Air Quality Impact Assessment for the Proposed Kangala Colliery Extension (Eloff Project) near Delmas, Mpumalanga

Project done on behalf of **Environmental Impact Management Services (EIMS)**

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Report Details

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Revision Record

Version	Date	Comments
Rev 0	October 2018	For client review

Competency Profiles

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Rochelle Bornman started her professional career in Air Quality in 2008 when she joined Airshed Planning Professionals (Pty) Ltd after having worked in malaria research at the Medical Research Council in Durban. Rochelle has worked on several air quality specialist studies between 2008 and 2018. She has experience on the various components including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality. Whilst most of his working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Mozambique, Namibia, Saudi Arabia and Mali.

NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report.	Report details (page ii)
The expertise of that person to compile a specialist report including curriculum vitae.	Report details (page ii) Appendix A
A declaration that the person is independent in a form as may be specified by the competent authority.	Report details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Introduction and background (Executive Summary) Section 1.2: Scope of Work Section 1.4: Project Approach and Methodology
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 3: Atmospheric Dispersion Potential
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Introduction and background (Executive Summary) Section 1.4: Project Approach and Methodology Section 1.4.4: Atmospheric Dispersion Modelling
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 3.1: Receiving Environment
An identification of any areas to be avoided, including buffers.	Not applicable
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.	Not applicable
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.5: Assumptions and Limitations
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 4.3: Impact Assessment. This assessment investigates the impacts of the baseline (Kangala) and project (Eloff operations).
Any mitigation measures for inclusion in the environmental management programme report	Section 6: Air Quality Management Measures
Any conditions for inclusion in the environmental authorisation	Section 6: Air Quality Management Measures
Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	Section 6: Air Quality Management Measures
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 7: Conclusion
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the environmental management programme report, and where applicable, the closure plan.	Section 6: Air Quality Management Measures Section 7.1: Recommendations
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable
A summary and copies if any comments that were received during any consultation process.	Not applicable.
Any other information requested by the competent authority.	Not applicable.

Executive Summary

An environmental air quality specialist study was conducted for the proposed opencast Kangala Colliery Extension (Eloff Project), which will be the life extension of Kangala from 2020 when the coal reserves at Kangala are depleted. The required surface infrastructure such as offices, stores facility, workshops, and change house already exists at Kangala and thus do not need to be replicated for the operations at the Eloff Project; however, the existing Kangala Coal Handling and Processing Plant (CHPP) will be up-sized during 2019 to ensure the higher ROM production from 2019 can be processed, and a new haul road will be established to link the Eloff open pit area to the Kangala CHPP.

The air quality investigation comprises both a baseline study and an impact assessment. The aim of the investigation was to quantify the possible impacts resulting from the mining activities on the surrounding environment and human health. Emission rates were quantified for the activities and dispersion modelling executed.

The main findings from the baseline assessment are as follows:

- The wind field is dominated by winds from the north and north-northeast with an average wind speed of 3.21 m/s. Wind speeds exceeding 5 m/s occurred with a frequency of 14%. The northerly wind flow increases during day-time conditions with north-northeasterly wind flow increasing during the night.

- The topography of the study area is fairly flat, comprising of undulating terrain slightly increasing in height above mean sea level to the northeast of the area. An analysis of topographical data indicated a slope of less than 1:10 over most of the project area. Average total annual rainfall for the study region is in the range of 681 mm. The climate is classified as warm and temperate. The region is the coldest during July with a minimum temperature of -3.4°C during the night and warmest during January when temperatures reach 31°C during the day.

- Based on the nature of the project and expected air quality impacts, a study area of 15 km east-west by 15 km north-south, with the Project site located centrally, was selected. Air quality sensitive receptors (AQSR) within the study area include farmsteads, residential areas, schools, a hospital and agricultural holdings.

- Existing sources of air emissions include power generation, agricultural activities, metallurgical manufacturing processes, opencast coal mining and residential fuel burning.

- The measured PM_{10} daily ground level concentrations from the Kangala PM_{10} monitoring station for the period May 2016 to July 2018 regularly exceeded the daily National Ambient Air Quality Standard (NAAQS) applicable from 2015. The PM_{10} period concentration (calculated from the daily concentrations for the monitoring period) was estimated at 25 µg/m³.

- Monitored dustfall levels at the UD-003 monitoring station exceeded the residential limit of 600 mg/m²/day more than twice per year, and for sequential months, during the 2015/2016, 2016/2017, and 2017/2018 sampling periods. This may be due to its close proximity to the R42 road.

- The Project is located within the Highveld Priority Area, in close proximity to Leeuwpan and Stuart (opencast) collieries.

To determine the significance of air pollution impacts from the proposed Project, two scenarios were assessed:

- **Baseline scenario** – representative of opencast mining activities at Kangala Colliery for the year July 2017 – June 2018; and
- **Project scenario** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026).

Each of these scenarios had 3 sub-scenarios, namely (a) unmitigated operations, (b) design mitigated operations[1] and (c) additionally mitigated operations[2].

The main findings from the impact assessment due to the baseline (Kangala) operations are as follows:

- The daily **PM_{10}** SA NAAQS was exceeded at 13 (out of 25) AQSRs for unmitigated activities. For the design mitigated scenario, simulated PM_{10} concentrations exceeded the daily SA NAAQS at 2 AQSRs, over an area up to 2.0km to the north, 1.0km to the east, 750m to the south and 1.5km to the southwest from the mining boundary. With additional mitigation, non-compliances were still simulated at 2 AQSRs. Over an annual average unmitigated PM_{10} impacts exceeded the annual NAAQS at 2 AQSRs. These impacts were reduced when design mitigation is applied, with exceedances simulated at only one AQSR and no exceedances for additionally mitigated activities.
- **$PM_{2.5}$** daily GLCs, with no mitigation in place, were in non-compliance with the 2030 NAAQSs at 4 AQSRs. Simulated impacts were reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at two AQSRs. With additional mitigation, simulated $PM_{2.5}$ daily GLCs were within compliance at all AQSRs. Over an annual average design mitigated simulated GLCs and additionally mitigated GLCs, were within compliance currently and after 2030.
- The simulated maximum daily **dustfall** rates due to the unmitigated scenario exceeded the NDCR for residential areas at only one AQSR. Simulated dustfall rates at all AQSRs were well within the residential limit for the design mitigated and additionally mitigated scenarios.
- The baseline operations resulted in **Medium** significance for unmitigated and **Low** significance for design mitigated operations. The highest PM_{10} impacts were mainly due to vehicle entrained dust from unpaved roads, whereas the highest $PM_{2.5}$ impacts were due to in-pit operations and the highest dustfall impacts were due to windblown dust from the discard and topsoil stockpiles.

The main findings from the impact assessment due to the Project (Eloff) operations are as follows:

- The daily **PM_{10}** SA NAAQS was exceeded at 25 (out of 25) AQSRs for unmitigated activities. For the design mitigated scenario, simulated PM_{10} concentrations exceeded the daily SA NAAQS at 6 AQSRs, over an area up to 2.8km to the southwest, 2.4km to the south, 2.4km to the east and 3.0km to the north from the mining boundary. With additional mitigation the footprint was reduced, with 3 AQSRs non-compliant. Over an annual average unmitigated PM_{10} impacts exceeded the annual NAAQS at 2 AQSRs. With design mitigation applied, exceedances were simulated at 2 AQSRs, and with additional mitigation applied, PM_{10} impacts exceeded the annual NAAQS at only one AQSR.
- **$PM_{2.5}$** daily GLCs, with no mitigation in place, were in non-compliance with the 2030 NAAQSs at 14 AQSRs. Simulated impacts were reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated

[1] Design mitigated activities include: 75% control efficiency (CE) on unpaved haul roads; 50% CE on materials handling; 50% CE on crushing and screening; 50% CE on grading activities; 70% CE on covered conveyor tipping points and 65% on windblown dust from conveyor belt with enclosed side and roof.
[2] Additional mitigation includes design mitigation and 90% CE on unpaved haul roads.

at only two AQSRs. With additional mitigation, simulated $PM_{2.5}$ daily GLCs were still in non-compliance at two AQSRs. Over an annual average design mitigated simulated GLCs and additionally mitigated GLCs, were within compliance currently and after 2030.

- The simulated maximum daily **dustfall** rates due to the unmitigated scenario exceeded the NDCR for residential areas at one AQSR. Simulated dustfall rates exceeded the NDCR for residential areas at one AQSR for the design mitigated scenario but were well within the residential limit for the additionally mitigated scenario.
- The Project operations resulted in **High** significance for design mitigated operations and **Medium** significance for additionally mitigated operations. Similar to the baseline scenario, the highest PM_{10} impacts were due to vehicle entrained dust from unpaved roads, whereas the highest $PM_{2.5}$ impacts were due to in-pit operations and the highest dustfall impacts were due to windblown dust from the discard and topsoil stockpiles.
- The impact significance associated with the proposed Eloff Colliery construction and decommissioning phases was determined as **Low**.
- The simulated footprint areas of exceedance for PM_{10} and $PM_{2.5}$ impacts, were found to be much larger for the Project Scenario (Eloff Project) than for the Baseline Scenario (Kangala operations). Even with additional mitigation applied on haul roads to achieve a control efficiency of 90% the area of exceedance of the daily PM_{10} NAAQS extended well beyond the mining rights boundary. This increase in magnitude may be explained by the higher throughput of annual ROM tonnages for the Eloff Project, and more vehicle entrained dust from the new haul road and in-pit roads. The up-sizing of the Kangala CHPP to process the higher ROM production will also lead to higher crushing emissions.

Recommendations

The proposed Eloff Project is located within the Highveld Priority Area and close to various mining and power generation sources. The management plan objectives for this priority area are to minimise impacts on the surrounding environment. It is therefore recommended that air quality management measures be implemented to ensure the lowest possible impacts on the surrounding environment from the mining operations. These measures should include:

- Implementation and monitoring of design mitigation measures. Additional mitigation measures are recommended to ensure mining related impacts remain within the Mine License Area. Based on the ranking of the main sources, these include:
  - Frequent water sprays (> 2 litres/m²/hr) on the in-pit roads to ensure a control efficiency of at least 75% and chemical suppressants on the unpaved haul roads to ensure a control efficiency of more than 90%;
  - Temporary wind breaks to be installed onto the topsoil stockpile (30% control efficiency) and vegetation cover to be established on the dormant areas and side slopes (40% control efficiency) (NPI, 2011).
- To ensure the impacts on the surrounding environment and human health remain acceptable throughout the Life of Mine (LoM), 3 dustfall units are recommended to be added to the existing dustfall monitoring network. Should dustfall at the Delmas residential receptor (EL-003) exceed the NDCR, it is recommended that a 3-month PM_{10} sampling campaign be undertaken to assess whether a permanent PM_{10} sampler should be installed.
- It is recommended that UCD1 buy out the two farmsteads (Nos 16 and 17) located within the footprint area of exceedance of the daily PM_{10} NAAQS, to ensure that people not be exposed to ambient air quality that may be harmful to human health.

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Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
APPA	Air Pollution Prevention Act
AQSR	Air Quality Sensitive Receptors
ASTM	American Standard Testing Method
CE	Control Efficiency
CHPP	Coal Handling and Processing Plant
DEA	Department of Environmental Affairs
DPM	Diesel Particulate Matter
EAP	Environmental Assessment Practitioner
EC	European Commission
EHS	Environmental, Health, and Safety (IFC)
EIA	Environmental Impact Assessment
GHG	Greenhouse gas
HPA	Highveld Priority Area
IFC	International Finance Corporation
IT	Interim target
Ltd	Limited
MM5	5th-generation Mesoscale Model
NAAQS	National Ambient Air Quality Standards
NAEIS	National Atmospheric Emissions Inventory System
NDCR	National Dust Control Regulations
NEMAQA	National Environment Management Air Quality Act
NPI	National Pollutant Inventory (Australia)
PCD	Pollution Control Dam
Pty	Proprietary
ROM	Run-of-mine
SAAQIS	South African Air Quality Information System
SABS	South African Bureau of Standards
SANS	South African National Standards
SA NAAQS	South African National Ambient Air Quality Standards
SA NDCR	South African National Dust Control Regulations
SoW	Scope of Work
UCD1	Universal Coal Development 1
US EPA	United States Environmental Protection Agency
WBG	World Bank Group
WHO	World Health Organisation
WRF	Weather Research and Forecasting

Glossary

Atmospheric dispersion model	A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere
Atmospheric stability	A measure of the propensity for vertical motion in the atmosphere
Calm / stagnation	A period when wind speeds of less than 0.5 m/s persist
Cartesian grid	A co-ordinate system whose axes are straight lines intersecting at right angles
Dispersion	The lowering of the concentration of pollutants by the combined processes of advection and diffusion

Symbols and Units

cm	centimetre
CO	Carbon monoxide
CO_2	Carbon dioxide
DPM	Diesel particulate matter
ha	Hectare
HCs	Hydrocarbons
km	Kilometre
mm	Millimetre
m	Metre
m^2	Metre squared
m^3	Metre cubed
m/s	Metres per second
Mg	Megagram, or tonne
NO	Nitrogen monoxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
Pb	Lead
PM	Particulate matter
$PM_{2.5}$	Particulate matter less than 2.5 µm in diameter
PM_{10}	Particulate matter less than 10 µm in diameter
SO_2	Sulfur dioxide
tpa	Tonnes per annum
tpm	Tonnes per month
TSP	Total suspended particulates
VOC	Volatile Organic Compound
°C	Degrees Celsius
µg/m^3	Micrograms per cubic metre (concentration)
µm	Micrometre
%	Percent

Air Quality Impact Assessment for the Proposed Kangala Colliery Extension (Eloff Project) near Delmas, Mpumalanga

1 INTRODUCTION

Universal Coal Development 1 (UCD1) wishes to apply for an environmental authorisation in support of the development of a new coal mining operation, known as the proposed Kangala Extension Project, or Eloff Project. Kangala has been an operating mine since April 2014. Eloff will be the life extension of Kangala from 2020 when the coal reserves at Kangala are depleted. Kangala Colliery is located 65 km due east of Johannesburg and 8.0 km south-west of the town of Delmas, in the Victor Khanye Local Municipality and the Nkangala District Municipality, Mpumalanga Province (Figure 1). The Eloff Project mining area is contiguous to the Kangala area and is situated close to the R42 provincial road and to the south of the R555 road. The proposed Eloff Project is anticipated to use a standard truck and shovel mining method based on strip mining design and layout. The existing Coal Handling and Processing Plant (CHPP) at Kangala Colliery will be utilised for the proposed Eloff Project.

The proposed activities will result in air quality impacts in the study area. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Environmental Impact Management Services (EIMS) to undertake an environmental air quality specialist study for the project as part of the Environmental Impact Assessment (EIA) process. The air quality investigation comprises both a baseline study and an impact assessment.

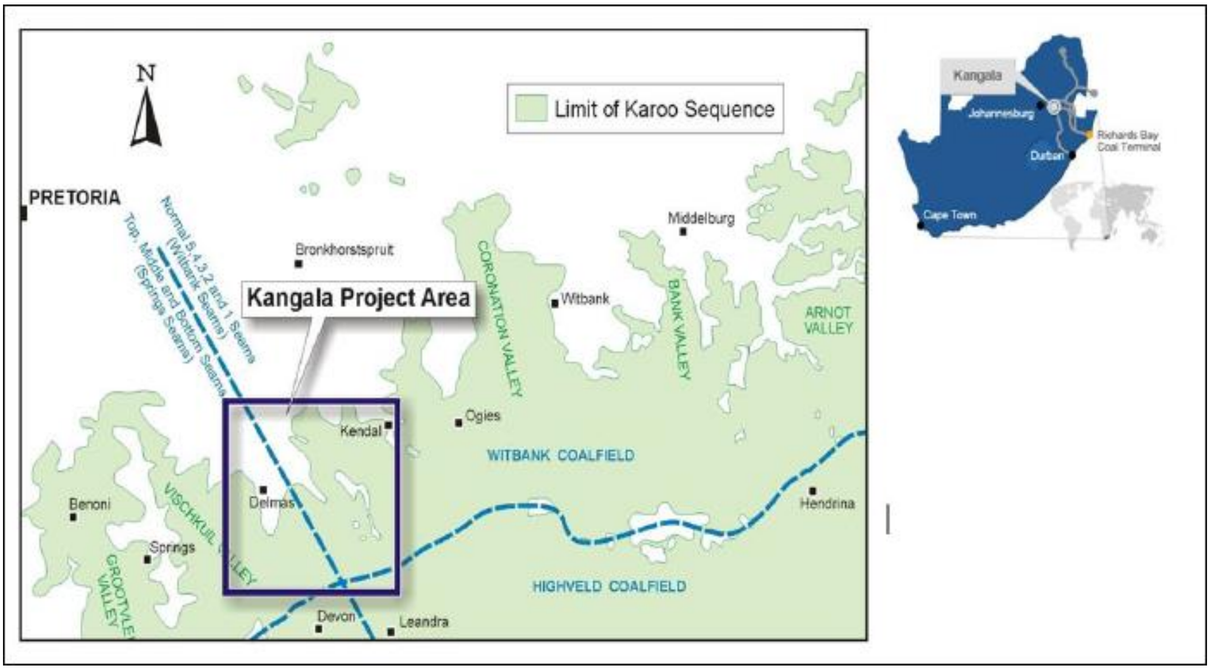

Figure 1: Kangala project area

1.1 Purpose

The main objective of the air quality specialist study was to determine the significance of impacts on the surrounding environment and human health at selected air quality sensitive receptors (AQSRs) given air emissions generated by activities proposed as part of the project.

1.2 Scope of Work

Based on the information supplied by EIMS the following tasks will be included in the scope of work:

1. A desktop air quality impact study, including:
    a. A review and identification of legal requirements pertaining to air quality;
    b. A desktop study of the receiving atmospheric environment (baseline) incl.:
        i. the identification of air quality sensitive receptors;
        ii. an analysis of regional climate and site-specific atmospheric dispersion taking into account local meteorology, land-use and topography; and
        iii. and analysis and assessment of existing (baseline) ambient air quality data (if available).
    c. The establishment of the future Eloff mining operations' emissions inventory;
    d. Atmospheric dispersion simulations for the future Eloff mine area;
    e. A human health risk and nuisance impact screening assessment based on dispersion simulation results;
    f. An Air Quality Impact Assessment (AQIA) as part of the Environmental Impact Assessment (EIA) process in the prescribed specialist report format.

1.3 Description of the Project Activities from an Air Quality Perspective

1.3.1 Construction Phase

The mining infrastructure that needs to be established to enable the production operations at the Eloff Project area is the following:

— Haul road to the tipping point at the CHPP
— Sumps for water management
— Piping system for water management
— Pollution Control Dam

The existing Kangala CHPP will be up-sized during 2019 to ensure the higher ROM production from 2019 can be processed. The required surface infrastructure such as offices, stores facility, workshops, and change house already exists at Kangala and thus do not need to be replicated for the operations at the Eloff Project area.

Gaseous and particulate emissions are expected to arise from construction activities. Typical sources of the fugitive emissions likely to occur during the construction phase are listed in Table 1.

Table 1: Typical sources of fugitive emissions associated with construction

Impact	Source	Activity
Gases	Vehicle tailpipe	Transport and general construction activities
Dustfall, PM_{10} and $PM_{2.5}$	Transport infrastructure	Clearing of vegetation and topsoil
		Levelling of proposed transportation route areas
	Up-sizing of existing CHPP	General construction activities
	Establishment of boxcut	Construction of overburden and topsoil stockpiles, vehicle activity, wind erosion from open areas

Each of the operations in Table 1 has their own duration and potential for dust generation. The impacts are likely to be localised and will depend on the dispersion potential of the site.

1.3.2 Operational Phase

Current mining activities at Kangala includes opencast mining and coal processing to deliver coal destined for the export and domestic markets. The current opencast pits at Kangala will be mined up to 2019 and mining operations will start at the Eloff Project in the middle of 2019, with the establishment of the box cut. The average strip ratio at Kangala Colliery is 1.32. As the production at Kangala ramps down, the production at Eloff will ramp up and by the year 2020, the total production will be from the Eloff Project. The average strip ratio at Eloff is estimated at 1.99. The estimated Life of Mine (LoM) for Eloff is 10 years. The forecasted mine schedule is shown in Figure 2.

The Kangala ROM coal is currently hauled to the existing ROM tip and the stockpile at the existing coal handling and processing plant (CHPP) (see Figure 3). This will continue to 2019 when the reserves at Kangala are depleted. The Kangala CHPP is situated on the Kangala Mining Right area and is 3.2 km from the R42 provincial road. At 6 480 operating hours per annum, the CHPP can process 4.2 million ROM tpa. The annual ROM production is planned to be increased to between 5.0 and 6.0 million ROM tpa from 2019. The current CHPP will be upsized during 2019 to cater for the increased ROM tonnes. The upsizing of the CHPP will not change the basic design but will only increase the rates of each process.

The ROM coal from the Eloff opencast will likewise be hauled to the existing ROM tip and the stockpile at the CHPP. For this purpose, a new haul road will be constructed from the Eloff opencast pit and this haul road will join with the existing Kangala haul road to the west of the CHPP (see Figure 3).

The Kangala CHPP consists of two processes:
- Crush and Screen: High-quality raw coal is directly crushed and screened to the final Eskom product.
- Dense medium separation (DMS) plant: Lower raw quality coal is crushed, screened, and then washed to produce a higher-grade coal that can be blended with the raw product to produce the final Eskom product.

There is an existing discard dump to the east of the CHPP to store the discard coal separated during the washing plant process. The discard is hauled by road to this discard dump for placement and compaction (Figure 3).

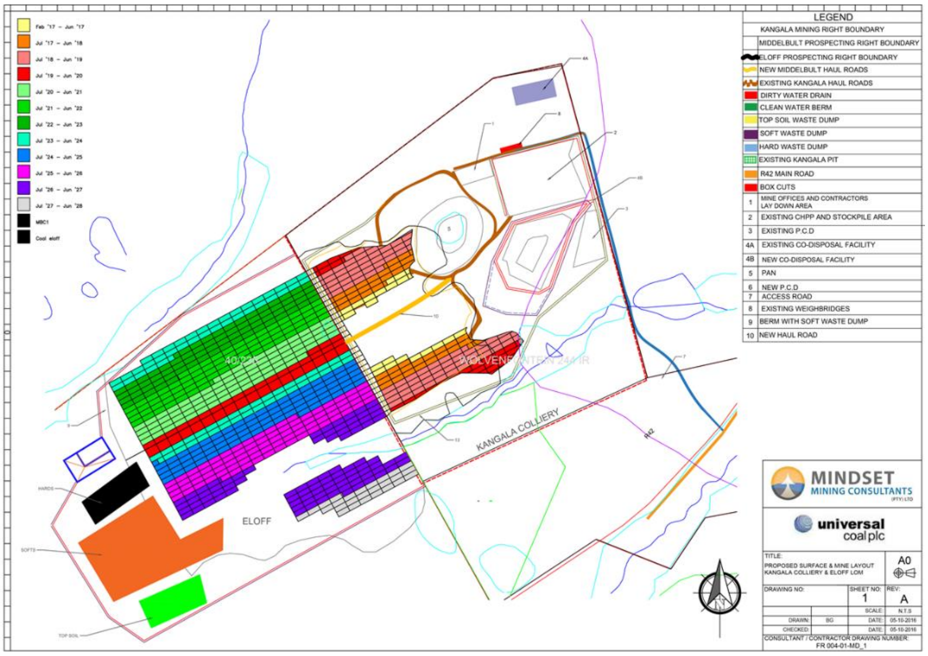

Figure 2: Forecasted mine schedule

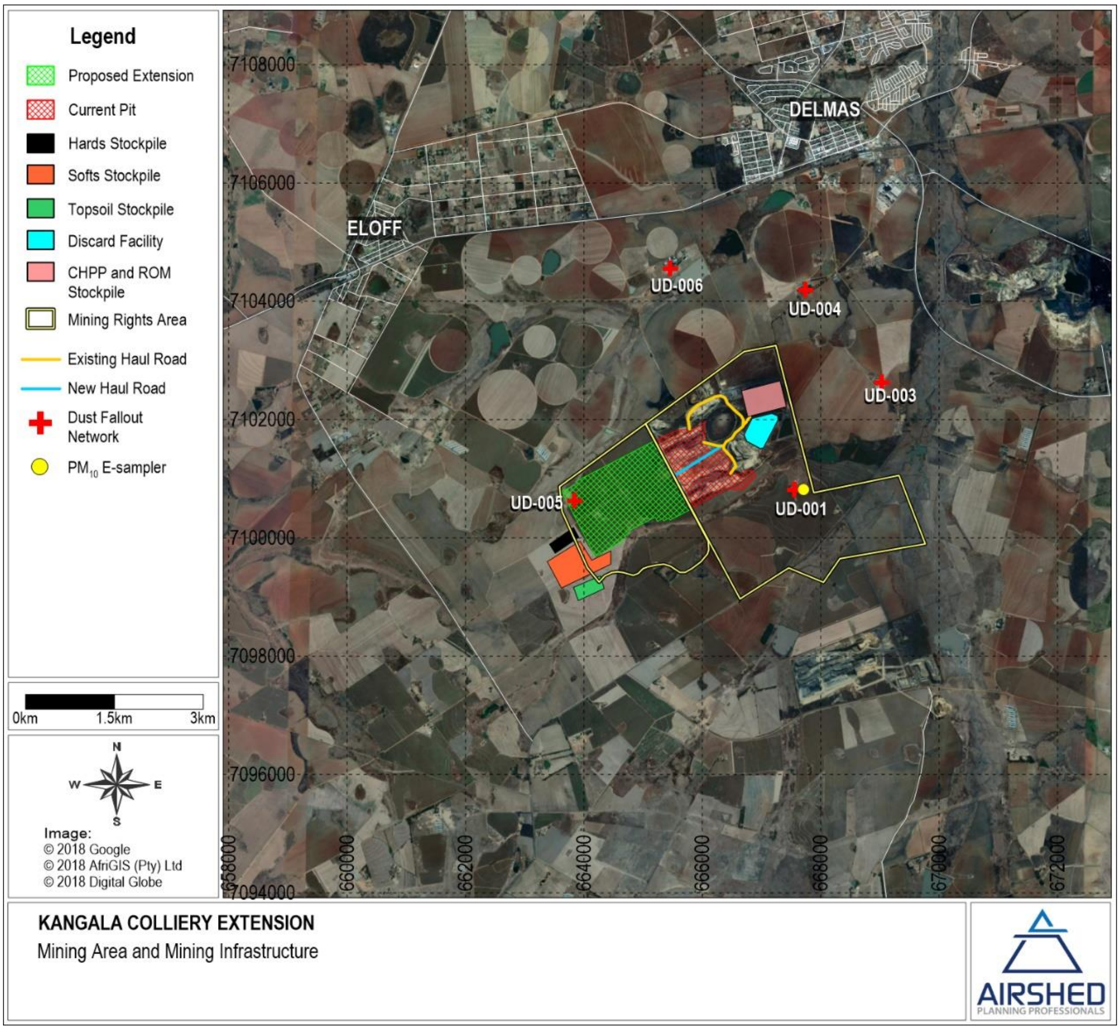

Figure 3: Site layout

1.3.2.1 Mining Method

The mining method that has been applied since the start of mining operations at Kangala (and will be applied during the Eloff project) is standard truck and shovel strip mining, which is described as follows:

- The topsoil is removed by truck and shovel and stored at the designated area.
- Thereafter, the softs will be removed by truck and shovel and stored at the designated material stockpiles.
- Next, cast blasting of the hard overburden material will be employed.
- Roll-over dozing of the hard overburden material will follow, where practical.
- Truck and shovel mining techniques are then applied to remove the hard overburden material in order to expose the various coal seams.
- Finally, the coal seams will be excavated by truck and shovel mining techniques.
- Any parting or inter-burden material between the coal seams will be drilled and blasted before being removed by the truck and shovel technique.

The process is repeated on a strip-by-strip basis. Material (apart from the topsoil) will then be rolled-over into the void created by the removal of the waste and coal in the previous bench, with the hard overburden and parting/ inter-burden forming the base, followed by the softs, levelled, and finally topsoil will be placed and seeded.

1.3.2.2 Coal Handling Processing Plant

The Kangala Colliery CHPP consists of a (i) crushing and screening plant, where high-quality raw coal (from the MBC1 and MBC2 seams) are directly crushed and screened to the final Eskom product; and (ii) DMS plant, where lower-quality raw coal (from the MBAB and MBD seams) is crushed and screened and then washed to produce a higher grade coal that can be blended with the raw product to produce the final Eskom product, and MM seam coal is crushed, screened and washed for an export product.

1.3.2.2.1 Crushing and Screening Plant

Raw coal from the mining process is fed to the crush and screen plant by haul trucks that tip their loads into the crush and screen plant 100 cubic metres ($m^{3)}$ feed bin. From there, the coal is fed to the primary crusher via a vibrating feeder. A magnet installed before the primary crusher removes tramp metal to protect the crushers from damage. The feed to the crusher has a maximum top size of 600 mm and produces a top size of 100 mm.

From the primary crusher, the coal is fed to the scalping screen via the scalping screen conveyor. A sacrifice conveyor is installed underneath the vibrating feeder to collect all the fines from this section and deliver it to the scalping screen conveyor as part of the feed to the scalping screen.

The scalping screen separates at 50 mm size maximum, which is the final product specification. The oversize (plus) + 50 mm are fed to the secondary crusher and the (minus) - 50 mm reports to the first overland conveyor as the final product. This conveyor is fitted with a weightometer and an auto sampler to determine production rates and quality of the crush and screen plant.

At the secondary crusher, the + 50 mm coal is re-crushed to the desired - 50 mm product requirement. The product from the secondary crusher also reports to the scalping screen for final classification by means of the recirculating conveyor.

The final product is transferred to the second overland conveyor that delivers the product to the product stockpile slew conveyor. The second overland conveyor is also fitted with a weightometer and an auto sampler to determine coal production and quality to Eskom.

The final Eskom product from the DMS plant is also added at the second overland conveyor for blending into the final Eskom product. The slew conveyor places the final product into separate 6 000 tonne stockpiles for pre-certification, from where it is transported to Eskom using road transport. The coal is processed at 350 tph through the crush and screen plant.

1.3.2.2.2 Dense Medium Separation Plant

Raw coal from the mining process is fed to the DMS plant by the haul trucks that tip their load into the DMS dedicated 100 m^3 feed bin. From there, the coal is fed to the primary crusher by a vibrating feeder. The primary crusher is a rotary breaker that removes rock from the lower grade coal and improves the yield and life of the downstream process. The feed to the breaker has a maximum top size of 600 mm and produces a top size of 100 mm.

From the rotary breaker, the coal is fed by a conveyor to the scalping screen. A magnet on the scalping screen conveyor protects the plant from damage by removing tramp metal to the feed of the scalping screen.

The scalping screen is a double deck resonance screens that separate the coal at 50 mm maximum, which is the final product specification. The oversize + 50 mm is fed to the secondary crusher, while the -50 mm is fed, by a sacrifice conveyor, to the primary wash conveyor as the feed to the primary wash section. At the secondary crusher, the + 50 mm coal is re-crushed to the desired -50 mm product requirement.

From the scalping screen, the coal is fed to the primary wash screen/ de-sliming screen via the de-sliming screen feed conveyor. This conveyor is fitted with a weightometer to determine the production rate of the DMS plant. The primary wash screen separates the - 1.0 mm fraction. Spray and dilution water are added to this screen to transport the coal further down the process.

The -1.0 mm fraction reports to the -1.0 mm tank from where it is pumped to the -1.0 mm spiral feed cyclone that separates at 125 microns. The -125 microns is fed to the thickeners. The underflow from the thickeners is pumped to the pollution control dam (PCD). The clean water from thickeners is collected in the clear water tank from where it is pumped to the process water tank for reuse in the process.

The + 125 micron – 1.0 mm fraction from the cyclone is fed to the spiral plant for separating the coal into the product and discard. Both the product and discard from the spirals are sent through dewatering cyclones and the water from the cyclones is returned to the –1.0 mm tank for reprocessing. Both the spiral product and discard is sent over dewatering screens for final dewatering. The spiral product reports to the product stockpiles and the spiral discard reports to the discard dump.

The + 1.0 mm - 50 mm fractions from the primary wash/ de-sliming screen are washed through the DMS cyclone plant following the normal process for such a plant. This would include dewatering of the product as well as discard and magnetite recovery.

The clean product coal is fed to either the product stockpile conveyor or the product transfer conveyor. From the product stockpile, conveyor product can be stockpiled and sold as export material or as an Eskom product. From the product transfer conveyor, the product is transferred to the overland conveyor. This conveyor is fitted with a weightometer and an auto sampler to determine the production rate and quality of the DMS plant.

The overland conveyor joins up with the overland conveyor from the crush and screen process where blending of the DMS and crush and screen coal takes place. The blended coal is then fed via the last overland conveyor to the slew conveyor for final stockpiling of the product, as per customer specification.

The discard from the DMS cyclone, after the drain and rinse and dewatering, is then transferred to the discard stockpile conveyor that feeds the discard bin from where the discard is removed by trucks to the discard dump. The discard stockpile conveyor is fitted with a weightometer to determine the production rate of discard.

1.3.2.3 Potential Air Emissions

Particulates represent the main criteria pollutant of concern in the assessment of operations from the Project. For the current assessment, the impacts were assessed against published PM_{10} and $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) and Dust Control Regulations (NDCR). The following operations are likely to result in atmospheric emissions:

- Drilling of waste rock and ROM;
- Blasting of waste rock and ROM;
- Truck and shovel operations in-pit;
- Hauling of ROM coal on unpaved roads;
- Primary and secondary crushing at the crushing and screening plant;
- Primary and secondary crushing at the DMS plant;
- Material transfer via conveyors to Eskom product stockpile from the crushing and screening plant;
- Material transfer via conveyors to Eskom product stockpile and export product stockpile from the DMS plant (wet process);
- Reclamation of coal from product stockpiles via frontend loader and loading to haul trucks; and
- Off-site hauling of product via the access road to the R42.

1.3.3 Decommissioning Phase

During decommissioning, bulk earthworks and demolishing activities are expected (Table 2). Very little information regarding specific activities during the decommissioning phase was available for consideration. The potential for impacts during this phase will depend on the extent of rehabilitation efforts during closure. Simulations of the decommissioning phase will not be included in the current study due to its temporary impacting nature.

Table 2: Activities and aspects identified for the decommissioning phase

Impact	Source	Activity
Dustfall, PM_{10} and $PM_{2.5}$	Stockpiles and mine pit	Dust generated during rehabilitation activities
	Associated infrastructure	Demolition of the associated infrastructure
Gases	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase

1.4 Approach and Methodology

The approach to, and methodology followed in the completion of tasks that formed part of the SoW are discussed in this section.

1.4.1 Project Information and Activity Review

All project related information referred to in this study was provided by EIMS. It includes responses to a detailed information requirements list submitted upon commencement of the study and the *Universal Coal Mining Works Programme* compiled by Mindset Mining Consultants (dated May 2018).

1.4.2 The Identification of Regulatory Air Quality Requirements and Assessment Criteria

In the evaluation regulations pertaining to air quality, reference was made to:

- Under the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEMAQA)
  - National Atmospheric Emission Reporting Regulations;
  - National Ambient Air Quality Standards (NAAQS) for criteria pollutants;
  - National Dust Control Regulations (NDCR); and
  - National Code of Practice for Air Dispersion Modelling.

1.4.3 Study of the Receiving Environment

Physical environmental parameters that influence the dispersion of pollutants in the atmosphere include terrain, land cover and meteorology. Readily available terrain and land cover data was obtained from via the United States Geological Survey (USGS) via the Earth Explorer website (U.S. Department of the Interior, U.S. Geological Survey, 2016). Use was made of Shuttle Radar Topography Mission (SRTM) (90 m, 3 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa.

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. In the absence of on-site meteorological data (that is required for atmospheric dispersion modelling), use was made of MM5[3] modelled meteorological data for the study site for the period 2014-2016.

Ambient monitoring data (PM_{10} concentrations and dust fallout levels) in the Project area is available for the period 2015-2018. Potential air quality sensitive receptors (AQSRs) were identified from Google Earth imagery.

1.4.4 Determining the Impact of the Project on the Receiving Environment

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts of the Project's emissions on the receiving environment. In the quantification of emissions, use was made of design parameters, as well as emission factors and emission equations, which associate the quantity of a pollutant to the activity associated with the release of that pollutant. Pollutants emissions were calculated using emission factors and equations as published by the United States Environmental Protection Agency (US EPA) and Australian Department of Environment and Energy (ADE) National Pollutant Inventory (NPI).

As per the National Code of Practice for Air Dispersion Modelling use was made of the US EPA AERMOD atmospheric dispersion modelling suite for the simulation of ambient air pollutant concentrations and dustfall rates. AERMOD is a Gaussian plume model best used for near-field applications where the steady-state meteorology assumption is most likely to apply. AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

[3] MM5 is a widely-used three-dimensional numerical meteorological model which contains non-hydrostatic dynamics, a variety of physics options for parameterizing cumulus clouds, microphysics, the planetary boundary layer and atmospheric radiation. MM5 has the capability to perform Four Dimensional Data Assimilation (FDDA), and are able to simulate a variety of meteorological phenomena such as tropical cyclones, severe convective storms, sea-land breezes, and terrain forced flows such as mountain valley wind systems.

1.4.5 *Compliance Assessment and Health Risk Screening*

Compliance was assessed by comparing simulated ambient criteria pollutant concentrations (PM_{10}, $PM_{2.5}$) and dustfall rates to NAAQS and NDCR respectively.

1.4.6 *Recommendation of Air Quality Management Measures*

The findings of the above components informed recommendations of air quality management measures, including mitigation and monitoring.

1.5 Assumptions, Exclusions and Limitations

The following important assumptions, exclusions and limitations to the specialist study should be noted:

1. No provision was made for:
   - Emission estimation, dispersion modelling and impacts assessment for the nearby Leeuwpan Colliery and Stuart Colliery, but impact prioritisation taking cumulative impacts into account was done to determine the final impact significance ratings associated with each phase of the project.
   - Ambient air quality sampling/monitoring.
   - Dust fallout sampling.
   - Meteorological monitoring.
2. The health risk assessment was limited to the screening of ambient air concentrations against NAAQS and applicable international legal guidelines and limits (WHO, IFC and US EPA). The scope of the study was confined to the quantification of impacts due to exposures via the inhalation pathway only.
3. The impact of the operational phase was determined quantitatively through emissions calculation and dispersion simulation. Due to their temporary nature, the assessment of impacts from the construction and closure phases is mainly of a qualitative nature. A general estimation of emissions due to the construction phase was provided. No impacts are expected post-closure provided the rehabilitation of final land forms is successful.
4. Meteorology:
   a. In the absence of on-site meteorological data (that is required for atmospheric dispersion modelling), use was made of MM5 modelled meteorological data for the study site for the period 2014-2016.
   b. The National Code of Practice for Air Dispersion Modelling prescribes the use of a minimum of one year on-site data or at least three years of appropriate off-site data for use in Level 2 assessments. It also states that the meteorological data must be for a period no older than five years to the year of assessment. The data set applied in this study complies with the requirements of the code of practice.
5. Emissions:
   a. The impact assessment was limited to airborne particulates (including TSP, PM_{10} and $PM_{2.5}$). These pollutants are either regulated under NAAQS or considered a key pollutant released by this operation.
   b. The quantification of sources of emission was restricted to the proposed Project. Although other existing sources of emission within the area were identified, such sources were not quantified as part of the emissions inventory and simulations. Their impact would be considered by ambient air quality monitoring in the region.
   c. In the absence of detailed construction and decommissioning plans, fugitive dust emissions for these phases were discussed qualitatively. The confidence rating of these emissions is therefore low.

2 REGULATORY REQUIREMENTS AND ASSESSMENT CRITERIA

The air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. The air quality guidelines and standards are normally given for specific averaging periods.

Ambient air quality standards and dustfall regulations, for pollutants applicable to this assessment are discussed in Section 2.1 and Section 2.2 respectively. National regulations regarding the reporting of atmospheric emissions are discussed in Section 2.4.

2.1 Ambient Air Quality Standards for Criteria Pollutants

The South African Bureau of Standards (SABS) was engaged to assist Department of Environmental Affairs (DEA) in the facilitation of the development of ambient air quality standards. This included the establishment of a technical committee to oversee the development of standards. National Ambient Air Quality Standards were determined based on international best practice for $PM_{2.5}$, PM_{10}, SO_2, NO_2, CO, ozone, lead and benzene. Particulates are the only pollutant of concern in terms of air quality from the Project. The NAAQS for particulates used for screening criteria in the current assessment is provided in Table 3.

Table 3: NAAQS for pollutants of concern for the current assessment

<table>
<tr><th>Substance</th><th>Molecular Formula / Notation</th><th>Averaging Period</th><th>Concentration (µg/m³)</th><th>Frequency of Exceedance (number of days per year)</th><th>Compliance Date</th><th>Reference</th></tr>
<tr><td rowspan="6">Particulate Matter</td><td rowspan="2">PM_{10}</td><td>24-hour</td><td>75</td><td>4</td><td>01-Jan-15</td><td rowspan="2">(Government Gazette 32816, 24 Dec 2009)</td></tr>
<tr><td>1 year</td><td>40</td><td>0</td><td>01-Jan-15</td></tr>
<tr><td rowspan="4">$PM_{2.5}$</td><td rowspan="2">24-hour</td><td>40</td><td>4</td><td>01-Jan-16 to 31-Dec-29</td><td rowspan="4">(Government Gazette 35463, 29 Jun 2012)</td></tr>
<tr><td>25</td><td>0</td><td>01-Jan-30</td></tr>
<tr><td rowspan="2">1 year</td><td>20</td><td>4</td><td>01-Jan-16 to 31-Dec-29</td></tr>
<tr><td>15</td><td>0</td><td>01-Jan-30</td></tr>
</table>

2.2 National Dust Control Regulations

Dustfall is assessed for nuisance impact and not for inhalation health impact. The National Dust Control Regulations (Department of Environmental Affairs, 2013) prescribes measures for the control of dust in residential and non-residential areas.

The acceptable dustfall rates as measured (using American Standard Testing Methodology (ASTM) D1739:1970 or equivalent) at and beyond the boundary of the premises where dust originates are given in Table 4.

In addition to the dustfall limits, the National Dust Control Regulations prescribe monitoring procedures and reporting requirements.

Table 4: Acceptable dustfall rates

Restriction Area	Dustfall rate (mg/m²/day, 30-days average) (D)	Permitted frequency of exceeding dustfall rate
Residential area	D < 600	Two within a year, not sequential months
Non-residential area	600 < D < 1 200	Two within a year, not sequential months

2.3 Highveld Priority Area

The Highveld Airshed was declared the second priority area by the minister at the end of 2007. This required that an Air Quality Management Plan for the area be developed. The plan includes the establishment of an emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area. The implication of this is that all contributing sources in the area will be assessed to determine the emission reduction targets to be achieved over the following few years.

The project area is located within the footprint demarcated as the Highveld Priority Area. Emission reduction strategies will be included for the numerous coal mines in the area with specific targets. The DEA published the management plan for the Highveld Priority Area in September 2011. Included in this management plan are seven goals, each of which has a further list of objectives that must be met. The goals for the Highveld Priority area are as follows:

- Goal 1: By 2015, organisational capacity in government is optimised to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards
- Goal 2: By 2020, industrial emissions are equitably reduced to achieve compliance with ambient air quality standards and dustfall limit values
- Goal 3: By 2020, air quality in all low-income settlements is in full compliance with ambient air quality standards
- Goal 4: By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy
- Goal 5: By 2020, a measurable increase in awareness and knowledge of air quality exists
- Goal 6: By 2020, biomass burning and agricultural emissions will be 30% less than current
- Goal 7: By 2020, emissions from waste management are 40% less than current

Goal 2 applies directly to the Project. The objectives associated with this goal include:

- Emissions are quantified from all sources;
- Gaseous and particulate emissions are reduced;
- Fugitive emissions are minimised;
- Emissions from dust generating activities are reduced;
- Incidences of spontaneous combustion are reduced;
- Abatement technology is appropriate and operational;
- Industrial Air Quality Management (AQM) decision making is robust and well-informed, with necessary information available;
- Clean technologies and processes are implemented;
- Adequate resources are available for AQM in industry;
- Ambient air quality standard and dustfall limit value exceedances as a result of industrial emissions are assessed; and,

- A line of communication exists between industry and communities.

Each of these objectives is further divided into activities, each of which have a timeframe, responsibility and indicator. Refer to the DEA (2011) Highveld Priority Management Plan for further details[4].

2.4 Reporting of Atmospheric Emissions

The National Atmospheric Emission Reporting Regulations (Government Gazette No. R283) came into effect on 2 April 2015.

The purpose of the regulations is to regulate the reporting of data and information from an identified point, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS), towards the compilation of atmospheric emission inventories. The NAEIS is a component of the South African Air Quality Information System (SAAQIS); its objective is to provide all stakeholders with relevant, up to date and accurate information on South Africa's emissions profile for informed decision making.

2.4.1 Classification of Emission Sources and Data Providers

Emission sources and data providers are classified according to groups A to D (listed in Table 5). According to Table 5 the Project would be classified under Group C ("Mines").

Table 5: Emission source groups, associated data providers, emission reporting requirements and relevant authorities

Group	Emission Source	Data Provider	NAEIS Reporting Requirements	Relevant Authority
A	Listed activity published in terms of section 21(1) of the Act.	Any person that undertakes a listed activity in terms of section 21(1) of the Act.	Emission reports must be made in the format required for NAEIS and should be in accordance with the atmospheric emission license or provisional atmospheric emission license.	Licensing authority.
B	Controlled emitter declared in terms of section 23(1) of the Act.	Any person that undertakes a listed activity in terms of section 21(1) of the Act and uses an appliance or conducts an activity which has been declared a controlled emitter in terms of section 23(1) of the Act. Any relevant air quality officer receiving emission reports as contemplated under notice made in terms of section 23 of the Act.	Any information that is required to be reported in terms of the notice published in the Gazette in term of section 23 of the Act.	The relevant air quality officer as contemplated under the notice made in terms of section 23 of the Act.

[4] This document can be downloaded from the SAAQIS website: www.saaqis.org.za

Group	Emission Source	Data Provider	NAEIS Reporting Requirements	Relevant Authority
C	Mines.	Any person, that holds a mining right or permit in term of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002).	Emission reports must be made in the format required for NAEIS.	Relevant air quality officer.
D	Facilities identified in accordance with the applicable municipal by-law.	Any person that operates facilities which generate criteria pollutants and has been identified in accordance with the applicable municipal By-law.	Emission reports must be made in the format required for NAEIS.	Relevant air quality officer.

2.4.2 Registration as Data Provider

The regulations specify that emission sources and data providers as classified in Table 5 must register on the NAEIS within 30 days from the date upon which these regulations came into effect.

Data providers must inform the relevant authority of changes if there are any:

- Change in registration details;
- Transfer of ownership; or
- Activities being discontinued.

2.4.3 Reporting or Submission of Information

A data provider must submit the required information for the **preceding calendar year** to the NAEIS **by 31 March** of each year. Records of data submitted must be kept for a period of 5 years and must be made available for inspection by the relevant authority.

2.4.4 Verification of Information

The relevant authority must request, in writing, a data provider to verify the information submitted if the information is incomplete or incorrect. The data provider then has 60 days to verify the information. If the verified information is incorrect or incomplete the relevant authority must instruct a data provider, in writing, to submit supporting documentation prepared by an independent person. The relevant authority cannot be held liable for cost of the verification of data.

2.4.5 Penalties

A person guilty of an offence in term of regulation 13 of these Regulations is liable in the case of a first conviction to a fine not exceeding R5 million or to imprisonment of a period not exceeding five years, and in the case of a second or subsequent conviction to a fine not exceeding R10 million or imprisonment for a period not exceeding 10 years and in respect of both instances to both such imprisonment.

3 DESCRIPTION OF THE BASELINE ENVIRONMENT

This chapter provides details of the receiving atmospheric environment which is described in terms of:

- Local AQSRs;
- The atmospheric dispersion potential;
- Baseline or pre-development ambient air pollutant contributors; and
- Pre-development ambient air pollutant levels.

In the absence of on-site meteorological data (that is required for atmospheric dispersion modelling), use was made of MM5 modelled meteorological data for the study site for the period 2014-2016.

3.1 Air Quality Sensitive Receptors

AQSRs generally include places of residence and areas where members of the public may be affected by atmospheric emissions generated by mining/industrial activities. The nearest receptors to the project location are farmsteads, residential areas, schools, a hospital and agricultural holdings (Figure 4).

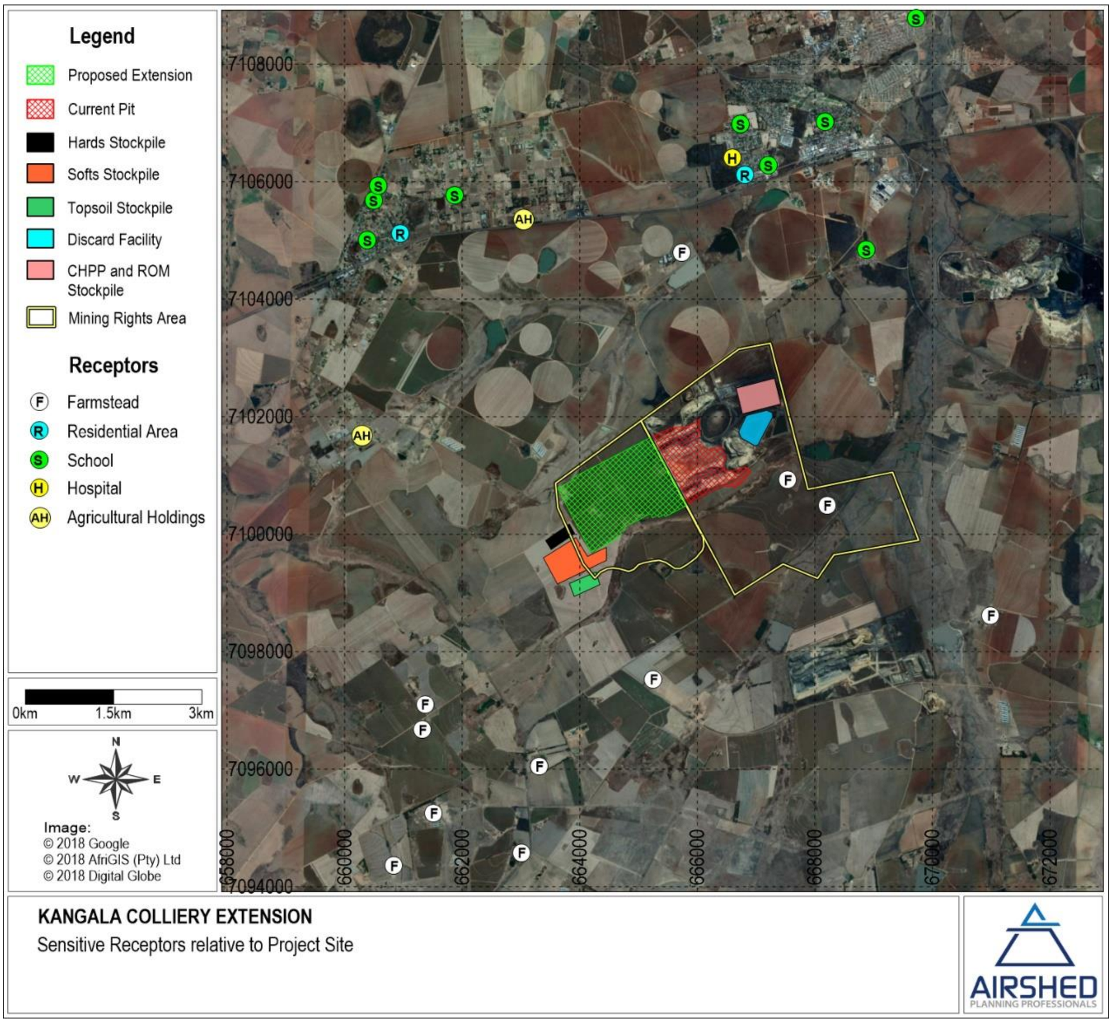

Figure 4: Location of sensitive receptors relative to the Project

3.2 Topography

Changes in terrain around an air pollution source can significantly influence the way the plume is dispersed. Hills or rough terrain influence the wind speed, wind direction and turbulence characteristics. Significant valleys can cause persistent drainage flows and restrict horizontal movement whereas sloping terrain may help provide katabatic or anabatic flows. The topography of the study area is fairly flat, comprising of undulating terrain slightly increasing in height above mean sea level to the northeast of the area. An analysis of topographical data indicated a slope of less than 1:10 from over most of the project area. Dispersion modelling guidance recommends the inclusion of topographical data in dispersion simulations only in areas where the slope exceeds 1:10 (US EPA, 2004).

3.3 Climate

3.3.1 Regional Climate

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher a pollution plume is able to rise) and determining the development of the mixing and inversion layers. Minimum, maximum and mean temperatures from the MM5 modelled data for the study site are shown in Table 6. Diurnal monthly average temperatures shown in Figure 5.

Average, maximum and minimum temperatures were 15.7°C, 31.0°C and -3.4°C, respectively. The month of July experienced the lowest temperature of -3.4°C whereas the maximum temperature of 31.0°C occurred in January. During the day, temperatures increase to reach maximum at around 14:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 05:00 i.e. just before sunrise.

Table 6: Minimum, maximum and average temperatures (MM5 modelled data for the study site, 2014 to 2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean temperature (°C)	20.6	20.6	18.8	15.3	11.9	8.8	8.1	11.7	15.1	17.3	18.9	20.9
Maximum (°C)	31.0	29.4	27.8	25.8	20.9	18.8	18.0	23.8	24.9	29.0	29.4	30.4
Minimum (°C)	12.1	11.0	9.4	4.1	1.1	-1.0	-3.4	-1.2	0.9	2.8	5.1	11.9

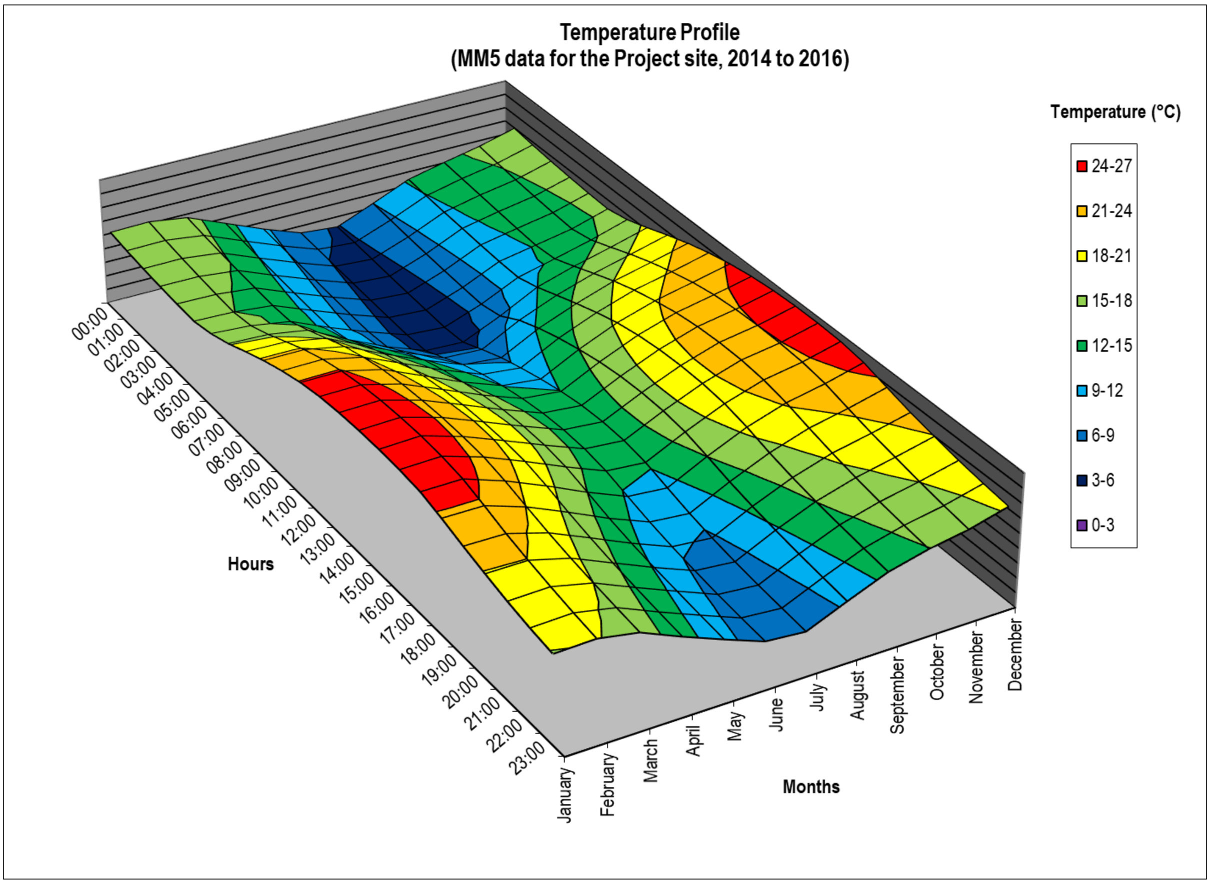

Figure 5: Diurnal monthly average temperature profile (MM5 modelled data for the study site, 2014 to 2016)

3.3.2 Mean Monthly and Annual Rainfall

Precipitation is important to air pollution studies since it represents an effective removal mechanism for atmospheric pollutants and inhibits dust generation potentials. According to the rainfall data from the Delmas Vlakplaas Weather Station between 1979 and 2009, the mean annual precipitation is 681 mm (Maartens, 2011). Precipitation occurs as showers and thunderstorms and falls mainly from October to March (about 58 days of measurable rain per year) with the maximum falls occurring in November, December and January. Rainstorms are often violent (up to 120 mm can occur in one day) with severe lightning and strong winds, sometimes accompanied by hail. The winter months are dry with the combined rainfall in June, July and August making up only 3.1 % of the annual total according to the data obtained from the Delmas Vlakplaas Weather Station. The annual rainfall by month from 1979 to 2009 is given in Figure 6.

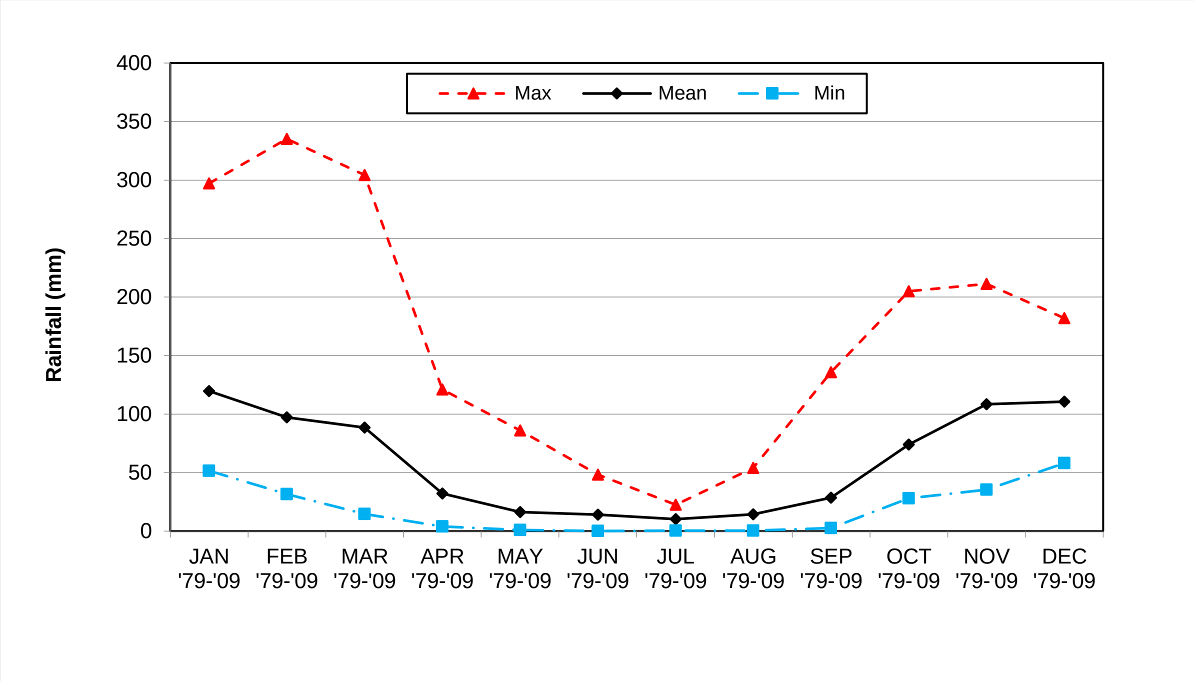

Figure 6: Average monthly precipitation at Delmas, Mpumalanga (Maartens, 2011)

3.3.3 *Atmospheric Stability*

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class.

The Monin-Obukhov length (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

Diurnal variation in atmospheric stability, as calculated from on-site data, and described by the inverse Monin-Obukhov length and the boundary layer depth is provided in Figure 7. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions.

For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called *looping* (Figure 7 (c)) and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as *coning* (Figure 7 (b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Figure 7 (a)) (Tiwary & Colls, 2010).

For ground level releases such as fugitive dust the highest ground level concentrations will occur during stable night-time conditions.

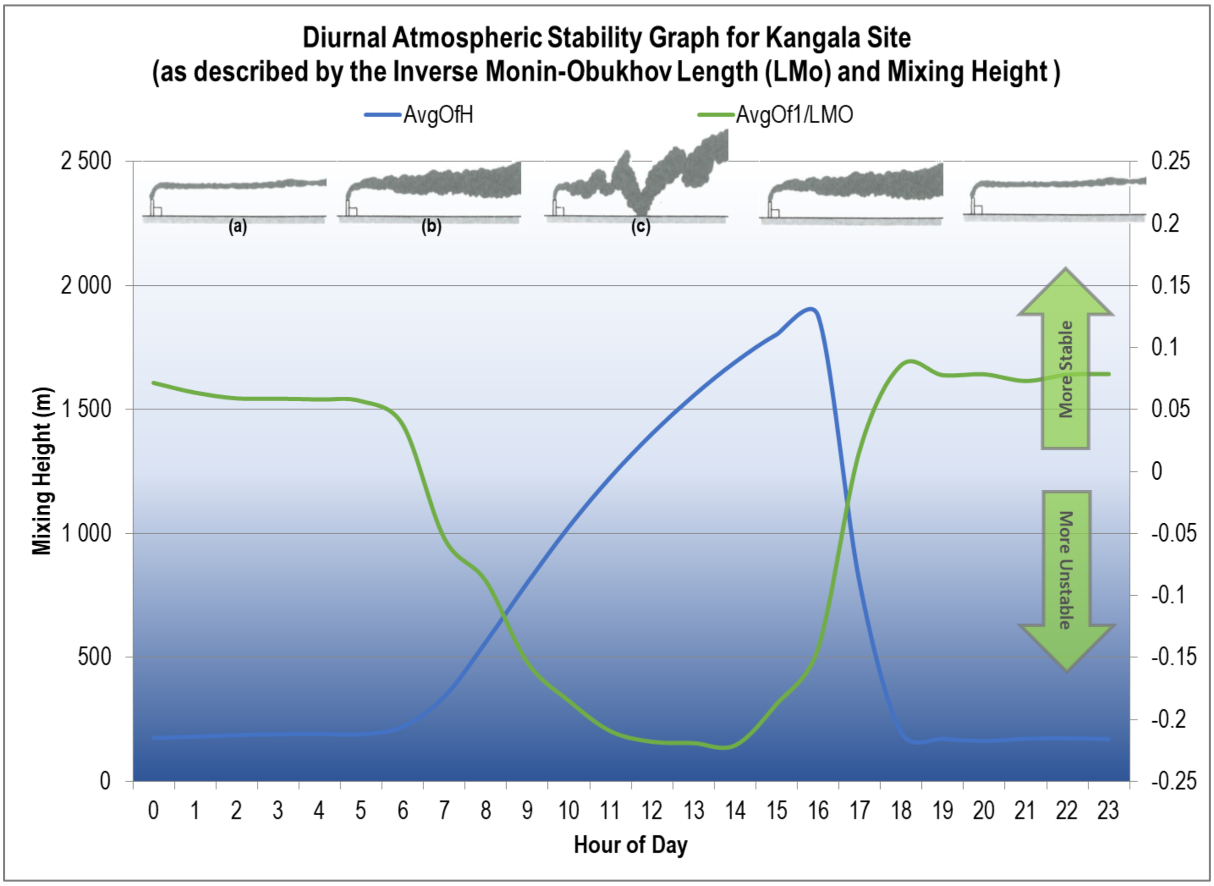

Figure 7: Diurnal atmospheric stability (MM5 modelled data for the study site, 2014 to 2016)

3.3.4 Surface Wind Field

The wind field determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is a function of the wind speed, in combination with the surface roughness. The wind field for the study area is described with the use of wind roses. Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the yellow area, for example, representing winds in between 4 and 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. Calm conditions are periods when the wind speed was below 1 m/s. These low values can be due to "meteorological" calm conditions when there is no air movement; or, when there may be wind but it is below the anemometer starting threshold. AERMET, the meteorological pre-processor to AERMOD, treats calm conditions (wind speeds <1 m/s) as missing data, which can result in overly conservative concentration estimates simulated in AERMOD. The Regulations regarding Air Dispersion Modelling (DEA, 2014) suggest that all wind speeds greater than or equal to the anemometer starting threshold and less than 1 m/s be replaced with the value of 1 m/s. This approach has been adopted.

The period wind field and diurnal variability in the wind field from the modelled MM5 data are shown in Figure 8 and Figure 9, while the seasonal variations in the wind field are provided in Figure 10. During the 2014 to 2016 period, the wind field was dominated by strong winds from the north, and north-northeast. The strongest winds (more than 6 m/s) were recorded from the north-northwest, north and north-northeast, occurring mostly during the day (06:00 to 18:00). An increase in dominant winds from the north-northeast occurred at night (18:00 to 06:00).

Seasonal wind fields vary - during spring and summer the dominant winds are from the north and north-northeast, with very little wind from the south, whereas the autumn and winter seasons are dominated by northerly winds with an increase in winds from the south and the east.

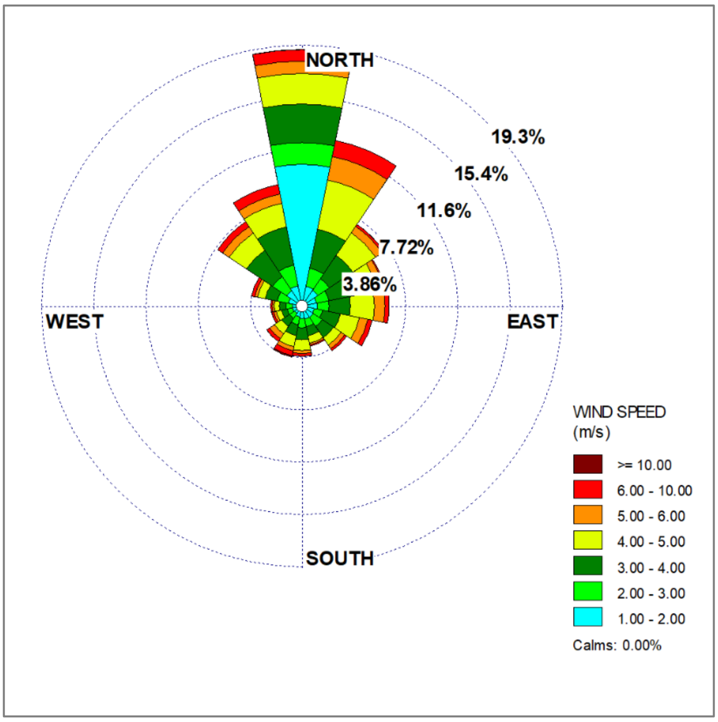

Figure 8: Period average wind rose (MM5 modelled data for the study site, 2014 to 2016)

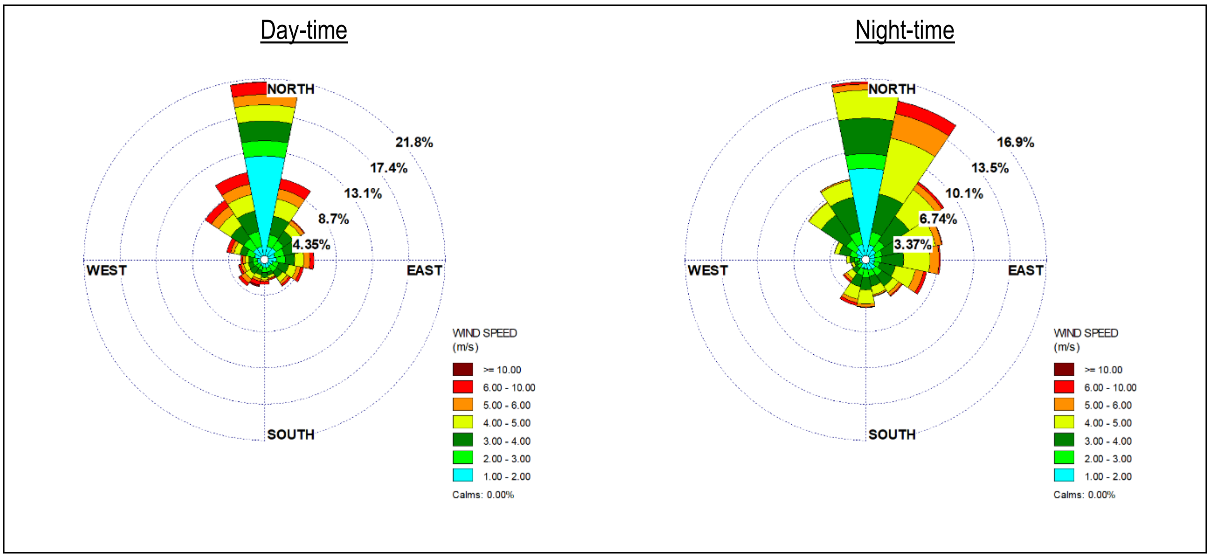

Figure 9: Day-time and night-time wind roses (MM5 modelled data for the study site, 2014 to 2016)

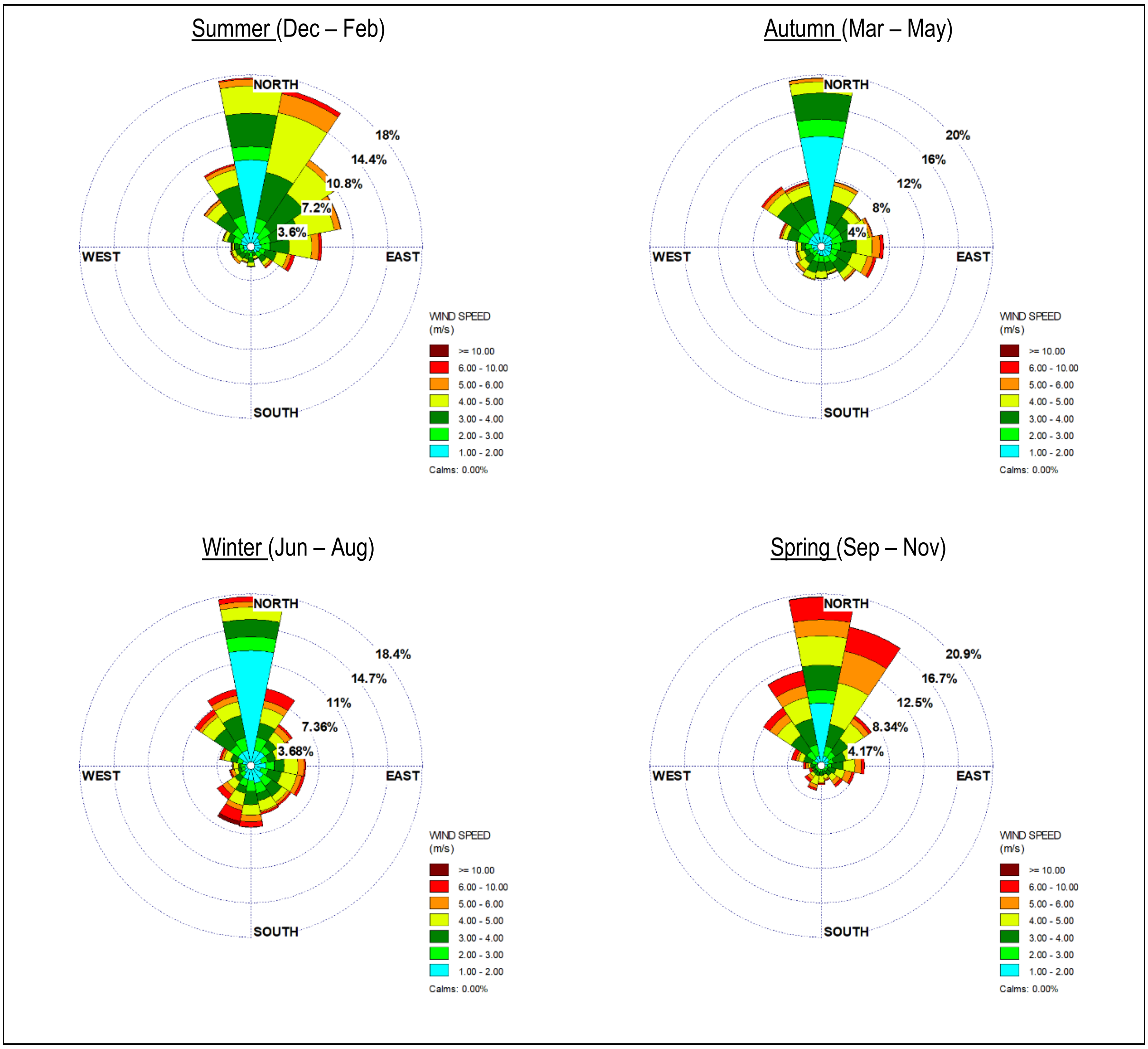

Figure 10: Seasonal wind roses (MM5 modelled data for the study site, 2014 to 2016)

3.4 Existing Sources of Emissions near the Project Site

Power generation, mining activities, farming and residential land-uses occur in the vicinity of the proposed Kangala Extension Project. These land-uses contribute to baseline pollutant concentrations via vehicle tailpipe emissions, household fuel combustion, biomass burning and various fugitive dust sources. Long-range transport of particulates, emitted from remote tall stacks and from large-scale biomass burning in countries to the north of South Africa, has been found to contribute to background fine particulate concentrations within the South African boundary (Andreae, et al., 1996; Garstang, Tyson, Swap, & Edwards, 1996; Piketh, Annegarn, & Kneen, 1996; Swap *et al*, 2003).

3.4.1 Power Generation

The closest power station is Kendal Power Station, situated approximately 32 km to the north-east of the Project site. Processing emissions and fugitive emission sources from these operations mainly comprise of boiler operations, materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from plant roads and windblown dust from open areas. These activities result in PM, NO_x, CO, SO_2, VOC and diesel particulate matter (DPM) releases.

3.4.2 Metallurgical Manufacturing

There are metallurgical manufacturing operations located in the vicinity of the Project. Processing emissions and fugitive emission sources from these operations mainly comprise of dryer and smelter operations, materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from plant roads and windblown dust from open areas. These activities result in PM, NO_x, CO, SO_2, VOC, DPM and trace metal releases.

3.4.3 Mining Operations

There are numerous existing and proposed mines located in the vicinity of the Project. Fugitive emissions sources from mining operations mainly comprise of land clearing operations (i.e. scraping, dozing and excavating), materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from haul roads, wind erosion from open areas and drilling and blasting. These activities mainly result in fugitive PM releases with NO_x, CO, SO_2, VOC and DPM being released during blasting operations as well as a result of diesel combustion and storage.

The closest mines are Leeuwpan and Stuart opencast coal mines to the north-east at distances of 7 km and 11.5 km respectively.

3.4.4 Agricultural operations

Agriculture is a land-use within the area surrounding the site. Particulate matter is the main pollutant of concern from agricultural activities as particulate emissions are deriving from windblown dust, burning crop residue, and dust entrainment as a result of vehicles travelling along dirt roads. In addition, pollen grains, mould spores and plant and insect parts from agricultural activities all contribute to the particulate load. Should chemicals be used for crop spraying, they would typically result in odoriferous emissions. Crop residue burning is an additional source of particulate emissions and other toxins.

3.4.5 Miscellaneous Fugitive Dust Sources

Fugitive PM emissions are generated through entrainment from local paved and unpaved roads, and erosion of open or sparsely vegetated areas. The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads and on the silt loading on the roadways. The extent, nature and duration of road-use activity and the moisture and silt content of soils are required to be known in order to quantify fugitive emissions from this source. The quantity of windblown dust is similarly a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

3.4.6 Vehicle Tailpipe Emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. Notable primary pollutants emitted by vehicles include CO_2, CO, hydrocarbons (HCs), SO_2, NO_x, DPM and Pb. Secondary pollutants include: NO_2, photochemical oxidants (e.g. ozone), HCs, sulphur acid, sulphates, nitric acid, nitric acid and nitrate aerosols. Hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses. Vehicle tailpipe emissions are localised sources and unlikely to impact far-field.

The R555 and R42 provincial roads are in close proximity to the project area and are both busy roads. The R42 provincial road crosses through the centre of the Eloff Project area in a north-east to south-west direction. The R555 provincial road runs along the north western boundary of the Eloff Project area.

3.4.7 Household Fuel Burning

Energy use within the residential sector is given as falling within three main categories, viz.: (i) traditional - consisting of wood, dung and bagasse, (ii) transitional - consisting of coal, paraffin and liquefied petroleum gas (LPG), and (iii) modern - consisting of electricity (increasingly this includes the use of renewable energy). The typical universal trend is given as being from (i) through (ii) to (iii). Pollutants include products of combustion (CO, NO_x, SO_2 and VOC), unburned HC and PM.

3.5 Measured Baseline Air Quality

Particulates represent the main pollutant of concern in the assessment of mining operations. The particulates in the atmosphere may contribute to visibility reduction, pose a threat to human health, or simply be a nuisance due to their soiling potential.

3.5.1 Measured Ambient Air Pollutant Concentrations

A Met-One E-Sampler is used to measure PM_{10} concentrations at Kangala Colliery. The E-Sampler was installed on 22 April 2015 at the main truck entrance near a security booth on the border of the mine. On 12 April 2016, the E-sampler was relocated to the nearby training centre (-26.202342°S; 28.677159°E) which is located further away from the main truck entrance (see Figure 3). The E-Sampler was relocated as per the request of the client due to its close proximity to the haul road (Rayten Engineering Solutions, Air Quality Monthly Monitoring Report, 14 October 2016).

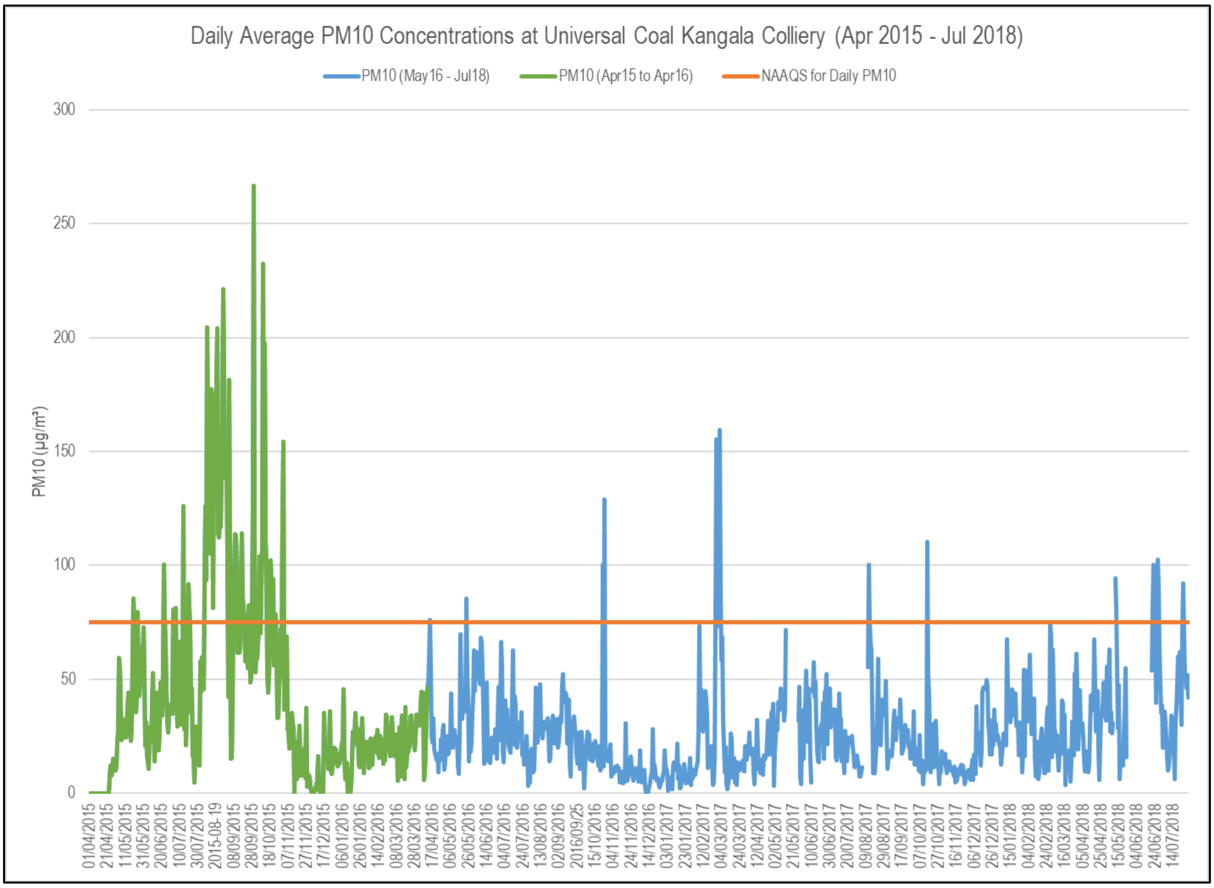

Figure 11: Measured daily PM_{10} concentrations for the Kangala Colliery monitoring station for the period April 2015 – July 2018

The PM_{10} concentrations that were measured between 22 April 2015 and 30 April 2016 regularly exceeded the daily NAAQS during the May to October period (65 exceedances). After the relocation of the monitoring station to UD-001 the frequency of exceedance was reduced to 13 exceedances between 1 May 2016 and 30 April 2017; 3 exceedances between 1 May 2017 and 30 April 2018; and 9 exceedances in the 3-month period 1 May 2018 to 31 July 2018. The annual average concentration was calculated from the monthly concentrations over the measuring period and was estimated to be 46 µg/m³ (2015/2016); 23 µg/m³ (2016/2017); and 26 µg/m³ (2017/2018).

3.5.2 Modelled Ambient Air Pollutant Concentrations

The Project is located within the Highveld Priority Area, but outside the modelled ambient "hotspot" areas where annual concentrations due to industrial sources exceed the PM_{10} NAAQS (Figure 12). The modelled PM_{10} predictions as provided in the Highveld Priority Area Management Plan (which excluded the mining operations and domestic fuel burning operations) shows that the project is located outside the areas where more than 4 days of exceedance per year may be expected.

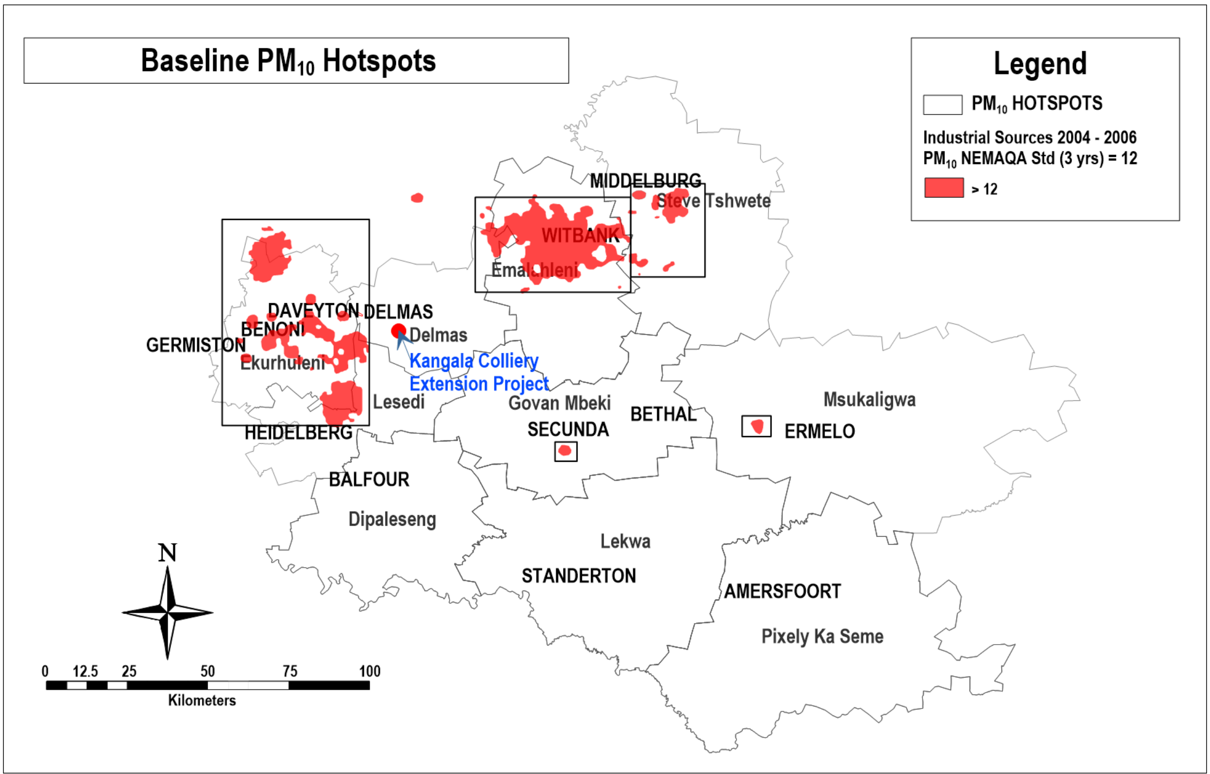

Figure 12: Modelled frequency of exceedance of 24-hour ambient PM_{10} standards in the Highveld Priority Area, indicating the modelled Air Quality Hot Spot areas

3.5.3 Dustfall Rates

The dustfall monitoring network consists of five buckets (shown in Figure 3). Both dustfall and PM_{10} is measured at UD-001, which is located within the mining rights area. Dustfall rates as measured during the period January 2015 to June 2018 are shown in Figure 13. The residential limit of 600 mg/m²/day was exceeded at UD-003 more than twice per year, and for sequential months, during the 2015/2016, 2016/2017, and 2017/2018 sampling periods. The only other monitoring stations where exceedances were recorded are UD-001 and UD-004; however, the exceedances were not in sequential months.

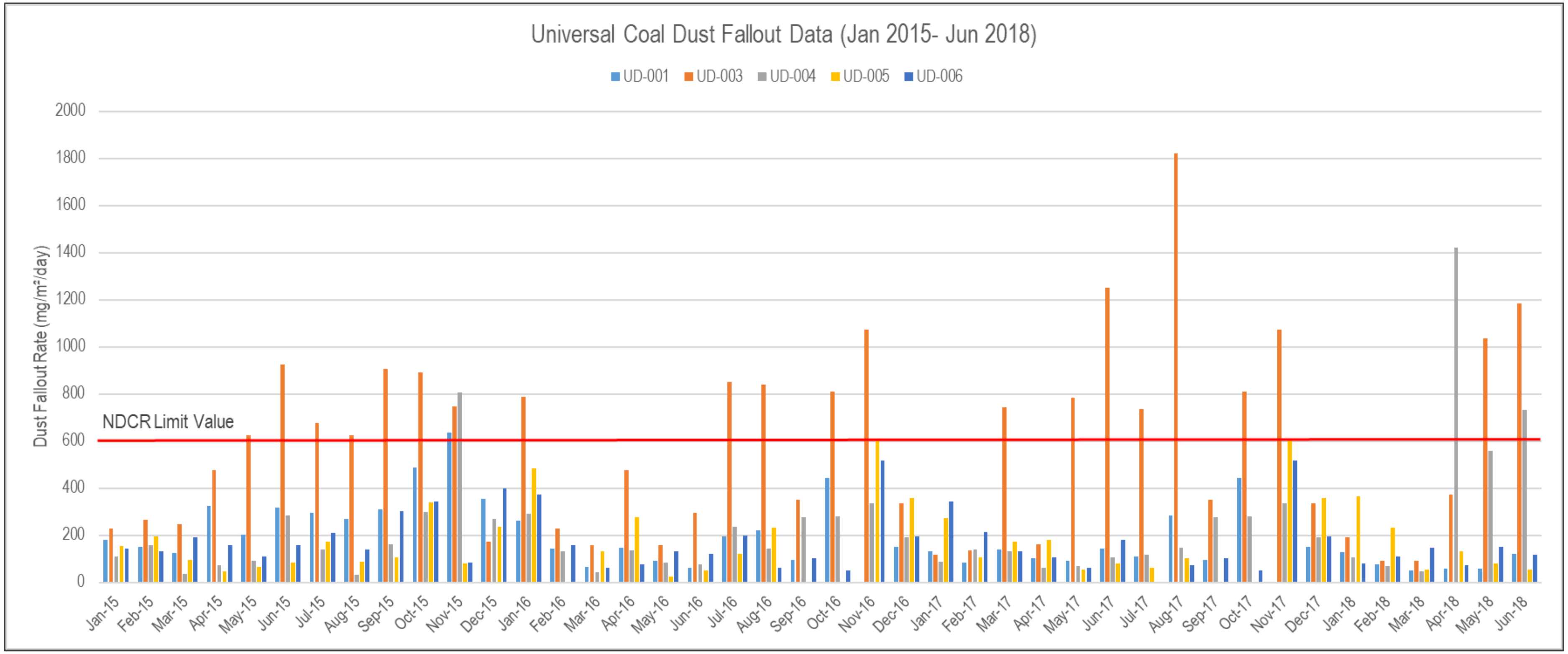

Figure 13: Monthly dustfall rates sampled at Kangala Colliery (January 2015 – June 2018)

4 Impact Assessment

The emissions inventory, dispersion modelling and results are discussed in Sections 4.1, 1.1 and 4.3 respectively.

4.1 Atmospheric Emissions

4.1.1 Construction Phase

A detailed construction plan for the up-sizing of the CHPP plant and construction of new haul road is required to quantitatively assess the impacts from this phase. Due to the lack of detailed information and the relatively short duration of most of the activities associated with the construction phase, no dispersion simulations were undertaken and a qualitative assessment was done.

The main pollutant of concern from construction operations is particulate matter, including PM_{10}, $PM_{2.5}$ and TSP. PM_{10} and $PM_{2.5}$ concentrations are associated with potential health impacts due to the size of the particulates being small enough to be inhaled. Nuisance effects are caused by the TSP fraction (20 µm to 75 µm in diameter) resulting in soiling of materials and visibility reductions. This could in effect also have financial implications due to the requirement for more cleaning materials.

Since the required surface infrastructure such as offices, stores facility, workshops, and change house already exists at Kangala and only limited construction activities are required at the site, the impacts due to construction activities are likely to be localised and of low magnitude.

4.1.2 Operational Phase

To determine the significance of air pollution impacts from the proposed Project, two scenarios were assessed:

- **Baseline scenario (Scenario 1)** – representative of opencast mining activities at Kangala Colliery for the year July 2017 – June 2018, with an estimated throughput of 3 091 721 tonnes of ore and 7 732 535 tonnes of overburden (strip ratio 2.50), with a yield of 70.15% and a CHPP capacity of 4.2 million ROM tpa; and
- **Project scenario (Scenario 2)** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026) with an estimated throughput of 5 232 449 tonnes of ore and 9 657 640 tonnes of overburden (strip ratio 1.85), with a yield of 91.22% and a CHPP capacity of between 5 and 6 million tpa.

Each of the scenarios had 3 sub-scenarios, namely (a) unmitigated operations, (b) design mitigated operations[5] and (c) additionally mitigated operations[6] (see Table 9 and footnotes 5 and 6 (p46) for explanation of design mitigation and additional mitigation).

The emission equations used to quantify emissions from the proposed activities are shown in Table 7. For each scenario, both unmitigated and mitigated activities were assessed. The estimated control factors for the various mining operations are listed in Table 9. The estimated emissions from baseline and Project mining operations are provided in Table 10 and Table 11 respectively.

Table 7: Emission equations used to quantify fugitive dust emissions from the proposed Project

Activity	Emission Equation	Source	Information assumed/provided
Materials handling (including conveyor transfer tips)	$$E = 0.0016\frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$$ Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively. An <u>average wind speed of 3.21 m/s</u> was used based on the modelled MM5 data for the period 2014 – 2016.	US-EPA AP42 Section 13.2.4	<u>The moisture content of materials are as follows:</u> *Overburden*: 7.9% (US EPA default mean moisture content, Table 11.9-3) *ROM coal*: 4.82% (EIA and EMP Report for Kangala Coal Mine, December 2014) *Washed coal*: 5.42% (EIA and EMP Report for Kangala Coal Mine, December 2014) The respective throughput of materials at the opencast area for Scenario 1 was calculated as 113 tph (ROM) and 304 tph (overburden). The throughput at the CHPP was calculated as: *ROM*: 3 091 721 tpa *Discard*: 922 913 tpa *Eskom product*: 2 004 000 tpa *Kusile product*: 22 807 tpa *Export product*: 142 000 tpa The respective throughput of materials at the opencast area for Scenario 2 was calculated as 113 tph (ROM) and 304 tph (overburden). The throughput at the CHPP was calculated as: *ROM*: 5 232 449 tpa *Discard*: 459 190 tpa *Eskom product*: 2 004 000 tpa *Kusile product*: 2 769 259 tpa <u>Hours of operation:</u> Opencast area – 4 shifts (20 hours operation) CHPP area – 4 shifts (20 hours operation)

Activity	Emission Equation	Source	Information assumed/provided
Vehicle entrainment on unpaved surfaces (mine roads)	$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b} \cdot 281.9$$ Where, E = particulate emission factor in grams per vehicle km travelled (g/VKT) k = basic emission factor for particle size range and units of interest s = road surface silt content (%) W = average weight (tonnes) of the vehicles travelling the road = 50 t The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$ and 1.5 for PM_{10}, and as 4.9 for TSP The empirical constant (a) is given as 0.9 for $PM_{2.5}$ and PM_{10}, and 4.9 for TSP. The empirical constant (b) is given as 0.45 for $PM_{2.5}$, PM_{10} and TSP.	US-EPA AP42 Section 13.2.2	In the absence of site-specific silt data, use was made of US EPA default mean silt content of 8.4%. Operational transport activities onsite include in-pit haul roads, hauling of ROM coal to the ROM stockpile at the CHPP area, and the transport of coal offsite. Hours of operation were given as 20 hrs per day, 7 days per week The capacity of the haul trucks to be used was given as 65 t. (coal haulers) and 100 t (waste haulers) The layout of the roads was provided. The width of the roads was determined from Google Earth as 25 m (on-site roads) and 10 m (off-site roads).
Drilling	$$E_{TSP} = 0.59\ kg/hole\ drilled$$ $$E_{PM_{10}} = 0.31\ kg/hole\ drilled$$ $$E_{PM_{2.5}} = 0.31\ kg/hole\ drilled$$	NPI Section: Mining	Number of drill holes per day was assumed as 100 (for waste rock) and 100 (for ore) (under the assumption of drilling areas of 2000 m² and spacing between drill holes of 4.5 m). Hours of operation were given as 20 hours per day, 7 days a week.
Blasting	$$E = 0.00022 \cdot (A)^{1.5}$$ Where, E = Emission factor (kg dust / t transferred) A = Blast area (m²)	NPI Section: Mining	The blast area was assumed as 2000 m² (for waste rock) and 2000 m² (for ore) respectively. The number of blasts for waste rock and ore was given as 3 blasts per week each, on alternate days.

Activity	Emission Equation	Source	Information assumed/provided
	The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively.		
Grading	$$E_{TSP} = 0.0034(S)^{2.5}\ kg/VKT$$ $$E_{PM10} = 0.0056(S)^{2.0}\ kg/VKT$$ Where, E = Emission factor (kg dust / t transferred) S = Mean vehicle speed (km/h) Fraction of $PM_{2.5}$ assumed to be 10% of PM_{10}	US-EPA AP42 Section 11.9.1	The speed of the grader was assumed to be 11.4 km/hr. The grader blade width was assumed to be 4.0 m and the grader blade depth was assumed to be 0.4 m. The VKT was calculated as 2.81 km per day (Kangala) and 4.11 km per day (Eloff). Hours of operation were assumed as 20 hrs per day, 7 days per week.
Crushing and screening	Primary: $$E_{TSP} = 0.01\ kg/t\ material\ processed$$ $$E_{PM10} = 0.004\ kg/t\ material\ processed$$ Secondary: $$E_{TSP} = 0.03\ kg/t\ material\ processed$$ $$E_{PM10} = 0.012\ kg/t\ material\ processed$$ Where, E = Default emission factor for high moisture content ore (>4%) Fraction of $PM_{2.5}$ taken from US-EPA crushed stone emission factor ratio for tertiary crushing	NPI Section: Mining	Scenario 1: The throughput of material was provided as 1 606 018 tpa coal (crush and screen plant) and 1 485 703 tpa coal (DMS plant). Scenario 2: The throughput of material was provided as 4 077 502 tpa coal (crush and screen plant) and 1 154 946 tpa coal (DMS plant). Hours of operation were given as 20 hrs per day, 7 days per week.
Wind Erosion	$$E(i) = G(i)10^{(0.134(\%clay)-6)}$$ For $$G(i) = 0.261\left[\frac{P_a}{g}\right]u^{*3}(1+R)(1-R^2)$$	Marticorena & Bergametti, 1995	Wind erosion was modelled for the ROM, overburden, topsoil and discard stockpiles. The particle size distribution for the various materials was obtained from similar processes (see Table 8).

Activity	Emission Equation	Source	Information assumed/provided
	And $$R = \frac{u_*^{\,t}}{u^*}$$ where, $E_{(i)}$ = emission rate (g/m²/s) for particle size class i P_a = air density (g/cm³) G = gravitational acceleration (cm/s³) u_*^t = threshold friction velocity (m/s) for particle size i u^* = friction velocity (m/s)		The moisture contents of ROM ore, overburden, topsoil and discard were assumed as 0.1%, 0.001%, 0.1% and 1% respectively. The particle densities of ROM ore, soft overburden, hard overburden, topsoil and discard were assumed as 1.6 t/m³, 2.2 t/m³, 3.8 t/m³, 1.8 t/m³ and 1.6 t/m³ respectively. Layout of ROM, overburden, topsoil and discard stockpiles was provided. Hourly emission rate file was calculated and simulated.
Wind-blown dust from conveyor	$$E_{TSP} = \mathrm{c}\ (\mathrm{u}^* - \mathrm{u}^{\mathrm{t}})\ (\text{in g/metre of conveyor})$$ where the dust emission rate E is equivalent to a constant c multiplied by the difference between the friction velocity (u*) and the threshold friction velocity of the coal (u^*_t). An estimate for the constant (*c*) has been made on data reported by GHD/Oceanics (1975) for measured conveyor emissions at a wind speed of 10 m/s. The PM_{10} fraction has been estimated as 45% of the TSP. The $PM_{2.5}$ fraction has been assumed as 50% of the PM_{10}. The approach is conservative since it assumes emissions from a conventional conveyor and based on emission factors provided for coal dust. A control efficiency of 65% for roofing and one side coverage of the conveyor was factored into the emissions calculation under the *mitigated* scenario. No mitigation measures were applied under the *unmitigated* scenario.	GHD/Oceanics (1975)	The section of the conveyor belt that emerges from the underground area to the ROM stockpiles was modelled as an area source. The width of the conveyor belt was assumed as 1.35 m. The length of the conveyor belt (open to wind erosion) was determined through on-screen digitising as 275 m. Typical values for particle density and particle size were assumed. The wind speed profile was created from modelled MM5 data for the study site for the period 2014-2016.

Table 8: Particle size distribution of ROM, product, discard, overburden and topsoil material (given as a fraction) (from similar processes)

Product/ Discard		ROM/ Overburden		Topsoil	
Size µm	Mass Fraction	Size µm	Mass Fraction	Size µm	Mass Fraction
1000	0	2000	0.158	2000	0.056
425	0.914	1000	0.211	1000	0.067
75	0.055	425	0.447	425	0.389
40	0	75	0.079	75	0.189
30	0	40	0.026	40	0.033
10	0	30	0.053	30	0.067
4	0.031	10	0.026	10	0.067
2	0	4	0	4	0.044
		2	0	2	0.089

The estimated control factors for the various mining operations are given in Table 9 below[5].

Table 9: Estimated control factors for various mining operations (NPi, 2012)

Operation/Activity	Control method and emission reduction
Drilling	No control
Blasting	No control
Windblown dust from stockpiles	No control
Windblown dust from conveyor	65% CE for enclosed side and roof
Unpaved haul roads	75% CE for water sprays; 90% CE for water sprays and chemical suppression[6]
Materials handling (loading and unloading)	50% CE for water sprays
Materials handling (covered conveyor tipping points)	70% CE for enclosure
Crushing and screening	50% CE for water sprays
Grading	50% CE for water sprays

Note: CE is Control Efficiency

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[5] Design mitigated activities include: 75% CE on unpaved haul roads; 50% CE on materials handling; 50% CE on crushing and screening; 50% CE on grading activities; 70% CE on covered conveyor tipping points and 65% on windblown dust from conveyor belt with enclosed side and roof.
[6] Additional mitigation includes design mitigation and 90% CE on unpaved haul roads.

Table 10: Calculated emission rates due to routine operations at Kangala Colliery (in tpa)

Highest Daily	SC1a – Unmitigated			SC1b – Design Mitigated			SC1c – Additional Mitigation		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Opencast (including drilling)	36.52	169.88	292.92	25.39	59.48	90.37	25.39	59.48	90.37
Blasting	0.18	3.19	6.14	0.18	3.19	6.14	0.18	3.19	6.14
Grading	0.07	0.75	1.53	0.04	0.37	0.76	0.04	0.37	0.76
Materials handling	0.77	5.11	10.80	0.39	2.55	5.40	0.39	2.55	5.40
Crushing and screening	24.73	49.47	123.67	12.37	24.73	61.83	12.37	24.73	61.83
Vehicle entrainment	40.96	409.55	1436.79	10.24	102.39	359.20	4.10	40.96	143.68
Wind erosion	11.14	28.42	187.83	10.67	27.49	51.04	10.67	27.49	51.04
Total	**114**	**666**	**2 060**	**59**	**220**	**575**	**53**	**159**	**359**

Table 11: Calculated emission rates due to proposed operations at Eloff Colliery (in tpa)

Highest Daily	SC2a – Unmitigated			SC2b – Design Mitigated			SC2c – Additional Mitigation		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Opencast (including drilling)	69.96	503.51	907.79	33.81	143.28	244.52	33.81	143.28	244.52
Blasting	0.18	3.19	6.14	0.18	3.19	6.14	0.18	3.19	6.14
Grading	0.11	1.09	2.23	0.05	0.54	1.12	0.05	0.54	1.12
Materials handling	1.10	7.27	15.38	0.55	3.64	7.69	0.55	3.64	7.69
Crushing and screening	24.73	49.47	123.67	12.37	24.73	61.83	12.37	24.73	61.83
Vehicle entrainment	94.13	941.31	3302.32	23.53	235.33	825.58	9.41	94.13	330.23
Wind erosion	11.14	28.42	187.83	10.67	27.49	51.04	10.67	27.49	51.04
Total	**201**	**1 534**	**4 545**	**81**	**438**	**1 198**	**67**	**297**	**703**

4.1.3 Closure and Decommissioning Phase

It is assumed that all the operations will have ceased by the closure phase of the project. The potential for impacts during this phase will depend on the extent of rehabilitation efforts during closure. Aspects and activities associated with the closure phase of the proposed operations are listed in Table 12. Simulations of the closure phase were not included in the current study due to its temporary impacting nature.

Table 12: Activities and aspects identified for the closure phase

Impact	Source	Activity
Generation of $PM_{2.5}$ and PM_{10}	Stockpiles and mine pit	Dust generated during rehabilitation activities
Generation of $PM_{2.5}$ and PM_{10}	Plant and infrastructure	Demolition of the process plant and infrastructure
Gas emissions	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase

4.2 Atmospheric Dispersion Modelling

The impact assessment of the project's operations on the environment is discussed in this section. To assess impact on human health and the environment the following important aspects need to be considered:

- The criteria against which impacts are assessed (Section 2);
- The potential of the atmosphere to disperse and dilute pollutants emitted by the project (Section 3.3);
- The AQSRs in the vicinity of the proposed mine (Section 3.1); and
- The methodology followed in determining ambient pollutant concentrations and dustfall rates (Section 1.4).

The impact of proposed operations on the atmospheric environment was determined through the simulation of ambient pollutant concentrations. Dispersion models simulate ambient pollutant concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements. It is therefore important to carefully select a dispersion model for the purpose.

4.2.1 Dispersion Model Selection

Gaussian-plume models are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. One of the most widely used Gaussian plume model is the US EPA AERMOD model that was used in this study. AERMOD is a model developed with the support of AERMIC, whose objective has been to include state-of the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature however retains the single straight-line trajectory limitation. AERMET is a meteorological pre-processor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. The output includes, for each receptor, location and height scale, which are elevations used for the computation of air flow around hills.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: source data, meteorological data (pre-processed by the AERMET model), terrain data, information on the nature of the receptor grid and pre-development or background pollutant concentrations or dustfall rates. Version 7.2.5 of AERMOD and its pre-processors were used in the study.

4.2.2 Meteorological Requirements

For the current study, use was made of 2014-2016 modelled MM5 data for the study site (Section 3.3).

4.2.3 Source Data Requirements

The AERMOD model can model point, jet, area, line and volume sources. Sources were modelled as follows:

- Open pit – modelled as open pit source;
- Grading – modelled as area source;
- Materials handling – modelled as volume sources;
- Crushing and screening – modelled as volume sources;
- Unpaved roads – modelled as area sources; and
- Windblown dust from stockpiles and conveyor – modelled as area sources.

4.2.4 Modelling Domain

The dispersion of pollutants expected to arise from proposed activities was modelled for an area covering 15 km (east-west) by 15 km (north-south). The area was divided into a grid matrix with a resolution of 100 m by 100m, with the project located centrally. AERMOD calculates ground-level (1.5 m above ground level) concentrations and dustfall rates at each grid and discrete receptor points (AQSRs).

4.3 Dispersion Modelling Results

Dispersion modelling was undertaken to determine highest daily and annual average ground level concentrations. Averaging periods were selected to facilitate the comparison of predicted pollutant concentrations to relevant ambient air quality and inhalation health criteria as well as dustfall regulations.

Pollutants with the potential to result in human health impacts which are assessed in this study include $PM_{2.5}$ and PM_{10}. Dustfall is assessed for its nuisance potential. Results are primarily provided in form of isopleths to present areas of exceedance of assessment criteria. Ground level concentration isopleths presented in this section depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified.

Isopleth plots reflect the incremental ground level concentrations (GLCs) for $PM_{2.5}$ and PM_{10} where exceedances of the relevant NAAQSs were simulated. Due to the unavailability of ambient baseline concentrations, the total cumulative pollutant concentrations could not be quantitatively determined but qualitative commentary is provided in the discussion of impact significance in Section 5.

It should also be noted that ambient air quality criteria apply to areas where the Occupational Health and Safety regulations do not apply, thus outside the property or lease area. Ambient air quality criteria are therefore not occupational health indicators but applicable to areas where the general public has access i.e. off-site. In the context of this project, ambient air quality guidelines and dustfall regulations would apply to any area outside the mining right area.

4.3.1 Scenario 1 – Current Kangala operations

Activities associated with open pit mining for year 2017/2018 were simulated (see Section 4.1.2 for explanation of how the opencast mining area was chosen). The results are provided in Figure 14 to Figure 15 for PM_{10}, Figure 16 to Figure 19 for $PM_{2.5}$, and Figure 20 for dustfall. The simulated GLCs and dustfall rates at each of the AQSRs are provided in Table 13 (PM_{10}), Table 14 ($PM_{2.5}$) and Table 15 (dustfall levels) respectively.

Mitigation measures assumed during mitigated Kangala opencast operations are:

- water sprays on haul roads assuming 75% CE due to continuous water sprays (Scenario 1b) and 90% CE on haul roads assuming water sprays and chemical suppression (Scenario 1c);
- materials handling (loading and unloading of waste rock, ROM and discard) assuming 50% CE due to water sprays at tip points (Scenario 1b and 1c);
- control efficiency on covered conveyor tipping points (materials handling) of 70% (Scenario 1b and 1c); and
- control efficiency on wind erosion due to conveyor belt (enclosed side and roof) of 65% (Scenario 1b and 1c).

The main findings are:

- From Table 13 it may be seen that the daily ***PM_{10}*** SA NAAQS is exceeded at 13 AQSRs for unmitigated activities. The area of exceedance for the combined design mitigated and additionally mitigated scenarios is shown in Figure 14. For the design mitigated scenario, simulated PM_{10} concentrations exceed the daily SA NAAQS at 2 AQSRs, over an area up to 2.0km to the north, 1.0km to the east, 750m to the south and 1.5km to the southwest from the mining boundary. With additional mitigation, only 1 AQSR (farmstead) is non-compliant. Over an annual average unmitigated PM_{10} impacts exceed the annual NAAQS at 2 AQSRs (Table 13). These impacts are reduced when design mitigation is applied, with exceedances simulated at only one AQSR, and no exceedances for additionally mitigated activities (Figure 15).

- ***$PM_{2.5}$*** GLCs – simulated concentrations for the unmitigated, design mitigated and additionally mitigated scenarios are shown in Table 14. $PM_{2.5}$ daily GLCs, with no mitigation in place, are likely to be in non-compliance with the 2030 NAAQSs at 4 AQSRs. Simulated impacts are reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at only one AQSR (Figure 16). With additional mitigation, simulated $PM_{2.5}$ daily GLCs are within compliance at all AQSRs. Over an annual average design mitigated simulated GLCs as provided in Figure 17, and additionally mitigated GLCs as provided in Figure 19, are within compliance currently and after 2030.

- Isopleth plots showing the area of exceedance of the residential limit due to design mitigated ***dustfall rates*** are shown in Figure 20. The simulated maximum daily dustfall rates due to the unmitigated scenario exceed the NDCR for residential areas at only one AQSR (Table 15). Simulated dustfall rates at all AQSRs are well within the residential limit for the design mitigated and additionally mitigated scenarios.

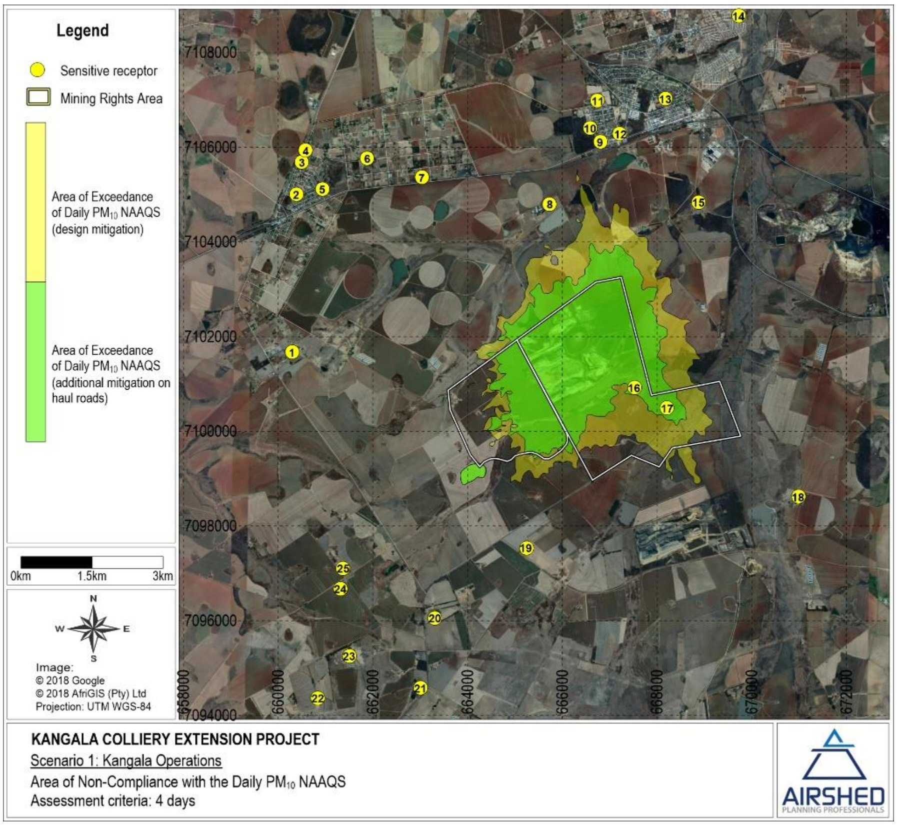


Figure 14: Scenario 1 – Area of non-compliance of PM_{10} 24-hour NAAQS due to design mitigated and additionally mitigated Kangala operations

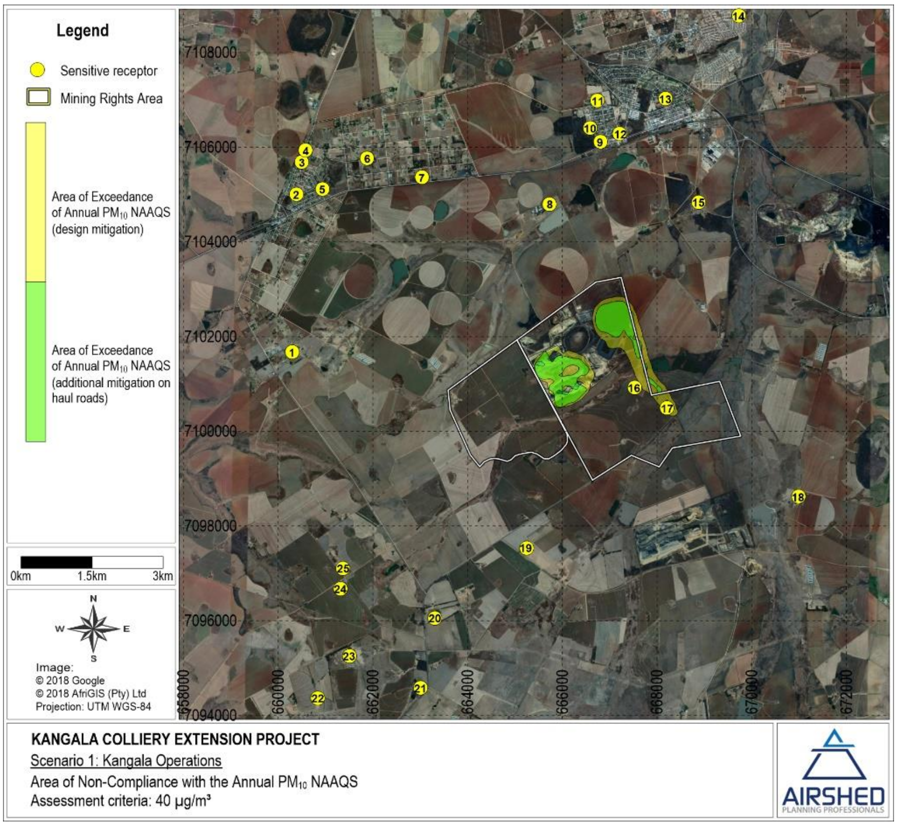


Figure 15: Scenario 1 – Area of non-compliance of PM_{10} annual NAAQS due to design mitigated and additionally mitigated Kangala operations

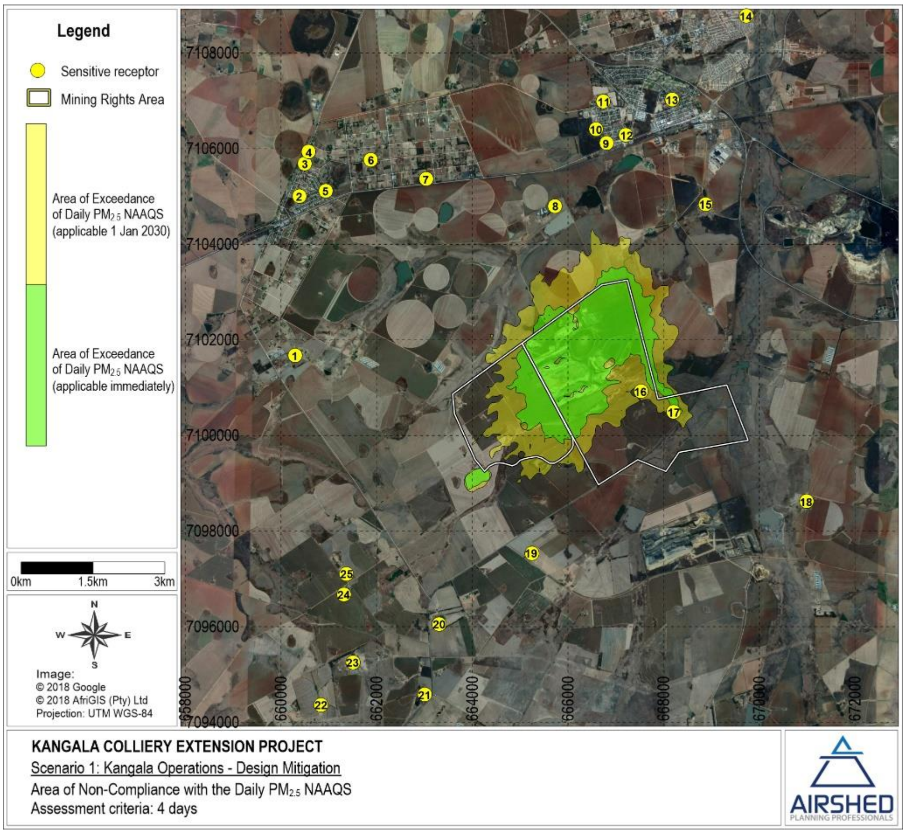


Figure 16: Scenario 1 – Area of non-compliance of $PM_{2.5}$ 24-hour NAAQS due to design mitigated Kangala operations

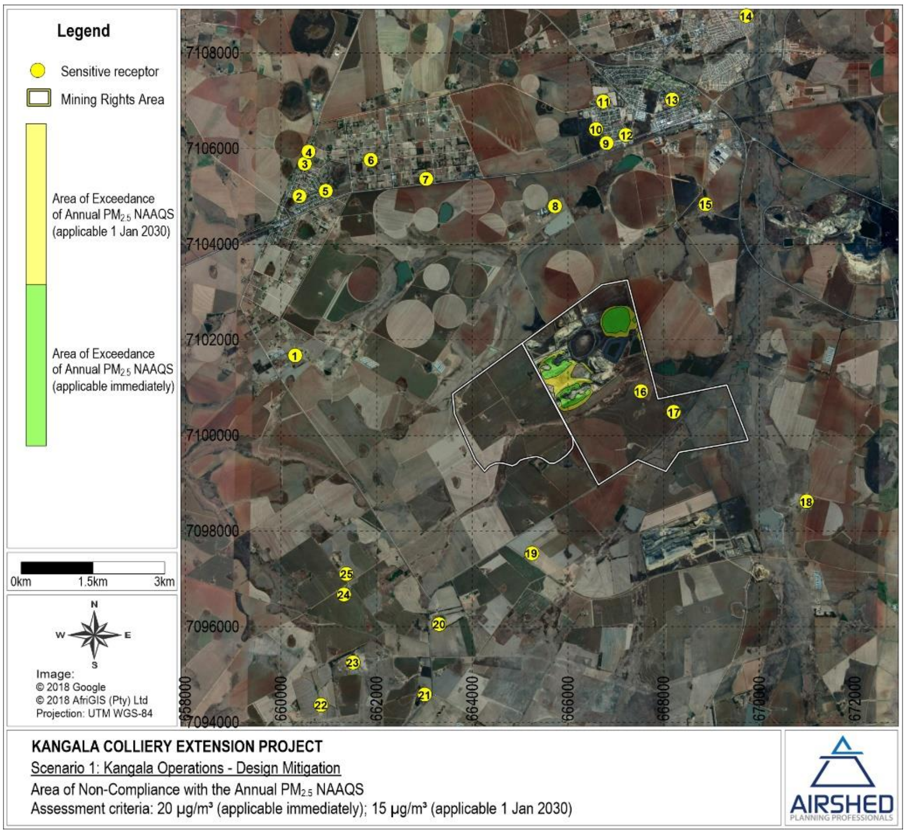


Figure 17: Scenario 1 – Area of non-compliance of $PM_{2.5}$ annual NAAQS due to design mitigated Kangala operations

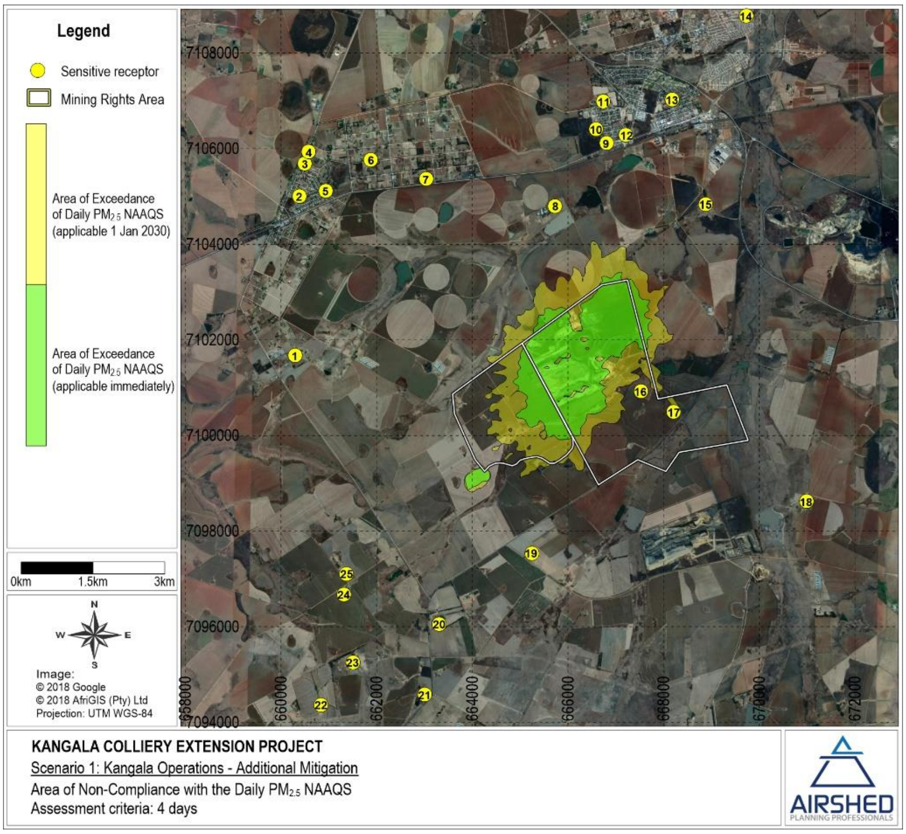


Figure 18: Scenario 1 – Area of non-compliance of $PM_{2.5}$ 24-hour NAAQS due to additionally mitigated Kangala operations

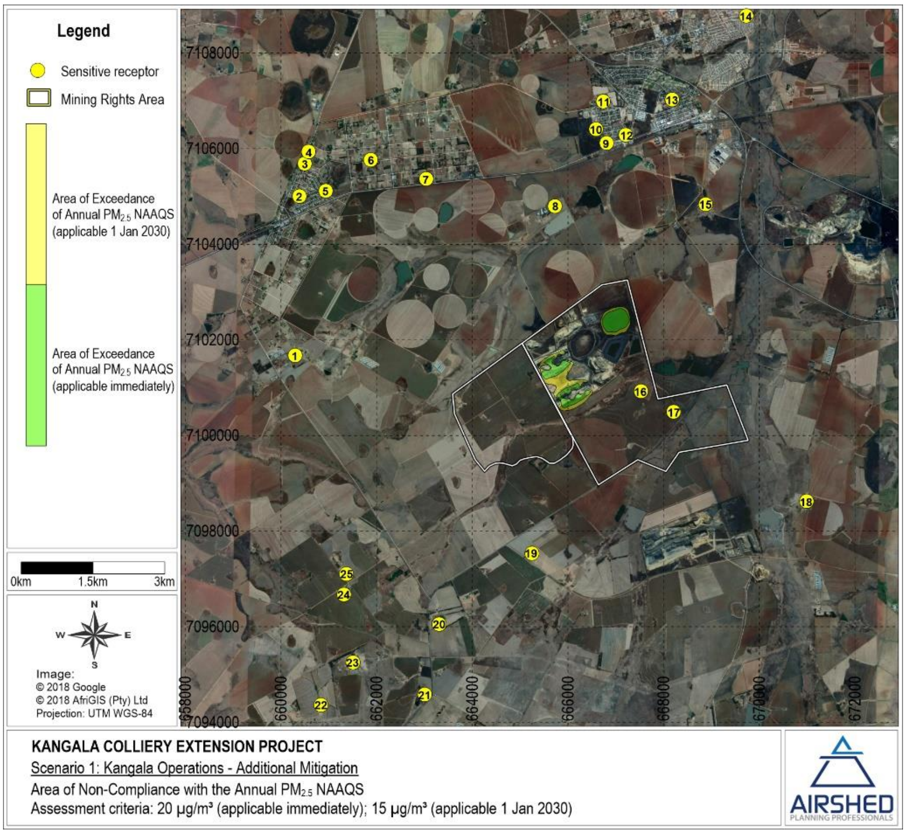


Figure 19: Scenario 1 – Area of non-compliance of $PM_{2.5}$ annual NAAQS due to additionally mitigated Kangala operations

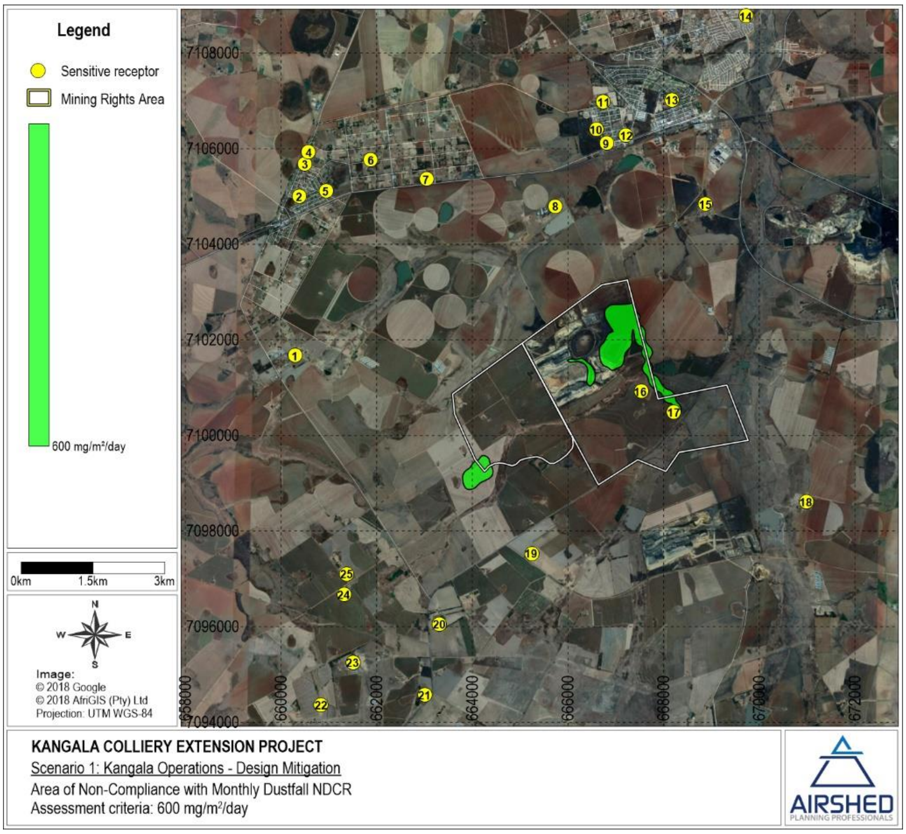


Figure 20: Scenario 1 – Simulated dustfall deposition rates due to design mitigated Kangala operations

Table 13: Simulated AQSR PM_{10} concentrations (in µg/m³) for unmitigated, design mitigated and additionally mitigated Kangala operations

AQ SR	AQSR Type	Scenario 1a – Unmitigated				Scenario 1b – Design mitigated				Scenario 1c – Additional mitigation			
		Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)
1	Agric. Holding	114	4	5	**No**	35	1	0	Yes	25	1	0	Yes
2	School	99	2	2	Yes	31	1	0	Yes	23	1	0	Yes
3	School	98	3	2	Yes	29	1	0	Yes	19	1	0	Yes
4	School	101	3	2	Yes	29	1	0	Yes	19	1	0	Yes
5	Residential	79	3	1	Yes	25	1	0	Yes	20	1	0	Yes
6	School	79	3	2	Yes	25	1	0	Yes	24	1	0	Yes
7	Agric. Holding	144	4	5	**No**	43	1	0	Yes	34	1	0	Yes
8	Farmstead	274	9	15	**No**	78	3	2	Yes	61	2	0	Yes
9	Residential	271	6	11	**No**	75	2	1	Yes	42	1	0	Yes
10	Hospital	241	6	11	**No**	67	2	1	Yes	39	1	0	Yes
11	School	183	4	7	**No**	52	1	0	Yes	33	1	0	Yes
12	School	221	6	9	**No**	60	2	0	Yes	37	1	0	Yes
13	School	142	4	6	**No**	44	1	0	Yes	31	1	0	Yes
14	School	66	2	0	Yes	18	1	0	Yes	14	0	0	Yes
15	School	224	7	9	**No**	63	2	1	Yes	43	1	0	Yes
16	Farmstead	832	105	159	**No**	224	28	37	**No**	125	14	9	**No**
17	Farmstead	2321	247	299	**No**	596	63	108	**No**	257	27	32	**No**
18	Farmstead	217	6	6	**No**	59	2	0	Yes	32	1	0	Yes
19	Farmstead	173	12	15	**No**	53	4	0	Yes	39	3	0	Yes
20	Farmstead	129	5	4	Yes	38	2	0	Yes	28	1	0	Yes
21	Farmstead	105	4	4	Yes	33	1	0	Yes	25	1	0	Yes
22	Farmstead	86	3	1	Yes	26	1	0	Yes	20	1	0	Yes
23	Farmstead	98	3	2	Yes	31	1	0	Yes	23	1	0	Yes
24	Farmstead	157	4	4	Yes	47	1	0	Yes	34	1	0	Yes
25	Farmstead	165	4	3	Yes	52	1	0	Yes	39	1	0	Yes

Table 14: Simulated AQSR $PM_{2.5}$ concentrations (in µg/m³) for unmitigated, design mitigated and additionally mitigated Kangala operations

AQ SR	AQSR Type	Scenario 1a – Unmitigated				Scenario 1b – Design mitigated				Scenario 1c – Additional mitigation			
		Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)
1	Agric. Holding	19	1	0	Yes	10	0	0	Yes	9	0	0	Yes
2	School	17	0	0	Yes	9	0	0	Yes	8	0	0	Yes
3	School	16	0	0	Yes	7	0	0	Yes	7	0	0	Yes
4	School	15	0	0	Yes	8	0	0	Yes	8	0	0	Yes
5	Residential	15	1	0	Yes	8	0	0	Yes	8	0	0	Yes
6	School	15	1	0	Yes	10	0	0	Yes	10	0	0	Yes
7	Agric. Holding	24	1	0	Yes	13	0	0	Yes	12	0	0	Yes
8	Farmstead	43	2	10	**No**	24	1	1	Yes	22	1	0	Yes
9	Residential	36	1	4	Yes	15	0	0	Yes	13	0	0	Yes
10	Hospital	33	1	4	Yes	15	0	0	Yes	13	0	0	Yes
11	School	28	1	2	Yes	13	0	0	Yes	12	0	0	Yes
12	School	29	1	3	Yes	15	0	0	Yes	13	0	0	Yes
13	School	25	1	2	Yes	12	0	0	Yes	11	0	0	Yes
14	School	11	0	0	Yes	6	0	0	Yes	5	0	0	Yes
15	School	35	1	6	**No**	17	0	0	Yes	15	0	0	Yes
16	Farmstead	111	13	66	**No**	45	4	8	**No**	40	3	4	Yes
17	Farmstead	256	26	134	**No**	72	7	20	**No**	38	4	4	Yes
18	Farmstead	28	1	3	Yes	11	0	0	Yes	9	0	0	Yes
19	Farmstead	30	2	1	Yes	15	1	0	Yes	14	1	0	Yes
20	Farmstead	21	1	0	Yes	11	0	0	Yes	10	0	0	Yes
21	Farmstead	19	1	0	Yes	10	0	0	Yes	9	0	0	Yes
22	Farmstead	15	0	0	Yes	8	0	0	Yes	7	0	0	Yes
23	Farmstead	17	1	0	Yes	9	0	0	Yes	8	0	0	Yes
24	Farmstead	26	1	2	Yes	13	0	0	Yes	12	0	0	Yes
25	Farmstead	30	1	2	Yes	16	0	0	Yes	15	0	0	Yes

Notes: **(a)** These reflect compliance with the 1 Jan 2030 NAAQSs

Table 15: Simulated AQSR total dustfall rates (in mg/m²/day) for unmitigated, design mitigated and additionally mitigated Kangala operations

AQSR	AQSR Type	Scenario 1a – Unmitigated (a)	Scenario 1b – Design mitigated (a)	Scenario 1c – Additional mitigation (a)
1	Agric. Holding	5	1	1
2	School	4	1	1
3	School	4	1	1
4	School	3	1	1
5	Residential	4	1	1
6	School	4	1	1
7	Agric. Holding	5	1	1
8	Farmstead	15	11	11
9	Residential	8	5	5
10	Hospital	9	7	6
11	School	8	6	6
12	School	9	7	7
13	School	8	6	6
14	School	7	5	5
15	School	18	11	10
16	Farmstead	236	78	56
17	Farmstead	**1295**	324	130
18	Farmstead	7	2	2
19	Farmstead	25	13	12
20	Farmstead	10	7	6
21	Farmstead	7	4	3
22	Farmstead	4	3	2
23	Farmstead	5	4	4
24	Farmstead	4	3	3
25	Farmstead	4	2	1

Notes: **(a)** Screened against the residential dustfall limit of 600 mg/m²/day

4.3.2 Scenario 2 – Proposed Eloff operations

Activities associated with open pit mining for year 2026 were simulated. The results are provided in Figure 21 to Figure 22 for PM_{10}, Figure 23 to Figure 26 for $PM_{2.5}$, and Figure 27 for dustfall. The simulated GLCs and dustfall rates at each of the AQSRs are provided in Table 16 (PM_{10}), Table 17 ($PM_{2.5}$) and Table 18 (dustfall levels) respectively.

Scenario 2a represents unmitigated Eloff operations, whereas Scenarios 2b and 2c represent mitigated Eloff operations. Mitigation measures assumed during mitigated Eloff opencast operations are described in Table 9 and footnotes 5 and 6.

The main findings are:

- From Table 16 it may be seen that the daily ***PM_{10}*** SA NAAQS is exceeded at all AQSRs (25) for unmitigated activities. The area of exceedance for the combined design mitigated and additionally mitigated scenarios is shown in Figure 21. For the design mitigated scenario, simulated PM_{10} concentrations exceed the daily SA NAAQS at 6 AQSRs, over an area up to up to 2.8km to the southwest, 2.4km to the south, 2.4km to the east and 3.0km to the north from the mining boundary. With additional mitigation, the footprint is reduced to half of the impact for the design mitigated scenario where 3 AQSRs are non-compliant. Over an annual average unmitigated PM_{10} impacts exceed the annual NAAQS at 2 AQSRs (Table 16). With design mitigation applied, exceedances were simulated at 2 AQSRs; with additional mitigation applied, PM_{10} impacts are in non-compliance with the annual NAAQS at only one AQSR (Figure 22).
- ***$PM_{2.5}$*** GLCs – simulated concentrations for the unmitigated, design mitigated and additionally mitigated scenarios are shown in Table 17. $PM_{2.5}$ daily GLCs, with no mitigation in place, are likely to be in non-compliance with the 2030 NAAQSs at 14 AQSRs. Simulated impacts are reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at two AQSRs (Figure 23). With additional mitigation, simulated $PM_{2.5}$ daily GLCs are still in non-compliance at two AQSRs (Figure 25). Over an annual average design mitigated simulated GLCs as provided in Figure 24, and additionally mitigated GLCs as provided in Figure 26, are within compliance currently and after 2030.
- Isopleth plots showing the area of exceedance of the residential limit due to design mitigated ***dustfall rates*** are shown in Figure 27. The simulated maximum daily dustfall rates due to the unmitigated scenario exceed the NDCR for residential areas at one AQSR (Table 18). Simulated dustfall rates exceed the NDCR for residential areas at one AQSR for the design mitigated scenario, but are well within the residential limit for the additionally mitigated scenario.

The simulated footprint areas of exceedance for PM_{10} and $PM_{2.5}$ impacts, as indicated in the isopleth contour plots, are much larger for Scenario 2 (Eloff Project) than for Scenario 1 (Kangala operations). Even with additional mitigation applied on haul roads to achieve a control efficiency of 90% the area of exceedance of the daily PM_{10} NAAQS extends well beyond the mining rights boundary. This increase in magnitude may be explained by the higher throughput of annual ROM tonnages for the Eloff Project, and more vehicle entrained dust from the new haul road and in-pit roads. The up-sizing of the Kangala CHPP to process the higher ROM production will also lead to higher crushing emissions.

In light of the large footprint area of exceedance of daily PM_{10} impacts, even with additional mitigation applied, it is recommended that UCD1 buy out the two farmsteads (Nos 16 and 17) (Figure 21) to ensure that people not be exposed to ambient air quality that may be harmful to human health.

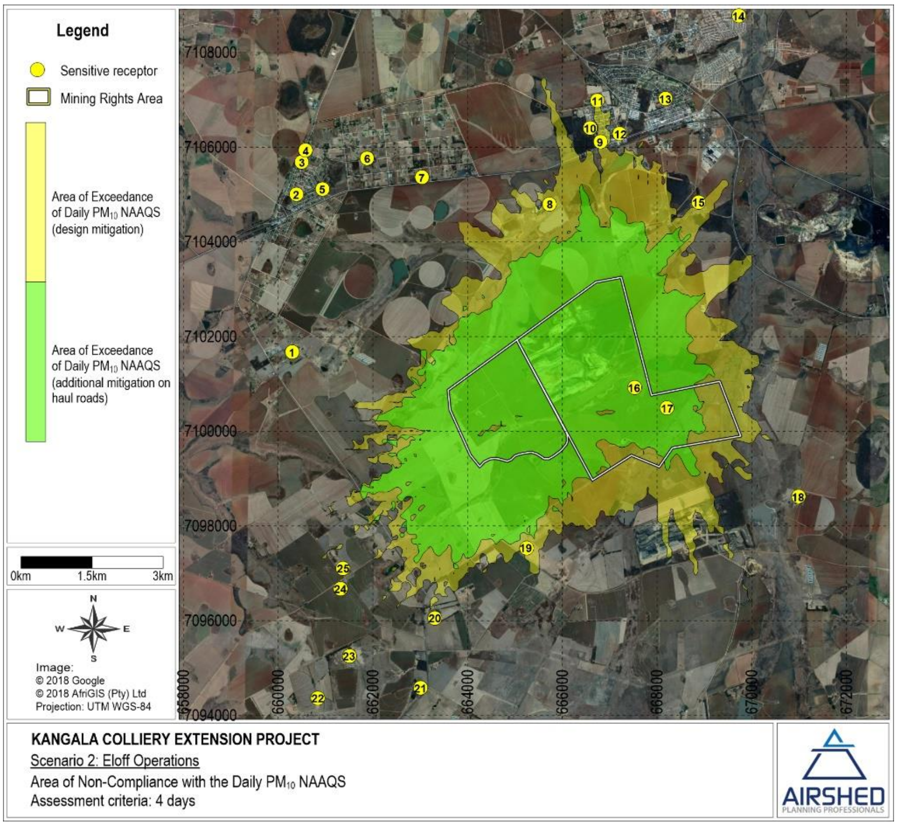


Figure 21: Scenario 2 – Area of non-compliance of PM_{10} 24-hour NAAQS due to design mitigated and additionally mitigated Eloff operations

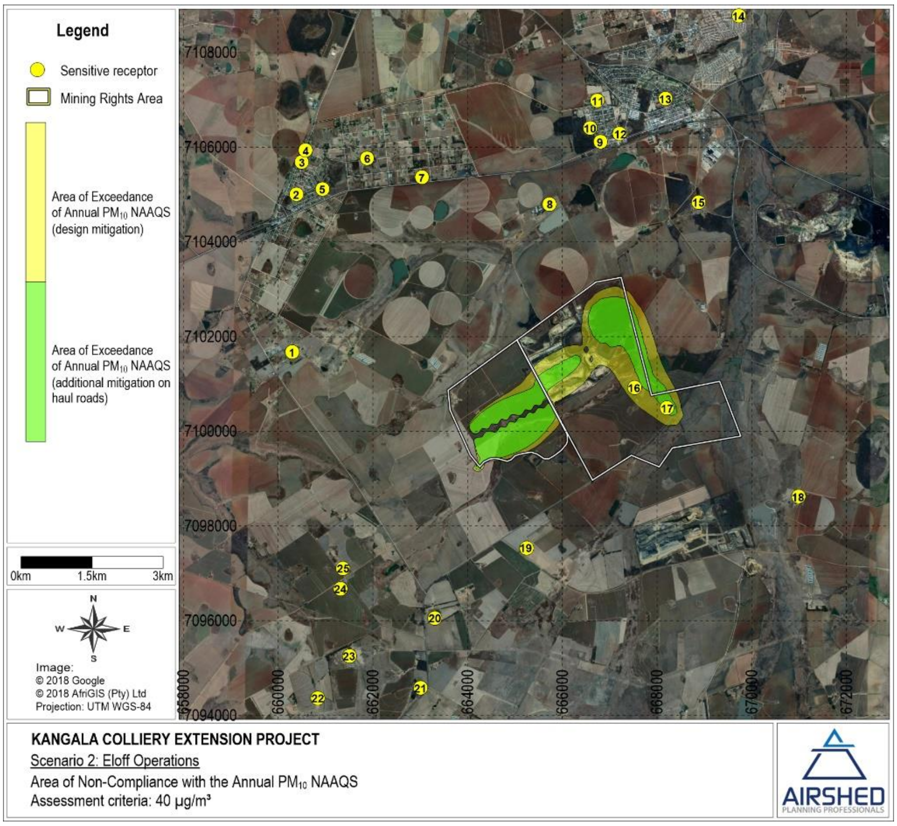


Figure 22: Scenario 2 – Area of non-compliance of PM_{10} annual NAAQS due to design mitigated and additionally mitigated Eloff operations

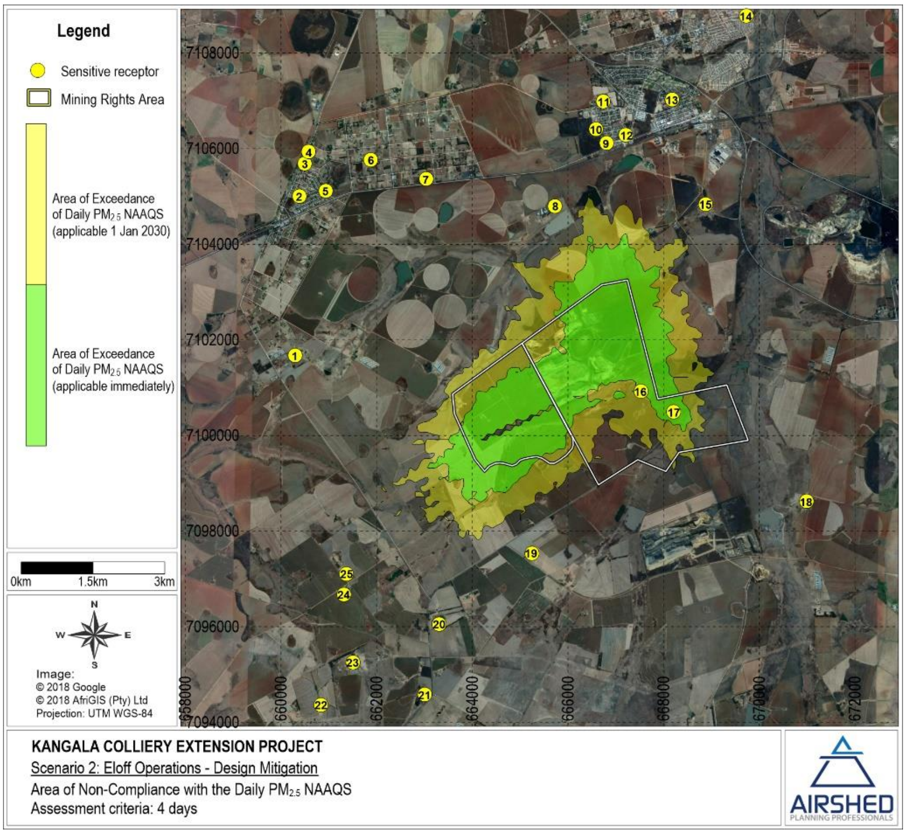


Figure 23: Scenario 2 – Area of non-compliance of $PM_{2.5}$ 24-hour NAAQS due to design mitigated Eloff operations

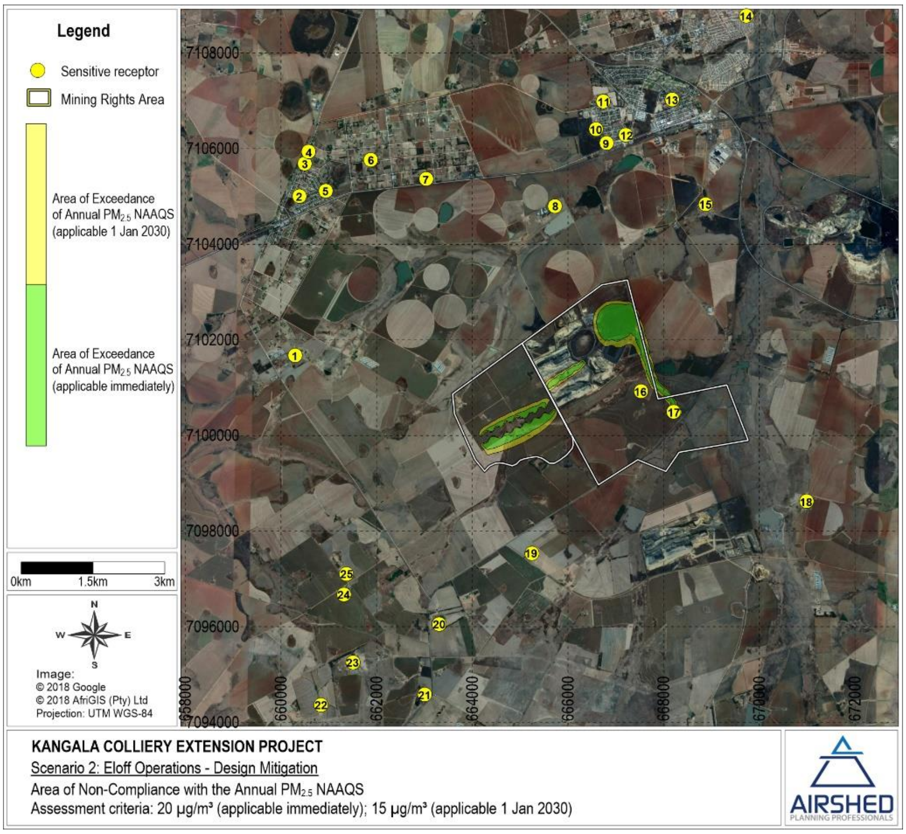


Figure 24: Scenario 2 – Area of non-compliance of $PM_{2.5}$ annual NAAQS due to design mitigated Eloff operations

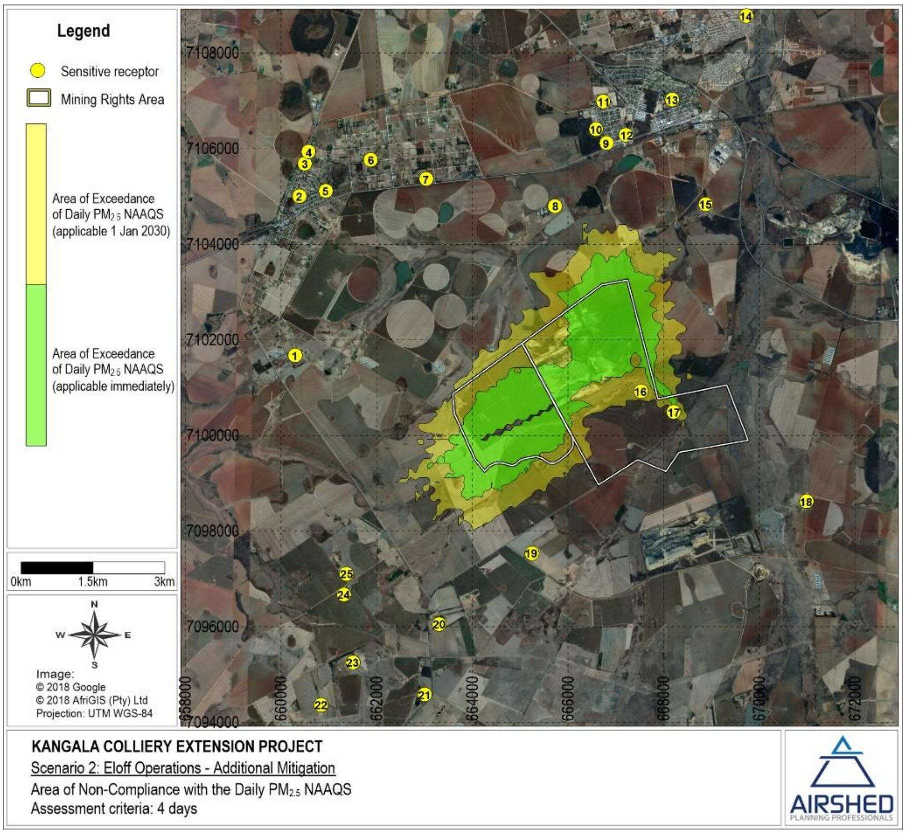


Figure 25: Scenario 2 – Area of non-compliance of $PM_{2.5}$ 24-hour NAAQS due to additionally mitigated Eloff operations

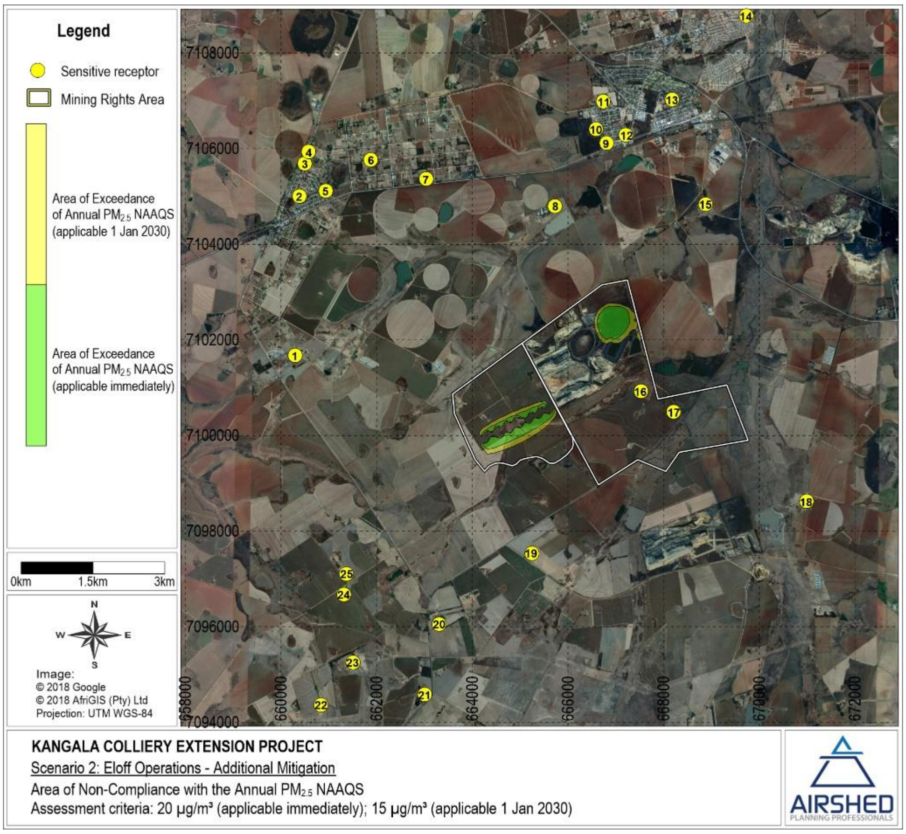


Figure 26: Scenario 2 – Area of non-compliance of $PM_{2.5}$ annual NAAQS due to additionally mitigated Eloff operations

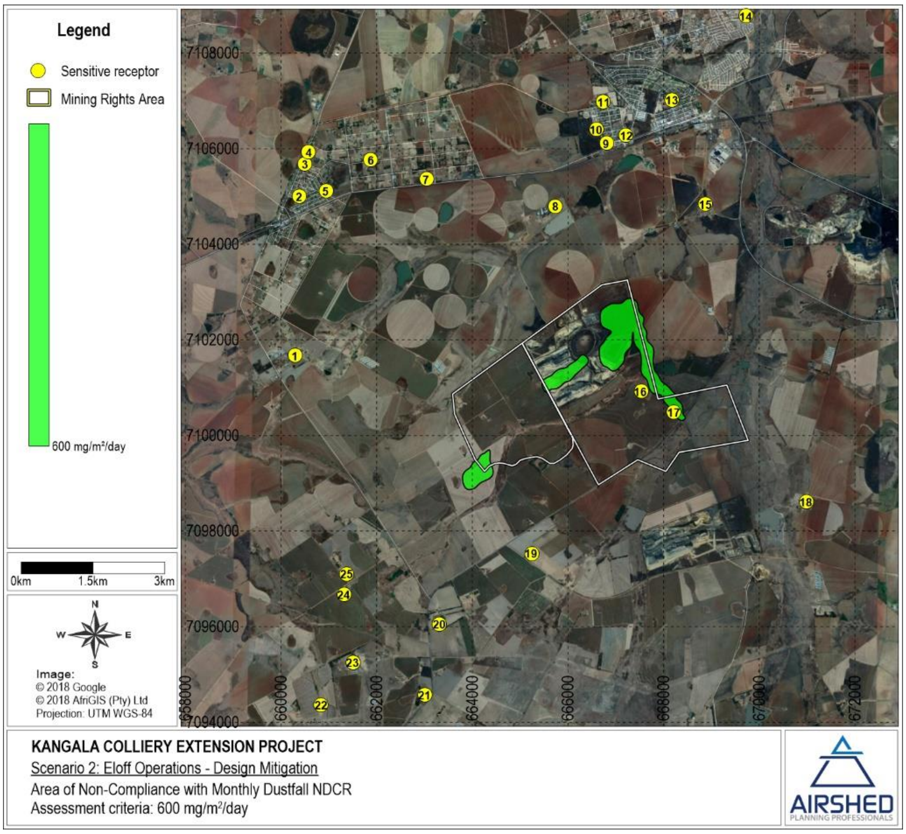


Figure 27: Scenario 2 – Simulated dustfall deposition rates due to design mitigated Eloff operations

Table 16: Simulated AQSR PM_{10} concentrations (in µg/m³) for unmitigated, design mitigated and additionally mitigated Eloff operations

AQ SR	AQSR Type	Scenario 2a – Unmitigated				Scenario 2b – Design mitigated				Scenario 2c – Additional mitigation			
		Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)
1	Agric. Holding	206	9	12	**No**	56	3	0	Yes	39	2	0	Yes
2	School	190	7	10	**No**	52	2	0	Yes	38	1	0	Yes
3	School	150	6	8	**No**	42	2	0	Yes	38	1	0	Yes
4	School	183	6	9	**No**	50	2	0	Yes	38	1	0	Yes
5	Residential	192	7	11	**No**	54	2	0	Yes	41	1	0	Yes
6	School	188	8	13	**No**	53	2	0	Yes	42	2	0	Yes
7	Agric. Holding	286	11	20	**No**	79	3	1	Yes	51	2	0	Yes
8	Farmstead	581	19	31	**No**	154	5	10	**No**	79	4	4	Yes
9	Residential	552	13	22	**No**	143	4	5	**No**	76	2	4	Yes
10	Hospital	518	12	20	**No**	136	3	3	Yes	69	2	2	Yes
11	School	346	10	18	**No**	94	3	4	Yes	50	2	0	Yes
12	School	489	11	20	**No**	127	3	3	Yes	61	2	1	Yes
13	School	291	8	14	**No**	77	2	1	Yes	35	1	0	Yes
14	School	165	5	9	**No**	47	1	0	Yes	35	1	0	Yes
15	School	402	13	21	**No**	113	3	6	**No**	73	2	1	Yes
16	Farmstead	1703	217	259	**No**	446	57	99	**No**	208	26	26	**No**
17	Farmstead	4984	535	324	**No**	1270	135	212	**No**	536	56	88	**No**
18	Farmstead	473	13	20	**No**	123	4	3	Yes	56	2	0	Yes
19	Farmstead	474	36	55	**No**	135	10	7	**No**	108	8	0	Yes
20	Farmstead	426	17	25	**No**	119	5	2	Yes	90	4	0	Yes
21	Farmstead	225	12	17	**No**	63	3	0	Yes	45	2	0	Yes
22	Farmstead	254	8	11	**No**	70	2	0	Yes	54	2	0	Yes
23	Farmstead	317	10	13	**No**	87	3	1	Yes	67	2	0	Yes
24	Farmstead	490	12	13	**No**	134	3	4	Yes	102	2	0	Yes
25	Farmstead	553	12	16	**No**	157	3	3	Yes	120	2	0	Yes

Table 17: Simulated AQSR $PM_{2.5}$ concentrations (in µg/m³) for unmitigated, design mitigated and additionally mitigated Eloff operations

AQ SR	AQSR Type	Scenario 2a – Unmitigated				Scenario 2b – Design mitigated				Scenario 2c – Additional mitigation			
		Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)
1	Agric. Holding	27	1	1	Yes	10	0	0	Yes	9	0	0	Yes
2	School	26	1	2	Yes	9	0	0	Yes	9	0	0	Yes
3	School	21	1	0	Yes	9	0	0	Yes	9	0	0	Yes
4	School	24	1	0	Yes	9	0	0	Yes	9	0	0	Yes
5	Residential	27	1	2	Yes	11	0	0	Yes	10	0	0	Yes
6	School	25	1	2	Yes	11	0	0	Yes	9	0	0	Yes
7	Agric. Holding	40	2	3	Yes	13	1	0	Yes	12	1	0	Yes
8	Farmstead	72	3	16	**No**	30	1	2	Yes	25	1	0	Yes
9	Residential	63	2	8	**No**	22	1	0	Yes	19	1	0	Yes
10	Hospital	60	2	8	**No**	19	1	0	Yes	16	1	0	Yes
11	School	46	1	7	**No**	16	1	0	Yes	14	0	0	Yes
12	School	56	2	8	**No**	17	1	0	Yes	15	1	0	Yes
13	School	35	1	6	**No**	12	0	0	Yes	9	0	0	Yes
14	School	24	1	0	Yes	11	0	0	Yes	9	0	0	Yes
15	School	58	2	9	**No**	24	1	0	Yes	21	0	0	Yes
16	Farmstead	204	25	129	**No**	69	7	25	**No**	63	4	12	**No**
17	Farmstead	534	55	244	**No**	145	14	70	**No**	72	6	15	**No**
18	Farmstead	54	2	5	**No**	16	1	0	Yes	12	0	0	Yes
19	Farmstead	68	5	17	**No**	29	2	2	Yes	26	2	2	Yes
20	Farmstead	57	2	5	**No**	24	1	0	Yes	21	1	0	Yes
21	Farmstead	30	2	3	Yes	12	1	0	Yes	11	1	0	Yes
22	Farmstead	33	1	2	Yes	14	0	0	Yes	12	0	0	Yes
23	Farmstead	41	1	3	Yes	17	1	0	Yes	15	0	0	Yes
24	Farmstead	65	2	6	Yes	27	1	2	Yes	24	1	0	Yes
25	Farmstead	75	2	5	Yes	31	1	2	Yes	27	1	1	Yes

Notes: (a) These reflect compliance with the 1 Jan 2030 NAAQSs

Table 18: Simulated AQSR total dustfall rates (in mg/m²/day) for unmitigated, design mitigated and additionally mitigated Eloff operations

AQSR	AQSR Type	Scenario 2a – Unmitigated) [(a)]	Scenario 2b – Design mitigated) [(a)]	Scenario 2c – Additional mitigation) [(a)]
1	Agric. Holding	15	4	3
2	School	9	3	2
3	School	8	2	1
4	School	7	2	1
5	Residential	9	3	1
6	School	8	2	1
7	Agric. Holding	10	3	2
8	Farmstead	23	12	12
9	Residential	16	7	6
10	Hospital	15	8	7
11	School	12	7	6
12	School	15	8	7
13	School	12	7	6
14	School	9	6	6
15	School	27	14	11
16	Farmstead	514	129	72
17	Farmstead	**2848**	**712**	285
18	Farmstead	15	4	2
19	Farmstead	47	19	16
20	Farmstead	26	10	9
21	Farmstead	17	6	5
22	Farmstead	9	3	3
23	Farmstead	11	5	4
24	Farmstead	12	4	3
25	Farmstead	14	4	3

Notes: **(a)** Screened against the residential dustfall limit of 600 mg/m²/day

5 IMPACT SIGNIFICANCE RATING

The significance of air quality impacts was assessed according to the methodology provided to this study (refer to Appendix B of this report for the methodology).

5.1 Incremental Impacts

The environmental risk of the air quality impacts due to project activities were found to be:

- **Operational phase** (current Kangala operations) (Table 19) ***Medium*** for unmitigated and ***Low*** for design mitigated activities (based on PM_{10} impacts which is the pollutant of most concern). The highest impacts are mainly due to unpaved roads (both in-pit and surface roads).
- **Construction phase** (Eloff Project) (Table 20) ***Low*** for unmitigated activities and ***Low*** with mitigation applied. This applies to $PM_{2.5}$ and PM_{10} concentrations and dustfall rates.
- **Operational phase** (Eloff Project) (Table 21 and Table 22) ***Medium*** for unmitigated and ***Medium*** for additionally mitigated activities (based on PM_{10} impacts). The highest impacts are mainly due to unpaved roads and in-pit activities.
- **Decommissioning Phase** (Eloff Project) (Table 23): the impacts are expected to be ***Low*** for unmitigated activities and ***Low*** with mitigation applied**.** This applies to $PM_{2.5}$ and PM_{10} concentrations and dustfall rates.

5.2 Cumulative impacts

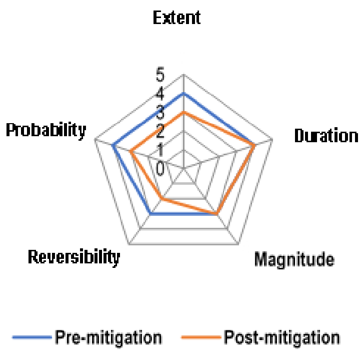
In order to prioritise the simulated impacts, it is necessary to assess the potentially significant impacts in terms of cumulative impacts and the degree to which the impact may cause irreplaceable loss of resources, as well as taking the public opinion and sentiment regarding the prospective development into account (see Appendix B for the methodology used to prioritise impacts).

The public response (PR) towards the proposed development was not known at the time of writing the report; it was assumed that PR is **Medium** (2). The assessment of whether the loss of resources due to the proposed development is irreversible (LR), is considered **Low** (1) for construction and decommissioning, and **Low to Medium** (2) for the operational phase. The cumulative impacts (CI) with respect to the Eloff Colliery construction and decommissioning phases are both assessed as **Low** (1), and the CI with respect to Eloff Colliery operational phase is assessed as **Medium** (2) for both design-mitigated operations and additionally mitigated operations. The priority score is determined by adding the scores for PR, CI and LR, giving a prioritisation factor (PF) of 1.17 for the construction phase and closure phase, and 1.50 for the operational phase.

The final impact significance associated with the proposed Eloff Colliery development is determined by multiplying the PF with the ER of the post-mitigation scoring, viz. **Low** for the construction phase (Table 20) and decommissioning phase (Table 23), **High** for the operational phase (with design mitigation applied) (Table 21) and **Medium** for the operational phase (additional mitigation applied) (Table 22).

Table 19: Significance rating for the current Kangala Operational Phase

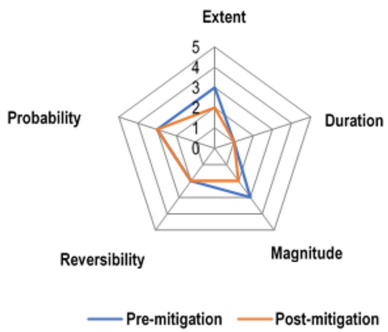
Impact Table



Impact Name	**Decline in Air Quality: Kangala Operations (Baseline)**				
Phase	**Operation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	3
Extent of Impact	4	3	Reversibility of Impact	3	2
Duration of Impact	4	4	Probability	4	3
Environmental Risk (Pre-mitigation)					-14.00
Mitigation Measures					
Environmental Risk (Post-mitigation)					-9.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response (assumption)					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.50
Final Significance					-13.50

Table 20: Significance rating for the Eloff Project (Construction)

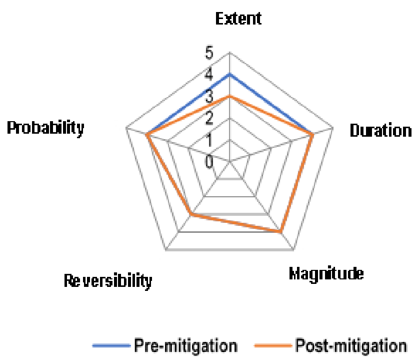
Impact Table



Impact Name	**Decline in Air Quality: Eloff Project**				
Phase	**Construction**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	3	2	Reversibility of Impact	2	2
Duration of Impact	1	1	Probability	3	3
Environmental Risk (Pre-mitigation)					-6.75
Mitigation Measures					
Environmental Risk (Post-mitigation)					-5.25
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response (assumption)					
Cumulative Impacts					1
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.17
Final Significance					-6.13

Table 21: Significance rating for the Eloff Project (Operation – Design Mitigation)

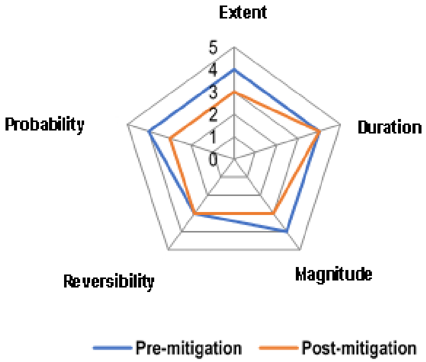
Impact Table



Impact Name	**Decline in Air Quality: Eloff Project**				
Phase	**Operation - Design Mitigation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	4	4
Extent of Impact	4	3	Reversibility of Impact	3	3
Duration of Impact	4	4	Probability	4	4
Environmental Risk (Pre-mitigation)					-15.00
Mitigation Measures					
Environmental Risk (Post-mitigation)					-14.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response (assumption)					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.50
Final Significance					-21.00

Table 22: Significance rating for the Eloff Project (Operation – Added Mitigation)

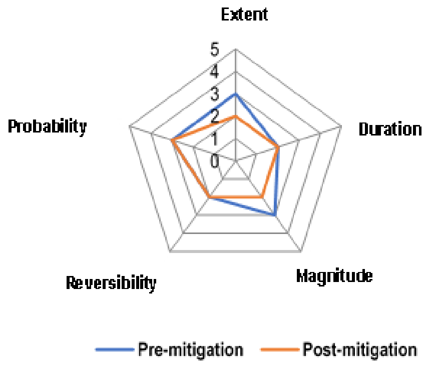
Impact Table



Impact Name	**Decline in Air Quality: Eloff Project**				
Phase	**Operation - Added Mitigation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	4	4
Extent of Impact	4	3	Reversibility of Impact	3	3
Duration of Impact	4	4	Probability	4	4
Environmental Risk (Pre-mitigation)					-15.00
Mitigation Measures					
Environmental Risk (Post-mitigation)					-9.75
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response (assumption)					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.50
Final Significance					-14.63

Table 23: Significance rating for the Eloff Project (Decommissioning)

Impact Table



Impact Name	**Decline in Air Quality: Eloff Project**				
Phase	**Decommissioning**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	3	2	Reversibility of Impact	2	2
Duration of Impact	2	2	Probability	3	3
Environmental Risk (Pre-mitigation)					-7.50
Mitigation Measures					
Environmental Risk (Post-mitigation)					-6.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response (assumption)					
Cumulative Impacts					1
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.17
Final Significance					-7.00

6 RECOMMENDED AIR QUALITY MANAGEMENT MEASURES

In the light of the Project being in the Highveld Priority Area, and close to various mining and power generation activities, it is recommended that air quality management planning forms part of the operational phase and decommissioning of the Project. The air quality management plan provides options on the control of dust at the main sources with the monitoring network designed as such to track the effectiveness of the mitigation measures. The sources need to be ranked according to sources strengths (emissions) and impacts. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

The main objective of the proposed air quality management measures for the project is to ensure that operations result in ambient air concentrations (specifically $PM_{2.5}$ and PM_{10}) and dustfall rates that are within the relevant ambient air quality standards and regulations outside the mining area and at the relevant AQSRs. In order to define site specific management objectives, the main sources of pollution need to be identified. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

6.1 Ranking of Sources

The ranking of sources serves to confirm the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources ranking can be established on:

- Emissions ranking; based on the comprehensive emissions inventory established for the operations (Section 4.1); and
- Impacts ranking; based on the simulated pollutant GLCs.

Ranking of sources based on emissions, are as follows:

- **Scenario 1**: the main source of emissions for design mitigated $PM_{2.5}$ is in-pit operations (43%) followed by crushing (21%); unpaved roads for PM_{10} (46%) and TSP (51%), followed by in-pit operations for PM_{10} (27%) and windblown dust for TSP (26%).
- **Scenario 2**: similar as for Scenario 1, the main source of emissions for design mitigated $PM_{2.5}$ is in-pit operations (42%) followed by unpaved roads (29%); unpaved roads for PM_{10} (54%) and TSP (62%), followed by in-pit operations for PM_{10} (33%) and TSP (18%).

Ranking of sources based on impacts, are as follows:

- **Scenario 1**: the main source of impact for design mitigated PM_{10} is vehicle entrained dust from unpaved roads, ranging in contribution to total simulated GLCs between 64% and 96%. The secondary source of impact for design mitigated PM_{10} is in-pit operations, ranging in contribution to total simulated GLCs between 2% and 28%. For $PM_{2.5}$ the main source of impact is in-pit operations, ranging in contribution between 9% and 65%, followed by crushing operations, ranging in contribution between 8% and 37%. The main source of impact for design mitigated dust fallout is windblown dust from the discard stockpile and topsoil stockpile, ranging in contribution to total simulated GLCs between 3% and 87%. The secondary source of impact for dust fallout is vehicle entrained dust from unpaved roads, ranging in contribution between 9% and 96%.
- **Scenario 2**: the main source of impact for design mitigated PM_{10} due to Eloff Colliery operations is vehicle entrained dust from unpaved roads, ranging in contribution to total simulated GLCs between 39% and 98%. The secondary source of impact for design mitigated PM_{10} is in-pit operations, ranging in contribution to total simulated GLCs between 1% and 53%. For design mitigated $PM_{2.5}$, in-pit operations were the main source of impact at 14 AQSRs,

ranging in contribution between 2% and 63%, followed by crushing operations, ranging in contribution between 6% and 45%. The main source of impact for design mitigated dust fallout is vehicle entrained dust from unpaved roads, ranging in contribution between 17% and 98%. The secondary source of impact for dust fallout is windblown dust from the discard stockpile and topsoil stockpile, ranging in contribution between 1% and 75%.

- **Decommissioning and Closure**: Likely activities to result in dust impacts during closure are:
    - infrastructure removal/demolition;
    - topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings; and
    - vehicle entrainment on unpaved road surfaces during rehabilitation – once that is done, vehicle activity associated with the mining operations should cease.

Table 24: Air Quality Management Plan – Operation Phase

Aspect	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Vehicle activity on unpaved roads	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Regular water sprays and chemical suppression on unpaved roads to ensure at least 90% control efficiency. • Monthly physical inspection of road surface, daily visual observation of entrained dust emissions from unpaved road surfaces.	Environmental Manager	On-going during operational phase
Drilling & Blasting	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Controlled blasting techniques to be used to ensure minimal dust generation. • Blasting only to be conducted on cloudless days, if possible. • Water sprays on drilling activities. • Addition of chemical surfactants to water sprays to lower water surface tension and increase binding properties. • Drilling to be controlled through water sprays or vacuum packs	Mine Production Engineer Drill Rig Operator Environmental Officer	On-going during operational phase
Materials Handling	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Increase in-pit material moisture content. • Drop height from excavator into haul trucks to be kept at a minimum for ore and waste rock. • Tipping onto ROM storage piles to be controlled through water sprays, should significant amounts of dust be generated. • Keep material handled by dozers and wheeled loaders moist to achieve a control efficiency of 50%, especially during dry periods. • Regular clean-up at loading areas.	Mine Production Engineer Environmental Officer	On-going during operational phase
Wind Erosion	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at ROM stockpile can achieve 50% control efficiency. Increase in moisture content provides higher threshold friction velocity and ensures that particulates are not as easily entrained due to high surface winds. • Reshape all disturbed areas to their natural contours. • Cover disturbed areas with previously collected topsoil and replant native species. • Rock cladding with larger pieces of waste rock is recommended to reduce wind erosion emissions from the overburden storage piles. • Revegetation of overburden stockpile is recommended.	Mining Engineer Environmental Officer	On-going during operational phase
Crushing	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at the crushers to achieve at least 50% control efficiency.	Mining Engineer Environmental Officer	On-going during operational phase

Table 25: Air Quality Management Plan - Decommissioning Phase

Aspect	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Wind erosion from exposed areas	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	Demolition of infrastructure to have water sprays where vehicle activity is high. Rehabilitation and vegetation of mined area.	Contractor(s) Environmental Manager	Post-operational, can cease once rehabilitation is in place

6.2 Ambient Monitoring

Environmental indicators are used in Environmental Land Use Planning and Management to simplify environmental assessments.

Indicators are defined as a single measure of a condition of an environmental element that represents the status or quality of that element. An index is a combination of a group of indicators to measure the overall status of an environmental element, and a threshold is the value of an indicator or index. For example, ambient PM_{10} concentrations monitored within a specific area will be the indicator, with the NAAQS being the threshold.

It is recommended that the existing dustfall monitoring network be expanded for the proposed Eloff project to continue the dustfall monitoring program during the operation of the mine.

The location of the new dust buckets EL-001 to EL-003 is provided in Figure 28. Should dustfall at the Delmas residential receptor (EL-003) exceed the NDCR, it is recommended that a 3-month PM_{10} sampling campaign be undertaken to assess whether a permanent PM_{10} sampler should be installed and to inform decision-making on additional mitigation measures that may be applied to the activities at the proposed Eloff Project.

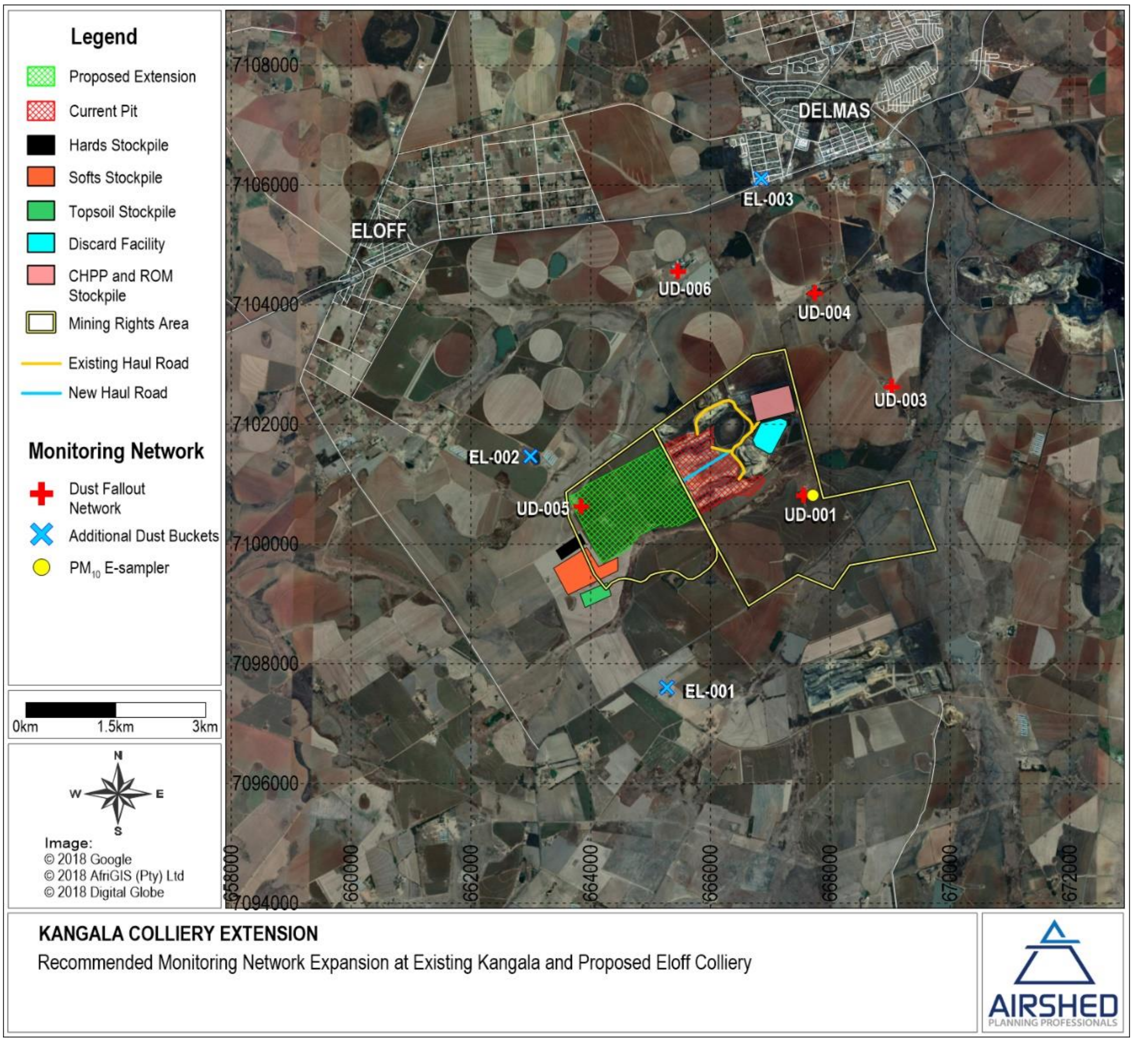


Figure 28: Recommended expansion of monitoring network at the proposed Eloff Project

The recommended performance assessment and reporting programme for dustfall monitoring is given in Table 26.

Table 26: Ambient air monitoring, performance assessment and reporting programme

Monitoring Strategy Criteria	Dustfall Monitoring
Monitoring objectives	- Assessment of compliance with dust control regulations. - Facilitate the measurement of progress against environmental targets. - Temporal trend analysis to determine the potential for nuisance impacts. - Tracking of progress due to pollution control measure implementation. - Informing the public of the extent of localised dust nuisance impacts occurring in the vicinity of the operations.
Monitoring location(s)	Three extra single dust buckets with recommended positions as provided in the section above. Should dustfall at the Delmas residential receptor (EL-003) exceed the NDCR, it is recommended that a 3-month PM_{10} sampling campaign be undertaken to assess whether a permanent PM_{10} sampler should be installed.
Sampling techniques	*Single Bucket Dustfall Monitors* Dustfall sampling measures the fallout of windblown settleable dust. Single bucket fallout monitors to be deployed following the American Society for Testing and Materials standard method for collection and analysis of dustfall (ASTM D1739). This method employs a simple device consisting of a cylindrical container exposed for one calendar month (30 days, ±2 days).
Accuracy of sampling technique	Margin of accuracy given as ±200 mg/m²/day.
Sampling frequency and duration	On-going, continuous monitoring to be implemented facilitating data collection over 1-month averaging period.
Commitment to QA/QC protocol	Comprehensive QA/QC protocol implemented.
Interim environmental targets (i.e. receptor-based performance indicator)	Maximum total daily dustfall (calculated from total monthly dustfall) of not greater than 600 mg/m²/day for residential areas. Maximum annual average dustfall to be less than 1 200 mg/m²/day on-site (non-residential areas).
Frequency of reviewing environmental targets	Annually (or may be triggered by changes in air quality regulations).
Action to be taken if targets are not met	(i) Source contribution quantification. (ii) Review of current control measures for significant sources (implementation of contingency measures where applicable).
Procedure to be followed in reviewing environmental targets and other elements of the monitoring strategy (e.g. sampling technique, duration, procedure)	Procedure to be drafted in liaison with interested and affected parties (I&APs). Points to be taken into account will include, for example: (i) trends in local and international ambient particulate guidelines and standards and/or compliance monitoring requirements, (ii) best practice with regard to monitoring methods, (iii) current trends in local air quality, i.e. is there an improvement or deterioration, (iv) future development plans within the airshed (etc.)
Progress reporting	At least annually to the necessary authorities.

7 CONCLUSIONS

An environmental air quality specialist study was conducted for the proposed opencast Kangala Colliery Extension (Eloff Project), which will be the life extension of Kangala from 2020 when the coal reserves at Kangala are depleted. The required surface infrastructure such as offices, stores facility, workshops, and change house already exists at Kangala and thus do not need to be replicated for the operations at the Eloff Project; however, the existing Kangala CHPP will be up-sized during 2019 to ensure the higher ROM production from 2019 can be processed, and a new haul road will be established to link the Eloff open pit area to the Kangala CHPP.

The air quality investigation comprises both a baseline study and an impact assessment. The aim of the investigation was to quantify the possible impacts resulting from the mining activities on the surrounding environment and human health. Emission rates were quantified for the activities and dispersion modelling executed.

The main findings from the baseline assessment are as follows:

- The wind field is dominated by winds from the north and north-northeast with an average wind speed of 3.21 m/s. Wind speeds exceeding 5 m/s occurred with a frequency of 14%. The northerly wind flow increases during day-time conditions with north-northeasterly wind flow increasing during the night.

- The topography of the study area is fairly flat, comprising of undulating terrain slightly increasing in height above mean sea level to the northeast of the area. An analysis of topographical data indicated a slope of less than 1:10 over most of the project area. Average total annual rainfall for the study region is in the range of 681 mm. The climate is classified as warm and temperate. The region is the coldest during July with a minimum temperature of -3.4°C during the night and warmest during January when temperatures reach 31°C during the day.

- Based on the nature of the project and expected air quality impacts, a study area of 15 km east-west by 15 km north-south, with the Project site located centrally, was selected. Air quality sensitive receptors (AQSR) within the study area include farmsteads, residential areas, schools, a hospital and agricultural holdings.

- Existing sources of air emissions include power generation, agricultural activities, metallurgical manufacturing processes, opencast coal mining and residential fuel burning.

- The measured PM_{10} daily ground level concentrations from the Kangala PM_{10} monitoring station for the period May 2016 to July 2018 regularly exceeded the daily NAAQS applicable from 2015. The PM_{10} period concentration (calculated from the daily concentrations for the monitoring period) was estimated at 25 µg/m³.

- Monitored dustfall levels at the UD-003 monitoring station exceeded the residential limit of 600 mg/m²/day more than twice per year, and for sequential months, during the 2015/2016, 2016/2017, and 2017/2018 sampling periods. This may be due to its close proximity to the R42 road.

- The Project is located within the Highveld Priority Area, in close proximity to Leeuwpan and Stuart (opencast) collieries.

To determine the significance of air pollution impacts from the proposed Project, two scenarios were assessed:

- **Baseline scenario** – representative of opencast mining activities at Kangala Colliery for the year July 2017 – June 2018; and

- **Project scenario** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026).

Each of these scenarios had 3 sub-scenarios, namely (a) unmitigated operations, (b) design mitigated operations[7] and (c) additionally mitigated operations[8].

The main findings from the impact assessment due to the baseline (Kangala) operations are as follows:

- The daily **PM_{10}** SA NAAQS was exceeded at 13 (out of 25) AQSRs for unmitigated activities. For the design mitigated scenario, simulated PM_{10} concentrations exceeded the daily SA NAAQS at 2 AQSRs, over an area up to 2.0km to the north, 1.0km to the east, 750m to the south and 1.5km to the southwest from the mining boundary. With additional mitigation, non-compliances were still simulated at 2 AQSRs. Over an annual average unmitigated PM_{10} impacts exceeded the annual NAAQS at 2 AQSRs. These impacts were reduced when design mitigation is applied, with exceedances simulated at only one AQSR and no exceedances for additionally mitigated activities.
- **$PM_{2.5}$** daily GLCs, with no mitigation in place, were in non-compliance with the 2030 NAAQSs at 4 AQSRs. Simulated impacts were reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at two AQSRs. With additional mitigation, simulated $PM_{2.5}$ daily GLCs were within compliance at all AQSRs. Over an annual average design mitigated simulated GLCs and additionally mitigated GLCs, were within compliance currently and after 2030.
- The simulated maximum daily **dustfall** rates due to the unmitigated scenario exceeded the NDCR for residential areas at only one AQSR. Simulated dustfall rates at all AQSRs were well within the residential limit for the design mitigated and additionally mitigated scenarios.
- The baseline operations resulted in **Medium** significance for unmitigated and **Low** significance for design mitigated operations. The highest PM_{10} impacts were mainly due to vehicle entrained dust from unpaved roads, whereas the highest $PM_{2.5}$ impacts were due to in-pit operations and the highest dustfall impacts were due to windblown dust from the discard and topsoil stockpiles.

The main findings from the impact assessment due to the Project (Eloff) operations are as follows:

- The daily **PM_{10}** SA NAAQS was exceeded at 25 (out of 25) AQSRs for unmitigated activities. For the design mitigated scenario, simulated PM_{10} concentrations exceeded the daily SA NAAQS at 6 AQSRs, over an area up to 2.8km to the southwest, 2.4km to the south, 2.4km to the east and 3.0km to the north from the mining boundary. With additional mitigation the footprint was reduced, with 3 AQSRs non-compliant. Over an annual average unmitigated PM_{10} impacts exceeded the annual NAAQS at 2 AQSRs. With design mitigation applied, exceedances were still simulated at 2 AQSRs, and with additional mitigation applied, PM_{10} impacts exceeded the annual NAAQS at only one AQSR.
- **$PM_{2.5}$** daily GLCs, with no mitigation in place, were in non-compliance with the 2030 NAAQSs at 14 AQSRs. Simulated impacts were reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at only two AQSRs. With additional mitigation, simulated $PM_{2.5}$ daily GLCs were still in non-compliance at two AQSRs. Over an annual average design mitigated simulated GLCs and additionally mitigated GLCs, were within compliance currently and after 2030.

[7] Design mitigated activities include: 75% CE on unpaved haul roads; 50% CE on materials handling; 50% CE on crushing and screening; 50% CE on grading activities; 70% CE on covered conveyor tipping points and 65% on windblown dust from conveyor belt with enclosed side and roof.
[8] Additional mitigation includes design mitigation and 90% CE on unpaved haul roads.

- The simulated maximum daily **dustfall** rates due to the unmitigated scenario exceeded the NDCR for residential areas at one AQSR. Simulated dustfall rates exceeded the NDCR for residential areas at one AQSR for the design mitigated scenario but were well within the residential limit for the additionally mitigated scenario.
- The Project operations resulted in **High** significance for design mitigated operations and **Medium** significance for additionally mitigated operations. Similar to the baseline scenario, the highest PM_{10} impacts were due to vehicle entrained dust from unpaved roads, whereas the highest $PM_{2.5}$ impacts were due to in-pit operations and the highest dustfall impacts were due to windblown dust from the discard and topsoil stockpiles.
- The impact significance associated with the proposed Eloff Colliery construction and decommissioning phases was determined as **Low**.
- The simulated footprint areas of exceedance for PM_{10} and $PM_{2.5}$ impacts, were found to be much larger for the Project Scenario (Eloff Project) than for the Baseline Scenario (Kangala operations). Even with additional mitigation applied on haul roads to achieve a control efficiency of 90% the area of exceedance of the daily PM_{10} NAAQS extended well beyond the mining rights boundary. This increase in magnitude may be explained by the higher throughput of annual ROM tonnages for the Eloff Project, and more vehicle entrained dust from the new haul road and in-pit roads. The up-sizing of the Kangala CHPP to process the higher ROM production will also lead to higher crushing emissions.

7.1 Recommendations

The proposed Eloff Project is located within the Highveld Priority Area and close to various mining and power generation sources. The management plan objectives for this priority area are to minimise impacts on the surrounding environment. It is therefore recommended that air quality management measures be implemented to ensure the lowest possible impacts on the surrounding environment from the mining operations. These measures should include:

- Implementation and monitoring of design mitigation measures. Additional mitigation measures are recommended to ensure mining related impacts remain within the Mine License Area. These include:
  - Frequent water sprays (> 2 litres/m²/hr) on the in-pit roads to ensure a control efficiency of at least 75% and chemical suppressants on the unpaved haul roads to ensure a control efficiency of more than 90%;
  - Temporary wind breaks to be installed onto the topsoil stockpile (30% control efficiency) and vegetation cover to be established on the dormant areas and side slopes (40% control efficiency) (NPI, 2011).
- To ensure the impacts on the surrounding environment and human health remain acceptable throughout the Life of Mine (LoM), 3 dustfall units are recommended to be added to the existing dustfall monitoring network. Should dustfall at the Delmas residential receptor (EL-003) exceed the NDCR, it is recommended that a 3-month PM_{10} sampling campaign be undertaken to assess whether a permanent PM_{10} sampler should be installed.
- It is recommended that UCD1 buy out the two farmsteads (Nos 16 and 17) located within the footprint area of exceedance of the daily PM_{10} NAAQS, to ensure that people not be exposed to ambient air quality that may be harmful to human health.

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9 Appendix A – Specialist Curriculum Vitae

CURRICULUM VITAE

Name	Rochelle Bornman
Date of Birth	24 August 1974
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Air Quality Specialist
Profession	Scientist
Years with Firm	10

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Member of National Association for Clean Air (NACA)

EXPERIENCE

- Emissions inventory compilation
- Meteorological, topographical and land use data processing and preparation
- Dispersion modelling experienced in SCREEN, AERMOD, ADMS, CALINE and CALPUFF dispersion models.
- Impact and compliance assessment
- Air quality and dust management plan preparation
- Atmospheric emission license application
- Industry sectors in which experience have been gained with specific reference to air quality include:
    - Opencast and underground mining of: copper, platinum, gold, iron, and coal.
    - Production of: copper, platinum, gold, base metals, iron, steel, and tyre pyrolysis.
    - Biomass to Energy production
    - Fire behaviour modelling

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), TANKS
- Other: Golden Software Surfer, Lakes Environmental WRPlot, MS Word, MS Excel, MS PowerPoint, ArcMap, ArcView

EDUCATION

- B. Land Surveying: 1997, *University of Pretoria*
- MPhil: (Geographical Information Systems and Remote Sensing) 1998, *University of Cambridge*

COURSES COMPLETED AND CONFERENCES ATTENDED

- NACA Conference 2010, 2011
- Laboratory Systems Course (ISO 17025: 2017) March 2018

COURSES PRESENTED

- Geodesy and Land Surveying at the University of Pretoria (1999)

COUNTRIES OF WORK EXPERIENCE

- South Africa, Namibia, Mozambique, Saudi Arabia, Mali

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Full professional proficiency

REFERENCES

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Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.

10 Appendix B – Significance Rating Methodology

10.1 Impact Significance Rating Methodology

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

Determination of Environmental Risk:

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER). The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$C = \frac{(E+D+M+R)}{4} \times N$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 27.

Table 27: Criteria for determining impact consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),

Aspect	Score	Definition
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/scored as per Table 28.

Table 28: Probability scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

ER= C x P

Table 29: Determination of environmental risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 30.

Table 30: Significance classes

Environmental Risk Score	
Value	**Description**
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
≥9; <17	Medium (i.e. where the impact could have a significant environmental risk),
≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

Impact Prioritisation:

In accordance with the requirements of Regulation 31 (2)(l) of the EIA Regulations (GNR 543), and further to the assessment criteria presented in the Section above it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

In addition, it is important that the public opinion and sentiment regarding a prospective development and consequent potential impacts is considered in the decision-making process.

In an effort to ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 31: Criteria for determining prioritisation

Public response (PR)	Low (1)	Issue not raised in public response.
	Medium (2)	Issue has received a meaningful and justifiable public response.
	High (3)	Issue has received an intense meaningful and justifiable public response.
Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 31. The impact priority is therefore determined as follows:

$$\textbf{Priority} = \textbf{PR} + \textbf{CI} + \textbf{LR}$$

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (refer to Table 32).

Table 32: Determination of prioritisation factor

Priority	Ranking	Prioritisation Factor
3	Low	1
4	Medium	1.17
5	Medium	1.33
6	Medium	1.5
7	Medium	1.67
8	Medium	1.83
9	High	2

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table 33: Final environmental significance rating

Environmental Significance Rating	
Value	**Description**
< 10	Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
≥10 <20	Medium (i.e. where the impact could influence the decision to develop in the area),
≥ 20	High (i.e. where the impact must have an influence on the decision process to develop in the area).