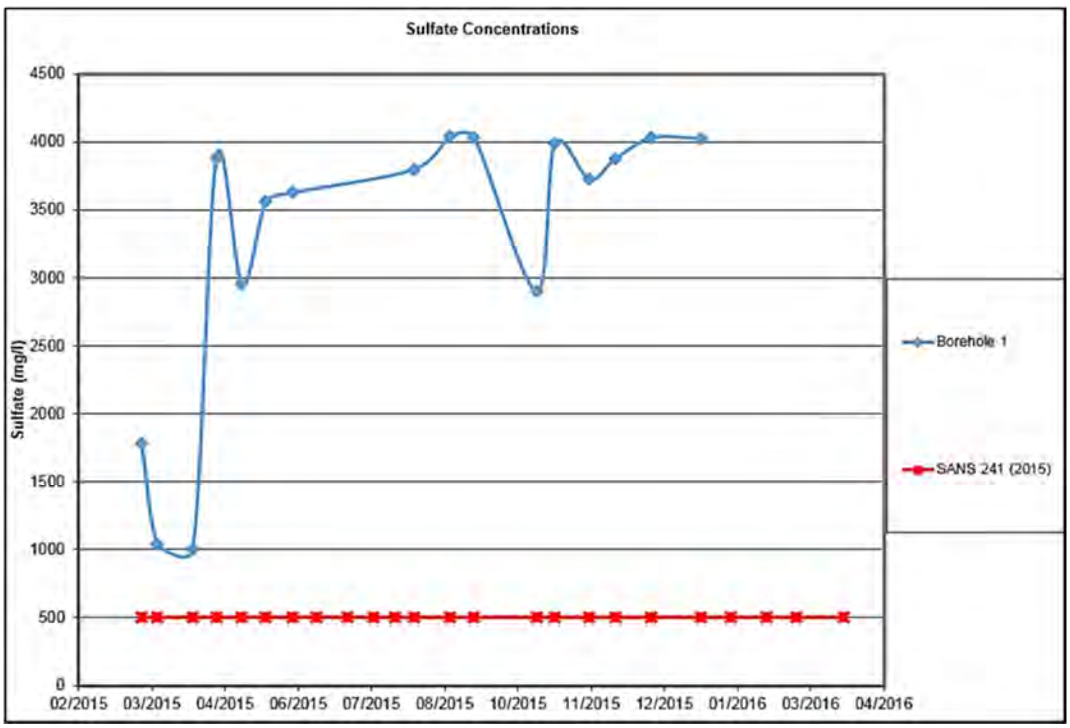



**Figure 5.2.1.c: Sulfate concentration over time for BH1**

The more recent water quality results, dating January 2018, as obtained from South32, are compared with the maximum recommended concentrations for domestic use as defined by the SANS 241-1: 2015 target water quality limits. The SANS 241-1: 2015 standard is applicable to all water services institutions and sets numerical limits for specific determinants to provide the minimum assurance necessary that the drinking water is deemed to present an acceptable health risk for lifetime consumption. The results of the screening for groundwater are presented in **Table 5.2.3.a** and **Table 5.2.3.b** and discussed in the sections below:

### 5.2.2 Groundwater quality vs SANS standards

- Nitrate as N exceeds the allowable limit in samples WBH 2S1.
- Fluoride exceeds the allowable limit in samples WBH 2S6, WBH 2S7, WBH 2S1.
- Electrical conductivity exceeds the allowable limit in samples NDB 6.
- TDS exceeds the allowable limit in samples NDB 6.
- pH exceeds the allowable limit in samples SKS BH1.
- Nitrate as N exceeds the allowable limit in samples WVK 3, NDB 3.
- Sulfate exceeds the allowable limit in samples SKS BH1, NDB 6.
- Fluoride exceeds the allowable limit in samples NDB 6.
- Total iron exceeds the allowable limit in samples SKS BH1.
- Total manganese exceeds the allowable limit in samples SKS BH1, NDB 6.
- Aluminium exceeds the allowable limit in samples SKS BH1, NDB 2.

The Piper diagram constructed using the sample chemistry (**Figure 5.2.2.a**) indicates that most samples have been affected by mining activities which is illustrated by the samples plotting in the top quadrant of the quadrilateral diamond. Samples unaffected by mining activities but plotting in the bottom and right quadrants of the quadrilateral diamond indicate water that is older and has undergone ion-exchange within the aquifer.

Additionally, it is important to note that samples UB110 and WBH2510 represent the water fractions of slurry material sampled from the underground and none of the screened constituents exceed the allowable concentrations of SANS241:2015.

However, it should be noted that the current groundwater quality on site shows an existing impact as a result of historic mining activities.

### 5.2.3 EC Profiling

As indicated in **Section 3.2**, EC profiles were recorded for selected boreholes as time and access permitted during the hydrocensus. The results of the EC profiling are included in **Appendix A** and illustrated in **Figure 5.2.3.a.** From these results the boreholes where groundwater has already been impacted by mining related activities include:

- SB84, located at VDD North and outside of the study area;
- UB11, located downstream of PSS dump towards the Olifants River;
- UB114, located downstream of PSS dump towards the Olifants River;
- UB88, located at VDD North and outside of the study area;
- VD10N, located at VDD North and outside of the study area.

**Table 5.2.3.a: Water qualities compared to SANS 241-1:2015 guidelines for human consumption (dataset 1)**

| Parameter | | Unit | SANS 241: 2015 Recommended Limits | Risk | Results | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | WBH 2S1 | WBH 2S5 | WBH 2S6 | WBH 2S7 | WBH 2S8 | WBH 2S10 | UB110 | WBH2510 |
| **Physical & Aesthetic Determinants** | | | | | | | | | | | | |
| Electrical conductivity at 25C | EC | mS/m | ≤ 170 | Aesthetic | 39.7 | 22.4 | 45.5 | 64.8 | 18.9 | 15.1 | 50.4 | 14.5 |
| Total Dissolved Solids | TDS | mg/ℓ | ≤ 1200 | Aesthetic | 252 | 116 | 278 | 424 | 104 | 82 | Not Analysed | Not Analysed |
| pH at 25C | | pH units | ≥ 5 to ≤9.7 | Aesthetic | 7.04 | 6.9 | 7.8 | 7.6 | 7.4 | 7.3 | 7.4 | 6.7 |
| **Chemical Determinants - Macro Determinants** | | | | | | | | | | | | |
| Nitrate as N | NO3 | mg/ℓ | ≤ 11 | Acute Health | 20.2 | 0.5 | 0.9 | 6.5 | 0.6 | 1 | BDL | 0.4 |
| Sulfate | SO4 | mg/ℓ | Acute Health ≤500; Aesthetic ≤250 | Acute Health/Aesthetic | 36.1 | 3.3 | 28.8 | 125 | 15.5 | 2.7 | 24 | BDL |
| Fluoride | F | µg/ℓ | ≤1500 | Chronic Health | BDL | BDL | 1290 | 420 | BDL | 340 | 1.4 | 0.3 |
| Chloride | Cl | mg/ℓ | ≤ 300 | Aesthetic | 20.1 | 46.6 | 11.7 | 33.8 | 7.34 | 7.02 | 26 | 5 |
| Sodium | Na | mg/ℓ | ≤ 200 | Aesthetic | 13.5 | 27.2 | 66.4 | 53.9 | 11.7 | 18.3 | 68 | 16 |
| | | | | | | | | | | | | |
| Total Iron | Fe | mg/ℓ | Acute Health ≤ 2; Aesthetic ≤0.3 | Acute/Aesthetic | BDL | BDL | 0.01 | 0.04 | BDL | 0.01 | 0.041 | 0.079 |
| Total manganese | Mn | mg/ℓ | Acute Health ≤0.4; Aesthetic ≤0.1 | Acute/Aesthetic | BDL | BDL | BDL | 0.01 | BDL | BDL | 0.248 | 0.315 |
| Aluminium | Al | µg/ℓ | ≤ 300 | Operational | 10 | BDL | 20 | 10 | 30 | 50 | BDL | BDL |
| **Concentration deemed to present at an unacceptable health risk for lifetime consumption.** | | | | | | | | | | | | |
| **BDL=Below Detection Level** | | | | | | | | | | | | |

**Table 5.2.3.b: Water qualities compared to SANS 241-1:2015 guidelines for human consumption (dataset 2)**

| Parameter | | Unit | SANS 241: 2015 Recommended Limits | Risk | Results | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | SKS BH1 | WVK 3 | NDB 2 | NDB 3 | NDB 6 |
| **Physical & Aesthetic Determinants** | | | | | | | | | |
| Electrical conductivity at 25C | EC | mS/m | ≤ 170 | Aesthetic | 140 | 22.7 | 9.73 | 42.2 | 430 |
| Total Dissolved Solids | TDS | mg/ℓ | ≤ 1200 | Aesthetic | 956 | 148 | 64 | 286 | 4 206 |
| pH at 25C | | pH units | ≥ 5 to ≤9.7 | Aesthetic | 3.2 | 6.6 | 5.8 | 6.1 | 7.1 |
| **Chemical Determinants - Macro Determinants** | | | | | | | | | |
| Nitrate as N | NO3 | mg/ℓ | ≤ 11 | Acute Health | 2 | 13.8 | 2.1 | 30.8 | 1.67 |
| Sulfate | SO4 | mg/ℓ | Acute Health ≤500; Aesthetic ≤250 | Acute Health/Aesthetic | 652 | 17.7 | 12.2 | 7.48 | 2 778 |
| Fluoride | F | µg/ℓ | ≤1500 | Chronic Health | BDL | BDL | BDL | BDL | 430 |
| Chloride | Cl | mg/ℓ | ≤ 300 | Aesthetic | 6.9 | 11.6 | 13.4 | 44.7 | 25.4 |
| Sodium | Na | mg/ℓ | ≤ 200 | Aesthetic | 16.5 | 10.8 | 7.3 | 19.8 | 127 |
| | | | | | | | | | |
| Total Iron | Fe | mg/ℓ | Acute Health ≤ 2; Aesthetic ≤0.3 | Acute/Aesthetic | 2 | BDL | 0.3 | 0.01 | BDL |
| Total manganese | Mn | mg/ℓ | Acute Health ≤0.4; Aesthetic ≤0.1 | Acute/Aesthetic | 1.4 | 0.02 | 0.06 | 0.1 | 8.6 |
| Aluminium | Al | µg/ℓ | ≤ 300 | Operational | 6 260 | 30 | 440 | 40 | 20 |

**Concentration deemed to at present an unacceptable health risk for lifetime consumption.**

**BDL=Below Detection Level**

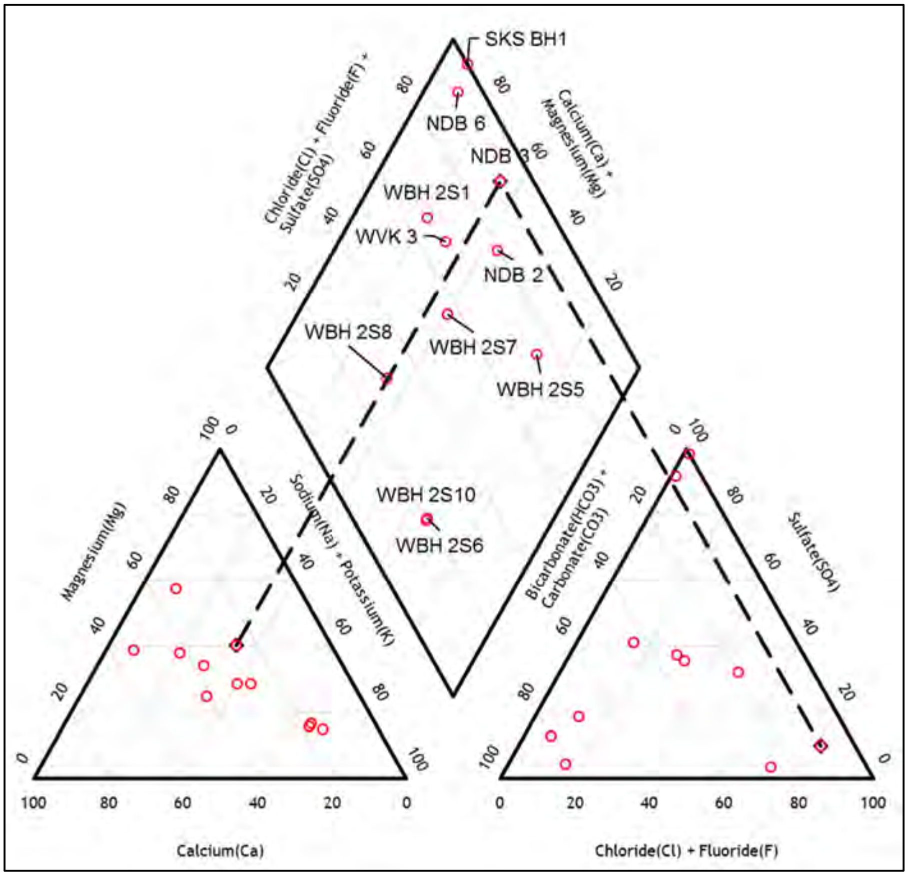



**Figure 5.2.2.a: Piper Diagram**

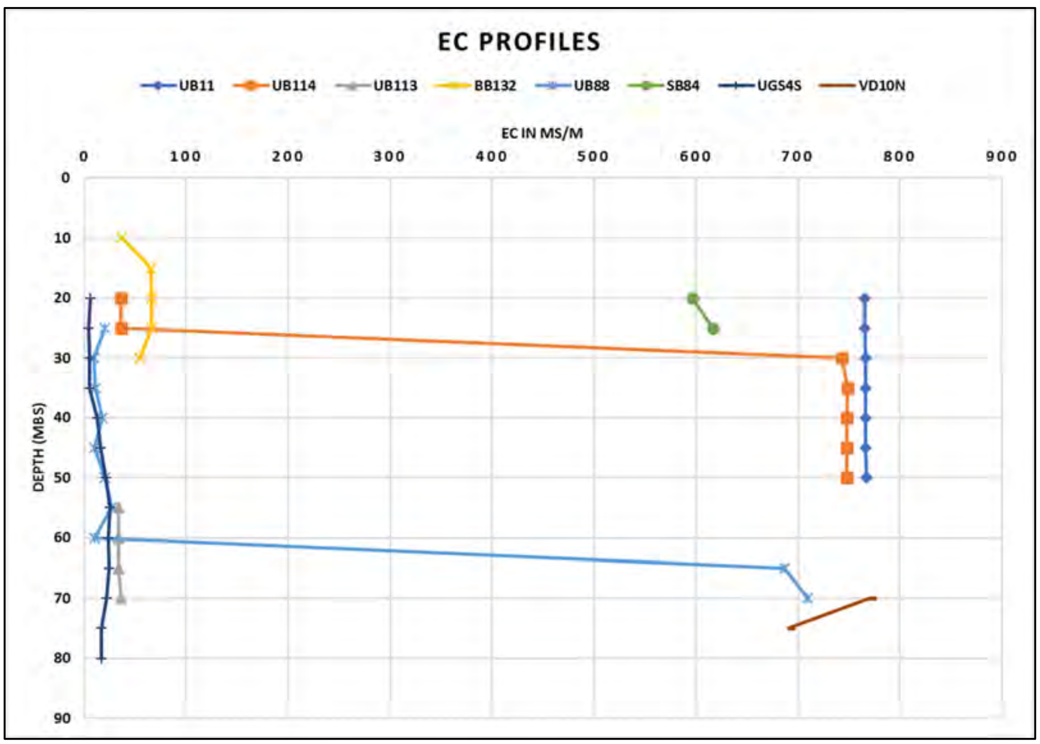



**Figure 5.2.3.a: EC Profiles**

# 6. AQUIFER CHARACTERISATION

## 6.1 Groundwater vulnerability

Aquifer vulnerability assessment indicates the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer. Stated in another way, it is a measure of the degree of insulation that the natural and manmade factors provide to keep contamination away from groundwater.

- Vulnerability is high if natural factors provide little protection to shield groundwater from contaminating activities at the land surface.
- Vulnerability is low if natural factors provide relatively good protection and if there is little likelihood that contaminating activities will result in groundwater degradation.

The following factors influence groundwater vulnerability:

- Depth to groundwater: Indicates the distance and time required for pollutants to move through the unsaturated zone to the aquifer.
- Recharge: The primary source of groundwater is precipitation, which aids the movement of a pollutant to the aquifer.
- Aquifer media: The rock matrices and fractures which serve as water bearing units.
- Soil media: The soil media (consisting of the upper portion of the vadose zone) affects the rate at which the pollutants migrate to groundwater.
- Topography: Indicates whether pollutants will run off or remain on the surface allowing for infiltration to groundwater to occur.
- Impact of the vadose zone: The part of the geological profile beneath the earth's surface and above the first principal water-bearing aquifer. The vadose zone can retard the progress of the contaminants.

The Groundwater Decision Tool (GDT) was used to quantify the vulnerability of the aquifer underlying the site using the below assumptions.

- Depth to groundwater below the site was estimated from water levels measured during the hydrocensus inferred to be at mean of ~10 mbs.
- Groundwater recharge of ~25 mm/a (3.5% recharge),
- Sandy clay soil vadose zone
- Gradient of 1% was assumed and used in the estimation.

The aquifer vulnerability for a contaminant released from surface to a specified position in the groundwater system after introduction at some location above the uppermost aquifer was determined using the criteria described below and assuming a worst-case scenario:

- Highly vulnerable (> 60), the natural factors provide little protection to shield groundwater from contaminating activities at the land surface.
- Medium Vulnerable = 30 to 60%, the natural factors provide some protection to shield groundwater from contaminating activities at the land surface, however based on the contaminant toxicity mitigation measures will be required to prevent any surface contamination from reaching the groundwater table.

- Low Vulnerability (< 30 %), natural factors provide relatively good protection and if there is little likelihood that contaminating activities will result in groundwater degradation
- The GDT calculated a vulnerability value of 53%, which is medium.

## 6.2 Aquifer Classification

The aquifer(s) underlying the subject area were classified in accordance with "*A South African Aquifer System Management Classification*, December 1995."

The main aquifers underlying the area were classified in accordance with the Aquifer System Management Classification document[2]. The aquifers were classified by using the following definitions:

- Sole Aquifer System: An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.
- Major Aquifer System: Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (EC of less than 150 mS/m).
- Minor Aquifer System: These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.
- Non-Aquifer System: These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Based on information collected during the hydrocensus it can be concluded that the aquifer system in the study area can be classified as a "Minor Aquifer System", based on the fact that the local population is not dependent on groundwater.

In order to achieve the Aquifer System Management and Second Variable Classifications, as well as the Groundwater Quality Management Index, a points scoring system as presented in **Table 6.2.a** and **Table 6.2.b** was used.

[2] Department of Water Affairs and Forestry & Water Research Commission (1995). A South African Aquifer System Management Classification. WRC Report No. KV77/95.

**Table 6.2.a: Ratings – Aquifer System Management and Second Variable Classifications**

| Aquifer System Management Classification | | |
|---|---|---|
| **Class** | **Points** | **Study area** |
| Sole Source Aquifer System: | 6 | |
| Major Aquifer System: | 4 | |
| Minor Aquifer System: | 2 | 2 |
| Non-Aquifer System: | 0 | |
| Special Aquifer System: | 0 – 6 | |
| **Second Variable Classification (Weathering/Fracturing)** | | |
| **Class** | **Points** | **Study area** |
| High: | 3 | |
| Medium: | 2 | 2 |
| Low: | 1 | |

**Table 6.2.b: Ratings - Groundwater Quality Management (GQM) Classification System**

| Aquifer System Management Classification | | |
|---|---|---|
| **Class** | **Points** | **Study area** |
| Sole Source Aquifer System: | 6 | |
| Major Aquifer System: | 4 | |
| Minor Aquifer System: | 2 | 2 |
| Non-Aquifer System: | 0 | |
| Special Aquifer System: | 0 – 6 | |
| **Aquifer Vulnerability Classification** | | |
| **Class** | **Points** | **Study area** |
| High: | 3 | |
| Medium: | 2 | 2 |
| Low: | 1 | |

As part of the aquifer classification, a Groundwater Quality Management (GQM) Index is used to define the level of groundwater protection required. The GQM Index is obtained by multiplying the rating of the aquifer system management and the aquifer vulnerability. The GQM index for the study area is presented in **Table 6.2.c.**

The vulnerability, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, in terms of the above, is classified as **medium.**

The level of groundwater protection based on the Groundwater Quality Management Classification:

**GQM Index** = Aquifer System Management x Aquifer Vulnerability

= 2 x 2 = 4

**Table 6.2.c: GQM Index for the Study Area**

| GQM Index | Level of Protection | Study Area |
|---|---|---|
| <1 | Limited | |
| 1 – 3 | Low Level | |
| 3 – 6 | Medium Level | 4 |
| 6 – 10 | High Level | |
| >10 | Strictly Non-Degradation | |

## 6.3 Aquifer Protection Classification

A Groundwater Quality Management Index of 4 was estimated for the study area from the ratings for the Aquifer System Management Classification. According to this estimate a **medium-level groundwater protection** is required for the aquifer. Reasonable and sound groundwater protection measures based on the modelling will therefore be recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.

DWS' water quality management objectives are to protect human health and the environment. Therefore, the significance of this aquifer classification is that measures must be taken to limit the risk to the following environments.

- The protection of the underlying aquifer;
- The protection of surface water drainage systems.

# 7. GROUNDWATER MODELLING

## 7.1 Assumptions and limitations

Specific assumptions related to the available field data include:

- The top of the aquifer is represented by the generated groundwater heads;
- The available geological / hydrogeological information (as discussed in the baseline section of this report) was used to describe the different aquifers. The available information on the geology and field tests is considered as correct;
- Certain aquifer parameters have not been determined in the field and therefore had to be estimated (**Table 7.6.a**).

It is important to note that a numerical groundwater model is a representation of the real system. It is therefore at most an approximation, and the level of accuracy depends on the quality of the data that is available. This implies that there are always errors associated with groundwater models due to uncertainty in the data and the capability of numerical methods to describe natural physical processes.

## 7.2 Software Model Choice

A three-dimensional numerical model was employed to simulate stresses to the aquifer system in both a spatial and temporal context. The finite element 3D-modelling package FEFLOW 7 (Finite Element subsurface FLOW system) was used. FEFLOW is a modular, three-dimensional finite element groundwater flow model, which was developed by DHI. FEFLOW uses finite element analysis to solve the groundwater flow equation of both saturated and unsaturated conditions, as well as mass and heat transport, also accounting for fluid density effects.

## 7.3 Model Set-up and Boundaries

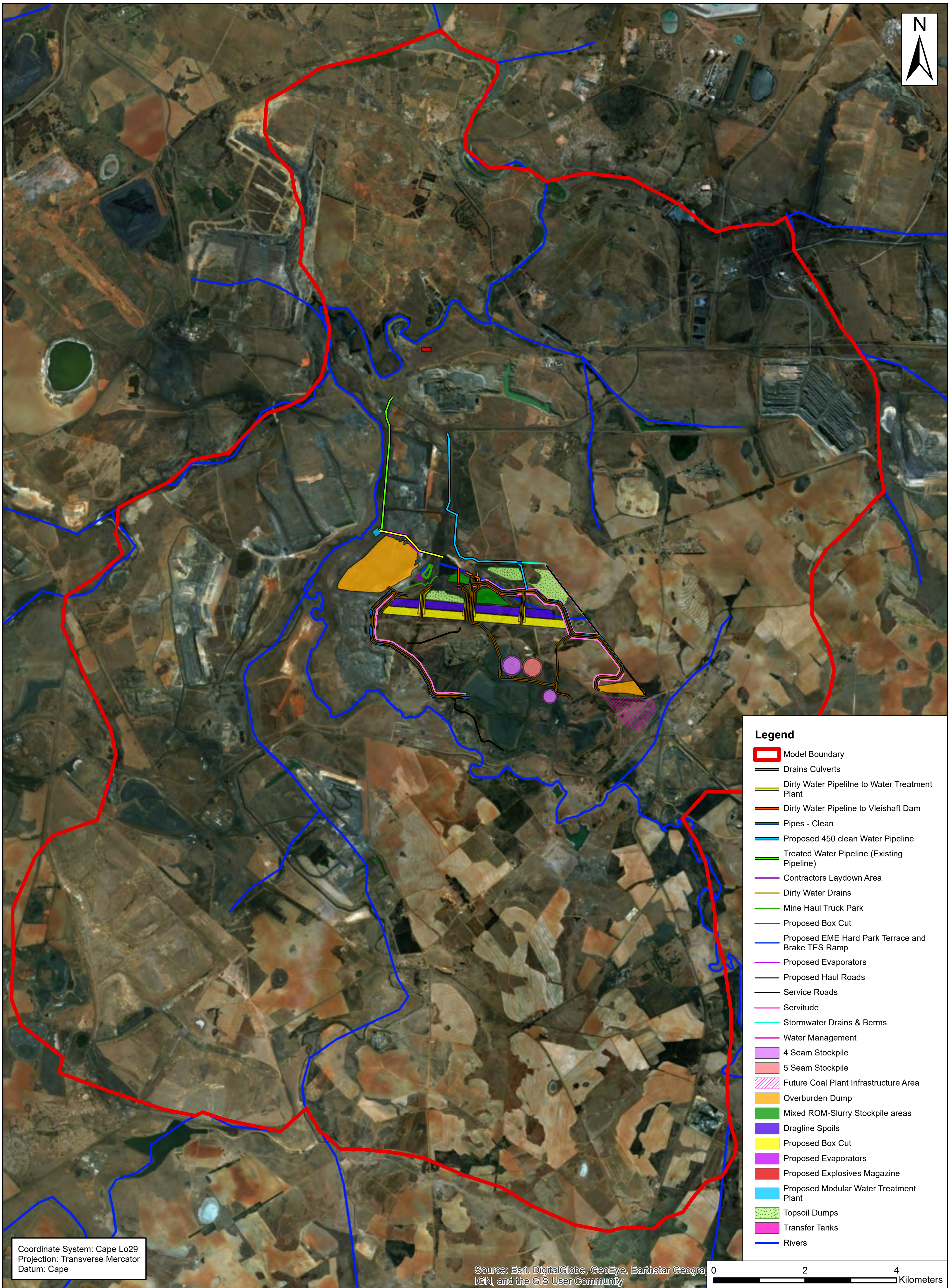
The model domain represents a subset of the regional groundwater regime. For the model to be realistic, the boundary conditions should therefore be selected to coincide with physical hydrogeological boundaries such as watersheds, etc. the model mesh consists of 375 613 mesh nodes and 642 144 mesh elements. Mesh quality is acceptable since obtuse angles greater than 90° total 2.1% and Delaunay-violating triangles total 0.03%.

Boundaries were chosen to include the area where the groundwater pollution plume could reasonably be expected to spread and simultaneously be far enough removed from site boundaries not to be affected by groundwater abstraction. The model domain is illustrated in **Figure** and the boundaries described in more detail in **Table 7.6.a.**

These boundaries resulted in an area of about 2 to 15 km around the project site, which is considered far enough for the expected groundwater effects not to be influenced by boundaries.

Boundary conditions should be specified for the entire boundary and may vary with time. At a given boundary section just one type of boundary condition can be assigned. As a simple example, it is not possible to specify groundwater flux and groundwater head at an identical boundary section. Boundaries in groundwater models can be specified as:

- Dirichlet (also known as constant head or constant concentration) boundary conditions;
- Neuman (or specified flux) boundary conditions; and
- Cauchy (or a combination of Dirichlet and Neuman) boundary conditions.

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Model domain

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Figure 7.3.a

### 7.4 Groundwater Elevation and Gradient

The calibrated static water levels as modelled have been contoured (**Figure 7.8.b**). Groundwater flow directions will be perpendicular to these contours and inversely proportional to the distance between contours. As can be expected, the groundwater flow is mainly from topographical high to low areas, eventually draining to the local streams.

### 7.5 Geometric Structure of the Model

The geometric structure of the model is discussed in detail in the Groundwater Sources and Sinks as well as the Conceptual Model sections of this report.

### 7.6 Groundwater Sources and Sinks

Although the most relevant aquifer parameters are optimised by the calibration of the model, many parameters are calculated and/or judged by conventional means. The fixed assumptions and input parameters listed in **Table 7.6.a** were used for the numerical model of this area.

**Table 7.6.a: Input parameters to the numerical flow model**

| Model Parameter | Value | Unit | Reference |
|---|---|---|---|
| Recharge to the aquifer | 0.0001 | m/d | Calculated |
| Recharge to the backfilled opencast mine | 0.0004 | m/d | Hodgson and Krantz (1998) |
| Boundaries | Topographic water divides and streams | - | Existing boundary conditions present at the site that would potentially include modelled impacts |
| Refinement | variable | m | Based on the scale of the mining area |
| Hydraulic conductivity | 0.01 | m/d | Existing hydrogeological report (Groundwater Complete, 2013) |
| Hydraulic anisotropy (vertical) | 10 | - | Anderson et al. (2015) |
| Effective porosity | 5 declining to 3 with depth in each layer | % | Wang et al. (2009) |
| Layers | 6 | Count | Regolith, weathered aquifer, fractured aquifer and coal seam depths with varying hydraulic parameters. |
| Longitudinal dispersion | 50 | m | Schulze-Makuch (2005) |
| Head error range | 15 | m | Calculated as less than 10% of the difference between the maximum and minimum calculated head elevations (Diersch, 2013) |

## 7.7 Conceptual Model

For this study, the subsurface was envisaged to consist of the following hydrogeological units:

- The upper few metres below surface consist of completely weathered material. This layer is anticipated to have a reasonable high hydraulic conductivity, but in general unsaturated. However, a seasonal aquifer perched on the bedrock probably does form in this layer, especially after high rainfall events. Flow in this perched aquifer is expected to follow the surface contours closely and emerge as fountains or seepage at lower elevations.
- The next few tens of metres can be subdivided into two aquifer systems comprising of slightly weathered, highly fractured sedimentary bedrock with a low hydraulic conductivity and the backfill material which has a high hydraulic conductivity. The permanent groundwater level resides in this unit and is about 1 to 10 metres below ground level. The groundwater flow direction in this unit is influenced by regional topography and for the site flow would be in general from high lying areas to the rivers and streams in the area, for the fractured bedrock. The hydrodynamics of the area will be greatly influenced by the mine as its hydraulic properties are similar to that of a gravel system. The hydraulic conductivity of this aquifer was estimated at 100 m/d.
- Below a few tens of meters, the fracturing of the aquifer is less frequent and fractures less significant due to increased pressure. This results in an aquifer of lower hydraulic conductivity and very slow groundwater flow velocities. The hydraulic conductivity of this aquifer was estimated at 0.01 m/d and was estimated from pumping test data as well as literature.

## 7.8 Steady state model calibration

Water level and quality data obtained during the hydrocensus were used to calibrate the steady state numerical groundwater flow model. The results obtained during the steady state scenarios were used as initial conditions to simulate dewatering and contaminant transport impacts. A graphical fit was obtained for the measured groundwater levels (**Figure 7.8.a**). All other parameters were unchanged, with values as listed in the paragraphs above.

It can be seen from **Table 7.8.b** that the root mean squared error is 11.5 m which is less than 10% of the overall groundwater level variation observed onsite. This is considered to be acceptable for flow calibration purposes (Diersch, 2013).

The observed groundwater levels were plotted against the simulated values in a scatter plot as shown in **Figure 5.2.2.a.** The distribution of the simulated values around the theoretical line indicates that the groundwater model does not have a notable bias to over simulate or under simulate the observed groundwater levels.

Simulated groundwater gradients are shown in **Figure 7.8.b**. This figure shows that the groundwater gradients generally mimic the surface topography as expected. Exceptions occur where localised dewatering occurs or where the influence of hydrogeological structures are unknown.

**Table 7.8.a: Optimal Calibrated Aquifer Parameters**

| Aquifer | Model layer | Layer thickness (m) | Porosity (%) | Hydraulic conductivity (m/d) |
|---|---|---|---|---|
| Unsaturated Zone | Layer 1 | 7-10 | 30 | 1 |
| Shallow Weathered Aquifer | Layer 2 | 10-30 | 5 | 0.1 |
| Coal Seam | Layer 3 | 2-4 | 4 | 0.01 |
| Fractured Aquifer | Layer 4 | 30 | 3 | 0.001 |
| Coal Seam | Layer 5 | 2-4 | 4 | 0.01 |
| Fractured Aquifer | Layer 6 | 30 | 3 | 0.001 |

**Table 7.8.b: Calibration Error Statistics**

| Average Observed GWL (mamsl) | Average Simulated GWL (mamsl) | Mean Error | Mean Absolute Error | Root Mean Squared Error |
|---|---|---|---|---|
| 1525.12 | 1527.64 | 9.2 | 11.4 | 11.5 |

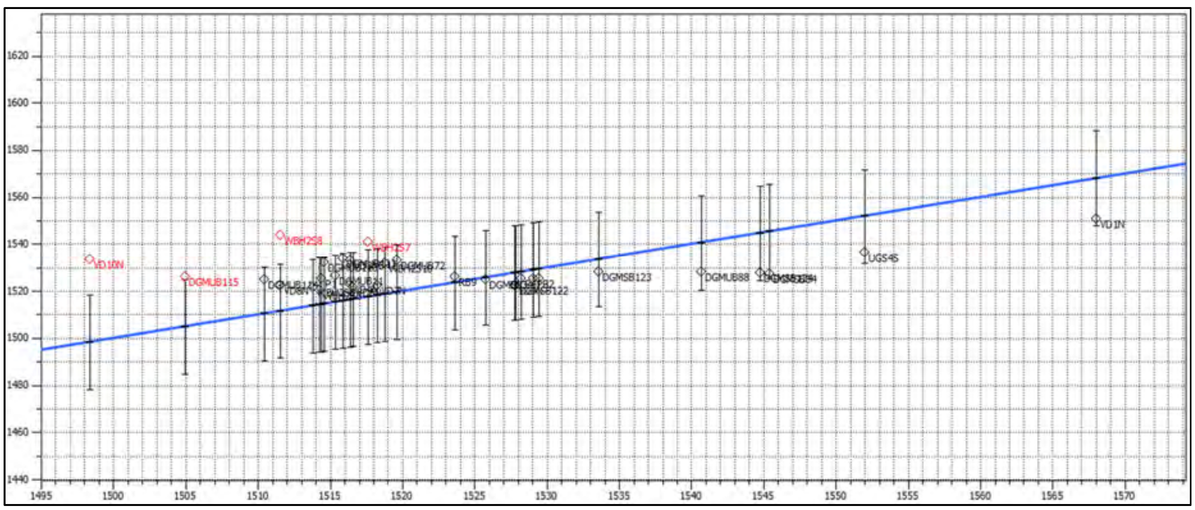
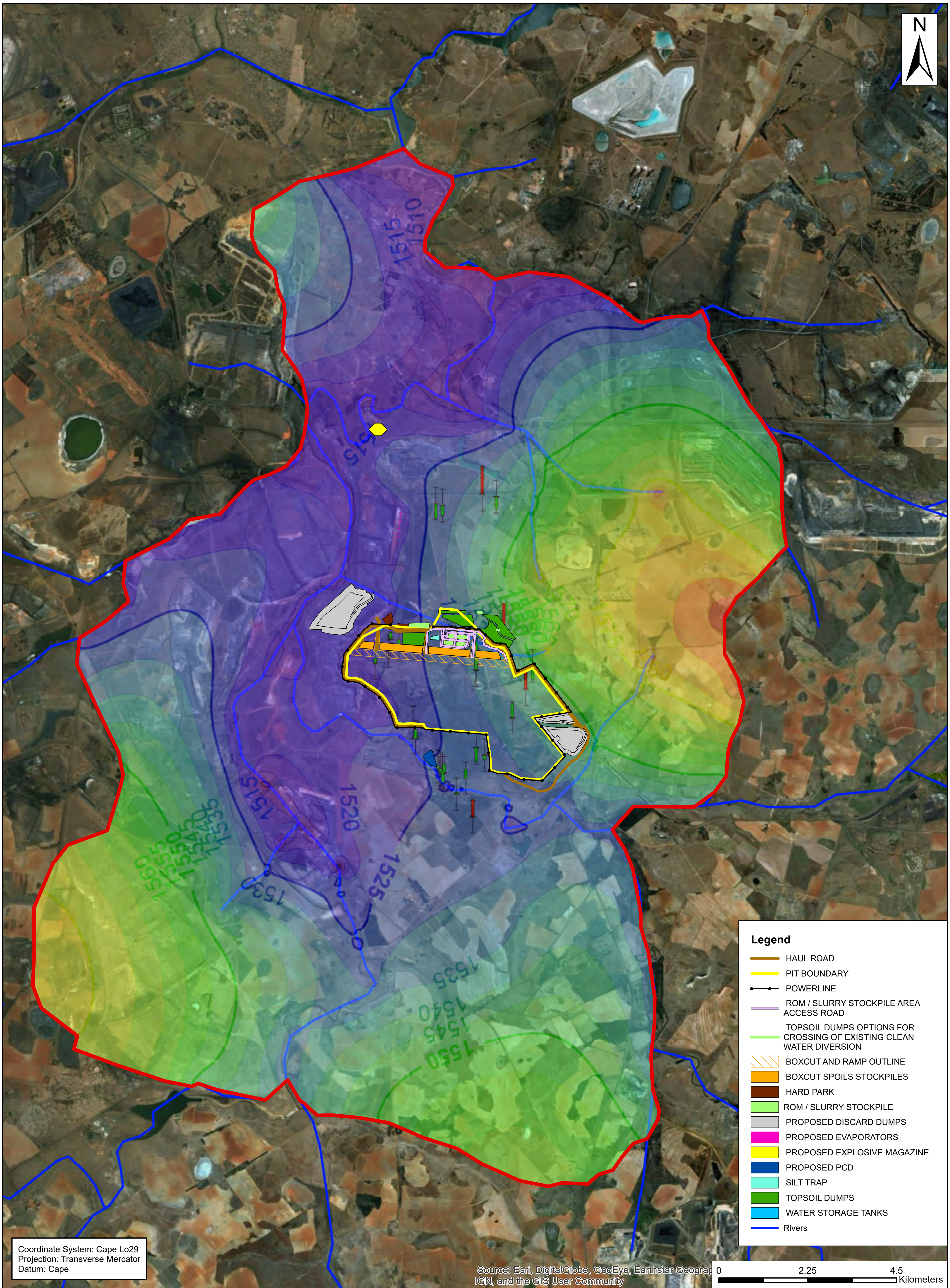



**Figure 7.8.a: Water Level Calibration Graph**

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Water Level Calibration Map

Job No: G535-04

Figure 7.8.b

### 7.8.1 Pre-Development

This model represents the pre-mining scenario and is used for calibration purposes. The model is representative of steady-state natural conditions prior to the application of stresses to the aquifer and provides a baseline from which all following calculations are performed. All required hydraulic parameters are defined and calibrated in this model as a simplified mathematical representation of the hydrogeological scenario on and around the site.

### 7.8.2 During Mining/Operational Phase

This model represents the groundwater situation during operation of mining. A drain was thus imposed under the mining area at mining depth. The modelling included the following transport and dewatering scenarios:

**Transport**

- Overburden Dumps.
- Mixed ROM coal and slurry drying areas.
- Final Rejects Dump (cumulative impact – existing authorised facility).
- Dragline Spoils.
- Proposed Evaporators.
- Vleishaft Dam (cumulative impact – existing authorised facility).
- 5Seam and 4Seam ROM Stockpiles.

**Dewatering**

- Proposed VDDC Opencast Mine Including Expansion Area Outside 2007 approved EMPR Amendment.
- Proposed 2 Seam Dewatering Prior to Mine Development.

The numerical groundwater flow model indicates the associated flow directions and velocities and simulated inflow rates towards the mining activities.

### 7.8.3 Post-Mining/Decommissioning and Closure Phase

This models the post-mining scenario, assuming that the most likely recharge over the rehabilitated opencast will be 0.0004 m/d. This amounts to a recharge of about 20% of rainfall, which is probably a worst-case scenario[3]. The modelling included the following transport and dewatering scenarios:

**Transport**

- Proposed VDDC Opencast Mine (after backfilling) Including Expansion Area Outside 2007 approved EMPR Amendment.
- Final Rejects Dump (cumulative impact – existing authorised facility).

[3] Grobbelaar, R et al: Long-Term Impact of Intermine Flow from Collieries in the Mpumalanga Coalfields, Sept 2004. Institute for Groundwater Studies, University of the Free State, Bloemfontein RSA.

**Discharge**

- Proposed VDDC Opencast Mine (After Backfilling) Including Expansion Area Outside 2007 approved EMPR Amendment.

# 8. HYDROGEOLOGICAL IMPACTS

It is the aim of this chapter to assess the likely hydrogeological impact that the mine might have on the receiving environment. The typical operational stages that will be considered in this section are:

- Construction Phase: Preparations at the specific site before actual operations commence.
- Operational Phase: The conditions expected to prevail during the operation of the site.
- Decommissioning Phase: The closing of operations, as well as site clean-up and rehabilitation.
- Post-mining Phase: This relates to the steady-state conditions following site-closure. A period will be considered after which it is assumed that impacts will steadily decrease, and the system will commence its return to the natural state.

## 8.1 Construction Phase

It is accepted for the purposes of this document that the construction phase will consist of preparations for the proposed opencast mining and associated infrastructure, which is assumed to consist mainly of establishment of infrastructure on site, the mobilisation of earth moving equipment and the opening of the boxcut.

### 8.1.1 Impacts on Groundwater Quantity

This phase is not expected to influence the groundwater levels.

### 8.1.2 Impacts on Groundwater Quality

This phase should thus cause very little additional impacts on the groundwater quality. It is expected that the current status quo will be maintained. However, it should be noted that the current groundwater quality on site shows an existing impact as a result of historic mining activities.

### 8.1.3 Groundwater Management

Pollution prevention starts in the planning phase of an operation through evaluation of mining plans and is aimed at understanding the potential impacts of alternative working methodologies and a conscious effort to select, design and implement the alternatives that maximise the ability to prevent pollution. Pre-establishment of an operation, typical pollution prevention considerations include those described below:

- Before operation, a conceptual closure plan that includes explicit consideration of closure and rehabilitation issues must be prepared and approved. These plans should define the sequence and nature of operations and detail the methods to be used in closure and restoration. This will include dewatering, contamination, surface water and stability considerations to ensure minimum impacts from mining. The plans as well as the numerical model should be updated regularly (every 3 to 5 years) during operation with available monitoring data. All operational planning and activities should be undertaken with eventual closure in mind, such that operations can end in a manner that minimizes the final risks and liabilities in the post-closure phase.

- Apply passive water management measures within the operations that are aimed at minimising the potential for water quality deterioration due to the oxidation of sulfide minerals by reducing the available contact time between water and exposed sulfide minerals.
- Construct detailed water and salt balances that take account of climatic and operational variability, as a planning tool to ensure that all pollution control dams are adequately sized and that they are integrated into a robust water reuse and reclamation strategy to ensure that captured contaminated water is effectively reused within the mining operations and that system spillages to the environment are avoided.
- Proper storage, handling and monitoring of fuel and chemicals used on site to minimize the risk of spillages to the environment.
- Institute detailed monitoring systems that are capable of detecting pollution at the earliest possible stage, at all facilities where significant pollution potential exists, in order that this can lead to rapid and effective management actions to address the pollution source and minimize it to the full extent possible.

## 8.2 Operational Phase

The operational phase is interpreted as the active opencast mining of the VDDC pit (including the opencast area which is additional to the mine layout in the 2007 approved EMPR Amendment) and the operation of the associated infrastructure. It is inevitable that these effects will impact on the groundwater regime. The potential impacts that will be considered are the groundwater quantity and quality. A summary of the potential impacts during operation can be seen in **Table 8.2.2.a** and **Table 8.2.2.b.**

### 8.2.1 Impacts on Groundwater Quantity

During the operational phase, it is expected that the main impact on the groundwater environment will be dewatering of the surrounding aquifer. Water entering the mining areas will have to be pumped out to enable mining activities to continue. This will cause a lowering in the groundwater table in- and adjacent to the mine.

The dewatering of the aquifer has been calculated for the proposed opencast using the calibrated numerical model as described above. It should be noted that dewatering of the historic underground workings was also calculated based on the report titled *South32 SA Coal Holdings (Pty) Limited Water Use Licence Application for Vandyksdrift Central Dewatering* by Jaco-K Consulting prepared in 2016 (JKC_0543). This report stated that an average dewatering rate of 24 Mℓ/d would be extracted from the workings for evaporation and dewatering purposes. Therefore, drawdown was calculated after 2 years of this dewatering when opencast mining would commence. Further to this, the mining sequence was also taken in consideration when calculating the drawdown. The calculated drawdown of this scenario is depicted in **Figure 8.2.2.a**, as contours of drawdown.

The computed inflow into the mine was calculated as tabled below in **Table 8.2.2.a**.

The actual inflow will depend on the area being mined at any one moment in time. However, at the last opencast strip, the inflow from the backfilled portion of the mine could be substantial.

It is important to view these numbers for the water make of the mine in relation to natural evaporation, as listed in the table. Illustrative volumes are included in the table as if the evaporation will take place over the whole open cut, for comparative purposes. This is illustrative that evaporation can contribute considerably to the removal of groundwater seepage into the opencast.

Furthermore, it should be realised that evaporation is a seasonal effect. Direct recharge from rainfall will in turn add to these volumes. The amount of direct recharge will depend on the season as well as the mining layout and storm water management.

### 8.2.2 Impacts on Groundwater Quality

The flow in the aquifer will be directed towards the mine (including the opencast area which is additional to the mine layout in the 2007 approved EMPR Amendment) at this stage and very little groundwater pollution affecting private users and surface water is thus expected (**Table 8.2.2.b** and **Figure 8.2.2.b**). Additionally, current contaminated groundwater could also flow into the mine, diverting the current contaminant plume from the defunct underground mine.

**Table 8.2.2.a: Summary of potential impacts during operation – dewatering**

| Mining Area | Maximum Drawdown (m) | Cone of depression from edge of pit (m) | Estimated Inflow per Boxcut ($m^3$/day) | Evaporation ($m^3$/day) | Potential Impacted Receptor | Expected Water Level Decline (m) |
|---|---|---|---|---|---|---|
| VDDC Opencast (including the opencast area which is additional to the mine layout in the 2007 approved EMPR Amendment) | 20-60 | 200-250 | Maximum of 265 $m^3$/d if pre-mining dewatering is performed | 5-50 | Boreholes VD9N, DGMSB124, DGMSB123, DGMUB113, WBH2S7, VD1N, DGMUB110, WBH2S10, VD3NBH1, WBH2S8, DGMUB72, WBH2S6, VD6N, WBH2S5, VD4N<br><br>The tributary of the Olifants River to the southeast of VDDC is likely to be impacted by drawdown caused by the mining activities and related dewatering on site (5-10m). | 20 – 50 |
| Proposed 2 Seam Dewatering Prior to Mine Development. | 2 | 0 | 25 000 $m^3$/d abstracted from total underground workings on average | Mechanical Evaporators | Borehole UB115 | 0-2 |

**Table 8.2.2.b: Summary of potential impacts during operation – contamination plume movement**

| Mining area | Potential impacted receptor | Estimated increase in concentrations during operation (mg/ℓ) | Contaminant |
|---|---|---|---|
| Overburden Dumps. | The Olifants River west of the opencast pit | 200-1 000 | $SO_4$ |
| Mixed ROM coal and slurry drying areas. | Old Vleishaft tributary which is now part of the dirty water system of the mine. | 200-1 000 | $SO_4$ |
| Final Rejects Dump (cumulative impact – existing authorised facility). | Boreholes DGMSB124, DGMSB123, DGMUB11, DGMUB114, P1, P2, P3, P4, DGMBB34, VD7N, VD8N and the Olifants River south of the opencast. | 200-1000 | $SO_4$ |
| Dragline Spoils. | Boreholes VD3NBH1, VD4N, VD6N, WBH2S5. | 200-1000 | $SO_4$ |
| Proposed Evaporators. | None. | - | $SO_4$ |
| Vleishaft Dam (cumulative impact – existing authorised facility). | Old Vleishaft tributary which is now part of the dirty water system of the mine. | 200-1 000 | $SO_4$ |
| 5Seam and 4Seam ROM Stockpiles | Old Vleishaft tributary which is now part of the dirty water system of the mine. | 200-1 000 | $SO_4$ |

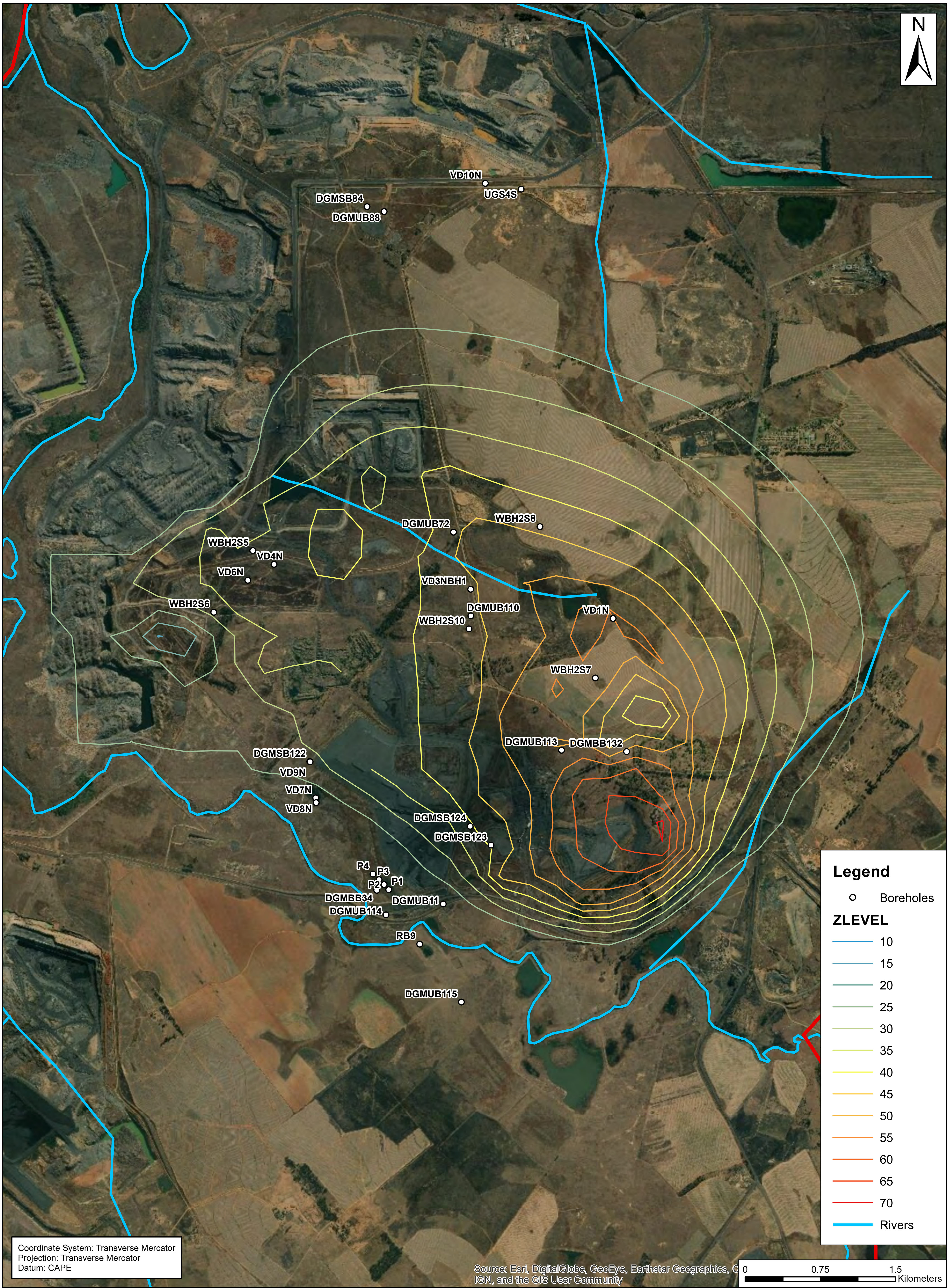


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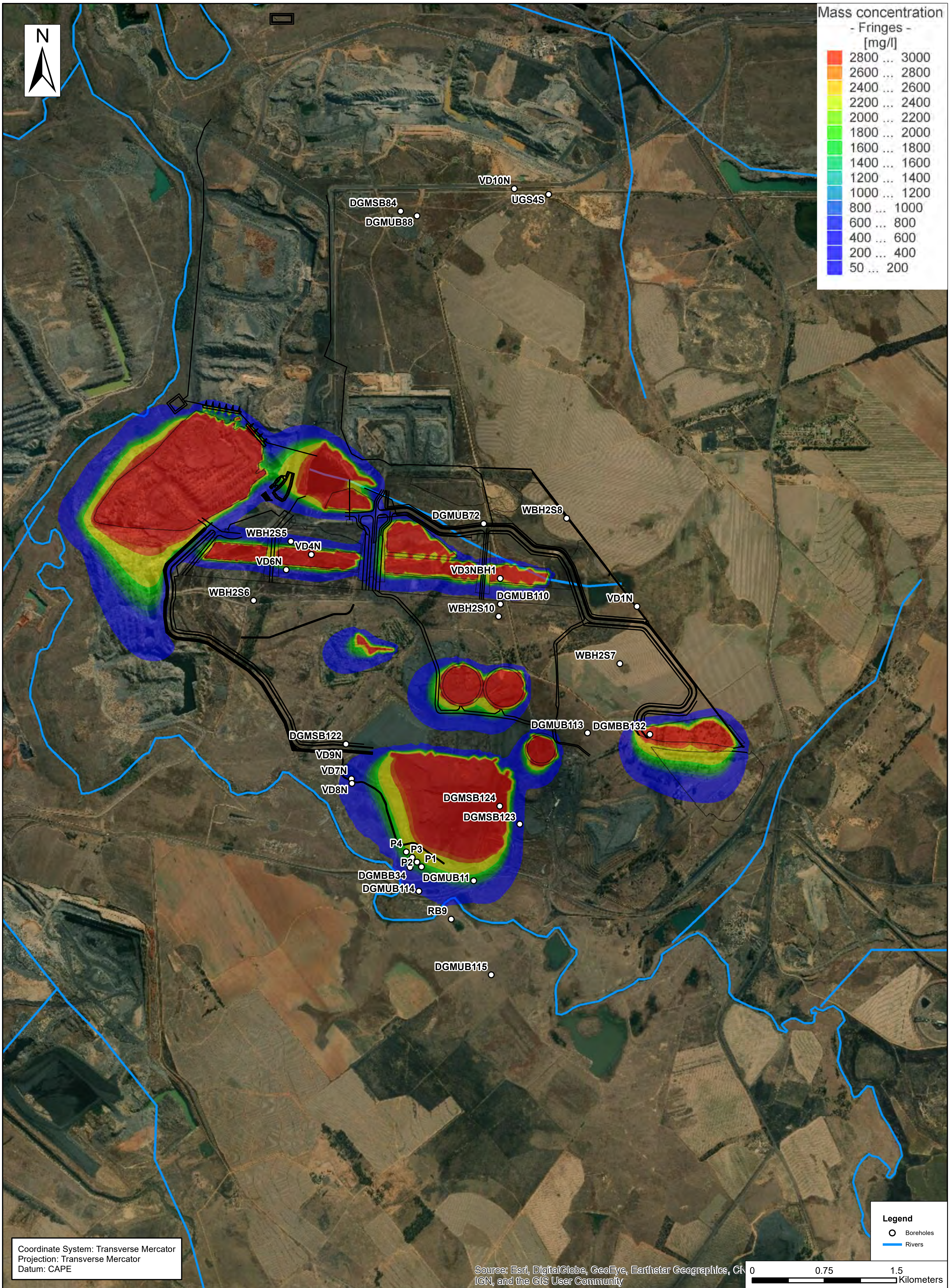
Figure 8.2.2.a

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Calculated Spread of Contamination During Mining

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Figure 8.2.2.b

## 8.3 Decommissioning Phase

During this phase it is assumed that dewatering of the opencast (including the opencast area which is additional to the mine layout in the 2007 approved EMPR Amendment) will cease, and it will be allowed to flood. The groundwater regime will return to a state of equilibrium once mining has stopped and the removal of water from the mining void has been discontinued.

The rise in groundwater level is predicted to be relatively quickly and the water levels are expected to recover in about 2-5 years. The quick recovery is ascribed to the elevated hydraulic conductivity of the surrounding bedrock due to historic mining activities as well as connections to surrounding defunct underground and opencast mines. The following possible impacts were identified at this stage:

- Following closure of the mine, the groundwater level will rise to an equilibrium that will differ from the pre-mining level due to the disturbance of the bedrock.
- Groundwater within the mined areas is expected to deteriorate due to chemical interactions between the geological material and the groundwater. The resulting groundwater pollution plume is expected to commence with downstream movement.
- Continued groundwater contamination is likely to be released from the waste storage facilities if not removed.

A summary of the potential impacts during the closure of the mine is shown in **Table 8.4.2.a.**

## 8.4 Post-Closure Phase

After closure, the water table will rise in the mine (including the opencast area which is additional to the approved mine layout in the 2007 approved EMPR Amendment) to reinstate equilibrium with the surrounding groundwater systems. However, the mined areas will have a large hydraulic conductivity compared to the pre-mining situation. Water recharge characteristics for coal mines in the area are summarised in **Table 8.4.a.**

**Table 8.4.a: Water recharge-characteristics for opencast mining in the Mpumalanga area (Hodgson and Krantz, 1998)[4]**

| Water Source | Water into opencast (% rainfall) | Suggested Mean value (% rainfall) |
|---|---|---|
| Rain onto ramps and voids | 20-100 | 70 |
| Rain onto not rehabilitated spoils | 30-80 | 60 |
| Rain onto levelled spoils (run-off) | 3-7 | 5 |
| Rain onto levelled spoils (Seepage) | 15-30 | 20 |
| Rain onto rehabilitated spoils (run-off) | 5-15 | 10 |
| Rain onto rehabilitated spoils (seepage) | 5-10 | 8 |
| | **(% of total pit water)** | **(% of total pit water)** |
| Surface run-off from pit surroundings | 5-15 | 6 |
| Groundwater seepage | 2-15 | 10 |

### 8.4.1 Groundwater Quantity

Following the closure of opencast mining (including the opencast area which is additional to the mine layout shown in the 2007 approved EMPR Amendment) and the cessation of the dewatering it is assumed to lead to groundwater rebound (**Figure 8.4.2.b**). This estimated rebound time in years for the opencast after cessation of pumping is shown in **Table 8.4.2.a.**

After rebound has reached equilibrium, decant has the potential to occur due to excessive rainfall and surface water run-off water entering the backfilled pit as well as the hydraulic parameters of the backfill material. The percentage of the rainfall/run-off that is recharged into the rehabilitated opencast and potential discharge depends on:

- The slope of the rehabilitated pit and its direct surroundings.
- The thickness and composition of the topsoil. i.e. clay content and compaction.
- The vegetation of the rehabilitation and its direct surroundings.
- The amount rainfall and intensity of the rainfall events.
- The size of the ramps and the final voids.

The predicted discharge areas are shown in **Figure 8.4.2.a.** Please note that predicted discharge areas may vary from exact discharge areas due to sub-surface heterogeneity, however the general areas of predicted discharge should be consistent. The calculated subsurface mine water movement resulting in decant will move through the south-eastern edge of the backfilled pit of VDDC (**Figure 8.4.2.a**). The calculated sub-surface decant elevation is approximately 1530 mamsl with a discharge volume of approximately 0.5 ℓ/s. The water level in the pit should be maintained approximately 5m below the sub-surface discharge elevation as a safe management level. Please note that this decant rate and elevation is based on the model that incorporates an intact geological barrier between the VDDC opencast and the SKS and Glencore backfilled pits to the west. This was communicated by South32 to J&W during a meeting held on 14 November 2018. The barrier between the SKS pit and the Glencore pit is

[4] Hodgson, F.D.I.; Krantz, R.M., (1998), "Groundwater Quality Deterioration in the Olifants River Catchment above the Loskop Dam with Specialised Investigations in the Witbank Dam Sub-Catchment", WRC Report no. 291/1/98.

believed to be compromised (**Figure 8.4.1.a**). Additionally, the decant value for SKS pit at the lowest point in the surface topography of the pit was calculated by J&W (2016) to reach a maximum volume of 18.5 ℓ/s at an elevation of 1510 mamsl.


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Barriers between SKS Pit, the Glencore Pit and the VDDC Pit

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Figure 8.4.1.a

## 8.4.2 Groundwater Quality

Once the normal groundwater flow conditions have been re-instated (**Figure 8.4.2.b**), polluted water could potentially migrate away from the mining area (including the opencast area which is additional to the mine layout shown in the 2007 approved EMPR Amendment) (**Figure 8.4.2.c**)

As some discards and exposed reactive mineral surfaces will remain in the mine, this outflow could be contaminated as a result of mine drainage. As sulfate is normally a significant solute in drainage from mines, sulfate concentration from the mine has been modelled as a conservative (non-reacting) indicator of mine drainage pollution. A starting concentration of 3 000 mg/ℓ has been assumed as a worst-case scenario based on the Jones & Wagener report of 2016. However, geological material is a transient contaminant source and decreases in the concentration of released contaminants are expected over time. A 1% decrease in contaminant concentrations in the mine were incorporated into the transport modelling[5]. This relates to sulfide mineral oxidation and dilution effects depleting the source of sulfate.

The migration of contaminated water from the mining area (including the opencast area which is additional to the mine layout shown in the 2007 approved EMPR Amendment) has been modelled as described, and the results are presented in **Figure 8.4.2.c** to **Figure 8.4.2.f** in terms of the extent of the pollution plume 10, 25, 50 and 100 years after the operations have ceased.

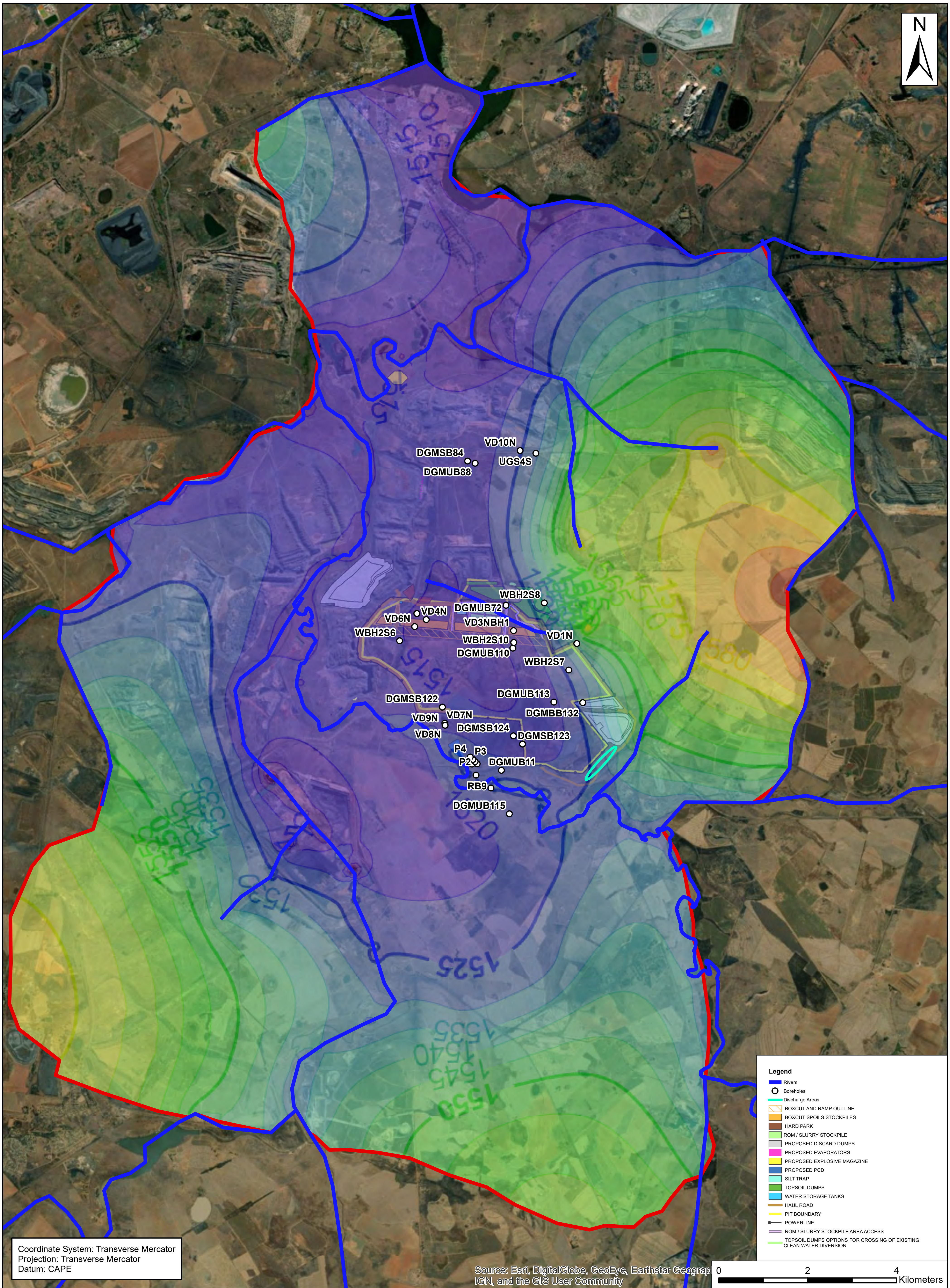
As stated previously, the results must be viewed with caution as a homogeneous aquifer has been assumed. Heterogeneities in the aquifer are unknown and the effect of this cannot be predicted. Furthermore, no chemical interaction of the leachate with the minerals in the surrounding bedrock has been assumed. As there must be some interaction and retardation of the plume, this calculation will therefore represent a worst-case scenario.

Within the limitations of the abovementioned assumptions, impacts have been estimated as listed in **Table 8.4.2.a**.

**Table 8.4.2.a: Summary of potential impacts post operations**

| Mining Area | Potential impacted receptor | Estimated increase in concentrations during closure (mg/ℓ) | Contaminant | Rebound Time in Years | Potential Discharge (Yes/No) | Potential Discharge Area |
|---|---|---|---|---|---|---|
| VDDC Opencast (including the opencast area which is additional to the mine layout shown in the 2007 approved EMPR Amendment) | Boreholes SB122-124, VD7N-9N, VD1N, WBH2S8, P1-P4, UB11, UB114 and the Olifantsriver and its tributaries | 200-2 000 | Sulfate | ±5 | Yes, sub-surface at approx. 1 530 mamsl and approx. 0.5 ℓ/s | Olifants River tributary to the south-east of the site via subsurface discharge |

[5] MACK, B. & SKOUSEN, J. 2008. Acidity Decay Curves of 40 Above Drainage Mines in West Virginia. *2008 National Ground Water Association Remediation of Abandoned Mines Conference.* Denver.

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Discharge Post-Mining

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Figure 8.4.2.a

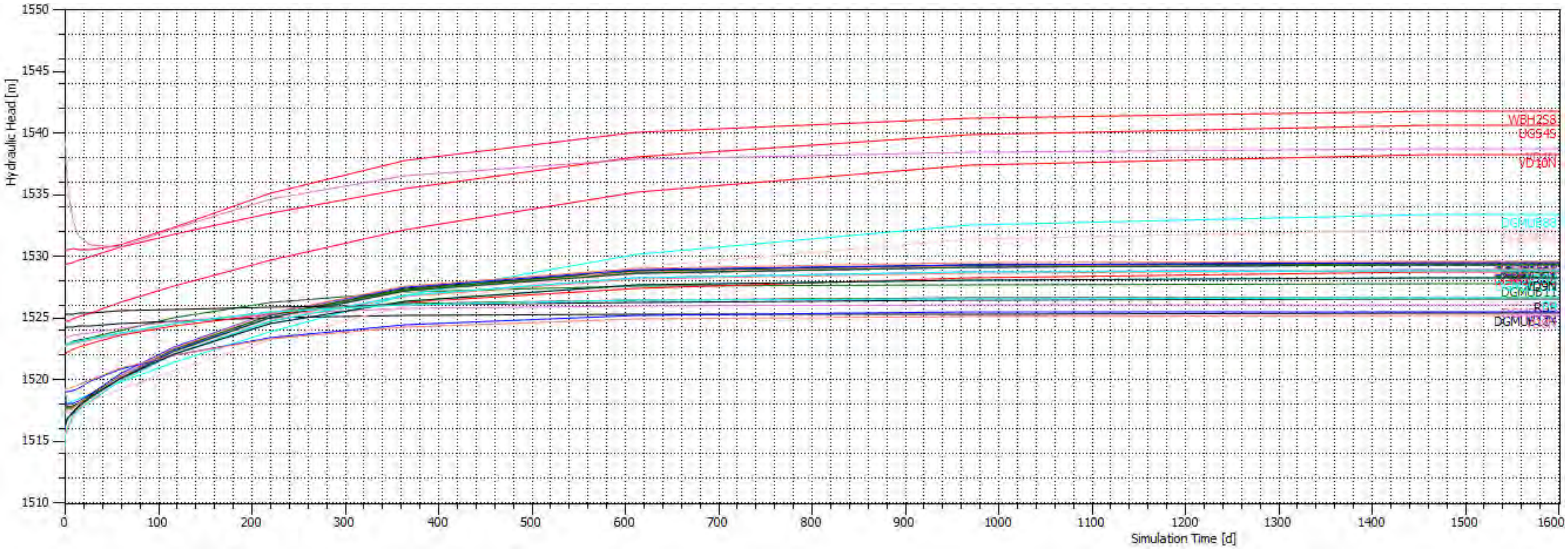
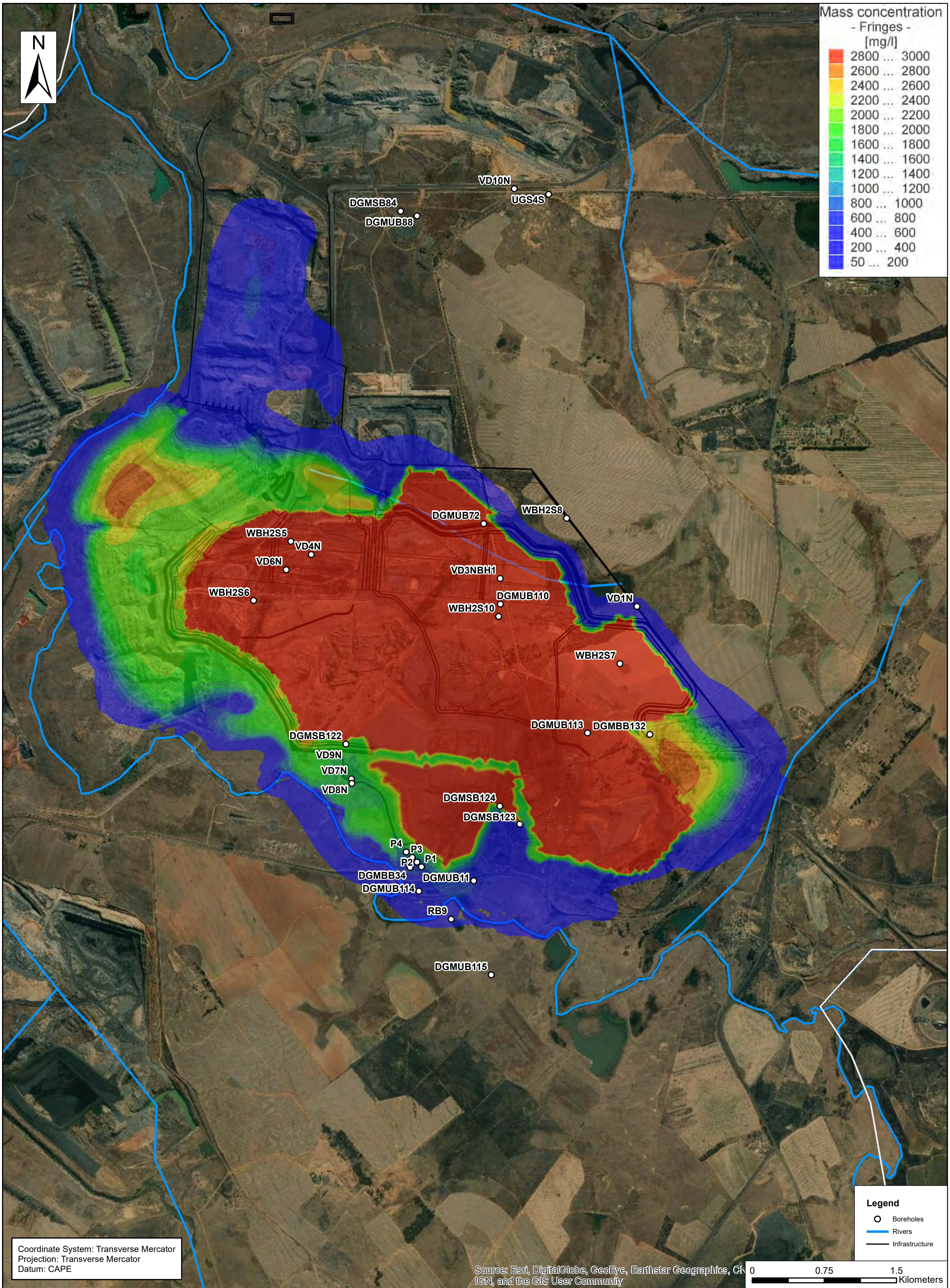



**Figure 8.4.2.b: Rebound Stage Curve Post-Mining**

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Calculated Spread of Contamination 10 Years Post Mining

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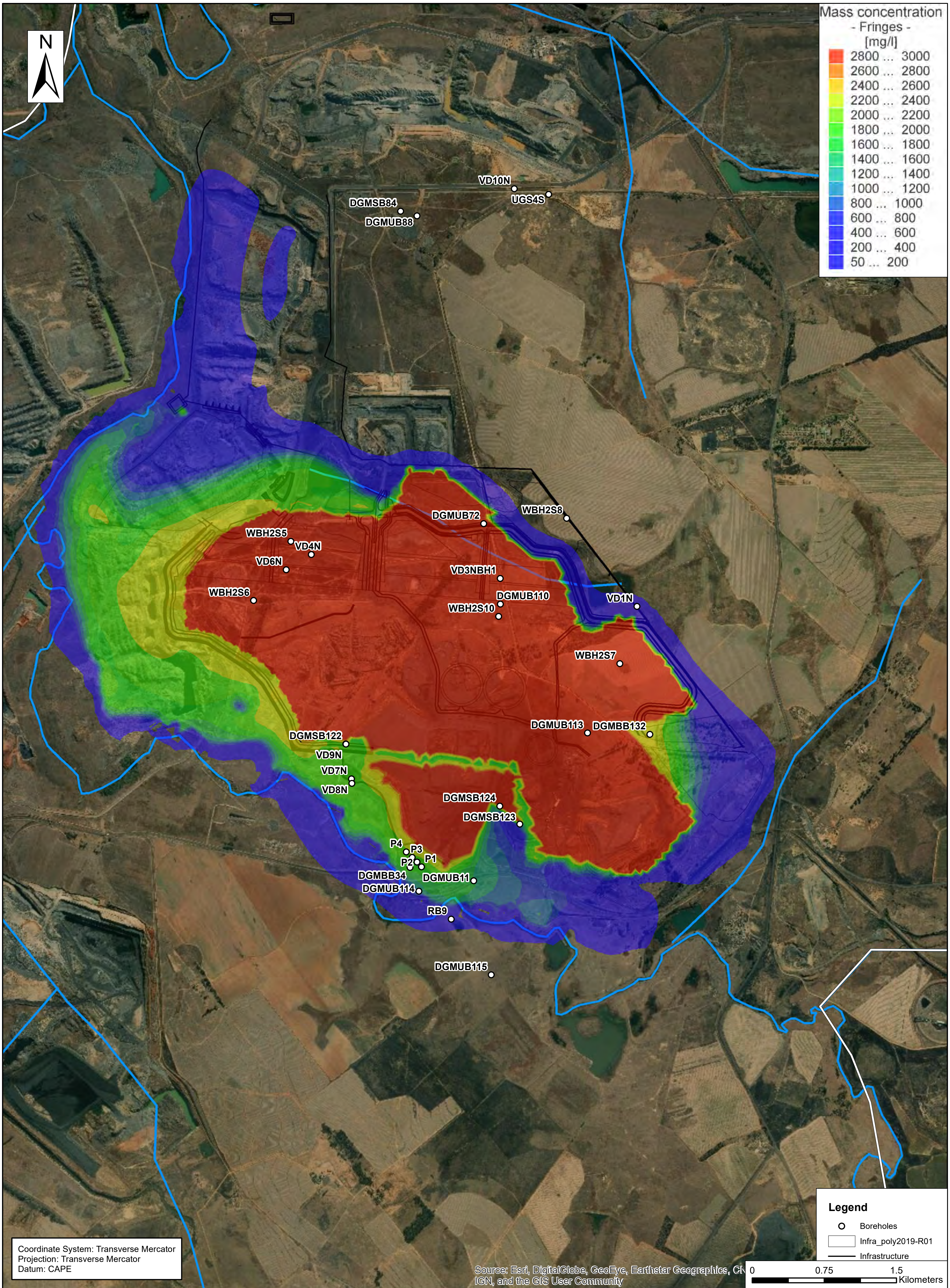
Figure 8.4.2.c

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Calculated Spread of Contamination 25 Years Post Mining

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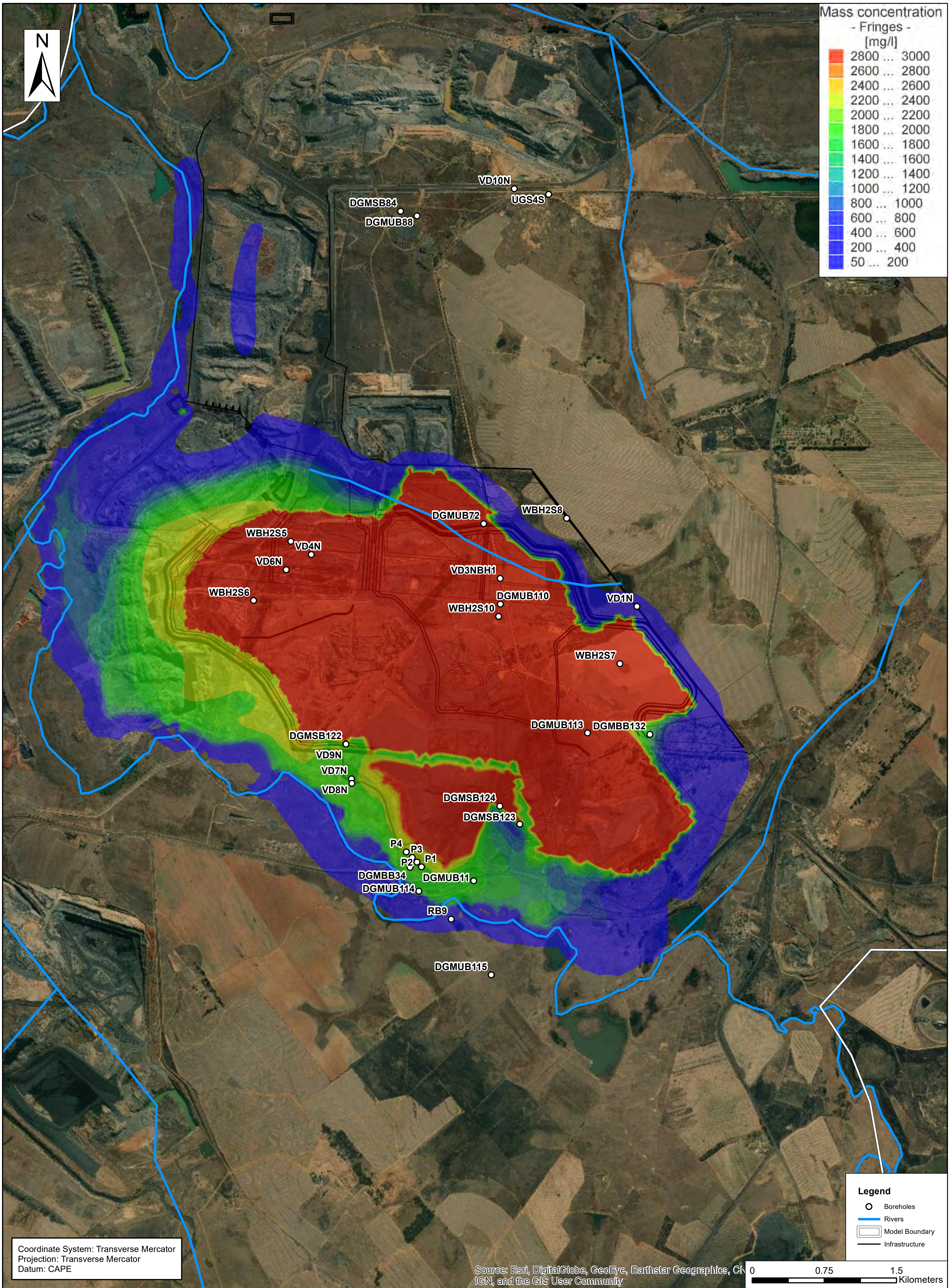
Figure 8.4.2.d

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Calculated Spread of Contamination 50 Years Post Mining

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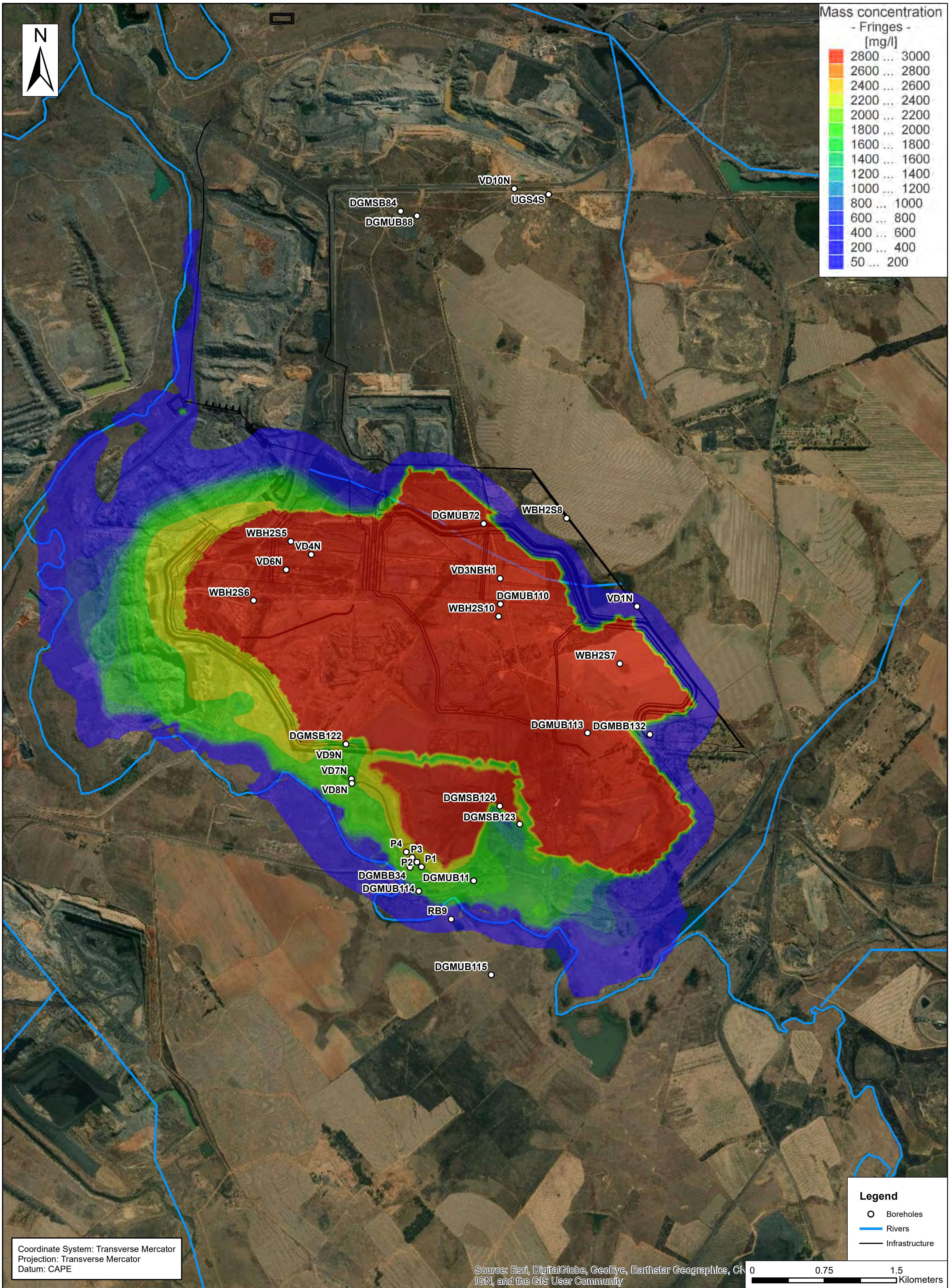
Figure 8.4.2.e

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Calculated Spread of Contamination 100 Years Post Mining

Job No: G535-04

Figure 8.4.2.f

### 8.4.3 Groundwater Management

- Update the numerical and geochemical model against monitored data during operations, every 5 years;
- AMD can be dealt with as follows;
  - Cover and capping design for the final rejects dump to reduce water and oxygen reactions;
  - Use overburden backfill in open pits;
  - Neutralisation (e.g. lime) and treatment (stimulation of sulfate reducing bacteria);
- Options for treatment of polluted groundwater post-closure include:
  - Reduce hydraulic head by water shedding and keeping the groundwater level in the backfilled pit below 1 530 mamsl until such time that the contamination plume has dissipated. The water level in the pit should be maintained approximately 5m below the sub-surface discharge elevation as a safe management level. The duration of contaminant generation should be estimated using a geochemical model;
  - Integrate capture store-release systems;
  - Utilise evapotranspiration;
  - Wetland filtration.

The post-closure groundwater management of the opencast should be done in two phases:

- Phase 1: Immediately after closure.
- Phase 2: After Rapid Flooding.

Please note that the numerical and geochemical model need to be updated against monitored data during the post-closure phase.

**Phase 1: Immediately after closure**

During mining the acid generating material and non-acid generating material should have been separated. The acid producing material should be placed as low in the pits as possible, followed by the non-acid generating material.

Rapid flooding should be done by diverting storm water channels and pumping of available groundwater into the pit until the acid producing material is inundated by the water.

**Phase 2: After Rapid Flooding**

After the acid producing material is inundated by the water:

- The final backfilled opencast topography should be engineered such that runoff is directed away from the mining areas.
- The final layer (just below the topsoil cover) should be as clayey as possible and compacted if feasible, to reduce recharge to the opencasts.
- Berms should then be constructed to allow free drainage of surface water around the rehabilitated pit.

# 9. GROUNDWATER MONITORING SYSTEM

## 9.1 Groundwater Monitoring Network

A groundwater monitoring system must adhere to the criteria mentioned below. As a result, the system should be developed accordingly.

### 9.1.1 Source, Plume, Impact and Background Monitoring

A groundwater monitoring network should contain monitoring positions which can assess the groundwater status at certain areas. The boreholes can be grouped classification according to the following purposes:

- Source monitoring: Monitoring boreholes are placed close to or in the source of contamination to evaluate the impact thereof on the groundwater chemistry.
- Plume monitoring: Monitoring boreholes are placed in the primary groundwater plume's migration path to evaluate the migration rates and chemical changes along the pathway.
- Impact monitoring: Monitoring of possible impacts of contaminated groundwater on sensitive ecosystems or other receptors. These monitoring points are also installed as early warning systems for contamination break-through at areas of concern.
- Background monitoring: Background groundwater quality is essential to evaluate the impact of a specific action/pollution source on the groundwater chemistry.

### 9.1.2 System Response Monitoring Network

**Groundwater levels:** The response of water levels to abstraction is monitored. Static water levels are also used to determine the flow direction and hydraulic gradient within an aquifer. Where possible all the above-mentioned borehole's water levels need to be recorded during each monitoring event.

### 9.1.3 Monitoring Frequency

In the operational phase and closure phase, quarterly monitoring of groundwater quality and groundwater levels is recommended. It is important to note that a groundwater-monitoring network should also be dynamic. This means that the network should be extended over time to accommodate the migration of potential contaminants through the aquifer as well as the expansion of infrastructure and/or addition of possible pollution sources.

## 9.2 Monitoring Parameters

The identification of the monitoring parameters is crucial and depends on the chemistry of possible pollution sources. They comprise a set of physical and/or chemical parameters (e.g. groundwater levels and predetermined organic and inorganic chemical constituents). Once a pollution indicator has been identified it can be used as a substitute to full analysis and therefore save costs. The use of pollution indicators should be validated on a regular basis in the different sampling positions. The parameters should be revised after each sampling event; some metals may be added to the analyses during the operational phase, especially if the pH drops.

***Physical Parameters:***

- Groundwater levels

***Chemical Parameters:***

- Field measurements:
  - pH, EC
- Laboratory analyses:
  - Anions and cations (Ca, Mg, Na, K, $NO_3$, Cl, $SO_4$, F, Fe, Mn, Al, & Alkalinity)
  - Other parameters (pH, EC, TDS)

## 9.3 Monitoring Boreholes

DWAF (1998) states that "A monitoring hole must be such that the section of the groundwater most likely to be polluted first, is suitably penetrated to ensure the most realistic monitoring result."[6]

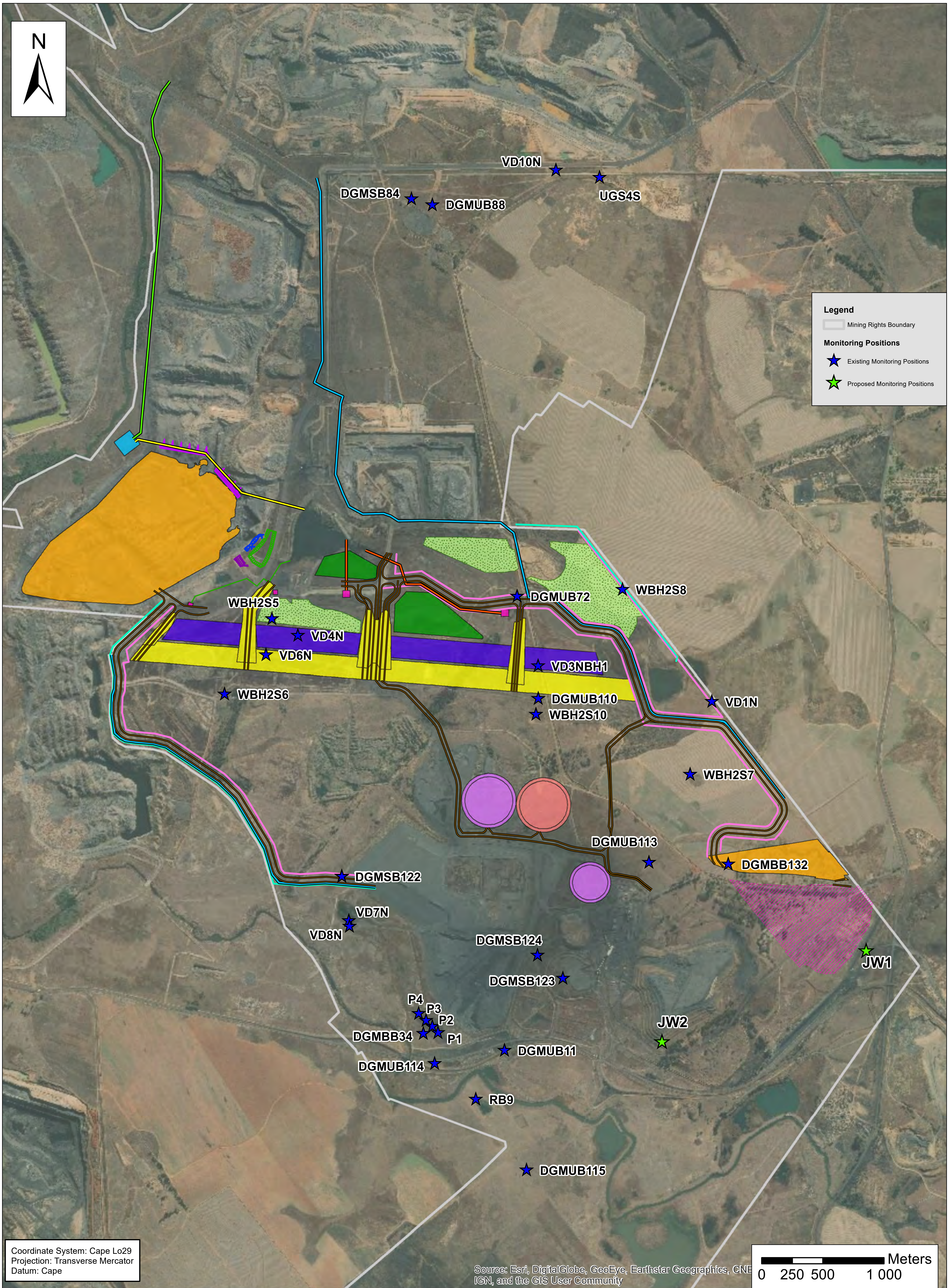
Currently a monitoring network does exist for VDDC. Future monitoring should as a minimum include the boreholes as listed in **Table 9.3.a** and the areas to site these monitoring boreholes are shown in **Figure 9.3.a**. Included in this list are proposed new boreholes JW1 and JW2 which should be sited by means of a geophysical survey. These boreholes can be utilised for water level monitoring during operations, as well as groundwater quality monitoring after decommissioning of the site. The depth of the proposed boreholes must be at least 40mbgl.

However, a monitoring network should be dynamic. This means that the network should be extended over time to accommodate the migration of contaminants through the aquifer as well as the expansion of infrastructure and/or addition of possible pollution sources. An audit on the monitoring network should be conducted annually.

[6] Department of Water Affairs and Forestry (DWAF). (1998). Minimum Requirements for the Water Monitoring at Waste Management Facilities. CTP Book Printers. Cape Town.

**Table 9.3.a: Proposed Monitoring Positions (New boreholes to be sited by geophysics)**

| ID | Longitude (East) | Latitude (South) | Owner | Property | Status | Category of borehole |
|---|---|---|---|---|---|---|
| WBH2S5 | 29.27697 | -26.0648 | South32 | VanDyksdrift | Existing | Source |
| WBH2S6 | 29.2731 | -26.0703 | South32 | VanDyksdrift | Existing | Source |
| WBH2S7 | 29.31118 | -26.0762 | South32 | VanDyksdrift | Existing | Source |
| WBH2S8 | 29.30562 | -26.0626 | South32 | VanDyksdrift | Existing | Source |
| WBH2S10 | 29.29857 | -26.0718 | South32 | VanDyksdrift | Existing | Source |
| UB11 | 29.29605 | -26.0966 | South32 | VanDyksdrift | Existing | Source |
| UB72 | 29.297 | -26.0631 | South32 | VanDyksdrift | Existing | Source |
| UB88 | 29.29 | -26.0342 | South32 | VanDyksdrift | Existing | Source |
| UB110 | 29.29875 | -26.0706 | South32 | VanDyksdrift | Existing | Source |
| UB113 | 29.30783 | -26.0827 | South32 | VanDyksdrift | Existing | Source |
| UB114 | 29.29035 | -26.0976 | South32 | VanDyksdrift | Existing | Source |
| UB115 | 29.29788 | -26.1054 | South32 | VanDyksdrift | Existing | Source |
| BB34 | 29.28942 | -26.0954 | South32 | VanDyksdrift | Existing | Source |
| BB132 | 29.31432 | -26.0828 | South32 | VanDyksdrift | Existing | Source |
| SB84 | 29.2883 | -26.0338 | South32 | VanDyksdrift | Existing | Source |
| SB122 | 29.28272 | -26.0838 | South32 | VanDyksdrift | Existing | Source |
| SB123 | 29.30082 | -26.0913 | South32 | VanDyksdrift | Existing | Source |
| SB124 | 29.29873 | -26.0896 | South32 | VanDyksdrift | Existing | Source |
| RB9 | 29.29372 | -26.1002 | South32 | VanDyksdrift | Existing | Source |
| UGS4S | 29.30366 | -26.0322 | South32 | VanDyksdrift | Existing | Source |
| VD1N | 29.31294 | -26.0708 | South32 | VanDyksdrift | Existing | Source |
| VD3N(BH1) | 29.29873 | -26.0682 | South32 | VanDyksdrift | Existing | Source |
| VD4N | 29.27909 | -26.066 | South32 | VanDyksdrift | Existing | Source |
| VD6N | 29.27649 | -26.0675 | South32 | VanDyksdrift | Existing | Source |
| VD7N | 29.28331 | -26.0871 | South32 | VanDyksdrift | Existing | Source |
| VD8N | 29.28336 | -26.0875 | South32 | VanDyksdrift | Existing | Source |
| VD9N | 29.28273 | -26.0838 | South32 | VanDyksdrift | Existing | Source |
| VD10N | 29.3001 | -26.0316 | South32 | VanDyksdrift | Existing | Source |
| P1 | 29.29062 | -26.0953 | South32 | VanDyksdrift | Existing | Source |
| P2 | 29.29015 | -26.0949 | South32 | VanDyksdrift | Existing | Source |
| P3 | 29.28964 | -26.0944 | South32 | VanDyksdrift | Existing | Source |
| P4 | 29.28903 | -26.0939 | South32 | VanDyksdrift | Existing | Source |
| DGM BB 127 | 29.25377 | -26.0596 | South32 | VanDyksdrift | Existing | Source |
| DGM BB 128 | 29.26257 | -26.0526 | South32 | VanDyksdrift | Existing | Source |
| **JW1** | **29.32561** | **-26.0892** | **South32** | **VanDyksdrift** | **New** | **Source** |
| **JW2** | **29.30893** | **-26.096** | **South32** | **VanDyksdrift** | **New** | **Source** |

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South32 SA Coal Holdings (Pty) Ltd
Vandyksdrift Central
Proposed Monitoring Network

Job No: G535-04

Figure 9.3.a

# 10. GROUNDWATER ENVIRONMENTAL MANAGEMENT PROGRAMME

The groundwater risk assessment methodology is based on defining and understanding the three basic components of the risk, i.e. the source of the risk (source term), the pathway along which the risk propagates, and finally the target that experiences the risk (receptor). The risk assessment approach is therefore aimed at describing and defining the relationship between cause and effect. In the absence of any one of the three components, it is possible to conclude that groundwater risk does not exist.

## 10.1 Current Groundwater Conditions

The current groundwater conditions at the site are described in the baseline section of the report.

## 10.2 Predicted Impacts of Mining

The predicted impacts of mining can be summarised as follows:

**During Mining – Water Quantity and Quality**

- VDDC Opencast is expected to receive maximum inflows of 265 $m^3$/d during mining if pre-mining dewatering is performed. The drawdown from this mine is expected to influence water levels in boreholes VD9N, DGMSB124, DGMSB123, DGMUB113, WBH2S7, VD1N, DGMUB110, WBH2S10, VD3NBH1, WBH2S8, DGMUB72, WBH2S6, VD6N, WBH2S5, VD4N as well as the tributary of the Olifants River to the southeast of VDDC. Expected water level decline at these receptors is expected to range between 20-60 m.
- Proposed 2 Seam dewatering prior to mine development is expected to abstract 25000 $m^3$/d. The drawdown from this mine dewatering is expected to influence water levels in borehole UB115. Expected water level decline at this receptor is expected to range between 0-2 m.
- Contamination from the Overburden Dump to the northwest of the opencast pit is expected to affect the Olifants River with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from Mixed ROM coal and slurry stockpile areas. is expected to affect the Old Vleishaft Tributary, which is now part of the dirty water system of the mine, with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from Final Rejects Dump is expected to affect Boreholes DGMSB124, DGMSB123, DGMUB11, DGMUB114, P1, P2, P3, P4, DGMBB34, VD7N, VD8N and the Olifants River to the south of the opencast with expected concentration increases of 200-1000 mg/L with regards to $SO_4$.
- Contamination from Vleishaft Dam is expected to affect the Old Vleishaft Tributary, which is now part of the dirty water system of the mine, with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from the Dragline Spoils is expected to affect Boreholes VD3NBH1, VD4N, VD6N, WBH2S5 with expected concentration increases of 200-1000 mg/L with regards to $SO_4$.

**Post-Mining – Water Quantity and Quality**

- Contamination from VDDC Opencast is expected to affect boreholes SB122-124, VD1N, VD7N-9N, WBH2S8, P1 -P4, UB11, UB114 and the Olifants River and its tributaries with expected sulfate concentration increases of 200-2 000 mg/ℓ. Groundwater levels in the VDDC Opencast area are expected to rebound within ±5 years. Decant from this mine is expected to take place at the Olifants River tributary to the south-east of the site via subsurface discharge at approximately 1 530 mamsl and approximately 0.5 ℓ/s.

## 10.3 Risk Assessment

In order to ensure uniformity, a standard impact assessment methodology is utilised so that a wide range of impacts can be compared. The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

A combined quantitative and qualitative methodology will be used to describe the impacts for each of the aforementioned assessment criteria. A summary of each of the qualitative descriptors along with the equivalent quantitative rating scale for each of the aforementioned criteria is given in **Table 10.3.a**.

**Table 10.3.a: Quantitative rating and equivalent descriptors for the impact assessment criteria.**

| RATING | SIGNIFICANCE | EXTENT SCALE | TEMPORAL SCALE |
|---|---|---|---|
| 1 | VERY LOW | *Isolated corridor / proposed corridor* | Incidental |
| 2 | LOW | *Study area* | Short-term |
| 3 | MODERATE | *Local* | Medium-term |
| 4 | HIGH | *Regional / Provincial* | Long-term |
| 5 | VERY HIGH | *Global / National* | Permanent |

A more detailed description of each of the assessment criteria is given in the following sections.

## 10.4 Significance Assessment

Significance rating (importance) of the associated impacts embraces the notion of extent and magnitude but does not always clearly define these since their importance in the rating scale is relative. For example, the magnitude (i.e. the size) of area affected by pollution may be large (100km$^2$) but the significance of this effect is dependent on the concentration or level of pollution. If the concentration is great, the significance of the impact would be HIGH or VERY HIGH, but if it is diluted it would be VERY LOW or LOW. A more detailed description of the impact significance rating scale is given in **Table 10.4.a** below.

**Table 10.4.a: Description of the significance rating scale.**

| RATING | | DESCRIPTION |
|---|---|---|
| 5 | VERY HIGH | Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit. |
| 4 | HIGH | Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these. |
| 3 | MODERATE | Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc. |
| 2 | LOW | Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these. |
| 1 | VERY LOW | Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale. |
| 0 | NO IMPACT | There is no impact at all - not even a very low impact on a party or system. |

## 10.5 Spatial Scale

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in **Table 10.5.a**.

**Table 10.5.a: Description of the significance rating scale.**

| RATING | | DESCRIPTION |
|---|---|---|
| 5 | Global/National | The maximum extent of any impact. |
| 4 | Regional/Provincial | The spatial scale is moderate within the bounds of impacts possible, and will be felt at a regional scale (District Municipality to Provincial Level). The impact will affect an area up to 50km from the proposed site / corridor. |
| 3 | Local | The impact will affect an area up to 5km from the proposed route corridor / site. |
| 2 | Study Area | The impact will affect a route corridor not exceeding the boundary of the corridor / site. |
| 1 | Isolated Sites / proposed site | The impact will affect an area no bigger than the corridor / site. |

## 10.6 Duration Scale

In order to accurately describe the impact, it is necessary to understand the duration and persistence of an impact in the environment. The temporal scale is rated according to criteria set out in **Table 10.6.a**.

**Table 10.6.a: Description of the temporal rating scale.**

| RATING | | DESCRIPTION |
|---|---|---|
| 1 | Incidental | The impact will be limited to isolated incidences that are expected to occur very sporadically. |
| 2 | Short-term | The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater. |
| 3 | Medium term | The environmental impact identified will operate for the duration of life of the project. |
| 4 | Long term | The environmental impact identified will operate beyond the life of operation. |
| 5 | Permanent | The environmental impact will be permanent. |

## 10.7 Degree of Probability

The probability or likelihood of an impact occurring will be described, as shown in **Table 10.7.a** below.

**Table 10.7.a: Description of the degree of probability of an impact occurring.**

| RATING | DESCRIPTION |
|---|---|
| 1 | Practically impossible |
| 2 | Unlikely |
| 3 | Could happen |
| 4 | Very Likely |
| 5 | It's going to happen / has occurred |

## 10.8 Degree of Certainty

As with all studies it is not possible to be 100% certain of all facts, and for this reason a standard "degree of certainty" scale is used as discussed in **Table 10.8.a**. The level of detail for specialist studies is determined according to the degree of certainty required for decision-making. The impacts are discussed in terms of affected parties or environmental components.

**Table 10.8.a: Description of the degree of certainty rating scale.**

| RATING | DESCRIPTION |
|---|---|
| Definite | More than 90% sure of a particular fact. |
| Probable | Between 70 and 90% sure of a particular fact, or of the likelihood of that impact occurring. |
| Possible | Between 40 and 70% sure of a particular fact, or of the likelihood of an impact occurring. |
| Unsure | Less than 40% sure of a particular fact or the likelihood of an impact occurring. |
| Can't know | The consultant believes an assessment is not possible even with additional research. |

## 10.9 Quantitative Description of Impacts

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus, the total value of the impact is described as the function of significance, spatial and temporal scale as described below.

$$\textbf{Impact Risk} = \frac{(\text{Significance} + \text{Spatial} + \text{Temporal})}{3} \times \frac{\text{Probability}}{5}$$

An example of how this rating scale is applied is shown in **Table 10.9.a**.

**Table 10.9.a: Example of Rating Scale.**

| IMPACT | SIGNIFICANCE | SPATIAL SCALE | TEMPORAL SCALE | PROBABILITY | RATING |
|---|---|---|---|---|---|
| | **Low** | **Local** | **Medium Term** | **Could Happen** | |
| Impact to groundwater | 2 | 3 | 3 | 3 | 1.6 |

*Note: The significance, spatial and temporal scales are added to give a total of 8, that is divided by 3 to give a criteria rating of 2,67. The probability (3) is divided by 5 to give a probability rating of 0,6. The criteria rating of 2,67 is then multiplied by the probability rating (0,6) to give the final rating of 1,6.*

The impact risk is classified according to 5 classes as described in **Table 10.9.b**.

**Table 10.9.b: Impact Risk Classes.**

| RATING | IMPACT CLASS | DESCRIPTION |
|---|---|---|
| 0.1 – 1.0 | 1 | Very Low |
| 1.1 – 2.0 | 2 | Low |
| 2.1 – 3.0 | 3 | Moderate |
| 3.1 – 4.0 | 4 | High |
| 4.1 – 5.0 | 5 | Very High |

Therefore, with reference to the example used, an impact rating of 1.6 will fall in the Impact Class 2, which will be considered to be a low impact.

**Table 10.9.c: Impact ratings for groundwater during mining**

| Activity | Aspect | Impact | Mitigation | Criteria | Rating prior to project (Initial Impact) | | Rating prior to mitigation (Additional Impact) | | Cumulative rating | | Rating post mitigation (Residual Impact) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **During Mining** | | | | | | | | | | | | |
| **Opencast Mining (including the opencast area which is additional to the mine layout in the 2007 approved EMPR Amendment)** | Lowering of Water Levels During Mining | **NEGATIVE IMPACT:**<br>Surrounding water users may experience a decrease in available volumes such as baseflow to rivers and borehole abstraction availability | Clean and dirty water systems should be separated as planned.<br>Groundwater monitoring boreholes should be sited at designated positions based on infrastructure layout, to comply with the design requirements of a groundwater monitoring system, as recommended.<br>Monitor static groundwater levels on a quarterly basis in all boreholes within a zone of one kilometre surrounding the mine to ensure that any deviation of the groundwater flow from the idealised predictions is detected in time and can be reacted on appropriately.<br>If surface water monitoring shows that the Olifants River or its tributaries are affected by mine dewatering, discharge of clean water into the tributaries should be considered. Timing and volumes should be determined by a surface water specialist.<br>The monitoring results must be interpreted annually by a qualified hydrogeologist and the monitoring network should be audited every 5 years.<br>The numerical model should be updated every 5 years during operation of the opencast by using the measured inflows, water levels and any potential future drilling and pump test information to re-calibrate and refine the impact prediction.<br>Dewatering and groundwater abstraction for mining purposes should be monitored so as to prevent negative impacts on the underlying aquifer.<br>Areas in the opencast where the defunct underground is intersected could be sealed with blasted overburden with engineered designs to limit groundwater ingress. | Significance | 2 | **Very Low** | 3 | **Moderate** | 3 | **Moderate** | 2 | **Very Low** |
| | | | | Spatial | 1 | | 3 | | 3 | | 1 | |
| | | | | Temporal | 1 | | 3 | | 3 | | 1 | |
| | | | | Probability | 1 | | 4 | | 4 | | 1 | |

| Activity | Aspect | Impact | Mitigation | Criteria | Rating prior to project (Initial Impact) | | Rating prior to mitigation (Additional Impact) | | Cumulative rating | | Rating post mitigation (Residual Impact) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **During Mining** | | | | | | | | | | | | |
| **Opencast Mining and Associated Waste Storage** | Waste Rock Dumps and Dragline Spoils | **NEGATIVE IMPACT:** | The overburden dump to the southeast of the opencast must be lined with, at least, a compacted clay to prevent contamination from entering the aquifer system. Groundwater monitoring must be instituted upgradient and downgradient of these facilities to monitor and intercept any potential contamination timeously. | Significance | 1 | **Very Low** | 4 | **Moderate** | 4 | **Moderate** | 3 | **Very Low** |
| | Mixed ROM and slurry areas | Surrounding water users may experience a decline in quality of baseflow to rivers and water abstracted from boreholes | Mixed ROM coal and Slurry Stockpiles must be lined to minimise contaminant infiltration to the aquifer system. Groundwater monitoring must be instituted upstream and downstream of these facilities to monitor and intercept any potential contamination timeously. | | | | | | | | | |
| | Mechanical evaporators | | Evaporation sprayers are likely to cause significant contaminant build-up over time at the selected discharge points. However, this contamination is likely to be similar to the geochemical nature of backfill material where the sprayers will be constructed. Modelling indicates no impact to sensitive receptors and it is likely that mobilised contamination will move into the VDDC opencast. No actions are therefore required in the vicinity of the sprayers during mining except occasional removal of salt build-up and disposal at an appropriate facility. | | | | | | | | | |
| | Final Rejects Dump and 5 Seam and 4 Seam Stockpiles | | Groundwater monitoring must be instituted upgradient and downgradient of these facilities to monitor and intercept any potential contamination timeously. | Spatial | 1 | | 2 | | 2 | | 2 | |
| | | | | Temporal | 1 | | 4 | | 4 | | 3 | |

| Activity | Aspect | Impact | Mitigation | Criteria | Rating prior to project (Initial Impact) | | Rating prior to mitigation (Additional Impact) | | Cumulative rating | | Rating post mitigation (Residual Impact) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **During Mining** | | | | | | | | | | | | |
| | Vleishaft Dam | | Groundwater monitoring must be instituted upstream and downstream of these facilities to monitor and intercept any potential contamination timeously. | Probability | 1 | | 4 | | 4 | | 2 | |

## Table 10.9.d: Impact ratings for groundwater post-mining

| Activity | Aspect | Impact | Mitigation | Criteria | Rating prior to project (Initial Impact) | | Rating prior to mitigation (Additional Impact) | | Cumulative rating | | Rating post mitigation (Residual Impact) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Post-Mining** | | | | | | | | | | | | |
| **Opencast Mining and Associated Waste Storage (including the opencast area which is additional to the mine layout in the 2007 approved EMPR Amendment)** | Discharge of Contaminated Mine Water After Mining | **NEGATIVE IMPACT:** Contaminated water may impact surrounding watercourses | Following mine closure and rehabilitation of the pit, the backfill will form an artificial aquifer which is likely to discharge. A decant management plan should be developed and should include measures such as the containment of seepage or discharge water in appropriate facilities. All sulfate containing waste material should be stored at the bottom of the opencast and should be left to be flooded as soon as possible to exclude oxygen. A discharge management plan must be developed which may include passive or active treatment options. Backfill material should be compacted and surface water flow should be routed around the backfilled opencast to reduce recharge to a maximal extent. Groundwater monitoring boreholes should be sited at designated positions based on mining layout, to comply with the design requirements of a groundwater monitoring system, as recommended. The monitoring results must be interpreted annually by a qualified hydrogeologist and the monitoring network should be audited every 5 years to ensure compliance with regulations. The water level in the backfilled opencast should be controlled by pumping to not exceed 1530mamsl to prevent decant. The water level in the pit should be maintained approximately 5m below the sub-surface discharge elevation as a safe management level. Alternatively, an interception trench must be constructed to capture contaminated subsurface seepage. | Significance | 1 | **Very Low** | 4 | **Moderate** | 4 | **Moderate** | 2 | **Very Low** |
| | | | | Spatial | 1 | | 2 | | 2 | | 1 | |
| | | | | Temporal | 1 | | 5 | | 5 | | 1 | |
| | | | | Probability | 1 | | 4 | | 4 | | 2 | |
| **Opencast Mining and Associated Waste Storage** | Waste Rock Dumps and Dragline Spoils | **NEGATIVE IMPACT:** | It is assumed that overburden dumps and dragline spoils will be deposited in the VDDC opencast as part of backfill material, thereby removing these source terms. | Significance | 1 | **Very Low** | 4 | **Moderate** | 4 | **Moderate** | 3 | **Very Low** |
| | Mixed ROM and slurry areas | Surrounding water users may experience a decline in quality of baseflow to rivers and water abstracted from boreholes | It is assumed that the Mixed ROM coal and Slurry stockpile areas will be removed after mining, thereby removing this source term. | | | | | | | | | |
| | Mechanical evaporators | | It is assumed that the evaporation sprayers will be removed after mining and any salt build-up caused will be removed. | | | | | | | | | |
| | Final Rejects Dump and 5 Seam and 4 Seam Stockpiles | | It is assumed that the 5 Seam and 4 Seam ROM Stockpiles will be removed after mining, thereby removing these source terms. Monitoring and contaminated seepage management must be maintained at the final rejects dump to minimise contamination of groundwater. Capping of this facility must also be implemented. | Spatial | 1 | | 3 | | 3 | | 2 | |
| | | | | Temporal | 1 | | 4 | | 4 | | 4 | |
| | Vleishaft Dam | | It is assumed that the Vleishaft Dam will be decommissioned and removed after mining, thereby removing this source term. | Probability | 1 | | 4 | | 4 | | 1 | |

## 11. CONCLUSION AND RECOMMENDATIONS

A hydrogeological assessment was undertaken at VDDC to determine the potential impact associated with the development of the proposed additional infrastructure associated with the opencast mining of the remaining coal pillars. Additional to the above infrastructure was the identification of an opencast mining area within the final VDDC mine layout not included in the approved mine layout as per the 2007 approved EMPR Amendment.

A hydrocensus was undertaken in 2018 by J&W on the entire VDDC footprint to record the local and regional static groundwater levels. A total of 35 boreholes were identified and were used in the calibration of the numerical groundwater model. The average depth to groundwater level for the study area was calculated to be 8.4 mbs when the boreholes drilled into the underground workings are not considered. When the underground workings boreholes are included the average depth increases to 25.8 mbs.

Electrical conductivity (EC) profiles were also performed on selected boreholes during the hydrocensus. As expected, boreholes that intersect the mine workings and those that are located downstream of the PSS Dump had elevated EC levels.

A three-dimensional numerical model was setup for three main simulated scenarios i.e. predevelopment phase or baseline scenario, operational phase and post mining or closure phase.

The **operational phase** modelling included the following transport and dewatering scenarios:

**Transport**

- Overburden Dumps.
- Mixed ROM coal and slurry drying areas.
- Final Rejects Dump (cumulative impact – existing authorised facility).
- Dragline Spoils.
- Proposed Evaporators.
- Vleishaft Dam (cumulative impact – existing authorised facility).
- 5Seam and 4Seam ROM Stockpiles.

**Dewatering**

- Proposed VDDC Opencast Mine (including the opencast mining area which is additional to the mine layout in the 2007 approved EMPR Amendment) and proposed 2 seam dewatering prior to mine development.

The **closure phase** modelling included the following transport and dewatering scenarios:

**Transport**

- Backfilled Opencast Mine, existing Final Rejects Dump

**Discharge**

- Backfilled Opencast Mine (including the opencast mining area which is additional to the mine layout in the 2007 approved EMPR Amendment).

***Operational phase impacts***

- VDDC Opencast is expected to receive maximum inflows of 265 $m^3$/d during mining if pre-mining dewatering is performed. The drawdown from this mine is expected to influence water levels in boreholes VD9N, DGMSB124, DGMSB123, DGMUB113, WBH2S7, VD1N, DGMUB110, WBH2S10, VD3NBH1, WBH2S8, DGMUB72, WBH2S6, VD6N, WBH2S5, VD4N as well as the tributary of the Olifants River to the southeast of VDDC. Expected water level decline at these receptors is expected to range between 20-60 m.
- Proposed 2 Seam dewatering prior to mine development is expected to abstract 25000 $m^3$/d. The drawdown from this mine dewatering is expected to influence water levels in borehole UB115. Expected water level decline at this receptor is expected to range between 0-2 m.
- Contamination from the Overburden Dump to the northwest of the opencast pit is expected to affect the Olifants River with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from Mixed ROM coal and slurry stockpile areas. is expected to affect the Old Vleishaft Tributary, which is now part of the dirty water system of the mine, with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from Final Rejects Dump is expected to affect Boreholes DGMSB124, DGMSB123, DGMUB11, DGMUB114, P1, P2, P3, P4, DGMBB34, VD7N, VD8N and the Olifants River to the south of the opencast with expected concentration increases of 200-1000 mg/L with regards to $SO_4$.
- Contamination from Vleishaft Dam is expected to affect the Old Vleishaft Tributary, which is now part of the dirty water system of the mine, with expected concentration increases of 200-1 000 mg/L with regards to $SO_4$.
- Contamination from the Dragline Spoils is expected to affect Boreholes VD3NBH1, VD4N, VD6N, WBH2S5 with expected concentration increases of 200-1000 mg/L with regards to $SO_4$.

***Decommissioning and closure phase impacts***

Contamination from VDDC Opencast is expected to affect boreholes SB122-124, VD1N, VD7N-9N, WBH2S8, P1 -P4, UB11, UB114 and the Olifants River and its tributaries with expected sulfate concentration increases of 200-2 000 mg/ℓ. Groundwater levels in the VDDC Opencast area are expected to rebound within ±5 years. Decant from this mine is expected to take place at the Olifants River tributary to the south-east of the site via subsurface discharge at approximately 1 530 mamsl and approximately 0.5 ℓ/s.

***Management of identified impacts during mining***

- Clean and dirty water systems should be separated as planned.
- Groundwater monitoring boreholes should be sited at designated positions based on infrastructure layout, to comply with the design requirements of a groundwater monitoring system, as recommended.
- If surface water monitoring shows that the Olifants River or its tributaries are affected by mine dewatering, discharge of clean water into the tributaries should be considered.
- The numerical model should be updated during operation of the opencast mine by using the measured inflows, water levels and any potential future drilling and pump test information to re-calibrate and refine the impact prediction.

- Dewatering and groundwater abstraction for mining purposes should be monitored so as to prevent negative impacts on the underlying aquifer.
- Areas in the opencast where the defunct underground is intersected could be sealed with blasted overburden with engineered designs to limit groundwater ingress.
- Since the contamination from the mechanical evaporators is likely to be similar to the geochemical nature of backfill material where the sprayers will be constructed, no impact to sensitive receptors is expected. It is likely that mobilised contamination will move into the VDDC opencast.
- The Mixed ROM coal and Slurry Stockpiles, proposed waste rock dumps and dragline spoils and Vleishaft Dam must all be lined to prevent any contamination from entering the aquifer system. Groundwater monitoring must be instituted upstream and downstream of these facilities to monitor and intercept any potential contamination timeously. Waste rock dumps and the dragline spoils must be lined with, at least, a compacted clay to prevent contamination from entering the aquifer system.

***Management of identified impacts after mining***

- Following mine closure and rehabilitation of the pit, the backfill will form an artificial aquifer which is likely to discharge. The water level in the backfilled opencast should be controlled by pumping to not exceed 1530mamsl to prevent decant. The water level in the pit should be maintained approximately 5m below the sub-surface discharge elevation as a safe management level. Alternatively, an interception trench must be constructed to capture contaminated subsurface seepage.
- All sulfate containing waste material should be stored at the bottom of the opencast and flooded as soon as possible to exclude oxygen.
- A discharge management plan must be developed which may include passive or active treatment options.
- Backfill material should be compacted and surface water flow should be routed around the backfilled opencast to reduce recharge to a maximal extent.
- It is assumed that the dragline spoils and overburden dumps will be deposited in the VDDC opencast as part of backfill material and that the Mixed ROM coal and slurry stockpile areas will all be removed either during or after mining thereby removing these source terms. It is considered likely that Vleishaft Dam will be removed after mining has ceased, thereby also removing this source. Groundwater monitoring at the final rejects dump must be maintained and contaminated seepage management implemented. Capping of this facility will also be mandatory.

***Specialist Statement***

Based on the information provided and the current and potential future impacts at the site, it is recommended that the project is approved from a hydrogeological perspective. All proposed mitigation measures must be implemented for the project to continue with minimal additional impacts to groundwater.

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for Jones & Wagener

16 September 2019
*Document source: https://joneswagener.sharepoint.com/JonesWagenerProjects/G535VDDCIRP/Shared Documents/PRJ/Geohydro Study/REP/G535-300/G535-300_REP_revD_ahthcni_VDDC_HydrogeologicalStudy_20190925.docx*
*Document template*

# APPENDIX A

## C1 – WATER QUALITY DATA

## C2 – EC PROFILES

# APPENDIX B

## NEMA APPENDIX 6 REQUIREMENTS

| GNR 326 | Description | |
|---|---|---|
| Appendix 6 (a) | A specialist report prepared in terms of these Regulations must contain— details of— the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a curriculum vitae; | Included |
| Appendix 6 (b) | A declaration that the specialist is independent in a form as may be specified by the competent authority; | Page ii |
| Appendix 6 (c) | An indication of the scope of, and the purpose for which, the report was prepared; | Section 1.2 |
| Appendix 6 (cA) | An indication of the quality and age of base data used for the specialist report; | Sections 3.1, 5, |
| Appendix 6 (cB) | A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change; | Sections 5, 6, 8 |
| Appendix 6 (d) | The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment; | Section 8 |
| Appendix 6 (e) | A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used; | Sections 3, 4, 5, 7 |
| Appendix 6 (f) | Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives; | Section 10 |
| Appendix 6 (g) | An identification of any areas to be avoided, including buffers; | Section 10 |
| Appendix 6 (h) | A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers; | Section 8 |
| Appendix 6 (i) | A description of any assumptions made and any uncertainties or gaps in knowledge; | Section 7 |
| Appendix 6 (j) | A description of the findings and potential implications of such findings on the impact of the proposed activity or activities; | Section 8, 10 |
| Appendix 6 (k) | Any mitigation measures for inclusion in the EMPr; | Section 10 |
| Appendix 6 (l) | Any conditions for inclusion in the environmental authorisation; | Section 10 |
| Appendix 6 (m) | Any monitoring requirements for inclusion in the EMPr or environmental authorisation; | Section 9, 10 |
| Appendix 6 (n) | A reasoned opinion –<br>• whether the proposed activity, activities or portions thereof should be authorised;<br>• regarding the acceptability of the proposed activity or activities; and<br>• if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan; | Section 10, 11 |
| Appendix 6 (o) | A description of any consultation process that was undertaken during the course of preparing the specialist report; | N/A |
| Appendix 6 (p) | A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and | N/A |
| Appendix 6 (q) | Any other information requested by the competent authority. | N/A |

# APPENDIX A1:

Water Quality Data

## SOUTH 32 - ADDITIONAL SAMPLING WUL

### SKS WUL - GROUNDWATERS

| QUALITY: 11 LAB REF NO: SOU /341 - 351 / D / 01 / 18 | | D 341 | D 342 | D 343 | D 344 | D 345 | D 346 | D 347 | D 348 | D 349 | D 350 | D 351 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | | WVK | WVK | WVK | WVK | WVK | WVK | WVK | WVK | WVK | WVK | WVK |
| Reason for sampling | | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements | NOT WUL Requirements |
| SAMPLE DESCRIPTION | | 2623 WBH 2S1 | 2626 WBH 2S5 | 2627 WBH 2S6 | 2628 WBH 2S7 | 2629 WBH 2S8 | 2631 WBH 2S10 | SKS BH1 (is this for the underground borehole) | WVK 3 | NDB 2 | NDB 3 | NDB 6 |
| Co - Ordinates | | S26°02.104' EO29°17.742' | S26°03.887' EO29°16.618' | S26°04.220' EO29°16.384' | S26°04.571' EO29°18.673' | S26°03.754' EO29°18.336' | S26°04.306' EO29°17.917' | S26°02'292 E29°18'105 | S26°02.098 E029°17.731 | S26°02'802 E029°16'997 | S26°02.504 E029°17'650 | S26°02'628 E029°17'168 |
| DATE RECEIVED: | | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 | 23-Jan-2018 |
| Sampler: Mbulelo & Albert | | | | | | | | | | | | |
| TIME OF SAMPLING | | 13:02 | 10:19 | 10:02 | 14:02 | 13:43 | 10:37 | 13:30 | 13:02 | 11:27 | 12:51 | 11:42 |
| WATER LEVEL | | 60.74 | 42.72 | 45.7 | 68.47 | 65.88 | 20:09 | 26.8 | 13:15 | 48.88 | 2.41 | 57.6 |
| *ANALYSIS RESULTS in mg/l* | Test Method | | | | | | | | | | | |
| pH Value at 25°C | LPM 51 / 82 | 7.04 | 6.88 | 7.78 | 7.58 | 7.35 | 7.31 | 3.19 | 6.55 | 5.81 | 6.08 | 7.10 |
| Conductivity in mS/m | LPM 51 / 82 | 39.7 | 22.4 | 45.5 | 64.8 | 18.9 | 15.1 | 140 | 22.7 | 9.73 | 42.2 | 430 |
| Total Dissolved Solids | LPM 2 | 252 | 116 | 278 | 424 | 104 | 82 | 956 | 148 | 64 | 286 | 4206 |
| Suspended Solids | LPM 1 | 20.4 | 3.60 | 7.60 | 29.2 | 298 | 193 | 420 | 1161 | 1861 | 118 | 722 |
| Iron as Fe | LPM 15 | <0.01 | <0.01 | 0.01 | 0.04 | <0.01 | 0.01 | 2.06 | <0.01 | 0.31 | 0.01 | <0.01 |
| Total Acidity as $CaCO_3$ to pH 8.3 | LPM 35 /81 | 4.50 | 3.40 | <2.0 | <2.0 | 3.20 | 2.90 | 93.0 | 5.50 | 6.70 | 4.40 | 12.0 |
| Total Alkalinity as $CaCO_3$ | LPM 11 /81 | 34 | 24 | 184 | 137 | 60 | 52 | Nil | 17 | 8 | 7 | 213 |
| Bicarbonate Alkalinity $HCO_3$ as $CaCO_3$ | LPM 11 /81 | 34 | 24 | 184 | 137 | 60 | 52 | Nil | 17 | 8 | 7 | 213 |
| Carbonate Alkalinity $CO_3$ as $CaCO_3$ | LPM 11 /81 | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| M Alkalinity | LPM 11 /81 | 34 | 24 | 184 | 137 | 60 | 52 | Nil | 17 | 8 | 7 | 213 |
| P Alkalinity | LPM 11 /81 | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Total Hardness as $CaCO_3$ | LPM 85 | 134 | 26 | 77 | 186 | 55 | 22 | 603 | 69 | 24 | 120 | 2999 |
| Turbidity as N.T.U | LPM 23 / 81 | 10.6 | 3.95 | 5.85 | 2.38 | 180 | 135 | 245 | 301 | 533 | 46.8 | 423 |
| Calcium Hardness as $CaCO_3$ | LPM 85 | 70 | 13 | 39 | 97 | 34 | 12 | 350 | 36 | 12 | 46 | 1094 |
| Magnesium Hardness as $CaCO_3$ | LPM 85 | 64 | 13 | 38 | 90 | 21 | 10 | 253 | 33 | 12 | 73 | 1905 |
| Free & Saline Ammonia $NH_3$ as N | LPM 29 / 76 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | 0.30 | <0.20 | 0.28 | 0.23 | 2.63 |
| Calcium as Ca | LPM 15 | 28.0 | 5.23 | 15.6 | 38.7 | 13.7 | 4.69 | 140 | 14.4 | 4.78 | 18.6 | 438 |
| Chloride as Cl | LPM 30 / 76 | 20.1 | 46.6 | 11.7 | 33.8 | 7.34 | 7.02 | 6.90 | 11.6 | 13.4 | 44.7 | 25.4 |
| Magnesium as Mg | LPM 15 | 15.5 | 3.17 | 9.22 | 21.8 | 5.00 | 2.50 | 61.60 | 8.02 | 3.02 | 17.8 | 463 |
| Nitrate & Nitrite as N | LPM 32 /76 | 20.2 | 0.46 | 0.93 | 6.48 | 0.58 | 0.97 | 2.00 | 13.8 | 2.14 | 30.8 | 1.67 |
| Ortho Phosphate $PO_4$ as P | LPM 33 / 76 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | 0.10 | <0.10 | <0.10 | 0.31 | <0.10 | <0.10 |
| Potassium as K | LPM 15 | 3.52 | 1.74 | 4.47 | 6.68 | 2.06 | 2.23 | 10.0 | 3.29 | 2.44 | 14.8 | 23.1 |
| Sodium as Na | LPM 15 | 13.5 | 27.2 | 66.4 | 53.9 | 11.7 | 18.3 | 16.5 | 10.8 | 7.34 | 19.8 | 127 |
| Silicon as Si | LPM 15 / 67 | 8.89 | 6.28 | 7.83 | 15.5 | 19.0 | 10.5 | 25.0 | 15.8 | 20.0 | 7.82 | 7.42 |
| Sulphate as $SO_4$ | LPM 28 / 76 | 36.1 | 3.26 | 28.8 | 125 | 15.5 | 2.69 | 652.0 | 17.7 | 12.2 | 7.48 | 2778 |
| Aluminium as Al | LPM 15 | 0.01 | <0.01 | 0.02 | 0.01 | 0.03 | 0.05 | 6.26 | 0.03 | 0.44 | 0.04 | 0.02 |
| Fluoride as F | LPM 27 /76 | <0.20 | <0.20 | 1.29 | 0.42 | <0.20 | 0.34 | <0.20 | <0.20 | <0.20 | <0.20 | 0.43 |
| Manganese as Mn | LPM 15 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 | 1.4 | 0.02 | 0.06 | 0.10 | 8.62 |
| Langelier Saturation Index | LPM 85 | -1.54 | -2.49 | -0.29 | -0.29 | -1.19 | -1.72 | -9.56 | -2.58 | -4.05 | -3.39 | 0.23 |
| Sodium Adsorption Ratio (SAR) | LPM 85 | 0.51 | 2.32 | 3.29 | 1.72 | 0.69 | 1.70 | 0.29 | 0.57 | 0.65 | 0.79 | 1.01 |
| TDS to EC Ratio | LPM 85 | 0.57 | 0.46 | 0.56 | 0.61 | 0.50 | 0.49 | 0.65 | 0.60 | 0.60 | 0.63 | 0.93 |
| Ion Balance (%) | LPM 85 | -1.30 | -3.94 | -2.06 | -4.07 | -3.19 | -2.97 | 0.08 | -2.14 | 1.68 | -1.11 | 2.94 |
| pHs by 21° Celsius | LPM 85 | 8.58 | 9.37 | 8.07 | 7.87 | 8.54 | 9.03 | 12.75 | 9.13 | 9.86 | 9.47 | 6.87 |

***All heavy metal analyses have been performed on filtered samples.***
***Tests marked with an asterisk * are not SANAS accredited***
***These results are related only to the items tested***

| *QUALITY CONTROL CHECKS* | D 341 | D 342 | D 343 | D 344 | D 345 | D 346 | D 347 | D 348 | D 349 | D 350 | D 351 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cation Balance* | 3.35 | 1.75 | 4.55 | 6.25 | 1.66 | 1.30 | 13.94 | 1.94 | 0.98 | 3.68 | 66.77 |
| *Anion Balance* | 3.44 | 1.89 | 4.74 | 6.78 | 1.77 | 1.38 | 13.91 | 2.02 | 0.94 | 3.76 | 62.96 |
| *% Difference* | -1.3 | -3.9 | -2.1 | -4.1 | -3.2 | -3.0 | 0.1 | -2.1 | 1.7 | -1.1 | 2.9 |
| *Measured TDS* | 252 | 116 | 278 | 424 | 104 | 82 | 956 | 148 | 64 | 286 | 4206 |
| *Calculated TDS* | 227 | 104 | 254 | 393 | 94 | 74 | 904 | 137 | 58 | 264 | 4001 |
| *Limits > 1.0 - <1.2* | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| *Calcul TDS / E.C. (0.55 - 0.70)* | 0.6 | 0.5 | 0.6 | 0.6 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.9 |

**P.L.G UYS**

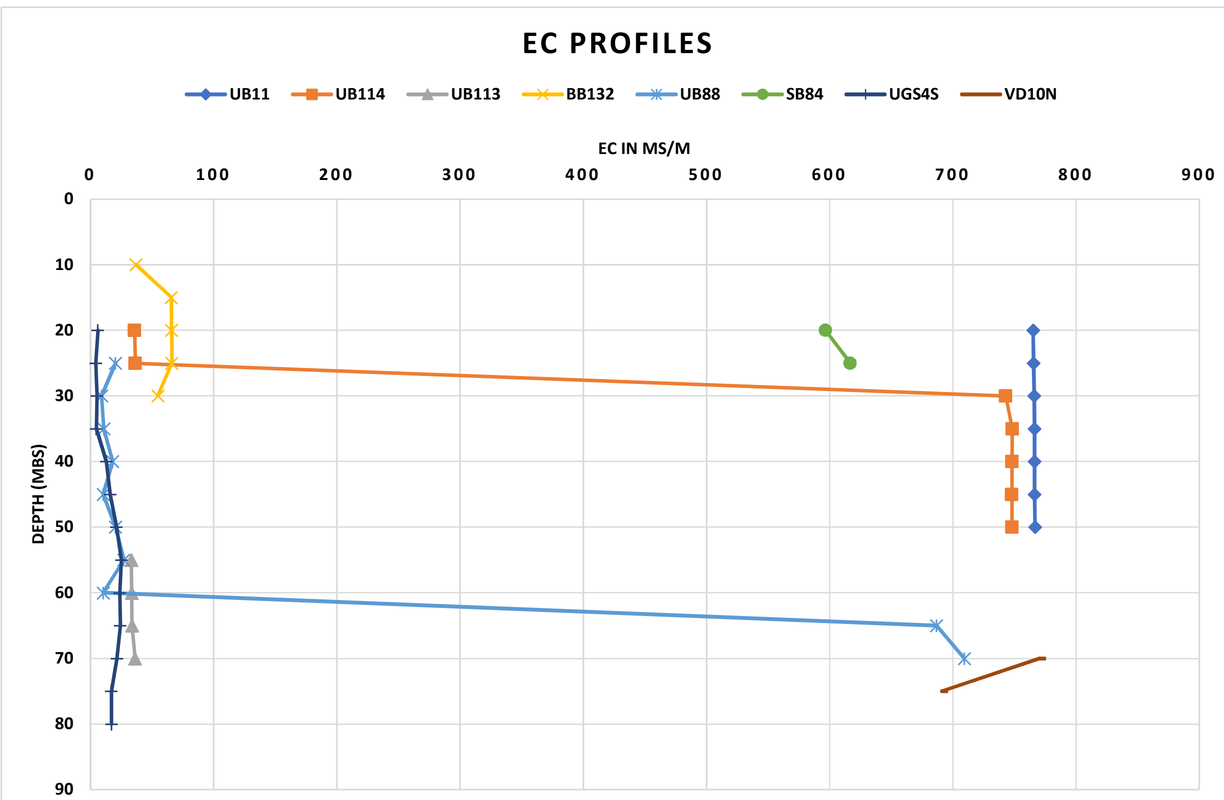
**( Technical Signatory)**

# APPENDIX A2:

EC Profiles

EC in mS/m

| mbs | UB11 | UB114 | RB9 | UB115 | UB113 | BB132 | UB88 | SB84 | UGS4S | VD10N |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | | | | | | | | |
| 10 | | | 592.8 | | | 37 | | | | |
| 15 | | | | | | 65.6 | | | | |
| 20 | 765.2 | 35.8 | | | | 65.8 | | 596.6 | 6 | |
| 25 | 765.6 | 36.4 | | 83.1 | | 66.1 | 20.4 | 616.7 | 4.4 | |
| 30 | 766 | 743 | | | | 54.8 | 9 | | 5.3 | |
| 35 | 766.2 | 748.3 | | | | | 10.9 | | 4.8 | |
| 40 | 766.3 | 748 | | | | | 18 | | 12.9 | |
| 45 | 766.3 | 747.9 | | | | | 10.3 | | 16.1 | |
| 50 | 766.7 | 748 | | | | | 20.3 | | 21.2 | |
| 55 | | | | | 33.2 | | 27.1 | | 25.2 | |
| 60 | | | | | 33.5 | | 10.4 | | 23.7 | |
| 65 | | | | | 33.7 | | 686.8 | | 24.3 | |
| 70 | | | | | 36.2 | | 709.3 | | 21.5 | 770.5 |
| 75 | | | | | | | | | 17 | 690.9 |
| 80 | | | | | | | | | 17.1 | |



## 8.10 Social Impact Assessment

# PROPOSED VANDYKSDRIFT CENTRAL (VDDC) SECTION: MINING AND INFRASTRUCTURE DEVELOPMENT, MPUMALANGA

## SOCIAL IMPACT ASSESSMENT

## FINAL REPORT

**JONES & WAGENER REFERENCE: G535**

**Submitted to:**

Jones and Wagener

Engineering and Environmental Consultants


**Submitted by:**

Batho Earth

PO Box 35130

MENLO PARK

0102


October 2019

## GLOSSARY OF ABBREVIATIONS

| | |
|---|---|
| DMR: | Department of Mineral Resources |
| DWS: | Department of Water and Sanitation |
| EA: | Environmental Authorisation |
| EAP: | Environmental Assessment Practitioner |
| EIA: | Environmental Impact Assessment |
| ELM: | eMalahleni Local Municipality |
| EMPr: | Environmental Management Programme |
| EMPR: | Environmental Management Programme Report |
| IDP: | Integrated Development Plan |
| IWULA: | Integrated Water Use Licence Application |
| IWWMP: | Integrated Water and Waste Management Plan |
| J&W: | Jones & Wagener Engineering and Environmental Consultants |
| LoA: | Life of Asset |
| LoOP: | Life of Operations |
| NEMA: | National Environmental Management Act: Act 107 of 1998 |
| NEM:WA: | National Environmental Waste Management Act: Act 59 of 2008 |
| NWA: | National Water Act: Act 36 of 1998 |
| NDM: | Nkangala District Municipality |
| ROM: | Run of Mine |
| SIA: | Social Impact Assessment |
| SKS: | Steenkoolspruit |
| SMME's: | Small, Medium, Micro Enterprises |
| StatsSA: | Statistics South Africa |
| South32: | South32 SA Coal Holdings (Pty) Ltd |
| VDDC: | Vandyksdrift Central |
| WTP: | Water Treatment Plant |
| WMLA: | Waste Management Licence Application |

**DOCUMENT STATUS**

**SOCIAL IMPACT ASSESSMENT:**

**Social Impact Assessment Report for public review**

**Date:** 1 October 2019

**Author:** Ms. Ingrid Snyman: Batho Earth

**Signature:**

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# 1. INTRODUCTION

South32 SA Coal Holdings (Pty) Ltd (South32)[1] is the holder of an amended mining right for coal, granted by the Minister of Mineral Resources, in terms of the Mineral and Petroleum Resources Development Act (MPRDA) and notarially executed on the 21st of May 2015 under DMR reference MP30/5/1/2/2/379MR, in respect of its Wolvekrans – Ifalethu Colliery[2].

The Wolvekrans – Ifalethu Colliery comprises of the following sections:

- Ifalethu Colliery (previously referred to as Wolvekrans North Section[3]) consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant Wolvekrans North Section consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant. This was previously known as Middelburg Colliery; and
- Wolvekrans Colliery (previously referred to as the Wolvekrans South Section) consisting of the Wolvekrans, Vlaklaagte (mining ceased), Driefontein, Boschmanskrans, Vandyksdrift, Albion and Steenkoolspruit sections, as well as the South Processing Plants (Eskom and Export). Some of these areas were previously known as Douglas Colliery.

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow pillar mining (opencast) of the area previously mined by underground bord and pillar mining. Authorisation of the VDDC mining project included the following:

- Opencast operation on the farm Kleinkopje 15 IS;
- Opencast operation on the farm Steenkoolspruit 18 IS;
- Pillar extraction operation on the farm Vandyksdrift 19 IS;
- Reclamation of existing slurry ponds; and
- Rewashing of existing discard dumps (PHD, 2006).

The water uses associated with the opencast mining have been authorised in terms of Water Use Licence (WUL) number 24084535 dated 10 October 2008, issued to Douglas Colliery Services Limited.

The No. 2 seam workings are flooded with water and must be dewatered to enable the open pit development to proceed. A dewatering strategy has therefore been developed and an application for Environmental Authorisation (EA) of the dewatering activities was submitted to the Department of Mineral Resources (DMR) (Jaco-K Consulting, 2016(a)); a decision in this

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[1] South32 SA Coal Holdings (Pty) Ltd was formerly known as BHP Billiton Energy Coal South Africa (Pty) Limited, ("BECSA") and will be referred to as South32 for purposes of this report

[2] Jones & Wagener (Pty) Ltd. (2019) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 8

[3] This was previously referred to as Middelburg Colliery

regard is pending. The water use activities associated with this upfront dewatering strategy have been authorised by WUL number 06/B11F/GCIJ/7943 dated 19 July 2018.

The 2007 approved EMPR Amendment included limited additional infrastructure in support of the opencast mining operations, as it was assumed at that stage that existing infrastructure will be used. In addition, the applications for authorisation of the activities associated with the dewatering strategy, were limited to the infrastructure to facilitate dewatering (i.e. dewatering boreholes, pumps, pipelines, storage tanks, mechanical evaporators, roads and power lines).

A pre-feasibility investigation has since been conducted, and the need to develop additional infrastructure to support the proposed opencast mining was identified. The additional infrastructure includes the following:

- Storm water management structures (drains and berms);
- Water management measures;
- Overburden dumps;
- ROM coal stockpile areas;
- Mixed ROM coal and slurry stockpile areas;
- Topsoil stockpiles following clearance of vegetation;
- Pipelines for the conveyance of water;
- Hard park area and brake test ramp; and
- Haul roads and service roads.

The proposed VDDC opencast pit boundary as determined through the pre-feasibility investigation also differs from the mining area approved in the 2007 EMPR amendment. An area of approximately 196 hectares in the latest mine lay-out was not included in the previous mine lay-out and is therefore not approved to be opencast mined. The area where the existing LAC dump is located, as well as a small area further north-east, were not included in the approved 2007 EMPR Amendment, and therefore requires authorisation for opencast mining (Also refer to Figure 5: Proposed Opencast Extension).

Jones & Wagener Engineering and Environmental Consultants (J&W) has been appointed by South32 as an independent Environmental Assessment Practitioner (EAP) to undertake an Integrated Regulatory Process (IRP) to obtain the required approvals/authorisations for the required infrastructure development to enable South32 to continue with opencast mining at VDDC.

The environmental applications include:

- Application for Environmental Authorisation (EA) through a Scoping and Environmental Impact Assessment Report (S&EIAR) process and the compilation of an Environmental Management Programme (EMPr) in terms of the National Environmental Management Act, 1998 (Act 107 of 1998; NEMA) and its 2014 Regulations, as amended in 2017;

- Waste Management Licence Application (WMLA) in terms of the National Environmental Management: Waste Act, 2008 (Act 59 of 2008; NEM:WA); and
- Integrated Water Use Licence Application (IWULA) in terms of the National Water Act, 1998 (Act 36 of 1998; NWA), including an Integrated Water and Waste Management Plan (IWWMP).

As part of the EA, a Social Impact Assessment (SIA) was undertaken.

### 1.1 Background to the Proposed Project and Study Area

The Wolvekrans – Ifalethu Colliery is an opencast mine using dragline, as well as truck and shovel operations, to extract coal and is located to the south-east of eMalahleni within the eMalahleni Local Municipality's (ELM) jurisdiction[4]. Ga-Nala (Kriel) is situated to the south of the colliery. The surface rights of the study area are largely owned by Ingwe Surface Holdings Ltd (South32).

The VDDC Mining and Infrastructure Development Project is a brownfields project within the greater Wolvekrans Colliery mining right area. VDDC is located on the western boundary of Wolvekrans Colliery and mainly falls within Ward 32 of the ELM. The site is approximately 30 km to the south east of eMalahleni town and to the west of the R544. The Duvha Power Station is in close proximity to the site. The VDDC footprint falls within a portion of the area used for the former Douglas Colliery underground mining. The Olifants River forms the southern boundary.

The proposed infrastructure and mining development will take place on the farms Kleinkopje 15 IS, Vandyksdrift 19 IS, Wolvekrans 17 IS and Steenkoolspruit 18 IS.

The VDDC area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow pillar mining (opencast) of the area previously mined by underground bord and pillar mining. Authorisation of the VDDC mining project included the following:

- Opencast operation on the farm Kleinkopje 15 IS;
- Opencast operation on the farm Steenkoolspruit 18 IS;
- Pillar extraction operation on the farm Vandyksdrift 19 IS;
- Reclamation of existing slurry ponds; and
- Rewashing of existing discard dumps (PHD, 2006).

The water uses associated with the opencast mining has been authorised in terms of water use licence number 24084535 dated 10 October 2008.

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[4] www.south32.net

The No. 2 seam workings are flooded with water and have to be dewatered to enable the open pit development to proceed. A dewatering strategy has therefore been developed and an application for Environmental Authorisation (EA) of the dewatering activities has been submitted to the Department of Mineral Resources (DMR). In addition, an Integrated Water Use Licence Application (IWULA) has been submitted to the Department of Water and Sanitation (DWS) for the water use activities associated with the dewatering strategy[5] and the water use licence was issued in July 2018.

### 1.2 Map of the Study Area

The following figure indicates the location of the proposed VDDC Mining and Infrastructure Development Project.

[5] Jones & Wagener (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 3

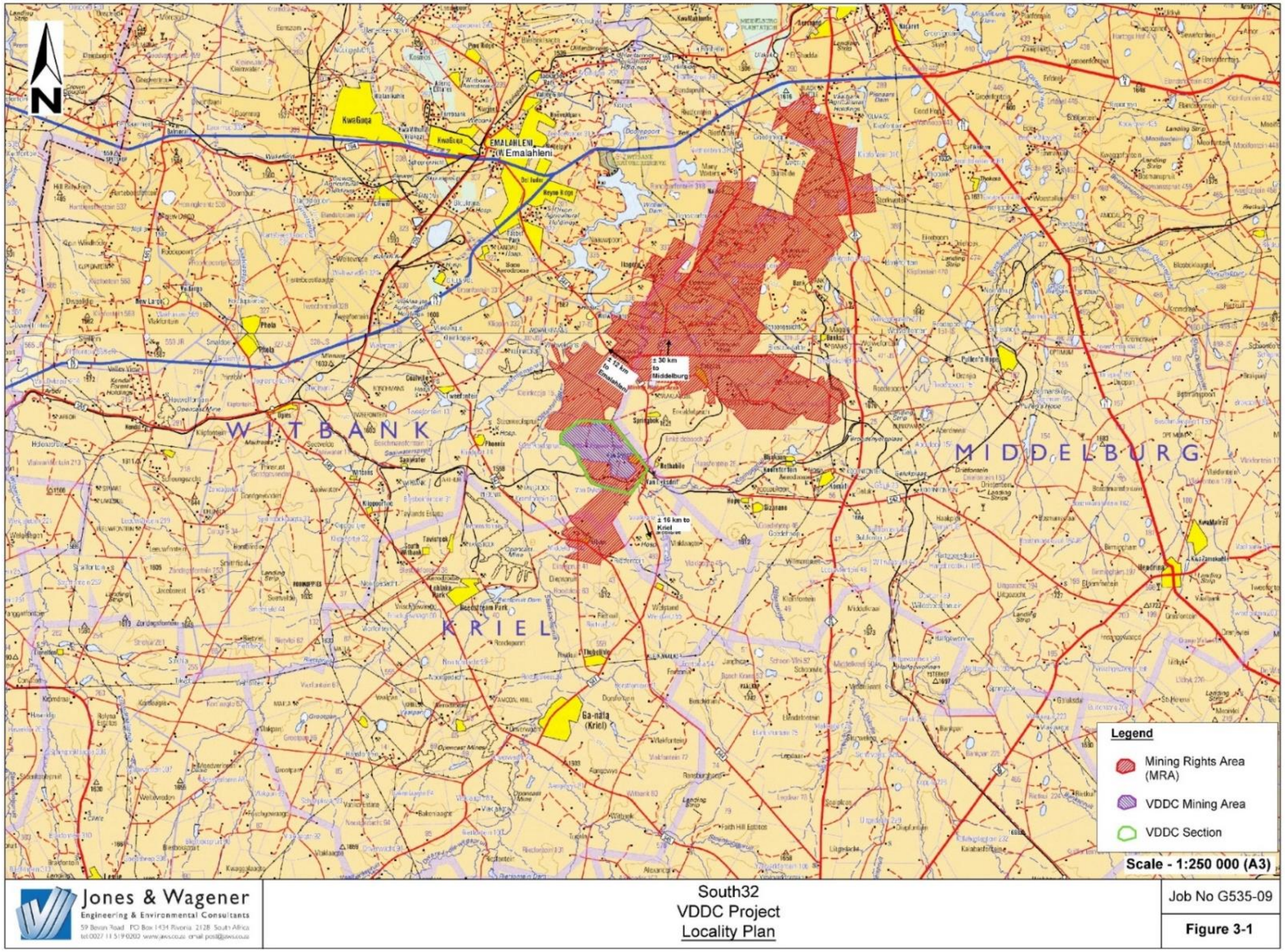


**Figure 1: Proposed VDDC Infrastructure Development Project: Location**

## 1.3 Locality and Land-Use

The existing authorized mining activities and the proposed infrastructure development falls within Ward 32 of the ELM. A small section of the northern section of the VDDC complex falls within the southern section of Ward 19.

The project area is characterised by extensive mining operations.

Farming is still undertaken within sections of the overall study area, adjacent and in close proximity to mining activities. Mining activities, however, are encroaching on the overall available farmland. Farming mainly includes crop production (maize) and cattle farming.

The project area is to the west of the R544 and west of the R544-R542 intersection. Different mining collieries/settlements are located along route R544 in the southeastern extents of the Municipality between Ga-Nala and eMalahleni City near the VDDC complex. These settlements developed in the mining belt and are mostly associated with the mining operations, power stations or railway stations respectively. These settlements have limited engineering service capacity and are not supported by any secondary economic base.[6]

The formal Van Dyksdrift Settlement was demolished (in approximately 2012), but some informal settlements still remain in the area.

The Lindokuhle settlement, situated to the south of the mining activities and to the west of the R544, is such an informal settlement. The Izingulubeni settlement, that was situated to the south of the railway line and in close proximity to Lindokuhle, was demolished in approximately 2014[7]. Two small retail facilities within the area are the Ideal Shopping Complex located at the entrance to Lindokuhle and the Vaalkrans complex near the R544-R542 intersection. The Van Dyksdrift area was classified as a fourth order development node according to the eMalahleni IDP.

The following settlements and sensitive receptors in close proximity to the proposed VDDC Infrastructure Development Project were identified:

- Lindokuhle settlement located south-east (approximately 1 km from the mining area) of the proposed infrastructure development. Lindokuhle has a small shopping complex (Ideal Supermarket).
- Springbok settlement situated approximately 3 km northeast of the proposed VDDC project along the R544.
- Kwajuma settlement located north-west of Springbok and approximately 2.5 km to the northeast of the northern boundary of the VDDC project.
- The old Anglo Village situated to the east of the R544 in very close proximity to the southeast of Kwajuma settlement.

[6] eMalahleni Local Municipality (2015). Spatial Development Framework

[7] Based on information obtained from Google Earth

- The Springbok Colliery Primary School is situated in the former Rethabile area (demolished in approximately 2017). This area is to the east of the R544 and R542, and approximately 1 km from the VDDC project's eastern boundary.
- Further informal settlements were identified at the following locations:
    - Opposite the entrance to the VDDC complex to the east of the R544;
    - Approximately 500 m to the south of the Vaalkrans shopping complex, to the east of the R542;
    - North east (approximately 700 m) of the Springbok Colliery Primary School;
    - In close proximity to the Bezuidenhoutsrus area of the railway line which is located to the south west of the project area in the direction of the R547; and
    - To the south of the project area along the R544 (east of the R544) near the road that links the R544 and the R547.

Various individual homesteads and farm buildings are further scattered across the wider study area e.g. south of Kwajuma, and two building complexes to the southwest of the southern boundary of the proposed development and Lindokuhle.

Thubelihle and Ga-Nala is approximately 20 km to the south along the R544.

The Lindokuhle and Kwajuma settlements, as well as the other informal settlements, do not seem to have access to any municipal infrastructure such as water and electricity. These settlements with poor living conditions are generally accessed via dirt roads.

Find a Google Earth image of the main settlements in Figure 2 below.

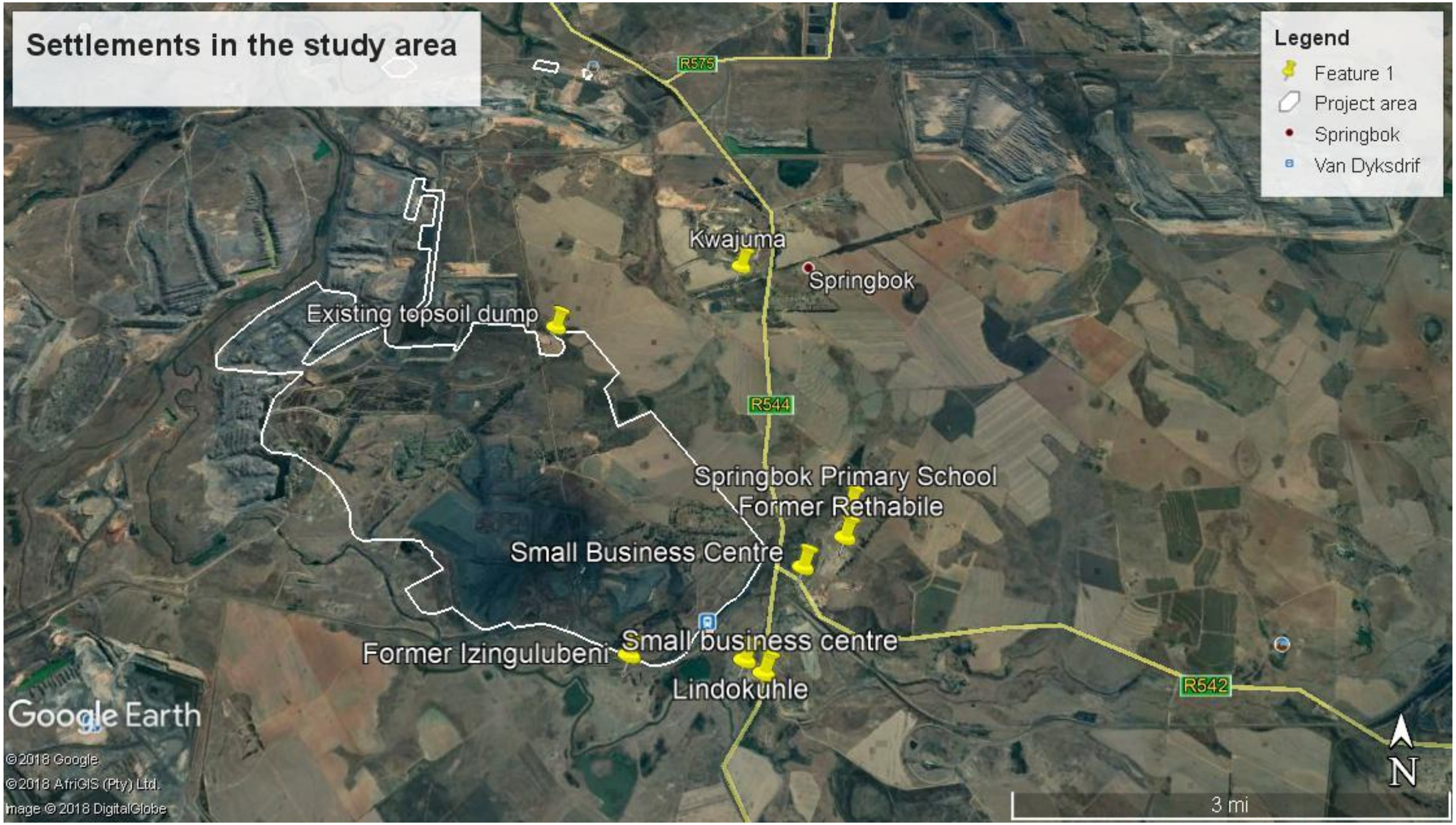


**Figure 2: Settlements within the study area**

### 1.4 Technical Details of the Project

#### 1.4.1 Existing Facilities

A short outline of the existing approved facilities at the existing operations is given below to allow a better understanding of the need for the proposed new infrastructure.

The existing facilities at the Steenkoolspruit (SKS) operations include the ROM tip and the overland conveyor system to the South Export Plant, the SKS complex offices, warehouse, change houses, workshops, wash bays, laydown areas, a sewage treatment plant and fuelling facilities. The southern SKS facilities currently in use by the Vandyksdrift North (VDDN) operation include contractors' offices, as well as a fuel, lube, air and coolant (FLAC) station[8].

An existing topsoil dump is located on the north-eastern boundary of the VDDC section with surface discard dumps on the southern portion of the VDDC resource area, namely the PSS and LAC dumps. A number of clean and dirty water management berms and canals have been constructed to ensure that runoff is managed.

Two Run-of-mine (ROM) coal stockpiles have been developed:

- A ROM coal pad located between the SKS void and the haul road, from where it is taken to the South Export Processing Plant via conveyors from the SKS crushing plant;
- A ROM stockpile area to the south of the Vleishaft Dam (an existing Pollution Control Dam), of which a portion is currently used as a hard park area.

Various existing haul roads are in place within the mining area.

The following map indicates the existing infrastructure.

[8] Jones & Wagener (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 8

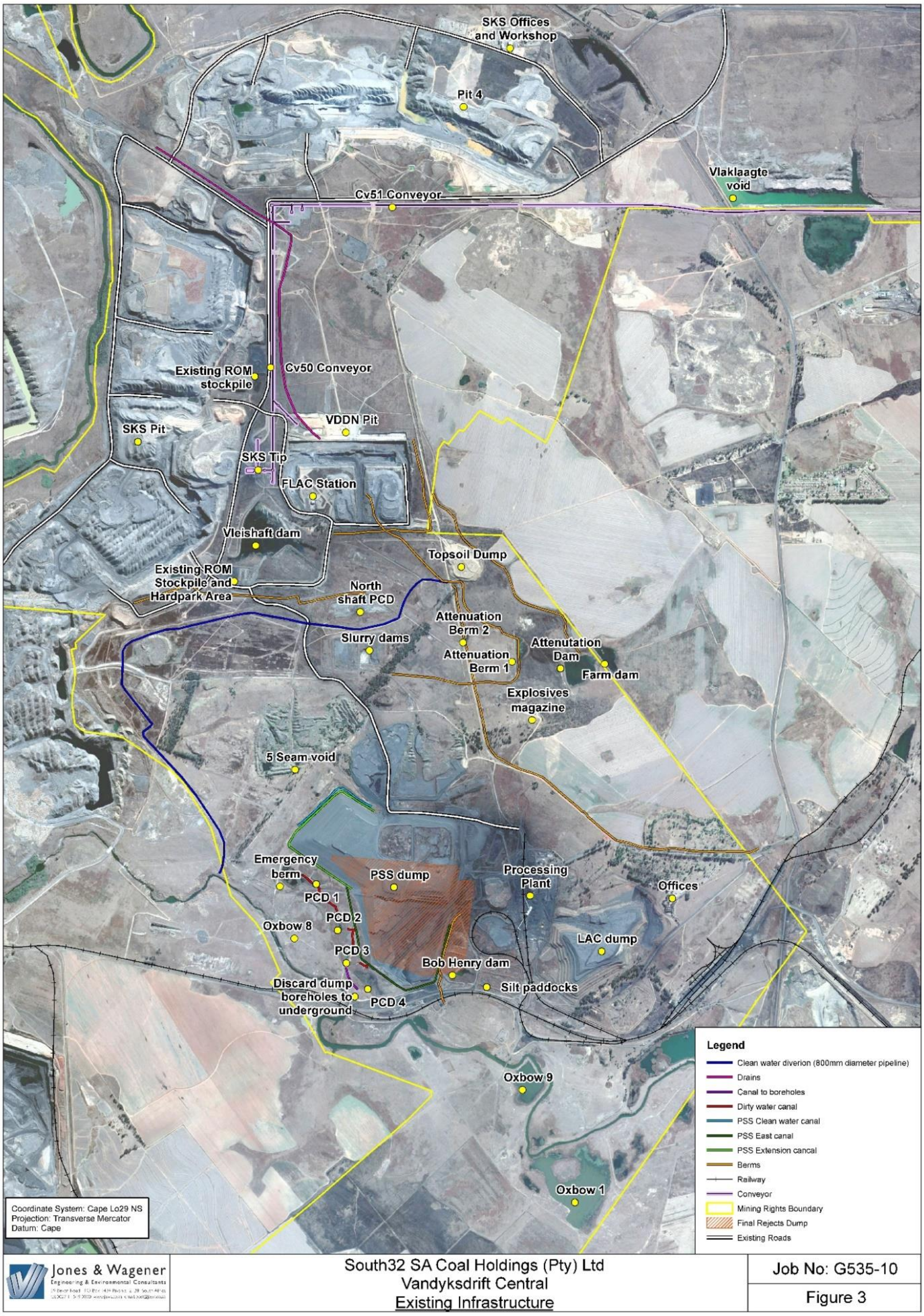


**Figure 3: VDDC: Existing infrastructure**

### 1.4.2 Proposed New Infrastructure

As indicated under Section 1, the additional infrastructure, which this application focuses on, includes the following[9]:

- Topsoil dumps – A topsoil dump is proposed to be located adjacent to the existing topsoil stockpile in the east of the project area. In addition, provision has been made for a topsoil stockpile area in between the ramps.
- Overburden Dumps - The boxcut will be done using a combination of dragline and truck and shovel. Overburden from the boxcut will be placed on four overburden dumps located in between the proposed ramps. In addition, two overburden dumps are proposed. A new overburden dump will be developed in the south-east of the project area and the existing overburden dump at the SKS pit will also be used.
- ROM stockpiles and Mixed ROM coal and slurry stockpile areas for the storage of material. The mixed material will be allowed to dewater for a period before it is removed to the existing SKS tip, from where it will be taken to the South Export Processing Plant. ROM coal from the No. 4 and No. 5 seams will be placed on transfer stockpiles. These stockpiles will be located on a partially reclaimed area of the PSS dump footprint. The stockpile positions will be moved as mining progresses but will remain within the footprint of the existing PSS dump or other previously mined out or disturbed areas;
- Storm water management structures, pollution control berms and drains;
- A proposed Water Treatment Plant (WTP) for the treatment of mine impacted water which will have a maximum capacity of 20 Mℓ/day;
- Pipelines for the conveyance of water (These pipes will be 450 to 600 mm in diameter and different pipes will convey mine impacted water between the transfer tanks and the Vleishaft dam, and between the Vleishaft dam and the new evaporator site at the SKS void); and
- New haul roads and service roads which will include:
    - Temporary high wall roads and dragline walkways which will be re-established as mining progresses;
    - Earth Moving Equipment (EME) haul roads (40 m width) from the bottom of box cut ramps to the existing haul roads;
    - Additional maintenance/service and access roads within the VDDC project area from the existing infrastructure to the box-cut;
    - New haul road to the No. 4 seam and No. 5 seam stockpiles;

[9] Jones & Wagener (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 8

- Construction of a new explosives magazine (the existing facility will be moved the north of Pit 4);
- A hard park will be developed between the Vleishaft Dam and the SKS pit. The hard park will include perimeter drains that convey polluted water runoff (primarily polluted with silt) to the SKS void;
- A brake test ramp will be provided for EME traffic at the hard park area.

The water requirements for the VDDC mining project will include the following usages:

- Potable water for human consumption or use in restrooms supplied by the existing SKS complex's water supply;
- Wash water for wash-down, either of vehicles, workshops or conveyor bunds supplied by the existing SKS complex's water supply;
- Water for dust suppression on bulk materials handling systems which will be sourced from mine impacted water;
- Water for dust suppression on haul roads;
- Fire water supplies; and
- Sewerage reticulation.

In order to manage the inflow of water into the mining operations, sumps will be constructed in the pit floor where the water will be collected at the bottom of the pit (at lowest points) and pumped out of the pit to the Vleishaft Dam and from there, to one of the evaporator sites, or to the proposed modular WTP or to Vlaklaagte void.

Access to the VDDC project area is via one of three existing approaches, depending on the size of the transport namely:

- Current SKS main entrance;
- Current Wolvekrans main entrance (via BMK workshops);
- Current VDD main entrance (opposite Springbok settlement).

All personnel transport and light delivery vehicles will enter the site via the current SKS main entrance. Personal vehicles will park in the existing and extended personnel vehicle parking, whilst busses will drop personnel off at the existing bus turnaround.

The construction phase is anticipated to be between 18 – 24 months and is planned to commence in July 2020, should the necessary environmental applications have been approved. The operational phase is expected to commence in January 2022. The following map provides an outline of the infrastructure proposed (Refer to Figure 4).

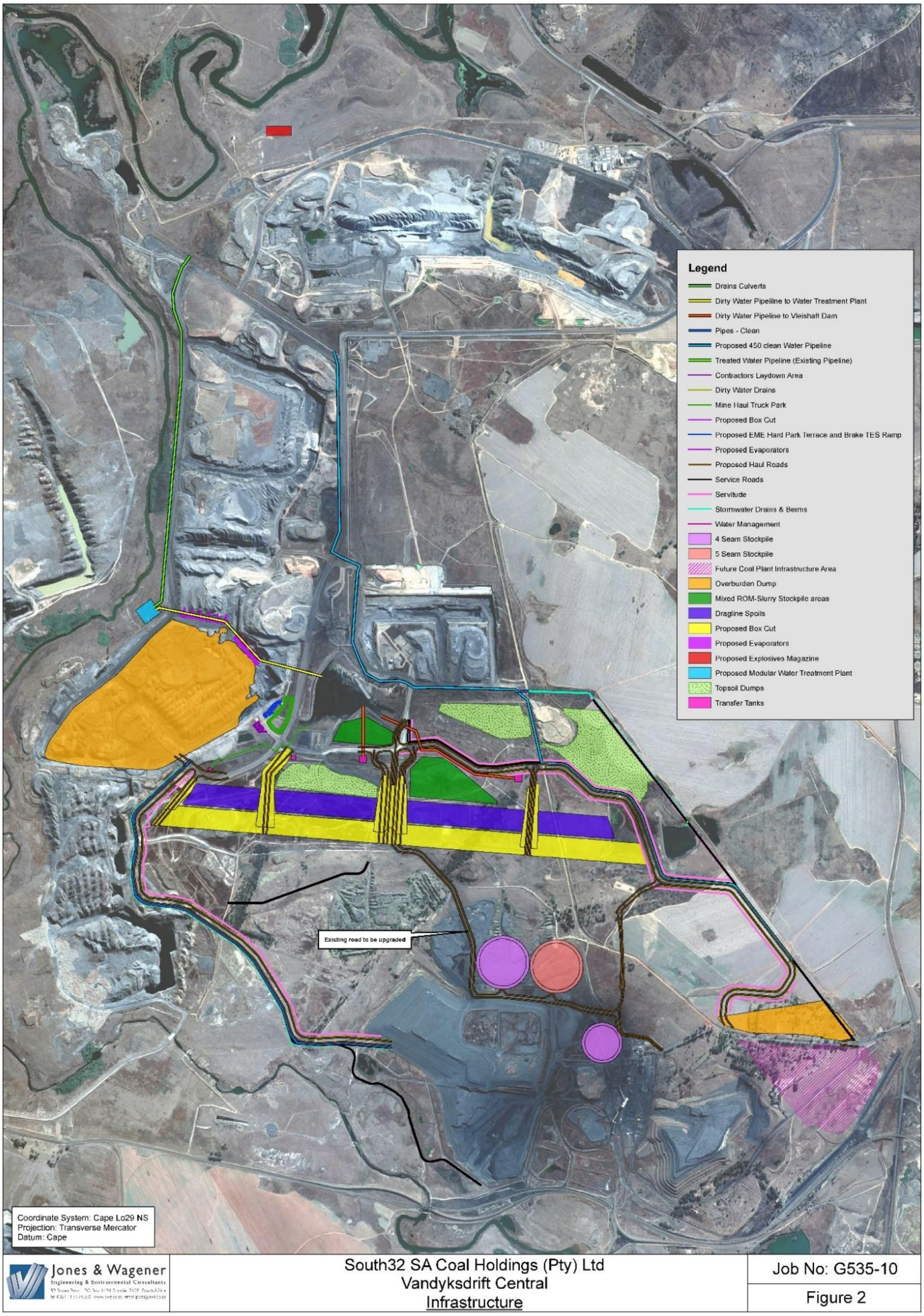


**Figure 4: VDDC: Proposed Infrastructure**

### 1.4.3 Change to opencast mining

The VDDC mine lay-out as determined through the pre-feasibility investigation, as well as the mine-lay-out included in the approved 2007 EMPR Amendment is shown on Figure 5: Proposed Opencast Extension. The area where the existing LAC dump is located, as well as a small area further north-east, were not included in the approved 2007 EMPR Amendment, and therefore requires authorisation for opencast mining.

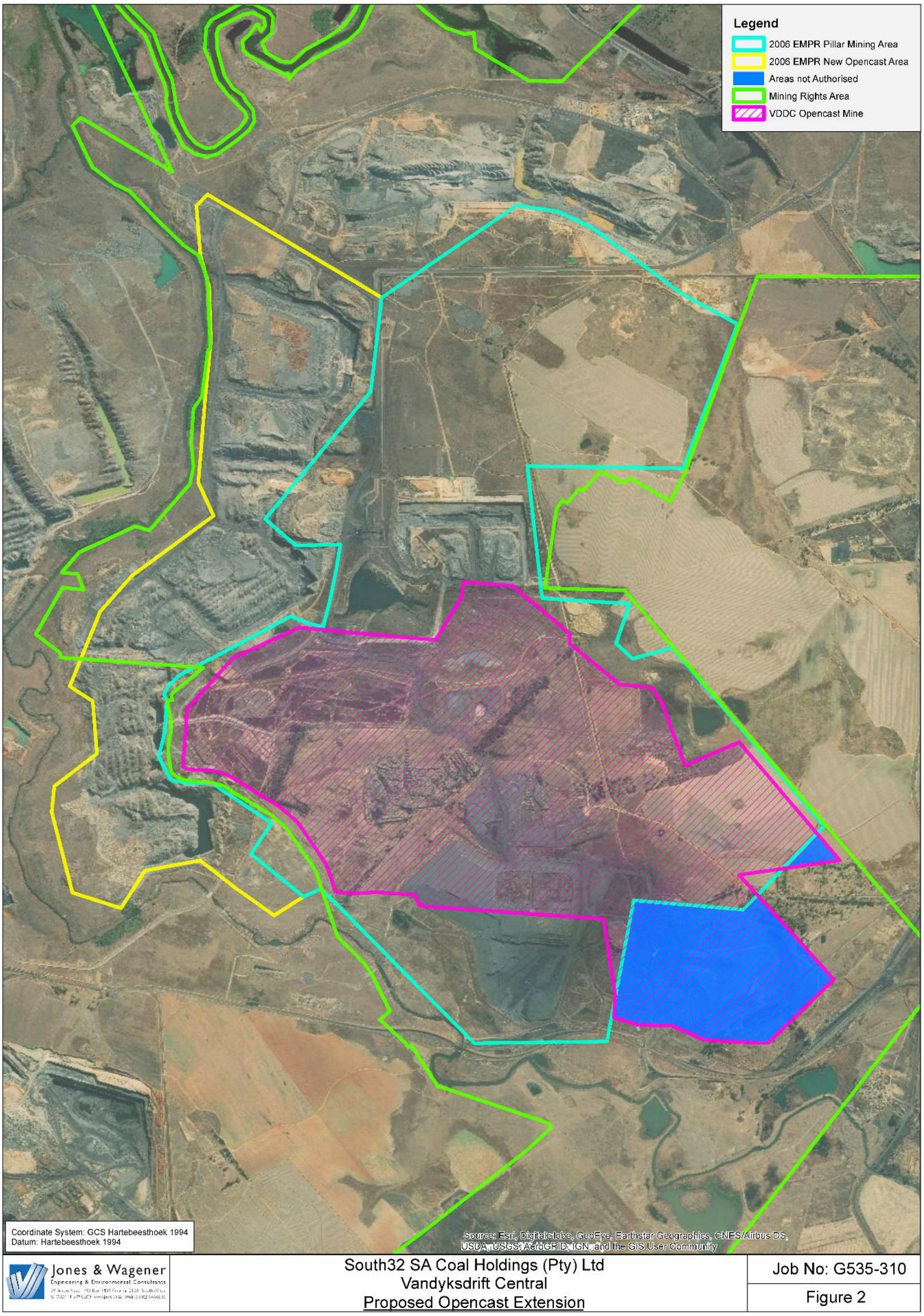


**Figure 5: Proposed Opencast Extension**

## 2. DEFINITION OF A SOCIAL IMPACT ASSESSMENT

Burdge (1995) describes a Social Impact Assessment (SIA) as the "…systematic analysis in advance of the likely impacts a development event (or project) will have on the day-to-day life (environmental) of persons and communities." A SIA therefore attempts to predict the probable impact of a development (before the development actually takes place) on people's way of life (how they live, work, play and interact with one another on a daily basis), their culture (their shared beliefs, customs and values) and their community (its cohesion, stability, character, services and facilities), by:

- Appraising the social impacts resulting from the proposed project;
- Relating the assessed social impacts of the project to future changes in the socio-economic environments that are not associated with it. This would serve to place the impacts of the project into context;
- Using the measurements (rating) to determine whether the impacts would be negative, neutral or positive;
- Determining the significance of the impacts; and
- Proposing mitigation measurements.

An SIA is thus concerned with the human dimensions of the environment, as it aims to balance social, economic and environmental objectives and seeks to predict, anticipate and understand the potential impacts of development.

The usefulness of an SIA as a planning tool is immediately clear, in that it can assist the project proponent to conceptualise and implement a project in a manner which would see the identified negative social impacts addressed through avoidance or mitigation and the positive impacts realised and optimised. It would also allow the community to anticipate, plan for and deal with the social changes once they come into effect. In this sense then, the SIA is an indispensable part of the environmental processes and any participative activity (e.g. community involvement in mitigation and monitoring during planning and implementation).

## 3. PURPOSE OF THE REPORT

The purpose of the SIA report is to provide the findings of the SIA undertaken during the EIA Phase through the following.

- Provide a brief overview of the current socio-economic status of the area and the social characteristics of the receiving environment;
- Review and update existing Baseline Studies in support of Applications for Environmental Authorisation, Waste Management Licence and Water Use Licence: Infrastructure Development in support of VDDC Mining;
- Indicate the anticipated core impact categories and impact areas (possible hot spots);
- Identify anticipated positive socio-economic impacts of the proposed project, including positive impacts and provide management measures for these impacts;

- Identify and highlighting negative social impacts (social hot spots) of the proposed project and indicate mitigation measures to deal with these impacts; and
- Present the findings, recommendations and conclusions of the social study.

# 4. LEGAL REQUIREMENTS AND GUIDELINES

## 4.1 General

The Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was amended and approved in 2007, to allow the opencast mining of the remaining coal reserves (extraction of remaining pillars, roof and floor) via opencast mining.

The following authorisations, however, will now be required for the proposed infrastructure and mining:

- Application for Environmental Authorisation through a Scoping and Environmental Impact Assessment Report (S&EIAR) process and the compilation of an Environmental Management Programme (EMPr) in terms of the National Environmental Management Act, 1998 (Act 107 of 1998; NEMA) and its Regulations;
- Waste Management Licence Application (WMLA) in terms of the National Environmental Management: Waste Act, 2008 (Act 59 of 2008; NEM:WA);
- Integrated Water Use Licence Application (IWULA) in terms of the National Water Act, 1998 (Act 36 of 1998; NWA), including an Integrated Water and Waste Management Plan (IWWMP); and

A Social Impact Assessment is required to be completed in support of the environmental authorisations for the Infrastructure and mining Development. The SIA will update information as included in the previous studies undertaken in 2013. It will further determine whether the proposed infrastructure development would have any negative impacts with regards to the social environment.

## 4.2 Checklist: Requirements for Specialist Reports, as Contained in the 2014 EIA Regulations as amended

**Table 1: Requirements for specialist reports, as contained in the 2014 EIA Regulations as amended**

| **EIA REGULATIONS 2014 GNR 982 Appendix 6**<br>**CONTENT OF THE SPECIALIST REPORTS** | **Status / Cross-reference in this Report** |
|---|---|
| a) details of the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a curriculum vitae; | Sections 13 and 14 |
| b) a declaration that the specialist is independent in a form as may be specified by the competent authority; | Section 15 |

| EIA REGULATIONS 2014 GNR 982 Appendix 6<br>CONTENT OF THE SPECIALIST REPORTS | Status / Cross-reference in this Report |
|---|---|
| c) an indication of the scope of, and the purpose for which, the report was prepared | Sections 1 and 3 |
| cA) an indication of the quality and age of base data used for the specialist report | Statistics from Census 2011 were used. Where available statistics from Household Survey of 2016 (StatsSA) were used. |
| cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change | Sections 7 and 8 |
| d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment; | Section 6.1 |
| e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used; | Section 6 |
| f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives; | Sections 7 and 8 |
| g) an identification of any areas to be avoided, including buffers; | Sections 7 and 8 |
| h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers | Sections 1.2, 1.2 and 1.3 |
| i) a description of any assumptions made and any uncertainties or gaps in knowledge; | Section 5 |
| j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities; | Section 11 |
| k) any mitigation measures for inclusion in the EMPr | Section 8 |
| l) any conditions for inclusion in the environmental | Section 11 |

| EIA REGULATIONS 2014 GNR 982 Appendix 6<br>CONTENT OF THE SPECIALIST REPORTS | Status / Cross-reference in this Report |
|---|---|
| authorisation; | |
| m) any monitoring requirements for inclusion in the EMPr or environmental authorisation; | Section 11 |
| n) a reasoned opinion<br>• whether the proposed activity, activities or portions thereof should be authorised;<br>• regarding the acceptability of the proposed activity or activities; and<br>• if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan; | Section 11 |
| o) a description of any consultation process that was undertaken during the course of preparing the specialist report; | Section 6.6 |
| p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and | Section 6.6 |
| q) any other information requested by the competent authority | N/A |
| 2) Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply. | - |

## 5. GAPS, LIMITATIONS AND ASSUMPTIONS

With regards to the SIA undertaken, the following should be noted:

- A SIA aims to identify possible social impacts that could occur in future. These impacts are based on existing baseline information. There is thus always an uncertainty with regards to the anticipated impact actually occurring, as well as the intensity thereof. Impact predictions have been made as accurately as possible based on the information available at the time of the study.
- Sources consulted are not exhaustive and additional information can still come to the fore to influence the contents, findings, ratings and conclusions made.

- Additional information may become known or available during a later stage, which could not have been allowed for at the time of the study.
- Technical and other information provided by the client is assumed to be correct.
- Individuals view possible social impacts differently due to their association with the anticipated impact. Impacts could therefore be perceived and rated differently than those contained in the SIA Report.
- Attempts were made to contact private property owners and the local councillor (Also refer to Section 6.6). Although interviews could only be conducted with some property owners, it is not anticipated that it would influence the findings of the report.

## 6. METHODOLOGY

The broad steps followed as part of the study are discussed below.

### 6.1 Site Visit

A site visit was undertaken on 31 July 2018. The aim for the consultants was to familiarise themselves with the site and possibly affected areas, as well as to obtain an overview of the social characteristics of the study area and the social setting of the proposed expansion project.

### 6.2 Scope of the Assessment

Based on information received from Jones and Wagener, the scope of the assessment was determined. The assessment consisted of a desktop study.

### 6.3 Literature Review, Analysis and Desktop Studies

The literature review assisted the consultant in confirming the social setting and characteristics of the study area, as well as the key economic activities. Data studied included Google Earth, the census data, project maps, project related documents compiled as part of the Van Dyksdrift Central Project and the VDDC Infrastructure Development Project, as well as planning documentation of the ELM e.g. the Integrated Development Plan (IDP).

### 6.4 Baseline Profile

Profiling involves a description of the social characteristics and history of the area being assessed, an analysis of demographic data, changes in the local population, and the land-use pattern in the study area, as well as any other significant developments in the area and thus social character over time.

### 6.5 Reporting

Positive and negative impacts to be expected during the construction and operational phases have been identified and noted in the Report.

### 6.6 Consultation

Interviewing of Interested and Affected Parties forms part of the research process (Refer to Section 12.2). A discussion guideline was developed which was used to obtain information from these key stakeholders. The aim was to gather specific information related to the social environment and insight into their perceptions with regards to the proposed development.

The Background Information Document (BID) and the discussion guideline were e-mailed to the councillor of Ward 32 and property owners whose contact details were available. This was followed up with telephonic interviews. To date, various attempts were made to contact the councillor and select property owners. Information obtained from those with whom interviews did take place, were included as part of the document.

### 6.7 Significance Criteria

The anticipated social impacts were rated according to a rating approach used and specified by Jones and Wagener (Pty) Ltd. The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

A combined quantitative and qualitative methodology will be used to describe the impacts for each of the aforementioned assessment criteria. A summary of each of the qualitative descriptors along with the equivalent quantitative rating scale for each of the aforementioned criteria is given in Table 2.

**Table 2: Quantitative rating and equivalent descriptors for the impact assessment criteria**

| RATING | SIGNIFICANCE | EXTENT SCALE | TEMPORAL SCALE |
|---|---|---|---|
| 1 | VERY LOW | Isolated corridor / proposed corridor | Incidental |
| 2 | LOW | Study area | Short-term |
| 3 | MODERATE | Local | Medium-term |
| 4 | HIGH | Regional / Provincial | Long-term |
| 5 | VERY HIGH | Global / National | Permanent |

A more detailed description of each of the assessment criteria is given in the following sections.

### 6.7.1 Nature

The nature of the impact is the consideration of what the impact will be and how it will be affected. This description is qualitative and gives an overview of what is specifically being considered. That is, the nature of the impact considers 'what is the cause, what is affected, and how is it affected?' This is discussed below each identified combination of factor and project phase.

### 6.7.2 Level of Significance

Significance rating (importance) of the associated impacts embraces the notion of extent and magnitude, but does not always clearly define these since their importance in the rating scale is very relative. A more detailed description of the impact significance rating scale is given in the table below:

**Table 3: Description of the significance rating scale**

| RATING | | DESCRIPTION |
|---|---|---|
| 5 | VERY HIGH | Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit. |
| 4 | HIGH | Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these. |
| 3 | MODERATE | Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc. |
| 2 | LOW | Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these. |
| 1 | VERY LOW | Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale. |
| 0 | NO IMPACT | There is no impact at all - not even a very low impact on a party or system. |

### 6.7.3 Spatial Scale

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in the table below:

**Table 4: Description of the spatial rating scale**

| RATING | | DESCRIPTION |
|---|---|---|
| 5 | Global/National | The maximum extent of any impact. |
| 4 | Regional/Provincial | The spatial scale is moderate within the bounds of impacts possible, and will be felt at a regional scale (District Municipality to Provincial Level). The impact will affect an area up to 50km from the proposed site / corridor. |
| 3 | Local | The impact will affect an area up to 5km from the proposed route corridor / site. |
| 2 | Study Area | The impact will affect a route corridor not exceeding the boundary of the corridor / site. |
| 1 | Isolated Sites / proposed site | The impact will affect an area no bigger than the corridor / site. |

### 6.7.4 Duration Scale

In order to accurately describe the impact it is necessary to understand the duration and persistence of an impact in the environment. The duration or temporal scale is rated according to criteria set out in the following table.

**Table 5: Description of the temporal rating scale**

| RATING | | DESCRIPTION |
|---|---|---|
| 1 | Incidental | The impact will be limited to isolated incidences that are expected to occur very sporadically. |
| 2 | Short-term | The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater. |
| 3 | Medium term | The environmental impact identified will operate for the duration of life of the project. |
| 4 | Long term | The environmental impact identified will operate beyond the life of operation. |
| 5 | Permanent | The environmental impact will be permanent. |

### 6.7.5 Degree of Probability

The probability or likelihood of an impact occurring will be described as shown below:

**Table 6: Description of the degree of probability of an impact occurring**

| RATING | DESCRIPTION |
|---|---|
| 1 | Practically impossible |
| 2 | Unlikely |
| 3 | Could happen |
| 4 | Very Likely |
| 5 | It's going to happen / has occurred |

### 6.7.6 Quantitative Description of Impacts

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus the total value of the impact is described as the function of significance, spatial and temporal scale as described below.

$$\textbf{\textit{Impact Risk}} = \frac{(\text{SIGNIFICANCE} + \textit{Spatial} + \text{Temporal})}{3} \times \frac{\text{Probability}}{5}$$

The above rating is applied as follows:

**Table 7: Example of Rating Scale**

| IMPACT | SIGNIFICANCE | SPATIAL SCALE | TEMPORAL SCALE | PROBABILITY | RATING |
|---|---|---|---|---|---|
| | LOW | *Local* | Medium Term | *Could Happen* | |
| E.g. Impact to air | **2** | ***3*** | **3** | **3** | **1.6** |

*Note: The significance, spatial and temporal scales are added to give a total of 8, that is divided by 3 to give a criteria rating of 2,67. The probability (3) is divided by 5 to give a probability rating of 0,6. The criteria rating of 2,67 is then multiplied by the probability rating (0,6) to give the final rating of 1,6.*

The impact risk is classified according to 5 classes as described in the table below.

**Table 8: Impact Risk Classes**

| RATING | IMPACT CLASS | DESCRIPTION |
|---|---|---|
| 0.1 – 1.0 | 1 | Very Low |
| 1.1 – 2.0 | 2 | Low |
| 2.1 – 3.0 | 3 | Moderate |
| 3.1 – 4.0 | 4 | High |
| 4.1 – 5.0 | 5 | Very High |

# 7. BASELINE DESCRIPTION OF THE RECEIVING ENVIRONMENT

## 7.1 Nkangala District Municipality

The Nkangala District Municipality (NDM) is a Category C municipality in the Mpumalanga Province. It comprises six local municipalities: Victor Khanye, eMalahleni, Steve Tshwete, Emakhazeni, Thembisile Hani, and Dr JS Moroka. The NDM has 160 towns and villages under its jurisdiction[10].

The district is host to the Maputo corridor which brings increased potential for economic growth and tourism development. In addition, the district shares the western side of its borders with the economic hub of Gauteng which opens up opportunities to a larger market, which is of benefit to the district's agricultural and manufacturing sectors. There is further potential in exporting goods that provides opportunities within the district[11].

The NDM's economy is dominated by electricity, manufacturing and mining. These sectors are followed by community services, trade, finance, transport, agriculture and construction. The relatively large economies of Steve Tshwete LM (Middelburg) and eMalahleni LM (Witbank/eMalahleni) sustain the economy of the Nkangala District to a large extent and are based on the steel industry with high reliance on the manufacturing sector[12].

However, the NDM is not exempt from the difficulties facing all municipalities in South Africa. Poverty and unemployment in the rural areas are a major threat to socioeconomic growth[13].

## 7.2 eMalahleni Local Municipality

The ELM has a mining and industrial history and is thus the most industrialised municipal area in the NDM. eMalahleni Municipality consists of the towns of eMalahleni, Ga-Nala (formerly Kriel) including Thubelihle and Ogies, including Phola, Rietspruit, Van Dyksdrift and Wilge.

The town of eMalahleni mainly came about due to mining, electricity and industrial activities in the area and is still surrounded by various mining activities as well as some farming activities such as the cultivation of crops. The landscape and land-use mainly consist of rural areas with scattered towns, as well as underground and opencast coalmines. The area also has the largest concentration of power stations in the country. The coal deposits and power stations in the southern section of the municipality thus have a major influence on the settlement patterns in the area. The fragmented development pattern is further intensified by the large areas that are undermined or those that have mining rights[14].

A key objective remains to prevent mining activity from encroaching onto high potential agricultural land and areas of high biodiversity; and to ensure that the areas of mining

[10] www.nkangaladm.gov.za

[11] www.localgovernment.co.za

[12] www.localgovernment.co.za

[13] www.nkangaladm.gov.za

[14] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

activity are properly rehabilitated and that the agricultural value of the land be restored once the mineral resources are depleted.

The following map indicates the location of the ELM in relation with the other local municipalities within the NDM.

**Figure 6: eMalahleni Local Municipality[15]**


The area surrounding eMalahleni does not lend itself to major tourism activities, as it is primarily a mining and farming area. The only conservation area under the jurisdiction of the ELM is the eMalahleni Nature Reserve established around the eMalahleni Dam[16].

The Vandyksdrift and the Izingulubeni Settlements that were in close proximity to the VDDC project have been demolished, but some informal settlements still remain in the area such as the Lindokuhle settlement situated to the south of the mining activities.[17] To the north east of the proposed infrastructure development is the Springbok settlement, which developed as a mining town[18]. The Ideal Shopping Complex is situated at the entrance to Lindokuhle and the Vaalkrans complex is near the R544-R542 intersection.

Various informal settlements and some farm buildings/homesteads were further identified.

Also refer to Section 1.3 for a description of the land-use and sensitive receptors in the area.

The proposed infrastructure development project mainly falls within Ward 32. A small section of the northern section of the VDDC complex falls within the southern section of Ward 19. Ward 25's northern boundary is in close proximity to the southern boundary of the VDDC complex area.

Statistics from these three wards will thus be included in the section below.

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[15] www.demarcation.org.za

[16] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[17] eMalahleni Local Municipality (2015). Spatial Development Framework

[18] eMalahleni Local Municipality (2015). Spatial Development Framework

### 7.3 Population Dynamics

#### 7.3.1 Population Figures

In 2011, the eMalahleni population was 395 466 individuals. According to the 2016 Community Survey, the population of the eMalahleni Local Municipality totals approximately 455 228 individuals, with 150 420 households and a 3.2% average annual population growth rate. As the economy of the eMalahleni area provides various employment opportunities, a large influx of individuals to the ELM area are experienced[19].

The eMalahleni municipal population is expected to increase to 516 399 individuals in 2020 and 646 708 individuals in 2030[20].

The following table provides an outline of the population figures in the wards in the study area. Ward 32 has a total population of 11 507 individuals.

**Table 9: Population figures**

| POPULATION FIGURES WITHIN WARDS[21] | |
|---|---|
| **Ward** | **Population** |
| **Ward 19** | 9 687 |
| **Ward 25** | 14 872 |
| **Ward 32** | 11 507 |

#### 7.3.2 Age Structure and Gender

The age structure of the eMalahleni Local Municipality indicates a fairly young population, as 25.2% of the local population is under the age of 14. Those within the working age (15-64) forms 71.2% of the local population[22].

This young population would in future put extreme pressure on the socio-economic fabric of the area. Pro-active planning with regards to employment creation, social activities, recreational facilities, sports and educational facilities, medical facilities, the development of the youth, training and capacity building programmes, would therefore be imperative.

From the table below it is clear that the age structure in the wards also reflect a very young population profile, which, in Wards 19 and 32, is even higher compared to the municipal average. This highlights the need for the provision of employment opportunities that would match the skills in the area.

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[19] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[20] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[21] StatsSA: 2011 Census

[22] Statssa.gov.za

**Table 10: Age Structure**

| AGE STRUCTURE OF POPULATION WITHIN WARDS[23] | | | |
|---|---|---|---|
| **Ward** | **Population under 15** | **Population 15 to 64** | **Population over 65** |
| **Ward 19** | 2 101 (21%) | 7 397 (76%) | 227 (2%) |
| **Ward 25** | 4 276 (28%) | 10 293 (69%) | 371 (2%) |
| **Ward 32** | 2 595 (22%) | 8 719 (75%) | 255 (2%) |

Within Wards 19 and 32, 48% of the population is males[24].

### 7.3.3 Population Stability

The increase in the population figure as a result of the average growth rate, but also due to the in-migration of various people from outside the municipality might be due to mining industries and businesses within the eMalahleni area. This trend impacts on the population stability and further results in the following social challenges:

- Informal settlements and back rooms– estimated 10 000 people residing in these areas;
- The provision of water supply to informal settlements without resident contributing to these services;
- Additional pressure on the provision of water, sanitation , and electricity infrastructure;
- Additional pressure on the local roads resulting in poor quality roads without sufficient capacity to handle the traffic volumes; and
- Increase in unemployment particularly amongst youth and unskilled which might impact on issues of crime, prostitution, and drug abuse[25].

According to information obtained, the majority of the population within Ward 19 (92.9%) and within Ward 32 (90.4%) were born in South Africa[26].

## 7.4 Education Levels

According to the Department of Education there are currently 34 pre-schools in the Emalahleni municipality. There are 58 primary schools and 19 secondary schools servicing the area and four tertiary education facilities in the Emalahleni area. The Edupark in eMalahleni

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[23] StatsSA: 2011 Census

[24] www.wazimap.co.za

[25] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[2626] www.wazimap.co.za

consists of the Tshwane University of Technology, Pretoria University and Unisa. The eMalahleni College is situated in the CBD in close proximity to the municipal offices. The other tertiary institutions are the Mpondozankomo Technical College in Ackerville and the Coal Training College in Klipfontein[27].

The ELM's performance with regards to the level of education obtained is higher compared to the other local municipalities in the Nkangala District. The 2011 highest level of education profile indicates a large proportion of individuals within the local municipality (49.8%) have at least a secondary (Grade 8-12) level of education. However, the majority still have only grade 12 qualifications with a small percentage who have obtained some secondary education. The rural areas also still have the highest level of "No Schooling"[28]. Vocational skills training for local industries and motivating individuals to obtain a Grade 12 (or equivalent) qualification is still necessary.

The educational profiles of those in the affected wards are similar to the figures of the ELM.

**Table 11: Education Profiles**

| MUNICIPALITY / WARD | NO SCHOOLING | GRADE 12 | HIGHER EDUCATION |
|---|---|---|---|
| Nkangala District Municipality[29] | 9% | 35% | 8.7% |
| eMalahleni Local Municipality[30] | 6% | 31% | 14% |
| Ward 19 | 5% | 33% | 16% |
| Ward 25 | 10% | 25% | 2% |
| Ward 32 | 9% | 27% | 4% |

## 7.5 Socio-Economic Environment

### 7.5.1 Labour Market

In 2011, the unemployment rate was 27.3% and the youth unemployment rate 36%[31]. The Community Survey of 2016 indicates that 23.2% of the local population is unemployed.

This unemployment rate is similar to that of the District. With such a large local economy, a lower unemployment rate is expected. Many people migrate to ELM in search of

[27] eMalahleni Local Municipality (2015). Spatial Development Framework

[28] eMalahleni Local Municipality (2015). Spatial Development Framework

[29] www.localgovernment.co.za

[30] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[31] www.statssa.gov.za

employment, but might not have the right skills to work in the local economy and thus put more pressure on the provision of services and infrastructure.

The investment climate of the municipality needs to improve and be conducive so it can accommodate the new job seekers. The municipality also needs to increase the levels of education and skills to improve the employability of young people[32].

The following table provides an outline of the employment profile of the residents of the wards within the area:

| EMPLOYMENT PROFILE PER WARD | | | | |
|---|---|---|---|---|
| **WARD** | **Employed** | **Unemployed** | **Discouraged work-seeker** | **Other not economically active** |
| **Ward 19** | 4261 (57%) | 1133 (15%) | 252 | 1751 |
| **Ward 25** | 4805 (46%) | 2559 (25%) | 445 | 2483 |
| **Ward 32** | 4304 (49%) | 1372 (16%) | 759 | 2285 |

### 7.5.2 Income Levels

In 2016, the average annual household income was R120 492, but 14% of the population still received no income[33].

The average annual household income is higher than the District average household income. The high average income and education levels should reflect a lower unemployment rate which means that there are more opportunities for employment for highly skilled workers, which again, highlights the importance of high levels of education.

Significant concentrations of people living under the Minimum Living Level (MLL) occur within eMalahleni. It is evident that 67.1% of households within the ELM earn an annual income well below the MLL, with the highest percentages of these households located in Emalahleni Rural (78.7%) and Emalahleni West (78.0%)[34]. The low income levels is concerning as it

[32] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[33] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[34] eMalahleni Local Municipality (2015). Spatial Development Framework

indicates high dependency levels of households on government grants, subsidies and services. Specific areas of concentration include eMalahleni, Ogies and Ga-Nala[35].

The people that depends on grants have increased from 34,849 to 89 585 people between 2012 to 2017. The grant with the largest recipients is the child support grant followed by old age grant.

Within Ward 32 the average annual household income was R29 400 which is more or less similar than those in ELM. Within Ward 19, the average annual household income was R57 300 which is double the amount compared to those within Ward 32[36].

### 7.5.3 Poverty

According to the 2016 Community Survey of StatSA, the so-called poverty headcount (multi-dimensionally) of eMalahleni deteriorated from 8.0% in 2011 to 10.9% in 2016 and is the second highest in the Province. The so-called poverty intensity also increased from 43.6% to 45.4% in the same period[37].

## 7.6 Household Profile and Services

The number of informal dwellings in the ELM increased from 23 138 in 2011 to 34 845 in 2016, which is an increase of more than 11 000 households[38]. According to information obtained, 56% of the population within Ward 32 lives in formal structures, while 15.2% lives in informal dwellings or shacks.

Accelerated service delivery is the key. Strong collaboration between the municipality, relevant national, provincial departments and public entities in prioritizing building of houses should be considered.

The Municipality is both a Water Services Authority (WSA) and a Water Services Provider (WSP). There are three water schemes operating in the Municipality, namely the:

- Witbank Water Treatment Works;
- Ga-Nala Water Treatment Works; and
- Rietspruit Water Treatment Works

The infrastructure, however, is approximately fifty years old and has reached the end of its designed life. The Municipality is planning to improve the reliability of the distribution network, including the refurbishment of its water treatment plant in eMalahleni, reducing the water losses, improving on the quality of water supplied, improving on the Blue Drop status targets and enhancing scheduled deliveries of portable water through water tankers.

[35] eMalahleni Local Municipality (2015). Spatial Development Framework

[36] Wazimap.co.za

[37] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[38] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

The number of households with access to piped water is 136 628 households with a share of 90.8% of households having access to piped water. There is however, 13 792 or 9.2% of households without access to piped water in 2016.

In Wards 32, 19 and 25 the majority of households received their water via a regional/local water scheme operated by a Water Service Authority or provider. However, in Ward 19 (856 households) and in Ward 32 (507 households) a number of households still depend on borehole water for household purposes[39].

The number of households with access to flush/chemical toilets improved in the relevant period is 108 868 households or a percentage access of 72.4% of households however, 2 186 households are without any toilet facilities (no toilets). The majority of households in Wards 19 and 32 have access to a flush toilet that is connected to a sewerage system[40].

Households with a connection to electricity were 106 306, which constitutes 70.7% in 2016. Within the area, 40 721 households are not connected to electricity at all, which is more than a quarter of the households. From information obtained from the 2011 Census, the majority of households within Wards 19 and 32 have access to electricity.

## 7.7 Infrastructure

The road infrastructure connecting eMalahleni to the rest of the country is extensive. The main road infrastructure consists of the N4 and N12 freeways which connects eMalahleni with Gauteng, as well as the rest of Mpumalanga (Nelspruit area) and Maputo. Running parallel to the N4 is a rail line that connects Gauteng through eMalahleni to Maputo.

Regional (provincial) roads further span the EML area e.g. the R104, R544, R545, R547, R555, R575, and R580. Most of these routes serve as freight routes for the transport of coal from mines to the power stations in the municipal area. These roads thus carry high traffic volumes, and typical with most rural type areas in South Africa, there is still a great need for upgrading and maintenance of this existing road infrastructure.

Maintenance and upgrading on other infrastructure also remains critical due to the general decline of infrastructure that has outlived their lifespan[41].

## 7.8 Community Health

According to Mpumalanga Department of Health, the HIV prevalence rate of eMalahleni was measured at 40.7% in 2013 (latest available figure)[42]. The eMalahleni Local Municipality has a shortage in terms of adequate basic health care services. Aspects that put additional pressure on these are the growing population, the poverty levels of the residents in the area, the spread of HIV/Aids and the enlargement of formal and informal settlements.

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[39] StatsSA: 2011 Census

[40] StatsSA: 2011 Census

[41] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[42] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

Within the Van Dyksdrift area there is only one mobile clinic functioning. The Naledi Clinic is situated at Naledi Village which is situated along the R575 nor the north of the VDDC area. The Impungwe District Hospital situated on the outskirts of eMalahleni is the nearest hospital to the area. Ga-Nala and Thubelihle have two clinics, which are thus approximately 20 km from the proposed site.

### 7.9 Crime

Crime is a source of concern within the area, especially within the informal settlements where unemployment levels are high. Residents in these areas usually resort to illegal activities as a source of income.

The Blinkpan Police Station, near Komati, is the nearest station to the study area. According to information from the SAPS, the major crimes noted at the Blinkpan Station includes theft, burglaries, drug related crime and contact crime[43].

It is thus unlikely that the criminal incidents would decrease should unemployment in the area prevails.

### 7.10 Profile of the Local Economy

The average annual economic growth rate for eMalahleni was at 2.4% over the period 1996 to 2015. The forecasted average annual GDP growth for eMalahleni for 2015-2020 is anticipated to be more or less 2% per annum in line with national and provincial growth expectations.

However, the local economy is not diversified due to the mining industry (44% of the GVA) which contributes the most to the local economy. This is followed by the utilities (11% of GVA) and trade sectors (9% of GVA). Mining also remains the most prominent sector in terms of its employment contribution with 23%, followed by the trade sector which provides 18% of the employment in the ELM area. The community and finance sectors both provide 12% of the employment[44].

In 2013, the eMalahleni GDP was R 58.1 billion. This figure indicates a 48.26% contribution to NDM GDP of R 120 billion in the same year and a 20.92% contribution to the GDP of Mpumalanga Province[45].

eMalahlani is also one of the municipalities which experienced population growth rates higher than their economic growth rates, which has significant negative implications from a GDP per capita and an infrastructure, service delivery, and job creation point of view.

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[43] www.saps.gov.za

[44] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

[45] eMalahleni Local Municipality (2017). Draft Integrated Development Plan 2018-2019

## 8. IMPACTS ASSOCIATED WITH THE PROPOSED VDDC INFRASTRUCTURE DEVELOPMENT PROJECT

The VDDC Infrastructure Development Project is a brownfields project within the greater mining right area. It should thus again be noted that extensive mining activities are already being undertaken in the area. The impacts of the current operations have thus been assessed prior to the specific mining activities commencing. An area of approximately 196 hectares in the latest mine lay-out was not included in the previous mine lay-out and is therefore not approved to be opencast mined. This impact assessment will therefore focus on the additional infrastructure development proposed as part of the VDDC project, as well as the open cast mining that was not previously authorised.

The following section provides a brief description of the social impacts anticipated to occur during the construction and operational stages of the proposed Infrastructure and Mining Development.

### 8.1 Employment Opportunities, Local Procurement and Inflow of Workforce

The development focuses on the employment creation associated with the erection, management and maintenance of the required infrastructure and activities associated with the open cast mining that was not previously authorised.

Therefore, it is anticipated that the development would result in limited additional employment opportunities with a temporary increase in the concentration of workers at the VDDC e.g. during the construction of the haul roads. Limited new opportunities such as some short term contract work could be generated for certain periods of time. Locals could be part of the teams involved in the short term contracts. Other activities associated with the development (e.g. topsoil and overburden dumps) would mainly entail mechanical operations and the associated activities would be seen as extensions of the existing mining activities and open cast mining.

Thus, even though the Wolvekrans – Ifalethu Colliery is operational and provides employment to various individuals and the fact that a large sector of the employed homeowners within the area are employed at the various mines in the area, the ELM IDP indicated that job creation within the Van Dyksdrift area remains a critical need.

During the operation of the mining activities and thus the functioning of the proposed infrastructure, maintenance, supervision and monitoring teams would be on site. Maintenance is expected to include emergency repairs, routine maintenance and general maintenance of the mining infrastructure which would be undertaken by a relative small group of individuals as it is anticipated that the operations would be mainly mechanically operated and maintained. These maintenance activities would not result in various employment opportunities.

With the number of employees currently concentrated within the study area, the possible slight increase in workers during the construction and operational phase on site is anticipated to have a limited impact on the social environment.

The positives with regard to employment creation thus remain with possible procurement of local small businesses and Small, Medium, Micro Enterprises (SMME's) with regards to the design, procurement, installation, construction and commissioning of the infrastructure, and open cast mining.

**Table 12: Employment Opportunities, Local Procurement and Inflow of Workers**

| IMPACT: EMPLOYMENT OPPORTUNITIES, PROCUREMENT AND INFLOW OF WORKERS | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to enhancement** | ***Post Enhancement*** | **Prior to enhancement** | ***Post Enhancement*** |
| **Significance (S)** | Low (2) | *Moderate (3)* | Very Low (1) | *Low (2)* |
| **Spatial Scale (SS)** | Regional/Provincial (4) | *Local (3)* | *Local (3)* | *Local (3)* |
| **Duration Scale (DS)** | Short-term (2) | *Short-term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Could Happen (3) | *Could Happen (3)* | Could Happen (3) | *Could Happen (3)* |
| **Impact Risk Rating (IRR) (S + SS + DS /3)** | 2.6 | *2.6* | 2.3 | *2.6* |
| **Probability Rating (PR) (P/5)** | 0.6 | *0.6* | 0.6 | *0.6* |
| **Final Rating (IRR x PR)** | 1.56 | *1.56* | 1.38 | *1.56* |
| **Impact Risk Class** | Low (1.56) | *Low (1.56)* | Low (1.38) | *Low (1.56)* |

**Enhancement:**

- Communities within close proximity to the mining activities should be given preference if any new employment opportunities will be created, as these communities will be mostly affected by the existing approved mining activities and proposed infrastructure development.
- Procurement and recruitment of individuals should be undertaken through formalised structures and according to processes that are in line with international best-practice standards.
- Procurement of goods, services, material and equipment should be focused on the local area where economically feasible
- Sub-contractors should adopt a recruitment policy to enhance employment positive impacts, limit in-migration of outside jobseekers and mitigate the potential impact of residual in-migration

## 8.2 Inflow of Jobseekers

The Wolvekrans – Ifalethu Colliery is operational and provides employment to various individuals. Even though a large sector of the homeowners within the municipal area is employed at the various mines in the area, the ELM IDP and Community Survey of 2016 indicated that 23.2% of the local population is still unemployed. The eMalahleni Municipality further experiences large scale in-migration to the ELM in search of employment. Some do not have the right skills to work in the local economy and thus put more pressure on the provision of services and infrastructure.

Even though the development is anticipated to create limited employment opportunities, it is possible that jobseekers could gather at the entrance to the colliery, due to the social profile of the local residents and residents of the larger municipal area. The distance of the settlements of Lindokuhle, Springbok and Kwajuma to the mining activities and the infrastructure development, as well as the socio-economic profile of the residents makes this impact even more likely.

The magnitude of the inflow of jobseekers, however, is difficult to predict. Even though there is a low probability of it resulting in severe negative impacts, pro-active mitigation measures should be implemented to address the issue and to avoid possible long term negative impacts in this regard (e.g. outsiders remaining in the area putting additional pressure on the local infrastructure and services, especially housing which is already a concern in the municipal area).

**Table 13: Inflow of Jobseekers**

| **IMPACT: INFLOW OF JOBSEEKERS** | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to mitigation** | ***Post Mitigation*** | **Prior to mitigation** | ***Post Mitigation*** |
| **Significance (S)** | Moderate (3) | *Low (2)* | Low (2) | *Low (2)* |
| **Spatial Scale (SS)** | Local (3) | *Local (3)* | Local (3) | *Local (3)* |
| **Duration Scale (DS)** | Short-term (2) | *Short-term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Very likely (4) | *Very likely (4)* | Could Happen (3) | *Unlikely (2)* |
| **Impact Risk Rating (IRR) (S + SS + DS /3)** | 2.6 | *2.3* | 2.6 | *2.6* |
| **Probability Rating (PR) (P/5)** | 0.8 | *0.8* | 0.6 | *0.4* |
| **Final Rating (IRR x PR)** | 2.08 | *1.84* | 1.56 | *1.04* |
| **Impact Risk Class** | Moderate (2.08) | *Low (1.84)* | Low (1.56) | *Very Low (1.04)* |
| **Mitigation:** | | | | |

| IMPACT: INFLOW OF JOBSEEKERS |
| --- |
| • The communication strategy with regards to the recruitment process and use of contractors to the local residents should ensure that unrealistic employment expectations are not created.<br>• Maximise the use of local labour if required and where possible.<br>• South32 should support efforts of the ELM to limit in-migration to the area and the subsequent development or extension of informal settlements in the area<br>• Sub-contractors should adopt a recruitment policy to enhance employment positive impacts, limit in-migration of outside jobseekers and mitigate the potential impact of residual in-migration |

## 8.3 Impact on Daily Living and Movement Patterns

Depending on the size of the vehicles transporting personnel, equipment, goods and mining material, access to the VDDC project area would be undertaken via the following options:

- Current SKS main entrance;
- Current Wolvekrans main entrance (via BMK workshops);
- Current VDD main entrance (opposite Springbok settlement)[46].

All personnel transport and light delivery vehicles will enter the site via the current SKS main entrance. Personal vehicles will park in the existing and extended personnel vehicle parking, whilst busses will drop personnel off at the existing bus turnaround[47].

Light delivery vehicles and heavy delivery vehicles up to 10t single body trucks will also enter via the existing SKS main entrance and deliver to the required location, or to the existing store facilities. The heavy delivery vehicles and lowbeds will access the site either via the WVK main entrance or the VDD main entrance depending on the destination on the VDDC Project area[48].

New roads required for the VDDC project include:

- Temporary high wall roads and dragline walkways which will be re-established as mining progresses;
- Earth Moving Equipment (EME) haul roads (40 m width) from the bottom of box cut ramps to the existing haul roads;
- Additional maintenance/service and access roads within the VDDC project area from the existing infrastructure to the box-cut;

[46] Jones & Wagner (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 8

[47] Jones & Wagner (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 3

[48] Jones & Wagner (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 3

- New haul road to the No. 4 seam and No. 5 seam stockpiles.[49]

These new roads are all located within the mining area and will not impact on daily movement.

The R544 is the main access route to the study area from Emalahleni and to the entrances discussed above. This road is already under pressure due to the existing traffic volumes. Construction related vehicles could have a further negative impact on the local roads, especially the R544 and smaller dirt roads (if used). Negative impacts relate to possible damage to the road surface and an increase in the traffic volumes which could pose an additional traffic safety risks to the road users and pedestrians. According to the eMalahleni SDF, the R544 has been listed as a priority road for maintenance.

The increased traffic volumes and construction of internal roads within the VDDC mining area could have negative impacts on the social environment due to increased noise and dust and possible health related impacts due to the gaseous emissions of the increased vehicular traffic. The intended use of existing haul roads and service roads could, however, limit this possible negative impact.

The above negative impacts should, however, be evaluated taking the existing impacts of the approved mining activities into consideration. This status quo and the limited direct impact that the proposed infrastructure development would have on the daily living and movement patterns of residents and road users were thus considered in the rating below.

**Table 14: Impact on Daily Living and Movement Patterns**

| **IMPACT: IMPACT ON DAILY LIVING AND MOVEMENT PATTERNS** | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to mitigation** | ***Post Mitigation*** | **Prior to mitigation** | ***Post Mitigation*** |
| **Significance (S)** | Low (2) | *Low (2)* | Low (2) | *Low (2)* |
| **Spatial Scale (SS)** | Local (3) | *Local (3)* | Local (3) | *Local (3)* |
| **Duration Scale (DS)** | Short-term (2) | *Short-term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Could Happen (3) | *Unlikely (2)* | Could Happen (3) | *Unlikely (2)* |
| **Impact Risk Rating (IRR)**<br>**(S + SS + DS /3)** | 2.3 | *2.3* | 2.6 | *2.6* |

[49] Jones & Wagner (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 8

| IMPACT: IMPACT ON DAILY LIVING AND MOVEMENT PATTERNS | | | | |
|---|---|---|---|---|
| **Probability Rating (PR) (P/5)** | 0.6 | *0.4* | 0.6 | *0.4* |
| **Final Rating (IRR x PR)** | 1.38 | *0.92* | 1.56 | *1.04* |
| **Impact Risk Class** | Low (1.38) | *Very Low (0.92)* | Low (1.56) | *Very Low (1.04)* |
| **Mitigation:**<br>• Strict adherence by contractors to speed limits within the mining area should be enforced<br>• Disciplinary action for reckless driving within the mining area should be implemented | | | | |

## 8.4 Residential Proximity

Van Dyksdrift has historically served a residential function, but the formal Van Dyksdrift Settlement was demolished, and only some informal settlements remained. There are two small retail facilities at Van Dyksdrift[50].

The proposed new mining and infrastructure developments would take place within the greater Wolvekrans – Ifalethu Colliery mining right area. It should further be noted that the mines have become an infrastructural feature in the area over time. Even though the Lindokuhle informal settlement is situated in close proximity to the southern portion of the VDDC opencast mining area and some of the new infrastructure proposed, the proposed development, together with the other existing mining activities in the area, is not expected to severely change the residents' type of lifestyle with resultant impacts on the local sense of place. It should be further noted that the mining development will be phased over an extended period. Intrusive visuals impacts due to the infrastructure are therefore considered of a low significance considering the existing status quo.

Other intrusion impacts anticipated to influence the daily living conditions of the Lindokuhle residents refer to noise and dust pollution. Ideally, residents should not live in such proximity to mining activities. The present activities have existing impacts on these residents, and the infrastructure development is not anticipated to worsen this existing impact. The extension of the open cast mining activities that would be phased over an extended period, however, could result in additional noise and dust. Any possible negative impacts in this regard must however be strictly mitigated.

Ongoing monitoring of possible negative impacts on the residents of the Lindokuhle Settlement should be undertaken to determine whether any specific mitigation measures would be required in future.

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[50] eMalahleni Local Municipality (2015). Spatial Development Framework

**Table 15: Residential Proximity**

| IMPACT: RESIDENTIAL PROXIMITY | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to mitigation** | ***Post Mitigation*** | **Prior to mitigation** | ***Post Mitigation*** |
| **Significance (S)** | Low (2) | *Low (2)* | Moderate (3) | *Moderate (3)* |
| **Spatial Scale (SS)** | Local (3) | *Local (3)* | Local (3) | *Local (3)* |
| **Duration Scale (DS)** | Short term (2) | *Short term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Could Happen (3) | *Could Happen (3)* | Very likely (4) | *Could Happen (3)* |
| **Impact Risk Rating (IRR)**<br>**(S + SS + DS /3)** | 2.3 | *2.3* | 3 | *3* |
| **Probability Rating (PR) (P/5)** | 0.6 | *0.6* | 0.8 | *0.6* |
| **Final Rating**<br>**(IRR x PR)** | 1.38 | *1.38* | 2.4 | *1.8* |
| **Impact Risk Class** | Low (1.38) | *Low (1.38)* | Moderate (2.4) | *Low (1.8)* |

**Mitigation:**

- During the construction of the proposed infrastructure and during the use of the infrastructure (operational phase) all activities associated with the operation and maintenance of the infrastructure should adhere to relevant regulations to limit noise and dust pollution
- Heavy vehicles should be in good working order to limit any noise and dust pollution
- Dust suppression methods should be strictly implemented
- Possible negative impacts on the surrounding landowners and nearby residents should be limited to minimise any possible negative impacts on these residents' quality of life.
- Also refer to the mitigation measures proposed as part of Sections 8.6, 8.7, 8.8, and 8.9.

## 8.5 Impact on Agricultural Activities

No farming activities would be affected on the proposed sites for the proposed development, as the area falls within the Wolvekrans – Ifalethu Colliery mining right area.

The main agricultural activities practiced in the larger area involve maize production with some cattle farming. Possible indirect negative impacts on such agricultural activities can occur. Should water sources be contaminated as a result of the activities associated with the infrastructure development, it could have severe negative impacts for affected farming activities, especially for landowners dependent on borehole water for agricultural and household purposes.

Dust from the topsoil dumps is also a source of concern. Any such pollution should thus be mitigated to ensure that the negative impacts do not manifest on crop production activities to the east and south of the project area. Mitigation must be implemented to ensure that no financial losses as a result of the infrastructure development on the farming practices occur.

**Table 16: Impact on Agricultural Activities**

| **IMPACT: AGRICULTURAL ACTIVITIES** | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to mitigation** | ***Post Mitigation*** | **Prior to mitigation** | ***Post Mitigation*** |
| **Significance (S)** | Low (2) | *Low (2)* | Moderate (3) | *Moderate (3)* |
| **Spatial Scale (SS)** | Local (3) | *Local (3)* | Local (3) | *Local (3)* |
| **Duration Scale (DS)** | Short term (2) | *Short term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Could Happen (3) | *Could Happen (3)* | Very likely (4) | *Could Happen (3)* |
| **Impact Risk Rating (IRR) (S + SS + DS /3)** | 2.3 | *2.3* | 3 | *3* |
| **Probability Rating (PR) (P/5)** | 0.6 | *0.6* | 0.8 | *0.6* |
| **Final Rating (IRR x PR)** | 1.38 | *1.38* | 2.4 | *1.8* |
| **Impact Risk Class** | Low (1.38) | *Low (1.38)* | Moderate (2.4) | *Low (1.8)* |
| **Mitigation:**<br>• Effective management of the mining activities associated with the infrastructure development would be required to avoid any environmental pollution (e.g. water) and limiting any increase in dust levels. | | | | |

## 8.6 Impact on Sense of Place

The social impact associated with the impact on the sense of place relates to the change in the landscape character and visual impact of the proposed mining and infrastructure such as the overburden and topsoil dumps, ROM stockpiles, and haul roads.

Mining infrastructure is usually perceived to have a visual invasiveness on the sense of place. The existing facilities as part of the current mining activities include a ROM tip, overland conveyor system, the SKS complex offices, warehouse, change houses, workshops, wash bays, laydown areas, an existing topsoil dump, surface discard dumps, water management berms and canals, as well as fuelling facilities.  A significant existing visual impact is thus present in the area.

The proposed infrastructure and open cast mining areas that were not previously authorised, would probably be visible to the residents of the Lindokuhle Settlement (approximately 1 km from the mining area).  Limited natural vegetation exists and would not be able to serve as screening in this regard.

Due to the presence of the existing mining activities with various different infrastructural developments nearby (roads, mining, conveyor belts, transmission lines, railway line and so forth), it is not expected that the proposed new infrastructure and open cast mining would be perceived as an individual or new impact but would be balanced with the existing visual impact of the overall Wolvekrans - Ifalethu Colliery. Even though no additional negative impacts on the sense of place in this regard is foreseen, the impact would still be rated negative due to the intrusive visual impact of additional infrastructure and open cast mining, mainly on the Lindokuhle Settlement.

**Table 17: Impact on Sense of Place**

| **IMPACT: SENSE OF PLACE** | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to mitigation** | ***Post Mitigation*** | **Prior to mitigation** | ***Post Mitigation*** |
| **Significance (S)** | Low (2) | *Low (2)* | Moderate (3) | *Moderate (3)* |
| **Spatial Scale (SS)** | Local (3) | *Local (3)* | Local (3) | *Local (3)* |
| **Duration Scale (DS)** | Short term (2) | *Short term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Could Happen (3) | *Could Happen (3)* | Very likely (4) | *Could Happen (3)* |
| **Impact Risk Rating (IRR) (S + SS + DS /3)** | 2.3 | *2.3* | 3 | *3* |
| **Probability Rating (PR) (P/5)** | 0.6 | *0.6* | 0.8 | *0.6* |
| **Final Rating (IRR x PR)** | 1.38 | *1.38* | 2.4 | *1.8* |
| **Impact Risk Class** | Low (1.38) | *Low (1.38)* | Moderate (2.4) | *Low (1.8)* |
| **Mitigation:**<br>• Appropriate site management and maintenance of the proposed infrastructure as stipulated in the EMP should be undertaken<br>• Rehabilitation activities should be undertaken as soon as possible or when steady state mining has been achieved to limit stockpiling | | | | |

| IMPACT: SENSE OF PLACE |
|---|
| • The mitigation measures of the Visual Impact Assessment should be strictly implemented. |

### 8.7 Safety and Security Risks

Safety and security issues relate to the possible inflow of workers to the area as a result of the project, the movement of mining vehicles and operation of equipment, and possible risks posed by the infrastructure itself.

As limited additional employees are foreseen and as the activities would take place within the mining right area, limited added safety and security risks are foreseen. The area where the mining and infrastructure development will take place is managed according to the mine's security guidelines.

The area is characterised by the movement of mining related vehicles from different mines. Even though limited, the movement of heavy vehicles (associated with the infrastructure development) on public roads further poses increased accident risks. The anticipated impact would thus not materialise where the infrastructure is proposed, but as a result of all the mining activities on the public roads such as the R544.

Occupational health and safety risks associated with mining operations are always a source of concern. The proposed infrastructure could create additional safety and security risks to residents, if not properly managed. Occupational safety risks related to the functioning of the proposed infrastructure would have to be dealt with under the Occupational Health and Safety Act (1993). The EMPr should also be strictly implemented, especially with regards to the proposed development that would be in close proximity to Lindokuhle.

The socio-economic conditions of residents of the informal settlements in the area indicate that those living in these settlements are mainly unemployed and could easily revert to criminal activities. The crime levels in the area are expected to continue as the proposed project would not alleviate the unemployment levels. Concerns in this regard relate to e.g. the illegal reworking of waste rock piles or selling of these products. Unauthorised entry to the mining area should thus be guarded against.

**Table 18: Safety and Security Risks**

| IMPACT: SAFETY AND SECURITY RISKS | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to mitigation** | ***Post Mitigation*** | **Prior to mitigation** | ***Post Mitigation*** |
| **Significance (S)** | Low (2) | *Low (2)* | Moderate (3) | *Moderate (3)* |
| **Spatial Scale (SS)** | Local (3) | *Local (3)* | Local (3) | *Local (3)* |
| **Duration Scale (DS)** | Short term (2) | *Short term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Could Happen (3) | *Unlikely (2)* | Could Happen (3) | *Unlikely (2)* |
| **Impact Risk Rating (IRR) (S + SS + DS /3)** | 2.3 | 2.3 | 3 | *3* |
| **Probability Rating (PR) (P/5)** | 0.6 | 0.4 | 0.6 | *0.4* |
| **Final Rating (IRR x PR)** | 1.38 | 0.92 | 1.8 | *1.2* |
| **Impact Risk Class** | Low (1.38) | Low (0.92) | Low (1.8) | *Low (1.2)* |

**Mitigation:**

- Risks of accidents should be recognised. Safety training should again be implemented focused on the designated drivers (employees) of heavy vehicles. The mine driving rules should be adhered to.
- Strict codes of conduct should be implemented for personnel operating heavy and light vehicles to minimize traffic hazards within the mining area
- Construction of the different types of roads within the mining area should be done in a manner which would facilitate safe and efficient movement of material, employees as well as other mining vehicles
- The different types of roads within the mining area should be maintained on a continuous basis to ensure safety
- Emergency procedures should be established that provide immediate response should an accident occur within the mining area
- Possible negative impacts on the surrounding landowners should be limited by ensuring that safety requirements within the mining area are adhered to
- Appropriate firefighting equipment should be on site and construction workers, as well as permanent employees should be appropriately trained for fire fighting

## 8.8 Health Risks

Concerns revolve around the possible public health impact of the proposed infrastructure (e.g. topsoil and overburden dumps, dust pollution due to wind erosion from topsoil stockpiles (although limited) and the use of unpaved haul roads) on the health of the surrounding landowners and communities, due to possible air/dust pollution. Dwellings could thus, especially in winter months or during windy periods, be negatively affected. Concerns also relate to the possible dust impact on agricultural practices if these are within the dispersion plume.

Gaseous emissions from construction vehicles and those vehicles on site could further impact on the air quality in the area.

The intensity would be influenced by various factors such as the prevalent wind direction and the location of the nearby settlements, as well as the mine waste management plan to be implemented.

The Air Quality Impact Assessment indicated that mining activities is one of the main contributors impacting on the air quality in the area. The proposed project is however not anticipated to increase the health risks as a result of possible increase in the air pollution (dust). Health risks, even though it could be negligible, should still be adequately dealt with and be taken into account in the monitoring processes stipulated as part of the EMPr. Care should also be taken to limit any possible health related impacts by striving towards international best practice.

**Table 19: Health Risks**

| **IMPACT: HEALTH RISKS** | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to mitigation** | ***Post Mitigation*** | **Prior to mitigation** | ***Post Mitigation*** |
| **Significance (S)** | Low (2) | *Low (2)* | Moderate (3) | *Moderate (3)* |
| **Spatial Scale (SS)** | Local (3) | *Local (3)* | Local (3) | *Local (3)* |
| **Duration Scale (DS)** | Short term (2) | *Short term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Could Happen (3) | *Unlikely (2)* | Could Happen (3) | *Unlikely (2)* |
| **Impact Risk Rating (IRR) (S + SS + DS /3)** | 2.3 | 2.3 | 3 | *3* |
| **Probability Rating (PR) (P/5)** | 0.6 | 0.4 | 0.6 | *0.4* |
| **Final Rating (IRR x PR)** | 1.38 | 0.92 | 1.8 | *1.2* |
| **Impact Risk Class** | Low (1.38) | Very Low (0.92) | Low (1.8) | *Low (1.2)* |
| **Mitigation:**<br>• Gaseous emissions should be minimized through proper operation and maintenance of vehicles | | | | |

| IMPACT: HEALTH RISKS |
|---|
| • Dust suppressants should be used on the roads within the mining area<br>• Fugitive dust emissions should thus be controlled through the implementation of appropriate environmental mitigation measures e.g. ongoing rehabilitation<br>• Possible negative impacts on the surrounding landowners and nearby residents should be limited by ensuring that health risks are minimised and mitigation measures are implemented as stipulated in the Air Quality Impact Assessment and EMPr<br>• The addition/upgrading of an on-site clinic for mine employees could be considered<br>• Vehicles should be in a good working order and adhere to mine driving rules |

## 8.9 Noise related impacts

It is not anticipated that the construction activities associated with the development of the infrastructure and the inflow of the workers to the area would significantly change the ambient noise levels in the area. Due to the existing mining activities in the area and the very limited number of workers involved in the process, the noise impacts with regards to the development of the infrastructure are therefore deemed moderate to low. Impacts of a moderate to low rating are anticipated from movement of vehicles and other machinery, based on the findings of the Noise Impact Assessment.

The impacts on the quality of life of nearby residents are thus not anticipated to be negatively impacted by the increase in noise levels as a result of the infrastructure development project.

**Table 20: Noise Related Impacts**

| IMPACT: NOISE RELATED IMPACTS | | | | |
|---|---|---|---|---|
| **PHASES** | **Construction Phase** | | **Operational Phase** | |
| | **Prior to mitigation** | ***Post Mitigation*** | **Prior to mitigation** | ***Post Mitigation*** |
| **Significance (S)** | Low (2) | *Low (2)* | Low (2) | *Low (2)* |
| **Spatial Scale (SS)** | Study area (2) | *Study area (2)* | Study area (2) | *Study area (2)* |
| **Duration Scale (DS)** | Short term (2) | *Short term (2)* | Medium term (3) | *Medium term (3)* |
| **Degree of Probability (P)** | Could Happen (3) | *Unlikely (2)* | Could Happen (3) | *Unlikely (2)* |
| **Impact Risk Rating (IRR) (S + SS + DS /3)** | 1.3 | *1.3* | 2.3 | *2.3* |
| **Probability Rating (PR) (P/5)** | 0.6 | *0.4* | 0.6 | *0.4* |
| **Final Rating (IRR x PR)** | 0.78 | *0.52* | 1.38 | *0.92* |

| IMPACT: NOISE RELATED IMPACTS | | | | |
|---|---|---|---|---|
| **Impact Risk Class** | Very Low (0.78) | *Very Low (0.92)* | Low (1.38) | *Very Low (0.92)* |
| **Mitigation:**<br>• A noise monitoring program should be implemented to ensure noise from activities and equipment meet or fall below noise guidelines<br>• Mitigation measures to limit any increase in noise as recommended by the Noise Impact Assessment specialist should be adhered to. | | | | |

## 9. DECOMMISSIONING AND CLOSURE

Decommissioning refers to the dismantling of the infrastructure and/or replacement of the infrastructure with newer technology. Possible social impacts to be experienced during decommissioning of the infrastructure could include the following:

- Limited job losses and/or off-set by jobs created as part of decommissioning the infrastructure or supplanting it;
- Negative impact on infrastructure development and maintenance;
- A change in community infrastructure;
- A change in the industrial focus of the area;
- Disruptions and nuisance factors associated with the actual decommissioning such as noise, visual and traffic related impacts;
- Increased safety risks associated with the decommissioning of the infrastructure;
- Remnants of possible environmental impacts; and
- Remaining visual impact as a result of mining.

As decommissioning or the replacement of the infrastructure is likely to only take place within approximately 25 years, it is recommended that a detailed Social Impact Assessment be undertaken then to determine the actual impacts on the changing social environment at that stage.

## 10. NO-GO ALTERNATIVE

The infrastructure is proposed to support the proposed opencast mining and assist with the management of potential pollution sources at the mine. It is therefore necessary to ensure that the life of mine of the Wolvekrans Colliery can continue until 2046 and to ensure that the contractual obligations are met. Should this not be implemented, the socio-economic development associated with the mining activities would not materialise. In addition, any possible negative social impacts associated with the mining activities would also not occur.

The most significant social impact with regards to the no-go alternative relates to the loss in employment opportunities and the overall direct and indirect economic impacts for the region when mining ceases.

As the mine is involved in various corporate social investment programmes these would not be further implemented and no impacts on poverty alleviation would occur as a result of such programmes. The potential loss in terms of employment and economic benefits to the local communities is considered as a critical negative impact.

The 'no-go alternative' should thus not be considered from a social point of view as the negative social impacts anticipated with the expansion project are deemed low. The negative impacts would further respond to mitigation as proposed. The proposed activities further falls within the mining rights area and the area is already characterised by and surrounded by various mining infrastructure.

## 11. CONCLUDING REMARKS

Based on the social assessment, the following concluding remarks should be noted:

- The proposed mining and infrastructure development would result in limited additional employment opportunities with a temporary increase in the concentration of workers at the VDDC. Negative social impacts associated with the inflow of a large workforce are thus reduced, but the specific development would then also result in limited socio-economic benefits for the local community members. It should however, again be noted that the mine has been in operation for many years. As part of the existing operations, various social initiatives have been undertaken and different socio-economic commitments have been proposed as part of the existing Social and Labour Plan (SLP).
- The inflow of jobseekers associated with the development is likely, but even if there is a low probability of it resulting in severe negative impacts, pro-active mitigation measures should be implemented to address the issue and to avoid possible long term impacts.
- It must be noted that Lindokuhle is in close proximity to the existing mining activities. Although it is not anticipated that the proposed development would directly impact on the Lindokuhle Settlement, apart from limited noise and dust pollution, mitigation measures should be strictly implemented to avoid any possible short and long term negative impacts on the residents' quality of life. Ongoing monitoring of possible negative impacts on the residents of the Lindokuhle Settlement should be undertaken to determine whether any specific mitigation measures would be required in future.
- It is anticipated that the negative social impacts can be mitigated by appropriate environmental mitigation measures as contained within the EMPr for the proposed infrastructure development project.

In view of the fact that mining activities are already undertaken in the area and that the proposed infrastructure and mining development will be situated within the Wolvekrans – Ifalethu Colliery Mining Right area, the proposed mining activity is not perceived to constitute a separate activity. It could rather be perceived as development associated with an existing activity. The infrastructure by itself will thus not necessarily introduce new social risks and hazards, but could increase the probability and scale of those already associated with the existing mining activities. It is therefore recommended that the proposed VDDC mining and infrastructure development can be authorised, but that the mitigation measures contained in this document be integrated within the EMPr.

## 12. SOURCES CONSULTED

### 12.1 Documents

Airshed Planning Professionals (2018) Vandyksdrift Central (VDDC) Infrastructure: Air Quality Impact Assessment

Airshed Planning Professionals (2019) Vandyksdrift Central (VDDC) Infrastructure: Noise Impact Assessment

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Jones & Wagener (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description for purpose of Integrated Regulatory Process – Revision 8

Jones & Wagener (Pty) Ltd. (2018) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Project Description: Consultation Scoping Report

Jones & Wagener (Pty) Ltd. (2019) Vandyksdrift Central (VDDC) Mining: Infrastructure Development: Visual Assessment: Impact Assessment Report

Nemai Consulting (2013) BHP Billiton Energy Coal South Africa (Pty) Ltd Vandyksdrif Central Project

SRK Consulting (2013) Vandyksdrift Central (VDDC) Project Preliminary Mine Closure Plan

### 12.2 Consultation

Mr. Peter Kane Bergman: Beestepan Boerdery: Farm Enkeldebosch 20 IS

Mr. Erasmus: Islardu Boerdery: Farm Enkeldebosch 20 IS

Ms. Thembi Shabalala: Councillor Ward 32 (attempts to conduct an interview were made)

Mr. Jaco van Dyk: Valco Boerdery: Farms Vaalkranz 29 IS and Farm Enkeldebosch 20 IS (attempts to conduct an interview were made)

### 12.3 Websites

www.demarcation.org.za

www.localgovernment.co.za

www.nkangaladm.gov.za

www.south32.net

www.statssa.gov.za

www.wazimap.co.za

## 13. EXPERIENCE RECORD OF THE SIA PRACTITIONER

Ms. Ingrid Snyman holds a BA Honours degree in Anthropology. She has more than fifteen years' experience in the social field. Ms. Snyman has been involved in various Social Impact Assessments during her career as social scientist. These project themes consist of infrastructure development, waste management, road development, water and sanitation programmes, township and other residential type developments. She has also been involved in the design and management of numerous public participation programmes and communication strategies, particularly on complex development projects that require various levels and approaches.

## 14. CURRICULAM VITAE OF SIA PRACTITIONER

## CURRICULUM VITAE: INGRID SNYMAN

| | | | |
|---|---|---|---|
| **Name:** | **Ingrid Helene Snyman** | | |
| **Profession:** | Social Development Consultant | **Name of firm:** | Batho Earth |
| **Years of Experience:** | 20 + years | | |

### KEY QUALIFICATIONS

- Social Impact Assessment (SIA)
- Public Participation programmes
- Communication, development of community structures and community facilitation
- Community-based training and
- Workshop reports

### EDUCATION

| | |
|---|---|
| 1992: | B A (Political Science) University of Pretoria |
| 1995: | B A (Hons) Anthropology University of Pretoria |
| 1996 - 1997: | Train the Trainers Centre for Development Administration – UNISA |

### EXPERIENCE RECORD

| | |
|---|---|
| 2000 to date: | Independent Development Consultant: Batho Earth |
| 1996 to 2000: | Social Consultant: Afrosearch (Pty) Ltd. |

### PROJECT EXPERIENCE

**Mining Industry**

- SEIA and PPP for the proposed Theta Hill Gold Mining Project near Pilgrim's Rest, Mpumalanga (ongoing)
- SIA for the proposed Khulu TSF at Dwarsrivier Mine, near Steelpoort, Limpopo Province (ongoing)
- Social Risk Assessment for Dwarsrivier Chrome Mine, near Steelpoort, Limpopo Province
- PPP for the development of various additional listed activities at the Dwarsrivier Chrome Mine, near Steelpoort, Limpopo Province
- SIA and Public Participation for the proposed Project 10161 and Project 10167 (Gold Mining) by Stonewall (Pty) Ltd., near Sabie and Pilgrims Rest, Mpumalanga
- SIA for the Manganese Mine North West Of Hotazel, Northern Cape (Mukulu Environmental Authorisation Project)
- SIA for the proposed South32 SA Coal Holdings Middelburg Colliery Environmental Management Plan (EMP) and Water Use Licence (WUL) Application Project (Life of Asset Open Cast Expansion and Dispatch Rider Project), Middelburg, Mpumalanga
- SIA for the proposed Manganese Mine on the Remaining Extent of the Farm Paling 434, Northern Cape Province: Revision And Amendment Of Existing Approved Environmental Management Programme (EMP) For A Mining Right
- SIA and Public Participation for the proposed Western Bushveld Joint Venture Project (Maseve Platinum Mine), North West Province
- Public Participation for Sable Platinum for the proposed prospecting application on the farm Doornpoort, Pretoria, Gauteng
- Public Participation for the prospecting application on the farms Frischgewaagd and Kleinfontein, Mpumalanga Province for PTM
- SIA to determine the impact of the Tharisa Mine on the neighbouring properties and property owners, Buffelspoort area, near Marikana, North West Province
- Public Participation for the prospecting application on the farm Klipfontein, Gauteng for PTM
- SIA as part of the Basic Assessment for the extension of the Komati coal stockyard, Mpumalanga

- SIA for the proposed Dorstfontein Mine Western Expansion Project, Kriel, Mpumalanga
- SIA for the proposed Grootboom Platinum Mine, Steelpoort, Limpopo Province
- SIA for the proposed Dorstfontein Mine Expansion Project, Kriel, Mpumalanga

**Bulk Infrastructure and Supply**

- SEIA for the proposed Greenwich Landfill Site, Newcastle, KwaZulu Natal
- SIA for the proposed Mangaung Gariep Water Augmentation Project, Free State
- SIA for the proposed development of the new Tshwane Regional General Waste Disposal Facility (Multisand Landfill), Pretoria, Gauteng Province
- SIA as part of the Basic Assessment for the proposed K97 Road northbound of the N4 at Bon Accord and investigation with regards to the possible resettlement of business premises, Pretoria, Gauteng
- SIA for the proposed extension of the Wemmershoek Wastewater Treatment Works (WWTW), decommissioning of the Franschhoek WWTW and construction of a transfer and outfall sewer between the two works, Franschhoek, Western Cape
- SIA for the proposed Lefaragathle, Mogono, Rasimone, Chaneng outfall sewer and Chaneng sewer treatment plant, Rustenburg (Phokeng), North West Province
- SIA for the proposed upgrading of railway stations and railway line for Metrorail in Mamelodi, Gauteng
- SIA for the proposed ACSA Remote Aprons Project, O.R. Tambo International Airport, Gauteng
- Public Participation and SIA as part of the Environmental Scoping Study for the proposed upgrading of the Waterval Water Care Works

**Ecosystem Services Review**

- Proposed Ngonye Falls Hydro-Electric Power Plant Project, Western Province, Zambia: Biodiversity Assessment: Stakeholder Engagement Plan and Social Assessment for the Ecosystem Services Review (ESR)

**Projects related to electricity generation, transmission and distribution**

- SIA for the proposed Crowthorne-Lulamisa power line, Midrand, Gauteng
- SIA as part of the Basic Assessment for the proposed Crowthorne Underground Cable, Gauteng
- SIA as part of the Basic Assessment for the proposed Diepsloot East Servitude and substation, Gauteng
- SIA for the proposed Mitchells Plain-Firgrove-Stikland Transmission Line project and investigation with regards to the possible resettlement of individuals within Mitchells Plain, Western Cape
- SIA for the proposed 400 kV Transmission Power Line for approximately 10km to the west of the existing Marathon Substation and possible resettlement of homesteads, Nelspruit area, Mpumalanga
- SIA as part of the Basic Assessment for the proposed construction of a 400 kV transmission line between the Ferrum substation (Kathu) and the Garona substation (Groblershoop), Northern Cape Province
- SIA as part of the Basic Assessment for the proposed construction of the Eskom Rhombus-Lethabong 88kv Powerline and Substation, North West Province
- SIA for the proposed Aberdeen-Droerivier 400 kV Transmission Power Line, Eastern and Western Cape Province
- SIA for the proposed Houhoek Substation Upgrade and Bacchus-Palmiet Loop-In and Loop-Out, near Botrivier, Western Cape Province
- SIA for the proposed Arnot-Gumeni 400 kV Transmission Power Line, Mpumalanga
- SIA for the proposed Aggeneis-Oranjemond Transmission Line project, Northern Cape Province
- SIA for the proposed Ariadne-Venus Transmission Line, KwaZulu Natal
- SIA for the proposed Dominion Reefs Power Line project, North West Province
- SIA for the proposed Kyalami Strengthening Project, Kyalami, Gauteng
- SIA for the proposed Apollo Lepini 400 kV Transmission Line Project, Tembisa, Gauteng
- Public Participation for the proposed new Medupi (then referred to as Matimba B) coal-fired power station in the Lephalale area, Limpopo Province

- Public Participation and SIA for the proposed Poseidon-Grassridge No. 3 400 kV Transmission line and the extension of the Grassridge Substation, Eastern Cape Province
- Public Participation and SIA for the proposed construction of power lines between the Grassridge Substation (near Port Elizabeth) and the Coega Industrial Development Zone, Eastern Cape Province
- Public Participation and SIA for the Matimba-Witkop No. 2 400 kV Transmission line, Limpopo Province

**Photovoltaic and Wind Energy Facilities**

- SIA for the proposed Christiana PV facility on the farm Hartebeestpan, North West Province
- SIA for the proposed Hertzogville PV facility on the farms Albert and Wigt, Free State Province
- SIA for the proposed Morgenzon PV facility on the farm Morgenzon, Northern Cape Province
- SIA as part of the Basic Assessment Process for the Exxaro Photovoltaic Facility, Lephalale, Limpopo Province
- SIA for the Upington Solar Energy Facility, Northern Cape Province
- SIA for the Kleinbegin Solar Energy Facility, Northern Cape Province
- SIA for the proposed Ilanga solar thermal power plant facility on a site near Upington, Northern Cape Province
- SIA and public participation for the proposed Karoo Renewable Energy Facility, Northern Cape
- SIA for the Wag'nbiekiespan Solar Energy Facility, Northern Cape Province
- SIA for the proposed Kathu and Sishen Solar Energy Facilities, Northern Cape Province
- Public Participation and SIA for the proposed Thupela Waterberg Photovoltaic Plant, Limpopo Province
- SIA for the proposed Kannikwa Vlakte Wind Farm Project, Northern Cape

**Township Developments**

- SIA for the proposed Mixed Land Use Township Establishment on the Remainder of Portion 406 of the Farm Pretoria Town and Townlands 351 JR, and investigation with regards to the possible resettlement of households, Salvokop, Tshwane CBD
- SIA for the proposed Mixed Land Use Development situated on the Remainder of Allandale 10 IR, known as Rabie Ridge Ext 7, Midrand, Gauteng
- SIA as part of the Basic Assessment for the proposed development of Project One (1) of the Vosloorus Extension 9 High Density Housing Project, Ekurhuleni Metropolitan Municipality
- SIA for the proposed Mapochsgronde Residential Development, Roossenekal, Limpop Province
- SIA for the proposed Cullinan Estate Development, Cullinan, Gauteng
- SIA for the proposed Vlakfontein Residential Development and investigation with regards to the possible resettlement of individual households, Brakpan, Gauteng
- SIA for the proposed township development/eco-estate on the farm Grants Valley, Eastern Cape

**Public Participation**

- Public Participation for Dwarsrivier Chrome Mine (Pty) Ltd.: Environmental Authorisation Application for various Listed Activities at the Dwarsrivier Chrome Mine, Near Steelpoort, Limpopo Province (ongoing)
- Public Participation for the proposed piggery near Modimolle, Limpopo Province
- Public Participation for the upgrading of the Menlyn Road Network and the investigation, as well as negotiations with regards to the resettlement of households, Pretoria, Gauteng
- Public participation and SIA for the proposed Platinum Highway Project from the N1 (Gauteng) to the Botswana Border (North West Province), including investigations with regards to the possible resettlement of individual households

## 15. DECLARATION OF INDEPENDENCE

I, Ingrid Snyman, declare that:

**General declaration:**

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Batho Earth

Name of company (if applicable):

Date: 15 August 2018

## 8.11 Blasting Impact Assessment

# Blast Management & Consulting

**Quality Service on Time**

# Report: Blast Impact Assessment

## Proposed Vandyksdrift Central (VDDC) Mining Project

| | |
|---|---|
| Date: | 1 July 2019 |
| BM&C Ref No: | JAWS~Vandyksdrift Central~VDDC Project~EIAReport~181206V02 |
| Clienf Ref No: | G535 |
| Signed: | |
| Name: | JD Zeeman |

## i. Document Prepared and Authorised by:

JD Zeeman
Blast Management & Consulting (2015/061002/07)
61 Sovereign Drive
Route 21 Corporate Park
Irene
South Africa

PO Box 61538
Pierre van Ryneveld
Centurion
0045

Cell: +27 82 854 2725 Tel: +27 (0)12 345 1445 Fax: +27 (0)12 345 1443

## ii. Study Team Qualifications and Background

The study team comprises J D Zeeman (as the member of Blast Management & Consulting) and Blast Management & Consulting employees. Blast Management & Consulting's main areas of concern are pre-blast consultation and monitoring, insitu monitoring, post-blast monitoring and consulting as well as specialised projects. Blast Management & Consulting has been active in the mining industry since 1997 and work has been done at various levels for mining companies in South Africa, Botswana, Namibia, Mozambique, Democratic Republic of Congo, Sierra Leone and Côte d'Ivoire.

J D Zeeman holds the following qualifications:

| | |
|---|---|
| 1985 - 1987 | Diploma: Explosives Technology, Technikon Pretoria |
| 1990 - 1992 | BA Degree, University of Pretoria |
| 1994 | National Higher Diploma: Explosives Technology, Technikon Pretoria |
| 1997 | Project Management Certificate, Damelin College |
| 2000 | Advanced Certificate in Blasting, Technikon SA |

Member: International Society of Explosive Engineers

## iii. Independence Declaration

Blast Management & Consulting is an independent company. The work done for the report was performed in an objective manner and according to national and international standards, which means that the results and findings may not all be positive for the client. Blast Management & Consulting has the required expertise to conduct such an investigation and draft the specialist report relevant to the study. Blast Management & Consulting did not engage in any behaviour that could be result in a conflict of interest in undertaking this study.

**Legal Requirements**

In terms of the NEMA 2014 EIA Regulations contained in GN R982 of 04 December 2014 (as amended by GN R 326 of 07 April 2017) all specialist studies must comply with Appendix 6 of the NEMA EIA Regulations, 2014 (as amended). Table 1 shows the requirements as indicated above.

Table 1: Legal Requirements for All Specialist Studies Conducted

| **Legal Requirement** | | Relevant Section in Specialist study |
|---|---|---|
| (1) | A specialist report prepared in terms of these Regulations must contain- | |
| (a) | details of- | |
| | (i) the specialist who prepared the report; and | i |
| | (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae; | Section ii and 25 |
| (b) | a declaration that the specialist is independent in a form as may be specified by the competent authority; | Section iii |
| (c) | an indication of the scope of, and the purpose for which, the report was prepared; | Section 4 |
| (cA) | an indication of the quality and age of base data used for the specialist report | Section 14 |
| (cB) | a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change; | Section 17.2 |
| (d) | the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment; | Section 8 |
| (e) | a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used; | Section 6 |
| (f) | details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternatives; | Section 11 |
| (g) | an identification of any areas to be avoided, including buffers; | Section 11 |
| (h) | a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers; | Section 11 |
| (i) | a description of any assumptions made and any uncertainties or gaps in knowledge; | Section 9 |
| (j) | a description of the findings and potential implications of such findings on the impact of the proposed activity, or activities; | Section 17 |
| (k) | any mitigation measures for inclusion in the EMPr; | Section 17.13 |
| (l) | any conditions/aspects for inclusion in the environmental authorisation; | Section 21 |

| **Legal Requirement** | | Relevant Section in Specialist study |
|---|---|---|
| (m) | any monitoring requirements for inclusion in the EMPr or environmental authorisation; | Section 20 |
| (n) | a reasoned opinion (Environmental Impact Statement)- | Section 23 |
| | whether the proposed activity, activities or portions thereof should be authorised; and | Section 23 |
| | if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan; | Section 23 |
| (o) | a description of any consultation process that was undertaken during the course of preparing the specialist report; | Section 12 |
| (p) | a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and | Section 12 |
| (q) | any other information requested by the competent authority. | None |

## iv. Document Control:

| Name & Company | Responsibility | Action | Date | Signature |
|---|---|---|---|---|
| C Zeeman Blast Management & Consulting | Document Preparation | Report Prepared | 06/12/2018 | |
| JD Zeeman Blast Management & Consulting | Consultant | Report Finalise | 28/12/2018 | |
| JD Zeeman Blast Management & Consulting | Consultant | Updated information correct comments | 10/02/2019 | |
| JD Zeeman Blast Management & Consulting | Consultant | Updated information: project descriptions and maps | 01/07/2019 | |
| JD Zeeman Blast Management & Consulting | Consultant | Minor spelling updates done. Fig 8 split for better view. Powerline relocation indicated | 10/09/2019 | |

| | | | | |
|---|---|---|---|---|
| | | | | |

## Table of Contents

**List of Acronyms used in this Report**

| | |
|---|---|
| a and b | Site Constant |
| ANFO | Ammonium nitrate fuel oil |
| APP | Air Pressure Pulse |
| B | Burden (m) |
| BH | Blast Hole |
| BM&C | Blast Management & Consulting |
| Bs | Scaled Burden ($m^{3/2}kg^{-1/2}$) |
| D | Distance (m) |
| D | Duration (s) |
| E | East |
| E | Explosive Mass (kg) |
| EIA | Environmental Impact Assessment |
| Freq. | Frequency |
| GRP | Gas Release Pulse |
| I&AP | Interested and Affected Parties |
| k | Factor value |
| L | Maximum Throw (m) |
| Lat/Lon | Latitude/Longitude |
| hddd°mm'ss.s" | Hours/degrees/minutes/seconds |
| M | Charge Height |
| m (SH) | Stemming height |
| M/S | Magnitude/Severity |
| Mc | Charge mass per metre column |
| N | North |
| NE | North East |
| NO | Nitrogen Monoxide |
| $NO_2$ | Nitrogen Dioxide |
| NOx | Nitrogen Oxide |
| NOx's | Noxious Fumes |
| NW | North West |
| P | Probability |
| POI | Points of Interest |
| PPD | Peak particle displacement |
| PPV | Peak Particle Velocity |
| PVS | Peak vector sum |
| RPP | Rock Pressure Pulse |
| S | Scale |

| | |
|---|---|
| S | South |
| SE | South East |
| SH | Stemming height (m) |
| SW | South West |
| T | Blasted Tonnage |
| TNT | Explosives (Trinitrotoluene) |
| USBM | United States Bureau of Mine |
| W | West |
| WGS 84 | Coordinates (South African) |
| WM | With Mitigation Measures |
| WOM | Without Mitigation Measures |

**List of Units used in this Report**

| | |
|---|---|
| % | percentage |
| cm | centimetre |
| dB | decibel |
| dBL | linear decibel |
| g | acceleration |
| $g/cm^3$ | gram per cubic centimetre |
| Hz | frequency |
| kg | kilogram |
| $kg/m^3$ | kilogram per cubic metre |
| kg/t | kilogram per tonne |
| km | kilometre |
| kPa | kilopascal |
| m | metre |
| $m^2$ | metre squared |
| MJ | Mega Joules |
| $MJ/m^3$ | Mega Joules per cubic meter |
| MJ/t | Mega Joules per tonne |
| mm/s | millimetres per second |
| $mm/s^2$ | millimetres per second square |
| ms | milliseconds |
| Pa | Pascal |
| ppm | parts per million |
| psi | pounds per square inch |
| θ | theta or angle |

**List of Figures**



**List of Tables**

# 1 Executive Summary

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed opencast mining operation. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report concentrates on the ground vibration and air blast intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed is typical roads (tar and gravel), low cost houses, corrugated iron structures, brick and mortar houses, boreholes and heritage sites.

The VDDC infrastructure and mining development project is a brownfields project within the greater Wolvekrans Colliery mining rights area.

The evaluation of the charges indicated nineteen POI's of concern for minimum charge and the maximum charge indicated fifty-one POI's of concern (included are the heritage site – graveyard and power lines/pylons inside the pit area) in relation to possible structural damage. On a human perception scale forty POI's were identified where vibration levels may be perceptible and higher for the minimum charge and fifty-two POI's for the maximum charge. Perceptible levels of vibration that may be experienced up to 3375 m, unpleasant up to 1527 m and intolerable up to 651 m. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 1050 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have lesser influence on these points.

Various heritage sites were identified by the Heritage Specialist that will require attention. One of these sites (graves – POI 17) falls within the Pit area. The Heritage Specialist has recommended that the graveyard be relocated. The portion of the Kromfontein 132 kV powerline traversing the proposed opencast mining area will also be re-aligned (this is the subject of a separate application).

Mitigation of ground vibration was considered and discussed. A positive contribution is that the box-cut areas are furthest away from the concerned infrastructure and will provide time to determine possible influence in the early stages of blasting.

The effect of ground vibration regarding human perception was also evaluated and adjudicated.

The effects of air blast indicate less influences than ground vibration. Levels predicted for the maximum charge ranges between 111.5 and 147.6 dB for all the POI's considered. This includes the nearest points such as the Buildings/Structures. These levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints. The closest structures at 249 m (POI 115) showed concerns of complaints at maximum charge.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 365 m. The absolute minimum unsafe zone is then the 365 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

No boreholes were observed that will require specific mitigation due to possible influence from blasting operations. Boreholes are located far enough away from blasting areas.

The project influences were assessed and evaluated. Pre-mitigation a general class 3 moderate influence was determined. Applying mitigations this level can be reduced to class 2 Low impact assessment.

This concludes this investigation for the proposed Vandyksdrift Central (VDDC) Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

# 2 Introduction

South32 SA Coal Holdings (Pty) Ltd (South32), is the holder of an amended mining right for coal, granted by the Minister of Mineral Resources, in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA) and notarially executed on the 21st of May 2015 under DMR reference MP30/5/1/2/2/379MR, in respect of its Wolvekrans – Ifalethu Colliery. This mining right comprises of the following areas:

- Ifalethu Colliery (previously referred to as Wolvekrans North Section[1]) consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant; and
- Wolvekrans Colliery (previously referred to as the Wolvekrans South Section) consisting of the Wolvekrans, Vlaklaagte (mining ceased), Driefontein, Boschmanskrans, Vandyksdrift, Albion and Steenkoolspruit sections, as well as the South Processing Plants (Eskom and Export). Some of these areas were previously known as Douglas Colliery.

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow pillar mining (opencast) of the area previously mined by underground bord and pillar mining. Authorisation of the VDDC mining project included the following:

- Opencast operation on the farm Kleinkopje 15 IS;
- Opencast operation on the farm Steenkoolspruit 18 IS;
- Pillar extraction operation on the farm Vandyksdrift 19 IS;
- Reclamation of existing slurry ponds; and
- Rewashing of existing discard dumps (PHD, 2006).

The water uses associated with the opencast mining have been authorised in terms of Water Use Licence (WUL) number 24084535 dated 10 October 2008, issued to Douglas Colliery Services Limited.

The No. 2 seam workings are flooded with water and must be dewatered to enable the open pit development to proceed. A dewatering strategy has therefore been developed and an application for Environmental Authorisation (EA) of the dewatering activities was submitted to the Department of Mineral Resources (DMR) (Jaco-K Consulting, 2016(a)); a decision in this regard is pending. The water use activities associated with this upfront dewatering strategy have been authorised by WUL number 06/B11F/GCIJ/7943 dated 19 July 2018.

[1] This was previously referred to as Middelburg Colliery

The 2007 approved EMPR Amendment included limited additional infrastructure in support of the opencast mining operations, as it was assumed at that stage that existing infrastructure will be used. In addition, the applications for authorisation of the activities associated with the dewatering strategy, were limited to the infrastructure to facilitate dewatering (i.e. dewatering boreholes, pumps, pipelines, storage tanks, mechanical evaporators, roads and power lines).

A pre-feasibility investigation has since been conducted, and the need to develop additional infrastructure to support the proposed opencast mining was identified. The additional infrastructure includes the following:

- Storm water management structures (drains and berms);
- Water management measures for the management of mine impacted water;
- Overburden dumps;
- ROM coal stockpile areas;
- Mixed ROM coal and slurry stockpile areas;
- Topsoil stockpiles following clearance of vegetation;
- Pipelines for the conveyance of water;
- Hard park area and brake test ramp; and
- Haul roads and service roads.

The proposed VDDC opencast pit boundary as determined through the pre-feasibility investigation also differs from the mining area approved in the 2007 EMPR amendment. An area of approximately 196 hectares in the latest mine lay-out was not included in the previous mine lay-out and is therefore not approved to be opencast mined.

As part of Environmental Impact Assessment (EIA), Blast Management & Consulting (BM&C) was contracted to perform a review of possible impacts from blasting operations and specifically for the proposed VDDC Project. Ground vibration, air blast and fly rock are some of the aspects that result from blasting operations and this study considers the possible influences that blasting may have on the surrounding area in this respect. The report concentrates on ground vibration and air blast and intends to provide information, calculations, predictions, possible influences and mitigating aspects of blasting operations for the project.

## 3 Objectives

The objectives of this document are: outlining the expected environmental effects that blasting operations could have on the surrounding environment; and proposing the specific mitigation measures that will be required. This study investigates the related influences of expected ground vibration, air blast and fly rock. These effects are investigated in relation to the blast site area and surrounds and the possible influence on nearby private installations, houses and the owners or occupants.

The objectives were dealt with whilst taking specific protocols into consideration. The protocols applied in this document are based on the author's experience, guidelines taken from literature research, client requirements and general indicators in the various appropriate pieces of South African legislation. There is no direct reference in the following acts to requirements and limits on the effect of ground vibration and air blast and some of the aspects addressed in this report:

- National Environmental Management Act No. 107 of 1998;
- Mine Health and Safety Act No. 29 of 1996;
- Mineral and Petroleum Resources Development Act No. 28 of 2002;
- Explosives Act No. 15 of 2003.

The guidelines and safe blasting criteria are based on internationally accepted standards and specifically criteria for safe blasting for ground vibration and recommendations on air blast published by the United States Bureau of Mines (USBM). There are no specific South African standards and the USBM is well accepted as standard for South Africa.

## 4 Scope of blast impact study

The scope of the study is determined by the terms of reference to achieve the objectives. The terms of reference can be summarised according to the following steps taken as part of the EIA study with regards to ground vibration, air blast and fly rock due to blasting operations.

- Background information of the proposed site;
- Blasting Operation Requirements;
- Site specific evaluation of blasting operations according to the following:
  - Evaluation of expected ground vibration levels from blasting operations at specific distances and on structures in surrounding areas;
  - Evaluation of expected ground vibration influence on neighbouring communities;
  - Evaluation of expected blasting influence on national and provincial roads surrounding the blasting operations if present;
  - Evaluation of expected ground vibration levels on water boreholes if present within 1500 m from blasting operations;
  - Evaluation of expected air blast levels at specific distances from the operations and possible influence on structures;
  - Evaluation of fly rock unsafe zone;
  - Discussion on the occurrence of noxious fumes and dangers of fumes;

- Evaluation the location of blasting operations in relation to surrounding areas according to the regulations from the applicable Acts.
- Impact Assessment;
- Mitigations;
- Recommendations;
- Conclusion.

## 5 Study area

The VDDC infrastructure and mining development project is a brownfields project within the greater Wolvekrans Colliery mining rights area. Wolvekrans Colliery is located between the towns of eMalahleni and Kriel, within the jurisdictional area of the eMalahleni Local Municipality and the Nkangala District Municipality of the Mpumalanga Province of South Africa at coordinates (Lat/Lon WGS84) 26° 4'32.17"S; 29°17'41.72"E.

Figure 1 shows a Locality Map of the proposed Project area. Figure 2 shows the proposed Infrastructure Area Map.

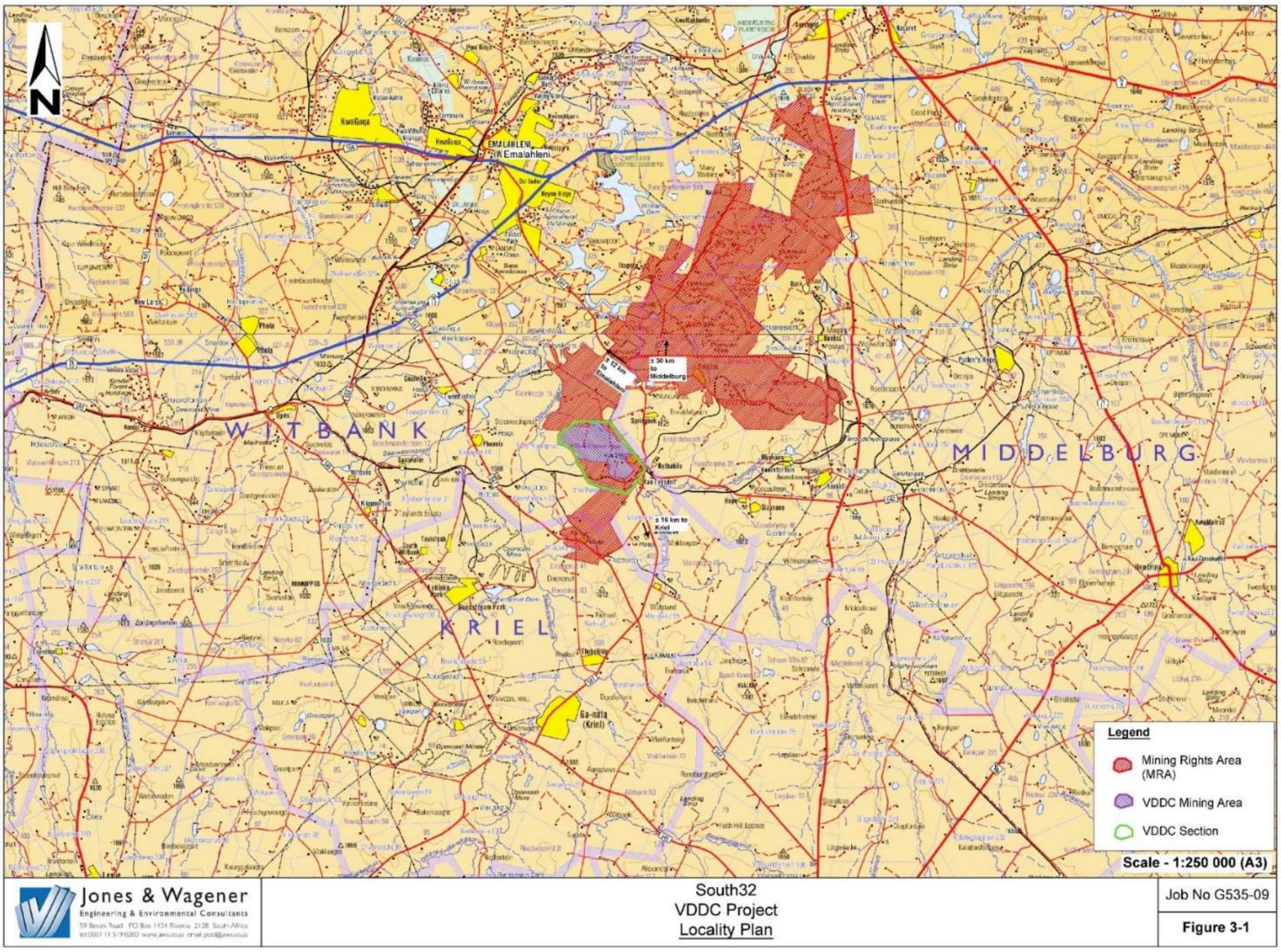


Figure 1: Locality Map of the proposed Project area

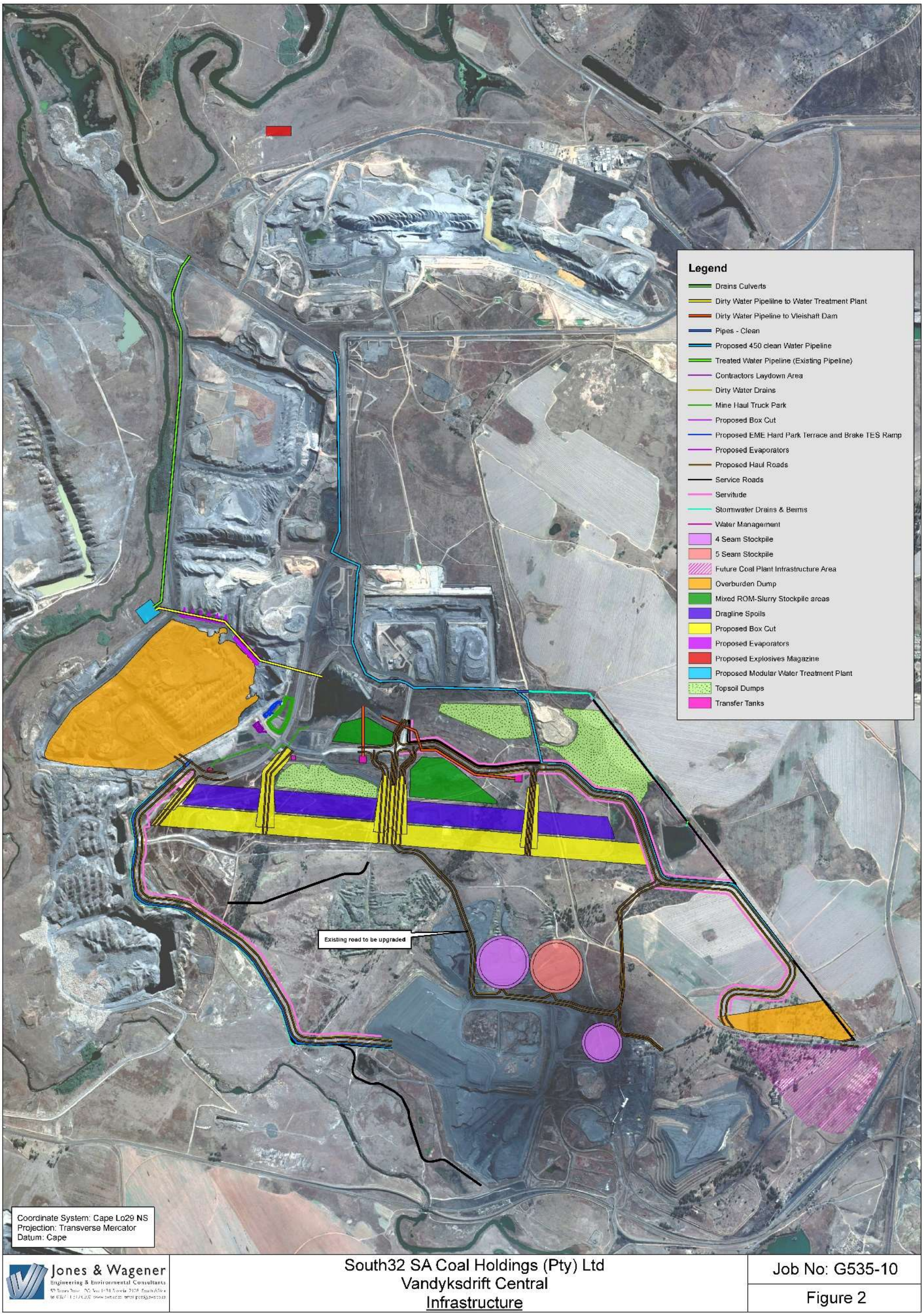


Figure 2: Proposed Infrastructure Map

## 6 Methodology

The detailed plan of study consists of the following sections:

- Site visit: Intention to understand location of the site and its surroundings;
- Identifying surface structures / installations that are found within reason from project site. A list of Point of Interests (POI's) are created that will be used for evaluation;
- Base line influence or Blast Monitoring: The project is evaluated as a new operation with no blasting activities currently being done in the project area specific. Information from other parts of the mine was considered.
- Site evaluation: This consists of evaluation of the mining operations and the possible influences from blasting operations. The methodology is modelling the expected impact based on the expected drilling and blasting information provided for the project. Various accepted mathematical equations are applied to determine the attenuation of ground vibration, air blast and fly rock. These values are then calculated over the distance investigated from site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors then gives an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels then gives an indication of the possible mitigation measures to be applied. The possible environmental or social impacts are then addressed in the detailed EIA phase investigation;
- Reporting: All data is prepared in a single report and provided for review.

## 7 Site Investigation

The site was visited on 11 July 2018. This site visit was done to get an understanding of the location and the structures and installations surrounding the proposed new pit areas.

## 8 Season applicable to the investigation

The drilling and blasting operations are not season dependable. The investigation into the possible effects from blasting operations is not season bounded.

## 9 Assumptions and Limitations

The following assumptions have been made:

- The project area is not currently part of the active mining operation. There are drilling and blasting operations currently active on other areas of the mine. No drilling or blasting is done for the area considered in this project.

- The anticipated levels of influence estimated in this report are calculated using standard accepted methodology according to international and local regulations.
- The assumption is made that the predictions are a good estimate with significant safety factors to ensure that expected levels are based on worst case scenarios. These will have to be confirmed with actual measurements once the operation is active.
- The limitation is that limited data was available from this operation for a confirmation of the predicted values from the existing operations.
- Blast Management & Consulting was not involved in the blast design. The information on blast design applied was provided by the client.
- The type of blasting conducted on the existing operations varies significantly with designs provided that shows different designs and results. A best estimate was applied for this project regarding blasting design and expected outcomes.
- The work done is based on the author's knowledge and information provided by the project applicant.

## 10 Legal Requirements

The protocols applied in this document are based on the author's experience, guidelines elicited by the literature research, client requirements and general indicators provided in the various applicable South African acts. There is no direct reference in the consulted acts specifically with regard to limiting levels for ground vibration and air blast. There is however specific requirements and regulations with regards to blasting operations and the effect of ground vibration and air blast and some of the aspects addressed in this report. The acts consulted are: National Environmental Management Act No. 107 of 1998; Mine Health and Safety Act No. 29 of 1996; Mineral and Petroleum Resources Development Act No. 28 of 2002; and the Explosives Act No. 15 of 2003.

The guidelines and safe blasting criteria applied in this study are as per internationally accepted standards, and specifically the United States Bureau of Mines (USBM) criteria for safe blasting for ground vibration and the recommendations on air blast. There are no specific South African standards and the USBM is well accepted as standard for South Africa. Additional criteria required by various institutions in South Africa was also taken into consideration, i.e. Eskom, Telkom, Transnet, Rand Water Board, etc.

In view of the acts consulted, the following guidelines and regulations are noted: (where possible detail was omitted and only some of the information indicated)

- **MINE HEALTH AND SAFETY ACT 29 OF 1996**

(Gazette No.17242, Notice No. 967 dated 14 June 1996. Commencement date: 15 January 1997 for all sections with the exception of sections 86(2) and (3), which came into operation on 15 January 1998, [Proc.No.4, Gazette No. 17725])

**MINE HEALTH AND SAFETY REGULATIONS**
Precautionary measures before initiating explosive charges
4.7 The employer must take reasonable measures to ensure that when blasting takes place, air and ground vibrations, shock waves and fly material are limited to such an extent and at such a distance from any building, public thoroughfare, railway, power line or any place where persons congregate to ensure that there is no significant risk to the health or safety of persons.

**General precautions**
4.16 The employer must take reasonable measures to ensure that:
4.16(1) in any mine other than a coal mine, no explosive charges are initiated during the shift unless –
(a) such explosive charges are necessary for the purpose of secondary blasting or reinitiating the misfired holes in development faces;
(b) written permission for such initiation has been granted by a person authorised to do so by the employer; and
(c) reasonable precautions have been taken to prevent, as far as possible, any person from being exposed to smoke or fumes from such initiation of explosive charges;
4.16(2) no blasting operations are carried out within a horizontal distance of 500 metres of any public building, public thoroughfare, railway line, power line, any place where people congregate or any other structure, which it may be necessary to protect in order to prevent any significant risk, unless:
(a) a risk assessment has identified a lesser safe distance and any restrictions and conditions to be complied with;
(b) a copy of the risk assessment, restrictions and conditions contemplated, in paragraph (a) have been provided for approval to the Principal Inspector of Mines;
(c) shot holes written permission has been granted by the Principal Inspector of Mines; and
(d) any restrictions and conditions determined by the Principal Inspector of Mines are complied with.

- **MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT 28 OF 2002**

(Gazette No. 23922, Notice No. 1273 dated 10 October 2002. Commencement date: 1 May 2004 [Proc. No. R25, Gazette No. 26264])
**MINERAL AND PETROLEUM RESOURCES DEVELOPMENT REGULATIONS**

**67. Blasting, vibration and shock management and control**
(1) A holder of a right or permit in terms of the Act must comply with the provisions of the Mine Health and Safety Act, 1996, (Act No. 29 of 1996), as well as other applicable law regarding blasting, vibration and shock management and control.
(2) An assessment of impacts relating to blasting, vibration and shock management and control, where applicable, must form part of the environmental impact assessment report and environmental management programme or the environmental management plan, as the case may be.

The current pit layout indicates that the planned pit areas may be close to private installations. The Mine Health and Safety Act has specific requirements regarding blasting within 500 m from private installations. This condition will be addressed in the recommendations.

## 11 Sensitivity of Project

A review of the project and the surrounding areas is done before any specific analysis is undertaken and sensitivity mapping is done, based on typical areas and distance from the proposed mining area. This sensitivity map uses distances normally associated where possible influences may occur and where influence is expected to be very low or none. Two different areas were identified in this regard:

- A highly sensitive area of 500 m around the mining area. Normally, this 500 m area is considered an area that should be cleared of all people and animals prior to blasting. Levels of ground vibration and air blast are also expected to be higher closer to the pit area.
- An area 500 m to 1500 m around the pit area can be considered as being a medium sensitive area. In this area, the possibility of impact is still expected, but it is lower. The expected level of influence may be low, but there may still be reason for concern, as levels could be low enough not to cause structural damage but still upset people.
- An area greater than 1500 m is considered low sensitivity area. In this area, it is relatively certain that influences will be low with low possibility of damages and limited possibility to upset people.

Figure 3 shows the sensitivity mapping with the identified points of interest (POI) in the surrounding areas for the proposed VDDC Project area. The specific influences will be determined through the work done for this project in this report.

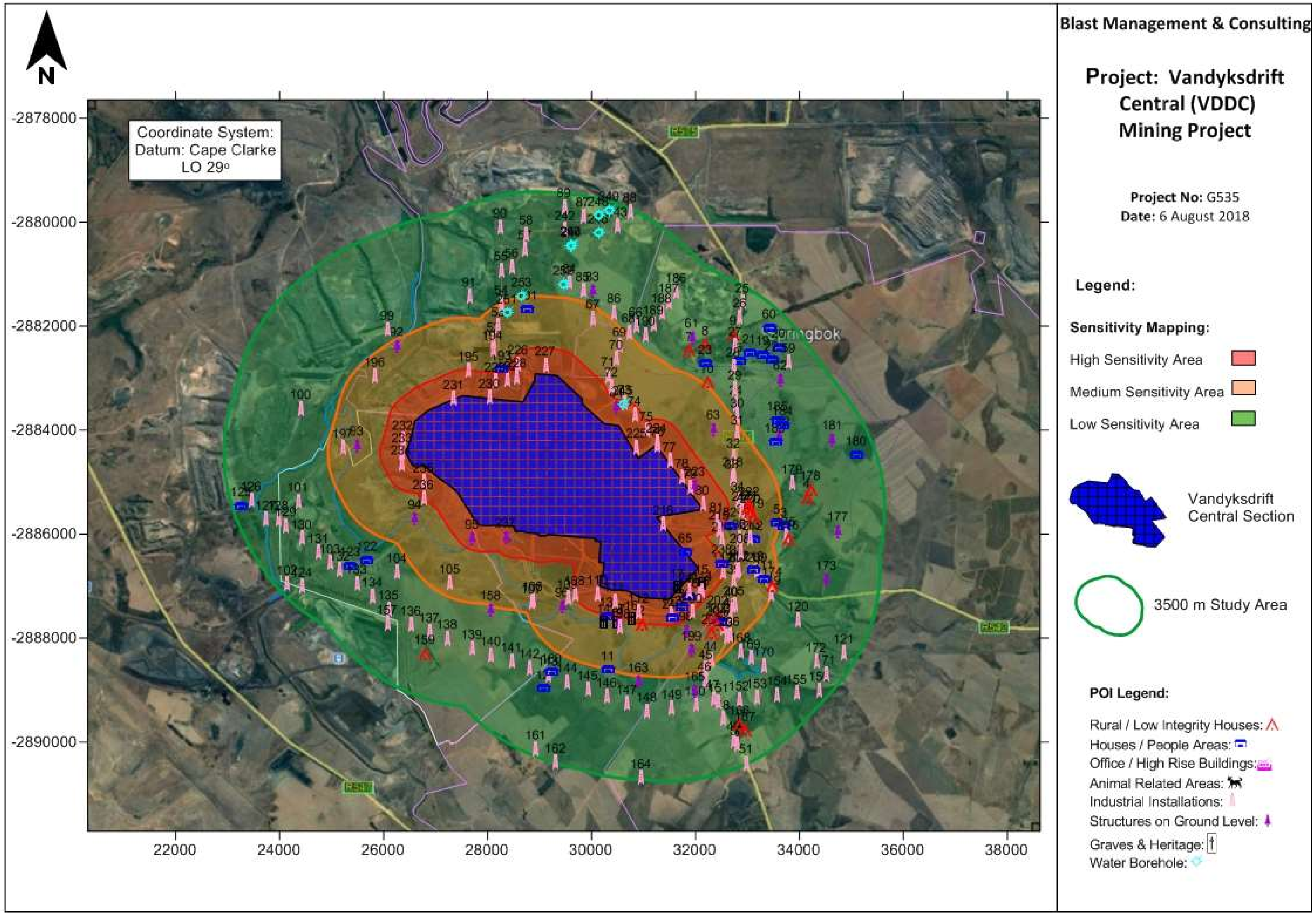


Figure 3: Identified sensitive areas

## 12 Consultation process

No specific consultation with external parties was utilised. The only consultation done was during the site visit to the mine with mine personnel. The work done is based on the author's knowledge and information provided by the client.

## 13 Influence from blasting operations

Blasting operations are required to break rock for excavation to access the targeted ore material. Explosives in blast holes provide the required energy to conduct the work. Ground vibration, air blast and fly rock are a result of the blasting process. Based on the regulations of the different acts consulted and international accepted standards these effects are required to be within certain limits. The following sections provide guidelines on these limits. As indicated, there are no specific South African ground vibration and air blast limit standard.

### 13.1 Ground vibration limitations on structures

Ground vibration is measured in velocity with units of millimetres per second (mm/s). Ground vibration can also be reported in units of acceleration or displacement if required. Different types of structures have different tolerances to ground vibration. A steel structure or a concrete structure will have a higher resistance to vibrations than a well-built brick and mortar house. A brick and mortar house will be more resistant to vibrations than a poorly constructed or a traditionally built mud house. Different limits are then applicable to the different types of structures. Limitations on ground vibration take the form of maximum allowable levels or intensity for different installations or structures. Ground vibration limits are also dependent on the frequency of the ground vibration. Frequency is the rate at which the vibration oscillates. Faster oscillation is synonymous with higher frequency and lower oscillation is synonymous with lower frequency. Lower frequencies are less acceptable than higher frequencies because structures have a low natural frequency. Significant ground vibration at low frequencies could cause increased structure vibrations due to the natural low frequency of the structure and this may lead to crack formation or damages.

Currently, the USBM criteria for safe blasting are applied as the industry standard where private structures are of concern. Ground vibration amplitude and frequency is recorded and analysed. The data is then evaluated accordingly. The USBM graph is used for plotting of data and evaluating the data. Figure 4 below provides a graphic representation of the USBM analysis for safe ground vibration levels. The USBM graph is divided mainly into two parts. The red lines in the figure are the USBM criteria:

- Analysed data displayed in the bottom half of the graph shows safe ground vibration levels,
- Analysed data displayed in the top half of the graph shows potentially unsafe ground vibration levels:

Added to the USBM graph is a blue line and green dotted line that represents 6 mm/s and 12.5 mm/s additional criteria that are applied by BM&C.

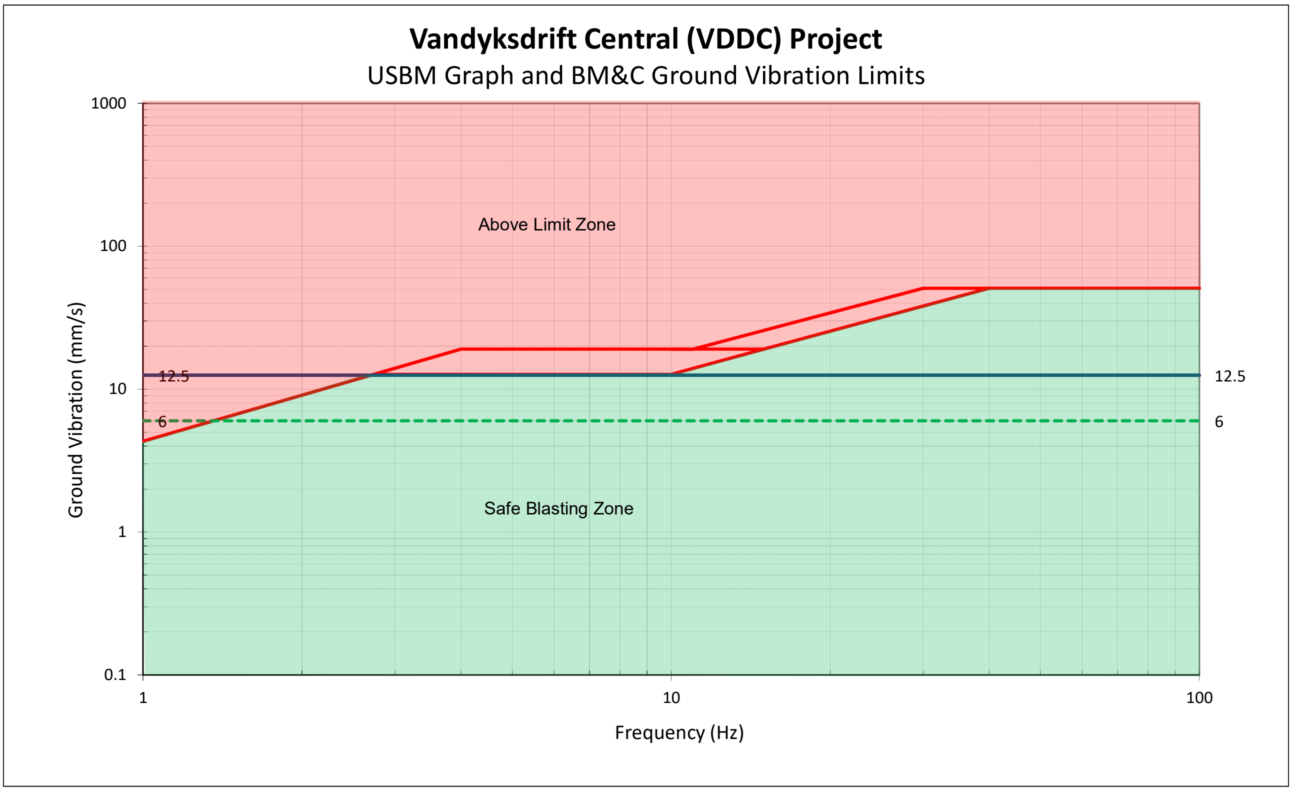


Figure 4: USBM Analysis Graph

The following additional limitations used by BM&C in general and that should be considered were determined through research and prescribed by the various institutions; these are as follows:

- National roads/tar roads: 150 mm/s (BM&C);
- Steel pipelines: 50 mm/s (Rand Water Board);
- Electrical lines: 75 mm/s (Eskom);
- Sasol Pipe Lines: 25 mms/s (Sasol);
- Railways: 150 mm/s (BM&C);

- Concrete less than 3 days old: 5 mm/s [2];
- Concrete after 10 days: 200 mm/s [3];
- Sensitive plant equipment: 12 mm/s or 25 mm/s, depending on type. (Some switches could trip at levels of less than 25 mm/s.)[2];
- Waterwells or Boreholes: 50 mm/s [4];

Considering the above limitations, BM&C work is based on the following:

- USBM criteria for safe blasting;
- The additional limits provided above;
- Consideration of private structures in the area of influence;
- Should structures be in poor condition, the basic limit of 25 mm/s is halved to 12.5 mm/s or when structures are in very poor condition limits will be restricted to 6 mm/s. It is a standard accepted method to reduce the limit allowed with poorer condition of structures;
- Traditionally built mud houses are limited to 6 mm/s. The 6 mm/s limit is used due to unknowns on how these structures will react to blasting. There is also no specific scientific data available that would indicate otherwise;
- Input from other consultants in the field locally and internationally.

### 13.2 Ground vibration limitations and human perceptions

A further aspect of ground vibration and frequency of vibration that must be considered is human perceptions. It should be realized that the legal limit set for structures is significantly greater than the comfort zone of human beings. Humans and animals are sensitive to ground vibration and the vibration of structures. Research has shown that humans will respond to different levels of ground vibration at different frequencies.

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[2] Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

[3] Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

[4] Berger P. R., & Associates Inc., Bradfordwoods, Pennsylvania, 15015, Nov 1980, Survey of Blasting Effects on Ground Water Supplies in Appalachia., Prepared for United States Department of Interior Bureau of Mines.

Ground vibration is experienced at different levels; BM&C considers only the levels that are experienced as "Perceptible", "Unpleasant" and "Intolerable". This is indicative of the human being's perceptions of ground vibration and clearly indicates that humans are sensitive to ground vibration and humans perceive ground vibration levels of 4.5 mm/s as unpleasant (See Figure 5). This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.

Indicated on Figure 5 is a blue solid line that indicates a ground vibration level of 12.5 mm/s and a green dotted line that indicates a ground vibration level of 6 mm/s. These are levels that are used in the evaluation.

Generally, people also assume that any vibration of a structure - windows or roofs rattling - will cause damage to the structure. An air blast is one of the causes of vibration of a structure and is the cause of nine out of ten complaints.

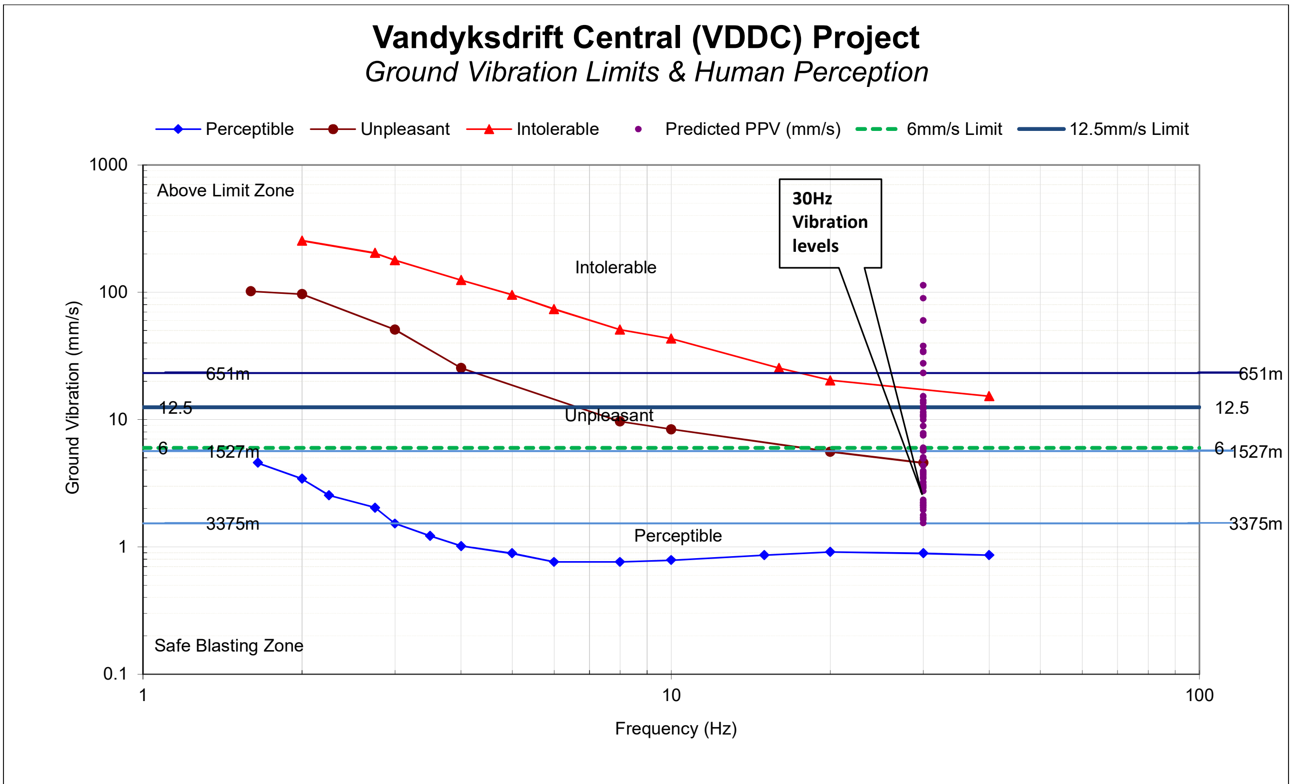



Figure 5: USBM Analysis with Human Perception

### 13.3 Air blast limitations on structures

Air blast or air-overpressure is a pressure wave generated from the blasting process. Air blast is measured as pressure in pascal (Pa) and reported as a decibel value (dBL). Air blast is normally associated with frequency levels less than 20 Hz, which is at the threshold for hearing. Air blast can be influenced by meteorological conditions such as, the final blast layout, timing, stemming, accessories used, blast covered by a layer of soil or not, etc. Air blast should not be confused with sound that is within the audible range (detected by the human ear). A blast does generate sound as well but for the purpose of possible damage capability we are only concerned with air blast in this report. The three main causes of air blasts can be observed as:

- Direct rock displacement at the blast; the air pressure pulse (APP);
- Vibrating ground some distance away from the blast; rock pressure pulse (RPP);
- Venting of blast holes or blowouts; the gas release pulse (GRP).

The general recommended limit for air blast currently applied in South Africa is 134dB. This is based on work done by the USBM. The USBM also indicates that the level is reduced to 128 dB in proximity of hospitals, schools and sensitive areas where people congregate. Based on work carried out by Siskind *et al.* (1980), monitored air blast amplitudes up to 135dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies. Persson *et al.* (1994) have published estimates of damage thresholds based on empirical data (Table 2). Levels given in Table 2 are at the point of measurement. The weakest points on a structure are the windows and ceilings.

Table 2: Damage Limits for Air Blast

| **Level** | **Description** |
|---|---|
| >130 dB | Resonant response of large surfaces (roofs, ceilings). Complaints start. |
| 150 dB | Some windows break |
| 170 dB | Most windows break |
| 180 dB | Structural Damage |

All attempts should be made to keep air blast levels from blasting operations well below 120dB where the public is of concern.

### 13.4 Air blast limitations and human perceptions

Considering human perceptions and the misunderstanding about ground vibration and air blast, BM&C generally recommends that blasting be done in such a way that air blast levels are kept below 120dB. This will ensure fewer complaints regarding blasting operations. The effect of air blast on structures that startle people will also be reduced, which in turn reduces the reasons for complaints. It is the effect on structures (like rattling windows, doors or a large roof surface) that startles people. These effects are sometimes erroneously identified as ground vibration and considered to be damaging the structure.

In this report, initial limits for evaluating conditions have been set at 120dB, 120 dB to 134dB and greater than 134dB. The USBM limits for nuisance are 134dB.

### 13.5 Fly rock

Blasting practices require some movement of rock to facilitate the excavation process. The extent of movement is dependent on the scale and type of operation. For example, blasting activities at large coal mines are designed to cast the blasted material over a greater distance than in quarries or hard rock operations. The movement should be in the direction of the free face, and therefore the orientation of the blast is important. Material or elements travelling outside of this expected range would be considered to be fly rock. Figure 6 shows schematic of fly rock definitions.

Fly rock can be categorised as follows:

- Throw - the planned forward movement of rock fragments that form the muck pile within the blast zone;
- Fly rock - the undesired propulsion of rock fragments through the air or along the ground beyond the blast zone by the force of the explosion that is contained within the blast clearance (exclusion) zone. When using this definition, fly rock, while undesirable, is only a safety hazard if a breach of the blast clearance (exclusion) zone occurs;
- Wild fly rock - the unexpected propulsion of rock fragments that travels beyond the blast clearance (exclusion) zone when there is some abnormality in a blast or a rock mass.

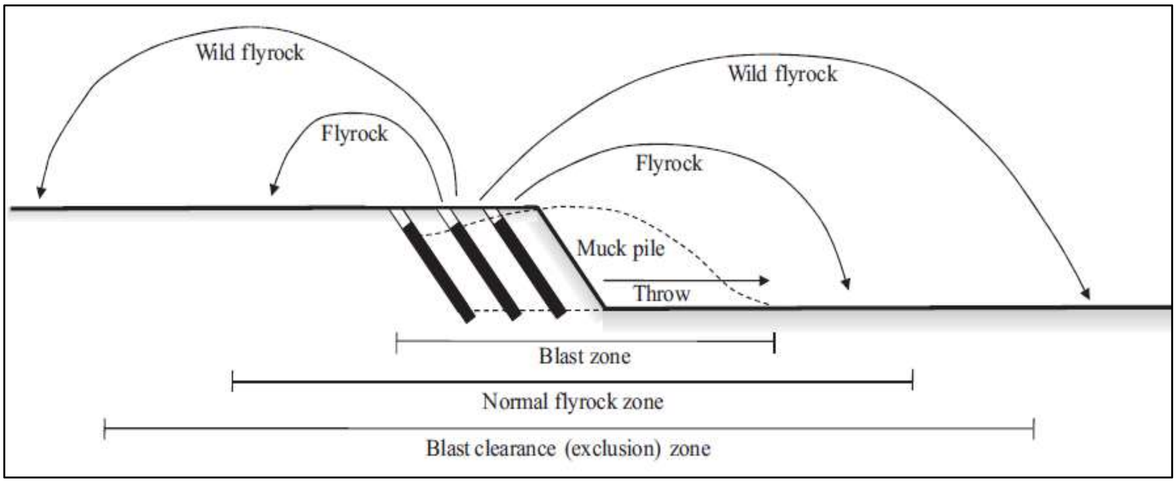



Figure 6: Schematic of fly rock terminology

Fly rock from blasting can result under the following conditions:
When burdens are too small, rock elements can be propelled out of the free face area of the blast;
When burdens are too large and movement of blast material is restricted and stemming length is not correct, rock elements can be forced upwards creating a crater forming fly rock;
If the stemming material is of poor quality or too little stemming material is applied, the stemming is ejected out of the blast hole, which can result in fly rock.

Stemming of correct type and length is required to ensure that explosive energy is efficiently used to its maximum and to control fly rock.

The occurrence of fly rock in any form will have impact if found to travel outside the safe boundary. If a road or structure or people or animals are within the safe boundary of a blast, irrespective of the possibility of fly rock or not, precautions should be taken to stop the traffic, remove people or animals for the period of the blast. The fact is that fly rock will cause damage to the road, vehicles or even death to people or animals. This safe boundary is determined by the appointed blaster or as per mine code of practice. BM&C uses a prediction calculation defined by the International Society of Explosives Engineers (ISEE) to assist with determining minimum distance.

### 13.6 Noxious Fumes

Explosives used in the mining environment are required to be oxygen balanced. Oxygen balance refers to the stoichiometry of the chemical reaction and the nature of gases produced from the detonation of the explosives. The creation of poisonous fumes such as nitrous oxides and carbon monoxide are particular undesirable. These fumes present themselves as red brown cloud after the blast has detonated. It has been reported that 10ppm to 20ppm can be mildly irritating. Exposure to 150 ppm or more (no time period given) has been reported to cause death from pulmonary oedema. It has been predicted that 50% lethality would occur following exposure to 174ppm for 1 hour. Anybody exposed must be taken to hospital for proper treatment.

Factors contributing to undesirable fumes are typically: poor quality control on explosive manufacture, damage to explosive, lack of confinement, insufficient charge diameter, excessive sleep time, water in blast holes, incorrect product used or product not loaded properly and specific types of rock/geology can also contribute to fumes.

### 13.7 Vibration impact on provincial and national roads

The influence of ground vibration on tarred roads are expected when levels is in the order of 150 mm/s and greater. Or when there is actual movement of ground when blasting is done too close to the road or subsidence is caused due to blasting operations. Normally 100 blast hole diameters are a minimum distance between structure and blast hole to prevent any cracks being formed into the surrounds of a blast hole. Crack forming is not restricted to this distance. Improper timing arrangements may also cause excessive back break and cracks further than expected. Fact remain that blasting must be controlled in the vicinity of roads. Air blast from blasting does not have influence on road surfaces. There is no record of influence on gravel roads due to ground vibration. The only time damage can be induced is when blasting is done next to the road and there is movement of ground. Fly rock will have greater influence on the road as damage from falling debris may impact on the road surface if no control on fly rock is considered.

## 13.8 Vibration will upset adjacent communities

The effects of ground vibration and air blast will have influence on people. These effects tend to create noises on structures in various forms and people react to these occurrences even at low levels. As with human perception given above – people will experience ground vibration at very low levels. These levels are well below damage capability for most structures.
Much work has also been done in the field of public relations in the mining industry. Most probably one aspect that stands out is "Promote good neighbour ship". This is achieved through communication and more communication with the neighbours. Consider their concerns and address in a proper manner.

The first level of good practice is to avoid unnecessary problems. One problem that can be reduced is the public's reaction to blasting. Concern for a person's home, particularly where they own it, could be reduced by a scheme of precautionary, compensatory and other measures which offer guaranteed remedies without undue argument or excuse.

In general, it is also in an operator's financial interests not to blast where there is a viable alternative. Where there is a possibility of avoiding blasting, perhaps through new technology, this should be carefully considered in the light of environmental pressures. Historical precedent may not be a helpful guide to an appropriate decision.

Independent structural surveys are one way of ensuring good neighbour ship. There is a part of inherent difficulty in using surveys as the interpretation of changes in crack patterns that occur may be misunderstood. Cracks open and close with the seasonal changes of temperature, humidity and drainage, and numbers increase as buildings age. Additional actions need to be done in order to supplement the surveys as well.

The means of controlling ground vibration, overpressure and fly rock have many features in common and are used by the better operators. It is said that many of the practices also aid cost-effective production. Together these introduce a tighter regime which should reduce the incidence of fly rock and unusually high levels of ground vibration and overpressure. The measures include the need for the following:

- Correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charges which may increase vibration by a factor of two,
- The setting-out and drilling of blasts should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted,

- Correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental overcharging,
- Correct stemming will help control air blast and fly rock and will also aid the control of ground vibration. Controlling the length of the stemming column is important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used,
- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

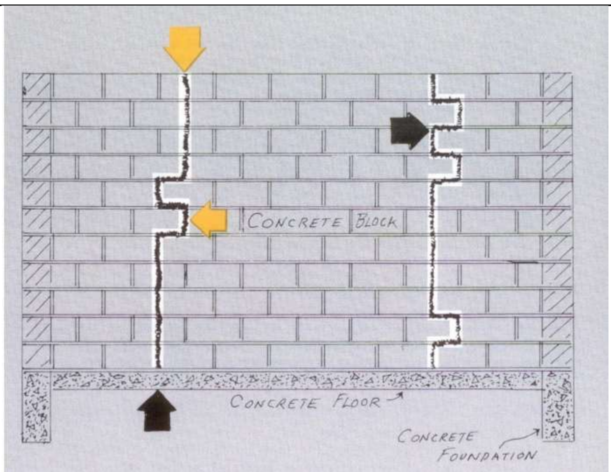
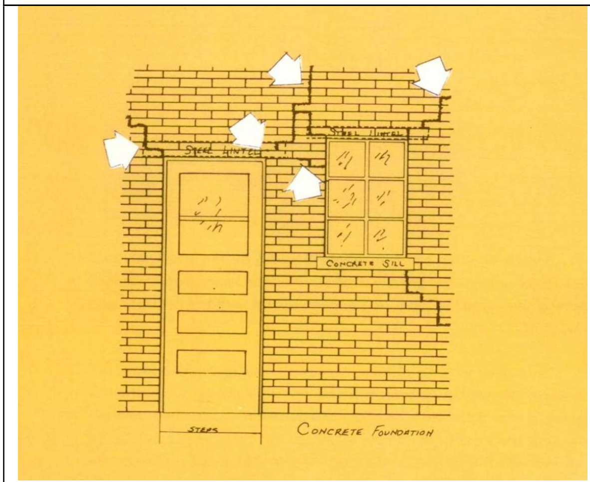
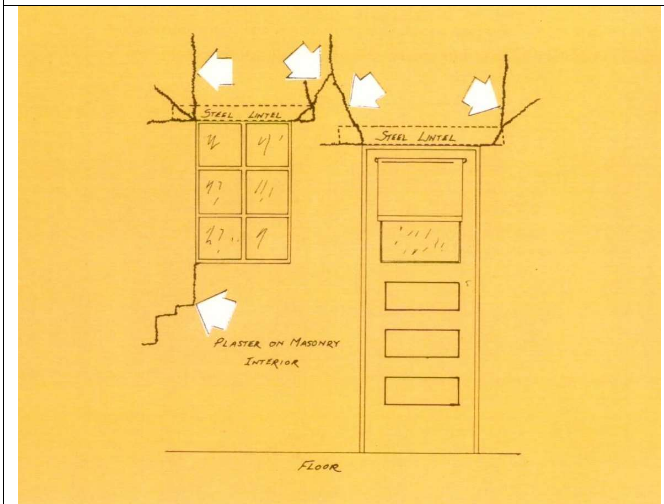
### 13.9 Cracking of houses and consequent devaluation

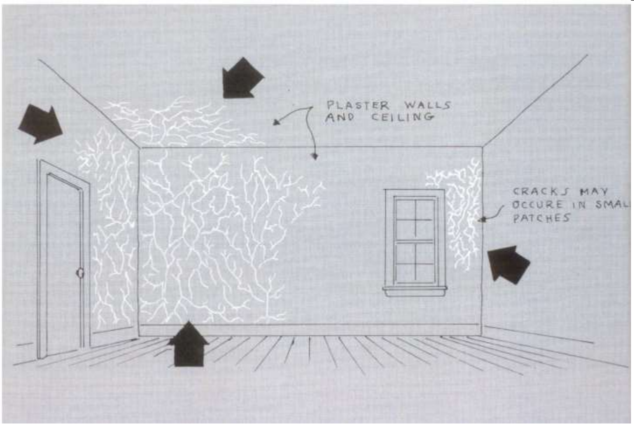
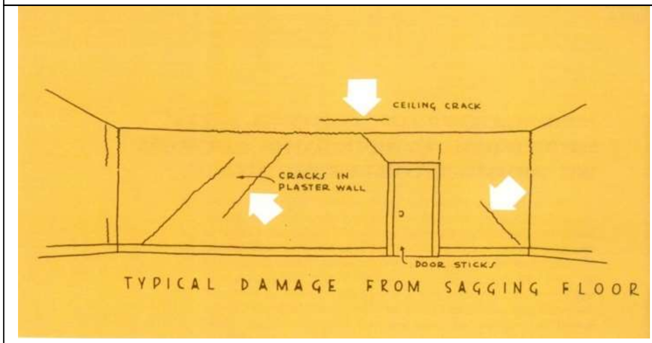
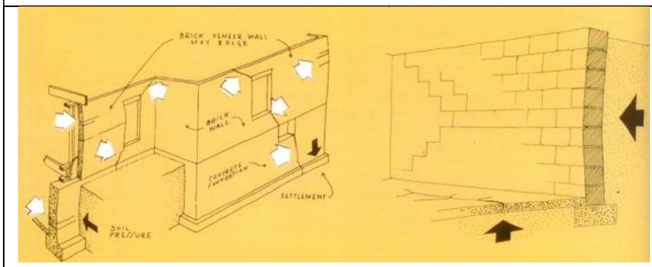
Houses in general have cracks. It is reported that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc. are more reason for cracks that have developed. Visual results of actual damage due to blasting operations are limited. There are cases where it did occur and a result is shown in Figure 7 below. A typical X crack formation is observed.

Figure 7: Example of blast induced damage.

The table below with figures show illustrations of non-blasting damage that could be found.

Table 3: Examples of typical non-blasting cracks

| | |
|---|---|
|   | Cracks Resulting from Shrinkage of Concrete Blocks |
|   | Typical Lintel Cracks |
|   | Typical Lintel Cracks |

| | |
|---|---|
|  | "Crazing" Cracks on Plaster |
|  | Plaster Cracks Caused by Sagging Floors |
|  | Cracks Resulting from Foundational Failure |

Observing cracks in the form indicated in Figure 7 on a structure will certainly influence the value as structural damage has occurred. The presence of general vertical cracks or horizontal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Proper building standards are not always applied and the general existence of cracks may be due to materials used. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. A property valuator will be required for this and I do believe that property value will include the total property and not just the house alone. Mining operations may not have influence to change the status quo of any property.

### 13.10 Water well Influence from Blasting Activities

Domestic, agricultural and monitoring boreholes are present around the proposed site. The author has not had much experience on the effect of blasting on water wells but specific research was done and results from this research work are presented.

Case 1 looked at 36 case histories. Vibration levels up 50 mm/s were measured. The well yield and aquifer storage improved as the mining neared the wells, because of the opening of the fractures from loss of lateral confinement, not blasting. This is similar to how stress-relief fractures form. At one site, the process was reversed after the mine was backfilled. It was more likely the fractures were recompressed. It was stated that blasting may cause some temporary (transient) turbidity similar to those events that cause turbidity without blasting.

Such as:

1. Natural sloughing off inside of the well bore due to inherent rock instability. This can be accelerated by frequent over pumping. This is common to wells completed through considerable thickness of poorly consolidated and/or highly fractured clay stones and shale's.
2. Significant rainfall events. The apertures of the shallow fractures that are intersected by a domestic well are commonly highly transmissive, thus will transmit substantial amounts of shallow flowing and rapidly recharging water. This water will commonly be turbid and can enter the well in high volumes. The lack of grouting of the near surface casing commonly allows this to happen. Also, if the top of the well is not grouted properly surface water can enter along the side of the casing and flow down the annulus.

The Berger Study observed ground-water impacts from manmade stress-release caused the rock mass removal during mining, but nothing from the blasting. The water quality and water levels were unaffected by the blasting. The "opening up" of the fractures lowered the ground-water levels by increasing the storage or porosity.

A study tested wells 50 m from a blast. Wells exhibited no quality or quantity impacts. Blast pressure surges ranged from 3 cm to 10 cm. Blasting caused no noticeable water table fluctuations and the hydraulic conductivity was unchanged. The pumping of the pit and encroachment of the high wall toward the wells dewatered the water table aquifer.

It may then be concluded from the studies researched as follows: Depending on the well construction, litho logic units encountered, and proximity to the blasting, it is believed that large shots could act as a catalyst for some well sloughing or collapse. However, the well would have to be inherently weak to begin with. The small to moderate shots will not show to impact wells. The minor water fluctuations attributed to blasting may cause a short-term turbidity problem, but do not pose any long-term problems. This fluctuation would not cause well collapse, as fluctuations from recharge and pumping occurs frequently. Long term changes to the well yield are more likely due to the opening of fractures from loss of lateral confinement. Short term dewatering of wells is caused by the opening of the fractures creating additional storage. A longer-term dewatering is caused by encroachment of the high wall and pumping of the pit water. The pit acts like a large pumping well. It is not believed that long term water quality problems will be caused by blasting alone. The possible exception is the introduction of residual nitrates, from the blasting materials, into the ground water system. This is only possible through wells that are hydro logically connected to a blasting site. Most of the long-term impacts on water quality are due to the mining (the breakup of the rocks). The influence will also be dependent if wells are beneath the excavation. Stress relief effects occur at shorter distances in this instance.

The results observed and levels recorded during research done showed that levels up to 50 mm/s or even higher in certain cases did not have any noticeable effect. It seems that safe conditions will be in the order of the 50 mm/s. In addition to this there are certain aspects that will need to be addressed prior to blasting operations.

## 14 Baseline Results

The base line information for the project area is based on zero influence with regards to blast impacts. No blasting is done in this area. On other areas of the mine blasting is done and some results have been obtained from this blasting and presented as limited baseline. As part of the baseline all possible structures in the expected influence area is identified and presented as part of structures considered in evaluation. Summary data was provided for blasting operations done in the existing operation. The data shows some blasts done in year prior to this project

### 14.1 Ground vibration and air blast data from blasting

Information from ground vibration and air blast monitoring done for previous blasting done was provided. The data is limited but still gives some idea of typical level of ground vibration and air blast. The following table provides information as measured by the contractor for the mine of different blasts that occurred over a period of time. The data indicates typical levels of ground vibration and air blast levels from blasting operations at specific locations. It is expected that blasting operations will be completed in existing area and progress to the new areas under this new application. It will be a continued process. Cumulative impacts from blasting is not expected to occur.

Table 4: Recorded data

| Recorded Results | | | Radial | | Vertical | | Transverse | | Vector Sum | | Air blast |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Authorized Location | Distance from Blast(m) | PPV (mm/s) | Freq (Hz) | PPV (mm/s) | Freq (Hz) | PPV (mm/s) | Freq (Hz) | PPV (mm/s) | Freq (Hz) | dB |
| 26/05/2017 | Deployment Centre | 244 | 33.655 | 28.4 | 22.479 | 42.6 | 22.733 | 21.3 | 35.09 | 32 | 130.3 |
| 22/12/2017 | Conveyor belt | Unknown | 7.747 | 14.6 | 3.683 | 102.4 | 5.558 | 11.3 | 7.93 | 14.6 | 148.1 |
| 22/12/2017 | Workshop | Unknown | 5.842 | 7.3 | 3.048 | 9.1 | 6.604 | 10.6 | 6.62 | 10.4 | 148.1 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16/08/2018 | Nearest Eskom Pylon North East | 120 | 39.24 | 8 | 38.802 | 14.2 | 11.811 | 13.4 | 45.04 | 8 | 148.2 |

## 14.2 Structure profile

As part of the baseline, all possible structures in a possible influence area are identified. The site was reviewed and detailed here. The site was reviewed using Google Earth imagery. Information sought during the review was to identify surface structures present in a 3500 m radius from the proposed mine boundary which will require consideration during modelling of blasting operations, e.g. houses, general structures, power lines, pipe lines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the Pit area. The list includes structures and points of interest (POI) within the 3500 m boundary – see Table 6 below. A list of structure locations was required in order to determine the allowable ground vibration limits and air blast limits. The identified POI's surrounding the pit area are rather congested. Three different figures are presented in order to display POI's effectively. Figure 8 shows an aerial view of the pit area and surroundings with POIs excluding industrial installations. Figure 9 shows only industrial type infrastructure POI's and Figure 10 shows only powerline installations POI's identified. The type of POIs identified is grouped into different classes. These classes are indicated as "Classification" in Table 5. The classification used is a BM&C classification and does not relate to any standard or national or international code or practice. Table 5 shows the descriptions for the classifications used.

Table 5: POI Classification used

| Class | Description |
|---|---|
| 1 | Rural Building and structures of poor construction |
| 2 | Private Houses and people sensitive areas |
| 3 | Office and High-rise buildings |
| 4 | Animal related installations and animal sensitive areas |
| 5 | Industrial buildings and installations |
| 6 | Earth like structures – no surface structure |
| 7 | Graves & Heritage |
| 8 | Water Borehole |

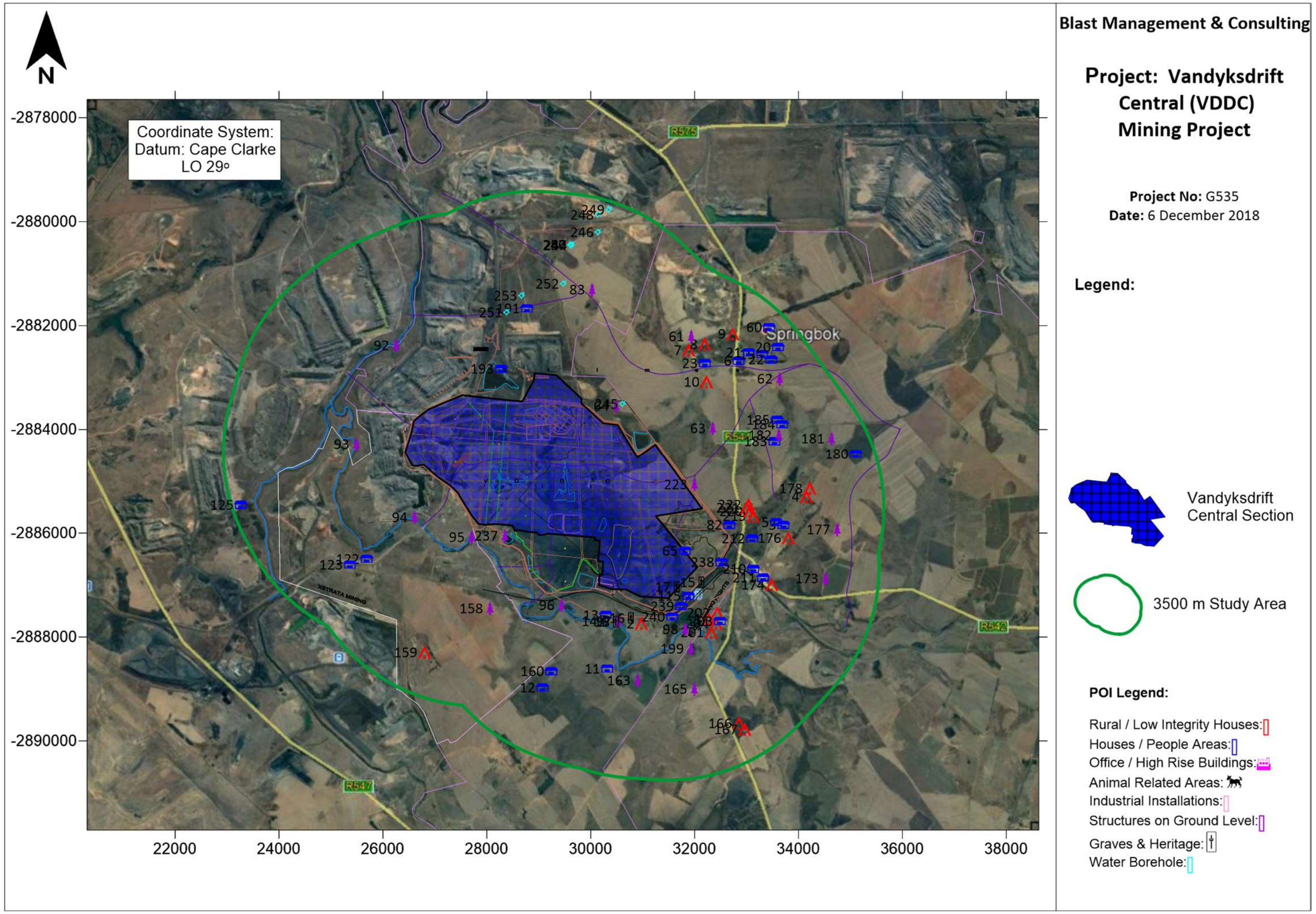



Figure 8: Aerial view and surface plan of the proposed mining area for Pit with points of interest identified

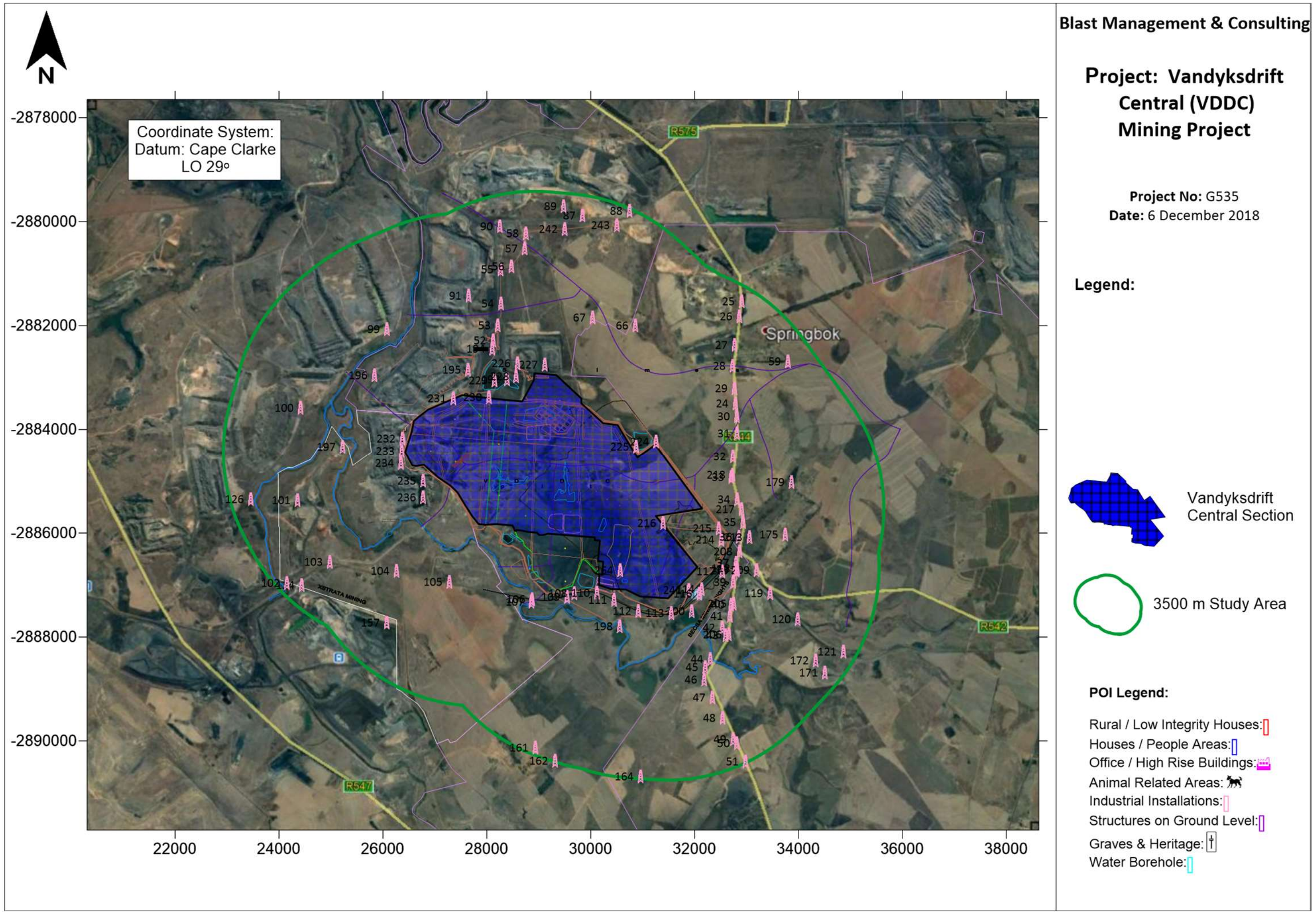



Figure 9: Aerial view and surface plan of the proposed mining area for Pit with Industrial infrastructure points of interest identified

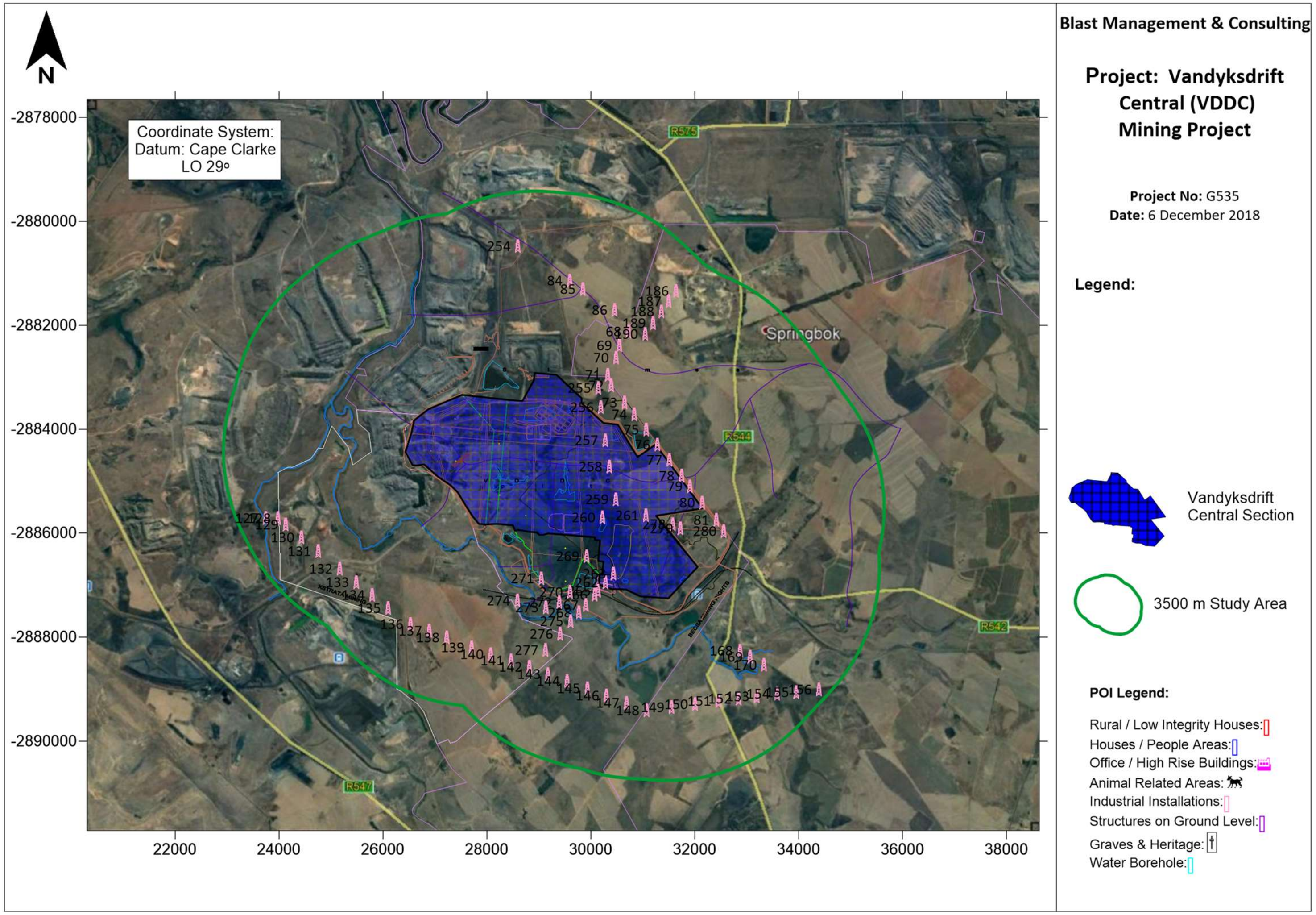



Figure 10: Aerial view and surface plan of the proposed mining area for Pit with Powerline points of interest identified

Table 6: List of points of interest identified (Cape Clarke – LO 29°)

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 1 | Informal Settlement (Lindokhule) | 1 | -32271.50 | 2887651.13 |
| 2 | Ruins | 1 | -30974.21 | 2887738.67 |
| 3 | School (Springbok) | 2 | -33709.08 | 2885842.15 |
| 4 | Informal Housing | 1 | -34153.83 | 2885298.75 |
| 5 | Buildings/Structures | 2 | -33570.19 | 2885790.20 |
| 6 | Springbok Mining Town Houses | 2 | -32848.62 | 2882673.55 |
| 7 | Informal Settlement (Kwajuma) | 1 | -31885.10 | 2882469.64 |
| 8 | Informal Settlement (Kwajuma) | 1 | -32194.91 | 2882355.53 |
| 9 | Informal Settlement (Kwajuma) | 1 | -32734.68 | 2882159.64 |
| 10 | Informal Housing | 1 | -32228.80 | 2883080.43 |
| 11 | Building/Structure | 2 | -30317.86 | 2888608.99 |
| 12 | Farm Buildings/Structures | 2 | -29070.53 | 2888971.74 |
| 13 | Buildings/Structures | 2 | -30291.07 | 2887574.45 |
| 14 | Heritage Site (Pump Station) | 7 | -30241.71 | 2887692.47 |
| 15 | Heritage Site (Railway Station) | 7 | -32130.50 | 2886945.19 |
| 16 | Heritage Site (Graveyard) | 7 | -30774.31 | 2887635.21 |
| 17 | Heritage Site (Graveyard) - Inside Pit Area | 7 | -31654.38 | 2887030.83 |
| 18 | Heritage Site (Pump Station) | 7 | -30482.58 | 2887706.80 |
| 19 | Springbok Mining Town Buildings | 2 | -33301.34 | 2882544.97 |
| 20 | Springbok Mining Town Church | 2 | -33604.57 | 2882410.98 |
| 21 | Springbok Mining Town Houses | 2 | -33040.38 | 2882514.66 |
| 22 | Springbok Mining Town Houses | 2 | -33471.34 | 2882650.99 |
| 23 | Buildings/Structures | 2 | -32196.50 | 2882721.32 |
| 24 | Communication Tower | 5 | -32785.10 | 2883496.66 |
| 25 | Pipeline | 5 | -32906.73 | 2881533.68 |
| 26 | Pipeline | 5 | -32859.43 | 2881823.02 |
| 27 | Pipeline | 5 | -32768.14 | 2882372.14 |
| 28 | Pipeline | 5 | -32730.66 | 2882772.25 |
| 29 | Pipeline | 5 | -32767.45 | 2883205.43 |
| 30 | Pipeline | 5 | -32812.63 | 2883743.51 |
| 31 | Pipeline | 5 | -32814.62 | 2884074.00 |
| 32 | Pipeline | 5 | -32737.00 | 2884519.50 |
| 33 | Pipeline | 5 | -32702.66 | 2884921.50 |
| 34 | Pipeline | 5 | -32818.94 | 2885348.83 |
| 35 | Pipeline | 5 | -32931.83 | 2885789.12 |
| 36 | Pipeline | 5 | -32852.75 | 2886070.43 |
| 37 | Pipeline | 5 | -32798.35 | 2886570.64 |
| 38 | Pipeline | 5 | -32786.29 | 2886705.38 |
| 39 | Pipeline | 5 | -32742.04 | 2886940.20 |
| 40 | Pipeline | 5 | -32702.05 | 2887378.18 |
| 41 | Pipeline | 5 | -32678.39 | 2887591.87 |

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 42 | Pipeline | 5 | -32533.14 | 2887817.98 |
| 43 | Pipeline | 5 | -32595.16 | 2887965.20 |
| 44 | Pipeline | 5 | -32301.20 | 2888423.38 |
| 45 | Pipeline | 5 | -32204.40 | 2888578.93 |
| 46 | Pipeline | 5 | -32183.50 | 2888818.23 |
| 47 | Pipeline | 5 | -32341.61 | 2889162.00 |
| 48 | Pipeline | 5 | -32538.39 | 2889555.32 |
| 49 | Pipeline | 5 | -32742.45 | 2889965.17 |
| 50 | Pipeline | 5 | -32811.43 | 2890043.26 |
| 51 | Pipeline | 5 | -32979.82 | 2890394.01 |
| 52 | Pipeline | 5 | -28120.73 | 2882284.37 |
| 53 | Pipeline | 5 | -28209.78 | 2881995.73 |
| 54 | Pipeline | 5 | -28272.61 | 2881574.93 |
| 55 | Pipeline | 5 | -28263.48 | 2880918.13 |
| 56 | Pipeline | 5 | -28473.06 | 2880859.06 |
| 57 | Pipeline | 5 | -28727.79 | 2880515.67 |
| 58 | Pipeline | 5 | -28751.51 | 2880224.45 |
| 59 | Reservoirs | 5 | -33796.85 | 2882687.66 |
| 60 | Buildings/Structures | 2 | -33433.09 | 2882030.38 |
| 61 | Cultivated Fields | 6 | -31935.90 | 2882205.01 |
| 62 | Cultivated Fields | 6 | -33638.85 | 2883019.22 |
| 63 | Cultivated Fields | 6 | -32350.99 | 2883972.43 |
| 64 | Cultivated Fields | 6 | -30490.37 | 2883543.67 |
| 65 | Buildings/Structures (Inside Pit Area) | 2 | -31813.45 | 2886337.60 |
| 66 | Power Station | 5 | -30858.48 | 2881998.27 |
| 67 | Cement Dam | 5 | -30035.57 | 2881844.67 |
| 68 | Power lines/Pylons | 5 | -30721.87 | 2882117.28 |
| 69 | Power lines/Pylons | 5 | -30546.16 | 2882383.69 |
| 70 | Power lines/Pylons | 5 | -30482.31 | 2882621.73 |
| 71 | Power lines/Pylons | 5 | -30323.92 | 2882953.37 |
| 72 | Power lines/Pylons | 5 | -30389.10 | 2883153.94 |
| 73 | Power lines/Pylons | 5 | -30646.32 | 2883483.97 |
| 74 | Power lines/Pylons | 5 | -30833.70 | 2883712.03 |
| 75 | Power lines/Pylons | 5 | -31063.96 | 2884006.90 |
| 76 | Power lines/Pylons | 5 | -31277.88 | 2884292.98 |
| 77 | Power lines/Pylons | 5 | -31508.85 | 2884594.26 |
| 78 | Power lines/Pylons | 5 | -31745.54 | 2884901.76 |
| 79 | Power lines/Pylons | 5 | -31903.89 | 2885104.23 |
| 80 | Power lines/Pylons | 5 | -32140.50 | 2885418.17 |
| 81 | Power lines/Pylons | 5 | -32413.68 | 2885749.12 |
| 82 | Buildings/Structures | 2 | -32668.59 | 2885841.19 |
| 83 | Cultivated Fields | 6 | -30027.77 | 2881307.56 |
| 84 | Power lines/Pylons | 5 | -29592.24 | 2881137.11 |
| 85 | Power lines/Pylons | 5 | -29844.36 | 2881302.29 |

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 86 | Power lines/Pylons | 5 | -30454.76 | 2881702.17 |
| 87 | Dam | 5 | -29841.04 | 2879880.27 |
| 88 | Mine Activity | 5 | -30746.76 | 2879791.82 |
| 89 | Dam | 5 | -29477.23 | 2879701.73 |
| 90 | Mine Buildings/Structures | 5 | -28249.49 | 2880088.82 |
| 91 | Mine Activity | 5 | -27649.39 | 2881423.79 |
| 92 | Olifants River | 6 | -26257.65 | 2882377.31 |
| 93 | Olifants River | 6 | -25490.67 | 2884279.57 |
| 94 | Olifants River | 6 | -26610.36 | 2885694.74 |
| 95 | Olifants River | 6 | -27710.35 | 2886077.44 |
| 96 | Olifants River | 6 | -29440.89 | 2887386.32 |
| 97 | Olifants River | 6 | -30531.68 | 2887694.82 |
| 98 | Olifants River | 6 | -31822.25 | 2887848.66 |
| 99 | Dam | 5 | -26076.55 | 2882067.21 |
| 100 | Mine Activity | 5 | -24413.73 | 2883581.03 |
| 101 | Dam | 5 | -24356.59 | 2885365.96 |
| 102 | Railway Line | 5 | -24151.05 | 2886961.94 |
| 103 | Railway Line | 5 | -24977.90 | 2886555.01 |
| 104 | Railway Line | 5 | -26260.67 | 2886727.22 |
| 105 | Railway Line | 5 | -27278.97 | 2886939.47 |
| 106 | Railway Line/Bridge | 5 | -28872.46 | 2887271.86 |
| 107 | Dam/Bridge | 5 | -28855.76 | 2887320.88 |
| 108 | Railway Line | 5 | -29682.66 | 2887156.89 |
| 109 | Power Station | 5 | -29543.99 | 2887228.55 |
| 110 | Railway Line | 5 | -30119.79 | 2887149.05 |
| 111 | Railway Line/Bridge | 5 | -30448.54 | 2887285.80 |
| 112 | Railway Line | 5 | -30916.51 | 2887497.74 |
| 113 | Railway Line | 5 | -31550.39 | 2887539.25 |
| 114 | Railway Line | 5 | -32136.13 | 2887080.04 |
| 115 | Buildings/Structures | 2 | -31875.06 | 2887206.82 |
| 116 | Railway Station Buildings | 5 | -32087.55 | 2887164.74 |
| 117 | Railway Line | 5 | -32531.46 | 2886734.03 |
| 118 | Railway Line/Bridge | 5 | -32816.48 | 2886678.38 |
| 119 | Railway Line | 5 | -33453.93 | 2887154.65 |
| 120 | Railway Line | 5 | -33984.53 | 2887655.36 |
| 121 | Railway Line | 5 | -34864.93 | 2888280.74 |
| 122 | Buildings/Structures | 2 | -25686.57 | 2886496.29 |
| 123 | Building/Structure | 2 | -25364.65 | 2886607.22 |
| 124 | Dam | 5 | -24435.63 | 2887001.87 |
| 125 | Building/Structure | 2 | -23265.45 | 2885454.03 |
| 126 | Cement Dam | 5 | -23456.65 | 2885345.98 |
| 127 | Power lines/Pylons | 5 | -23741.32 | 2885713.13 |
| 128 | Power lines/Pylons | 5 | -23978.28 | 2885715.25 |
| 129 | Power lines/Pylons | 5 | -24125.72 | 2885838.30 |

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 130 | Power lines/Pylons | 5 | -24428.64 | 2886083.98 |
| 131 | Power lines/Pylons | 5 | -24751.85 | 2886348.92 |
| 132 | Power lines/Pylons | 5 | -25167.47 | 2886686.01 |
| 133 | Power lines/Pylons | 5 | -25485.18 | 2886945.98 |
| 134 | Power lines/Pylons | 5 | -25789.54 | 2887190.83 |
| 135 | Power lines/Pylons | 5 | -26096.35 | 2887442.25 |
| 136 | Power lines/Pylons | 5 | -26528.13 | 2887747.04 |
| 137 | Power lines/Pylons | 5 | -26887.34 | 2887876.89 |
| 138 | Power lines/Pylons | 5 | -27224.82 | 2888005.94 |
| 139 | Power lines/Pylons | 5 | -27703.14 | 2888196.85 |
| 140 | Power lines/Pylons | 5 | -28070.50 | 2888327.36 |
| 141 | Power lines/Pylons | 5 | -28462.40 | 2888445.41 |
| 142 | Power lines/Pylons | 5 | -28814.98 | 2888568.89 |
| 143 | Power lines/Pylons | 5 | -29171.58 | 2888708.51 |
| 144 | Power lines/Pylons | 5 | -29541.14 | 2888841.57 |
| 145 | Power lines/Pylons | 5 | -29931.77 | 2888983.62 |
| 146 | Power lines/Pylons | 5 | -30297.02 | 2889121.28 |
| 147 | Power lines/Pylons | 5 | -30686.23 | 2889261.27 |
| 148 | Power lines/Pylons | 5 | -31070.99 | 2889404.76 |
| 149 | Power lines/Pylons | 5 | -31550.90 | 2889345.11 |
| 150 | Power lines/Pylons | 5 | -32003.38 | 2889286.86 |
| 151 | Power lines/Pylons | 5 | -32450.33 | 2889223.51 |
| 152 | Power lines/Pylons | 5 | -32842.75 | 2889180.37 |
| 153 | Power lines/Pylons | 5 | -33189.80 | 2889135.65 |
| 154 | Power lines/Pylons | 5 | -33581.43 | 2889085.70 |
| 155 | Power lines/Pylons | 5 | -33951.67 | 2889057.76 |
| 156 | Power lines/Pylons | 5 | -34388.06 | 2889003.22 |
| 157 | Mine Activity | 5 | -26072.70 | 2887721.42 |
| 158 | Cultivated Fields | 6 | -28063.51 | 2887447.09 |
| 159 | Informal Houses | 1 | -26799.39 | 2888295.93 |
| 160 | Buildings/Structures | 2 | -29239.70 | 2888655.61 |
| 161 | Cement Dam | 5 | -28934.40 | 2890128.41 |
| 162 | Cement Dam | 5 | -29314.66 | 2890381.51 |
| 163 | Pan | 6 | -30905.66 | 2888835.08 |
| 164 | Dam | 5 | -30960.04 | 2890682.43 |
| 165 | Cultivated Fields | 6 | -31997.14 | 2889000.15 |
| 166 | Informal Houses | 1 | -32854.34 | 2889657.39 |
| 167 | Informal Houses | 1 | -32963.71 | 2889775.12 |
| 168 | Power lines/Pylons | 5 | -32869.30 | 2888260.69 |
| 169 | Power lines/Pylons | 5 | -33063.21 | 2888376.57 |
| 170 | Power lines/Pylons | 5 | -33328.52 | 2888530.54 |
| 171 | Conveyor | 5 | -34507.06 | 2888685.35 |
| 172 | Dam | 5 | -34331.05 | 2888451.43 |
| 173 | Cultivated Fields | 6 | -34523.09 | 2886872.26 |

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 174 | Informal Housing | 1 | -33484.94 | 2886990.92 |
| 175 | Reservoirs | 5 | -33744.16 | 2886026.18 |
| 176 | Ruins | 1 | -33804.83 | 2886092.79 |
| 177 | Cultivated Fields | 6 | -34745.32 | 2885928.46 |
| 178 | Informal Housing | 1 | -34217.90 | 2885139.49 |
| 179 | Dam | 5 | -33865.09 | 2885017.85 |
| 180 | Structure | 2 | -35100.36 | 2884470.90 |
| 181 | Cultivated Fields | 6 | -34639.95 | 2884170.29 |
| 182 | Cultivated Fields | 6 | -33623.14 | 2884103.93 |
| 183 | Structure | 2 | -33536.73 | 2884222.73 |
| 184 | Structure | 2 | -33685.31 | 2883898.44 |
| 185 | Structure | 2 | -33584.12 | 2883810.51 |
| 186 | Power lines/Pylons | 5 | -31636.50 | 2881335.40 |
| 187 | Power lines/Pylons | 5 | -31494.19 | 2881533.81 |
| 188 | Power lines/Pylons | 5 | -31354.59 | 2881731.04 |
| 189 | Power lines/Pylons | 5 | -31194.85 | 2881956.24 |
| 190 | Power lines/Pylons | 5 | -31043.47 | 2882165.00 |
| 191 | Structure | 2 | -28772.06 | 2881667.77 |
| 192 | Dam | 5 | -28388.17 | 2883032.31 |
| 193 | Structure | 2 | -28273.19 | 2882830.44 |
| 194 | Conveyor | 5 | -28103.42 | 2882443.36 |
| 195 | Dam | 5 | -27637.81 | 2882848.26 |
| 196 | Mine Buildings/Structures | 5 | -25836.98 | 2882953.82 |
| 197 | Dam | 5 | -25223.17 | 2884333.52 |
| 198 | Dam | 5 | -30557.90 | 2887793.45 |
| 199 | Pan | 6 | -31929.77 | 2888224.40 |
| 200 | Dam | 5 | -31943.51 | 2887503.28 |
| 201 | Informal Settlement (Lindokhule) | 1 | -32317.23 | 2887907.72 |
| 202 | Informal Settlement (Lindokhule) | 1 | -32435.02 | 2887534.69 |
| 203 | Shopping Centre (Lindokhule) | 2 | -32487.06 | 2887692.98 |
| 204 | Informal Settlement (Lindokhule) | 1 | -32409.90 | 2887737.04 |
| 205 | R544 Road | 5 | -32750.96 | 2887357.51 |
| 206 | R544 Road | 5 | -32658.62 | 2887949.13 |
| 207 | R544 Road | 5 | -32812.08 | 2886717.70 |
| 208 | R542 Road | 5 | -32864.89 | 2886352.43 |
| 209 | R542 Road | 5 | -33193.51 | 2886711.85 |
| 210 | Shopping Centre | 2 | -33128.16 | 2886687.37 |
| 211 | Buildings/Structures | 2 | -33317.19 | 2886853.92 |
| 212 | Buildings/Structures | 2 | -33109.95 | 2886102.33 |
| 213 | Reservoir | 5 | -33055.26 | 2886077.62 |
| 214 | Dam | 5 | -32514.75 | 2886125.41 |
| 215 | Road | 5 | -32463.71 | 2885908.24 |
| 216 | Road | 5 | -31393.02 | 2885806.08 |
| 217 | R544 Road | 5 | -32902.99 | 2885539.04 |

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 218 | R544 Road | 5 | -32727.90 | 2884875.83 |
| 219 | Informal Housing | 1 | -33128.44 | 2885672.98 |
| 220 | Informal Housing | 1 | -33061.44 | 2885579.07 |
| 221 | Informal Housing | 1 | -33002.20 | 2885510.95 |
| 222 | Informal Housing | 1 | -33036.99 | 2885450.50 |
| 223 | Cultivated Fields | 6 | -31997.87 | 2885062.04 |
| 224 | Dam | 5 | -31258.26 | 2884229.57 |
| 225 | Dam | 5 | -30873.90 | 2884328.42 |
| 226 | Mine Buildings/Structures | 5 | -28591.00 | 2882724.61 |
| 227 | Mine Activity | 5 | -29115.51 | 2882749.13 |
| 228 | Mine Buildings/Structures | 5 | -28562.37 | 2882973.09 |
| 229 | Dam | 5 | -28148.42 | 2883052.82 |
| 230 | Mine Buildings/Structures | 5 | -28040.40 | 2883376.03 |
| 231 | Dam | 5 | -27354.93 | 2883398.20 |
| 232 | Dam | 5 | -26374.24 | 2884174.18 |
| 233 | Dam | 5 | -26361.40 | 2884415.81 |
| 234 | Dam | 5 | -26345.90 | 2884648.97 |
| 235 | Dam | 5 | -26773.13 | 2884991.71 |
| 236 | Dam | 5 | -26771.72 | 2885311.04 |
| 237 | Pan | 6 | -28351.69 | 2886048.92 |
| 238 | Building/Structure | 2 | -32514.43 | 2886558.36 |
| 239 | Building/Structure | 2 | -31739.66 | 2887406.91 |
| 240 | Building/Structure | 2 | -31567.28 | 2887607.14 |
| 241 | Cement Dam | 5 | -31887.15 | 2887094.54 |
| 242 | Pipeline | 5 | -29498.69 | 2880142.59 |
| 243 | Pipeline | 5 | -30503.05 | 2880067.91 |
| 244 | Borehole (WBH 2S1) | 8 | -29623.41 | 2880456.63 |
| 245 | Borehole (WBH 2S8) | 8 | -30607.18 | 2883505.57 |
| 246 | Borehole (SKS BH2) | 8 | -30135.02 | 2880201.13 |
| 247 | Borehole (VLKR 3) | 8 | -29605.09 | 2880445.51 |
| 248 | Borehole (WVK 1) | 8 | -30136.89 | 2879868.76 |
| 249 | Borehole (WVK 2) | 8 | -30343.98 | 2879769.53 |
| 250 | Borehole (WVK 3) | 8 | -29605.09 | 2880445.51 |
| 251 | Borehole (NDB 2) | 8 | -28377.85 | 2881742.75 |
| 252 | Borehole (NDB 3) | 8 | -29468.29 | 2881194.89 |
| 253 | Borehole (NDB 6) | 8 | -28663.78 | 2881422.08 |
| 254 | Power lines/Pylons | 5 | -28593.52 | 2880473.05 |
| 255 | Power lines/Pylons | 5 | -30142.28 | 2883202.79 |
| 256 | Power lines/Pylons | 5 | -30190.90 | 2883575.02 |
| 257 | Power lines/Pylons (Inside Pit Area) | 5 | -30277.04 | 2884211.06 |
| 258 | Power lines/Pylons (Inside Pit Area) | 5 | -30355.73 | 2884725.92 |
| 259 | Power lines/Pylons (Inside Pit Area) | 5 | -30477.99 | 2885354.76 |
| 260 | Power lines/Pylons (Inside Pit Area) | 5 | -30220.30 | 2885700.02 |
| 261 | Power lines/Pylons (Inside Pit Area) | 5 | -31057.93 | 2885661.44 |

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 262 | Power lines/Pylons (Inside Pit Area) | 5 | -30281.03 | 2886948.38 |
| 263 | Power lines/Pylons (Inside Pit Area) | 5 | -30433.06 | 2886779.17 |
| 264 | Power Station (Inside Pit Area) | 5 | -30567.03 | 2886714.64 |
| 265 | Power lines/Pylons | 5 | -30136.45 | 2887110.44 |
| 266 | Power lines/Pylons | 5 | -30071.18 | 2887183.23 |
| 267 | Power lines/Pylons | 5 | -29900.32 | 2887381.56 |
| 268 | Power lines/Pylons | 5 | -29767.08 | 2887525.82 |
| 269 | Power lines/Pylons | 5 | -29916.77 | 2886446.33 |
| 270 | Power lines/Pylons | 5 | -29596.72 | 2887131.43 |
| 271 | Power lines/Pylons | 5 | -29044.09 | 2886871.72 |
| 272 | Power lines/Pylons | 5 | -29390.32 | 2887327.36 |
| 273 | Power lines/Pylons | 5 | -29132.22 | 2887428.93 |
| 274 | Power lines/Pylons | 5 | -28586.06 | 2887296.54 |
| 275 | Power lines/Pylons | 5 | -29608.68 | 2887693.07 |
| 276 | Power lines/Pylons | 5 | -29409.09 | 2887938.20 |
| 277 | Power lines/Pylons | 5 | -29124.43 | 2888248.49 |
| 278 | Power lines/Pylons | 5 | -31575.31 | 2885832.25 |
| 279 | Power lines/Pylons | 5 | -31721.89 | 2885912.09 |
| 280 | Power lines/Pylons | 5 | -32554.54 | 2885963.25 |

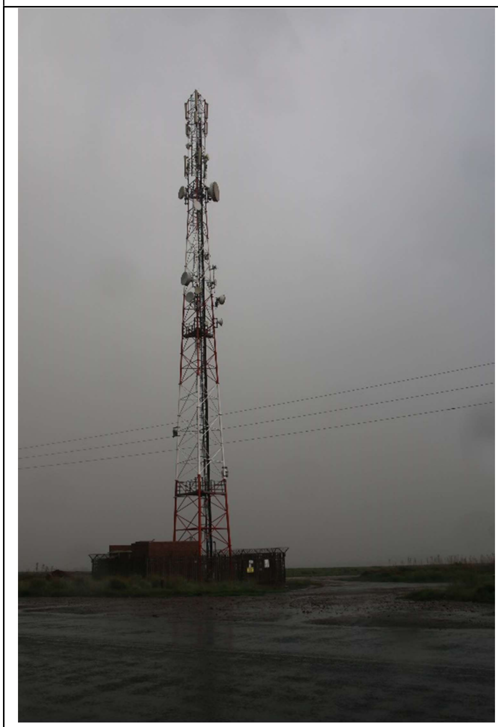
During the site visit the structures were observed and the initial POI list ground-truthed and finalised as represented in this section. Structures ranged from well-built structures to informal building styles. Table 7 shows photos of structures found in the area.

Table 7: Structure Profile

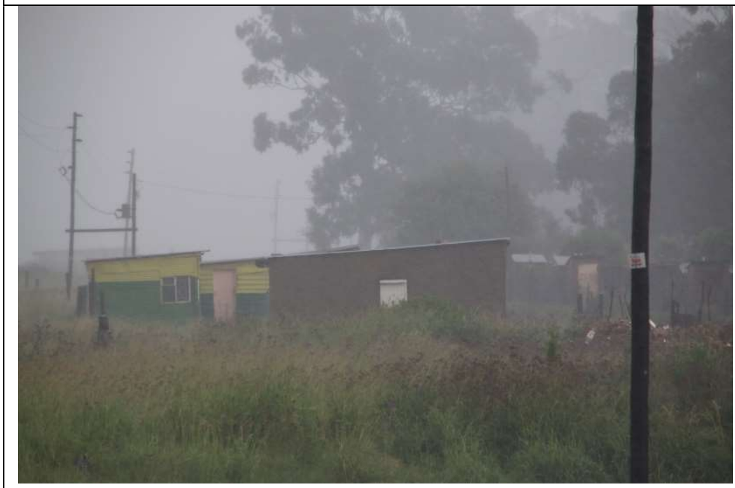
| Structure Photo | Description |
|---|---|
|  | Brick Strcutures with currugated iron roofs |

| | |
|---|---|
|  | Caltex Garage |
|  | Brick and mortar structures |
|  | Brick and mortar structures and substation |

| | |
|---|---|
|  | Brick and mortar structures |
|  | Old brick structure |
|  | Mudhouses in informal settlement |

| | |
|---|---|
|  | Pipeline infrastructure |
|  | Maize fields |
|  | Cellular tower |

| | |
|---|---|
|  | Structures |
|  | House |
|  | Corrugated iron structure |

| | |
|---|---|
|  | Informal settlement with mud houses |
|  | Brick and corrugate iron structures |
|  | Old shop – brick structure |

| | |
|---|---|
|  | Powerlines |
|  | Brick structures and business |
|  | Brick structures and supermarket |

| | |
|---|---|
|  | Brick structures – seems to be housing units |
|  | Substation |
|  | Informarmal settlement with mud structures |

| | |
|---|---|
|  | Train bridge and railway infrastructure |
|  | Railway line |
|  | Powerline |

| | |
|---|---|
|  | Informal settlement with mixed type structures – mud houses and concrete pallisade type |
|  | Brick structures and businesses |

## 15 Blasting Operations

The following mining process is envisaged.

The VDDC area was identified as the most likely coal source to replace the Steenkoolspruit operation and to fulfil the current contracts and market obligations of the mining complex. The plan calls for the establishment of a large box cut by the means of the truck and shovel mining method and then the introduction of two draglines from ceased mining operations within the complex. The owner operated 40 cubic meter shovels and the draglines will be backed up by smaller contactor operated shovels in effect pre-stripping the waste material above the dragline waste material horizon.

In order to evaluate the possible influence from blasting operations with regards to ground vibration, air blast and fly rock a planned blast design is required to determine possible influences. In the mining process blasting will definitely be required for the overburden material. Indications are that coal will firstly be mechanically dug and ripped with drilling and blasting as a last option.

This report concentrates on the drilling and blasting of the overburden. Coal requires significantly less explosives per unit than the overburden. The overburden blasts are then considered as a worst-case scenario and is used as indicator of possible influence.

Currently a final blast design for the project is not available but information from the existing operations was provided. Using data provided JKSimblast blast design software was used to design and simulate the blast. This designed blast was applied for the evaluation done in this report. The simulation of the blast provided the best prediction possible. Table 8 shows summary technical information of the blast designed. Outcome of the design on JKSimblast is summarised in Table 9. Figure 11 below shows the blast layout with blast holes, simulation and maximum charge mass per delay. Figure 12 shows simulation timing contours with number of blast holes per delay from the typical timing applied.

Table 8: Blast design technical information

| Blast Layout | |
|---|---|
| Burden (m) | 7.0 |
| Spacing (m) | 7.0 |
| Average Bench Height (m) | 19.7 |
| Hole Depth (m) | varies |
| Sub-drill (m) | 0 |
| No. of Holes | 230 |
| No. of Rows | 10 |
| Hole Diameter (mm) | 251 |
| Initiation on Face | No |
| Free Face Clean | No |
| Area | VDD |
| Block ID | VDD Ramp 2 |
| Stemming Length (m) | 6.5 |
| Stemming Material | Discard |
| Drill Pattern | Square |
| Free-Face available | No |
| Number Of Faces | 1 |
| Type Of Blast | OB |
| Explosives and Initiation System | |
| Explosives Type | HEF207 |
| Cup density (g/cc) | 1.05 |
| Explosives Mass per Hole (kg) | Varies |
| Explosives Mass per Delay (kg) | Varies |
| Powder factor (kg/m3) | 0.84 |
| Initiation System | AXXIS EDD's |
| Booster Type and Size | 800g Trojan |
| Inter-Burden Delay (ms) | Please see timing figure |
| Inter-Spacing Delay (ms) | Please see timing figure |
| Down-hole Delay (ms) | N/A |

Table 9: Blast design information from simulation

| | | | |
|---|---|---|---|
| **DESIGN FACTORS FOR:** | | | |
| **Blast Name:** | **Block01** | | |
| **Scenario:** | **10** | **Scenario 10** | |
| **Area Option:** | | **-1** | |
| **Hole Option:** | **Block01** | **50** | |
| **Deck Option:** | **Block01** | **51** | |
| **Downhole Delay Option:** | **Block01** | **52** | |
| **Surface Delay Option:** | **Block01** | **53** | |
| Using Marked Holes and blast Parameters: | | | |
| | | | |
| | Av. Burden | 7 | m |
| | Av. Spacing | 7 | m |
| | All Hole Lengths | 4 334.000 | m |
| | Volume | 212 366.008 | m³ |
| | Rock SG | 2.7 | |
| | Tonnage | 573 388.222 | tonnes |
| | Marked Holes | 220 | |
| | Charge Mass | 165 246.322 | kg |
| | Charge Energy | 454 427.385 | MJ |
| | POWDER FACTOR | 0.778 | kg/m³ |
| | POWDER FACTOR | 0.288 | kg/t |
| | ENERGY FACTOR | 2.14 | MJ/m³ |
| | ENERGY FACTOR | 0.793 | MJ/t |

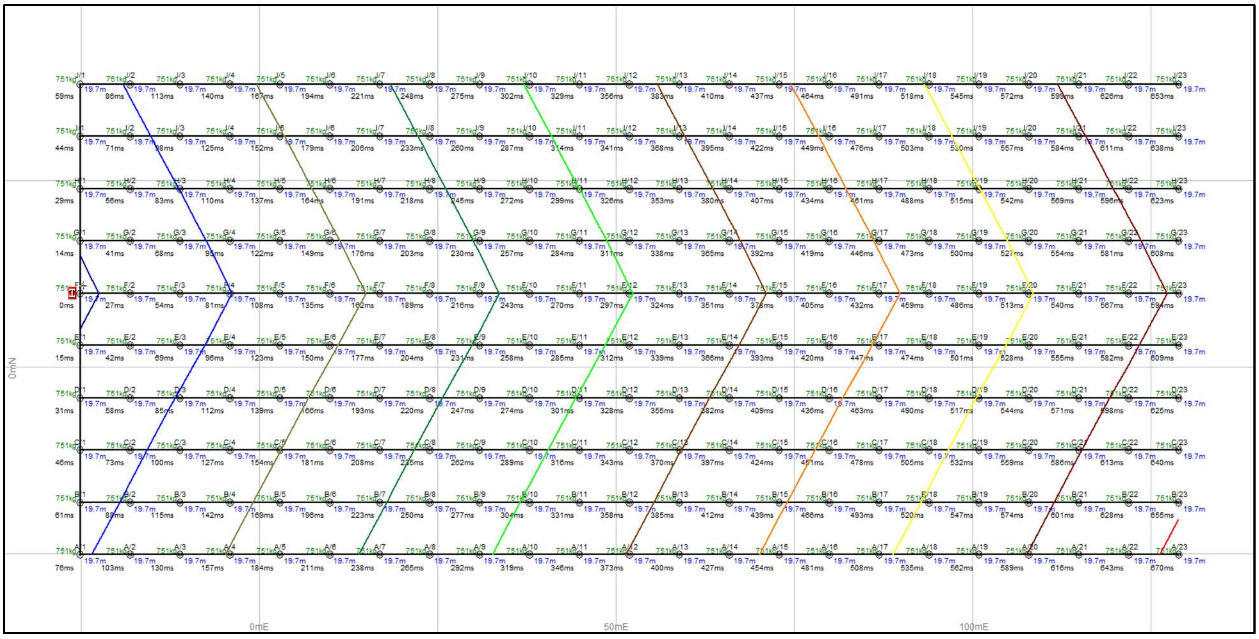


Figure 11: Blast holes layout with length and charge mass

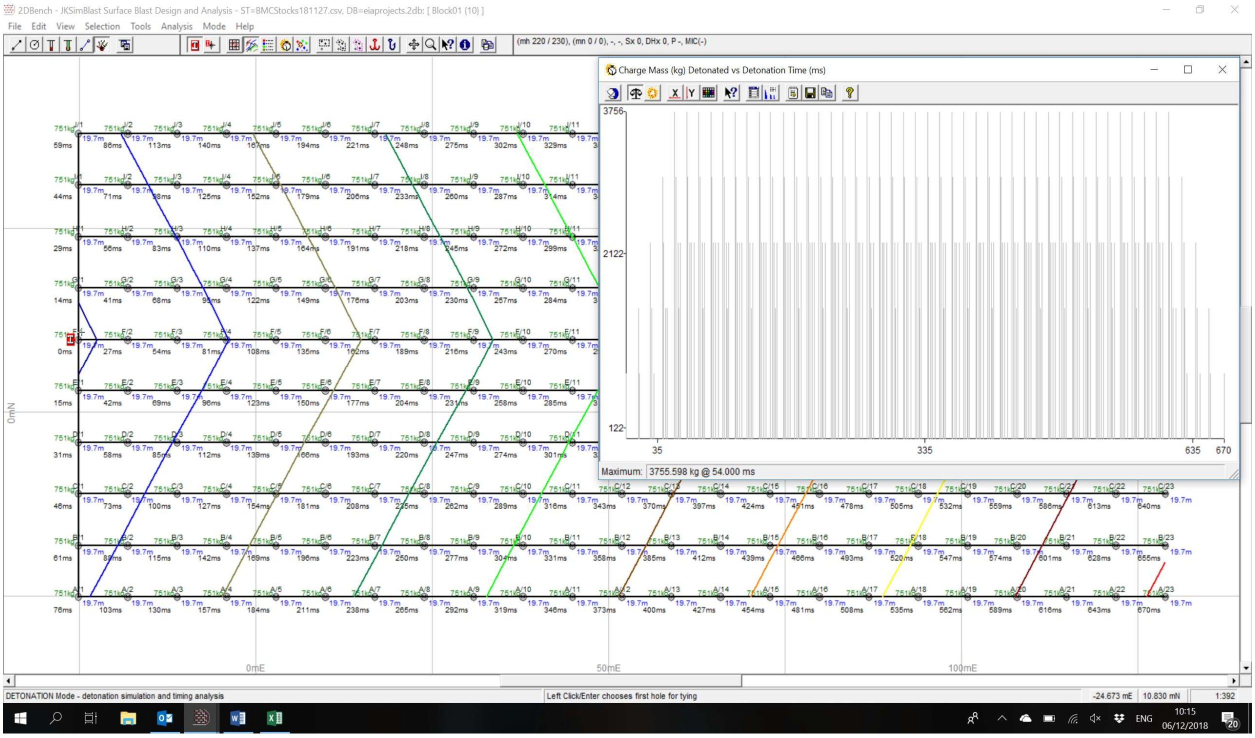



Figure 12: Simulation and decks per delay graph

The simulation work done provided information that is applied for predicting ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 251 mm diameter single blast hole and the maximum charge was extracted from the blast simulation in JKSimblast. The maximum charge relates to the total number of blast holes that detonates simultaneously based on the blast layout and initiation timing of the blast. Thus, the maximum mass of explosives detonating at once. The minimum charge relates to 751 kg and the maximum charge relates to 3756 kg. These values were applied in all predictions for ground vibration and air blast.

### 15.1 Ground Vibration

Predicting ground vibration and possible decay, a standard accepted mathematical process of scaled distance is used. The equation applied (Equation 1) uses the charge mass and distance with two site constants. The site constants are specific to a site where blasting is to be done. In the absence of measured values an acceptable standard set of constants is applied.

**Equation 1:**

$$PPV = a(\frac{D}{\sqrt{E}})^{-b}$$

Where:
PPV = Predicted ground vibration (mm/s)
a = Site constant
b = Site constant
D = Distance (m)
E = Explosive Mass (kg)

Applicable and accepted factors a&b for new operations is as follows:
Factors:
a = 1143
b = -1.65

Utilizing the abovementioned equation and the given factors, allowable levels for specific limits and expected ground vibration levels can then be calculated for various distances.

Review of the type of structures that are found within the possible influence zone of the proposed mining area and the limitations that may be applicable, different limiting levels of ground vibration will be required. This is due to the typical structures and installations observed surrounding the site and location of the project area. Structures types and qualities vary greatly and this calls for limits to be considered as follows: 6 mm/s, 12.5 mm/s levels and 25 mm/s at least.

Based on the designs presented on expected drilling and charging design, the following Table 10 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. The charge masses are 751 kg and 3756 kg for the Pit.

Table 10: Expected Ground Vibration at Various Distances from Charges Applied in this Study

| No. | Distance (m) | Expected PPV (mm/s) for 751 kg Charge | Expected PPV (mm/s) for 3756 kg Charge |
|---|---|---|---|
| 1 | 50.0 | 423.8 | 1599.2 |
| 2 | 100.0 | 217.1 | 819.1 |
| 3 | 150.0 | 69.2 | 261.0 |
| 4 | 200.0 | 43.0 | 162.4 |
| 5 | 250.0 | 29.8 | 112.4 |
| 6 | 300.0 | 22.0 | 83.2 |
| 7 | 400.0 | 13.7 | 51.7 |
| 8 | 500.0 | 9.5 | 35.8 |
| 9 | 600.0 | 7.0 | 26.5 |
| 10 | 700.0 | 5.4 | 20.5 |
| 11 | 800.0 | 4.4 | 16.5 |
| 12 | 900.0 | 3.6 | 13.6 |
| 13 | 1000.0 | 3.0 | 11.4 |
| 14 | 1250.0 | 2.1 | 7.9 |
| 15 | 1500.0 | 1.5 | 5.8 |
| 16 | 1750.0 | 1.2 | 4.5 |
| 17 | 2000.0 | 1.0 | 3.6 |
| 18 | 2500.0 | 0.7 | 2.5 |
| 19 | 3000.0 | 0.5 | 1.9 |
| 20 | 3500.0 | 0.4 | 1.4 |

## 15.2 Air blast

The prediction of air blast as a pre-operational effect is difficult to define exactly. There are many variables that have influence on the outcome of air blast. Air blast is the direct result from the blast process, although influenced by meteorological conditions, wind strength and direction, the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result. Air blast is also an aspect that can be controlled to a great degree by applying basic rules.
In most cases mainly an indication of typical levels can be obtained. The indication of levels or the prediction of air blast in this report is used to predefine possible indicators of concern.

Standard accepted prediction equations are applied for the prediction of air blast. A standard cube root scaling prediction formula is applied for air blast predictions. The following Equation 2 was used to calculate possible air blast values in millibar. This equation does not take temperature or any weather conditions into account.

Equation 2:

$$P = \mathrm{A}\ \mathrm{x}\ (\frac{\mathrm{D}}{\mathrm{E}^{\frac{1}{3}}})^{-B}$$

Where:

$P$ = Air blast level (mB)

D = Distance from source (m)

E = Maximum charge mass per delay (kg)

A = Constant - (5.37)

B = Constant – (-0.79)

The constants for A and B were then selected according to the information as provided in Figure 13 below. Various types of mining operations are expected to yield different results. The information provided in Figure 13 is based on detailed research that was conducted for each of the different types of mining environments. In this report, the data for "Coal Mines (high wall)" was applied in the prediction or air blast.

**Air Overpressure Prediction Equations**

| Blasting | Metric Equations mb | U.S. Equations psi | Statistical Type | Source |
|---|---|---|---|---|
| Open air (no confinement) | $P = 3589 \times SD_3^{-1.38}$ | $P = 187 \times SD_3^{-1.38}$ | Best Fit | Perkins |
| Coal mines (parting) | $P = 2596 \times SD_3^{-1.62}$ | $P = 169 \times SD_3^{-1.62}$ | Best Fit | USBM RI 8485 |
| Coal mines (highwall) | $P = 5.37 \times SD_3^{-0.79}$ | $P = 0.162 \times SD_3^{-0.79}$ | Best Fit | USBM RI 8485 |
| Quarry face | $P = 37.1 \times SD_3^{-0.97}$ | $P = 1.32 \times SD_3^{-0.97}$ | Best Fit | USBM RI 8485 |
| Metal Mine | $P = 14.3 \times SD_3^{-0.71}$ | $P = 0.401 \times SD_3^{-0.71}$ | Best Fit | USBM RI 8485 |
| Construction (average) | $P = 24.8 \times SD_3^{-1.1}$ | $P = 1 \times SD_3^{-1.1}$ | Best Fit | Oriard (2005) |
| Construction (highly confined) | $P = 2.48 \times SD_3^{-1.1}$ | $P = 0.1 \times SD_3^{-1.1}$ | Best Fit | Oriard (2005) |
| Buried (total confinement) | $P = 1.73 \times SD_3^{-0.96}$ | $P = 0.061 \times SD_3^{-0.96}$ | Best Fit | USBM RI 8485 |

*Table 26.7 - Air overpressure prediction equations.*

Figure 13: Proposed prediction equations

The air pressure calculated in Equation 2 is converted to decibels in Equation 3. The reporting of air blast in the decibel scale is more readily accepted in the mining industry.

Equation 3:

$$\mathrm{p}_s = 20\ \mathrm{x}\ \log\frac{P}{P_o}$$

Where:

$\mathrm{p}_s$ = Air blast level (dB)

$P$ = Air blast level (Pa (mB x 100))

$P_o$ = Reference Pressure (2 x $10^{-5}$ Pa)

Although the above equation was applied for prediction of air blast levels, additional measures are also recommended to ensure that air blast and associated fly-rock possibilities are minimized as best possible.

As discussed earlier the prediction of air blast is very subjective. Following in Table 11 below is a summary of values predicted according to Equation 2.

Table 11: Air Blast Predicted Values

| No. | Distance (m) | Air blast (dB) for 751 kg Charge | Air blast (dB) for 3756 kg Charge |
|---|---|---|---|
| 1 | 50.0 | 136.9 | 140.6 |
| 2 | 100.0 | 134.1 | 137.8 |
| 3 | 150.0 | 129.4 | 133.0 |
| 4 | 200.0 | 127.4 | 131.1 |
| 5 | 250.0 | 125.8 | 129.5 |
| 6 | 300.0 | 124.6 | 128.3 |
| 7 | 400.0 | 122.6 | 126.3 |
| 8 | 500.0 | 121.1 | 124.8 |
| 9 | 600.0 | 119.9 | 123.5 |
| 10 | 700.0 | 118.8 | 122.5 |
| 11 | 800.0 | 117.9 | 121.5 |
| 12 | 900.0 | 117.1 | 120.7 |
| 13 | 1000.0 | 116.3 | 120.0 |
| 14 | 1250.0 | 114.8 | 118.5 |
| 15 | 1500.0 | 113.6 | 117.3 |
| 16 | 1750.0 | 112.6 | 116.2 |
| 17 | 2000.0 | 111.6 | 115.3 |
| 18 | 2500.0 | 110.1 | 113.8 |
| 19 | 3000.0 | 108.8 | 112.6 |
| 20 | 3500.0 | 107.8 | 111.5 |

## 16 Construction Phase: Impact Assessment and Mitigation Measures

During the construction phase no mining drilling and blasting operations is expected. No detail impact evaluation was done the construction phase.

# 17 Operational Phase: Impact Assessment and Mitigation Measures

The area surrounding the proposed mining area was reviewed for structures, traffic, roads, human interface, animals' interface etc. Various installations and structures were observed. These are listed in Table 6. This section concentrates on the outcome of modelling the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces. In evaluation, the charge mass scenarios selected as indicated in section 14.2 is considered with regards to ground vibration and air blast.

Ground vibration and air blast was calculated from the edge of the pit outline and modelled accordingly. Blasting further away from the pit edge will certainly have lesser influence on the surroundings. A worst case is then applicable with calculation from pit edge. As explained previously reference is only made to some structures and these references covers the extent of all structures surrounding the mine.

The following aspects with comments are addressed for each of the evaluations done:

- Ground Vibration Modelling Results
- Ground Vibration and human perception
- Vibration impact on national and provincial road
- Vibration will upset adjacent communities
- Cracking of houses and consequent devaluation
- Air blast Modelling Results
- Impact of fly rock
- Noxious fumes Influence Results

Please note that this analysis does not take geology, topography or actual final drill and blast pattern into account. The data is based on good practise applied internationally and considered very good estimates based on the information provided and supplied in this document.

## 17.1 Review of expected ground vibration

Presented herewith are the expected ground vibration level contours and discussion of relevant influences. Expected ground vibration levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns and human perception. Tables are provided for each of the different charge models done with regards to:

- "Tag" No. is the number corresponding to the POI figures;
- "Description" indicates the type of the structure;
- "Distance" is the distance between the structure and edge of the pit area;

- "Specific Limit" is the maximum limit for ground vibration at the specific structure or installation;
- "Predicted PPV (mm/s)" is the calculated ground vibration at the structure;
- The "Structure Response @ 10Hz and Human Tolerance @ 30Hz" indicates the possible concern and if there is any concern for structural damage or potential negative human perception respectively. Indicators used are "perceptible"," unpleasant", "intolerable" which stems from the human perception information given and indicators such as "high" or "low" is given for the possibility of damage to a structure. Levels below 0.76 mm/s could be considered to have negligible possibility of influence.

Ground vibration is calculated and modelled for the pit area at the minimum and maximum charge mass at specific distances from the opencast mining area. The charge masses applied are according to blast designs discussed in Section 15. These levels are then plotted and overlaid with current mining plans to observe possible influences at structures identified. Structures or POI's for consideration are also plotted in this model. Ground vibration predictions were done considering distances ranging from 50 m to 3500 m around the opencast mining area.

The simulation provided shows ground vibration contours only for a limited number of levels. The levels used are considered the basic limits that will be applicable for the type of structures observed surrounding the pit area. These levels are: 6 mm/s, 12.5 mm/s, 25 mm/s and 50 mm/s. This enables immediate review of possible concerns that may be applicable to any of the privately-owned structures, social gathering areas or sensitive installations.

Data is provided as follows: Vibration contours; a table with predicted ground vibration values and evaluation for each POI. Additional colour codes used in the tables are as follows:

| |
|---|
| Structure Evaluations: |
| Vibration levels higher than proposed limit applicable to Structures / Installations is coloured "Red" |
| People's Perception Evaluation: |
| Vibration levels indicated as Intolerable on human perception scale is coloured "Red" |
| Vibration levels indicated as Unpleasant on human perception scale is coloured "Mustard" |
| Vibration levels indicated as Perceptible on human perception scale is coloured "Light Green" |
| POI's that are found inside the pit area is coloured "Olive Green" |

Simulations for expected ground vibration levels from minimum and maximum charge mass are presented below.

- ***Minimum charge mass per delay – 751 kg***

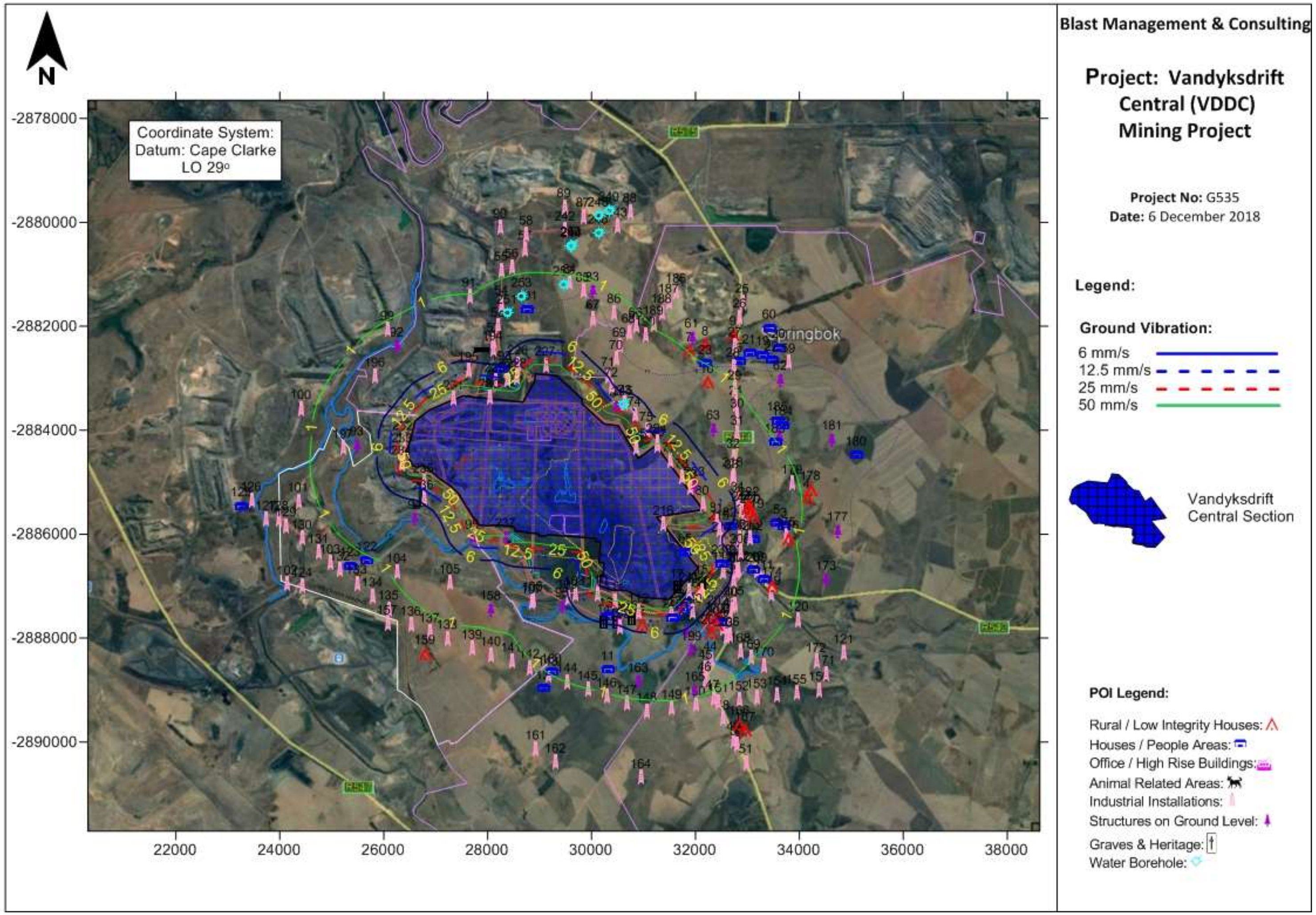



Figure 14: Ground vibration influence from minimum charge per delay (751 kg) for Pit Area

Table 12: Ground vibration evaluation for minimum charge for Pit Area

| Tag | Description | Specific Limit (mm/s) | Distance (m) | Total Mass/Delay (kg) | Predicted PPV (mm/s) | Structure Response @ 10Hz | Human Tolerance @ 30Hz |
|---|---|---|---|---|---|---|---|
| 1 | Informal Settlement (Lindokhule) | 6 | 842 | 751 | 4.0 | Acceptable | Perceptible |
| 2 | Ruins | 6 | 517 | 751 | 9.0 | Problematic | Unpleasant |
| 3 | School (Springbok) | 25 | 1641 | 751 | 1.3 | Acceptable | Perceptible |
| 4 | Informal Housing | 6 | 2067 | 751 | 0.9 | Acceptable | Perceptible |
| 5 | Buildings/Structures | 12.5 | 1495 | 751 | 1.6 | Acceptable | Perceptible |
| 6 | Springbok Mining Town Houses | 12.5 | 2374 | 751 | 0.7 | Acceptable | Too Low |
| 7 | Informal Settlement (Kwajuma) | 6 | 1989 | 751 | 1.0 | Acceptable | Perceptible |
| 8 | Informal Settlement (Kwajuma) | 6 | 2283 | 751 | 0.8 | Acceptable | Perceptible |
| 9 | Informal Settlement (Kwajuma) | 6 | 2716 | 751 | 0.6 | Acceptable | Too Low |
| 10 | Informal Housing | 6 | 1669 | 751 | 1.3 | Acceptable | Perceptible |
| 11 | Building/Structure | 12.5 | 1528 | 751 | 1.5 | Acceptable | Perceptible |
| 12 | Farm Buildings/Structures | 12.5 | 2263 | 751 | 0.8 | Acceptable | Perceptible |
| 13 | Buildings/Structures | 12.5 | 512 | 751 | 9.1 | Acceptable | Unpleasant |
| 14 | Heritage Site (Pump Station) | 50 | 637 | 751 | 6.4 | Acceptable | N/A |
| 15 | Heritage Site (Railway Station) | 25 | 257 | 751 | 28.4 | Problematic | N/A |
| 16 | Heritage Site (Graveyard) | 50 | 453 | 751 | 11.2 | Acceptable | N/A |
| 17 | Heritage Site (Graveyard) - Inside Pit Area | 50 | - | 751 | - | - | - |
| 18 | Heritage Site (Pump Station) | 50 | 628 | 751 | 6.5 | Acceptable | N/A |
| 19 | Springbok Mining Town Buildings | 12.5 | 2782 | 751 | 0.6 | Acceptable | Too Low |
| 20 | Springbok Mining Town Church | 12.5 | 3097 | 751 | 0.5 | Acceptable | Too Low |
| 21 | Springbok Mining Town Houses | 12.5 | 2620 | 751 | 0.6 | Acceptable | Too Low |
| 22 | Springbok Mining Town Houses | 12.5 | 2840 | 751 | 0.5 | Acceptable | Too Low |
| 23 | Buildings/Structures | 12.5 | 1958 | 751 | 1.0 | Acceptable | Perceptible |
| 24 | Communication Tower | 25 | 1780 | 751 | 1.2 | Acceptable | N/A |
| 25 | Pipeline | 50 | 3341 | 751 | 0.4 | Acceptable | N/A |
| 26 | Pipeline | 50 | 3067 | 751 | 0.5 | Acceptable | N/A |
| 27 | Pipeline | 50 | 2559 | 751 | 0.6 | Acceptable | N/A |
| 28 | Pipeline | 50 | 2222 | 751 | 0.8 | Acceptable | N/A |
| 29 | Pipeline | 50 | 1945 | 751 | 1.0 | Acceptable | N/A |
| 30 | Pipeline | 50 | 1651 | 751 | 1.3 | Acceptable | N/A |
| 31 | Pipeline | 50 | 1452 | 751 | 1.6 | Acceptable | N/A |
| 32 | Pipeline | 50 | 1119 | 751 | 2.5 | Acceptable | N/A |
| 33 | Pipeline | 50 | 847 | 751 | 4.0 | Acceptable | N/A |
| 34 | Pipeline | 50 | 741 | 751 | 5.0 | Acceptable | N/A |
| 35 | Pipeline | 50 | 873 | 751 | 3.8 | Acceptable | N/A |
| 36 | Pipeline | 50 | 930 | 751 | 3.4 | Acceptable | N/A |
| 37 | Pipeline | 50 | 762 | 751 | 4.7 | Acceptable | N/A |
| 38 | Pipeline | 50 | 746 | 751 | 4.9 | Acceptable | N/A |
| 39 | Pipeline | 50 | 753 | 751 | 4.8 | Acceptable | N/A |
| 40 | Pipeline | 50 | 970 | 751 | 3.2 | Acceptable | N/A |
| 41 | Pipeline | 50 | 1099 | 751 | 2.6 | Acceptable | N/A |
| 42 | Pipeline | 50 | 1147 | 751 | 2.4 | Acceptable | N/A |
| 43 | Pipeline | 50 | 1293 | 751 | 2.0 | Acceptable | N/A |
| 44 | Pipeline | 50 | 1425 | 751 | 1.7 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 45 | Pipeline | 50 | 1508 | 751 | 1.5 | Acceptable | N/A |
| 46 | Pipeline | 50 | 1714 | 751 | 1.2 | Acceptable | N/A |
| 47 | Pipeline | 50 | 2092 | 751 | 0.9 | Acceptable | N/A |
| 48 | Pipeline | 50 | 2532 | 751 | 0.7 | Acceptable | N/A |
| 49 | Pipeline | 50 | 2989 | 751 | 0.5 | Acceptable | N/A |
| 50 | Pipeline | 50 | 3089 | 751 | 0.5 | Acceptable | N/A |
| 51 | Pipeline | 50 | 3478 | 751 | 0.4 | Acceptable | N/A |
| 52 | Pipeline | 50 | 1028 | 751 | 2.9 | Acceptable | N/A |
| 53 | Pipeline | 50 | 1175 | 751 | 2.3 | Acceptable | N/A |
| 54 | Pipeline | 50 | 1499 | 751 | 1.5 | Acceptable | N/A |
| 55 | Pipeline | 50 | 2111 | 751 | 0.9 | Acceptable | N/A |
| 56 | Pipeline | 50 | 2111 | 751 | 0.9 | Acceptable | N/A |
| 57 | Pipeline | 50 | 2412 | 751 | 0.7 | Acceptable | N/A |
| 58 | Pipeline | 50 | 2700 | 751 | 0.6 | Acceptable | N/A |
| 59 | Reservoirs | 50 | 3075 | 751 | 0.5 | Acceptable | N/A |
| 60 | Buildings/Structures | 12.5 | 3243 | 751 | 0.4 | Acceptable | Too Low |
| 61 | Cultivated Fields | 200 | 2220 | 751 | 0.8 | Acceptable | N/A |
| 62 | Cultivated Fields | 200 | 2748 | 751 | 0.6 | Acceptable | N/A |
| 63 | Cultivated Fields | 200 | 1146 | 751 | 2.4 | Acceptable | N/A |
| 64 | Cultivated Fields | 200 | 363 | 751 | 16.1 | Acceptable | N/A |
| 65 | Buildings/Structures (Inside Pit Area) | 12.5 | - | 751 | - | - | - |
| 66 | Power Station | 50 | 1735 | 751 | 1.2 | Acceptable | N/A |
| 67 | Cement Dam | 50 | 1310 | 751 | 1.9 | Acceptable | N/A |
| 68 | Power lines/Pylons | 75 | 1555 | 751 | 1.5 | Acceptable | N/A |
| 69 | Power lines/Pylons | 75 | 1240 | 751 | 2.1 | Acceptable | N/A |
| 70 | Power lines/Pylons | 75 | 1023 | 751 | 2.9 | Acceptable | N/A |
| 71 | Power lines/Pylons | 75 | 677 | 751 | 5.8 | Acceptable | N/A |
| 72 | Power lines/Pylons | 75 | 629 | 751 | 6.5 | Acceptable | N/A |
| 73 | Power lines/Pylons | 75 | 448 | 751 | 11.4 | Acceptable | N/A |
| 74 | Power lines/Pylons | 75 | 375 | 751 | 15.2 | Acceptable | N/A |
| 75 | Power lines/Pylons | 75 | 455 | 751 | 11.1 | Acceptable | N/A |
| 76 | Power lines/Pylons | 75 | 142 | 751 | 75.4 | Problematic | N/A |
| 77 | Power lines/Pylons | 75 | 101 | 751 | 133.4 | Problematic | N/A |
| 78 | Power lines/Pylons | 75 | 100 | 751 | 135.1 | Problematic | N/A |
| 79 | Power lines/Pylons | 75 | 103 | 751 | 129.5 | Problematic | N/A |
| 80 | Power lines/Pylons | 75 | 100 | 751 | 134.7 | Problematic | N/A |
| 81 | Power lines/Pylons | 75 | 386 | 751 | 14.5 | Acceptable | N/A |
| 82 | Buildings/Structures | 12.5 | 651 | 751 | 6.1 | Acceptable | Unpleasant |
| 83 | Cultivated Fields | 200 | 1784 | 751 | 1.2 | Acceptable | N/A |
| 84 | Power lines/Pylons | 75 | 1833 | 751 | 1.1 | Acceptable | N/A |
| 85 | Power lines/Pylons | 75 | 1726 | 751 | 1.2 | Acceptable | N/A |
| 86 | Power lines/Pylons | 75 | 1677 | 751 | 1.3 | Acceptable | N/A |
| 87 | Dam | 50 | 3113 | 751 | 0.5 | Acceptable | N/A |
| 88 | Mine Activity | 200 | 3461 | 751 | 0.4 | Acceptable | N/A |
| 89 | Dam | 50 | 3250 | 751 | 0.4 | Acceptable | N/A |
| 90 | Mine Buildings/Structures | 25 | 2912 | 751 | 0.5 | Acceptable | N/A |
| 91 | Mine Activity | 200 | 1919 | 751 | 1.0 | Acceptable | N/A |
| 92 | Olifants River | 200 | 1435 | 751 | 1.7 | Acceptable | N/A |
| 93 | Olifants River | 200 | 1066 | 751 | 2.7 | Acceptable | N/A |
| 94 | Olifants River | 200 | 976 | 751 | 3.1 | Acceptable | N/A |
| 95 | Olifants River | 200 | 290 | 751 | 23.3 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 96 | Olifants River | 200 | 838 | 751 | 4.0 | Acceptable | N/A |
| 97 | Olifants River | 200 | 611 | 751 | 6.8 | Acceptable | N/A |
| 98 | Olifants River | 200 | 683 | 751 | 5.7 | Acceptable | N/A |
| 99 | Dam | 50 | 1794 | 751 | 1.2 | Acceptable | N/A |
| 100 | Mine Activity | 200 | 2220 | 751 | 0.8 | Acceptable | N/A |
| 101 | Dam | 50 | 2303 | 751 | 0.8 | Acceptable | N/A |
| 102 | Railway Line | 150 | 3330 | 751 | 0.4 | Acceptable | N/A |
| 103 | Railway Line | 150 | 2468 | 751 | 0.7 | Acceptable | N/A |
| 104 | Railway Line | 150 | 1817 | 751 | 1.1 | Acceptable | N/A |
| 105 | Railway Line | 150 | 1253 | 751 | 2.1 | Acceptable | N/A |
| 106 | Railway Line/Bridge | 50 | 1284 | 751 | 2.0 | Acceptable | N/A |
| 107 | Dam/Bridge | 50 | 1334 | 751 | 1.9 | Acceptable | N/A |
| 108 | Railway Line | 150 | 527 | 751 | 8.7 | Acceptable | N/A |
| 109 | Power Station | 50 | 681 | 751 | 5.7 | Acceptable | N/A |
| 110 | Railway Line | 150 | 160 | 751 | 62.1 | Acceptable | N/A |
| 111 | Railway Line/Bridge | 50 | 208 | 751 | 40.3 | Acceptable | N/A |
| 112 | Railway Line | 150 | 284 | 751 | 24.1 | Acceptable | N/A |
| 113 | Railway Line | 150 | 296 | 751 | 22.5 | Acceptable | N/A |
| 114 | Railway Line | 150 | 353 | 751 | 16.9 | Acceptable | N/A |
| 115 | Buildings/Structures | 12.5 | 249 | 751 | 30.0 | Problematic | Intolerable |
| 116 | Railway Station Buildings | 25 | 376 | 751 | 15.2 | Acceptable | N/A |
| 117 | Railway Line | 150 | 495 | 751 | 9.7 | Acceptable | N/A |
| 118 | Railway Line/Bridge | 50 | 775 | 751 | 4.6 | Acceptable | N/A |
| 119 | Railway Line | 150 | 1495 | 751 | 1.6 | Acceptable | N/A |
| 120 | Railway Line | 150 | 2181 | 751 | 0.8 | Acceptable | N/A |
| 121 | Railway Line | 150 | 3253 | 751 | 0.4 | Acceptable | N/A |
| 122 | Buildings/Structures | 12.5 | 2036 | 751 | 0.9 | Acceptable | Perceptible |
| 123 | Building/Structure | 12.5 | 2286 | 751 | 0.8 | Acceptable | Perceptible |
| 124 | Dam | 50 | 3161 | 751 | 0.5 | Acceptable | N/A |
| 125 | Building/Structure | 12.5 | 3375 | 751 | 0.4 | Acceptable | Too Low |
| 126 | Cement Dam | 50 | 3164 | 751 | 0.5 | Acceptable | N/A |
| 127 | Power lines/Pylons | 75 | 3001 | 751 | 0.5 | Acceptable | N/A |
| 128 | Power lines/Pylons | 75 | 2782 | 751 | 0.6 | Acceptable | N/A |
| 129 | Power lines/Pylons | 75 | 2699 | 751 | 0.6 | Acceptable | N/A |
| 130 | Power lines/Pylons | 75 | 2560 | 751 | 0.6 | Acceptable | N/A |
| 131 | Power lines/Pylons | 75 | 2472 | 751 | 0.7 | Acceptable | N/A |
| 132 | Power lines/Pylons | 75 | 2459 | 751 | 0.7 | Acceptable | N/A |
| 133 | Power lines/Pylons | 75 | 2528 | 751 | 0.7 | Acceptable | N/A |
| 134 | Power lines/Pylons | 75 | 2463 | 751 | 0.7 | Acceptable | N/A |
| 135 | Power lines/Pylons | 75 | 2380 | 751 | 0.7 | Acceptable | N/A |
| 136 | Power lines/Pylons | 75 | 2333 | 751 | 0.7 | Acceptable | N/A |
| 137 | Power lines/Pylons | 75 | 2267 | 751 | 0.8 | Acceptable | N/A |
| 138 | Power lines/Pylons | 75 | 2268 | 751 | 0.8 | Acceptable | N/A |
| 139 | Power lines/Pylons | 75 | 2373 | 751 | 0.7 | Acceptable | N/A |
| 140 | Power lines/Pylons | 75 | 2423 | 751 | 0.7 | Acceptable | N/A |
| 141 | Power lines/Pylons | 75 | 2248 | 751 | 0.8 | Acceptable | N/A |
| 142 | Power lines/Pylons | 75 | 2081 | 751 | 0.9 | Acceptable | N/A |
| 143 | Power lines/Pylons | 75 | 1984 | 751 | 1.0 | Acceptable | N/A |
| 144 | Power lines/Pylons | 75 | 1944 | 751 | 1.0 | Acceptable | N/A |
| 145 | Power lines/Pylons | 75 | 1964 | 751 | 1.0 | Acceptable | N/A |
| 146 | Power lines/Pylons | 75 | 2013 | 751 | 1.0 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 147 | Power lines/Pylons | 75 | 2061 | 751 | 0.9 | Acceptable | N/A |
| 148 | Power lines/Pylons | 75 | 2173 | 751 | 0.8 | Acceptable | N/A |
| 149 | Power lines/Pylons | 75 | 2095 | 751 | 0.9 | Acceptable | N/A |
| 150 | Power lines/Pylons | 75 | 2101 | 751 | 0.9 | Acceptable | N/A |
| 151 | Power lines/Pylons | 75 | 2194 | 751 | 0.8 | Acceptable | N/A |
| 152 | Power lines/Pylons | 75 | 2355 | 751 | 0.7 | Acceptable | N/A |
| 153 | Power lines/Pylons | 75 | 2536 | 751 | 0.7 | Acceptable | N/A |
| 154 | Power lines/Pylons | 75 | 2779 | 751 | 0.6 | Acceptable | N/A |
| 155 | Power lines/Pylons | 75 | 3030 | 751 | 0.5 | Acceptable | N/A |
| 156 | Power lines/Pylons | 75 | 3311 | 751 | 0.4 | Acceptable | N/A |
| 157 | Mine Activity | 200 | 2596 | 751 | 0.6 | Acceptable | N/A |
| 158 | Cultivated Fields | 200 | 1572 | 751 | 1.4 | Acceptable | N/A |
| 159 | Informal Houses | 6 | 2685 | 751 | 0.6 | Acceptable | Too Low |
| 160 | Buildings/Structures | 12.5 | 1904 | 751 | 1.0 | Acceptable | Perceptible |
| 161 | Cement Dam | 50 | 3364 | 751 | 0.4 | Acceptable | N/A |
| 162 | Cement Dam | 50 | 3477 | 751 | 0.4 | Acceptable | N/A |
| 163 | Pan | 200 | 1616 | 751 | 1.4 | Acceptable | N/A |
| 164 | Dam | 50 | 3455 | 751 | 0.4 | Acceptable | N/A |
| 165 | Cultivated Fields | 200 | 1822 | 751 | 1.1 | Acceptable | N/A |
| 166 | Informal Houses | 6 | 2766 | 751 | 0.6 | Acceptable | Too Low |
| 167 | Informal Houses | 6 | 2922 | 751 | 0.5 | Acceptable | Too Low |
| 168 | Power lines/Pylons | 75 | 1695 | 751 | 1.3 | Acceptable | N/A |
| 169 | Power lines/Pylons | 75 | 1916 | 751 | 1.0 | Acceptable | N/A |
| 170 | Power lines/Pylons | 75 | 2215 | 751 | 0.8 | Acceptable | N/A |
| 171 | Conveyor | 150 | 3188 | 751 | 0.4 | Acceptable | N/A |
| 172 | Dam | 50 | 2904 | 751 | 0.5 | Acceptable | N/A |
| 173 | Cultivated Fields | 200 | 2490 | 751 | 0.7 | Acceptable | N/A |
| 174 | Informal Housing | 6 | 1480 | 751 | 1.6 | Acceptable | Perceptible |
| 175 | Reservoirs | 50 | 1719 | 751 | 1.2 | Acceptable | N/A |
| 176 | Ruins | 6 | 1798 | 751 | 1.1 | Acceptable | Perceptible |
| 177 | Cultivated Fields | 200 | 2677 | 751 | 0.6 | Acceptable | N/A |
| 178 | Informal Housing | 6 | 2154 | 751 | 0.9 | Acceptable | Perceptible |
| 179 | Dam | 50 | 1837 | 751 | 1.1 | Acceptable | N/A |
| 180 | Structure | 12.5 | 3181 | 751 | 0.4 | Acceptable | Too Low |
| 181 | Cultivated Fields | 200 | 2880 | 751 | 0.5 | Acceptable | N/A |
| 182 | Cultivated Fields | 200 | 2075 | 751 | 0.9 | Acceptable | N/A |
| 183 | Structure | 12.5 | 1934 | 751 | 1.0 | Acceptable | Perceptible |
| 184 | Structure | 12.5 | 2249 | 751 | 0.8 | Acceptable | Perceptible |
| 185 | Structure | 12.5 | 2222 | 751 | 0.8 | Acceptable | Perceptible |
| 186 | Power lines/Pylons | 75 | 2750 | 751 | 0.6 | Acceptable | N/A |
| 187 | Power lines/Pylons | 75 | 2508 | 751 | 0.7 | Acceptable | N/A |
| 188 | Power lines/Pylons | 75 | 2269 | 751 | 0.8 | Acceptable | N/A |
| 189 | Power lines/Pylons | 75 | 1995 | 751 | 1.0 | Acceptable | N/A |
| 190 | Power lines/Pylons | 75 | 1741 | 751 | 1.2 | Acceptable | N/A |
| 191 | Structure | 12.5 | 1261 | 751 | 2.1 | Acceptable | Perceptible |
| 192 | Dam | 50 | 397 | 751 | 13.9 | Acceptable | N/A |
| 193 | Structure | 12.5 | 586 | 751 | 7.3 | Acceptable | Unpleasant |
| 194 | Conveyor | 150 | 951 | 751 | 3.3 | Acceptable | N/A |
| 195 | Dam | 50 | 499 | 751 | 9.5 | Acceptable | N/A |
| 196 | Mine Buildings/Structures | 25 | 1295 | 751 | 2.0 | Acceptable | N/A |
| 197 | Dam | 50 | 1329 | 751 | 1.9 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 198 | Dam | 50 | 689 | 751 | 5.6 | Acceptable | N/A |
| 199 | Pan | 200 | 1068 | 751 | 2.7 | Acceptable | N/A |
| 200 | Dam | 50 | 501 | 751 | 9.4 | Acceptable | N/A |
| 201 | Informal Settlement (Lindokhule) | 6 | 1051 | 751 | 2.8 | Acceptable | Perceptible |
| 202 | Informal Settlement (Lindokhule) | 6 | 882 | 751 | 3.7 | Acceptable | Perceptible |
| 203 | Shopping Centre (Lindokhule) | 50 | 1028 | 751 | 2.9 | Acceptable | Perceptible |
| 204 | Informal Settlement (Lindokhule) | 6 | 1002 | 751 | 3.0 | Acceptable | Perceptible |
| 205 | R544 Road | 150 | 992 | 751 | 3.1 | Acceptable | N/A |
| 206 | R544 Road | 150 | 1328 | 751 | 1.9 | Acceptable | N/A |
| 207 | R544 Road | 150 | 772 | 751 | 4.6 | Acceptable | N/A |
| 208 | R542 Road | 150 | 875 | 751 | 3.8 | Acceptable | N/A |
| 209 | R542 Road | 150 | 1153 | 751 | 2.4 | Acceptable | N/A |
| 210 | Shopping Centre | 50 | 1087 | 751 | 2.6 | Acceptable | Perceptible |
| 211 | Buildings/Structures | 12.5 | 1289 | 751 | 2.0 | Acceptable | Perceptible |
| 212 | Buildings/Structures | 12.5 | 1164 | 751 | 2.4 | Acceptable | Perceptible |
| 213 | Reservoir | 50 | 1104 | 751 | 2.6 | Acceptable | N/A |
| 214 | Dam | 50 | 692 | 751 | 5.5 | Acceptable | N/A |
| 215 | Road | 150 | 529 | 751 | 8.7 | Acceptable | N/A |
| 216 | Road | 150 | 25 | 751 | 1289.3 | Problematic | N/A |
| 217 | R544 Road | 150 | 804 | 751 | 4.3 | Acceptable | N/A |
| 218 | R544 Road | 150 | 894 | 751 | 3.6 | Acceptable | N/A |
| 219 | Informal Housing | 6 | 1040 | 751 | 2.8 | Acceptable | Perceptible |
| 220 | Informal Housing | 6 | 964 | 751 | 3.2 | Acceptable | Perceptible |
| 221 | Informal Housing | 6 | 903 | 751 | 3.6 | Acceptable | Perceptible |
| 222 | Informal Housing | 6 | 941 | 751 | 3.3 | Acceptable | Perceptible |
| 223 | Cultivated Fields | 200 | 202 | 751 | 42.2 | Acceptable | N/A |
| 224 | Dam | 50 | 202 | 751 | 42.3 | Acceptable | N/A |
| 225 | Dam | 50 | 174 | 751 | 54.3 | Problematic | N/A |
| 226 | Mine Buildings/Structures | 25 | 388 | 751 | 14.4 | Acceptable | N/A |
| 227 | Mine Activity | 200 | 183 | 751 | 49.8 | Acceptable | N/A |
| 228 | Mine Buildings/Structures | 25 | 337 | 751 | 18.2 | Acceptable | N/A |
| 229 | Dam | 50 | 351 | 751 | 17.0 | Acceptable | N/A |
| 230 | Mine Buildings/Structures | 25 | 24 | 751 | 1427.3 | Problematic | N/A |
| 231 | Dam | 50 | 23 | 751 | 1570.9 | Problematic | N/A |
| 232 | Dam | 50 | 192 | 751 | 46.1 | Acceptable | N/A |
| 233 | Dam | 50 | 188 | 751 | 47.5 | Acceptable | N/A |
| 234 | Dam | 50 | 192 | 751 | 45.9 | Acceptable | N/A |
| 235 | Dam | 50 | 300 | 751 | 22.1 | Acceptable | N/A |
| 236 | Dam | 50 | 567 | 751 | 7.7 | Acceptable | N/A |
| 237 | Pan | 200 | 208 | 751 | 40.4 | Acceptable | N/A |
| 238 | Building/Structure | 12.5 | 484 | 751 | 10.0 | Acceptable | Unpleasant |
| 239 | Building/Structure | 12.5 | 287 | 751 | 23.7 | Problematic | Intolerable |
| 240 | Building/Structure | 12.5 | 366 | 751 | 15.9 | Problematic | Unpleasant |
| 241 | Cement Dam | 50 | 182 | 751 | 50.3 | Problematic | N/A |
| 242 | Pipeline | 50 | 2812 | 751 | 0.5 | Acceptable | N/A |
| 243 | Pipeline | 50 | 3111 | 751 | 0.5 | Acceptable | N/A |
| 244 | Borehole (WBH 2S1) | 50 | 2512 | 751 | 0.7 | Acceptable | N/A |
| 245 | Borehole (WBH 2S8) | 50 | 417 | 751 | 12.8 | Acceptable | N/A |
| 246 | Borehole (SKS BH2) | 50 | 2864 | 751 | 0.5 | Acceptable | N/A |
| 247 | Borehole (VLKR 3) | 50 | 2521 | 751 | 0.7 | Acceptable | N/A |
| 248 | Borehole (WVK 1) | 50 | 3185 | 751 | 0.4 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 249 | Borehole (WVK 2) | 50 | 3338 | 751 | 0.4 | Acceptable | N/A |
| 250 | Borehole (WVK 3) | 50 | 2521 | 751 | 0.7 | Acceptable | N/A |
| 251 | Borehole (NDB 2) | 50 | 1302 | 751 | 2.0 | Acceptable | N/A |
| 252 | Borehole (NDB 3) | 50 | 1761 | 751 | 1.2 | Acceptable | N/A |
| 253 | Borehole (NDB 6) | 50 | 1521 | 751 | 1.5 | Acceptable | N/A |
| 254 | Power lines/Pylons | 75 | 2469 | 751 | 0.7 | Acceptable | N/A |
| 255 | Power lines/Pylons | 75 | 385 | 751 | 14.6 | Acceptable | N/A |
| 256 | Power lines/Pylons | 75 | 191 | 751 | 46.3 | Acceptable | N/A |
| 257 | Power lines/Pylons (Inside Pit Area) | 75 | - | 751 | - | - | - |
| 258 | Power lines/Pylons (Inside Pit Area) | 75 | - | 751 | - | - | - |
| 259 | Power lines/Pylons (Inside Pit Area) | 75 | - | 751 | - | - | - |
| 260 | Power lines/Pylons (Inside Pit Area) | 75 | - | 751 | - | - | - |
| 261 | Power lines/Pylons (Inside Pit Area) | 75 | - | 751 | - | - | - |
| 262 | Power lines/Pylons (Inside Pit Area) | 75 | - | 751 | - | - | - |
| 263 | Power lines/Pylons (Inside Pit Area) | 75 | - | 751 | - | - | - |
| 264 | Power Station (Inside Pit Area) | 50 | - | 751 | - | - | - |
| 265 | Power lines/Pylons | 75 | 118 | 751 | 102.6 | Problematic | N/A |
| 266 | Power lines/Pylons | 75 | 214 | 751 | 38.6 | Acceptable | N/A |
| 267 | Power lines/Pylons | 75 | 474 | 751 | 10.4 | Acceptable | N/A |
| 268 | Power lines/Pylons | 75 | 670 | 751 | 5.9 | Acceptable | N/A |
| 269 | Power lines/Pylons | 75 | 230 | 751 | 34.2 | Acceptable | N/A |
| 270 | Power lines/Pylons | 75 | 603 | 751 | 7.0 | Acceptable | N/A |
| 271 | Power lines/Pylons | 75 | 871 | 751 | 3.8 | Acceptable | N/A |
| 272 | Power lines/Pylons | 75 | 860 | 751 | 3.9 | Acceptable | N/A |
| 273 | Power lines/Pylons | 75 | 1137 | 751 | 2.4 | Acceptable | N/A |
| 274 | Power lines/Pylons | 75 | 1332 | 751 | 1.9 | Acceptable | N/A |
| 275 | Power lines/Pylons | 75 | 900 | 751 | 3.6 | Acceptable | N/A |
| 276 | Power lines/Pylons | 75 | 1216 | 751 | 2.2 | Acceptable | N/A |
| 277 | Power lines/Pylons | 75 | 1636 | 751 | 1.3 | Acceptable | N/A |
| 278 | Power lines/Pylons | 75 | 149 | 751 | 69.8 | Acceptable | N/A |
| 279 | Power lines/Pylons | 75 | 212 | 751 | 39.0 | Acceptable | N/A |
| 280 | Power lines/Pylons | 75 | 632 | 751 | 6.5 | Acceptable | N/A |

- **Maximum charge mass per delay - 3756 kg**

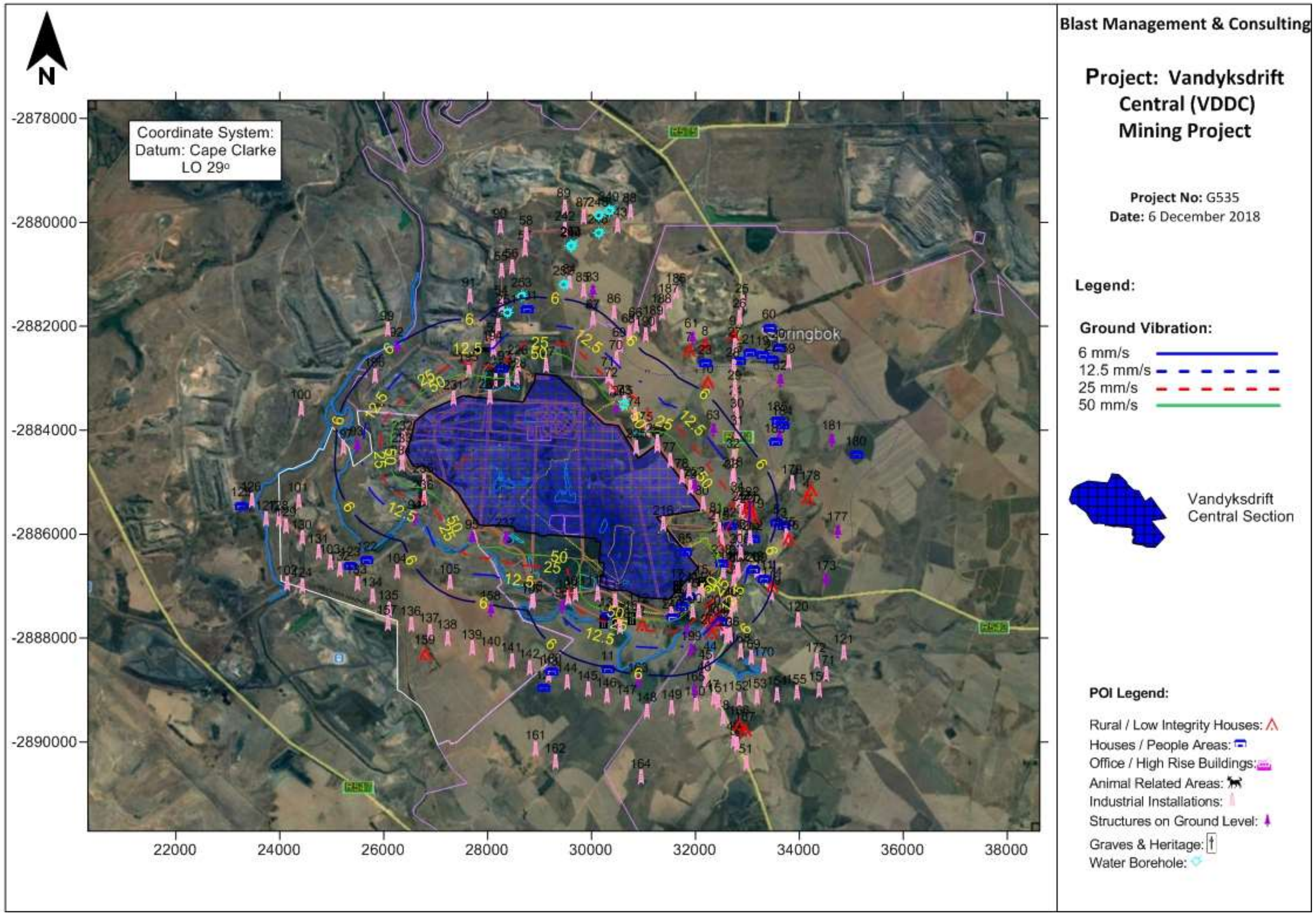



Figure 15: Ground vibration influence from maximum charge for Pit Area

Table 13: Ground vibration evaluation for maximum charge for Pit

| Tag | Description | Specific Limit (mm/s) | Distance (m) | Total Mass/Delay (kg) | Predicted PPV (mm/s) | Structure Response @ 10Hz | Human Tolerance @ 30Hz |
|---|---|---|---|---|---|---|---|
| 1 | Informal Settlement (Lindokhule) | 6 | 842 | 3756 | 15.2 | Problematic | Unpleasant |
| 2 | Ruins | 6 | 517 | 3756 | 33.9 | Problematic | Intolerable |
| 3 | School (Springbok) | 25 | 1641 | 3756 | 5.0 | Acceptable | Perceptible |
| 4 | Informal Housing | 6 | 2067 | 3756 | 3.4 | Acceptable | Perceptible |
| 5 | Buildings/Structures | 12.5 | 1495 | 3756 | 5.9 | Acceptable | Unpleasant |
| 6 | Springbok Mining Town Houses | 12.5 | 2374 | 3756 | 2.7 | Acceptable | Perceptible |
| 7 | Informal Settlement (Kwajuma) | 6 | 1989 | 3756 | 3.7 | Acceptable | Perceptible |
| 8 | Informal Settlement (Kwajuma) | 6 | 2283 | 3756 | 2.9 | Acceptable | Perceptible |
| 9 | Informal Settlement (Kwajuma) | 6 | 2716 | 3756 | 2.2 | Acceptable | Perceptible |
| 10 | Informal Housing | 6 | 1669 | 3756 | 4.9 | Acceptable | Perceptible |
| 11 | Building/Structure | 12.5 | 1528 | 3756 | 5.7 | Acceptable | Unpleasant |
| 12 | Farm Buildings/Structures | 12.5 | 2263 | 3756 | 3.0 | Acceptable | Perceptible |
| 13 | Buildings/Structures | 12.5 | 512 | 3756 | 34.5 | Problematic | Intolerable |
| 14 | Heritage Site (Pump Station) | 50 | 637 | 3756 | 24.0 | Acceptable | N/A |
| 15 | Heritage Site (Railway Station) | 25 | 257 | 3756 | 107.3 | Problematic | N/A |
| 16 | Heritage Site (Graveyard) | 50 | 453 | 3756 | 42.1 | Acceptable | N/A |
| 17 | Heritage Site (Graveyard) - Inside Pit Area | 50 | - | 3756 | - | - | - |
| 18 | Heritage Site (Pump Station) | 50 | 628 | 3756 | 24.6 | Acceptable | N/A |
| 19 | Springbok Mining Town Buildings | 12.5 | 2782 | 3756 | 2.1 | Acceptable | Perceptible |
| 20 | Springbok Mining Town Church | 12.5 | 3097 | 3756 | 1.8 | Acceptable | Perceptible |
| 21 | Springbok Mining Town Houses | 12.5 | 2620 | 3756 | 2.3 | Acceptable | Perceptible |
| 22 | Springbok Mining Town Houses | 12.5 | 2840 | 3756 | 2.0 | Acceptable | Perceptible |
| 23 | Buildings/Structures | 12.5 | 1958 | 3756 | 3.8 | Acceptable | Perceptible |
| 24 | Communication Tower | 25 | 1780 | 3756 | 4.4 | Acceptable | N/A |
| 25 | Pipeline | 50 | 3341 | 3756 | 1.6 | Acceptable | N/A |
| 26 | Pipeline | 50 | 3067 | 3756 | 1.8 | Acceptable | N/A |
| 27 | Pipeline | 50 | 2559 | 3756 | 2.4 | Acceptable | N/A |
| 28 | Pipeline | 50 | 2222 | 3756 | 3.1 | Acceptable | N/A |
| 29 | Pipeline | 50 | 1945 | 3756 | 3.8 | Acceptable | N/A |
| 30 | Pipeline | 50 | 1651 | 3756 | 5.0 | Acceptable | N/A |
| 31 | Pipeline | 50 | 1452 | 3756 | 6.2 | Acceptable | N/A |
| 32 | Pipeline | 50 | 1119 | 3756 | 9.5 | Acceptable | N/A |
| 33 | Pipeline | 50 | 847 | 3756 | 15.0 | Acceptable | N/A |
| 34 | Pipeline | 50 | 741 | 3756 | 18.7 | Acceptable | N/A |
| 35 | Pipeline | 50 | 873 | 3756 | 14.3 | Acceptable | N/A |
| 36 | Pipeline | 50 | 930 | 3756 | 12.9 | Acceptable | N/A |
| 37 | Pipeline | 50 | 762 | 3756 | 17.9 | Acceptable | N/A |
| 38 | Pipeline | 50 | 746 | 3756 | 18.5 | Acceptable | N/A |
| 39 | Pipeline | 50 | 753 | 3756 | 18.2 | Acceptable | N/A |
| 40 | Pipeline | 50 | 970 | 3756 | 12.0 | Acceptable | N/A |
| 41 | Pipeline | 50 | 1099 | 3756 | 9.8 | Acceptable | N/A |
| 42 | Pipeline | 50 | 1147 | 3756 | 9.1 | Acceptable | N/A |
| 43 | Pipeline | 50 | 1293 | 3756 | 7.5 | Acceptable | N/A |
| 44 | Pipeline | 50 | 1425 | 3756 | 6.4 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 45 | Pipeline | 50 | 1508 | 3756 | 5.8 | Acceptable | N/A |
| 46 | Pipeline | 50 | 1714 | 3756 | 4.7 | Acceptable | N/A |
| 47 | Pipeline | 50 | 2092 | 3756 | 3.4 | Acceptable | N/A |
| 48 | Pipeline | 50 | 2532 | 3756 | 2.5 | Acceptable | N/A |
| 49 | Pipeline | 50 | 2989 | 3756 | 1.9 | Acceptable | N/A |
| 50 | Pipeline | 50 | 3089 | 3756 | 1.8 | Acceptable | N/A |
| 51 | Pipeline | 50 | 3478 | 3756 | 1.5 | Acceptable | N/A |
| 52 | Pipeline | 50 | 1028 | 3756 | 10.9 | Acceptable | N/A |
| 53 | Pipeline | 50 | 1175 | 3756 | 8.7 | Acceptable | N/A |
| 54 | Pipeline | 50 | 1499 | 3756 | 5.8 | Acceptable | N/A |
| 55 | Pipeline | 50 | 2111 | 3756 | 3.3 | Acceptable | N/A |
| 56 | Pipeline | 50 | 2111 | 3756 | 3.3 | Acceptable | N/A |
| 57 | Pipeline | 50 | 2412 | 3756 | 2.7 | Acceptable | N/A |
| 58 | Pipeline | 50 | 2700 | 3756 | 2.2 | Acceptable | N/A |
| 59 | Reservoirs | 50 | 3075 | 3756 | 1.8 | Acceptable | N/A |
| 60 | Buildings/Structures | 12.5 | 3243 | 3756 | 1.6 | Acceptable | Perceptible |
| 61 | Cultivated Fields | 200 | 2220 | 3756 | 3.1 | Acceptable | N/A |
| 62 | Cultivated Fields | 200 | 2748 | 3756 | 2.2 | Acceptable | N/A |
| 63 | Cultivated Fields | 200 | 1146 | 3756 | 9.1 | Acceptable | N/A |
| 64 | Cultivated Fields | 200 | 363 | 3756 | 60.9 | Acceptable | N/A |
| 65 | Buildings/Structures (Inside Pit Area) | 12.5 | - | 3756 | - | - | - |
| 66 | Power Station | 50 | 1735 | 3756 | 4.6 | Acceptable | N/A |
| 67 | Cement Dam | 50 | 1310 | 3756 | 7.3 | Acceptable | N/A |
| 68 | Power lines/Pylons | 75 | 1555 | 3756 | 5.5 | Acceptable | N/A |
| 69 | Power lines/Pylons | 75 | 1240 | 3756 | 8.0 | Acceptable | N/A |
| 70 | Power lines/Pylons | 75 | 1023 | 3756 | 11.0 | Acceptable | N/A |
| 71 | Power lines/Pylons | 75 | 677 | 3756 | 21.7 | Acceptable | N/A |
| 72 | Power lines/Pylons | 75 | 629 | 3756 | 24.5 | Acceptable | N/A |
| 73 | Power lines/Pylons | 75 | 448 | 3756 | 43.0 | Acceptable | N/A |
| 74 | Power lines/Pylons | 75 | 375 | 3756 | 57.5 | Acceptable | N/A |
| 75 | Power lines/Pylons | 75 | 455 | 3756 | 41.9 | Acceptable | N/A |
| 76 | Power lines/Pylons | 75 | 142 | 3756 | 284.5 | Problematic | N/A |
| 77 | Power lines/Pylons | 75 | 101 | 3756 | 503.5 | Problematic | N/A |
| 78 | Power lines/Pylons | 75 | 100 | 3756 | 509.9 | Problematic | N/A |
| 79 | Power lines/Pylons | 75 | 103 | 3756 | 488.7 | Problematic | N/A |
| 80 | Power lines/Pylons | 75 | 100 | 3756 | 508.3 | Problematic | N/A |
| 81 | Power lines/Pylons | 75 | 386 | 3756 | 54.9 | Acceptable | N/A |
| 82 | Buildings/Structures | 12.5 | 651 | 3756 | 23.2 | Problematic | Intolerable |
| 83 | Cultivated Fields | 200 | 1784 | 3756 | 4.4 | Acceptable | N/A |
| 84 | Power lines/Pylons | 75 | 1833 | 3756 | 4.2 | Acceptable | N/A |
| 85 | Power lines/Pylons | 75 | 1726 | 3756 | 4.6 | Acceptable | N/A |
| 86 | Power lines/Pylons | 75 | 1677 | 3756 | 4.9 | Acceptable | N/A |
| 87 | Dam | 50 | 3113 | 3756 | 1.8 | Acceptable | N/A |
| 88 | Mine Activity | 200 | 3461 | 3756 | 1.5 | Acceptable | N/A |
| 89 | Dam | 50 | 3250 | 3756 | 1.6 | Acceptable | N/A |
| 90 | Mine Buildings/Structures | 25 | 2912 | 3756 | 2.0 | Acceptable | N/A |
| 91 | Mine Activity | 200 | 1919 | 3756 | 3.9 | Acceptable | N/A |
| 92 | Olifants River | 200 | 1435 | 3756 | 6.3 | Acceptable | N/A |
| 93 | Olifants River | 200 | 1066 | 3756 | 10.3 | Acceptable | N/A |
| 94 | Olifants River | 200 | 976 | 3756 | 11.9 | Acceptable | N/A |
| 95 | Olifants River | 200 | 290 | 3756 | 87.9 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 96 | Olifants River | 200 | 838 | 3756 | 15.3 | Acceptable | N/A |
| 97 | Olifants River | 200 | 611 | 3756 | 25.7 | Acceptable | N/A |
| 98 | Olifants River | 200 | 683 | 3756 | 21.4 | Acceptable | N/A |
| 99 | Dam | 50 | 1794 | 3756 | 4.3 | Acceptable | N/A |
| 100 | Mine Activity | 200 | 2220 | 3756 | 3.1 | Acceptable | N/A |
| 101 | Dam | 50 | 2303 | 3756 | 2.9 | Acceptable | N/A |
| 102 | Railway Line | 150 | 3330 | 3756 | 1.6 | Acceptable | N/A |
| 103 | Railway Line | 150 | 2468 | 3756 | 2.6 | Acceptable | N/A |
| 104 | Railway Line | 150 | 1817 | 3756 | 4.3 | Acceptable | N/A |
| 105 | Railway Line | 150 | 1253 | 3756 | 7.9 | Acceptable | N/A |
| 106 | Railway Line/Bridge | 50 | 1284 | 3756 | 7.6 | Acceptable | N/A |
| 107 | Dam/Bridge | 50 | 1334 | 3756 | 7.1 | Acceptable | N/A |
| 108 | Railway Line | 150 | 527 | 3756 | 32.9 | Acceptable | N/A |
| 109 | Power Station | 50 | 681 | 3756 | 21.5 | Acceptable | N/A |
| 110 | Railway Line | 150 | 160 | 3756 | 234.3 | Problematic | N/A |
| 111 | Railway Line/Bridge | 50 | 208 | 3756 | 152.1 | Problematic | N/A |
| 112 | Railway Line | 150 | 284 | 3756 | 91.1 | Acceptable | N/A |
| 113 | Railway Line | 150 | 296 | 3756 | 85.1 | Acceptable | N/A |
| 114 | Railway Line | 150 | 353 | 3756 | 63.6 | Acceptable | N/A |
| 115 | Buildings/Structures | 12.5 | 249 | 3756 | 113.1 | Problematic | Intolerable |
| 116 | Railway Station Buildings | 25 | 376 | 3756 | 57.4 | Problematic | N/A |
| 117 | Railway Line | 150 | 495 | 3756 | 36.5 | Acceptable | N/A |
| 118 | Railway Line/Bridge | 50 | 775 | 3756 | 17.4 | Acceptable | N/A |
| 119 | Railway Line | 150 | 1495 | 3756 | 5.9 | Acceptable | N/A |
| 120 | Railway Line | 150 | 2181 | 3756 | 3.2 | Acceptable | N/A |
| 121 | Railway Line | 150 | 3253 | 3756 | 1.6 | Acceptable | N/A |
| 122 | Buildings/Structures | 12.5 | 2036 | 3756 | 3.5 | Acceptable | Perceptible |
| 123 | Building/Structure | 12.5 | 2286 | 3756 | 2.9 | Acceptable | Perceptible |
| 124 | Dam | 50 | 3161 | 3756 | 1.7 | Acceptable | N/A |
| 125 | Building/Structure | 12.5 | 3375 | 3756 | 1.5 | Acceptable | Perceptible |
| 126 | Cement Dam | 50 | 3164 | 3756 | 1.7 | Acceptable | N/A |
| 127 | Power lines/Pylons | 75 | 3001 | 3756 | 1.9 | Acceptable | N/A |
| 128 | Power lines/Pylons | 75 | 2782 | 3756 | 2.1 | Acceptable | N/A |
| 129 | Power lines/Pylons | 75 | 2699 | 3756 | 2.2 | Acceptable | N/A |
| 130 | Power lines/Pylons | 75 | 2560 | 3756 | 2.4 | Acceptable | N/A |
| 131 | Power lines/Pylons | 75 | 2472 | 3756 | 2.6 | Acceptable | N/A |
| 132 | Power lines/Pylons | 75 | 2459 | 3756 | 2.6 | Acceptable | N/A |
| 133 | Power lines/Pylons | 75 | 2528 | 3756 | 2.5 | Acceptable | N/A |
| 134 | Power lines/Pylons | 75 | 2463 | 3756 | 2.6 | Acceptable | N/A |
| 135 | Power lines/Pylons | 75 | 2380 | 3756 | 2.7 | Acceptable | N/A |
| 136 | Power lines/Pylons | 75 | 2333 | 3756 | 2.8 | Acceptable | N/A |
| 137 | Power lines/Pylons | 75 | 2267 | 3756 | 3.0 | Acceptable | N/A |
| 138 | Power lines/Pylons | 75 | 2268 | 3756 | 3.0 | Acceptable | N/A |
| 139 | Power lines/Pylons | 75 | 2373 | 3756 | 2.7 | Acceptable | N/A |
| 140 | Power lines/Pylons | 75 | 2423 | 3756 | 2.6 | Acceptable | N/A |
| 141 | Power lines/Pylons | 75 | 2248 | 3756 | 3.0 | Acceptable | N/A |
| 142 | Power lines/Pylons | 75 | 2081 | 3756 | 3.4 | Acceptable | N/A |
| 143 | Power lines/Pylons | 75 | 1984 | 3756 | 3.7 | Acceptable | N/A |
| 144 | Power lines/Pylons | 75 | 1944 | 3756 | 3.8 | Acceptable | N/A |
| 145 | Power lines/Pylons | 75 | 1964 | 3756 | 3.7 | Acceptable | N/A |
| 146 | Power lines/Pylons | 75 | 2013 | 3756 | 3.6 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 147 | Power lines/Pylons | 75 | 2061 | 3756 | 3.5 | Acceptable | N/A |
| 148 | Power lines/Pylons | 75 | 2173 | 3756 | 3.2 | Acceptable | N/A |
| 149 | Power lines/Pylons | 75 | 2095 | 3756 | 3.4 | Acceptable | N/A |
| 150 | Power lines/Pylons | 75 | 2101 | 3756 | 3.4 | Acceptable | N/A |
| 151 | Power lines/Pylons | 75 | 2194 | 3756 | 3.1 | Acceptable | N/A |
| 152 | Power lines/Pylons | 75 | 2355 | 3756 | 2.8 | Acceptable | N/A |
| 153 | Power lines/Pylons | 75 | 2536 | 3756 | 2.5 | Acceptable | N/A |
| 154 | Power lines/Pylons | 75 | 2779 | 3756 | 2.1 | Acceptable | N/A |
| 155 | Power lines/Pylons | 75 | 3030 | 3756 | 1.8 | Acceptable | N/A |
| 156 | Power lines/Pylons | 75 | 3311 | 3756 | 1.6 | Acceptable | N/A |
| 157 | Mine Activity | 200 | 2596 | 3756 | 2.4 | Acceptable | N/A |
| 158 | Cultivated Fields | 200 | 1572 | 3756 | 5.4 | Acceptable | N/A |
| 159 | Informal Houses | 6 | 2685 | 3756 | 2.2 | Acceptable | Perceptible |
| 160 | Buildings/Structures | 12.5 | 1904 | 3756 | 3.9 | Acceptable | Perceptible |
| 161 | Cement Dam | 50 | 3364 | 3756 | 1.5 | Acceptable | N/A |
| 162 | Cement Dam | 50 | 3477 | 3756 | 1.5 | Acceptable | N/A |
| 163 | Pan | 200 | 1616 | 3756 | 5.2 | Acceptable | N/A |
| 164 | Dam | 50 | 3455 | 3756 | 1.5 | Acceptable | N/A |
| 165 | Cultivated Fields | 200 | 1822 | 3756 | 4.2 | Acceptable | N/A |
| 166 | Informal Houses | 6 | 2766 | 3756 | 2.1 | Acceptable | Perceptible |
| 167 | Informal Houses | 6 | 2922 | 3756 | 1.9 | Acceptable | Perceptible |
| 168 | Power lines/Pylons | 75 | 1695 | 3756 | 4.8 | Acceptable | N/A |
| 169 | Power lines/Pylons | 75 | 1916 | 3756 | 3.9 | Acceptable | N/A |
| 170 | Power lines/Pylons | 75 | 2215 | 3756 | 3.1 | Acceptable | N/A |
| 171 | Conveyor | 150 | 3188 | 3756 | 1.7 | Acceptable | N/A |
| 172 | Dam | 50 | 2904 | 3756 | 2.0 | Acceptable | N/A |
| 173 | Cultivated Fields | 200 | 2490 | 3756 | 2.5 | Acceptable | N/A |
| 174 | Informal Housing | 6 | 1480 | 3756 | 6.0 | Acceptable | Unpleasant |
| 175 | Reservoirs | 50 | 1719 | 3756 | 4.7 | Acceptable | N/A |
| 176 | Ruins | 6 | 1798 | 3756 | 4.3 | Acceptable | Perceptible |
| 177 | Cultivated Fields | 200 | 2677 | 3756 | 2.2 | Acceptable | N/A |
| 178 | Informal Housing | 6 | 2154 | 3756 | 3.2 | Acceptable | Perceptible |
| 179 | Dam | 50 | 1837 | 3756 | 4.2 | Acceptable | N/A |
| 180 | Structure | 12.5 | 3181 | 3756 | 1.7 | Acceptable | Perceptible |
| 181 | Cultivated Fields | 200 | 2880 | 3756 | 2.0 | Acceptable | N/A |
| 182 | Cultivated Fields | 200 | 2075 | 3756 | 3.4 | Acceptable | N/A |
| 183 | Structure | 12.5 | 1934 | 3756 | 3.8 | Acceptable | Perceptible |
| 184 | Structure | 12.5 | 2249 | 3756 | 3.0 | Acceptable | Perceptible |
| 185 | Structure | 12.5 | 2222 | 3756 | 3.1 | Acceptable | Perceptible |
| 186 | Power lines/Pylons | 75 | 2750 | 3756 | 2.1 | Acceptable | N/A |
| 187 | Power lines/Pylons | 75 | 2508 | 3756 | 2.5 | Acceptable | N/A |
| 188 | Power lines/Pylons | 75 | 2269 | 3756 | 3.0 | Acceptable | N/A |
| 189 | Power lines/Pylons | 75 | 1995 | 3756 | 3.6 | Acceptable | N/A |
| 190 | Power lines/Pylons | 75 | 1741 | 3756 | 4.6 | Acceptable | N/A |
| 191 | Structure | 12.5 | 1261 | 3756 | 7.8 | Acceptable | Unpleasant |
| 192 | Dam | 50 | 397 | 3756 | 52.3 | Problematic | N/A |
| 193 | Structure | 12.5 | 586 | 3756 | 27.6 | Problematic | Intolerable |
| 194 | Conveyor | 150 | 951 | 3756 | 12.4 | Acceptable | N/A |
| 195 | Dam | 50 | 499 | 3756 | 35.9 | Acceptable | N/A |
| 196 | Mine Buildings/Structures | 25 | 1295 | 3756 | 7.4 | Acceptable | N/A |
| 197 | Dam | 50 | 1329 | 3756 | 7.1 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 198 | Dam | 50 | 689 | 3756 | 21.1 | Acceptable | N/A |
| 199 | Pan | 200 | 1068 | 3756 | 10.2 | Acceptable | N/A |
| 200 | Dam | 50 | 501 | 3756 | 35.6 | Acceptable | N/A |
| 201 | Informal Settlement (Lindokhule) | 6 | 1051 | 3756 | 10.5 | Problematic | Unpleasant |
| 202 | Informal Settlement (Lindokhule) | 6 | 882 | 3756 | 14.0 | Problematic | Unpleasant |
| 203 | Shopping Centre (Lindokhule) | 50 | 1028 | 3756 | 10.9 | Acceptable | Unpleasant |
| 204 | Informal Settlement (Lindokhule) | 6 | 1002 | 3756 | 11.4 | Problematic | Unpleasant |
| 205 | R544 Road | 150 | 992 | 3756 | 11.6 | Acceptable | N/A |
| 206 | R544 Road | 150 | 1328 | 3756 | 7.1 | Acceptable | N/A |
| 207 | R544 Road | 150 | 772 | 3756 | 17.5 | Acceptable | N/A |
| 208 | R542 Road | 150 | 875 | 3756 | 14.2 | Acceptable | N/A |
| 209 | R542 Road | 150 | 1153 | 3756 | 9.0 | Acceptable | N/A |
| 210 | Shopping Centre | 50 | 1087 | 3756 | 9.9 | Acceptable | Unpleasant |
| 211 | Buildings/Structures | 12.5 | 1289 | 3756 | 7.5 | Acceptable | Unpleasant |
| 212 | Buildings/Structures | 12.5 | 1164 | 3756 | 8.9 | Acceptable | Unpleasant |
| 213 | Reservoir | 50 | 1104 | 3756 | 9.7 | Acceptable | N/A |
| 214 | Dam | 50 | 692 | 3756 | 20.9 | Acceptable | N/A |
| 215 | Road | 150 | 529 | 3756 | 32.7 | Acceptable | N/A |
| 216 | Road | 150 | 25 | 3756 | 4865.3 | Problematic | N/A |
| 217 | R544 Road | 150 | 804 | 3756 | 16.4 | Acceptable | N/A |
| 218 | R544 Road | 150 | 894 | 3756 | 13.7 | Acceptable | N/A |
| 219 | Informal Housing | 6 | 1040 | 3756 | 10.7 | Problematic | Unpleasant |
| 220 | Informal Housing | 6 | 964 | 3756 | 12.1 | Problematic | Unpleasant |
| 221 | Informal Housing | 6 | 903 | 3756 | 13.5 | Problematic | Unpleasant |
| 222 | Informal Housing | 6 | 941 | 3756 | 12.6 | Problematic | Unpleasant |
| 223 | Cultivated Fields | 200 | 202 | 3756 | 159.4 | Acceptable | N/A |
| 224 | Dam | 50 | 202 | 3756 | 159.8 | Problematic | N/A |
| 225 | Dam | 50 | 174 | 3756 | 205.0 | Problematic | N/A |
| 226 | Mine Buildings/Structures | 25 | 388 | 3756 | 54.4 | Problematic | N/A |
| 227 | Mine Activity | 200 | 183 | 3756 | 187.9 | Acceptable | N/A |
| 228 | Mine Buildings/Structures | 25 | 337 | 3756 | 68.5 | Problematic | N/A |
| 229 | Dam | 50 | 351 | 3756 | 64.2 | Problematic | N/A |
| 230 | Mine Buildings/Structures | 25 | 24 | 3756 | 5385.8 | Problematic | N/A |
| 231 | Dam | 50 | 23 | 3756 | 5927.9 | Problematic | N/A |
| 232 | Dam | 50 | 192 | 3756 | 174.1 | Problematic | N/A |
| 233 | Dam | 50 | 188 | 3756 | 179.4 | Problematic | N/A |
| 234 | Dam | 50 | 192 | 3756 | 173.3 | Problematic | N/A |
| 235 | Dam | 50 | 300 | 3756 | 83.3 | Problematic | N/A |
| 236 | Dam | 50 | 567 | 3756 | 29.1 | Acceptable | N/A |
| 237 | Pan | 200 | 208 | 3756 | 152.6 | Acceptable | N/A |
| 238 | Building/Structure | 12.5 | 484 | 3756 | 37.8 | Problematic | Intolerable |
| 239 | Building/Structure | 12.5 | 287 | 3756 | 89.5 | Problematic | Intolerable |
| 240 | Building/Structure | 12.5 | 366 | 3756 | 60.0 | Problematic | Intolerable |
| 241 | Cement Dam | 50 | 182 | 3756 | 189.7 | Problematic | N/A |
| 242 | Pipeline | 50 | 2812 | 3756 | 2.1 | Acceptable | N/A |
| 243 | Pipeline | 50 | 3111 | 3756 | 1.8 | Acceptable | N/A |
| 244 | Borehole (WBH 2S1) | 50 | 2512 | 3756 | 2.5 | Acceptable | N/A |
| 245 | Borehole (WBH 2S8) | 50 | 417 | 3756 | 48.4 | Acceptable | N/A |
| 246 | Borehole (SKS BH2) | 50 | 2864 | 3756 | 2.0 | Acceptable | N/A |
| 247 | Borehole (VLKR 3) | 50 | 2521 | 3756 | 2.5 | Acceptable | N/A |
| 248 | Borehole (WVK 1) | 50 | 3185 | 3756 | 1.7 | Acceptable | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 249 | Borehole (WVK 2) | 50 | 3338 | 3756 | 1.6 | Acceptable | N/A |
| 250 | Borehole (WVK 3) | 50 | 2521 | 3756 | 2.5 | Acceptable | N/A |
| 251 | Borehole (NDB 2) | 50 | 1302 | 3756 | 7.4 | Acceptable | N/A |
| 252 | Borehole (NDB 3) | 50 | 1761 | 3756 | 4.5 | Acceptable | N/A |
| 253 | Borehole (NDB 6) | 50 | 1521 | 3756 | 5.7 | Acceptable | N/A |
| 254 | Power lines/Pylons | 75 | 2469 | 3756 | 2.6 | Acceptable | N/A |
| 255 | Power lines/Pylons | 75 | 385 | 3756 | 55.2 | Acceptable | N/A |
| 256 | Power lines/Pylons | 75 | 191 | 3756 | 174.8 | Problematic | N/A |
| 257 | Power lines/Pylons (Inside Pit Area) | 75 | - | 3756 | - | - | - |
| 258 | Power lines/Pylons (Inside Pit Area) | 75 | - | 3756 | - | - | - |
| 259 | Power lines/Pylons (Inside Pit Area) | 75 | - | 3756 | - | - | - |
| 260 | Power lines/Pylons (Inside Pit Area) | 75 | - | 3756 | - | - | - |
| 261 | Power lines/Pylons (Inside Pit Area) | 75 | - | 3756 | - | - | - |
| 262 | Power lines/Pylons (Inside Pit Area) | 75 | - | 3756 | - | - | - |
| 263 | Power lines/Pylons (Inside Pit Area) | 75 | - | 3756 | - | - | - |
| 264 | Power Station (Inside Pit Area) | 50 | - | 3756 | - | - | - |
| 265 | Power lines/Pylons | 75 | 118 | 3756 | 387.2 | Problematic | N/A |
| 266 | Power lines/Pylons | 75 | 214 | 3756 | 145.7 | Problematic | N/A |
| 267 | Power lines/Pylons | 75 | 474 | 3756 | 39.1 | Acceptable | N/A |
| 268 | Power lines/Pylons | 75 | 670 | 3756 | 22.1 | Acceptable | N/A |
| 269 | Power lines/Pylons | 75 | 230 | 3756 | 129.0 | Problematic | N/A |
| 270 | Power lines/Pylons | 75 | 603 | 3756 | 26.2 | Acceptable | N/A |
| 271 | Power lines/Pylons | 75 | 871 | 3756 | 14.3 | Acceptable | N/A |
| 272 | Power lines/Pylons | 75 | 860 | 3756 | 14.6 | Acceptable | N/A |
| 273 | Power lines/Pylons | 75 | 1137 | 3756 | 9.2 | Acceptable | N/A |
| 274 | Power lines/Pylons | 75 | 1332 | 3756 | 7.1 | Acceptable | N/A |
| 275 | Power lines/Pylons | 75 | 900 | 3756 | 13.6 | Acceptable | N/A |
| 276 | Power lines/Pylons | 75 | 1216 | 3756 | 8.3 | Acceptable | N/A |
| 277 | Power lines/Pylons | 75 | 1636 | 3756 | 5.1 | Acceptable | N/A |
| 278 | Power lines/Pylons | 75 | 149 | 3756 | 263.6 | Problematic | N/A |
| 279 | Power lines/Pylons | 75 | 212 | 3756 | 147.3 | Problematic | N/A |
| 280 | Power lines/Pylons | 75 | 632 | 3756 | 24.3 | Acceptable | N/A |

## 17.2 Summary of ground vibration levels

The opencast operation was evaluated for expected levels of ground vibration from future blasting operations. Review of the site and the surrounding installations / houses / buildings showed that structures vary in distances from the pit area. The influences will also vary with distance from the pit area. The model used for evaluation does indicate significant levels. It will be imperative to ensure that a monitoring program is done to confirm levels of ground vibration to ensure that ground vibration levels are not exceeded.

The distances between structures and the pit area is a contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated that levels of ground vibration will change as well. In view of the maximum charge specific attention will need to be given to specific areas. The minimum charge used indicated nineteen POI's of concern and the maximum charge indicated fifty-one POI's of concern (included are the heritage site – graveyard and power lines/pylons inside the pit area) in relation to possible structural damage. On a human perception scale forty POI's were identified where vibration levels may be perceptible and higher for the minimum charge and fifty-two POI's for the maximum charge. Perceptible levels of vibration that may be experienced up to 3375 m, unpleasant up to 1527 m and intolerable up to 651 m. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 1050 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have lesser influence on these points.

The evaluation mainly considered a distance up to 3500 m from the pit area. The closest structures observed are the Buildings/Structures, Road, Power Lines/Pylons, Railway Line and Heritage Site (Railway Station). The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human perception. The ground vibration levels predicted ranged between 1.5 mm/s and 8719.1 mm/s for structures surrounding the open pit area.

The nearest public houses are located 249 m from the pit boundary. Ground vibration level predicted at this building where people may be present is 113.1 mm/s for the maximum charge. In view of this specific mitigations will be required. There are Buildings/Structures inside the pit area but as understood these will be relocated.

Structure conditions ranged from industrial construction to poor condition structures. Water boreholes identified are at close proximity to the Pit area. There are a significant number of water boreholes within the mining rights area and it is uncertain what the long-term plan will be for these boreholes. A mitigation plan will be required to determine if these boreholes will be retained or replaced.

Five Heritage Sites which include Graves, Pump Station and Railway Station were identified by the Heritage Specialist. One of these sites (graves – POI 17) falls within the Pit area. Specific recommendations will be required from the Heritage Specialist regarding the graves as it could be problematic in terms of potential damage.

Mitigation of ground vibration was considered and discussed in Section 17.13. A detail inspection of the area and accurate identification of structures will also need to be done to ensure the levels of ground vibration allowable and limit to be applied.

A positive contribution is that the box-cut areas are furthest away from the concerned infrastructure. This will assist in establishing more accurately what the possible influence may be and will provide to adjust blast parameters for lesser influence.

### 17.3 Ground Vibration and human perception

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to an average of 30Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 16 below). The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. Based on the maximum charge and ground vibration predicted over distance it can be seen from Figure 16 that up to a distance of 3375 m people may experience levels of ground vibration as perceptible. At 1527 m and closer the perception of ground vibration could be unpleasant. Closer than 651 m the levels will be intolerable and generally greater than limits applied for structures in the areas.

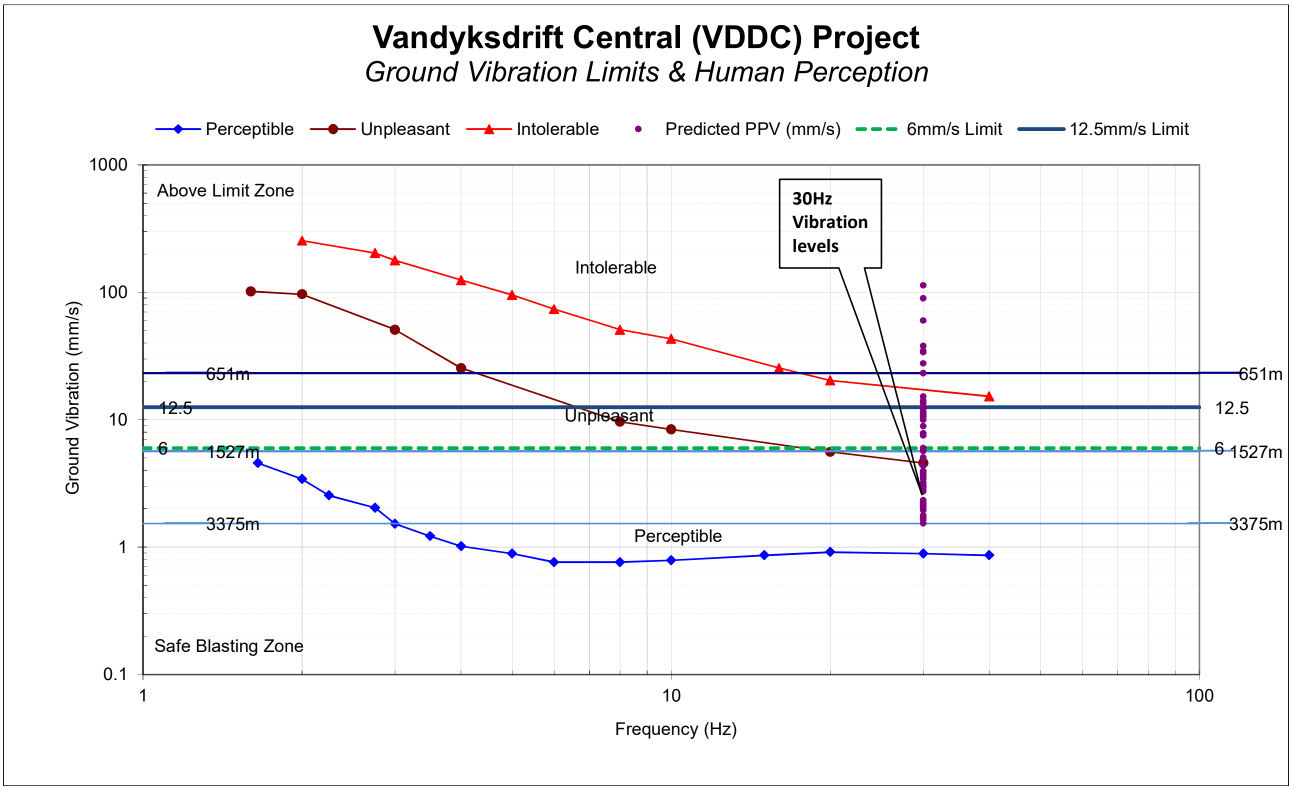



Figure 16: The effect of ground vibration with human perception and vibration limits

### 17.4 Vibration impact on roads

There are no National roads at close proximity of the pit area that will require specific consideration regarding effects from blasting operations. There are provincial roads in the vicinity of the project area to be considered. The R542 and R544 roads are located to the eastern side of the Pit area at 875 m (R542) and 772 m (R544). Expected ground vibration levels at these roads are within the recommended limits. No specific actions are required for these roads. There is a road that runs through the project area (POI 216). Mining layout indicates that this road will be demolished. No specific blasting restrictions will be applicable for this road.

### 17.5 Potential that vibration will upset adjacent communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. The nearest non-mine buildings/structures (POI 115) is approximately 249 m from the planned operation. These buildings are part of the railway station and located such that levels of ground vibration predicted may be problematic and damaging. Buildings/structures at POI 65 is located inside Pit Area.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 3375 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 2286 m. Within these distance ranges there are a number of houses. The anticipated ground vibration levels are certain to have possibility of upsetting the house holds within these ranges. Intolerable levels are expected up to a distance of 651 m.

The importance of good public relations cannot be over emphasised. People tend to react negatively on experiencing of effects from blasting such as ground vibration and air blast. Even at low levels when damage to structures is out of the question it may upset people. Proper and appropriate communication with neighbours about blasting, monitoring and actions done for proper control will be required.

### 17.6 Cracking of houses and consequent devaluation

The structures found in the areas of concern ranges from informal building style to brick and mortar structures. There are various buildings found within the 3500 m range from the mining area. Building style and materials will certainly contribute to additional cracking apart from influences such as blasting operations.

The presence of general vertical cracks, horizontal and diagonal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. Mining operations may not have influence to change the status quo of any property if correct precautions are considered.

The proposed limits as applied in this document i.e. 6 mm/s, 12.5 mm/s and 25 mm/s are considered sufficient to ensure that additional damage is not introduced to the different categories of structures. It is expected that, should levels of ground vibration be maintained within these limits, the possibility of inducing damage is limited.

### 17.7 Review of expected air blast

Presented herewith are the expected air blast level contours and discussion of relevant influences. Expected air blast levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns. Tables are provided for each of the different charge models done with regards to:

- "Tag" No. is number corresponding to the location indicated on POI figures;
- "Description" indicates the type of the structure;
- "Distance" is the distance between the structure and edge of the pit area;
- "Air Blast (dB)" is the calculated air blast level at the structure;
- "Possible concern" indicates if there is any concern for structural damage or human perception. Indicators used are:
  - "Problematic" where there is real concern for possible damage – at levels greater than 134 dB;
  - "Complaint" where people will be complaining due to the experienced effect on structures at levels of 120 dB and higher (not necessarily damaging);
  - "Acceptable" if levels are less than 120 dB;
  - "Low" where there is very limited possibility that the levels will give rise to any influence on people or structures. Levels below 115 dB could be considered to have low or negligible possibility of influence.

Presented are simulations for expected air blast levels from two different charge masses at each pit area. Colour codes used in tables are as follows:

| |
|---|
| Air blast levels higher than proposed limit is coloured "Red" |
| Air blast levels indicated as possible Complaint is coloured "Mustard" |
| POI's that are found inside the pit area is coloured "Olive Green" |

- ***Minimum charge mass per delay – 751 kg***

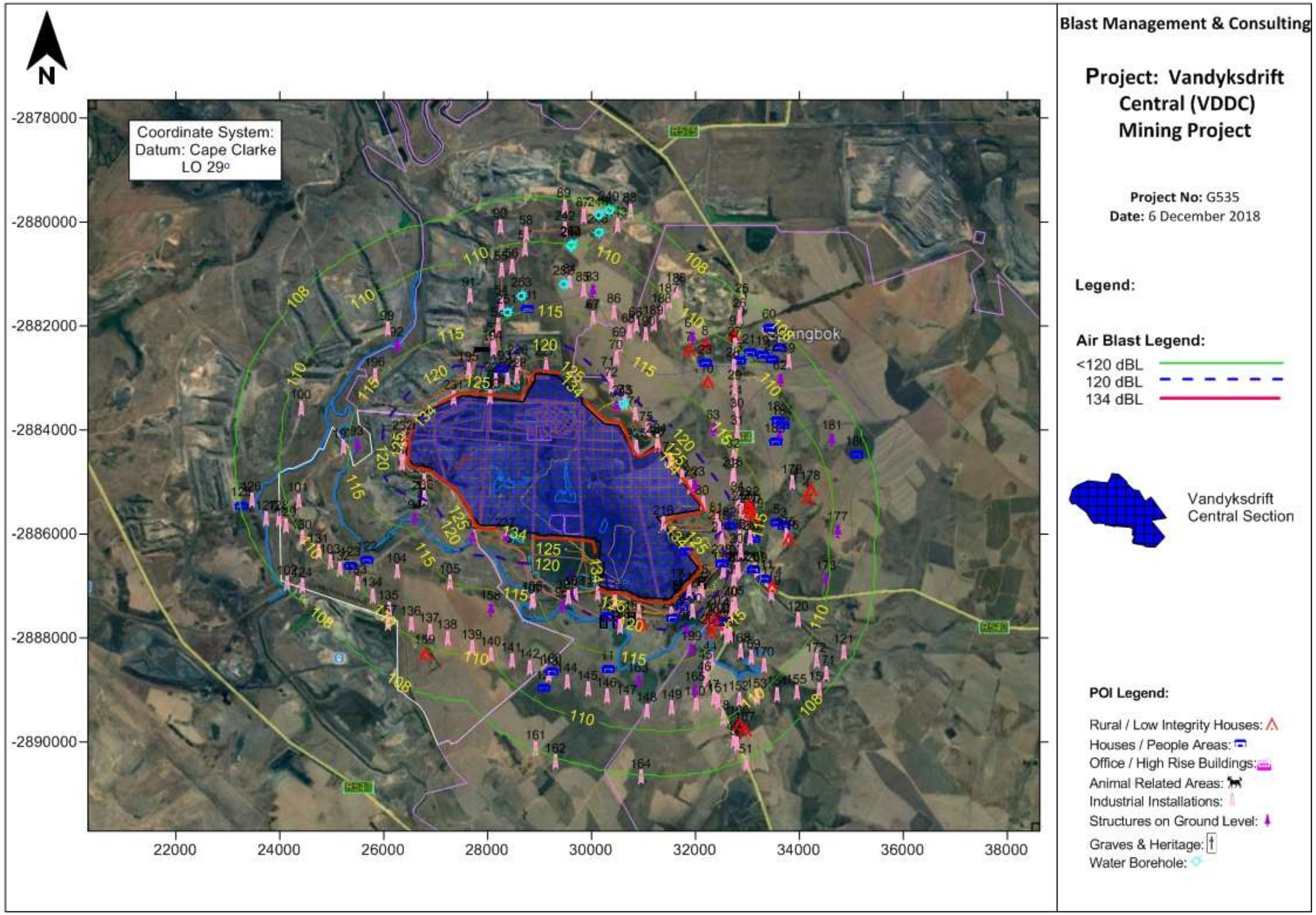



Figure 17: Air blast influence from minimum charge for Pit Area

Table 14: Air blast evaluation for minimum charge for Pit

| Tag | Description | Distance (m) | Air blast (dB) | Possible Concern? |
|---|---|---|---|---|
| 1 | Informal Settlement (Lindokhule) | 842 | 117.6 | Acceptable |
| 2 | Ruins | 517 | 120.9 | Complaint |
| 3 | School (Springbok) | 1641 | 113.0 | Acceptable |
| 4 | Informal Housing | 2067 | 111.4 | Acceptable |
| 5 | Buildings/Structures | 1495 | 113.6 | Acceptable |
| 6 | Springbok Mining Town Houses | 2374 | 110.5 | Acceptable |
| 7 | Informal Settlement (Kwajuma) | 1989 | 111.7 | Acceptable |
| 8 | Informal Settlement (Kwajuma) | 2283 | 110.8 | Acceptable |
| 9 | Informal Settlement (Kwajuma) | 2716 | 109.5 | Acceptable |
| 10 | Informal Housing | 1669 | 112.9 | Acceptable |
| 11 | Building/Structure | 1528 | 113.4 | Acceptable |
| 12 | Farm Buildings/Structures | 2263 | 110.8 | Acceptable |
| 13 | Buildings/Structures | 512 | 120.9 | Complaint |
| 14 | Heritage Site (Pump Station) | 637 | 119.5 | N/A |
| 15 | Heritage Site (Railway Station) | 257 | 125.7 | N/A |
| 16 | Heritage Site (Graveyard) | 453 | 121.8 | N/A |
| 17 | Heritage Site (Graveyard) - Inside Pit Area | - | - | - |
| 18 | Heritage Site (Pump Station) | 628 | 119.6 | N/A |
| 19 | Springbok Mining Town Buildings | 2782 | 109.4 | Acceptable |
| 20 | Springbok Mining Town Church | 3097 | 108.6 | Acceptable |
| 21 | Springbok Mining Town Houses | 2620 | 109.8 | Acceptable |
| 22 | Springbok Mining Town Houses | 2840 | 109.2 | Acceptable |
| 23 | Buildings/Structures | 1958 | 111.8 | Acceptable |
| 24 | Communication Tower | 1780 | 112.5 | N/A |
| 25 | Pipeline | 3341 | 108.1 | N/A |
| 26 | Pipeline | 3067 | 108.8 | N/A |
| 27 | Pipeline | 2559 | 110.0 | N/A |
| 28 | Pipeline | 2222 | 110.9 | N/A |
| 29 | Pipeline | 1945 | 111.8 | N/A |
| 30 | Pipeline | 1651 | 113.0 | N/A |
| 31 | Pipeline | 1452 | 113.8 | N/A |
| 32 | Pipeline | 1119 | 115.6 | N/A |
| 33 | Pipeline | 847 | 117.5 | N/A |
| 34 | Pipeline | 741 | 118.4 | N/A |
| 35 | Pipeline | 873 | 117.3 | N/A |
| 36 | Pipeline | 930 | 116.8 | N/A |
| 37 | Pipeline | 762 | 118.2 | N/A |
| 38 | Pipeline | 746 | 118.4 | N/A |
| 39 | Pipeline | 753 | 118.3 | N/A |
| 40 | Pipeline | 970 | 116.6 | N/A |

| | | | | |
|---|---|---|---|---|
| 41 | Pipeline | 1099 | 115.7 | N/A |
| 42 | Pipeline | 1147 | 115.4 | N/A |
| 43 | Pipeline | 1293 | 114.6 | N/A |
| 44 | Pipeline | 1425 | 114.0 | N/A |
| 45 | Pipeline | 1508 | 113.5 | N/A |
| 46 | Pipeline | 1714 | 112.7 | N/A |
| 47 | Pipeline | 2092 | 111.4 | N/A |
| 48 | Pipeline | 2532 | 110.0 | N/A |
| 49 | Pipeline | 2989 | 108.9 | N/A |
| 50 | Pipeline | 3089 | 108.6 | N/A |
| 51 | Pipeline | 3478 | 107.8 | N/A |
| 52 | Pipeline | 1028 | 116.2 | N/A |
| 53 | Pipeline | 1175 | 115.3 | N/A |
| 54 | Pipeline | 1499 | 113.6 | N/A |
| 55 | Pipeline | 2111 | 111.2 | N/A |
| 56 | Pipeline | 2111 | 111.2 | N/A |
| 57 | Pipeline | 2412 | 110.4 | N/A |
| 58 | Pipeline | 2700 | 109.5 | N/A |
| 59 | Reservoirs | 3075 | 108.6 | N/A |
| 60 | Buildings/Structures | 3243 | 108.3 | Acceptable |
| 61 | Cultivated Fields | 2220 | 110.9 | N/A |
| 62 | Cultivated Fields | 2748 | 109.4 | N/A |
| 63 | Cultivated Fields | 1146 | 115.4 | N/A |
| 64 | Cultivated Fields | 363 | 123.3 | N/A |
| 65 | Buildings/Structures (Inside Pit Area) | - | - | - |
| 66 | Power Station | 1735 | 112.6 | N/A |
| 67 | Cement Dam | 1310 | 114.5 | N/A |
| 68 | Power lines/Pylons | 1555 | 113.3 | N/A |
| 69 | Power lines/Pylons | 1240 | 114.9 | N/A |
| 70 | Power lines/Pylons | 1023 | 116.2 | N/A |
| 71 | Power lines/Pylons | 677 | 119.0 | N/A |
| 72 | Power lines/Pylons | 629 | 119.5 | N/A |
| 73 | Power lines/Pylons | 448 | 121.9 | N/A |
| 74 | Power lines/Pylons | 375 | 123.1 | N/A |
| 75 | Power lines/Pylons | 455 | 121.8 | N/A |
| 76 | Power lines/Pylons | 142 | 129.7 | N/A |
| 77 | Power lines/Pylons | 101 | 132.1 | N/A |
| 78 | Power lines/Pylons | 100 | 132.1 | N/A |
| 79 | Power lines/Pylons | 103 | 132.0 | N/A |
| 80 | Power lines/Pylons | 100 | 132.1 | N/A |
| 81 | Power lines/Pylons | 386 | 122.9 | N/A |
| 82 | Buildings/Structures | 651 | 119.3 | Acceptable |
| 83 | Cultivated Fields | 1784 | 112.4 | N/A |
| 84 | Power lines/Pylons | 1833 | 112.3 | N/A |
| 85 | Power lines/Pylons | 1726 | 112.7 | N/A |

| | | | | |
|---|---|---|---|---|
| 86 | Power lines/Pylons | 1677 | 112.9 | N/A |
| 87 | Dam | 3113 | 108.6 | N/A |
| 88 | Mine Activity | 3461 | 108.0 | N/A |
| 89 | Dam | 3250 | 108.3 | N/A |
| 90 | Mine Buildings/Structures | 2912 | 109.1 | N/A |
| 91 | Mine Activity | 1919 | 111.9 | N/A |
| 92 | Olifants River | 1435 | 113.9 | N/A |
| 93 | Olifants River | 1066 | 115.9 | N/A |
| 94 | Olifants River | 976 | 116.5 | N/A |
| 95 | Olifants River | 290 | 124.8 | N/A |
| 96 | Olifants River | 838 | 117.6 | N/A |
| 97 | Olifants River | 611 | 119.7 | N/A |
| 98 | Olifants River | 683 | 118.9 | N/A |
| 99 | Dam | 1794 | 112.4 | N/A |
| 100 | Mine Activity | 2220 | 110.9 | N/A |
| 101 | Dam | 2303 | 110.6 | N/A |
| 102 | Railway Line | 3330 | 108.1 | N/A |
| 103 | Railway Line | 2468 | 110.2 | N/A |
| 104 | Railway Line | 1817 | 112.3 | N/A |
| 105 | Railway Line | 1253 | 114.8 | N/A |
| 106 | Railway Line/Bridge | 1284 | 114.6 | N/A |
| 107 | Dam/Bridge | 1334 | 114.4 | N/A |
| 108 | Railway Line | 527 | 120.7 | N/A |
| 109 | Power Station | 681 | 119.0 | N/A |
| 110 | Railway Line | 160 | 128.9 | N/A |
| 111 | Railway Line/Bridge | 208 | 127.1 | N/A |
| 112 | Railway Line | 284 | 125.0 | N/A |
| 113 | Railway Line | 296 | 124.7 | N/A |
| 114 | Railway Line | 353 | 123.5 | N/A |
| 115 | Buildings/Structures | 249 | 125.9 | Complaint |
| 116 | Railway Station Buildings | 376 | 123.0 | N/A |
| 117 | Railway Line | 495 | 121.2 | N/A |
| 118 | Railway Line/Bridge | 775 | 118.1 | N/A |
| 119 | Railway Line | 1495 | 113.6 | N/A |
| 120 | Railway Line | 2181 | 111.0 | N/A |
| 121 | Railway Line | 3253 | 108.3 | N/A |
| 122 | Buildings/Structures | 2036 | 111.5 | Acceptable |
| 123 | Building/Structure | 2286 | 110.8 | Acceptable |
| 124 | Dam | 3161 | 108.5 | N/A |
| 125 | Building/Structure | 3375 | 108.1 | Acceptable |
| 126 | Cement Dam | 3164 | 108.5 | N/A |
| 127 | Power lines/Pylons | 3001 | 108.8 | N/A |
| 128 | Power lines/Pylons | 2782 | 109.4 | N/A |
| 129 | Power lines/Pylons | 2699 | 109.5 | N/A |
| 130 | Power lines/Pylons | 2560 | 110.0 | N/A |

| | | | | |
|---|---|---|---|---|
| 131 | Power lines/Pylons | 2472 | 110.2 | N/A |
| 132 | Power lines/Pylons | 2459 | 110.2 | N/A |
| 133 | Power lines/Pylons | 2528 | 110.0 | N/A |
| 134 | Power lines/Pylons | 2463 | 110.2 | N/A |
| 135 | Power lines/Pylons | 2380 | 110.5 | N/A |
| 136 | Power lines/Pylons | 2333 | 110.6 | N/A |
| 137 | Power lines/Pylons | 2267 | 110.8 | N/A |
| 138 | Power lines/Pylons | 2268 | 110.8 | N/A |
| 139 | Power lines/Pylons | 2373 | 110.5 | N/A |
| 140 | Power lines/Pylons | 2423 | 110.4 | N/A |
| 141 | Power lines/Pylons | 2248 | 110.9 | N/A |
| 142 | Power lines/Pylons | 2081 | 111.4 | N/A |
| 143 | Power lines/Pylons | 1984 | 111.7 | N/A |
| 144 | Power lines/Pylons | 1944 | 111.8 | N/A |
| 145 | Power lines/Pylons | 1964 | 111.7 | N/A |
| 146 | Power lines/Pylons | 2013 | 111.6 | N/A |
| 147 | Power lines/Pylons | 2061 | 111.4 | N/A |
| 148 | Power lines/Pylons | 2173 | 111.0 | N/A |
| 149 | Power lines/Pylons | 2095 | 111.4 | N/A |
| 150 | Power lines/Pylons | 2101 | 111.2 | N/A |
| 151 | Power lines/Pylons | 2194 | 111.0 | N/A |
| 152 | Power lines/Pylons | 2355 | 110.5 | N/A |
| 153 | Power lines/Pylons | 2536 | 110.0 | N/A |
| 154 | Power lines/Pylons | 2779 | 109.4 | N/A |
| 155 | Power lines/Pylons | 3030 | 108.8 | N/A |
| 156 | Power lines/Pylons | 3311 | 108.1 | N/A |
| 157 | Mine Activity | 2596 | 109.8 | N/A |
| 158 | Cultivated Fields | 1572 | 113.3 | N/A |
| 159 | Informal Houses | 2685 | 109.7 | Acceptable |
| 160 | Buildings/Structures | 1904 | 111.9 | Acceptable |
| 161 | Cement Dam | 3364 | 108.1 | N/A |
| 162 | Cement Dam | 3477 | 107.8 | N/A |
| 163 | Pan | 1616 | 113.1 | N/A |
| 164 | Dam | 3455 | 108.0 | N/A |
| 165 | Cultivated Fields | 1822 | 112.3 | N/A |
| 166 | Informal Houses | 2766 | 109.4 | Acceptable |
| 167 | Informal Houses | 2922 | 109.1 | Acceptable |
| 168 | Power lines/Pylons | 1695 | 112.8 | N/A |
| 169 | Power lines/Pylons | 1916 | 111.9 | N/A |
| 170 | Power lines/Pylons | 2215 | 110.9 | N/A |
| 171 | Conveyor | 3188 | 108.5 | N/A |
| 172 | Dam | 2904 | 109.1 | N/A |
| 173 | Cultivated Fields | 2490 | 110.1 | N/A |
| 174 | Informal Housing | 1480 | 113.7 | Acceptable |
| 175 | Reservoirs | 1719 | 112.7 | N/A |

| | | | | |
|---|---|---|---|---|
| 176 | Ruins | 1798 | 112.4 | Acceptable |
| 177 | Cultivated Fields | 2677 | 109.7 | N/A |
| 178 | Informal Housing | 2154 | 111.1 | Acceptable |
| 179 | Dam | 1837 | 112.3 | N/A |
| 180 | Structure | 3181 | 108.5 | Acceptable |
| 181 | Cultivated Fields | 2880 | 109.1 | N/A |
| 182 | Cultivated Fields | 2075 | 111.4 | N/A |
| 183 | Structure | 1934 | 111.8 | Acceptable |
| 184 | Structure | 2249 | 110.9 | Acceptable |
| 185 | Structure | 2222 | 110.9 | Acceptable |
| 186 | Power lines/Pylons | 2750 | 109.4 | N/A |
| 187 | Power lines/Pylons | 2508 | 110.1 | N/A |
| 188 | Power lines/Pylons | 2269 | 110.8 | N/A |
| 189 | Power lines/Pylons | 1995 | 111.6 | N/A |
| 190 | Power lines/Pylons | 1741 | 112.6 | N/A |
| 191 | Structure | 1261 | 114.8 | Acceptable |
| 192 | Dam | 397 | 122.7 | N/A |
| 193 | Structure | 586 | 120.0 | Acceptable |
| 194 | Conveyor | 951 | 116.7 | N/A |
| 195 | Dam | 499 | 121.1 | N/A |
| 196 | Mine Buildings/Structures | 1295 | 114.6 | N/A |
| 197 | Dam | 1329 | 114.4 | N/A |
| 198 | Dam | 689 | 118.9 | N/A |
| 199 | Pan | 1068 | 115.9 | N/A |
| 200 | Dam | 501 | 121.1 | N/A |
| 201 | Informal Settlement (Lindokhule) | 1051 | 116.0 | Acceptable |
| 202 | Informal Settlement (Lindokhule) | 882 | 117.2 | Acceptable |
| 203 | Shopping Centre (Lindokhule) | 1028 | 116.2 | Acceptable |
| 204 | Informal Settlement (Lindokhule) | 1002 | 116.3 | Acceptable |
| 205 | R544 Road | 992 | 116.4 | N/A |
| 206 | R544 Road | 1328 | 114.4 | N/A |
| 207 | R544 Road | 772 | 118.1 | N/A |
| 208 | R542 Road | 875 | 117.3 | N/A |
| 209 | R542 Road | 1153 | 115.4 | N/A |
| 210 | Shopping Centre | 1087 | 115.8 | Acceptable |
| 211 | Buildings/Structures | 1289 | 114.6 | Acceptable |
| 212 | Buildings/Structures | 1164 | 115.3 | Acceptable |
| 213 | Reservoir | 1104 | 115.7 | N/A |
| 214 | Dam | 692 | 118.9 | N/A |
| 215 | Road | 529 | 120.7 | N/A |
| 216 | Road | 25 | 141.5 | N/A |
| 217 | R544 Road | 804 | 117.8 | N/A |
| 218 | R544 Road | 894 | 117.1 | N/A |
| 219 | Informal Housing | 1040 | 116.1 | Acceptable |
| 220 | Informal Housing | 964 | 116.6 | Acceptable |

| | | | | |
|---|---|---|---|---|
| 221 | Informal Housing | 903 | 117.0 | Acceptable |
| 222 | Informal Housing | 941 | 116.8 | Acceptable |
| 223 | Cultivated Fields | 202 | 127.3 | N/A |
| 224 | Dam | 202 | 127.3 | N/A |
| 225 | Dam | 174 | 128.3 | N/A |
| 226 | Mine Buildings/Structures | 388 | 122.8 | N/A |
| 227 | Mine Activity | 183 | 128.0 | N/A |
| 228 | Mine Buildings/Structures | 337 | 123.8 | N/A |
| 229 | Dam | 351 | 123.5 | N/A |
| 230 | Mine Buildings/Structures | 24 | 141.9 | N/A |
| 231 | Dam | 23 | 142.3 | N/A |
| 232 | Dam | 192 | 127.7 | N/A |
| 233 | Dam | 188 | 127.8 | N/A |
| 234 | Dam | 192 | 127.6 | N/A |
| 235 | Dam | 300 | 124.6 | N/A |
| 236 | Dam | 567 | 120.2 | N/A |
| 237 | Pan | 208 | 127.1 | N/A |
| 238 | Building/Structure | 484 | 121.3 | Complaint |
| 239 | Building/Structure | 287 | 124.9 | Complaint |
| 240 | Building/Structure | 366 | 123.2 | Complaint |
| 241 | Cement Dam | 182 | 128.0 | N/A |
| 242 | Pipeline | 2812 | 109.2 | N/A |
| 243 | Pipeline | 3111 | 108.6 | N/A |
| 244 | Borehole (WBH 2S1) | 2512 | 110.1 | N/A |
| 245 | Borehole (WBH 2S8) | 417 | 122.3 | N/A |
| 246 | Borehole (SKS BH2) | 2864 | 109.2 | N/A |
| 247 | Borehole (VLKR 3) | 2521 | 110.1 | N/A |
| 248 | Borehole (WVK 1) | 3185 | 108.5 | N/A |
| 249 | Borehole (WVK 2) | 3338 | 108.1 | N/A |
| 250 | Borehole (WVK 3) | 2521 | 110.1 | N/A |
| 251 | Borehole (NDB 2) | 1302 | 114.6 | N/A |
| 252 | Borehole (NDB 3) | 1761 | 112.5 | N/A |
| 253 | Borehole (NDB 6) | 1521 | 113.5 | N/A |
| 254 | Power lines/Pylons | 2469 | 110.2 | N/A |
| 255 | Power lines/Pylons | 385 | 122.9 | N/A |
| 256 | Power lines/Pylons | 191 | 127.7 | N/A |
| 257 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 258 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 259 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 260 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 261 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 262 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 263 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 264 | Power Station (Inside Pit Area) | - | - | - |
| 265 | Power lines/Pylons | 118 | 131.0 | N/A |

| | | | | |
|---|---|---|---|---|
| 266 | Power lines/Pylons | 214 | 126.9 | N/A |
| 267 | Power lines/Pylons | 474 | 121.5 | N/A |
| 268 | Power lines/Pylons | 670 | 119.1 | N/A |
| 269 | Power lines/Pylons | 230 | 126.4 | N/A |
| 270 | Power lines/Pylons | 603 | 119.8 | N/A |
| 271 | Power lines/Pylons | 871 | 117.3 | N/A |
| 272 | Power lines/Pylons | 860 | 117.4 | N/A |
| 273 | Power lines/Pylons | 1137 | 115.5 | N/A |
| 274 | Power lines/Pylons | 1332 | 114.4 | N/A |
| 275 | Power lines/Pylons | 900 | 117.1 | N/A |
| 276 | Power lines/Pylons | 1216 | 115.0 | N/A |
| 277 | Power lines/Pylons | 1636 | 113.0 | N/A |
| 278 | Power lines/Pylons | 149 | 129.4 | N/A |
| 279 | Power lines/Pylons | 212 | 127.0 | N/A |
| 280 | Power lines/Pylons | 632 | 119.5 | N/A |

- **Maximum charge mass per delay - 3756 kg**

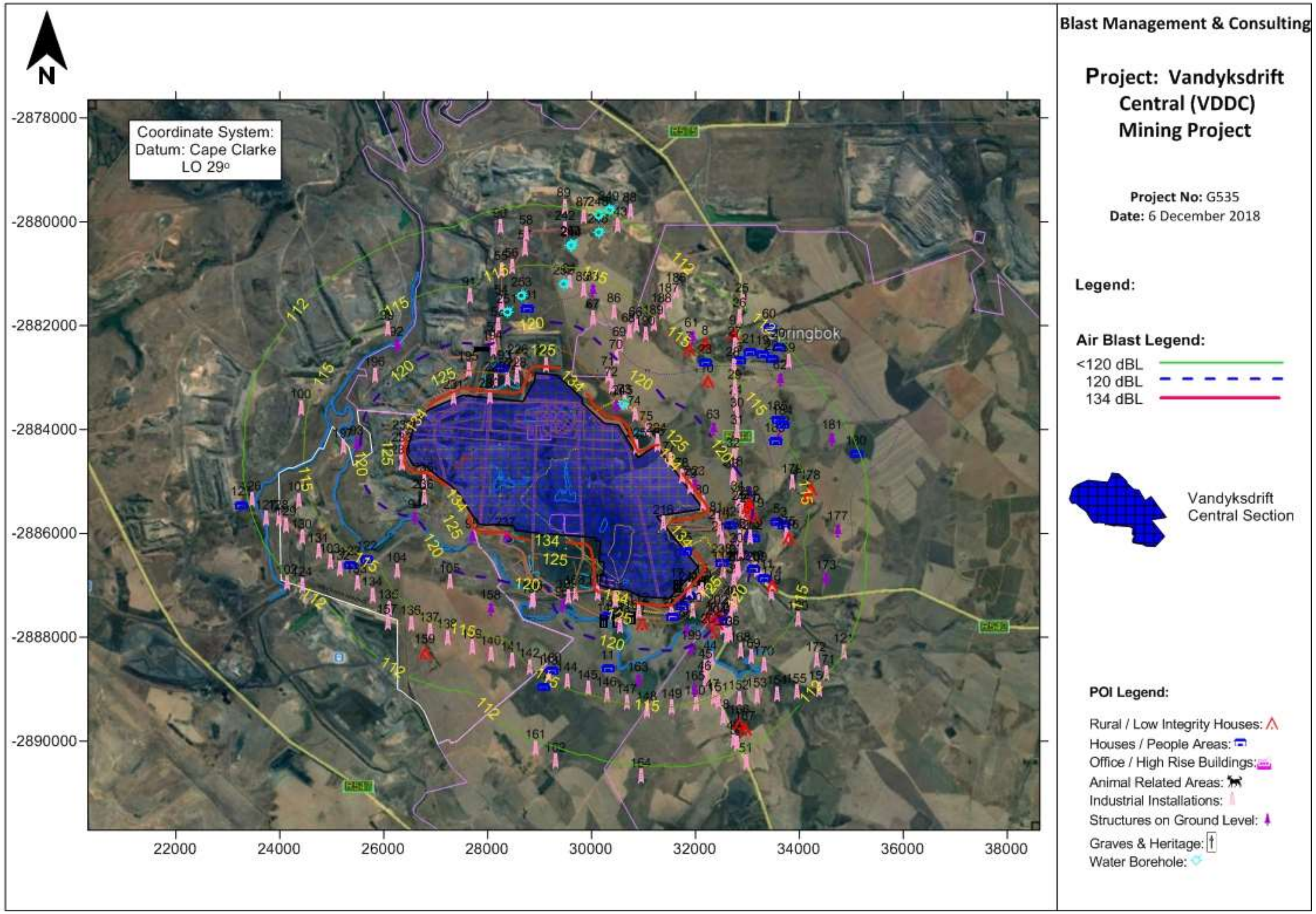



Figure 18: Air blast influence from maximum charge for Pit Area

Table 15: Air blast influence from maximum charge for Pit

| Tag | Description | Distance (m) | Air blast (dB) | Possible Concern? |
|---|---|---|---|---|
| 1 | Informal Settlement (Lindokhule) | 842 | 121.2 | Complaint |
| 2 | Ruins | 517 | 124.5 | Complaint |
| 3 | School (Springbok) | 1641 | 116.7 | Acceptable |
| 4 | Informal Housing | 2067 | 115.0 | Acceptable |
| 5 | Buildings/Structures | 1495 | 117.3 | Acceptable |
| 6 | Springbok Mining Town Houses | 2374 | 114.2 | Acceptable |
| 7 | Informal Settlement (Kwajuma) | 1989 | 115.3 | Acceptable |
| 8 | Informal Settlement (Kwajuma) | 2283 | 114.4 | Acceptable |
| 9 | Informal Settlement (Kwajuma) | 2716 | 113.2 | Acceptable |
| 10 | Informal Housing | 1669 | 116.5 | Acceptable |
| 11 | Building/Structure | 1528 | 117.1 | Acceptable |
| 12 | Farm Buildings/Structures | 2263 | 114.4 | Acceptable |
| 13 | Buildings/Structures | 512 | 124.6 | Complaint |
| 14 | Heritage Site (Pump Station) | 637 | 123.1 | N/A |
| 15 | Heritage Site (Railway Station) | 257 | 129.3 | N/A |
| 16 | Heritage Site (Graveyard) | 453 | 125.5 | N/A |
| 17 | Heritage Site (Graveyard) - Inside Pit Area | - | - | - |
| 18 | Heritage Site (Pump Station) | 628 | 123.2 | N/A |
| 19 | Springbok Mining Town Buildings | 2782 | 113.1 | Acceptable |
| 20 | Springbok Mining Town Church | 3097 | 112.3 | Acceptable |
| 21 | Springbok Mining Town Houses | 2620 | 113.4 | Acceptable |
| 22 | Springbok Mining Town Houses | 2840 | 112.9 | Acceptable |
| 23 | Buildings/Structures | 1958 | 115.4 | Acceptable |
| 24 | Communication Tower | 1780 | 116.1 | N/A |
| 25 | Pipeline | 3341 | 111.8 | N/A |
| 26 | Pipeline | 3067 | 112.4 | N/A |
| 27 | Pipeline | 2559 | 113.6 | N/A |
| 28 | Pipeline | 2222 | 114.6 | N/A |
| 29 | Pipeline | 1945 | 115.5 | N/A |
| 30 | Pipeline | 1651 | 116.6 | N/A |
| 31 | Pipeline | 1452 | 117.5 | N/A |
| 32 | Pipeline | 1119 | 119.3 | N/A |
| 33 | Pipeline | 847 | 121.2 | N/A |
| 34 | Pipeline | 741 | 122.1 | N/A |
| 35 | Pipeline | 873 | 120.9 | N/A |
| 36 | Pipeline | 930 | 120.5 | N/A |
| 37 | Pipeline | 762 | 121.9 | N/A |
| 38 | Pipeline | 746 | 122.0 | N/A |
| 39 | Pipeline | 753 | 122.0 | N/A |
| 40 | Pipeline | 970 | 120.3 | N/A |

| | | | | |
|---|---|---|---|---|
| 41 | Pipeline | 1099 | 119.4 | N/A |
| 42 | Pipeline | 1147 | 119.1 | N/A |
| 43 | Pipeline | 1293 | 118.3 | N/A |
| 44 | Pipeline | 1425 | 117.6 | N/A |
| 45 | Pipeline | 1508 | 117.2 | N/A |
| 46 | Pipeline | 1714 | 116.3 | N/A |
| 47 | Pipeline | 2092 | 115.0 | N/A |
| 48 | Pipeline | 2532 | 113.7 | N/A |
| 49 | Pipeline | 2989 | 112.6 | N/A |
| 50 | Pipeline | 3089 | 112.4 | N/A |
| 51 | Pipeline | 3478 | 111.5 | N/A |
| 52 | Pipeline | 1028 | 119.8 | N/A |
| 53 | Pipeline | 1175 | 118.9 | N/A |
| 54 | Pipeline | 1499 | 117.3 | N/A |
| 55 | Pipeline | 2111 | 114.9 | N/A |
| 56 | Pipeline | 2111 | 114.9 | N/A |
| 57 | Pipeline | 2412 | 114.0 | N/A |
| 58 | Pipeline | 2700 | 113.3 | N/A |
| 59 | Reservoirs | 3075 | 112.4 | N/A |
| 60 | Buildings/Structures | 3243 | 112.0 | Acceptable |
| 61 | Cultivated Fields | 2220 | 114.6 | N/A |
| 62 | Cultivated Fields | 2748 | 113.2 | N/A |
| 63 | Cultivated Fields | 1146 | 119.1 | N/A |
| 64 | Cultivated Fields | 363 | 127.0 | N/A |
| 65 | Buildings/Structures (Inside Pit Area) | - | - | - |
| 66 | Power Station | 1735 | 116.3 | N/A |
| 67 | Cement Dam | 1310 | 118.2 | N/A |
| 68 | Power lines/Pylons | 1555 | 117.0 | N/A |
| 69 | Power lines/Pylons | 1240 | 118.5 | N/A |
| 70 | Power lines/Pylons | 1023 | 119.9 | N/A |
| 71 | Power lines/Pylons | 677 | 122.7 | N/A |
| 72 | Power lines/Pylons | 629 | 123.2 | N/A |
| 73 | Power lines/Pylons | 448 | 125.5 | N/A |
| 74 | Power lines/Pylons | 375 | 126.7 | N/A |
| 75 | Power lines/Pylons | 455 | 125.4 | N/A |
| 76 | Power lines/Pylons | 142 | 133.4 | N/A |
| 77 | Power lines/Pylons | 101 | 135.8 | N/A |
| 78 | Power lines/Pylons | 100 | 135.8 | N/A |
| 79 | Power lines/Pylons | 103 | 135.6 | N/A |
| 80 | Power lines/Pylons | 100 | 135.8 | N/A |
| 81 | Power lines/Pylons | 386 | 126.5 | N/A |
| 82 | Buildings/Structures | 651 | 123.0 | Complaint |
| 83 | Cultivated Fields | 1784 | 116.1 | N/A |
| 84 | Power lines/Pylons | 1833 | 115.9 | N/A |
| 85 | Power lines/Pylons | 1726 | 116.3 | N/A |

| | | | | |
|---|---|---|---|---|
| 86 | Power lines/Pylons | 1677 | 116.5 | N/A |
| 87 | Dam | 3113 | 112.3 | N/A |
| 88 | Mine Activity | 3461 | 111.6 | N/A |
| 89 | Dam | 3250 | 111.9 | N/A |
| 90 | Mine Buildings/Structures | 2912 | 112.8 | N/A |
| 91 | Mine Activity | 1919 | 115.6 | N/A |
| 92 | Olifants River | 1435 | 117.6 | N/A |
| 93 | Olifants River | 1066 | 119.6 | N/A |
| 94 | Olifants River | 976 | 120.2 | N/A |
| 95 | Olifants River | 290 | 128.5 | N/A |
| 96 | Olifants River | 838 | 121.3 | N/A |
| 97 | Olifants River | 611 | 123.4 | N/A |
| 98 | Olifants River | 683 | 122.6 | N/A |
| 99 | Dam | 1794 | 116.1 | N/A |
| 100 | Mine Activity | 2220 | 114.6 | N/A |
| 101 | Dam | 2303 | 114.3 | N/A |
| 102 | Railway Line | 3330 | 111.8 | N/A |
| 103 | Railway Line | 2468 | 113.9 | N/A |
| 104 | Railway Line | 1817 | 115.9 | N/A |
| 105 | Railway Line | 1253 | 118.5 | N/A |
| 106 | Railway Line/Bridge | 1284 | 118.3 | N/A |
| 107 | Dam/Bridge | 1334 | 118.1 | N/A |
| 108 | Railway Line | 527 | 124.4 | N/A |
| 109 | Power Station | 681 | 122.7 | N/A |
| 110 | Railway Line | 160 | 132.6 | N/A |
| 111 | Railway Line/Bridge | 208 | 130.8 | N/A |
| 112 | Railway Line | 284 | 128.7 | N/A |
| 113 | Railway Line | 296 | 128.4 | N/A |
| 114 | Railway Line | 353 | 127.2 | N/A |
| 115 | Buildings/Structures | 249 | 129.6 | Complaint |
| 116 | Railway Station Buildings | 376 | 126.7 | N/A |
| 117 | Railway Line | 495 | 124.9 | N/A |
| 118 | Railway Line/Bridge | 775 | 121.8 | N/A |
| 119 | Railway Line | 1495 | 117.3 | N/A |
| 120 | Railway Line | 2181 | 114.7 | N/A |
| 121 | Railway Line | 3253 | 111.9 | N/A |
| 122 | Buildings/Structures | 2036 | 115.2 | Acceptable |
| 123 | Building/Structure | 2286 | 114.4 | Acceptable |
| 124 | Dam | 3161 | 112.1 | N/A |
| 125 | Building/Structure | 3375 | 111.7 | Acceptable |
| 126 | Cement Dam | 3164 | 112.1 | N/A |
| 127 | Power lines/Pylons | 3001 | 112.6 | N/A |
| 128 | Power lines/Pylons | 2782 | 113.1 | N/A |
| 129 | Power lines/Pylons | 2699 | 113.3 | N/A |
| 130 | Power lines/Pylons | 2560 | 113.6 | N/A |

| | | | | |
|---|---|---|---|---|
| 131 | Power lines/Pylons | 2472 | 113.8 | N/A |
| 132 | Power lines/Pylons | 2459 | 113.9 | N/A |
| 133 | Power lines/Pylons | 2528 | 113.7 | N/A |
| 134 | Power lines/Pylons | 2463 | 113.9 | N/A |
| 135 | Power lines/Pylons | 2380 | 114.1 | N/A |
| 136 | Power lines/Pylons | 2333 | 114.2 | N/A |
| 137 | Power lines/Pylons | 2267 | 114.4 | N/A |
| 138 | Power lines/Pylons | 2268 | 114.4 | N/A |
| 139 | Power lines/Pylons | 2373 | 114.2 | N/A |
| 140 | Power lines/Pylons | 2423 | 114.0 | N/A |
| 141 | Power lines/Pylons | 2248 | 114.5 | N/A |
| 142 | Power lines/Pylons | 2081 | 115.0 | N/A |
| 143 | Power lines/Pylons | 1984 | 115.3 | N/A |
| 144 | Power lines/Pylons | 1944 | 115.5 | N/A |
| 145 | Power lines/Pylons | 1964 | 115.4 | N/A |
| 146 | Power lines/Pylons | 2013 | 115.3 | N/A |
| 147 | Power lines/Pylons | 2061 | 115.1 | N/A |
| 148 | Power lines/Pylons | 2173 | 114.7 | N/A |
| 149 | Power lines/Pylons | 2095 | 115.0 | N/A |
| 150 | Power lines/Pylons | 2101 | 115.0 | N/A |
| 151 | Power lines/Pylons | 2194 | 114.6 | N/A |
| 152 | Power lines/Pylons | 2355 | 114.2 | N/A |
| 153 | Power lines/Pylons | 2536 | 113.6 | N/A |
| 154 | Power lines/Pylons | 2779 | 113.1 | N/A |
| 155 | Power lines/Pylons | 3030 | 112.5 | N/A |
| 156 | Power lines/Pylons | 3311 | 111.8 | N/A |
| 157 | Mine Activity | 2596 | 113.5 | N/A |
| 158 | Cultivated Fields | 1572 | 117.0 | N/A |
| 159 | Informal Houses | 2685 | 113.3 | Acceptable |
| 160 | Buildings/Structures | 1904 | 115.6 | Acceptable |
| 161 | Cement Dam | 3364 | 111.7 | N/A |
| 162 | Cement Dam | 3477 | 111.5 | N/A |
| 163 | Pan | 1616 | 116.8 | N/A |
| 164 | Dam | 3455 | 111.6 | N/A |
| 165 | Cultivated Fields | 1822 | 115.9 | N/A |
| 166 | Informal Houses | 2766 | 113.1 | Acceptable |
| 167 | Informal Houses | 2922 | 112.7 | Acceptable |
| 168 | Power lines/Pylons | 1695 | 116.4 | N/A |
| 169 | Power lines/Pylons | 1916 | 115.6 | N/A |
| 170 | Power lines/Pylons | 2215 | 114.6 | N/A |
| 171 | Conveyor | 3188 | 112.1 | N/A |
| 172 | Dam | 2904 | 112.8 | N/A |
| 173 | Cultivated Fields | 2490 | 113.8 | N/A |
| 174 | Informal Housing | 1480 | 117.3 | Acceptable |
| 175 | Reservoirs | 1719 | 116.3 | N/A |

| | | | | |
|---|---|---|---|---|
| 176 | Ruins | 1798 | 116.0 | Acceptable |
| 177 | Cultivated Fields | 2677 | 113.3 | N/A |
| 178 | Informal Housing | 2154 | 114.8 | Acceptable |
| 179 | Dam | 1837 | 115.8 | N/A |
| 180 | Structure | 3181 | 112.1 | Acceptable |
| 181 | Cultivated Fields | 2880 | 112.8 | N/A |
| 182 | Cultivated Fields | 2075 | 115.0 | N/A |
| 183 | Structure | 1934 | 115.5 | Acceptable |
| 184 | Structure | 2249 | 114.5 | Acceptable |
| 185 | Structure | 2222 | 114.6 | Acceptable |
| 186 | Power lines/Pylons | 2750 | 113.1 | N/A |
| 187 | Power lines/Pylons | 2508 | 113.7 | N/A |
| 188 | Power lines/Pylons | 2269 | 114.4 | N/A |
| 189 | Power lines/Pylons | 1995 | 115.3 | N/A |
| 190 | Power lines/Pylons | 1741 | 116.3 | N/A |
| 191 | Structure | 1261 | 118.4 | Acceptable |
| 192 | Dam | 397 | 126.3 | N/A |
| 193 | Structure | 586 | 123.7 | Complaint |
| 194 | Conveyor | 951 | 120.4 | N/A |
| 195 | Dam | 499 | 124.8 | N/A |
| 196 | Mine Buildings/Structures | 1295 | 118.3 | N/A |
| 197 | Dam | 1329 | 118.1 | N/A |
| 198 | Dam | 689 | 122.6 | N/A |
| 199 | Pan | 1068 | 119.6 | N/A |
| 200 | Dam | 501 | 124.8 | N/A |
| 201 | Informal Settlement (Lindokhule) | 1051 | 119.7 | Acceptable |
| 202 | Informal Settlement (Lindokhule) | 882 | 120.9 | Complaint |
| 203 | Shopping Centre (Lindokhule) | 1028 | 119.8 | Acceptable |
| 204 | Informal Settlement (Lindokhule) | 1002 | 120.0 | Acceptable |
| 205 | R544 Road | 992 | 120.1 | N/A |
| 206 | R544 Road | 1328 | 118.1 | N/A |
| 207 | R544 Road | 772 | 121.8 | N/A |
| 208 | R542 Road | 875 | 120.9 | N/A |
| 209 | R542 Road | 1153 | 119.0 | N/A |
| 210 | Shopping Centre | 1087 | 119.5 | Acceptable |
| 211 | Buildings/Structures | 1289 | 118.3 | Acceptable |
| 212 | Buildings/Structures | 1164 | 119.0 | Acceptable |
| 213 | Reservoir | 1104 | 119.4 | N/A |
| 214 | Dam | 692 | 122.5 | N/A |
| 215 | Road | 529 | 124.4 | N/A |
| 216 | Road | 25 | 145.2 | N/A |
| 217 | R544 Road | 804 | 121.5 | N/A |
| 218 | R544 Road | 894 | 120.8 | N/A |
| 219 | Informal Housing | 1040 | 119.8 | Acceptable |
| 220 | Informal Housing | 964 | 120.3 | Complaint |

| | | | | |
|---|---|---|---|---|
| 221 | Informal Housing | 903 | 120.7 | Complaint |
| 222 | Informal Housing | 941 | 120.5 | Complaint |
| 223 | Cultivated Fields | 202 | 131.0 | N/A |
| 224 | Dam | 202 | 131.0 | N/A |
| 225 | Dam | 174 | 132.0 | N/A |
| 226 | Mine Buildings/Structures | 388 | 126.5 | N/A |
| 227 | Mine Activity | 183 | 131.7 | N/A |
| 228 | Mine Buildings/Structures | 337 | 127.5 | N/A |
| 229 | Dam | 351 | 127.2 | N/A |
| 230 | Mine Buildings/Structures | 24 | 145.6 | N/A |
| 231 | Dam | 23 | 146.0 | N/A |
| 232 | Dam | 192 | 131.4 | N/A |
| 233 | Dam | 188 | 131.5 | N/A |
| 234 | Dam | 192 | 131.3 | N/A |
| 235 | Dam | 300 | 128.3 | N/A |
| 236 | Dam | 567 | 123.9 | N/A |
| 237 | Pan | 208 | 130.8 | N/A |
| 238 | Building/Structure | 484 | 125.0 | Complaint |
| 239 | Building/Structure | 287 | 128.6 | Complaint |
| 240 | Building/Structure | 366 | 126.9 | Complaint |
| 241 | Cement Dam | 182 | 131.7 | N/A |
| 242 | Pipeline | 2812 | 113.0 | N/A |
| 243 | Pipeline | 3111 | 112.3 | N/A |
| 244 | Borehole (WBH 2S1) | 2512 | 113.7 | N/A |
| 245 | Borehole (WBH 2S8) | 417 | 126.0 | N/A |
| 246 | Borehole (SKS BH2) | 2864 | 112.9 | N/A |
| 247 | Borehole (VLKR 3) | 2521 | 113.7 | N/A |
| 248 | Borehole (WVK 1) | 3185 | 112.1 | N/A |
| 249 | Borehole (WVK 2) | 3338 | 111.8 | N/A |
| 250 | Borehole (WVK 3) | 2521 | 113.7 | N/A |
| 251 | Borehole (NDB 2) | 1302 | 118.2 | N/A |
| 252 | Borehole (NDB 3) | 1761 | 116.1 | N/A |
| 253 | Borehole (NDB 6) | 1521 | 117.1 | N/A |
| 254 | Power lines/Pylons | 2469 | 113.8 | N/A |
| 255 | Power lines/Pylons | 385 | 126.6 | N/A |
| 256 | Power lines/Pylons | 191 | 131.4 | N/A |
| 257 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 258 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 259 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 260 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 261 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 262 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 263 | Power lines/Pylons (Inside Pit Area) | - | - | - |
| 264 | Power Station (Inside Pit Area) | - | - | - |
| 265 | Power lines/Pylons | 118 | 134.7 | N/A |

| | | | | |
|---|---|---|---|---|
| 266 | Power lines/Pylons | 214 | 130.6 | N/A |
| 267 | Power lines/Pylons | 474 | 125.1 | N/A |
| 268 | Power lines/Pylons | 670 | 122.8 | N/A |
| 269 | Power lines/Pylons | 230 | 130.1 | N/A |
| 270 | Power lines/Pylons | 603 | 123.5 | N/A |
| 271 | Power lines/Pylons | 871 | 121.0 | N/A |
| 272 | Power lines/Pylons | 860 | 121.1 | N/A |
| 273 | Power lines/Pylons | 1137 | 119.1 | N/A |
| 274 | Power lines/Pylons | 1332 | 118.1 | N/A |
| 275 | Power lines/Pylons | 900 | 120.7 | N/A |
| 276 | Power lines/Pylons | 1216 | 118.7 | N/A |
| 277 | Power lines/Pylons | 1636 | 116.7 | N/A |
| 278 | Power lines/Pylons | 149 | 133.1 | N/A |
| 279 | Power lines/Pylons | 212 | 130.7 | N/A |
| 280 | Power lines/Pylons | 632 | 123.2 | N/A |

### 17.8 Summary of findings for air blast

Review of the air blast levels indicate some concerns. Air blast predicted for the maximum charge ranges between 111.5 and 147.6 dB for all the POI's considered. This includes the nearest points such as the Buildings/Structures. These levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints. The closest structures at 249 m (POI 115) showed concerns of complaints at maximum charge. Minimum charge predictions identified that six POI's at pit area could experience levels of air blast that could lead to complaints. Maximum charge predictions indicate that thirteen POI's at pit area could experience air blast that could lead to complaints. Apart from the buildings/structures (POI 65) inside the pit area, none were identified where damage may be induced.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 130 m and closer to pit boundary. The Buildings/Structures at POI 65 is expected to be relocated and will then not be of concern as it is currently inside the pit area. Infrastructure at the pit area such as roads, heritage sites, power lines/pylons and Hydrocencus boreholes are present but air blast does not have any influence on these installations.

The possible negative effects from air blast are expected to be the same than that of ground vibration. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pit is located such that "free blasting" – meaning no controls on blast preparation – will not be possible. The effect of stemming control will need to be considered. In many cases the lack of proper control on stemming material and length contributes mostly to complaints from neighbours.

### 17.9 Fly-rock unsafe zone

The occurrence of fly rock in any form will have a negative impact if found to travel outside the unsafe zone. This unsafe zone may be anything between 10 m or 1000 m. A general unsafe zone applied by most mines is normally considered to be within a radius of 500 m from the blast; but needs to be qualified and determined as best possible.

Calculations are also used to help and assist determining safe distances. A safe distance from blasting is calculated following rules and guidelines from the International Society of Explosives Engineers (ISEE) Blasters Handbook. Using this calculation, the minimum safe distances can be determined that should be cleared of people, animals and equipment. Figure 19 shows the results from the ISEE calculations for fly rock range based on a 251 mm diameter blast hole and 6.5 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 365 m. The absolute minimum unsafe zone is then the 365 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Figure 20 shows the area around the Pit that incorporates the 365 m unsafe zone.

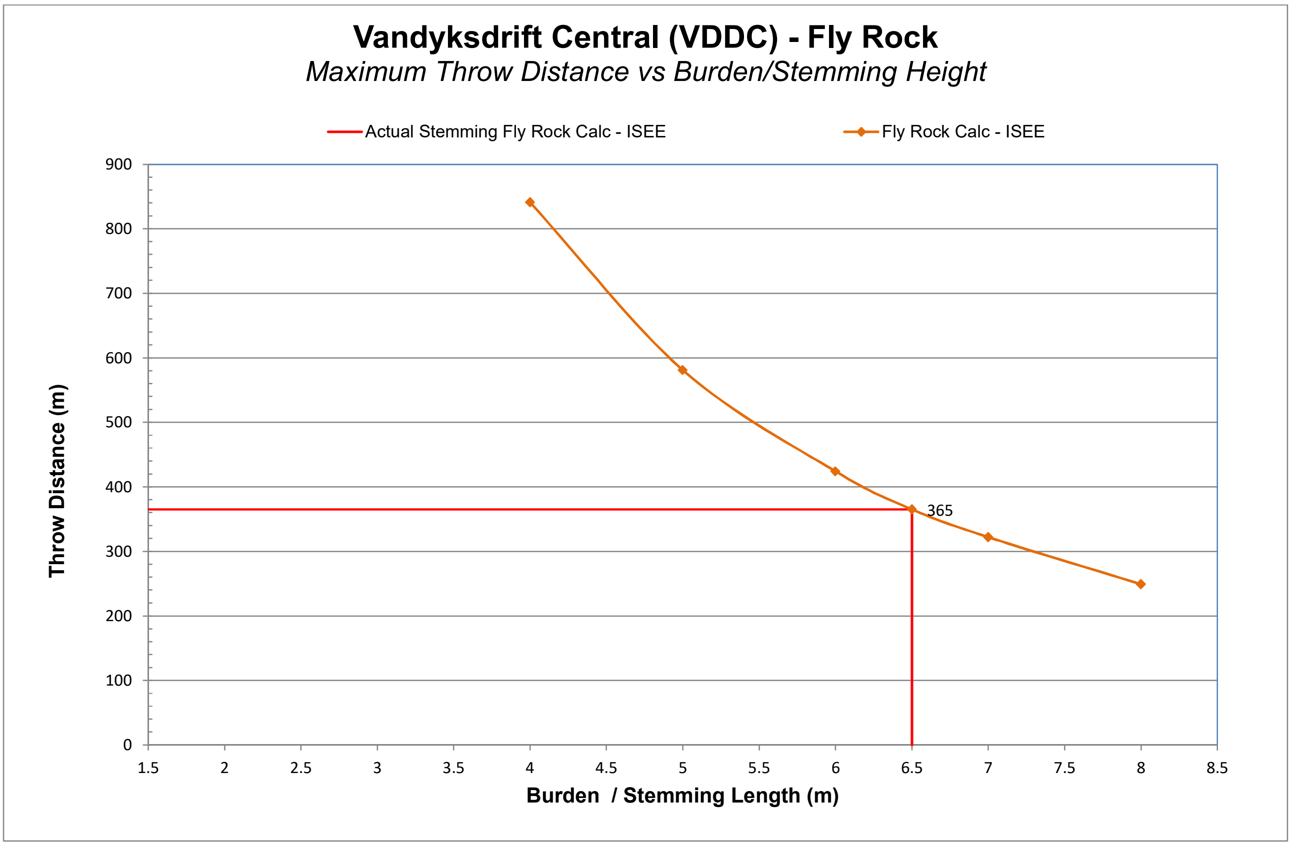



Figure 19: Fly rock prediction calculation

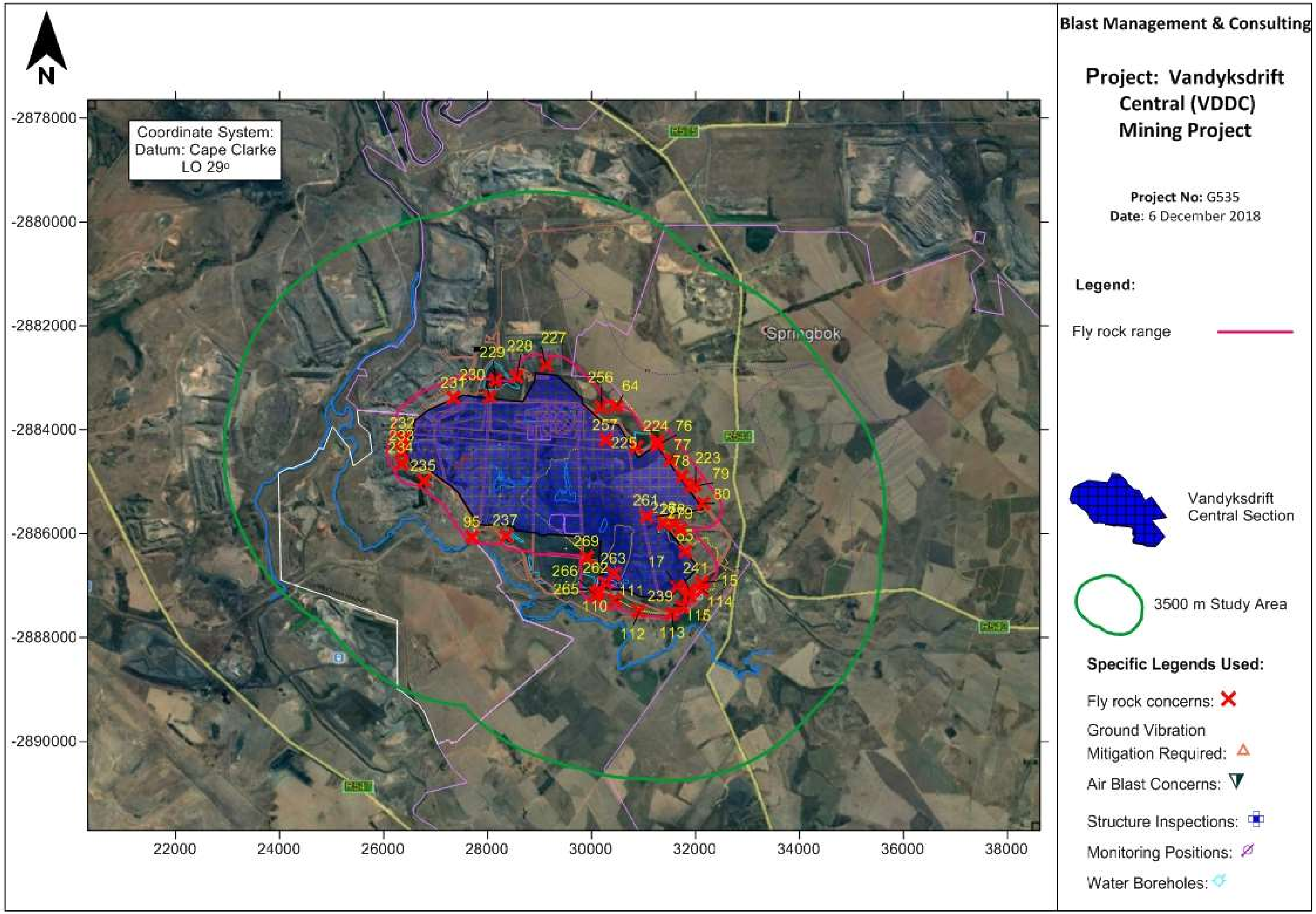



Figure 20: Predicted Fly Rock Exclusion Zone for the Pit

Review of the calculated unsafe zone showed forty-two POI's for the Pit (including six POI's inside the pit area at this stage), are within the unsafe zone. This includes mainly the Railway Lines, Power Lines, Building/Structures, Dam and Graves. Table 16 below shows the POI's of concern and coordinates.

Table 16: Fly rock concern POI's

| Tag | Description | Y | X |
|---|---|---|---|
| 15 | Heritage Site (Railway Station) | -32130.50 | 2886945.19 |
| 17 | Heritage Site (Graveyard) – (Inside Pit Area) | -31654.38 | 2887030.83 |
| 64 | Cultivated Fields | -30490.37 | 2883543.67 |
| 65 | Buildings/Structures (Inside Pit Area) | -31813.45 | 2886337.60 |
| 76 | Power lines/Pylons | -31277.88 | 2884292.98 |
| 77 | Power lines/Pylons | -31508.85 | 2884594.26 |
| 78 | Power lines/Pylons | -31745.54 | 2884901.76 |
| 79 | Power lines/Pylons | -31903.89 | 2885104.23 |
| 80 | Power lines/Pylons | -32140.50 | 2885418.17 |
| 95 | Olifants River | -27710.35 | 2886077.44 |
| 110 | Railway Line | -30119.79 | 2887149.05 |
| 111 | Railway Line/Bridge | -30448.54 | 2887285.80 |
| 112 | Railway Line | -30916.51 | 2887497.74 |
| 113 | Railway Line | -31550.39 | 2887539.25 |
| 114 | Railway Line | -32136.13 | 2887080.04 |
| 115 | Buildings/Structures | -31875.06 | 2887206.82 |
| 216 | Road | -31393.02 | 2885806.08 |
| 223 | Cultivated Fields | -31997.87 | 2885062.04 |
| 224 | Dam | -31258.26 | 2884229.57 |
| 225 | Dam | -30873.90 | 2884328.42 |
| 227 | Mine Activity | -29115.51 | 2882749.13 |
| 228 | Mine Buildings/Structures | -28562.37 | 2882973.09 |
| 229 | Dam | -28148.42 | 2883052.82 |
| 230 | Mine Buildings/Structures | -28040.40 | 2883376.03 |
| 231 | Dam | -27354.93 | 2883398.20 |
| 232 | Dam | -26374.24 | 2884174.18 |
| 233 | Dam | -26361.40 | 2884415.81 |
| 234 | Dam | -26345.90 | 2884648.97 |
| 235 | Dam | -26773.13 | 2884991.71 |
| 237 | Pan | -28351.69 | 2886048.92 |
| 239 | Building/Structure | -31739.66 | 2887406.91 |
| 241 | Cement Dam | -31887.15 | 2887094.54 |
| 256 | Power lines/Pylons | -30190.90 | 2883575.02 |
| 257 | Power lines/Pylons (Inside Pit Area) | -30277.04 | 2884211.06 |

| Tag | Description | Y | X |
|---|---|---|---|
| 261 | Power lines/Pylons (Inside Pit Area) | -31057.93 | 2885661.44 |
| 262 | Power lines/Pylons (Inside Pit Area) | -30281.03 | 2886948.38 |
| 263 | Power lines/Pylons (Inside Pit Area) | -30433.06 | 2886779.17 |
| 265 | Power lines/Pylons | -30136.45 | 2887110.44 |
| 266 | Power lines/Pylons | -30071.18 | 2887183.23 |
| 269 | Power lines/Pylons | -29916.77 | 2886446.33 |
| 278 | Power lines/Pylons | -31575.31 | 2885832.25 |
| 279 | Power lines/Pylons | -31721.89 | 2885912.09 |

## 17.10 Noxious fumes

The occurrence of fumes in the form the NOx gas is not a given and very dependent on various factors as discussed in Section 13.6. However, the occurrence of fumes should be closely monitored. Furthermore, nothing can be stated as to fume dispersal to nearby farmsteads, but if anybody is present in the path of the fume cloud it could be problematic.

## 17.11 Water borehole influence

Location of boreholes for water was evaluated for possible influence from blasting. Ten Hydrocencus boreholes were identified within the influence area at the Pit. There are boreholes that are in close proximity of the blasting areas but are found to be within acceptable limits. Table 17 shows all the identified boreholes.
Figure 21 shows the location of the boreholes in the area.

Table 17: Identified water boreholes

| Tag | Description | Y | X | Specific Limit (mm/s) | Distance (m) to nearest Pit | Predicted PPV (mm/s) |
|---|---|---|---|---|---|---|
| 244 | Borehole (WBH 2S1) | -29623.41 | 2880456.63 | 50 | 2512 | 2.5 |
| 245 | Borehole (WBH 2S8) | -30607.18 | 2883505.57 | 50 | 417 | 48.4 |
| 246 | Borehole (SKS BH2) | -30135.02 | 2880201.13 | 50 | 2864 | 2.0 |
| 247 | Borehole (VLKR 3) | -29605.09 | 2880445.51 | 50 | 2521 | 2.5 |
| 248 | Borehole (WVK 1) | -30136.89 | 2879868.76 | 50 | 3185 | 1.7 |
| 249 | Borehole (WVK 2) | -30343.98 | 2879769.53 | 50 | 3338 | 1.6 |
| 250 | Borehole (WVK 3) | -29605.09 | 2880445.51 | 50 | 2521 | 2.5 |
| 251 | Borehole (NDB 2) | -28377.85 | 2881742.75 | 50 | 1302 | 7.4 |
| 252 | Borehole (NDB 3) | -29468.29 | 2881194.89 | 50 | 1761 | 4.5 |
| 253 | Borehole (NDB 6) | -28663.78 | 2881422.08 | 50 | 1521 | 5.7 |

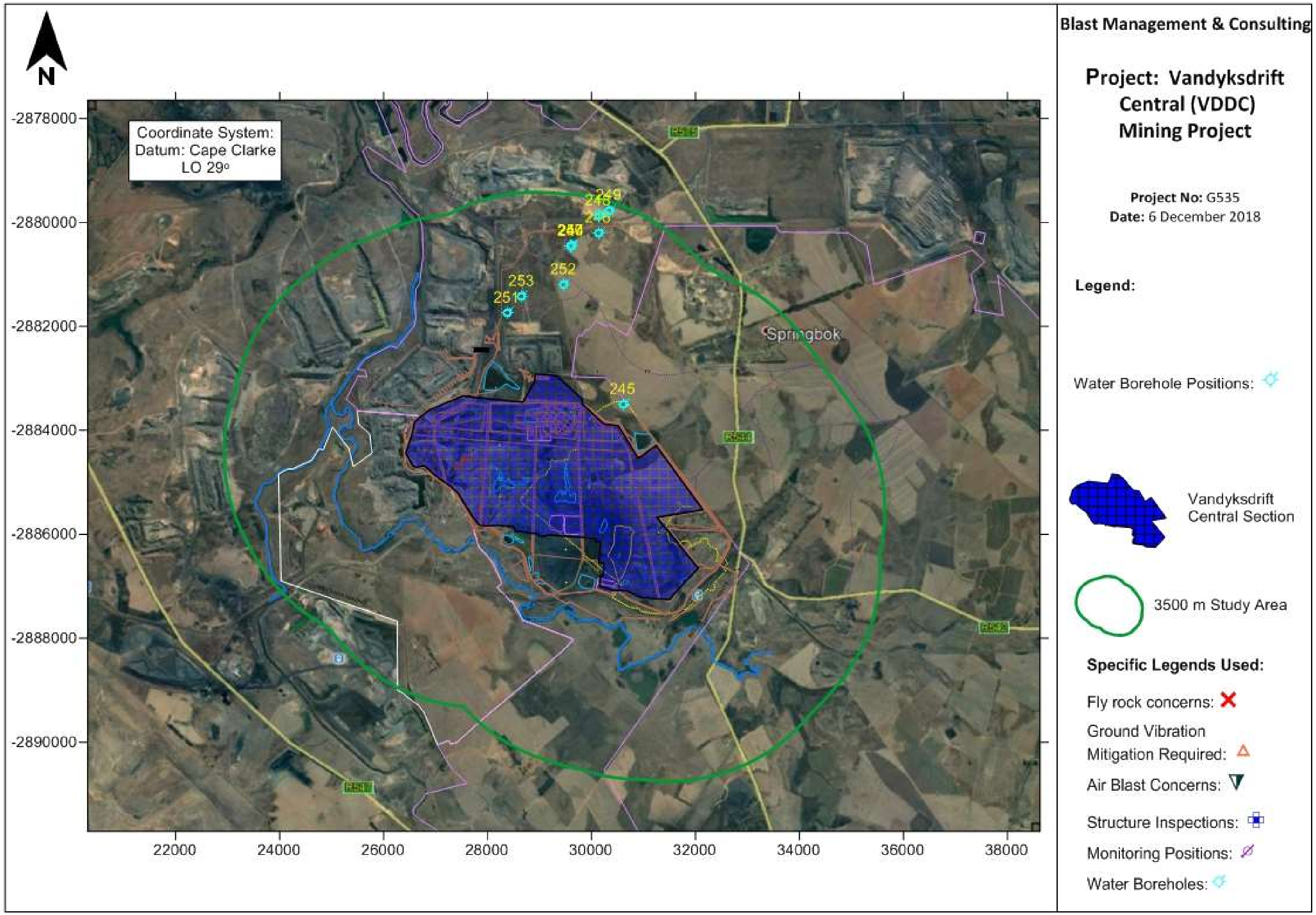



Figure 21: Location of the Boreholes for the Pit

## 17.12 Potential Environmental Impact Assessment: Operational Phase

The following is the impact assessment of the various concerns covered by this report. The impact assessment and evaluation below were used for analysis and evaluation of aspects discussed in this report. The outcome of the analysis is provided in Table 25 with before mitigation and after mitigation. This risk assessment is a one-sided analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation. The blasting impacts are evaluated as influence from a single blast. There is reason to believe that only when limits are exceeded on a regular basis that a cumulative effect may then be considered. If levels are within the safe limits no additional cumulative influences are experienced. Cumulative effect can only be determined through a process of active monitoring.

**Assessment Methodology**

In order to ensure uniformity, a standard impact assessment methodology will be utilised so that a wide range of impacts can be compared. The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

A combined quantitative and qualitative methodology will be used to describe the impacts for each of the aforementioned assessment criteria. A summary of each of the qualitative descriptors along with the equivalent quantitative rating scale for each of the aforementioned criteria is given in Table 18.

Table 18: Quantitative rating and equivalent descriptors for the impact assessment criteria

| RATING | SIGNIFICANCE | EXTENT SCALE | TEMPORAL SCALE |
|---|---|---|---|
| 1 | VERY LOW | Isolated corridor / proposed corridor | Incidental |
| 2 | LOW | Study area | Short-term |
| 3 | MODERATE | Local | Medium-term |
| 4 | HIGH | Regional / Provincial | Long-term |
| 5 | VERY HIGH | Global / National | Permanent |

A more detailed description of each of the assessment criteria is given in the following sections.

**Significance Assessment**

Significance rating (importance) of the associated impacts embraces the notion of extent and magnitude but does not always clearly define these since their importance in the rating scale is very relative. For example, the magnitude (i.e. the size) of the area affected by atmospheric pollution may be extremely large (1 000 km2) but the significance of this effect is dependent on the concentration or level of pollution. If the concentration is great, the significance of the impact would be HIGH or VERY HIGH, but if it is diluted it would be VERY LOW or LOW. Similarly, if 60 ha of a grassland type are destroyed the impact would be VERY HIGH if only 100 ha of that grassland type were known. The impact would be VERY LOW if the grassland type was common. A more detailed description of the impact significance rating scale is given in Table 19 below.

Table 19: Description of the significance rating scale

| RATING | | DESCRIPTION |
|---|---|---|
| 5 | VERY HIGH | Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit. |
| 4 | HIGH | Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these. |
| 3 | MODERATE | Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc. |
| 2 | LOW | Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these. |
| 1 | VERY LOW | Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale. |
| 0 | NO IMPACT | There is no impact at all - not even a very low impact on a party or system. |

**Spatial Scale**

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in Table 20.

Table 20: Description of the spatial scale

| RATING | | DESCRIPTION |
|---|---|---|
| 5 | Global/National | The maximum extent of any impact. |
| 4 | Regional/Provincial | The spatial scale is moderate within the bounds of impacts possible and will be felt at a regional scale (District Municipality to Provincial Level). The impact will affect an area up to 50km from the proposed site / corridor. |
| 3 | Local | The impact will affect an area up to 5km from the proposed route corridor / site. |
| 2 | Study Area | The impact will affect a route corridor not exceeding the boundary of the corridor / site. |
| 1 | Isolated Sites / proposed site | The impact will affect an area no bigger than the corridor / site. |

**Temporal Scale**

In order to accurately describe the impact, it is necessary to understand the duration and persistence of an impact in the environment. The temporal scale is rated according to criteria set out in Table 21.

Table 21: Description of the temporal rating scale

| RATING | | DESCRIPTION |
|---|---|---|
| 1 | Incidental | The impact will be limited to isolated incidences that are expected to occur very sporadically. |
| 2 | Short-term | The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater. |
| 3 | Medium term | The environmental impact identified will operate for the duration of life of the project. |
| 4 | Long term | The environmental impact identified will operate beyond the life of operation. |
| 5 | Permanent | The environmental impact will be permanent. |

**Degree of Probability**

The probability or likelihood of an impact occurring will be described, as shown in **Table 22** below.

Table 22: Description of the degree of probability of an impact occurring

| RATING | DESCRIPTION |
|---|---|
| 1 | Practically impossible |
| 2 | Unlikely |

| RATING | DESCRIPTION |
|---|---|
| 3 | Could happen |
| 4 | Very Likely |
| 5 | It's going to happen / has occurred |

**Quantitative Description of Impacts**

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus, the total value of the impact is described as the function of significance, spatial and temporal scale as described below.

$$\textit{Impact Risk} = \frac{\text{(SIGNIFICANCE} + \textit{Spatial} + \text{Temporal)}}{3} \times \frac{\text{Probability}}{5}$$

An example of how this rating scale is applied is shown in Table 23.

Table 23: Example of Rating Scale

| IMPACT | SIGNIFICANCE | SPATIAL SCALE | TEMPORAL SCALE | PROBABILITY | RATING |
|---|---|---|---|---|---|
| | LOW | Local | Medium Term | Could Happen | |
| Impact to air | 2 | 3 | 3 | 3 | 1.6 |

Note: The significance, spatial and temporal scales are added to give a total of 8, that is divided by 3 to give a criteria rating of 2.67. The probability (3) is divided by 5 to give a probability rating of 0.6. The criteria rating of 2.67 is then multiplied by the probability rating (0.6) to give the final rating of 1.6. The impact risk is then classified according to 5 classes as described in Table 24.

Table 24: Impact Risk Classes

| RATING | IMPACT CLASS | DESCRIPTION |
|---|---|---|
| 0.1 – 1.0 | 1 | Very Low |
| 1.1 – 2.0 | 2 | Low |
| 2.1 – 3.0 | 3 | Moderate |
| 3.1 – 4.0 | 4 | High |
| 4.1 – 5.0 | 5 | Very High |

Therefore, with reference to the example used for air quality above, an impact rating of 1.6 will fall in the Impact Class 2, which will be considered to be a low impact.

### 17.12.1 Assessment

The assessment done was based on evaluating the points of interested that showed expected levels greater than limits. This is however based on the worst-case scenario where blasting is done at the shortest distance from pit area to the point of interest. In after mitigation consideration was given to the fact that blasting will not be constantly at the short distance and the period of time that the influence may be present is significantly reduced due to that only areas or blocks will be blasted at a time.

Table 25: Impact Assessment Outcome before Mitigation

| No. | Impact | Identified Point of Interest | Significance | Spatial | Temporal | Probability | Impact Risk Before Mitigation | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Score | Score | Score | Score | Rating | Class | Description |
| **Construction Phase** | | | | | | | | | |
| | None | | 0 | 0 | 0 | 0 | 0 | | |
| **Operational Phase** | | | | | | | | | |
| 1 | Ground vibration Impact: | Buildings/Structures | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 2 | | Cement Dam | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 3 | | Dam | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 4 | | Heritage Site (Railway Station) | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 5 | | Informal Housing | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6 | | Informal Settlement (Lindokhule) | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 7 | | Mine Buildings/Structures | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 8 | | Power lines/Pylons | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 9 | | Railway Line | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 10 | | Railway Line/Bridge | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 11 | | Railway Station Buildings | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 12 | | Road | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 13 | | Ruins | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 14 | | Planned new Infrastructure: Pipelines, Roads, dumps, brake test ramp etc. | 3 | 2 | 3 | 3 | 1.6 | 2 | Low |
| 15 | Air blast Impact: | Mine Buildings/Structures | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 16 | | Planned new Infrastructure: Pipelines, Roads, dumps, brake test ramp etc. | 3 | 2 | 3 | 2 | 1.067 | 2 | Low |
| 17 | Fly Rock Impact: | Buildings/Structures | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 18 | | Cement Dam | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 19 | | Dam | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 20 | | Heritage Site (Railway Station) | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 21 | | Mine Activity | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 22 | | Mine Buildings/Structures | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 23 | | Olifants River | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 24 | | Pan | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 25 | | Power lines/Pylons | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 26 | | Railway Line | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 27 | | Railway Line/Bridge | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 28 | | Road | 4 | 3 | 3 | 4 | 2.667 | 3 | Moderate |
| 29 | | Planned new Infrastructure: Pipelines, Roads, dumps, brake test ramp etc. | 3 | 2 | 2 | 4 | 1.867 | 2 | Low |
| **Closure and Post-Closure Phase** | | | | | | | | | |
| | None | | 0 | 0 | 0 | 0 | 0 | | |

Table 26: Impact Assessment Outcome after Mitigation

| No. | Impact | Identified Point of Interest | Mitigation Measures | Significance | Spatial | Temporal | Probability | Impact Risk after Mitigation | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Score | Score | Score | Score | Rating | Class | Description |
| **Construction Phase** | | | **Construction Phase** | | | | | | | |
| | None | | | 0 | 0 | 0 | 0 | 0 | | |
| **Operational Phase** | | | **Operational Phase** | | | | | | | |
| 1 | Ground vibration Impact: | Buildings/Structures | Reduce Charge Mass/Delay, Smaller blasts, Smaller diameter blastholes, Smaller charges, Reconsider blast initiation system - electronics, Relocate POI's of concern at least 500 m, proper blast design. | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 2 | | Cement Dam | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 3 | | Dam | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 4 | | Heritage Site (Railway Station) | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 5 | | Informal Housing | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 6 | | Informal Settlement (Lindokhule) | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 7 | | Mine Buildings/Structures | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | | Power lines/Pylons | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 9 | | Railway Line | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 10 | | Railway Line/Bridge | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 11 | | Railway Station Buildings | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 12 | | Road | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 13 | | Ruins | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 14 | | Planned new Infrastructure: Pipelines, Roads, dumps, brake test ramp etc. | Blasting is restricted to short period of time at any of the infrastructure. | 3 | 2 | 2 | 3 | 1.4 | 2 | Low |
| 15 | Air blast Impact: | Mine Buildings/Structures | Reduce Charge Mass/Delay, increase stemming length, controls put in place for management of stemming lengths and quality stemming material, Relocate POI's of concern at least 500m, Proper blast design. | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 16 | | Planned new Infrastructure: Pipelines, Roads, dumps, brake test ramp etc. | | 3 | 2 | 3 | 2 | 1.067 | 2 | Low |
| 17 | Fly Rock Impact: | Buildings/Structures | Reduce Charge Mass/Delay, increase stemming length, controls put in place for management of stemming lengths and quality stemming material, Relocate POI's of concern at least 500m, Proper blast design. | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 18 | | Cement Dam | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 19 | | Dam | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 20 | | Heritage Site (Railway Station) | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 21 | | Mine Activity | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 22 | | Mine Buildings/Structures | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 23 | | Olifants River | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 24 | | Pan | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | | Power lines/Pylons | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 26 | | Railway Line | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 27 | | Railway Line/Bridge | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 28 | | Road | | 3 | 3 | 2 | 3 | 1.6 | 2 | Low |
| 29 | | Planned new Infrastructure: Pipelines, , Roads, dumps, brake test ramp etc. | | 3 | 2 | 2 | 3 | 1.4 | 2 | Low |
| **Closure and Post-Closure Phase** | | | **Closure and Post-Closure Phase** | | | | | | | |
| | None | | | 0 | 0 | 0 | 0 | 0 | | |

## 17.13 Mitigations

In review of the evaluations made in this report it is certain that specific mitigation will be required with regards to ground vibration. Ground vibration is the primary possible cause of structural damage and requires more detailed planning in preventing damage and maintaining levels within accepted norms. Air blast and fly rock can be controlled using proper charging methodology irrespective of the blast hole diameter and patterns used. Ground vibration requires more detailed planning and forms the focus for mitigation measures.

Specific impacts are expected at the following POI's identified. Table 27 shows list of POI's that will need to be considered and Table 28 the POI's that needs specific attention due to location of the infrastructure. Figure 22 shows the location of these POI's in relation to the pit areas.

Table 27: Structures identified as problematic in and around the project area

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 1 | Informal Settlement (Lindokhule) | 1 | -32271.50 | 2887651.13 |
| 2 | Ruins | 1 | -30974.21 | 2887738.67 |
| 13 | Buildings/Structures | 2 | -30291.07 | 2887574.45 |
| 15 | Heritage Site (Railway Station) | 7 | -32130.50 | 2886945.19 |
| 17 | Heritage Site (Graveyard) - Inside Pit Area | 7 | -31654.38 | 2887030.83 |
| 65 | Buildings/Structures (Inside Pit Area) | 2 | -31813.45 | 2886337.60 |
| 76 | Power lines/Pylons | 5 | -31277.88 | 2884292.98 |
| 77 | Power lines/Pylons | 5 | -31508.85 | 2884594.26 |
| 78 | Power lines/Pylons | 5 | -31745.54 | 2884901.76 |
| 79 | Power lines/Pylons | 5 | -31903.89 | 2885104.23 |
| 80 | Power lines/Pylons | 5 | -32140.50 | 2885418.17 |
| 82 | Buildings/Structures | 2 | -32668.59 | 2885841.19 |
| 110 | Railway Line | 5 | -30119.79 | 2887149.05 |
| 111 | Railway Line/Bridge | 5 | -30448.54 | 2887285.80 |
| 115 | Buildings/Structures | 2 | -31875.06 | 2887206.82 |
| 116 | Railway Station Buildings | 5 | -32087.55 | 2887164.74 |
| 192 | Dam | 5 | -28388.17 | 2883032.31 |
| 193 | Structure | 2 | -28273.19 | 2882830.44 |
| 201 | Informal Settlement (Lindokhule) | 1 | -32317.23 | 2887907.72 |
| 202 | Informal Settlement (Lindokhule) | 1 | -32435.02 | 2887534.69 |
| 204 | Informal Settlement (Lindokhule) | 1 | -32409.90 | 2887737.04 |
| 216 | Road | 5 | -31393.02 | 2885806.08 |
| 219 | Informal Housing | 1 | -33128.44 | 2885672.98 |
| 220 | Informal Housing | 1 | -33061.44 | 2885579.07 |
| 221 | Informal Housing | 1 | -33002.20 | 2885510.95 |
| 222 | Informal Housing | 1 | -33036.99 | 2885450.50 |
| 224 | Dam | 5 | -31258.26 | 2884229.57 |
| 225 | Dam | 5 | -30873.90 | 2884328.42 |

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 226 | Mine Buildings/Structures | 5 | -28591.00 | 2882724.61 |
| 228 | Mine Buildings/Structures | 5 | -28562.37 | 2882973.09 |
| 229 | Dam | 5 | -28148.42 | 2883052.82 |
| 230 | Mine Buildings/Structures | 5 | -28040.40 | 2883376.03 |
| 231 | Dam | 5 | -27354.93 | 2883398.20 |
| 232 | Dam | 5 | -26374.24 | 2884174.18 |
| 233 | Dam | 5 | -26361.40 | 2884415.81 |
| 234 | Dam | 5 | -26345.90 | 2884648.97 |
| 235 | Dam | 5 | -26773.13 | 2884991.71 |
| 238 | Building/Structure | 2 | -32514.43 | 2886558.36 |
| 239 | Building/Structure | 2 | -31739.66 | 2887406.91 |
| 240 | Building/Structure | 2 | -31567.28 | 2887607.14 |
| 241 | Cement Dam | 5 | -31887.15 | 2887094.54 |
| 256 | Power lines/Pylons | 5 | -30190.90 | 2883575.02 |
| 261 | Power lines/Pylons (Inside Pit Area) | 5 | -31057.93 | 2885661.44 |
| 262 | Power lines/Pylons (Inside Pit Area) | 5 | -30281.03 | 2886948.38 |
| 263 | Power lines/Pylons (Inside Pit Area) | 5 | -30433.06 | 2886779.17 |
| 264 | Power Station (Inside Pit Area) | 5 | -30567.03 | 2886714.64 |
| 265 | Power lines/Pylons | 5 | -30136.45 | 2887110.44 |
| 266 | Power lines/Pylons | 5 | -30071.18 | 2887183.23 |
| 269 | Power lines/Pylons | 5 | -29916.77 | 2886446.33 |
| 278 | Power lines/Pylons | 5 | -31575.31 | 2885832.25 |
| 279 | Power lines/Pylons | 5 | -31721.89 | 2885912.09 |

Table 28: Structures identified that needs specific attention due to location inside the planned pit area

| Tag | Description | Classification | Y | X |
|---|---|---|---|---|
| 17 | Heritage Site (Graveyard) - Inside Pit Area | 7 | -31654.38 | 2887030.83 |
| 65 | Buildings/Structures (Inside Pit Area) | 2 | -31813.45 | 2886337.60 |
| 261 | Power lines/Pylons (Inside Pit Area) | 5 | -31057.93 | 2885661.44 |
| 262 | Power lines/Pylons (Inside Pit Area) | 5 | -30281.03 | 2886948.38 |
| 263 | Power lines/Pylons (Inside Pit Area) | 5 | -30433.06 | 2886779.17 |
| 264 | Power Station (Inside Pit Area) | 5 | -30567.03 | 2886714.64 |

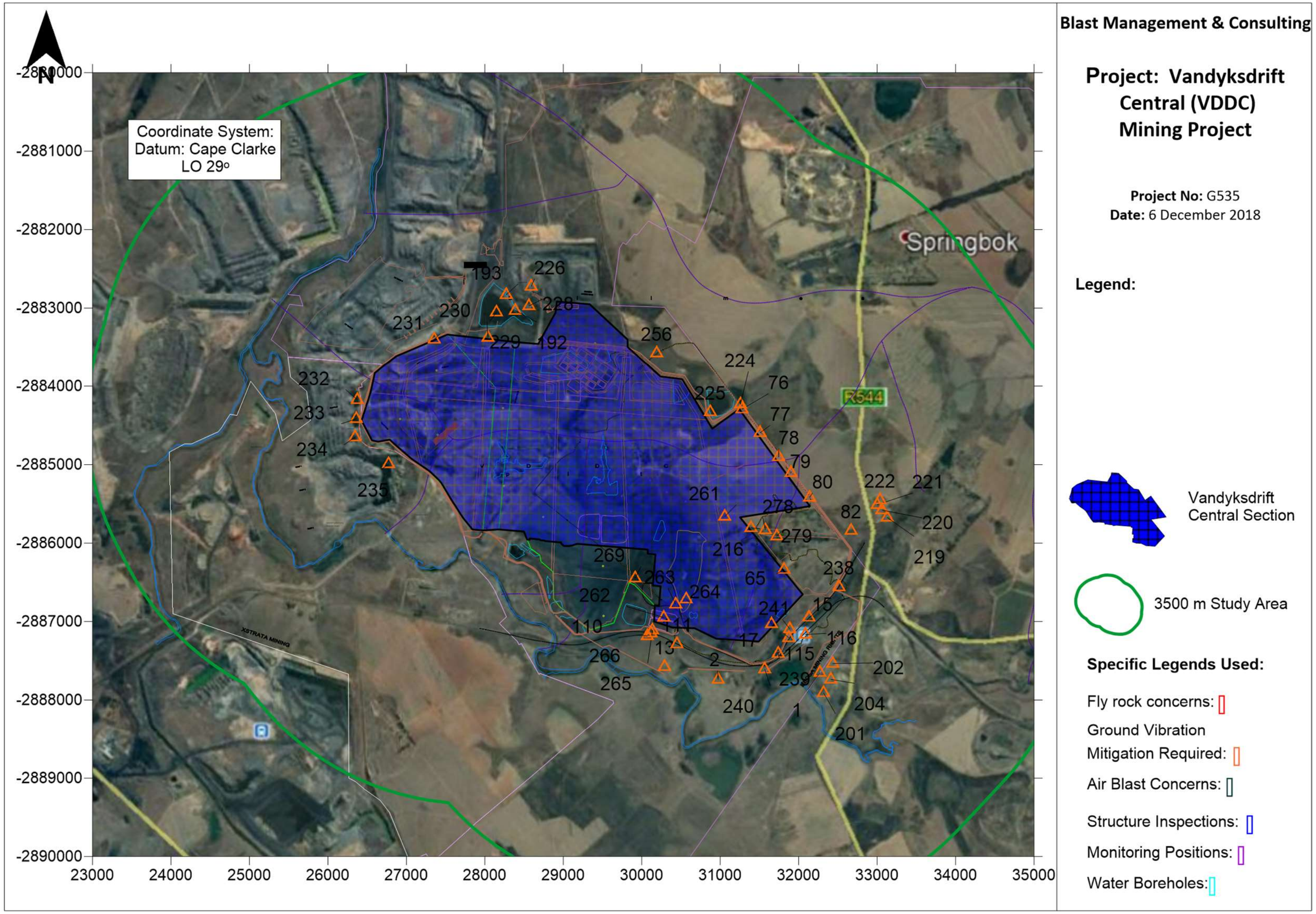



Figure 22: Structures identified where ground vibration mitigation will be required.

Mitigation of ground vibration for this can be done applying the following methods:

- Do blast design that considers the actual blasting and the ground vibration levels to be adhered too.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.
- Relocate the POI / acquire the POI of concern – mined owned.

The identified POI's of concern is found in close proximity of the actual operations. Some of the POI's identified includes mine infrastructure. In order to give indication of the possibilities of mitigation to consider two basic indicators are presented. Firstly, the maximum charge per delay that can be allowed for the shortest distance between blast and POI. Secondly the minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay. These table gives indication for planning of blasts when blast at shortest distance to the POI's.

Table 29 do show mitigation in the form of maximum charge mass that will be allowed to maintain safe levels of ground vibration. Table 30 shows minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay.

Table 29: Mitigation measures: Maximum charge per delay for distance to POI

| Tag | Description | Y | X | Specific Limit (mm/s) | Distance (m) | Total Mass/Delay (kg) | Predicted PPV (mm/s) | Structure Response @ 10Hz |
|---|---|---|---|---|---|---|---|---|
| 1 | Informal Settlement (Lindokhule) | -32271.50 | 2887651.13 | 6 | 842 | 1222 | 6.0 | Acceptable |
| 2 | Ruins | -30974.21 | 2887738.67 | 6 | 517 | 461 | 6.0 | Acceptable |
| 13 | Buildings/Structures | -30291.07 | 2887574.45 | 12.5 | 512 | 1098 | 12.5 | Acceptable |
| 15 | Heritage Site (Railway Station) | -32130.50 | 2886945.19 | 25 | 257 | 642 | 25.0 | Acceptable |
| 76 | Power lines/Pylons | -31277.88 | 2884292.98 | 75 | 142 | 746 | 75.0 | Acceptable |
| 77 | Power lines/Pylons | -31508.85 | 2884594.26 | 75 | 101 | 374 | 75.0 | Acceptable |
| 78 | Power lines/Pylons | -31745.54 | 2884901.76 | 75 | 100 | 368 | 75.0 | Acceptable |
| 79 | Power lines/Pylons | -31903.89 | 2885104.23 | 75 | 103 | 387 | 75.0 | Acceptable |
| 80 | Power lines/Pylons | -32140.50 | 2885418.17 | 75 | 100 | 369 | 75.0 | Acceptable |
| 82 | Buildings/Structures | -32668.59 | 2885841.19 | 12.5 | 651 | 1779 | 12.5 | Acceptable |
| 110 | Railway Line | -30119.79 | 2887149.05 | 150 | 160 | 2188 | 150.0 | Acceptable |
| 111 | Railway Line/Bridge | -30448.54 | 2887285.80 | 50 | 208 | 976 | 50.0 | Acceptable |
| 115 | Buildings/Structures | -31875.06 | 2887206.82 | 12.5 | 249 | 260 | 12.5 | Acceptable |
| 116 | Railway Station Buildings | -32087.55 | 2887164.74 | 25 | 376 | 1371 | 25.0 | Acceptable |
| 192 | Dam | -28388.17 | 2883032.31 | 50 | 397 | 3555 | 50.0 | Acceptable |
| 193 | Structure | -28273.19 | 2882830.44 | 12.5 | 586 | 1439 | 12.5 | Acceptable |
| 201 | Informal Settlement (Lindokhule) | -32317.23 | 2887907.72 | 6 | 1051 | 1903 | 6.0 | Acceptable |
| 202 | Informal Settlement (Lindokhule) | -32435.02 | 2887534.69 | 6 | 882 | 1340 | 6.0 | Acceptable |
| 204 | Informal Settlement (Lindokhule) | -32409.90 | 2887737.04 | 6 | 1002 | 1730 | 6.0 | Acceptable |
| 216 | Road | -31393.02 | 2885806.08 | 150 | 25 | 55 | 150.0 | Acceptable |

| Tag | Description | Y | X | Specific Limit (mm/s) | Distance (m) | Total Mass/Delay (kg) | Predicted PPV (mm/s) | Structure Response @ 10Hz |
|---|---|---|---|---|---|---|---|---|
| 219 | Informal Housing | -33128.44 | 2885672.98 | 6 | 1040 | 1864 | 6.0 | Acceptable |
| 220 | Informal Housing | -33061.44 | 2885579.07 | 6 | 964 | 1601 | 6.0 | Acceptable |
| 221 | Informal Housing | -33002.20 | 2885510.95 | 6 | 903 | 1406 | 6.0 | Acceptable |
| 222 | Informal Housing | -33036.99 | 2885450.50 | 6 | 941 | 1526 | 6.0 | Acceptable |
| 224 | Dam | -31258.26 | 2884229.57 | 50 | 202 | 919 | 50.0 | Acceptable |
| 225 | Dam | -30873.90 | 2884328.42 | 50 | 174 | 679 | 50.0 | Acceptable |
| 226 | Mine Buildings/Structures | -28591.00 | 2882724.61 | 25 | 388 | 1463 | 25.0 | Acceptable |
| 228 | Mine Buildings/Structures | -28562.37 | 2882973.09 | 25 | 337 | 1107 | 25.0 | Acceptable |
| 229 | Dam | -28148.42 | 2883052.82 | 50 | 351 | 2776 | 50.0 | Acceptable |
| 230 | Mine Buildings/Structures | -28040.40 | 2883376.03 | 25 | 24 | 6 | 25.0 | Acceptable |
| 231 | Dam | -27354.93 | 2883398.20 | 50 | 23 | 12 | 50.0 | Acceptable |
| 232 | Dam | -26374.24 | 2884174.18 | 50 | 192 | 828 | 50.0 | Acceptable |
| 233 | Dam | -26361.40 | 2884415.81 | 50 | 188 | 798 | 50.0 | Acceptable |
| 234 | Dam | -26345.90 | 2884648.97 | 50 | 192 | 833 | 50.0 | Acceptable |
| 235 | Dam | -26773.13 | 2884991.71 | 50 | 300 | 2022 | 50.0 | Acceptable |
| 238 | Building/Structure | -32514.43 | 2886558.36 | 12.5 | 484 | 983 | 12.5 | Acceptable |
| 239 | Building/Structure | -31739.66 | 2887406.91 | 12.5 | 287 | 345 | 12.5 | Acceptable |
| 240 | Building/Structure | -31567.28 | 2887607.14 | 12.5 | 366 | 561 | 12.5 | Acceptable |
| 241 | Cement Dam | -31887.15 | 2887094.54 | 50 | 182 | 746 | 50.0 | Acceptable |
| 256 | Power lines/Pylons | -30190.90 | 2883575.02 | 75 | 191 | 1347 | 75.0 | Acceptable |
| 265 | Power lines/Pylons | -30136.45 | 2887110.44 | 75 | 118 | 514 | 75.0 | Acceptable |
| 266 | Power lines/Pylons | -30071.18 | 2887183.23 | 75 | 214 | 1679 | 75.0 | Acceptable |
| 269 | Power lines/Pylons | -29916.77 | 2886446.33 | 75 | 230 | 1946 | 75.0 | Acceptable |
| 278 | Power lines/Pylons | -31575.31 | 2885832.25 | 75 | 149 | 819 | 75.0 | Acceptable |
| 279 | Power lines/Pylons | -31721.89 | 2885912.09 | 75 | 212 | 1658 | 75.0 | Acceptable |

Table 30: Mitigation measures: Minimum distance for minimum and maximum charge to POI

| Tag | Description | Y | X | Specific Limit (mm/s) | Distance (m) | Total Mass/Delay (kg) | Predicted PPV (mm/s) | Structure Response @ 10Hz |
|---|---|---|---|---|---|---|---|---|
| **Minimum distance required between blast and POI for Minimum Charge per delay** | | | | | | | | |
| 1 | Informal Settlement (Lindokhule) | -32271.50 | 2887651.13 | 6 | 660 | 751 | 6.0 | Acceptable |
| 2 | Ruins | -30974.21 | 2887738.67 | 6 | 660 | 751 | 6.0 | Acceptable |
| 13 | Buildings/Structures | -30291.07 | 2887574.45 | 12.5 | 423 | 751 | 12.5 | Acceptable |
| 15 | Heritage Site (Railway Station) | -32130.50 | 2886945.19 | 25 | 278 | 751 | 25.0 | Acceptable |
| 76 | Power lines/Pylons | -31277.88 | 2884292.98 | 75 | 143 | 751 | 75.0 | Acceptable |
| 77 | Power lines/Pylons | -31508.85 | 2884594.26 | 75 | 143 | 751 | 75.0 | Acceptable |
| 78 | Power lines/Pylons | -31745.54 | 2884901.76 | 75 | 143 | 751 | 75.0 | Acceptable |
| 79 | Power lines/Pylons | -31903.89 | 2885104.23 | 75 | 143 | 751 | 75.0 | Acceptable |
| 80 | Power lines/Pylons | -32140.50 | 2885418.17 | 75 | 143 | 751 | 75.0 | Acceptable |
| 82 | Buildings/Structures | -32668.59 | 2885841.19 | 12.5 | 423 | 751 | 12.5 | Acceptable |
| 110 | Railway Line | -30119.79 | 2887149.05 | 150 | 94 | 751 | 150.0 | Acceptable |
| 111 | Railway Line/Bridge | -30448.54 | 2887285.80 | 50 | 183 | 751 | 50.0 | Acceptable |
| 115 | Buildings/Structures | -31875.06 | 2887206.82 | 12.5 | 423 | 751 | 12.5 | Acceptable |
| 116 | Railway Station Buildings | -32087.55 | 2887164.74 | 25 | 278 | 751 | 25.0 | Acceptable |
| 192 | Dam | -28388.17 | 2883032.31 | 50 | 183 | 751 | 50.0 | Acceptable |

| Tag | Description | Y | X | Specific Limit (mm/s) | Distance (m) | Total Mass/Delay (kg) | Predicted PPV (mm/s) | Structure Response @ 10Hz |
|---|---|---|---|---|---|---|---|---|
| 193 | Structure | -28273.19 | 2882830.44 | 12.5 | 423 | 751 | 12.5 | Acceptable |
| 201 | Informal Settlement (Lindokhule) | -32317.23 | 2887907.72 | 6 | 660 | 751 | 6.0 | Acceptable |
| 202 | Informal Settlement (Lindokhule) | -32435.02 | 2887534.69 | 6 | 660 | 751 | 6.0 | Acceptable |
| 204 | Informal Settlement (Lindokhule) | -32409.90 | 2887737.04 | 6 | 660 | 751 | 6.0 | Acceptable |
| 216 | Road | -31393.02 | 2885806.08 | 150 | 94 | 751 | 150.0 | Acceptable |
| 219 | Informal Housing | -33128.44 | 2885672.98 | 6 | 660 | 751 | 6.0 | Acceptable |
| 220 | Informal Housing | -33061.44 | 2885579.07 | 6 | 660 | 751 | 6.0 | Acceptable |
| 221 | Informal Housing | -33002.20 | 2885510.95 | 6 | 660 | 751 | 6.0 | Acceptable |
| 222 | Informal Housing | -33036.99 | 2885450.50 | 6 | 660 | 751 | 6.0 | Acceptable |
| 224 | Dam | -31258.26 | 2884229.57 | 50 | 183 | 751 | 50.0 | Acceptable |
| 225 | Dam | -30873.90 | 2884328.42 | 50 | 183 | 751 | 50.0 | Acceptable |
| 226 | Mine Buildings/Structures | -28591.00 | 2882724.61 | 25 | 278 | 751 | 25.0 | Acceptable |
| 228 | Mine Buildings/Structures | -28562.37 | 2882973.09 | 25 | 278 | 751 | 25.0 | Acceptable |
| 229 | Dam | -28148.42 | 2883052.82 | 50 | 183 | 751 | 50.0 | Acceptable |
| 230 | Mine Buildings/Structures | -28040.40 | 2883376.03 | 25 | 278 | 751 | 25.0 | Acceptable |
| 231 | Dam | -27354.93 | 2883398.20 | 50 | 183 | 751 | 50.0 | Acceptable |
| 232 | Dam | -26374.24 | 2884174.18 | 50 | 183 | 751 | 50.0 | Acceptable |
| 233 | Dam | -26361.40 | 2884415.81 | 50 | 183 | 751 | 50.0 | Acceptable |
| 234 | Dam | -26345.90 | 2884648.97 | 50 | 183 | 751 | 50.0 | Acceptable |
| 235 | Dam | -26773.13 | 2884991.71 | 50 | 183 | 751 | 50.0 | Acceptable |
| 238 | Building/Structure | -32514.43 | 2886558.36 | 12.5 | 423 | 751 | 12.5 | Acceptable |
| 239 | Building/Structure | -31739.66 | 2887406.91 | 12.5 | 423 | 751 | 12.5 | Acceptable |
| 240 | Building/Structure | -31567.28 | 2887607.14 | 12.5 | 423 | 751 | 12.5 | Acceptable |
| 241 | Cement Dam | -31887.15 | 2887094.54 | 50 | 183 | 751 | 50.0 | Acceptable |
| 256 | Power lines/Pylons | -30190.90 | 2883575.02 | 75 | 143 | 751 | 75.0 | Acceptable |
| 265 | Power lines/Pylons | -30136.45 | 2887110.44 | 75 | 143 | 751 | 75.0 | Acceptable |
| 266 | Power lines/Pylons | -30071.18 | 2887183.23 | 75 | 143 | 751 | 75.0 | Acceptable |
| 269 | Power lines/Pylons | -29916.77 | 2886446.33 | 75 | 143 | 751 | 75.0 | Acceptable |
| 278 | Power lines/Pylons | -31575.31 | 2885832.25 | 75 | 143 | 751 | 75.0 | Acceptable |
| 279 | Power lines/Pylons | -31721.89 | 2885912.09 | 75 | 143 | 751 | 75.0 | Acceptable |
| **Minimum distance required between blast and POI for Maximum Charge per delay** | | | | | | | | |
| **Tag** | **Description** | **Y** | **X** | **Specific Limit (mm/s)** | **Distance (m)** | **Total Mass/Delay (kg)** | **Predicted PPV (mm/s)** | **Structure Response @ 10Hz** |
| 1 | Informal Settlement (Lindokhule) | -32271.50 | 2887651.13 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 2 | Ruins | -30974.21 | 2887738.67 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 13 | Buildings/Structures | -30291.07 | 2887574.45 | 12.5 | 946 | 3756 | 12.5 | Acceptable |
| 15 | Heritage Site (Railway Station) | -32130.50 | 2886945.19 | 25 | 622 | 3756 | 25.0 | Acceptable |
| 76 | Power lines/Pylons | -31277.88 | 2884292.98 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 77 | Power lines/Pylons | -31508.85 | 2884594.26 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 78 | Power lines/Pylons | -31745.54 | 2884901.76 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 79 | Power lines/Pylons | -31903.89 | 2885104.23 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 80 | Power lines/Pylons | -32140.50 | 2885418.17 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 82 | Buildings/Structures | -32668.59 | 2885841.19 | 12.5 | 946 | 3756 | 12.5 | Acceptable |
| 110 | Railway Line | -30119.79 | 2887149.05 | 150 | 210 | 3756 | 150.0 | Acceptable |
| 111 | Railway Line/Bridge | -30448.54 | 2887285.80 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 115 | Buildings/Structures | -31875.06 | 2887206.82 | 12.5 | 946 | 3756 | 12.5 | Acceptable |
| 116 | Railway Station Buildings | -32087.55 | 2887164.74 | 25 | 622 | 3756 | 25.0 | Acceptable |

| Tag | Description | Y | X | Specific Limit (mm/s) | Distance (m) | Total Mass/Delay (kg) | Predicted PPV (mm/s) | Structure Response @ 10Hz |
|---|---|---|---|---|---|---|---|---|
| 192 | Dam | -28388.17 | 2883032.31 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 193 | Structure | -28273.19 | 2882830.44 | 12.5 | 946 | 3756 | 12.5 | Acceptable |
| 201 | Informal Settlement (Lindokhule) | -32317.23 | 2887907.72 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 202 | Informal Settlement (Lindokhule) | -32435.02 | 2887534.69 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 204 | Informal Settlement (Lindokhule) | -32409.90 | 2887737.04 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 216 | Road | -31393.02 | 2885806.08 | 150 | 210 | 3756 | 150.0 | Acceptable |
| 219 | Informal Housing | -33128.44 | 2885672.98 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 220 | Informal Housing | -33061.44 | 2885579.07 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 221 | Informal Housing | -33002.20 | 2885510.95 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 222 | Informal Housing | -33036.99 | 2885450.50 | 6 | 1476 | 3756 | 6.0 | Acceptable |
| 224 | Dam | -31258.26 | 2884229.57 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 225 | Dam | -30873.90 | 2884328.42 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 226 | Mine Buildings/Structures | -28591.00 | 2882724.61 | 25 | 622 | 3756 | 25.0 | Acceptable |
| 228 | Mine Buildings/Structures | -28562.37 | 2882973.09 | 25 | 622 | 3756 | 25.0 | Acceptable |
| 229 | Dam | -28148.42 | 2883052.82 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 230 | Mine Buildings/Structures | -28040.40 | 2883376.03 | 25 | 622 | 3756 | 25.0 | Acceptable |
| 231 | Dam | -27354.93 | 2883398.20 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 232 | Dam | -26374.24 | 2884174.18 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 233 | Dam | -26361.40 | 2884415.81 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 234 | Dam | -26345.90 | 2884648.97 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 235 | Dam | -26773.13 | 2884991.71 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 238 | Building/Structure | -32514.43 | 2886558.36 | 12.5 | 946 | 3756 | 12.5 | Acceptable |
| 239 | Building/Structure | -31739.66 | 2887406.91 | 12.5 | 946 | 3756 | 12.5 | Acceptable |
| 240 | Building/Structure | -31567.28 | 2887607.14 | 12.5 | 946 | 3756 | 12.5 | Acceptable |
| 241 | Cement Dam | -31887.15 | 2887094.54 | 50 | 408 | 3756 | 50.0 | Acceptable |
| 256 | Power lines/Pylons | -30190.90 | 2883575.02 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 265 | Power lines/Pylons | -30136.45 | 2887110.44 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 266 | Power lines/Pylons | -30071.18 | 2887183.23 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 269 | Power lines/Pylons | -29916.77 | 2886446.33 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 278 | Power lines/Pylons | -31575.31 | 2885832.25 | 75 | 319 | 3756 | 75.0 | Acceptable |
| 279 | Power lines/Pylons | -31721.89 | 2885912.09 | 75 | 319 | 3756 | 75.0 | Acceptable |

Apart from the mitigations suggested there is already approved plans for relocation of powerlines so that no powerlines will be located within the pit boundaries. The following Figure 23 shows the relocation path of the powerline.

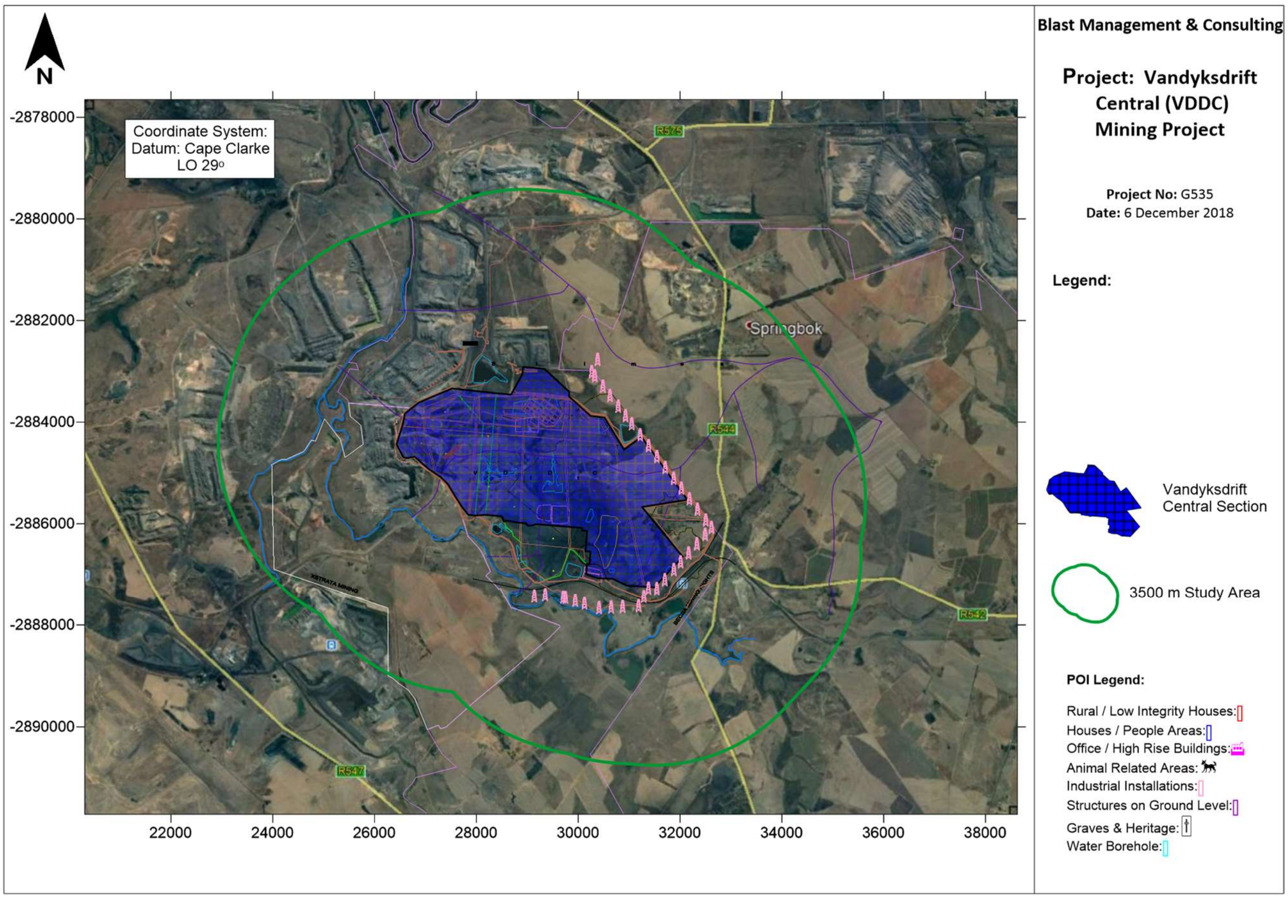



Figure 23: Relocation of Powerline

## 18 Closure Phase: Impact Assessment and Mitigation Measures

During the closure phase no mining, drilling and blasting operations are expected. It is uncertain if any blasting will be done for demolition. If any demolition blasting will be required it will be reviewed as civil blasting and addressed accordingly.

## 19 Alternatives (Comparison and Recommendation)

No specific alternative mining methods are currently under discussion or considered for drilling and blasting.

## 20 Monitoring

A monitoring programme for recording blasting operations is recommended. The following elements should be part of such a monitoring program:

- Ground vibration and air blast results;

- Blast Information summary;
- Meteorological information at time of the blast;
- Fly rock observations.

Most of the above aspects do not require specific locations of monitoring. Ground vibration and air blast monitoring requires identified locations for monitoring. Monitoring of ground vibration and air blast is done to ensure that the generated levels of ground vibration and air blast comply with recommendations. Proposed positions were selected to indicate the nearest points of interest at which levels of ground vibration and air blast should be within the accepted norms and standards as proposed in this report. The monitoring of ground vibration will also qualify the expected ground vibration and air blast levels and assist in mitigating these aspects properly. This will also contribute to proper relationships with the neighbours.

Twelve monitoring positions were identified as possible locations that will need to be considered. Not all points will be required at once but active monitoring and observation of where blasting is done will dictate the requirements for the areas around the pit. Some of these points may be applicable to more than one location to be monitored – specifically regarding the railway line and Eskom pylons – roving station may be applied. Monitoring positions are indicated in Figure 24 and Table 31 lists the positions with coordinates. These points will need to be re-defined after the first blasts done and the monitoring programme defined.

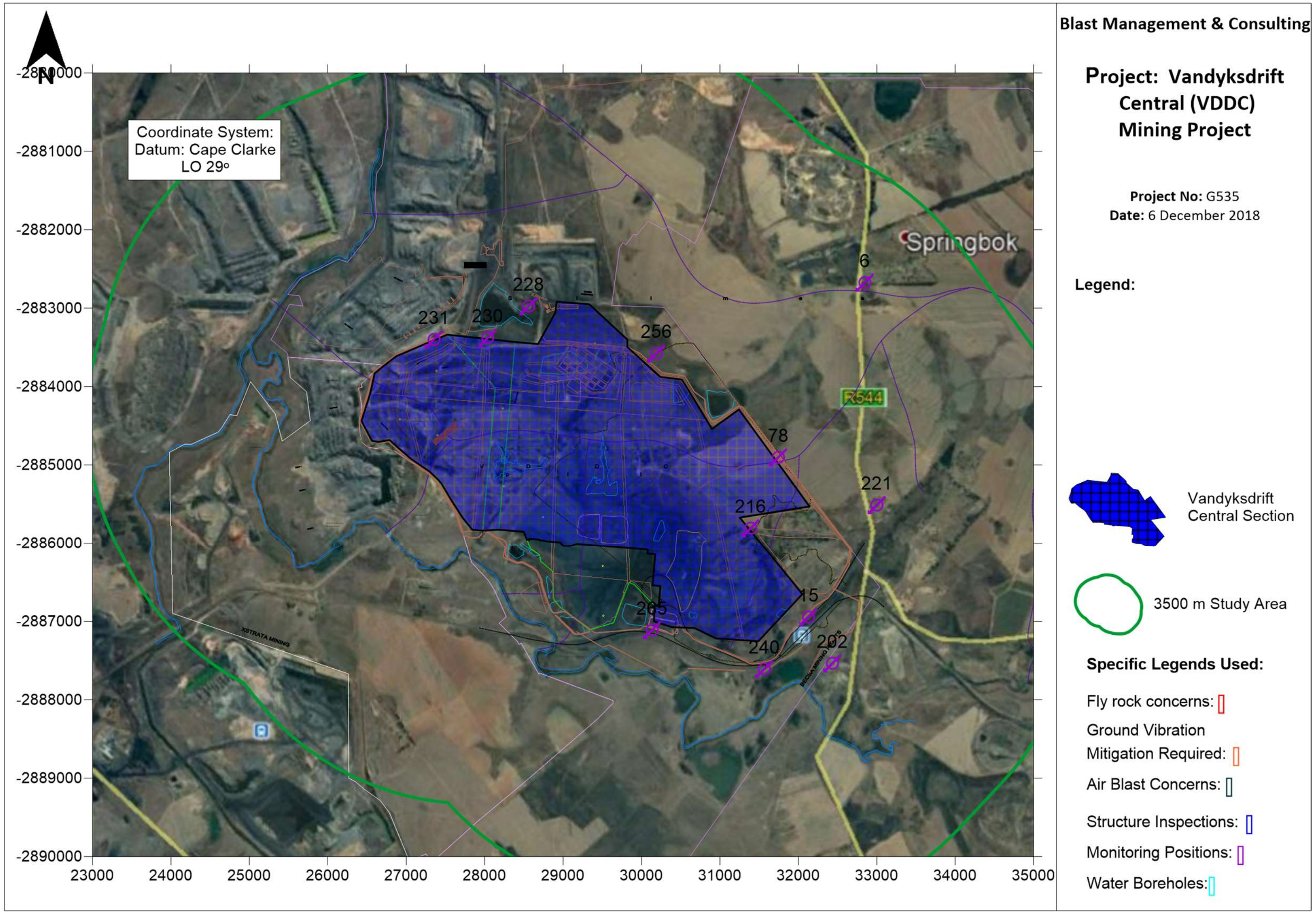



Figure 24: Suggested monitoring positions

Table 31: List of possible monitoring positions

| Tag | Description | Y | X |
|---|---|---|---|
| 6 | Springbok Mining Town Houses | -32848.62 | 2882673.55 |
| 15 | Heritage Site (Railway Station) | -32130.50 | 2886945.19 |
| 78 | Power lines/Pylons | -31745.54 | 2884901.76 |
| 202 | Informal Settlement (Lindokhule) | -32435.02 | 2887534.69 |
| 216 | Road | -31393.02 | 2885806.08 |
| 221 | Informal Housing | -33002.20 | 2885510.95 |
| 228 | Mine Buildings/Structures | -28562.37 | 2882973.09 |
| 230 | Mine Buildings/Structures | -28040.40 | 2883376.03 |
| 231 | Dam | -27354.93 | 2883398.20 |
| 240 | Building/Structure | -31567.28 | 2887607.14 |
| 256 | Power lines/Pylons | -30190.90 | 2883575.02 |
| 265 | Power lines/Pylons | -30136.45 | 2887110.44 |

## 21 Recommendations

The following recommendations are proposed.

### 21.1 Regulatory requirements

Regulatory requirements indicate specific requirements for all non-mining structures and installations within 500 m from the mining operation. Various POI's are observed within the pit that needs consideration as well within 500 m from the mining area. The mine will have to apply for the necessary authorisations as prescribed in the various acts, and specifically Mine Health and Safety Act Reg 4.16 as well as recommendations regarding infrastructure within the pit area. Table 32 shows list of these installations. Figure 25 below shows the 500 m boundary around the opencast pit area. The location of non-mining installations is clearly observed.

Table 32: List of possible installations within the regulatory 500 m

| Tag | Description | Y | X |
|---|---|---|---|
| 15 | Heritage Site (Railway Station) | -32130.50 | 2886945.19 |
| 16 | Heritage Site (Graveyard) | -30774.31 | 2887635.21 |
| 17 | Heritage Site (Graveyard) - Inside Pit Area | -31654.38 | 2887030.83 |
| 64 | Cultivated Fields | -30490.37 | 2883543.67 |
| 65 | Buildings/Structures (Inside Pit Area) | -31813.45 | 2886337.60 |
| 73 | Power lines/Pylons | -30646.32 | 2883483.97 |
| 74 | Power lines/Pylons | -30833.70 | 2883712.03 |
| 75 | Power lines/Pylons | -31063.96 | 2884006.90 |

| Tag | Description | Y | X |
|---|---|---|---|
| 76 | Power lines/Pylons | -31277.88 | 2884292.98 |
| 77 | Power lines/Pylons | -31508.85 | 2884594.26 |
| 78 | Power lines/Pylons | -31745.54 | 2884901.76 |
| 79 | Power lines/Pylons | -31903.89 | 2885104.23 |
| 80 | Power lines/Pylons | -32140.50 | 2885418.17 |
| 81 | Power lines/Pylons | -32413.68 | 2885749.12 |
| 95 | Olifants River | -27710.35 | 2886077.44 |
| 110 | Railway Line | -30119.79 | 2887149.05 |
| 111 | Railway Line/Bridge | -30448.54 | 2887285.80 |
| 112 | Railway Line | -30916.51 | 2887497.74 |
| 113 | Railway Line | -31550.39 | 2887539.25 |
| 114 | Railway Line | -32136.13 | 2887080.04 |
| 115 | Buildings/Structures | -31875.06 | 2887206.82 |
| 116 | Railway Station Buildings | -32087.55 | 2887164.74 |
| 117 | Railway Line | -32531.46 | 2886734.03 |
| 192 | Dam | -28388.17 | 2883032.31 |
| 195 | Dam | -27637.81 | 2882848.26 |
| 216 | Road | -31393.02 | 2885806.08 |
| 223 | Cultivated Fields | -31997.87 | 2885062.04 |
| 224 | Dam | -31258.26 | 2884229.57 |
| 225 | Dam | -30873.90 | 2884328.42 |
| 226 | Mine Buildings/Structures | -28591.00 | 2882724.61 |
| 227 | Mine Activity | -29115.51 | 2882749.13 |
| 228 | Mine Buildings/Structures | -28562.37 | 2882973.09 |
| 229 | Dam | -28148.42 | 2883052.82 |
| 230 | Mine Buildings/Structures | -28040.40 | 2883376.03 |
| 231 | Dam | -27354.93 | 2883398.20 |
| 232 | Dam | -26374.24 | 2884174.18 |
| 233 | Dam | -26361.40 | 2884415.81 |
| 234 | Dam | -26345.90 | 2884648.97 |
| 235 | Dam | -26773.13 | 2884991.71 |
| 237 | Pan | -28351.69 | 2886048.92 |
| 238 | Building/Structure | -32514.43 | 2886558.36 |
| 239 | Building/Structure | -31739.66 | 2887406.91 |
| 240 | Building/Structure | -31567.28 | 2887607.14 |
| 241 | Cement Dam | -31887.15 | 2887094.54 |
| 245 | Borehole (WBH 2S8) | -30607.18 | 2883505.57 |
| 255 | Power lines/Pylons | -30142.28 | 2883202.79 |
| 256 | Power lines/Pylons | -30190.90 | 2883575.02 |
| 257 | Power lines/Pylons (Inside Pit Area) | -30277.04 | 2884211.06 |
| 258 | Power lines/Pylons (Inside Pit Area) | -30355.73 | 2884725.92 |
| 260 | Power lines/Pylons (Inside Pit Area) | -30220.30 | 2885700.02 |
| 261 | Power lines/Pylons (Inside Pit Area) | -31057.93 | 2885661.44 |
| 262 | Power lines/Pylons (Inside Pit Area) | -30281.03 | 2886948.38 |
| 263 | Power lines/Pylons (Inside Pit Area) | -30433.06 | 2886779.17 |
| 264 | Power Station (Inside Pit Area) | -30567.03 | 2886714.64 |
| 265 | Power lines/Pylons | -30136.45 | 2887110.44 |
| 266 | Power lines/Pylons | -30071.18 | 2887183.23 |

| Tag | Description | Y | X |
|---|---|---|---|
| 267 | Power lines/Pylons | -29900.32 | 2887381.56 |
| 269 | Power lines/Pylons | -29916.77 | 2886446.33 |
| 278 | Power lines/Pylons | -31575.31 | 2885832.25 |
| 279 | Power lines/Pylons | -31721.89 | 2885912.09 |

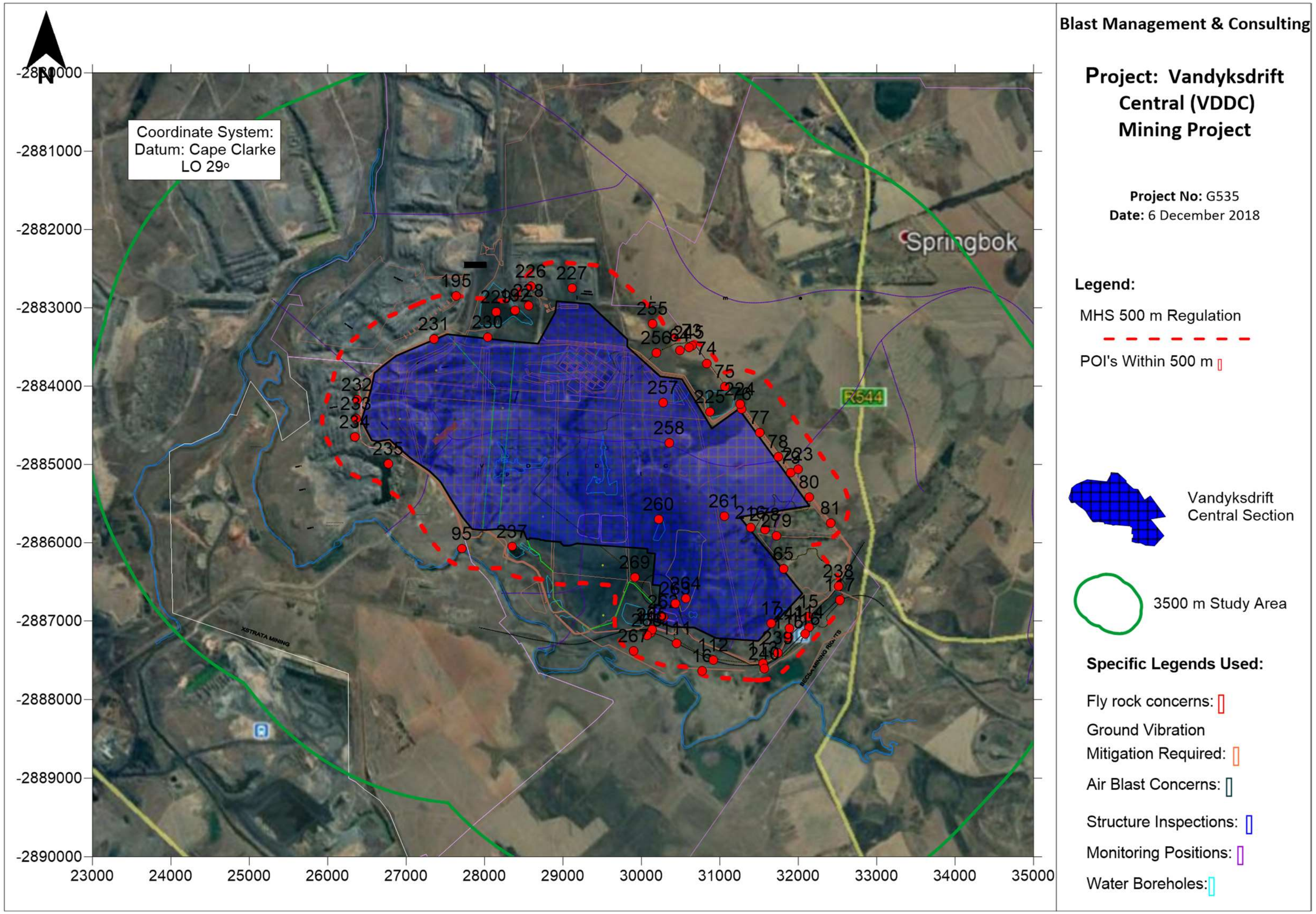



Figure 25: Regulatory 500 m range for the opencast area

### 21.2 Blast Designs

Blast designs can be reviewed prior to first blast planned and done. Specific attention can be given to the possible use of electronic initiation rather than conventional timing systems. This will allow for single blast hole firing instead of multiple blast holes. Single blast hole firing will provide single hole firing – thus less charge mass per delay and less influence.

### 21.3 Test Blasting

It is always good to conduct a first test blast to confirm levels and ground vibration and air blast. It is recommended that such a blast be done and detail monitoring done and used to help define blasting operations going forward. This test blast can be based on the existing design and only after this blast it may be necessary to define if changes are required or not.

### 21.4 Stemming length

The current proposed stemming lengths used provides for some control on fly rock. Consideration can be given to increase this length for better control. Specific designs where distances between blast and point of concern are known should be considered. Recommended stemming length should range between 20 and 30 times the blast hole diameter. In cases for better fly control this should range between 30 and 34 times the blast holes diameter. Increased stemming lengths will also contribute to more acceptable air blast levels.

### 21.5 Safe blasting distance and evacuation

Calculated minimum safe distance is 365 m. The final blast designs that may be used will determine the final decision on safe distance to evacuate people and animals. This distance may be greater pending the final code of practice of the mine and responsible blaster's decision on safe distance. The blaster has a legal obligation concerning the safe distance and he needs to determine this distance.

### 21.6 Road and railway management

There are no National roads at close proximity of the pit areas that will require specific consideration regarding effects from blasting operations. There are smaller gravel and farm roads in the vicinity of the project area to be considered. Additional to the roads is the railway lines that are located within 500 m from the pit boundary. These roads and the railway lines will require management when blasting operations are done within 500 m or as per mine's code of practice. Management may include the temporary closure of roads and detail liaison with rail authorities. During blasting care must be taken to ensure all people and animals cleared to outside the unsafe area as determined by the blaster.

### 21.7 Photographic Inspections

The option of photographic survey of structures surrounding the mine is recommended. Generally, a 1500 m range is considered a good and reliable distance to use specific for the large opencast mining environment where levels at structures will be experienced as perceptible or unpleasant. A photographic inspection also provides information of structure quality that can be applied for defining blast design to maintain safe blasting levels. A process of evaluating ground vibration and air blast levels observed in nearby communities needs to be put in place and inspections scheduled accordingly. Blasting operations will initially not be within the proposed distance from structures. Thus, when distance between blasts and structures / houses are within the recommended distance a photographic survey should be considered. A survey may not be required prior to project start for all identified structures or houses. The mine will be operating for a significant number of years. This will give advantage on any negotiations with regards to complaints from neighbours on structural issues due to blasting. This process can however only succeed if done in conjunction with a proper monitoring program. It is expected that ground vibration levels will be significantly less than proposed limits at 1500 m but this process will ensure record of the pre-blasting status of the nearest structures to the pit areas. Figure 26 shows extent of the range of 1500 m around the opencast pit with POI's identified. It must be noted that a point may represent a group of structures found in the vicinity of the point identified.

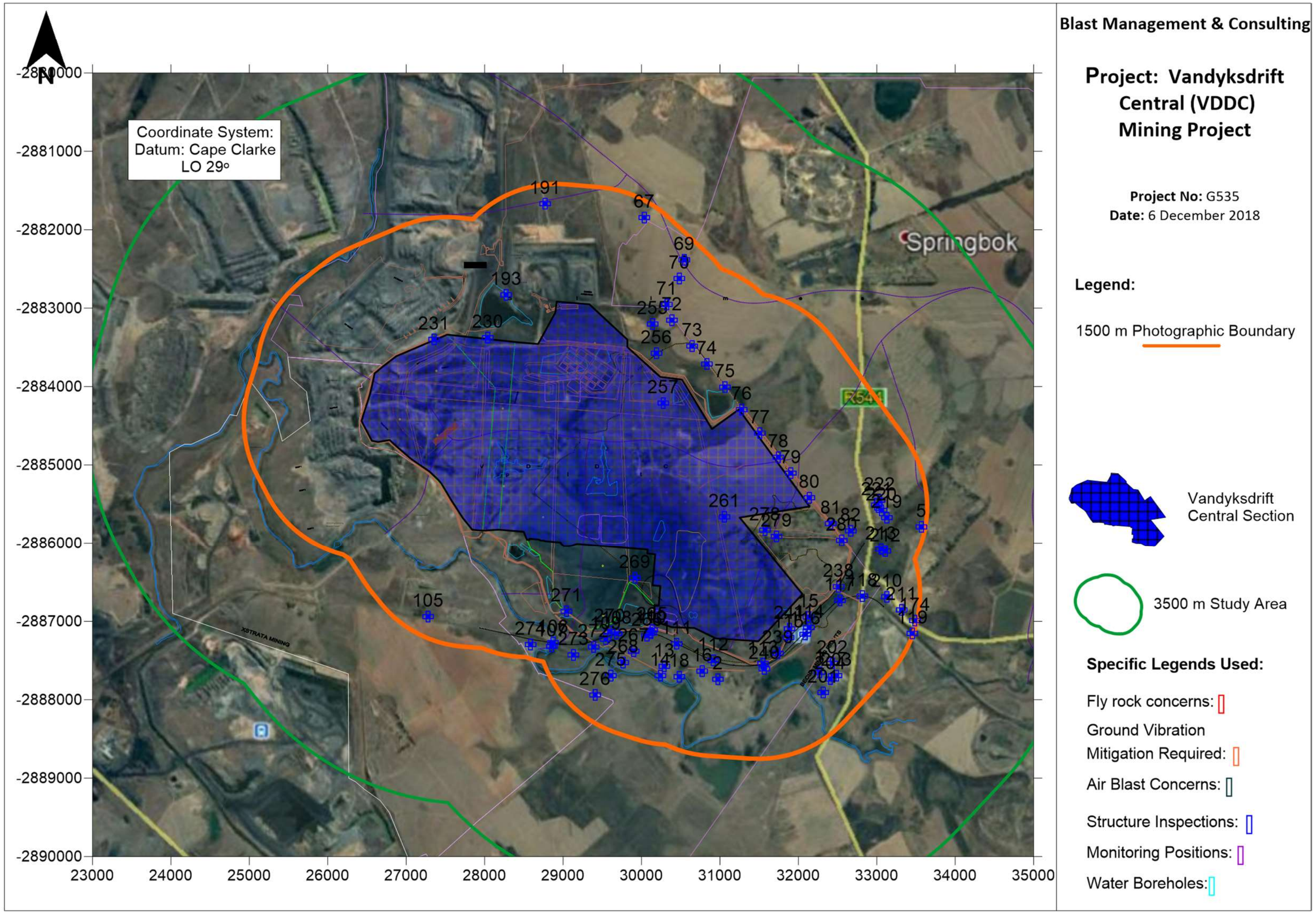



Figure 26: 1500 m area around opencast pit identified for structure inspections.

Table 33: Combined list of structures identified for inspections

| Tag | Description | Y | X |
|---|---|---|---|
| 231 | Dam | -27354.93 | 2883398.20 |
| 230 | Mine Buildings/Structures | -28040.40 | 2883376.03 |
| 78 | Power lines/Pylons | -31745.54 | 2884901.76 |
| 80 | Power lines/Pylons | -32140.50 | 2885418.17 |
| 77 | Power lines/Pylons | -31508.85 | 2884594.26 |
| 79 | Power lines/Pylons | -31903.89 | 2885104.23 |
| 265 | Power lines/Pylons | -30136.45 | 2887110.44 |
| 76 | Power lines/Pylons | -31277.88 | 2884292.98 |
| 278 | Power lines/Pylons | -31575.31 | 2885832.25 |
| 110 | Railway Line | -30119.79 | 2887149.05 |
| 241 | Cement Dam | -31887.15 | 2887094.54 |
| 256 | Power lines/Pylons | -30190.90 | 2883575.02 |
| 261 | Power lines/Pylons (Inside Pit Area) | -31057.93 | 2885661.44 |
| 111 | Railway Line/Bridge | -30448.54 | 2887285.80 |
| 279 | Power lines/Pylons | -31721.89 | 2885912.09 |
| 266 | Power lines/Pylons | -30071.18 | 2887183.23 |
| 269 | Power lines/Pylons | -29916.77 | 2886446.33 |
| 115 | Buildings/Structures | -31875.06 | 2887206.82 |
| 15 | Heritage Site (Railway Station) | -32130.50 | 2886945.19 |
| 112 | Railway Line | -30916.51 | 2887497.74 |
| 239 | Building/Structure | -31739.66 | 2887406.91 |
| 113 | Railway Line | -31550.39 | 2887539.25 |
| 257 | Power lines/Pylons (Inside Pit Area) | -30277.04 | 2884211.06 |
| 114 | Railway Line | -32136.13 | 2887080.04 |
| 240 | Building/Structure | -31567.28 | 2887607.14 |
| 74 | Power lines/Pylons | -30833.70 | 2883712.03 |
| 116 | Railway Station Buildings | -32087.55 | 2887164.74 |
| 255 | Power lines/Pylons | -30142.28 | 2883202.79 |
| 81 | Power lines/Pylons | -32413.68 | 2885749.12 |
| 73 | Power lines/Pylons | -30646.32 | 2883483.97 |
| 16 | Heritage Site (Graveyard) | -30774.31 | 2887635.21 |
| 75 | Power lines/Pylons | -31063.96 | 2884006.90 |
| 267 | Power lines/Pylons | -29900.32 | 2887381.56 |
| 238 | Building/Structure | -32514.43 | 2886558.36 |
| 117 | Railway Line | -32531.46 | 2886734.03 |
| 13 | Buildings/Structures | -30291.07 | 2887574.45 |
| 2 | Ruins | -30974.21 | 2887738.67 |
| 108 | Railway Line | -29682.66 | 2887156.89 |
| 193 | Structure | -28273.19 | 2882830.44 |
| 270 | Power lines/Pylons | -29596.72 | 2887131.43 |
| 18 | Heritage Site (Pump Station) | -30482.58 | 2887706.80 |
| 72 | Power lines/Pylons | -30389.10 | 2883153.94 |
| 280 | Power lines/Pylons | -32554.54 | 2885963.25 |
| 14 | Heritage Site (Pump Station) | -30241.71 | 2887692.47 |

| Tag | Description | Y | X |
|---|---|---|---|
| 82 | Buildings/Structures | -32668.59 | 2885841.19 |
| 268 | Power lines/Pylons | -29767.08 | 2887525.82 |
| 71 | Power lines/Pylons | -30323.92 | 2882953.37 |
| 109 | Power Station | -29543.99 | 2887228.55 |
| 118 | Railway Line/Bridge | -32816.48 | 2886678.38 |
| 1 | Informal Settlement (Lindokhule) | -32271.50 | 2887651.13 |
| 272 | Power lines/Pylons | -29390.32 | 2887327.36 |
| 271 | Power lines/Pylons | -29044.09 | 2886871.72 |
| 202 | Informal Settlement (Lindokhule) | -32435.02 | 2887534.69 |
| 275 | Power lines/Pylons | -29608.68 | 2887693.07 |
| 221 | Informal Housing | -33002.20 | 2885510.95 |
| 222 | Informal Housing | -33036.99 | 2885450.50 |
| 220 | Informal Housing | -33061.44 | 2885579.07 |
| 204 | Informal Settlement (Lindokhule) | -32409.90 | 2887737.04 |
| 70 | Power lines/Pylons | -30482.31 | 2882621.73 |
| 203 | Shopping Centre (Lindokhule) | -32487.06 | 2887692.98 |
| 219 | Informal Housing | -33128.44 | 2885672.98 |
| 201 | Informal Settlement (Lindokhule) | -32317.23 | 2887907.72 |
| 210 | Shopping Centre | -33128.16 | 2886687.37 |
| 213 | Reservoir | -33055.26 | 2886077.62 |
| 273 | Power lines/Pylons | -29132.22 | 2887428.93 |
| 212 | Buildings/Structures | -33109.95 | 2886102.33 |
| 276 | Power lines/Pylons | -29409.09 | 2887938.20 |
| 69 | Power lines/Pylons | -30546.16 | 2882383.69 |
| 105 | Railway Line | -27278.97 | 2886939.47 |
| 191 | Structure | -28772.06 | 2881667.77 |
| 106 | Railway Line/Bridge | -28872.46 | 2887271.86 |
| 211 | Buildings/Structures | -33317.19 | 2886853.92 |
| 67 | Cement Dam | -30035.57 | 2881844.67 |
| 274 | Power lines/Pylons | -28586.06 | 2887296.54 |
| 107 | Dam/Bridge | -28855.76 | 2887320.88 |
| 174 | Informal Housing | -33484.94 | 2886990.92 |
| 5 | Buildings/Structures | -33570.19 | 2885790.20 |
| 119 | Railway Line | -33453.93 | 2887154.65 |

## 21.8 Recommended ground vibration and air blast levels

The ground vibration and air blast levels limits recommended for blasting operations in this area are provided in Table 34.

Table 34: Recommended ground vibration air blast limits

| Structure Description | Ground Vibration Limit (mm/s) | Air Blast Limit (dBL) |
|---|---|---|
| National Roads/Tar Roads: | 150 | N/A |
| Electrical Lines: | 75 | N/A |
| Railway: | 150 | N/A |

<table>
<tr><th>Structure Description</th><th>Ground Vibration Limit (mm/s)</th><th>Air Blast Limit (dBL)</th></tr>
<tr><td>Transformers</td><td>25</td><td>N/A</td></tr>
<tr><td>Water Wells</td><td>50</td><td>N/A</td></tr>
<tr><td>Telecoms Tower</td><td>50</td><td>134</td></tr>
<tr><td>General Houses of proper construction</td><td>USBM Criteria or 25 mm/s</td><td rowspan="3">Shall not exceed 134dB at point of concern but 120 dB preferred</td></tr>
<tr><td>Houses of lesser proper construction (preferred)</td><td>12.5</td></tr>
<tr><td>Rural building – Mud houses</td><td>6</td></tr>
</table>

### 21.9 Blasting times

A further consideration of blasting times is when weather conditions could influence the effects yielded by blasting operations. It is recommended not to blast too early in the morning when it is still cool or when there is a possibility of atmospheric inversion or too late in the afternoon in winter. Do not blast in fog. Do not blast in the dark. Refrain as far as possible from blasting when wind is blowing strongly in the direction of an outside receptor. Do not blast with low overcast clouds. These 'do nots' stem from the influence that weather has on air blast. The energy of air blast cannot be increased but it is distributed differently and therefore is difficult to mitigate.

### 21.10 Third party monitoring

Third party consultation and monitoring should be considered for all ground vibration and air blast monitoring work. This will bring about unbiased evaluation of levels and influence from an independent group. Monitoring could be done using permanent installed stations. Audit functions may also be conducted to assist the mine in maintaining a high level of performance with regards to blast results and the effects related to blasting operations.

## 22 Knowledge Gaps

The data provided from client and information gathered was sufficient to conduct this study. Surface surroundings change continuously and this should be taken into account prior to initial blasting operations considered. This report may need to be reviewed and updated if necessary. This report is based on data provided and internationally accepted methods and methodology used for calculations and predictions.

## 23 Project Result

In view of the data evaluated it is the opinion of the author that the project can be executed successfully with proper management and control on the aspects of ground vibration, air blast and fly rock. Specific problems were identified and recommendations made.

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed opencast mining operation. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report concentrates on the ground vibration and air blast intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed is typical roads (tar and gravel), low cost houses, corrugated iron structures, brick and mortar houses, boreholes and heritage sites.

The VDDC infrastructure and mining development project is a brownfields project within the greater Wolvekrans Colliery mining rights area.

The evaluation of the charges indicated nineteen POI's of concern for minimum charge and the maximum charge indicated fifty-one POI's of concern (included are the heritage site – graveyard and power lines/pylons inside the pit area) in relation to possible structural damage. On a human perception scale forty POI's were identified where vibration levels may be perceptible and higher for the minimum charge and fifty-two POI's for the maximum charge. Perceptible levels of vibration that may be experienced up to 3375 m, unpleasant up to 1527 m and intolerable up to 651 m. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 1050 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have lesser influence on these points.

Various heritage sites were identified by the Heritage Specialist that will require attention. One of these sites (graves – POI 17) falls within the Pit area. The Heritage Specialist has recommended that the graveyard be relocated. The portion of the Kromfontein 132 kV powerline traversing the proposed opencast mining area will also be re-aligned (this is the subject of a separate application).

Mitigation of ground vibration was considered and discussed. A positive contribution is that the box-cut areas are furthest away from the concerned infrastructure and will provide time to determine possible influence in the early stages of blasting.

The effect of ground vibration regarding human perception was also evaluated and adjudicated.

The effects of air blast indicate less influences than ground vibration. Levels predicted for the maximum charge ranges between 111.5 and 147.6 dB for all the POI's considered. This includes the nearest points such as the Buildings/Structures. These levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints. The closest structures at 249 m (POI 115) showed concerns of complaints at maximum charge.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 365 m. The absolute minimum unsafe zone is then the 365 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

No boreholes were observed that will require specific mitigation due to possible influence from blasting operations. Boreholes are located far enough away from blasting areas.

The project influences were assessed and evaluated. Pre-mitigation a general class 3 moderate influence was determined. Applying mitigations this level can be reduced to class 2 Low impact assessment.

This concludes this investigation for the proposed Vandyksdrift Central (VDDC) Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

## 24 Curriculum Vitae of Author

J D Zeeman was a member of the Permanent Force - SA Ammunition Core for period January 1983 to January 1990. During this period, work involved testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition.

From July 1992 to December 1995, Mr Zeeman worked at AECI Explosives Ltd. Initial work involved testing science on small scale laboratory work and large-scale field work. Later, work entailed managing various testing facilities and testing projects. Due to restructuring of the Technical Department, Mr Zeeman was retrenched but fortunately was able to take up an appointment with AECI Explosives Ltd.’s Pumpable Emulsion Explosives Group for underground applications.

From December 1995 to June 1997 Mr Zeeman provided technical support to the Underground Bulk Systems Technology business unit and performed project management on new products.

Mr Zeeman started Blast Management & Consulting in June 1997. The main areas of focus are Pre-blast monitoring, Insitu monitoring, Post-blast monitoring and specialized projects.

Mr Zeeman holds the following qualifications:

| | |
|---|---|
| 1985 - 1987 | Diploma: Explosives Technology, Technikon Pretoria |
| 1990 - 1992 | BA Degree, University of Pretoria |
| 1994 | National Higher Diploma: Explosives Technology, Technikon Pretoria |
| 1997 | Project Management Certificate: Damelin College |
| 2000 | Advanced Certificate in Blasting, Technikon SA |

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997, with work being done at various levels for all the major mining companies in South Africa. Some of the projects in which BM&C has been involved include:
Iso-Seismic Surveys for Kriel Colliery in conjunction with Bauer & Crosby Pty Ltd.; Iso-Seismic surveys for Impala Platinum Limited; Iso-Seismic surveys for Kromdraai Opencast Mine; Photographic Surveys for Kriel Colliery; Photographic Surveys for Goedehoop Colliery; Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village; Photographic Surveys for Aquarius – Everest South Project; Photographic Surveys for Kromdraai Opencast Mine; Photographic inspections for various other companies, including Landau Colliery, Platinum Joint Venture – three mini-pit areas; Continuous ground vibration and air blast monitoring for various coal mines; Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients, e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road; Monitoring of ground vibration induced on surface in underground mining environment; Monitoring and management of blasting in close relation to water pipelines in opencast mining environment; Specialized testing of explosives characteristics; Supply and service of seismographs and VOD measurement equipment and accessories; Assistance in protection of ancient mining works for Rhino Minerals (Pty) Ltd.; Planning, design, auditing and monitoring of blasting in new quarry on new road project, Sterkspruit, with Africon, B&E International and Group 5 Roads; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Pandora Joint Venture 180 houses – whole village; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Section - 1000 houses / structures.

BM&C have installed a world class calibration facility for seismographs, which is accredited by Instantel, Ontario Canada as an accredited Instantel facility. The projects listed above are only part of the capability and professional work that is done by BM&C.

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