ENVIRONMENTAL & ENGINEERING

REPORT

EXXARO COAL CENTRAL (PTY) LTD

AIR QUALITY IMPACT ASSESSMENT (AQIA)

REPORT REF: 18-639-SPS

(PORTION 0 OF THE FARM RIETKUIL 57, PORTIONS 2, 3, AND 8 OF THE FARM DORSTFONTEIN 71, PORTIONS 5, 11, AND 13 OF THE FARM WELSTAND 55, PORTION 0 OF THE FARM RIETKUIL 558 - MPUMALANGA PROVINCE.)

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EXPERTISE OF THE REVIEWER

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Education	- Senior Certificate Matric (Cum Laude). - B.Sc. Geography (Cum Laude) (University of Pretoria). - BSc Honors Environmental Management and Analysis (Cum Laude) (University of Pretoria). - MSc Project Management (Thesis Cum Laude) (University of Pretoria).
Professional skills	Mr. Henno Engelbrecht has 10 years working experience as an Environmental Consultant and specialized in Environmental Management and Analysis. Henno worked for Environmental Assurance Pty (Ltd) as an environmental consultant since completing his studies until mid-2013 and served an array of clients in various fields of environmental practice. He has vast environmental monitoring & measurement, environmental authorisations, mine closure, and environmental impact assessment experience and worked within various project teams, up to the level of Programme Manager being responsible for all projects which fell within the Environmental Assurance (Pty) Ltd programme. His expertise led to his specialist inputs and studies to be used in several Environmental Impact Assessments, Water Use License Applications, Waste License Applications, Air Emission License Applications and Mine Closure/Rehabilitation Planning Activities. Henno holds the MSc Project Management degree at the Engineering Faculty with the University of Pretoria. He worked in mining, industrial, natural and construction environments but his expertise lies mainly within the mining sector and currently holds the position of Director at Eco Elementum (Pty).
Skills	- Mine Closure financial quantum determination, mine closure planning and reporting. - Rehabilitation planning, reporting, management and coordination of opencast and underground mining. - Ambient air quality monitoring, measurement and implementation (passive and active) in accordance to the National Environmental Management: Air Quality Act 39 of 2004, Government Notice 248 NEM: AQA (39/2004) which contains the Listed Activities, and the National Ambient Air Quality Standards (SANS 1929: 2005). - Noise monitoring and measurement according to SANS 10103:2008, the measurement and rating of environmental noise with respect to annoyance and to speech communication & SANS 10328:2008, Methods for environmental noise impact assessment. - Water quality monitoring, measurement, reporting and data analyses including surface water, ground water, process water, sewage water and biological indicators. - Groundwater hydrocensus studies – borehole surface water depth monitoring, measurement, transections and analysis. - ISO 14001 Environmental Management Systems auditing, system implementation, training and environmental analysis (creation of aspect/impact registers, contractor training, general environmental awareness training, legal compliance audits, GAP analysis, documentation reviews, roles and authority allocations etc.) - Legal compliance auditing and reporting in accordance with the National Environmental Management Acts and other associated environmental related (NEMA listed activities, Air Quality Act listed activities, Water Use Licensing, Waste Licensing, Air Emissions Licensing etc.) - Environmental training (contractor training, monitoring and measurement training, awareness training). - Environmental impact assessments and Integrated Water Use License Applications. - Environmental Management Plan development, monitoring, compliance auditing etc. - Environmental Control Officer Site inspections- non-conformance reporting (NCR), corrective action request (CAR) and preventative action request (PAR).

EXECUTIVE SUMMARY

Exxaro Coal Central (Pty) Ltd (Exxaro) appointed Nsovo Environmental Consulting (Pty) Ltd (Nsovo) to undertake environmental authorisations associated with the proposed Dorstfontein Expansion Project. The applicant wants to expand on their current operations at the Dorstfontein complex situated on an area of 3 202 ha on portion 0 of the farm Rietkuil 57, portions 2, 3, and 8 of the farm Dorstfontein 71, portions 5, 11, and 13 of the farm Welstand 55, portion 0 of the farm Rietkuil 558 in the Mpumalanga Province of South Africa.

Nsovo appointed Eco-Elementum (Pty) Ltd to undertake the Air Quality Impact Assessment for the Dorstfontein Expansion project.

Dorstfontein West mine is an underground mine with both 2 and 4-seam operated by Exxaro Coal Central (Pty) Ltd. Exxaro Dorstfontein West proposes to undertake the following activities:

- Pillar extraction mining which will be undertaken on the 4-seam for purposes of extending the operational life of the mine and creating an opportunity to derive value from re-sources that would have been sterilised;
- The extension of the discard dump which has become necessary due to the life of the current discard dump coming to the end in 2022. The discard dump extension will cater for both Slurry and discard coal and is expected to cater for the life of mine; and
- The construction of a conveyor belt from DCM West which will be linked to the conveyor systems at DCM East to ensure seamless coal is conveyed from DCM West to DCM East where the coal will be loaded into trains and thereafter transported to Richards Bay Terminal.

The purpose of this study is to:

1. Study the available information relevant to the pre and post-development ambient air quality pollution concentrations in the environment;
2. Identify the major existing air emission sources in the environment;
3. Identify the existing sensitive air pollution areas in the environment;
4. Estimate by means of measurements and integration of the results with those of any relevant existing information the present ambient air quality climate;
5. Identify the mining related processes and equipment that will cause the major contribution to the future air quality impact;
6. Consider, evaluate and rate the potential air quality impacts; and
7. Propose relevant management and mitigation measures to lessen the anticipated impacts.

SUMMARY OF FINDINGS

The air quality impact assessment undertaken for the project includes a meteorological overview of the area.

An emissions inventory was undertaken with the aim of quantifying emissions associated with the activities involved in the mining and processing of coal. The emissions for specific activities such as conveyor transport, haul road transport, wind erosion and materials handling activities were calculate and the cumulative impacts were compared to the relevant ambient air quality standards to determine legal compliance.

The findings reported here is therefore a combination of historical, observed and previously modelled data and provided the background and predicted scenario of various pollutants in the proposed Exxaro Dorstfontein West Expansion project mining area. The operational phases were assessed. Based on the dispersion modelling simulations, the following conclusions can be summarised as follows:

Table 1: Summary of all predicted Values

Average Value from all Receptors				
	Conveyor Mitigated			
	Extension	**Site 1**	**Site 2**	**Site 3**
PM10 Daily	**1.68**	2.56	3.06	3.96
PM10 Annual	**0.17**	0.18	0.19	0.25
TSP Monthly	8.50	3.09	**2.18**	2.73
TSP Annual	3.14	1.40	**0.87**	0.98

The **Expansion of the current Discard Dump** or building a new Discard Dump at the proposed location of **Site 2** while using a conveyor system to transport the ROM, are predicted to have the least impact in terms of Air quality on the sensitive receptors when comparing the PM10 predicted concentrations and TSP dust fallout.

Table 2: Summary of the count of minimum predicted Values

Count of minimum Values at all Receptors				
	Conveyor Mitigated			
	Extension	**Site 1**	**Site 2**	**Site 3**
PM10 Daily	16	**12**	2	3
PM10 Annual	**20**	19	8	9
TSP Monthly	15	**24**	19	10
TSP Annual	19	21	**23**	18

When comparing the amount of receptors that are predicted to have the lowest value for all the relevant scenarios, the **Expansion of the current Discard Dump** or building a new Discard Dump at the proposed location of **Site 1** while using a conveyor system to transport the ROM, are predicted to have the least impact in terms of Air quality on the sensitive receptors when comparing the PM10 predicted concentrations and TSP dust fallout.

Based on the results presented the following recommendations are outlined:

- Conveyor Transport is the preferred option.
- Although the Expansion of the Discard dump and Site 1 are predicted to have the least air quality impact at the sensitive, when mitigated and using a conveyor system to transport the material, all discard dump options fall within the relevant air quality limits.

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Glossary

Assessment	A systematic, independent and documented review of operations and practises to ensure that relevant requirements are met. Qualified professionals with relevant auditing experience should conduct audits and, where possible, independent external auditors should also be used.
Construction	The time period that corresponds to any event, process, or activity that occurs during the Construction phase (e.g., building of site, buildings, and processing units) of the proposed project. This phase terminates when the project goes into full operation or use.
Director-General	means the Director-General of the Department;
Environmental Component	An attribute or constituent of the environment (i.e., air quality; marine water; waste management; geology, seismicity, soil, and groundwater; marine ecology; terrestrial ecology, noise, traffic, socio-economic) that may be impacted by the proposed project.
Environmental Impact	A positive or negative condition that occurs to an environmental component as a result of the activity of a project or facility. This impact can be directly or indirectly caused by the project's different phases (i.e., Construction, Operation, and Decommissioning).
Record of Decision	Is an environmental authorisation issued by a state department.
Responsible authority	in relation to a specific power or duty in respect of water uses, means - (a) if that power or duty has been assigned by the Minister to a catchment management agency, that catchment management agency; or (b) if that power or duty has not been so assigned, the Minister;
Air quality	A measure of exposure to air which is not harmful to your health. Air quality is measured against health risk thresholds (levels) which are designed to protect ambient air quality. Various countries including South Africa have Air Quality Standards (legally binding health risk thresholds) which aim to protect human health due to exposure to pollutants within the living space.
Ambient air	The air of the surrounding environment.
Baseline	The current and existing condition before any development or action.
Boundary layer	Within the earth's atmosphere, the boundary layer is defined as the planets boundary layer which is the air layer near the ground affected by diurnal heat, moisture or momentum transfer to or from the surface.
Climatology	The study of the long term effect of weather over a certain area during a certain period.
Concentration	When a pollutant is measured in ambient air it is referred to as the concentration of that pollutant in air. Pollutant concentrations are measured in ambient air for various reasons, i.e. to determine whether concentrations are exceeding available health risk thresholds (air quality standards); to determine how different sources of pollution contribute to ambient air concentrations in an area; to validate dispersion modelling conducted for an area; to determine how pollutant concentrations fluctuate over time in an area; and to determine the areas with the highest pollution concentrations.
Condensation	The change of physical state of matter from a gaseous phase into a liquid phase.
Dispersion model	A mathematical model which can be used to assess pollutant concentrations and deposition rates from a wide variety of sources. Various dispersion modelling computer programs have been developed.
Dispersion potential	The potential a pollutant has of being transported from the source of emission by wind or upward diffusion. Dispersion potential is determined by wind velocity, wind direction, height of the mixing layer, atmospheric stability, presence of inversion layers and various other meteorological conditions.
Emission	The rate at which a pollutant is emitted from a source of pollution.
Emission factor	A representative value, relating the quantity of a pollutant to a specific activity resulting in the release of the pollutant to atmosphere.
Evaporation	The opposite of condensation.
Front	A synoptic-scale swath of cloud and precipitation associated with a significant horizontal zonal temperature gradient. A front is warm when warm air replaces cold on the passage of the front; with a cold front cold air replaces warm air.
Fugitive dust	Dust generated from an open source and is not discharged to the atmosphere in a confined flow stream.
Inversion	An increase of atmospheric temperature with an increase in height.
Mixing layer	The layer of air within which pollutants are mixed by turbulence. Mixing depth is the height of this layer from the earth's surface
Particulate matter (PM)	The collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface and includes dust, smoke, soot, pollen and soil particles. Particulate matter is classified as a criteria pollutant, thus national air quality standards have been developed in order to protect the public from exposure to the inhalable fractions. PM can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions: * PM10 (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung); * PM2.5, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less); * PM10-2.5, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and * Ultra fine particles generally defined as those less than 0.1 microns.
Precipitation	Ice particles or water droplets large enough to fall at least 100 m below the cloud base before evaporating.
Relative Humidity	The vapour content of the air as a percentage of the vapour content needed to saturate air at the same temperature.

PROJECT INFORMATION

Table 3: Applicant Details

Name of Applicant:	Exxaro Coal Central (Pty) Ltd
Contact Person:	
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Physical Address:	
File Reference Number DMR:	

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Table 5: Specialist Details

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Website:	www.ecoelementum.co.za

1. INTRODUCTION

Exxaro Coal Central (Pty) Ltd (Exxaro) appointed Nsovo Environmental Consulting (Pty) Ltd (Nsovo) to undertake environmental authorisations associated with the proposed Dorstfontein Expansion Project. The applicant wants to expand on their current operations at the Dorstfontein complex situated on an area of 3 202 ha on portion 0 of the farm Rietkuil 57, portions 2, 3, and 8 of the farm Dorstfontein 71, portions 5, 11, and 13 of the farm Welstand 55, portion 0 of the farm Rietkuil 558 in the Mpumalanga Province of South Africa.

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Table 6: Project Locality

Farm Name:	PORTION 0 OF THE FARM RIETKUIL 57, PORTIONS 2, 3, AND 8 OF THE FARM DORSTFONTEIN 71, PORTIONS 5, 11, AND 13 OF THE FARM WELSTAND 55, PORTION 0 OF THE FARM RIETKUIL 558 - MPUMALANGA PROVINCE
Application Area:	3 202 ha
Magisterial District:	Nkangala District Municipality, Mpumalanga Province South Africa
Distance and direction from nearest town:	The Project Area is ~ 4 km north-east of Kriel, ~ 40 km south-east of Witbank and ~ 48 km west of Hendrina.

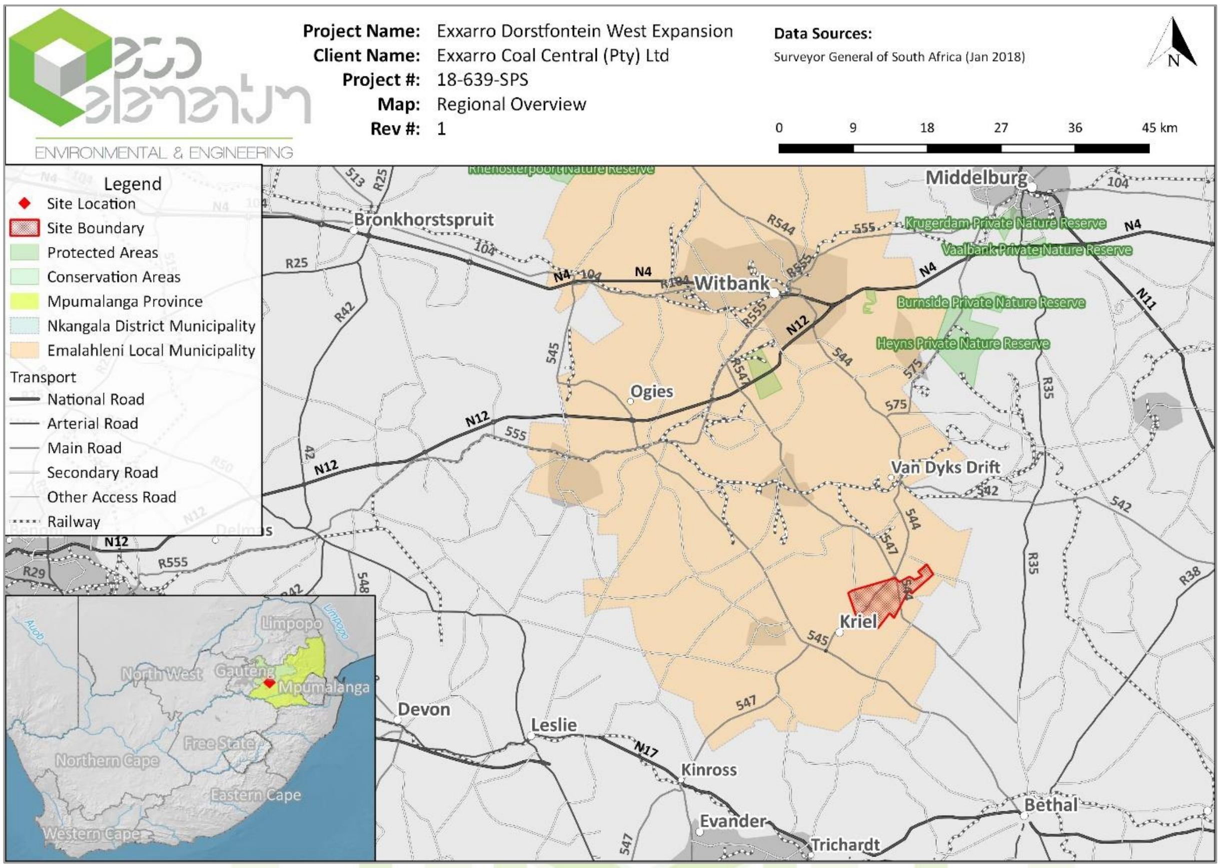

Figure 1: Map indicating the regional overview of the proposed Exxaro Dorstfontein Expansion project.

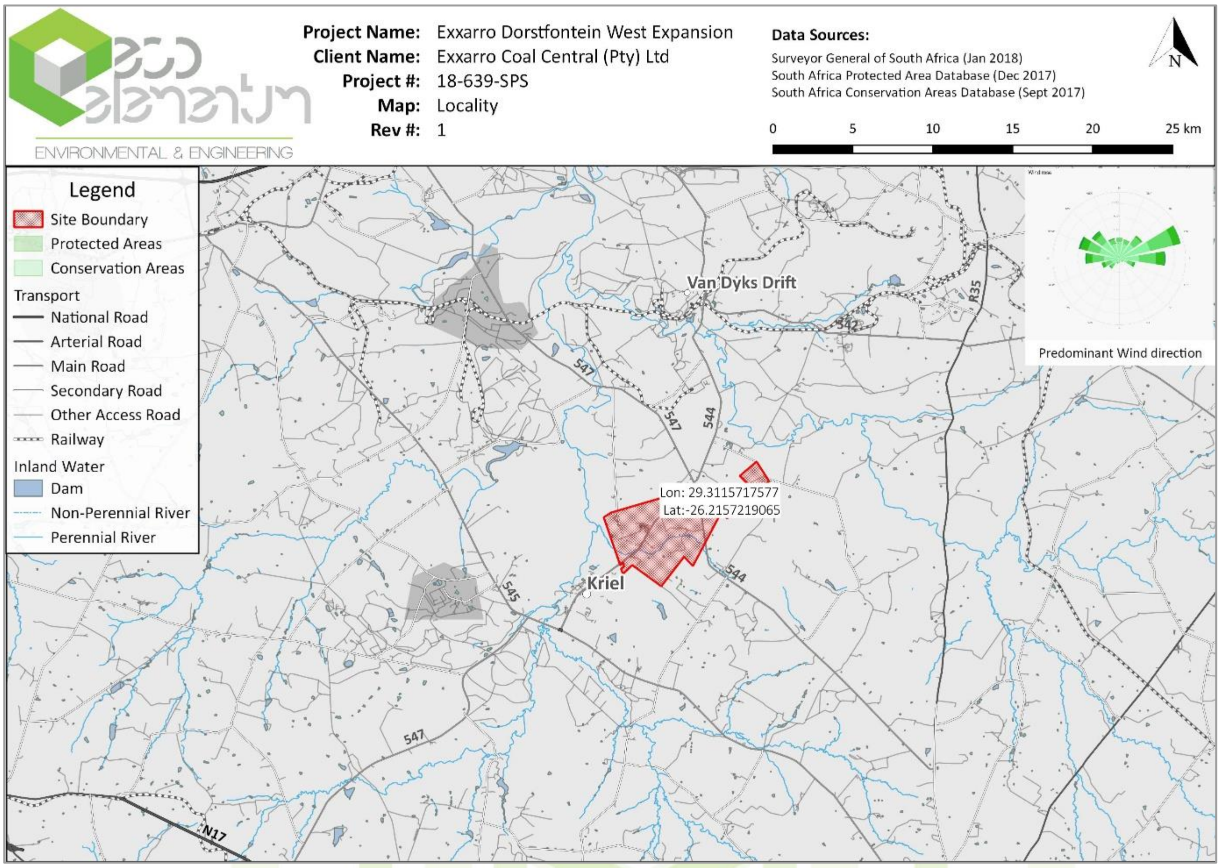

Figure 2: Locality map of the proposed Exxaro Dorstfontein Expansion project.

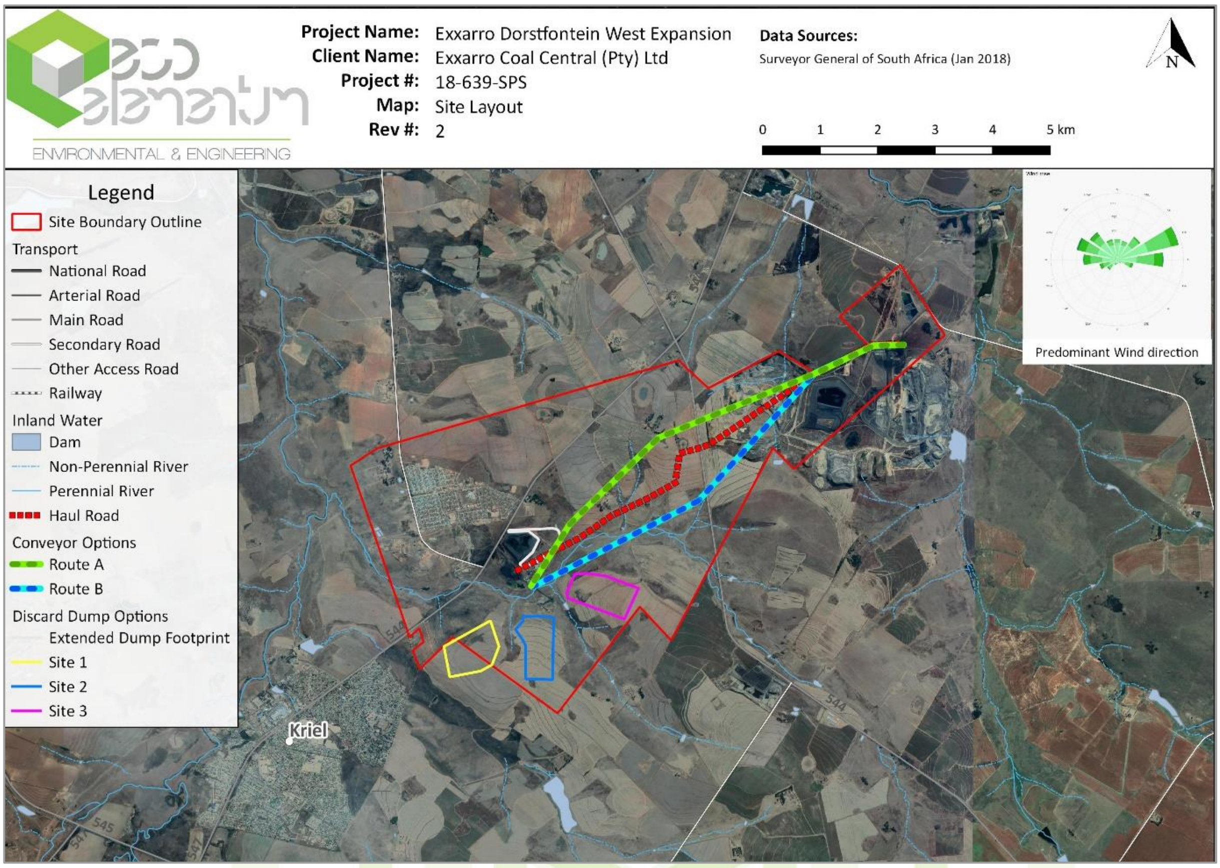

Figure 3: Proposed Site Layout for the proposed Exxaro Dorstfontein Expansion project.

2. SCOPE OF WORK

The purpose of this study is to:

1. Study the available information relevant to the pre and post-development ambient air quality pollution concentrations in the environment;
2. Identify the major existing air emission sources in the environment;
3. Identify the existing sensitive air pollution areas in the environment;
4. Estimate by means of measurements and integration of the results with those of any relevant existing information the present ambient air quality climate;
5. Identify the mining related processes and equipment that will cause the major contribution to the future air quality impact;
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3. STUDY AREA

3.1 Location

3.1.1 Industries

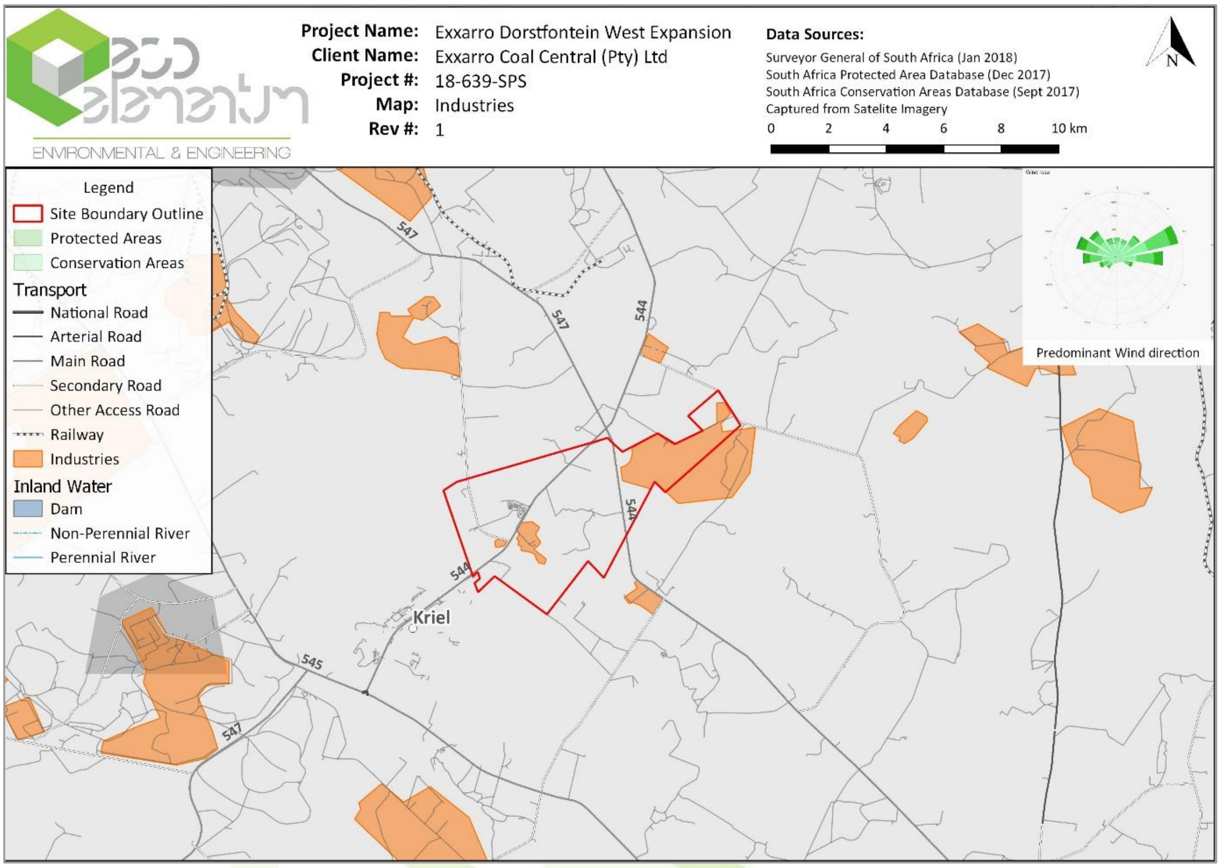


Figure 4: Other industries in the immediate vicinity of the proposed Exxaro Dorstfontein Expansion project.

From a desktop study of satellite imagery, industrial operations, including other mining operations, power station, and other industries were identified in the immediate vicinity of the proposed Exxaro Dorstfontein Expansion project. The current operations is included in the identification. The industries are dispersed around the project.

3.1.2 Population

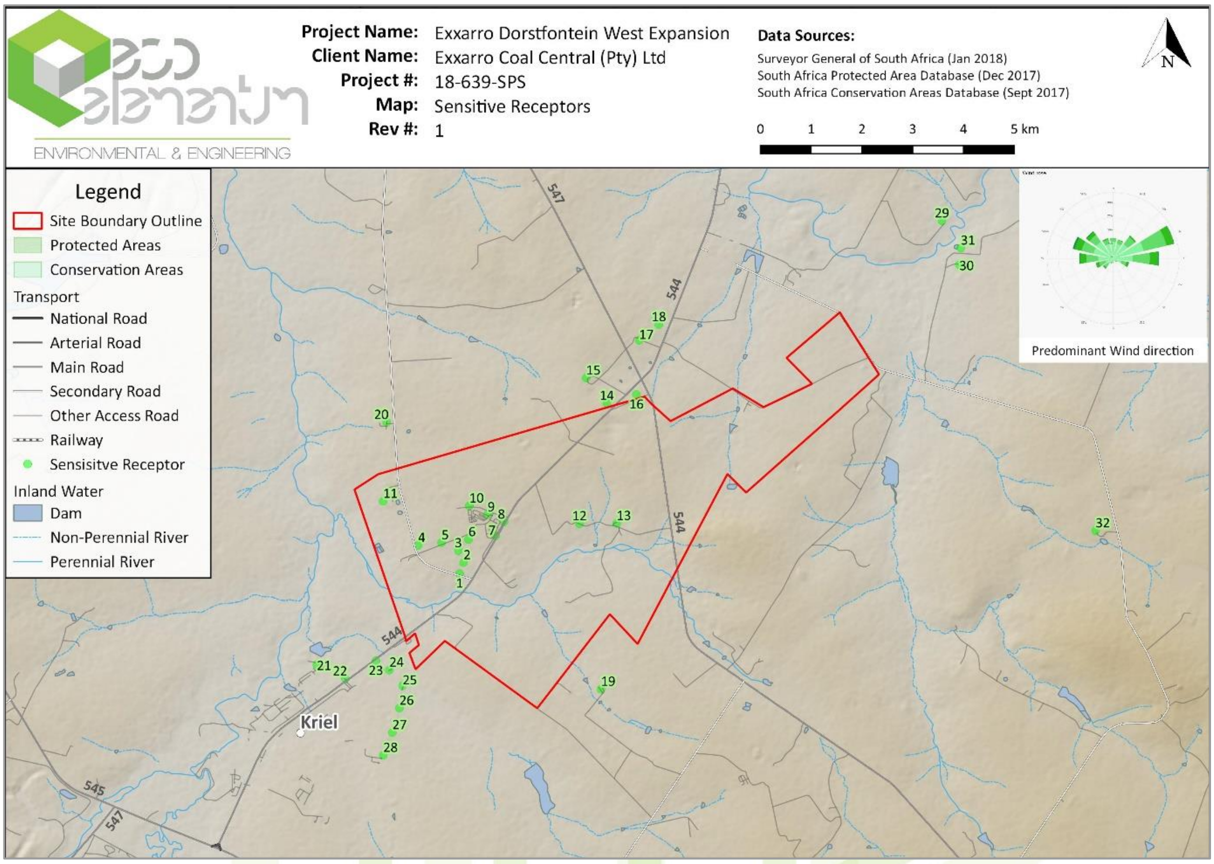


Figure 5: Population areas within the immediate vicinity of the proposed Exxaro Dorstfontein Expansion project.

From a desktop study of satellite imagery various sensitive receptors in the form of human habitation areas, consisting of farm houses, and the town of Kriel have been identified within the immediate vicinity of the proposed operations. It should be noted that the sensitive receptors in the area may differ from those identified as not all areas may have been identified from the imagery successfully.

3.1.3 Topography

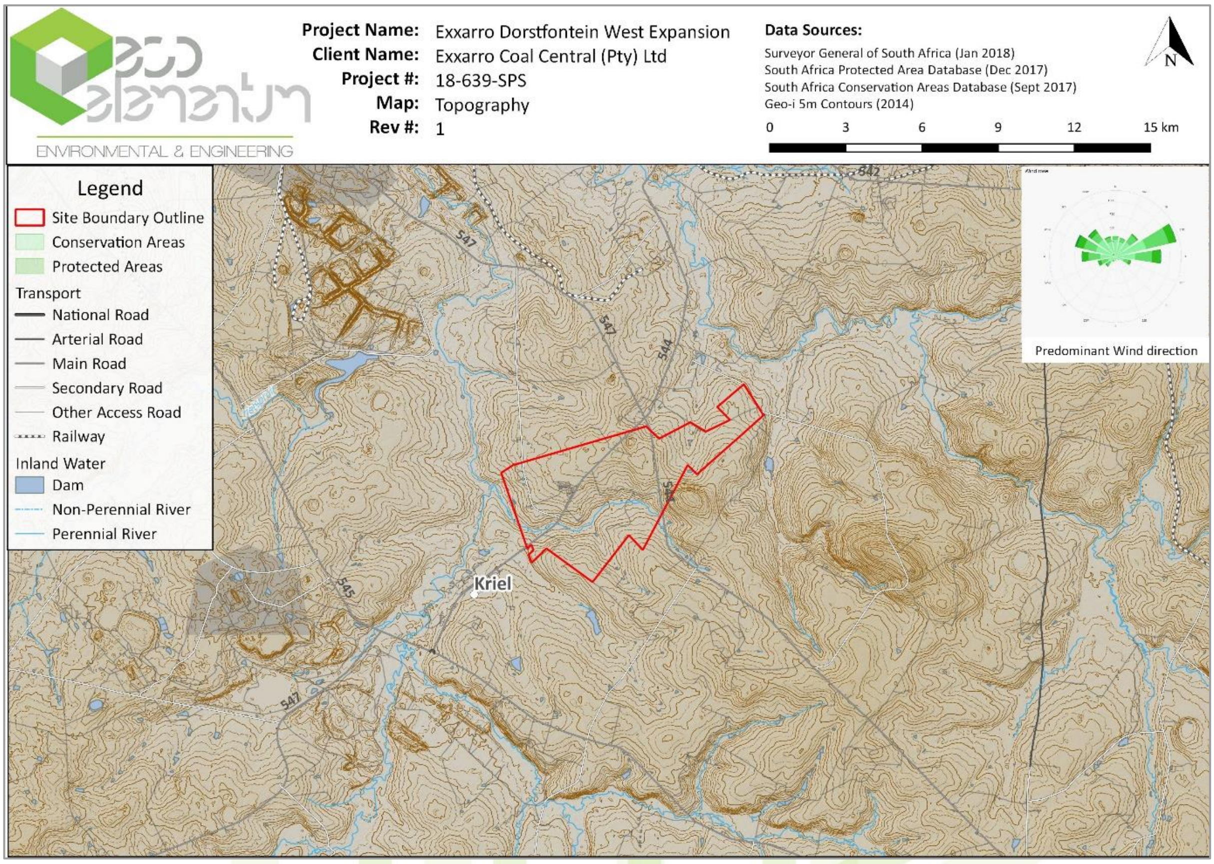


Figure 6 3D map showing the terrain relief of the area around the proposed Exxaro Dorstfontein Expansion project.

The proposed mining operation area is situated in undulated terrain as can be seen in Figure 6 above. No major topographical features can be found in the immediate vicinity.

3.2 Meteorological Data

3.2.1 Regional Air Quality

South Africa is located in the sub-tropics where high pressures and subsidence dominate. However, the southern part of the continent can serve as a source of hot air that intrudes sub-tropics, and that sometimes lead to convective movement of air masses. On average, a low pressure will develop over the southern part of the continent, while the normal high pressures will remain over the surrounding oceans. These high pressures are known as Indian High Pressure Cells and Atlantic High pressure Cells. The intrusion of continents will allow for the development of circulation patterns that draw moisture (rain) from either tropics (hot air masses over equator) or from the mid-latitude and temperate latitudes.

Southern Africa is influenced by two major high pressure cells, in addition to various circulation systems prevailing in the adjacent tropical and temperate latitudes. The mean circulation of the atmosphere over Southern Africa is anticyclonic throughout the year (except near the surface) due to the dominance of the three high pressure cells, namely South Atlantic High Pressure, off the west coast, the South Indian High Pressure off the east coast and the Continental High Pressure over the interior.

It is these climatic conditions and circulation movements that are responsible for the distribution and dispersion of air pollutants within the proposed Dorstfontein Expansion Project area and between neighbouring provinces and countries bordering South Africa.

3.2.2 Meso-Scale Meteorology

The nature of the local climate will determine what will happen to the pollution when it is released into the atmosphere (Tyson and Preston-Whyte, 2000). Pollution levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will have an effect on the rate of transport and dispersion of pollution.

The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion (Tyson and Preston-Whyte, 2000).

Inversion occurs under conditions of stability when a layer of warm air is situated directly above a layer of cool air. This layer prevents a pollutant from diffusing freely upward, resulting in an increased pollutant concentration at or close to the earth's surface. Surface inversions develop under conditions of clear, calm and dry conditions and often occur at night and during winter (Tyson and Preston- Whyte, 2000). Radiative loss during the night results in the development of a cold layer of air close to the earth's surface. These surface inversions are however, usually destroyed as soon as the sun rises and warm the earth's surface. With the absence of surface inversions, the pollutants are able to diffuse freely upward; this upward motion may however be prevented by the presence of an elevated inversion (Tyson and Preston-Whyte, 2000).

Elevated inversions occur commonly in high pressure areas. Sinking air warms adiabatically to temperatures in excess of those in the mixed boundary layer. The interface between the upper, gently subsiding air is marked by an absolutely stable layer or an elevated subsidence inversion. This type of elevated inversions is most common over Southern Africa (Tyson and Preston-Whyte, 2000).

The climate and atmospheric dispersion potential of the interior of South Africa is determined by atmospheric conditions associated with the continental high pressure cell located over the interior. The continental high pressure present over the region in the winter months results in fine conditions with little rainfall and light winds with a northerly flow. Elevated inversions are common in such high pressure areas due to the subsidence of air. This reduces the mixing depth and suppresses the vertical dispersion of pollutants, causing increased pollutant concentrations (Tyson and Preston- Whyte, 2000).

Seasonal variations in the positions of the high pressure cells have an effect on atmospheric conditions over the region. For most of the year the tropical easterlies cause an air flow with a north-easterly to north-westerly component. In the winter months the high pressure cells move northward, displacing the tropical easterlies northward resulting in disruptions to the westerly circulation. The disruptions result in a succession of cold fronts over the area in winter with pronounced variations in wind direction, wind speeds, temperature, humidity, and surface pressure.

Airflow ahead of a cold front passing over the area has a strong north-north-westerly to north-easterly component, with stable and generally cloud-free conditions. Once the front has passed, the airflow is reflected as having a dominant southerly component (Tyson and Preston-Whyte, 2000).

Easterly and westerly wave disturbances cause a southerly wind flow and tend to hinder the persistence of inversions by destroying them or increasing their altitude, thereby facilitating the dilution and dispersion of pollutants. Pre-frontal conditions tend to reduce the mixing depth. The potential for the accumulation of pollutants during pre-frontal conditions is therefore enhanced over the plateau (Tyson and Preston-Whyte, 2000).

3.2.3 Site-Specific Dispersion Potential

A period wind rose for the site is presented in Figure 8 below. Wind roses comprise of 16 spokes which represents the direction from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories.

Based on an evaluation of the meteorological data simulations run from a global NEMS weather model at ~30 km resolution from 1985 to current of the project area. The following deductions regarding the prevailing wind direction and wind frequency can be assessed. Looking at Figure 8 below, the predominant wind direction is predicted to occur mainly from the east-north-east to direction more than 1100 hours per year with wind speeds higher than 5 km/h. Secondary winds of more than 5 km/h can be expected from the east and the north west to west 839 and 1 987 hours per year respectively.

At the site, calm conditions with wind speeds of 12 km/h or less, are predicted 2-7 days per month throughout the year. 12-19 km/h winds are predicted 10-16 days per month through the year. Wind speeds of more than 19 km/h are predicted to occur 9-19 days per year on average.

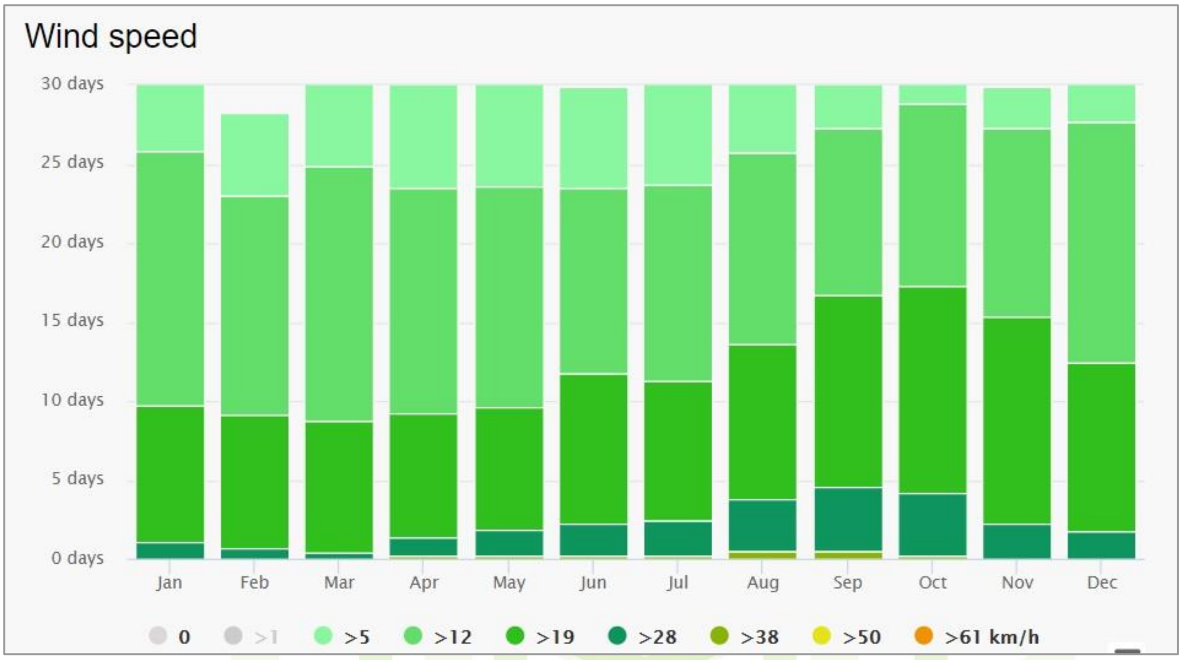


Figure 7: Wind Class Frequency Distribution per month.

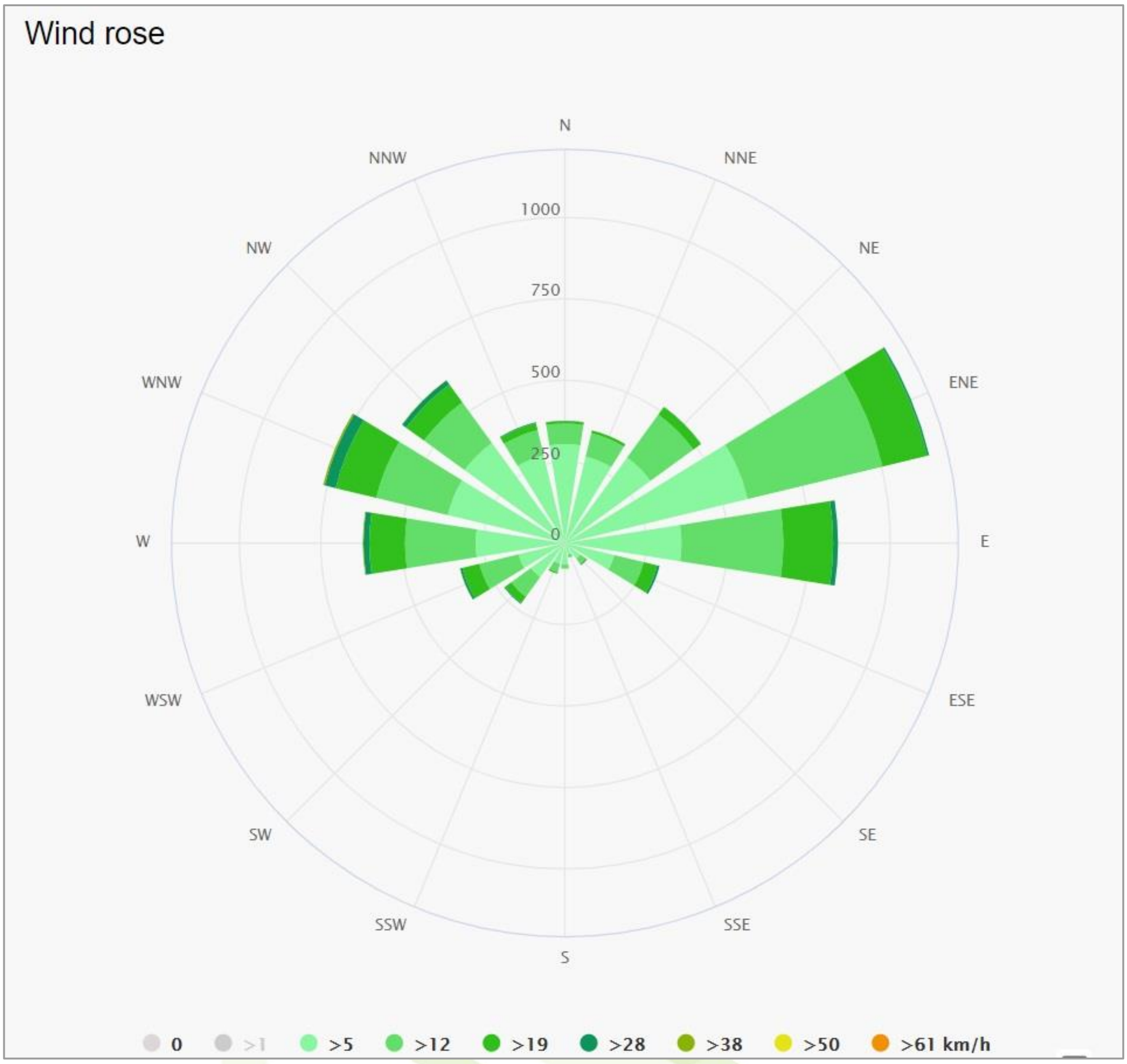


Figure 8: NEMS 30 km simulation model wind rose for the proposed Exxaro Dorstfontein Expansion project area for the period 1985 to current.

3.2.4 Atmospheric Stability

The tendency of the atmosphere to resist or enhance vertical motion and thus turbulence is termed atmospheric stability. Stability is related to both the change of temperature with height and wind speed. A neutral atmosphere neither enhances nor inhibits mechanical turbulence. An unstable atmosphere enhances turbulence, whereas a stable atmosphere inhibits mechanical turbulence. The turbulence of the atmosphere is the most important parameter affecting dilution of air pollution as the more unstable the atmosphere, the greater the dilution of air pollution.

Atmospheric stability is commonly categorised into six stability classes as per Table 7 below. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5 - 6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night-time a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Table 7: Atmospheric Stability Classes

A	Very unstable	calm wind, clear skies, hot daytime conditions
B	Moderately unstable	clear skies, daytime conditions
C	Unstable	moderate wind, slightly overcast daytime conditions
D	Neutral	high winds or cloudy days and nights
E	Stable	moderate wind, slightly overcast night-time conditions
F	Very stable	low winds, clear skies, cold night-time conditions

A neutral atmospheric potential neither enhances nor inhibits mechanical turbulences. Unstable atmospheric condition enhances turbulence, whereas stable conditions inhibit mechanical turbulence.

3.2.5 Temperature

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella and Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may dissolve in water to form acids. Temperature also provides an indication of the rate of development and dissipation of the mixing layer.

Based on an evaluation of the meteorological data simulations run from the global NEMS weather model at ~30 km resolution from 1985 to current of the project area. The following deductions can be made; In the summer months' maximum average daily temperatures are predicted to be 25°C to 26°C on average with a maximum of 32°C possible during hot days, dropping to a predicted 8°C to 13°C on average at night and 2°C minimum on cold nights. During winter months the average day time temperature are predicted in the 18°C to 21°C range while cold winter night time temperatures predicted to drop to -3°C.

Falling in a summer rainfall area, the location is predicted to receive the most precipitation in the summer months of October to March overall. November to January are predicted the highest rainfall months with between 85 mm to 107 mm predicted per month during these months. February, March and October is predicted to receive 54 mm to 76 mm precipitation. All other months are predicted to receive less than 26 mm precipitation on average during the month.

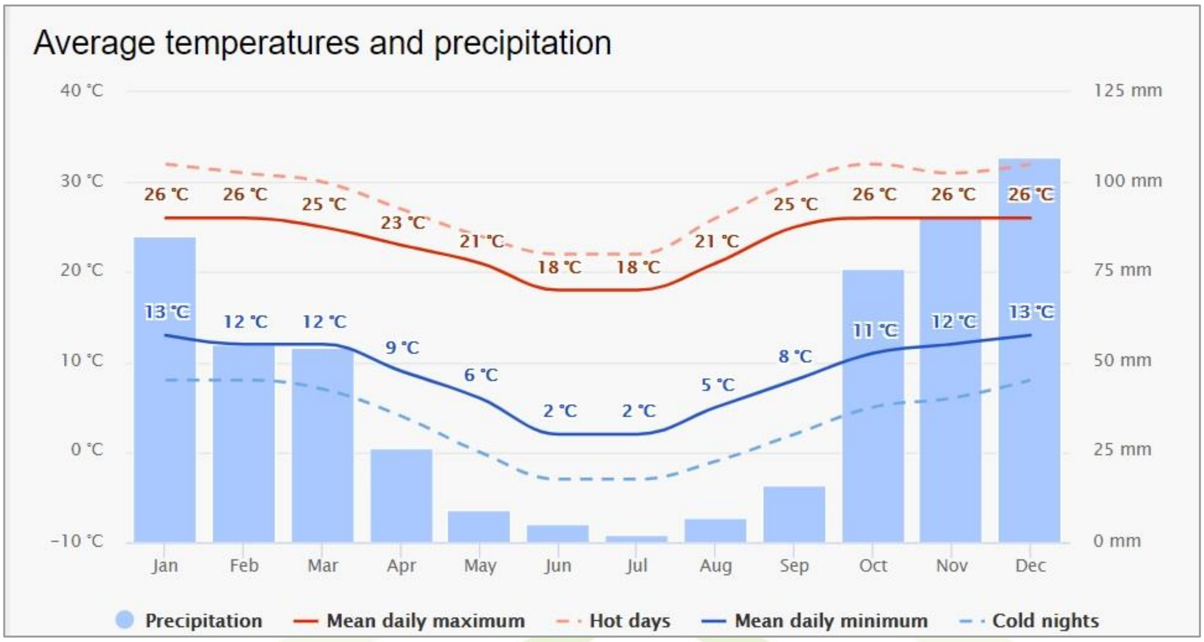


Figure 9: Temp and precipitation simulation results from the NEMS model for the proposed Exxaro Dorstfontein Expansion project area (1985 - current).

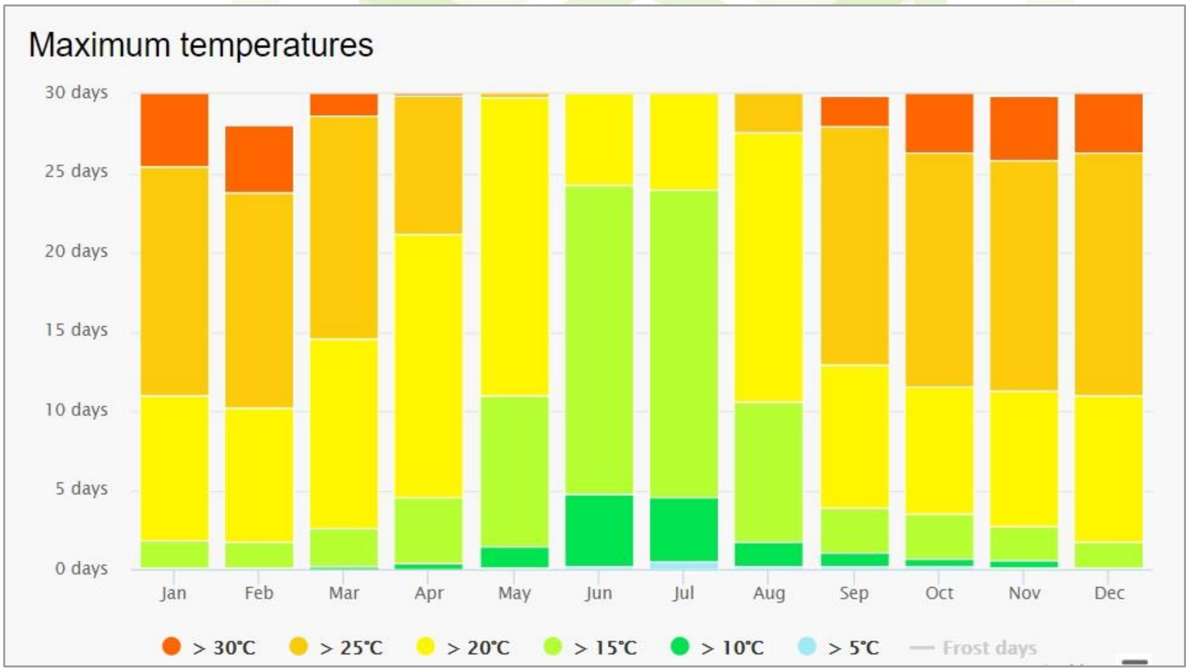


Figure 10: Maximum temperatures as simulated from the NEMS 30 km model for the proposed Exxaro Dorstfontein Expansion project area (1985 – current).

3.2.6 Precipitation

Precipitation cleanses the air by washing out particles suspended in the atmosphere (Kupchella & Hyland, 1993). It is calculated that precipitation accounts for about 80-90% of the mass of particles removed from the atmosphere (CEPA/FPAC Working Group, 1999). The total precipitation predicted at the Exxaro Dorstfontein Expansion project area is shown in Figure 11 below.

The highest precipitation days are predicted during the months of October to March. During these months' precipitation is predicted to only occur 13 to 23 days on average. The rest of the year precipitation is predicted to occur less than 6 days per month.

Figure 11: Day count of total daily precipitation per month for the proposed Exxaro Dorstfontein Expansion project area for the period 1985 – current.

3.2.7 Winds Speed, Temperature and Precipitation Validation

To validate the NEMS model simulation results, only weather stations with more than 10 years' consistent data are considered for validation. The validation is thus not necessarily the closest station with actual measured data but rather the closest reliable station. The measurements from the chosen station is then aggregated on a weekly or monthly data. Figure 12 below show the closest station to the proposed Exxaro Dorstfontein Expansion project area that fall within the validation criteria as stated above, in this case Ermelo, 69 km away and at a similar altitude. The recorded data show good correlation in respect to temperature and wind speed. No precipitation comparison were made.

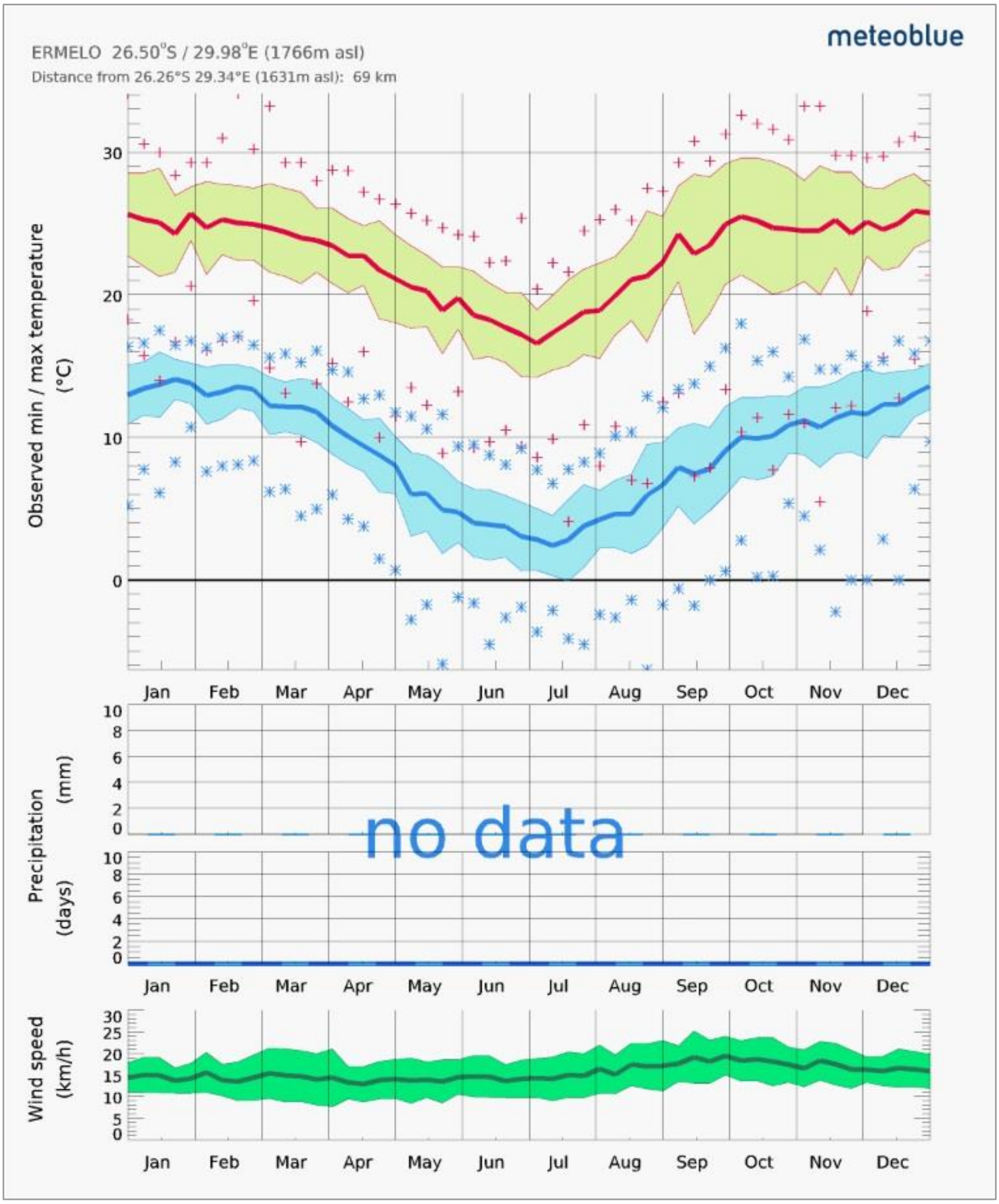


Figure 12: Measurement data for the closest measurement location with enough data to verify the NEMS model result.

3.3 Description Of The Activities To Be Undertaken

3.3.1 Description of Mining Method

Dorstfontein West mine is an underground mine with both 2 and 4-seam operated by Exxaro Coal Central (Pty) Ltd. Exxaro Dorstfontein West proposes to undertake the following activities:

- Pillar extraction mining which will be undertaken on the 4-seam for purposes of extending the operational life of the mine and creating an opportunity to derive value from re-sources that would have been sterilised;

- The extension of the discard dump which has become necessary due to the life of the current discard dump coming to the end in 2022. The discard dump extension will cater for both Slurry and discard coal and is expected to cater for the life of mine; and
- The construction of a conveyor belt from DCM West which will be linked to the conveyor systems at DCM East to ensure seamless coal is conveyed from DCM West to DCM East where the coal will be loaded into trains and thereafter transported to Richards Bay Terminal.

4. OVERVIEW

The National Environmental Management: Air Quality Act, Act No. 39 of 2004 is in the process of replacing, and has to a large extent already replaced, the Atmospheric Pollution Prevention Act (APPA), Act 45 of 1965. The Air Quality Act requires a shift from source-based air pollution control to a receiving environment, air quality management approach. Key features of the new approach to air quality governance include:

1. Decentralisation of air quality management responsibilities.
2. A requirement that all significant sources be identified, quantified and addressed.
3. Setting of ambient air quality targets as goals to achieve emission reductions.
4. Recognition of source-based, command-and-control measures (i.e. authorities set source requirements and emission limits requiring adherence by responsible parties), in addition to alternative measures, including market incentives and disincentives, voluntary programmes, and education and awareness.
5. Promotion of cost-optimised mitigation and management measures.
6. Required air quality management planning by authorities and emission reduction and management planning by sources.
7. Access to information and public consultation.
8. The new approach has significant implications for government, business and civil society.

This report and investigation aims to identify potential air quality impacts as a result of the proposed operations and therefore propose management and mitigation measures to mitigate the impact. This assessment forms part of the environmental impact assessment phase of this investigation and will focus on the impacts from the proposed mine in order to provide a better understanding of the magnitude of these impacts.

As a summary the following proposed activities related to air emissions will be established and executed and are associated with the Exxaro Dorstfontein Expansion project:

1. Site preparation;
2. Underground mining;
3. Wind-blown emissions from Discard dumps;
4. Materials handling;
5. Mine closure and rehabilitation.

4.1 Particulate Matter

Particulate matter (PM) is the collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. PM includes dust, smoke, pollen and soil particles (Kemp, 1998). PM has been linked to a range of serious respiratory and cardiovascular health problems. The key effects associated with exposure to ambient particulate matter include: premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis, decreased lung function, and an increased risk of myocardial infarction (USEPA, 1996).

PM can principally be characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions (USEPA, 1996):

1. PM10 (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are generally not deposited in the lung);
2. PM2.5, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less);
3. PM10-2.5, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and

4. Ultra-fine particles generally defined as those less than 0.1 microns.

Particles can be classified by their aerodynamic properties into coarse particles, PM10 (particulate matter with an aerodynamic diameter of less than 10 µm) and fine particles, PM2.5 (particulate matter with an aerodynamic diameter of less than 2.5 µm) (Harrison and van Grieken, 1998). The fine particles contain the secondarily formed aerosols such as sulphates and nitrates, combustion particles and re-condensed organic and metal vapours. The coarse particles contain earth crust materials and fugitive dust from roads and industries (Fenger, 2002).

Fine and coarse particles are distinct in terms of the emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters. Fine particles are directly emitted from combustion sources and are also formed secondarily from gaseous precursors such as sulphur dioxide, nitrogen oxides, or organic compounds. Fine particles are generally composed of sulphate, nitrate, chloride and ammonium compounds, organic and elemental carbon, and metals. Combustion of coal, oil, diesel, gasoline, and wood, as well as high temperature process sources such as smelters and steel mills, produce emissions that contribute to fine particle formation. Fine particles can remain in the atmosphere for days to weeks and travel through the atmosphere hundreds to thousands of kilometres, while coarsest particles typically deposit to the earth within minutes to hours and within tens of kilometres from the emission source.

Some scientists have postulated that ultra-fine particles, by virtue of their small size and large surface area to mass ratio may be especially toxic. There are studies that suggest these particles may leave the lung and travel through the blood to other organs, including the heart. Coarse particles are typically mechanically generated by crushing or grinding and are often dominated by resuspended dusts and crustal material from paved or unpaved roads or from construction, farming, and mining activities (USEPA, 1996).

In terms of health impacts, particulate air pollution effects are broad, but are predominately associated with effects of the respiratory and cardiovascular systems (WHO, 2005). Particle size is important for health because it controls where in the respiratory system a given particle deposits. Fine particles have been found to be more damaging to human health than coarse particles as larger particles are less respirable in that they do not penetrate deep into the lungs compared to smaller particles (Manahan, 1991). Larger particles are deposited into the extra thoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000).

A study by Pope and Burnett (2002) indicated that PM2.5 leads to high plaque deposits in arteries, causing vascular inflammation and atherosclerosis (Kaonga and Kgabi, 2009). No evidence of a threshold in the relationship between particulate concentrations and adverse human health effects has been determined (Burger and Scorgie, 2000a; Burger and Scorgie 2000b; WHO 2005).

4.1.1 Short-Term Exposure

Recent studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 µg/m³). Morbidity effects associated with short-term exposure to particulates include increases in lower respiratory symptoms, medication use and small reductions in lung function.

4.1.2 Long-Term Exposure

Long-term exposure to low concentrations (~10 µg/m³) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2000). Those most at risk include the elderly, individuals with pre-existing heart or lung disease, asthmatics and children; with an increased risk associated with an increase in exposure (WHO 2005).

4.1.3 Nuisance Dust

Nuisance dust may be defined as coarse fraction of airborne particulates. Nuisance dust is known to result in the soiling of materials and has the potential to reduce visibility. Nuisance dust has a long history of having little adverse effect on the lungs. Any reaction that may occur from nuisance dust is potentially reversible. However, excessive concentrations of nuisance dust in the workplace may reduce visibility, may cause unpleasant deposits in eyes, nasal passages and may cause injury to the skin or mucous membranes by the chemical or mechanical action. The light is scattered and visibility is diminished by the atmospheric particulate.

Various costs are associated with the loss of visibility, including: the need for artificial illumination and heating; delays, disruption and accidents involving traffic; vegetation growth reduction associated with reduced photosynthesis; and commercial losses associated with aesthetics. The soiling of building and materials due to dust frequently gives rise to damages and costs related to the increased need for washing, cleaning and repainting. Dustfall may also impact negatively on sensitive industries, e.g. bakeries or textile industries. Certain elements in dust may damage materials. For instance, it was found that sulphur and chlorine if present in dust may cause damage to copper (Maeda et al., 2001).

Nuisance dust can also cause serious aesthetic deterioration in the surrounding environment and communities. Fortunately, due to relatively large particulate matter sizes associated with the mining emissions and the relatively short release height of the pollutants, such negative impacts are usually confined in relatively small areas. Within these areas of impact, fugitive dust may result in damage to the vegetation and agriculture. The deposited particulate matter may block the plant leaf stomata hence inhibit gas exchange, or smother the plant leaf surfaces reducing photosynthesis levels. Besides the impacts on vegetation, health effects of particulates on mine personnel and public may also be significant.

Air pollution is a recognized health hazard for man and domestic animals (Newman et al., 1979). Air pollutants have had a worldwide effect on both wild birds and wild mammals, often causing decreases in local animal populations (Newman et al., 1979). The major effects of industrial air pollution on wildlife include direct mortality, debilitating industrial-related injury and disease, physiological stress, anaemia, and bioaccumulation. Some air pollutants have caused a change in the distribution of certain wildlife species.

4.2 The Importance of Managing Dust

Managing dust from mines is important as it can impact local and regional air quality, adversely affect local amenity and pose a risk to public health.

4.3 Protecting Local And Regional Air Quality

An important aspect of the protection of air quality from mining operations is to minimise dust generated from sources such as wind erosion, crushing & screening, vehicles using unsealed roads and blasting. Mines are required by the National Environmental Management Air Quality Act to meet certain criteria for ambient air quality. In order to meet these criteria, mines must manage the emissions of dust from their activities in a competent manner.

4.3.1 Community Health

Health impacts of mine dust vary depending on the nature of the particles, their origin and their size, which is measured as particulate matter (PM). Exposure to fine particles can have potential health impacts on the respiratory system. Infants and children, elderly people, people with existing respiratory conditions, heart disease or diabetes may be more susceptible to the health effects from fine and coarse particles. Mines must be operated with proper dust controls to ensure that people are not affected by the dust generated.

4.3.2 Community Amenity

If not properly managed, dust from mines can be a nuisance to local communities. Nuisance dust usually has a particle size larger than 10 microns (gravimetric dust fallout). High levels of nuisance dust may reduce visibility and amenity. The presence of nuisance dust can also cause a perceived increase in health risk. The impact of dust from mines on local amenity depends on the distance from the mine site and climatic conditions including wind speed and direction. Concerns about amenity from mine site dust often relate to the 'visibility' of dust plumes and dust sources. Visible dust is usually due to short-term episodes of high emissions, such as blasting. Other amenity impacts include dust depositing on fabrics (such as washing) or on house roofs, and dust transported from roofs to water tanks during rain.

5. RELEVANT LEGISLATION, GUIDELINES AND STANDARDS

5.1 National Environmental Management: Air Quality, 2004 (Act 39 Of 2004)

The National Environmental Management: Air Quality Act 39 of 2004 shifted the approach of air quality management from source-based control to receptor-based control. The Act made provision for National ambient air quality standards, however it is generally accepted that more stringent standards can be established at the Provincial and Local levels. Emissions are controlled through the listing of activities that are sources of emission and the issuing of emission licences for these listed activities. Atmospheric emission standards have been established for each of these activities and an atmospheric licence is now required to operate.

The issuing of emission licences for Listed Activities will be the responsibility of the Metropolitan and District Municipalities. Municipalities are required to 'designate an Air Quality Officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality'. The appointed Air Quality Officer will be responsible for the issuing of atmospheric emission licences or the Air Quality Officer could delegate the responsibility to the Director of Community Environmental Services.

According to the Act, the Department of Environmental Affairs) (DEA), the provincial environmental departments and local authorities (district and local municipalities) are separately and jointly responsible for the implementation and enforcement of various aspects of NEM: AQA. Each of these spheres of government is obliged to appoint an Air Quality Officer and to co-operate with each other and co-ordinate their activities through mechanisms provided for in the National Environment Management Act, 1998 (Act 107 of 1998) (NEMA).

The purpose of NEM: AQA is to set norms and standards that relate to:

- Institutional frameworks, roles and responsibilities;
- Air quality management planning;
- Air quality monitoring and information management;
- Air quality management measures; and
- General compliance and enforcement.

5.1.1 National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (Government Gazette No. 36794 - No. R 827)

Water and Environmental Affairs Minister Edna Molewa has published the National Dust Control Regulations on 1 November 2013, in terms of the National Environmental Management Air Quality Act, which prescribes general measures for the control of dust.

Table 8: Dust Fallout permitted rates

Restriction Areas	Dust Fall Rate (mg/m³/day - 30 day average)	Permitted Frequency of exceeding dust fall rate
Residential Areas	D < 600	2 within a year, not sequential months
Non-Residential Area	600 < D < 1200	2 within a year, not sequential months

According to regulations, any person conducting any activity in such a way that would give rise to dust in quantities and concentrations that exceeded the dustfall standard set out in the regulation was impelled to, upon receipt of a notice from an air quality officer, implement a dustfall monitoring programme.

The method to be used for measuring the dustfall rate and the guideline for locating sampling points would be the American Standards for Testing and Materials method, or an equivalent method approved by any internally recognised body.

The regulation further stated that an Air Quality Officer could require any person, through a written notice, to undertake a dustfall monitoring programme if the officer reasonably suspected that the person was contravening the regulations or that the activity being conducted required a fugitive dust emission management plan. A person required to implement the programme must then, within a specified period, submit a dustfall monitoring report to the air quality officer. A dustfall monitoring report must provide information on the location of sampling sites, classification of the area where samplers were located, as well as reference to the standard methods used for site selection, sampling and analysis.

The report would also be required to provide meteorological data for the sampling area, the dustfall monitoring results, including a comparison of current year and historical results for each site, as well as a tabular summary of compliance with the dustfall standard. Any person that had exceeded the dustfall standard must, within three months after submission of the dustfall monitoring report, develop and submit a dustfall management plan to the Air Quality Officer for approval. This management plan must identify all possible sources of dust within the affected site, detail the best practicable measures to be undertaken to mitigate dust emissions, identify the line management responsible for implementation and incorporate the dust fallout monitoring plan. Such a plan would need to be implemented within a month of the date of approval and an implementation progress report must be submitted to the Air Quality Officer at agreed time intervals.

5.1.2 Legislation for Local Government

The Local Government: Municipal Systems Act 32 of 2000, together with the Municipal Structures Act 117 of 1998, establishes local government as an autonomous sphere of government with specific powers and functions as defined by the Constitution. Section 155 of the Constitution provides for the establishment of Category A, B and C municipalities each having different levels of municipal executive and legislative authorities. According to Section 156(1) of the Constitution, a municipality has the executive authority in respect of, and has the right to, administer the local government matters (listed in Part B of Schedule 4 and Part B of Schedule 5) that deal with air pollution.

5.1.3 Ambient Air Quality Guidelines and Standards

Guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and well-being (WHO, 2000). Once the guidelines are adopted as standards, they become legally enforceable. The South African Bureau of Standards (SABS), in collaboration with DEA, established ambient air quality standards for gravimetric dust fallout and is listed in the Table 9 below.

5.2 South African National Standard – SANS 1929:2011

5.2.1 Ambient Air Quality – Limits for Common Pollutants

Table 9: Limits for PM10 in ug/m³

Average period	Concentration (µg/m³)	Frequency of exceedances
Target		
24 h	75	4
1 year	40	0

Table 10: Four-band scale evaluation criteria for dust deposition in mg/m²/day

Band Number	Band Description Label	Dust Fall Rate (mg/m²/day - 30 day average)	Comment
1	Residential	D < 600	Permissible for residential and light commercial.
2	Industrial	D < 1200	Permissible for heavy commercial and industrial.
3	Action	1200 < D < 2400	Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year.
4	Alert	D > 2400	Immediate action and remediation required following the first incidence of the dustfall rate being exceeded. Incident report to be submitted to the relevant authority.

Table 11: Target, action and alert thresholds for dust deposition in mg/m²/day

Level	Dust Fall Rate (mg/m²/day - 30 day average)	Average Period	Permitted frequency of exceeding dustfall rate
Target	300	Annual	
Action Residential	600	30 days	2 within any year, no 2 sequential months
Action Industrial	1 200	30 days	2 within any year, not sequential months
Alert Threshold	2 400	30 days	None. First incidence of dustfall rate being exceeded requires remediation and compulsory report to the relevant authorities.

6. BASELINE RESULTS

6.1 CURRENT DUST DEPOSITION MONITORING RESULTS

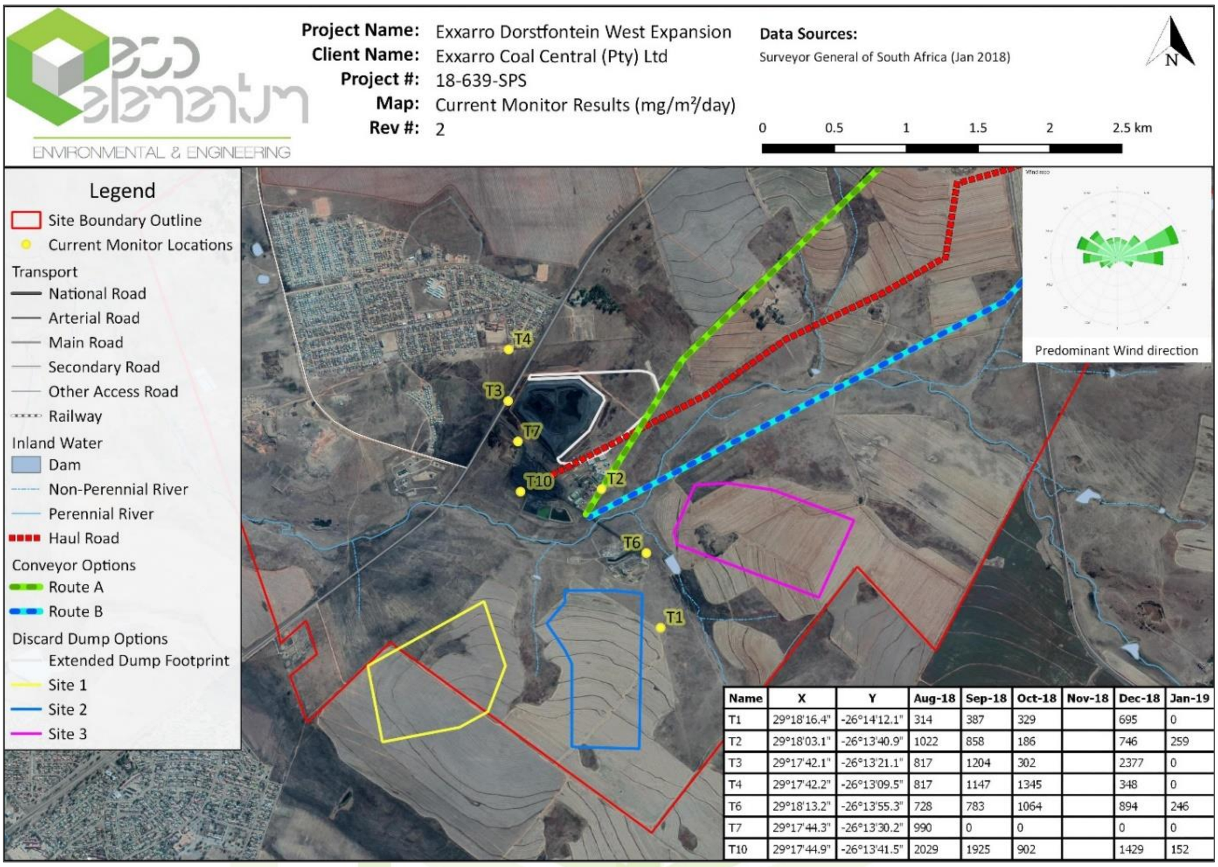


Figure 13: Current Monitor Locations and Results

Table 12: Current Dust Deposition Monitor Results at the Exxaro Dorstfontein Project in mg/m²/day

Name	X	Y	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19
T1	29°18'16.4"	-26°14'12.1"	314	387	329		695	
T2	29°18'03.1"	-26°13'40.9"	1022	858	186		746	259
T3	29°17'42.1"	-26°13'21.1"	817	**1204**	302		**2377**	
T4	29°17'42.2"	-26°13'09.5"	***817***	***1147***	**1345**		348	
T6	29°18'13.2"	-26°13'55.3"	728	783	1064		894	246
T7	29°17'44.3"	-26°13'30.2"	990					
T10	29°17'44.9"	-26°13'41.5"	**2029**	**1925**	902		**1429**	152

For the current operation there are exceedances at the monitor locations that fall outside of the allowable exceedances. Bucket T4 is situated in a residential area and exceeded the residential limit of 600 mg/m²/day for 3 consecutive months. Bucket T10 also exceeded the industrial limit for 2 consecutive months during the monitoring period. It should be noted that due to the nature of the sampling method, it may show exceedances due to other source contributions that are not part of the current operations. It is however highly recommended to further investigate the locations of the exceedances to determine the sources of the dust fallout.

7. METHODOLOGY

The AERMOD Gaussian plume model were selected to be used to model the predicted impacts of the proposed operations of the Exxaro Dorstfontein Expansion project.

7.1 Passive Sampling

At the time of this report, a passive sampling campaign do exist for the proposed Exxaro Dorstfontein Expansion project. See Section 6: BASELINE RESULTS for detailed results. It is recommended to expand the passive sampling campaign to include all wind directions and the outskirts of the town of Kriel. Below is the features of a passive sampling campaign:

At each gravimetric dust fallout gauge/receptor point there is a stand built according to specification containing the dust sample collection bucket. Samples are collected after a 1 month running period (+-30 day's exposure). After sample collection, the samples are taken to the relevant SANAS accredited laboratory as required. A visual site investigation is done where after correlations are drawn and findings identified and reported on.

Dust buckets of a standard size and shape are prepared and set up at locations related to the eight main compass points on the borders of the property so that dust can settle in them for periods of 30 +/-2 days. The dust buckets are then sealed and replaced with new empty ones and send away to the SANAS accredited laboratory for analysis. The masses of the water-soluble and –insoluble components of the material collected are then determined and results are reported as mg/m²/day. This methodology is described according to South African National Standards 1929:2004 and the American Society for Testing and Materials (ASTM) Designation: D 1739-98 (2010). The results for this method of testing are obtained by gravimetrical weighing. The apparatus required include open top buckets/containers not less than 150 mm in diameter with a height not less than twice its diameter. The buckets must be placed on a stand at a height of 2 +/- 0.2 m above the ground.

7.2 Active Sampling

For the Active Sampling the new DUSTTRAK II Dust Monitor can be used is a battery-operated, data-logging, light-scattering laser photometer that gives you real-time aerosol mass readings. This active sampling machine uses a sheath air system that isolates the aerosol in the optics chamber to keep the optics clean for improved reliability and low maintenance. Site layout for the sampling points has been carried out according to the eight main compass directions; the site layout and equipment placement is done in accordance with the ASTM standard, D 1739 – 2010, thereafter relevant sampling reference numbers were allocated to the receptors accordingly.

7.2.1 Features & Benefits

- New high concentration Model 8531 measures 0.5 to 400 mg/m³;
- Easy to program, easy to operate;
- Integrated pump allows use of size-selective aerosol inlet conditioners;
- New graphical user interface with large colour touch screen;
- Performs in-line gravimetric analysis for custom reference calibrations;
- Automatic zeroing (with optional zero module) minimizes the effect of zero drift;
- Displays real-time concentration (mg/m³) during sampling;
- Alarm set point from 0.002 to 100 mg/m³;
- Particle size range 0.1 to 10 µm;
- Display statistics: max, min. and average readings and elapsed time;
- Analog output allows remote access to real-time particle concentration data;
- Sheath air system keeps optics chamber clean for improve reliability and low maintenance; and
- Pre-program, analyse data, print graphs and create report with TRAKPRO™ Data Analysis Software.

7.2.2 Applications

- Ambient/work area monitoring;
- Industrial/occupational hygiene surveys;
- Indoor air quality investigations;
- Fugitive emissions monitoring;
- Site perimeter monitoring;
- Fence line monitoring;
- Dust control operations;
- Environmental research studies;
- Baseline trending and screening;
- Point source monitoring;
- Engineering studies;
- Engineering control evaluations;
- Corrective action validation;
- Remote and process monitoring;
- Emissions monitoring;
- Aerosol research studies; and
- Outdoor unattended environmental monitoring.

Figure 14: Dusttrak Particulate Sampler Image.

Table 13: Dust track Particle Sampler Specifications

Product Specification	Description
Sensor Type	90° light scattering
Particle Size Range	to 10 µm
Aerosol Concentration Range	8530 Desktop 0.001 to 150 mg/m3 8531 Desktop High Conc. 0.001 to 400 mg/m3 8532 Handheld 0.001 to 150 mg/m3
Resolution	±0.1% of reading or 0.001 mg/m3, whichever is greater
Zero Stability	±0.002 mg/m3 per 24 hours at 10 sec time constant
Flow Rate	3.0 L/min set at factory, 1.40 to 3.0 L/min, user adjustable
Flow Accuracy	±5% of factory set point, internal flow controlled
Temperature Coefficient	+0.001 mg/m3 per °C
Operational Temp	32 to 120°F (0 to 50°C)
Storage Temp	-4 to 140°F (-20 to 60°C)
Operational Humidity	0 to 95% RH, non-condensing
Time Constant	User adjustable, 1 to 60 seconds
Data Logging	5 MB of on-board memory (>60,000 data points) 45 days at 1 minute logging interval
Log Interval	User adjustable, 1 second to 1 hour
Physical Size (HWD)	Handheld 12.5 x 12.1 x 31.6 cm Desktop 13.5 x 21.6 x 22.4 cm
Weight	Handheld 2.9 lb (1.3 kg), 3.3 lb (1.5 kg) with battery Desktop 3.5 lb (1.6 kg), 4.5 lb (2.0 kg)–1 battery, 5.5 lb (2.5 kg)–2 batteries

7.3 Dispersion Model

Emission factors are quantified using the Australian National Pollutant Inventory (NPI) which is an improvement on the US Environmental Protection Agency (US.EPA) AP-42 document of Air Pollution Emission Factors for Australian conditions, for fugitive dust deriving from material handling, on-site roads, milling and crushing operations, drilling and blasting, and wind erosion from exposed surfaces. Various mitigation measures were incorporated into the project design as discussed in the emission factor section.

Dispersion models represents the most likely outcome of experimental results; it does not contain all the features of a real world system but contain the feature of interest for management of an issue. Gaussian plume models have an uncertainty range of between -50% to 200%.

There will always be some error in any geophysical model, the total uncertainty can be described as the sum of three components:

- Uncertainty due to errors in the model physics;
- Uncertainty due to data errors; and
- Uncertainty due to the atmospheric conditions.

7.3.1 Model Selection

Increasing reliance has been placed on estimates from models as the primary basis for environmental and health impact assessments. It is therefore important to carefully select a dispersion model for the purpose. Dispersion models compute ambient concentrations as a function of source configurations, and meteorological characteristics, providing a tool to calculate the spatial and temporal patterns in the ground level concentrations arising from the emissions of emissions sources.

Gaussian-plume models are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. The most widely used Gaussian plume model is the US.EPA AERMOD model.

The regulatory model of the US.EPA, AERMET/AERMOD dispersion model suite, was chosen for the study. AERMET uses both surface and upper air data. The model also has a terrain pre-processor (AERMAP) for including a large topography into the model. The AERMET/AERMOD suite was developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective was to include state-of the-art science in regulatory models.

1. AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources.
2. 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.
3. 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 which are used for the computation of air flow around hills.

A disadvantage of the model is the range of uncertainty of the model predictions could to be -50% to 200% and spatial varying wind fields, due to topography or other factors cannot be included. The accuracy of the model improves with fairly strong wind speeds and during neutral atmospheric conditions.

The stochastic uncertainty includes all errors or uncertainties in data such as source variability, observed concentrations, and meteorological data. Model evaluation studies suggest that the data input error term is often a major contributor to total uncertainty. Even in the best tracer studies, the source emissions are known only with an accuracy of ±5%, which translates directly into a minimum error of that magnitude in the model predictions. It is also well known that wind direction errors are the major cause of poor agreement, especially for relatively short-term predictions (minutes to hourly) and long downwind distances. All of the above factors contribute to the inaccuracies not associated with the mathematical models themselves.

Input data required for the AERMOD model include:

- Source emissions and type data;
- Meteorological data (pre-processed by the AERMET model);
- Terrain data; and
- The receptor grid.

7.3.2 Meteorological Data

AERMOD requires two specific input files generated by the AERMET pre-processor. AERMET is designed to be run as a three-stage processor and operates on three types of data (upper air data, on-site measurements, and the national meteorological database).

Use was made of the MM5 AERMET ready weather data as provided by Lakes Environmental for the period 1 January 2018 to 31 December 2018.

7.3.3 Source Data

AERMOD is able to model point, area, volume, pit and line sources. Wind erosion sources such as stockpiles, and unpaved roads modelled as area sources. Material transfer points and crushing and screening were modelled as volume sources. With the input sources using pit retention factors applied to the emission as described in the Australian NPI.

7.3.4 Sensitive Receptor Grid

The pollutant dispersion is setup for a modelled domain of 10 km (north-south) by 10 km (east-west) with the centre of the proposed project area in the centre of the modelling domain. The area was divided into a grid with a resolution 100 m (north-south) by 100 m (east-west). AERMOD simulates ground-level concentrations for the complete receptor grid. All sensitive receptors as indicated in Figure 5 were also included as sensitive receptors.

7.3.5 Modelling Runs

Modelling was undertaken for the operational phase scenarios. The conveyor is modelled as covered and the loading and offloading of the conveyor options are the same locations thus the air emissions is expected to be negligible from the conveyor itself. The maintenance road for the conveyor is expected to be used intermitted and thus expected to have a negligible impact on the air quality.

1. Un-mitigated - material being handled dry;
   a. Using the Haul Road
      i. Discard Dump Extension
      ii. Discard Dump Site 1
      iii. Discard Dump Site 2
      iv. Discard Dump Site 3
   b. Using the Conveyor
      i. Discard Dump Extension
      ii. Discard Dump Site 1
      iii. Discard Dump Site 2
      iv. Discard Dump Site 3
2. Mitigated – As Specified in Table 16.
   a. Using the Haul Road
      i. Discard Dump Extension
      ii. Discard Dump Site 1
      iii. Discard Dump Site 2
      iv. Discard Dump Site 3
   b. Using the Conveyor
      i. Discard Dump Extension
      ii. Discard Dump Site 1
      iii. Discard Dump Site 2
      iv. Discard Dump Site 3

The construction and decommissioning phases were qualitatively assessed.

7.3.6 Modelling Results

Dispersion modelling was undertaken to determine 2nd highest daily and annual average ground level concentrations (GLCs) for PM10 Total daily dust fallout rates were also simulated. These averaging periods are selected to draw comparisons between PM10 predicted concentrations/ deposition with relevant air quality guidelines and dust fallout limits, respectively.

Isopleths plots are also generated, for the preferred scenario, to visually display the interpolated values from the concentrations predicted by the model for each of the receptor grid points. Plots reflecting daily averaging periods contain only the 2nd highest predicted ground level concentrations for the daily concentration, over the entire period for which simulations were undertaken. It is therefore possible that even though a high hourly or daily average concentration is predicted at certain locations, this may only be true for one day during the modelling period.

8. BASELINE AIR QUALITY MEASUREMENT RESULTS

8.1 Discussion Of The Baseline Air Quality

8.1.1 Sensitive Receptors

Sensitive receptors identified in the immediate vicinity of the study area and proposed project area have been listed below:

- Farm steads; and
- Outskirts of the town of Kriel.

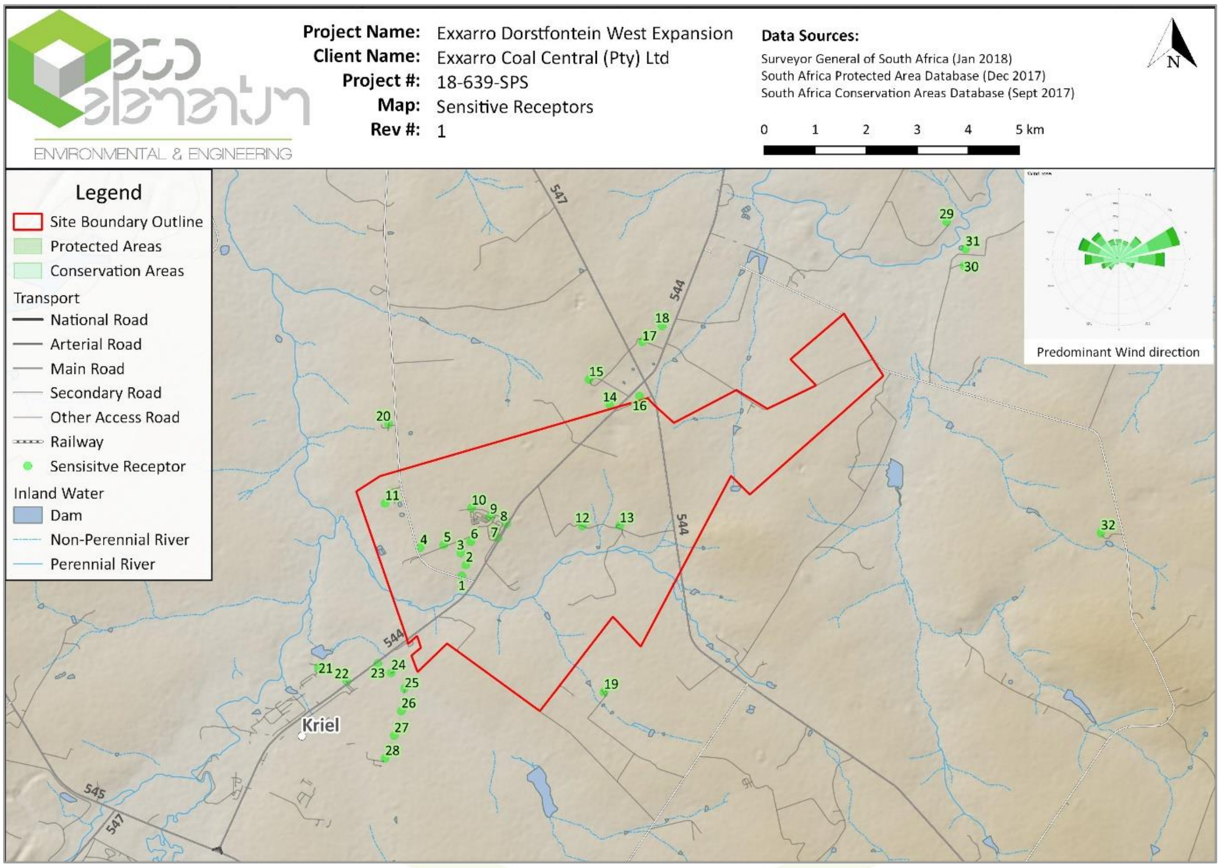


Figure 15: Sensitive receptors in the immediate area of the mining boundary.

8.1.1.1 Vehicle Exhaust Gases

Vehicle exhausts contain a number of pollutants including carbon dioxide (CO²), carbon monoxide (CO), hydrocarbons, oxides of nitrogen (NOx), sulphur and PM10. Tiny amounts of poisonous trace elements such as lead, cadmium and nickel are also present. The quantity of each pollutant emitted depends upon the type and quantity of fuel used, engine size, speed of the vehicle and abatement equipment fitted. Once emitted, the pollutants are diluted and dispersed in the ambient air. Pollutant concentrations in the air can be measured or modelled and then compared with ambient air quality criteria.

8.1.1.2 Veld Fires

Veld fires are widespread across the world, occurring in autumn, winter and early spring. In addition to controlled burning for fire-breaks and veld management, many fires are set deliberately for mischievous reasons. Some are accidental, notably those started by motorists throwing cigarettes out of car windows. Emissions from veld fires are similar to those generated by coal and wood combustion. Whilst veld fire smoke primarily impacts visibility and landscape aesthetic quality, it also contributes to the degradation of regional scale air quality. Dry combustible material is consumed first when a fire starts. Surrounding live, green material is dried by the large amount of heat that is released when there are veld fires, sometimes this material also burn. The major pollutants from veld burning are particulate matter, carbon monoxide, and volatile organics. Nitrogen oxides are emitted at rates from 1 to 4 g/kg burned, depending on combustion temperatures. Emissions of sulphur oxides are negligible (USEPA, 1996).

8.1.1.3 Trucks Passing On the Roads, Loading And Offloading Raw Materials

Dust emissions occur when soil is crushed by a vehicle, as a result of the soil moisture level being low. Vehicles used on the roads will generate PM-10 emissions throughout the area and they carry soils onto the paved roads which would increase entrainment PM-10 emissions. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic.

8.1.1.4 Wind Erosion As A Result Of ROM Material and Topsoil Stockpiles

The topsoil and waste rock stockpiles generated during the construction phase will be minimal and probably used for construction purposes on site (berm and foundations for buildings), reason being that this will be limited to the mining areas – since the project is mainly an opencast operation. At the ROM stockpile, there will be constant transfer of ore from the opencast to the stockpile and then to the crushing/screening.

8.1.1.5 Material Handling (Loading, Hauling and Tipping)

Material handling during loading, hauling and tipping as mining processes has been known to have influence on dust generation in terms of increasing the fugitive dust emissions being generated. With the different kind of materials – topsoil, soft, and hard, tipping will be negligible. The tipping is mostly associated with the ROM at the processing plant vicinity. During these activities factors such as the surrounding wind regime, the material tipping rate, and the moisture content of the material all have an influence on the dust generation at the tipping transfer points.

9. FINDINGS

9.1 Existing Baseline Air Quality

The findings in this report is based on typical values for generalized operations where no information was available.

9.2 Generalised Site Impacts

From current information it is assumed that the main impacting sources are dust generated from road transport to the discard dumps and wind-blown dust from exposed surfaces. A secondary source is the materials handling to load and offload the conveyor systems.

An operational water truck should be effective for the suppression of dust on unpaved access roads. Control techniques for fugitive dust sources generally involve watering, chemical stabilization and the reduction of surface wind speed though the use of windbreaks and source enclosures. Watering represents a commonly used, relatively inexpensive option, but provides only temporary dust control. Although the chemical treatment of exposed surfaces is more expensive, it provides for longer dust suppression. The use of chemicals may, however, have adverse effects on the receiving biophysical environment if not carefully selected. The construction of windbreaks and source enclosures are not always practical due to the size of many fugitive dust sources (Cowherd et al., 1988; EPA, 1996).

Preventative measures aimed at the reduction of the source extent, or process modifications and adjusted work practices, may reduce fugitive emissions. Measures aimed at reducing the extent of the source of fugitive dust include: the reduction in the mass of material being handled, the elimination of track-on on paved roads, and the paving of unpaved roads. (Track-on refers to the material carried onto the paved road by vehicles from the unpaved shoulders of paved roads and from adjoining unpaved roads.)

Mitigating measures entail the periodic removal of deposited material to reduce dust generation. Examples of mitigating control measures include the clean-up of spillage on paved roads (broom and vacuum sweeping) and at conveyor transfer points (Cowherd et al., 1988; EPA, 1996). Ideally a higher priority should be given to measures aimed at preventing the deposition of materials onto the surface, rather than cleaning up deposited material.

9.2.1 Exposed Surface Wind Erosion Dust Generating Capacity

Vegetal cover retards erosion by binding the residue with a root network, by sheltering the residue surface and by trapping material already eroded. Vegetation is considered the most effective control measure in terms of its ability to control water erosion. In investigating the feasibility of vegetation types the following properties are normally taken into account: indigenous plants; ability to establish and regenerate quickly; proven effective for reclamation elsewhere; tolerant to the climatic conditions of the area; high rate of root production; easily propagated by seed or cuttings; and nitrogen-fixing ability.

The long-term effectiveness of suitable vegetation selected for the site will be dependent on (a) the nature of the cover, and (b) the availability of aftercare. The Department of Minerals and Energy in Western Australia in its Guidelines on the Safe Design and Operating Standards for Tailings Storages (1996), for example, stipulates a covering of a minimum of 500 mm of suitable waste rock, followed by a layer of topsoil (or growth medium) and subsequent seeding. According to these guidelines all external surfaces should have a self-generating cover compatible with the surrounding environment.

9.2.2 Unpaved/Gravel Roads Dust Control

The access roads on-site were identified as the second most significant source of dust emissions. Three types of measures may be taken to reduce emissions from unpaved roads:

a. measures aimed at reducing the extent of unpaved roads, e.g. paving,

b. traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds, and

c. measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (EPA, 1987; Cowhert *et al.*, 1988; APCD, 1995).

Given the indication that unsurfaced roads would be watered, control efficiencies which may be achieved through wet suppression were investigated. In addition, the reduction in vehicle entrainment due to reduced vehicle kilometres travelled are also included.

Permanent improvements in travel surfaces, such as the paving of a road, results in continuous control efficiencies. The control efficiencies obtained by wet suppression and the use of chemical stabilizers are, however, cyclic rather than continuous by nature as indicated previously. The efficiency afforded by the application of water or chemicals decay over time, requiring periodic reapplication to maintain the desired average efficiency (Cowherd et al., 1988). The following empirical model for the estimation of the average control efficiency of watering, developed by the US-EPA (EPA, 1996), can be applied in the estimation of control efficiencies achievable by unpaved road watering programmes:

$$C = 100 - \left(\frac{0.8pdt}{i}\right)$$

Where,

c = average control efficiency (%)

d = average hourly daytime traffic rate (hr-1)

i = application intensity (litres per m2)

t = time between applications (hr)

p = potential average hourly daytime evaporation rate (mm/hr)

10. DISPERSION MODEL

10.1 Emissions Inventory

Table 14 below describes the through put rates on which the calculations were based. In the quantification of the emissions the emission factor equations published by the US.EPA as well as the NPI compiled by the Australian Government. Table 16 shows the summarised Emissions Inventory.

Table 14: Modelling Parameter Summary

Project Specific Information			
Type	**Spec**	**Quantity**	**Unit**
Material	ROM	118670	tpm
Material Bulk Density	ROM*	1.3	g/cm³
Operations	Hours (Pit)*	24	
	Days*	31	
Discard Dump	Height*	30	m
Haul Road	Width	8	m
	Length	7.6	km
Haul Trucks - ROM	Type	Bell B40D	
	Height	4.2	m
	Width	3.8	m
	Payload	37	t
	Trips	26.73	per h
	VKT	2013.13	per h
Note:	** Assumed*		

Table 15: NPI Emission Factors

NPI Emission Factors				
Operation	**TSP**	**PM_{10}**	**Units**	**Rating**
Misc Transfer Point (Including Conveyor)	0.00032	0.00015	kg/t	U
Loading to Trains	0.0004	0.00017	Kg/t	U
Wind Erosion	0.4	0.2	kg/ha/h	U
Haul Road	4.23	1.25	kg/VKT	B

10.1.1 Mitigation Measures

10.1.1.1 Material Handling

According to the Australian NPI, dust generation from material transfer points can be reduced by 50% where water sprays are applied. Adding wind break can reduce the dust emissions with 30%. Enclosing the operations, the emissions will become insignificant.

10.1.1.2 Conveyor Belt

The Australian NPI has 3 different mitigation levels for conveyor belts systems. 70% reduction of fugitive dust can be achieved by enclosing the conveyor belt. 90% reduction when Water Sprays with chemicals are used, and 99% reduction in fugitive emissions can be achieved when the conveyor system is enclosed and fabric filter system installed.

10.1.1.3 Stockpile

Wind erosion from stockpiles can be mitigated by 50% using water sprays according to the Australian NPI. Revegetation of stockpiles can bring 90% mitigation.

Total enclosure of the stockpiles can mitigate erosion by 99%. (Also from the Australian NPI.)

10.1.1.4 Haul Road

For haul roads the Australian NPI indicate that dust emissions can be mitigated by 50% for level 1 watering (2 litres/m²/h) or 75% for level 2 watering (>2 litres/m²/h).

Sealing the road or salt-encrusted roads can mitigate 100% according to the Australian NPI.

Table 16: Calculated Source Emission Rates Summary

Emissions Released								
Operation	**Unmitigated**			**Mitigated**				
	TSP	**PM10**	**Unit**	**TSP**	**PM10**	**Unit**	**Reduction**	**Method**
Load / Unload Conveyor	0.014	0.007	g/s	0.007	0.003	g/s	50%	Water Sprays
Load Trains	0.018	0.008	g/s	0.009	0.004	g/s	50%	Water Sprays
Wind Erosion	1.11E-05	5.56E-06	g/s/m²	5.56E-06	2.78E-06	g/s/m²	50%	Water Sprays
Haul Road	2.98E-02	1.41E-03	g/s/m²	7.46E-03	3.53E-04	g/s/m²	75%	Level 2 Watering (>2 liters/m²/h)

10.2 Modelling Results

Only the following scenario is plotted as this is considering the preferred scenario considering the result from the air quality model.

1. Mitigated – As Specified in Table 16.
    a. Using the Conveyor
        i. Discard Dump Extension.

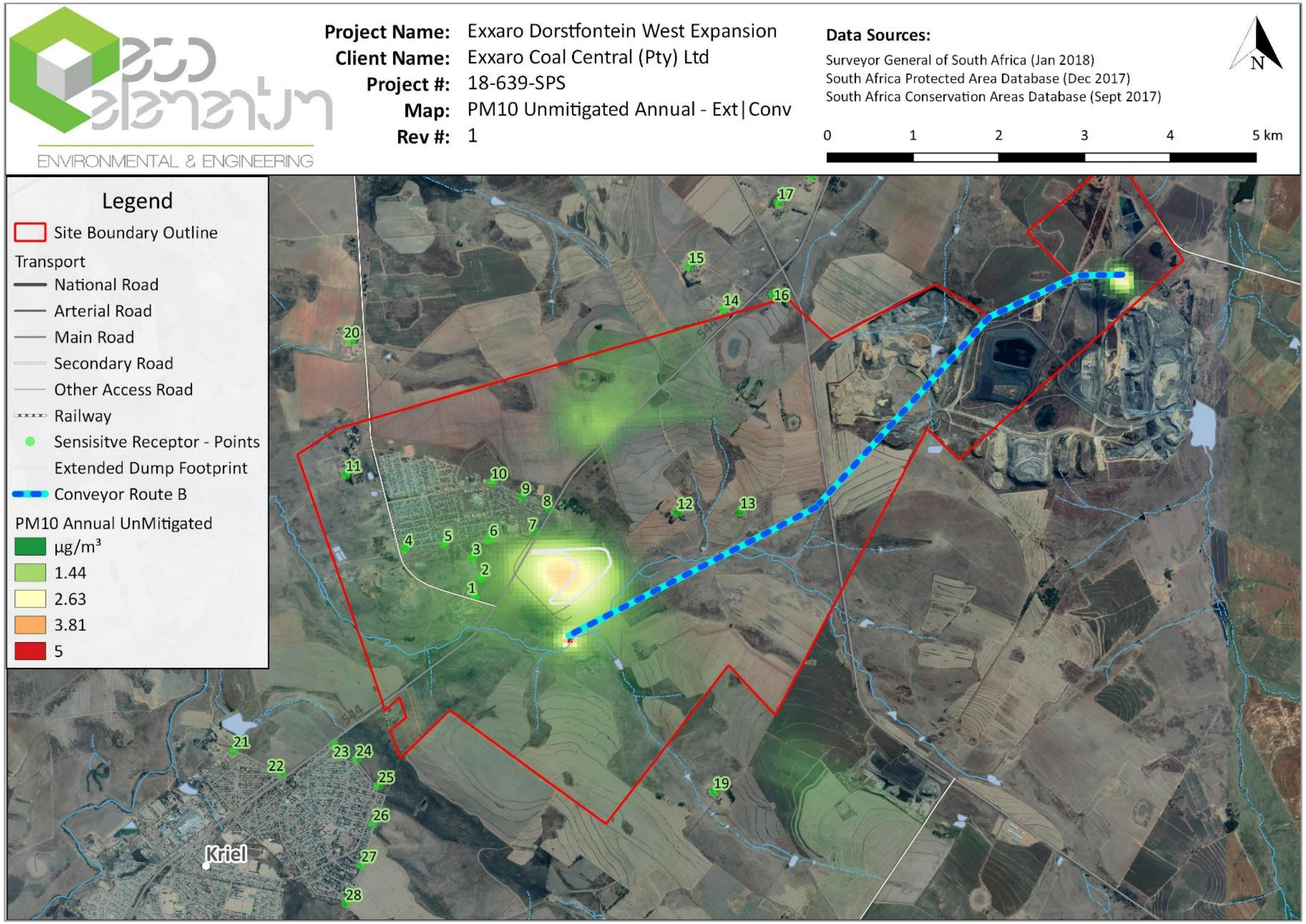


Figure 16: **Predicted average annual concentrations for PM10 for the proposed Conveyor and Discard Dump Extension when unmitigated.**

Figure 17: Predicted average annual concentrations for PM10 for the proposed Conveyor and Discard Dump Extension operations when mitigated.

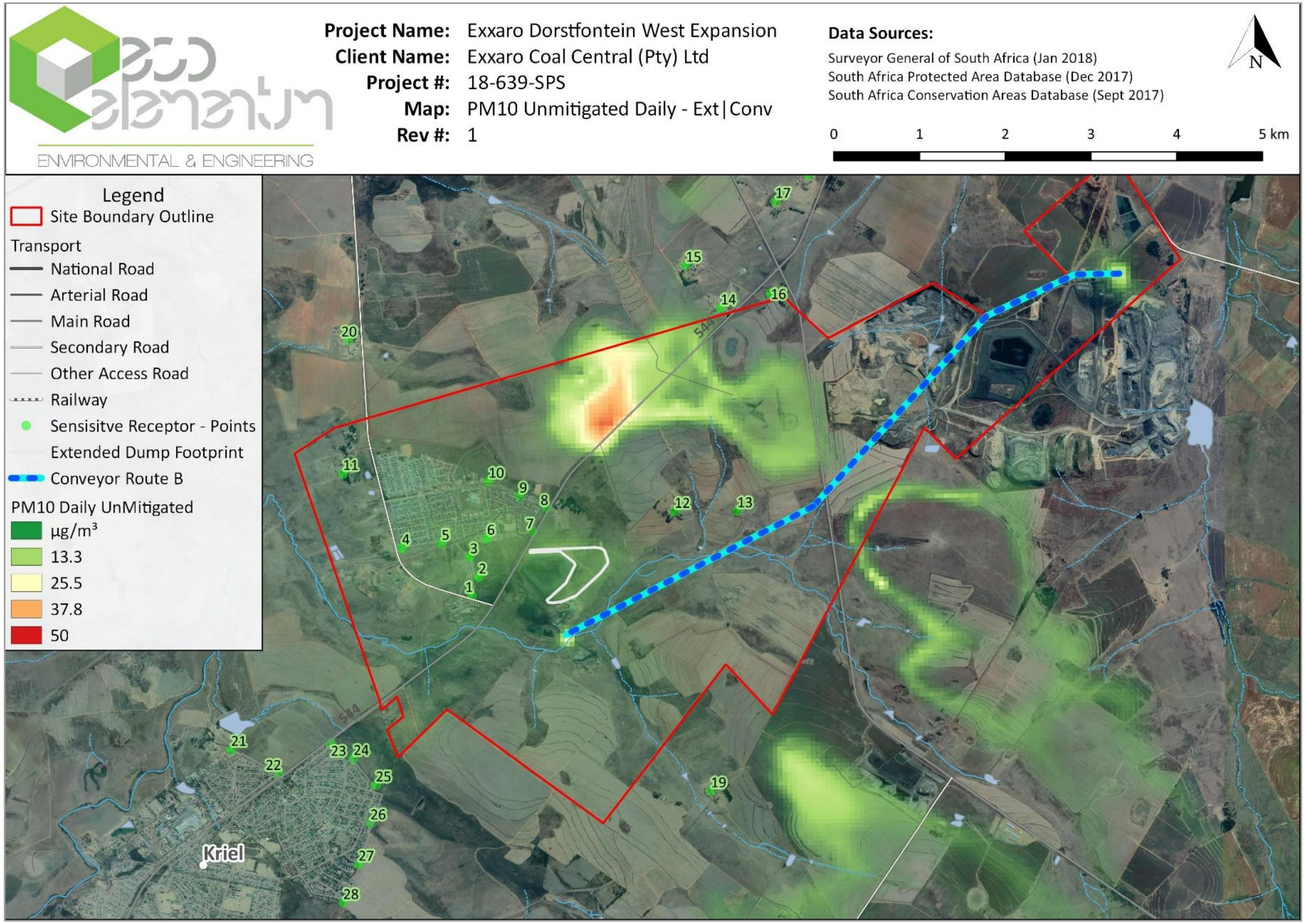


Figure 18: Predicted 2nd Highest daily concentrations for PM10 for the proposed Conveyor and Discard Dump Extension operations when unmitigated.

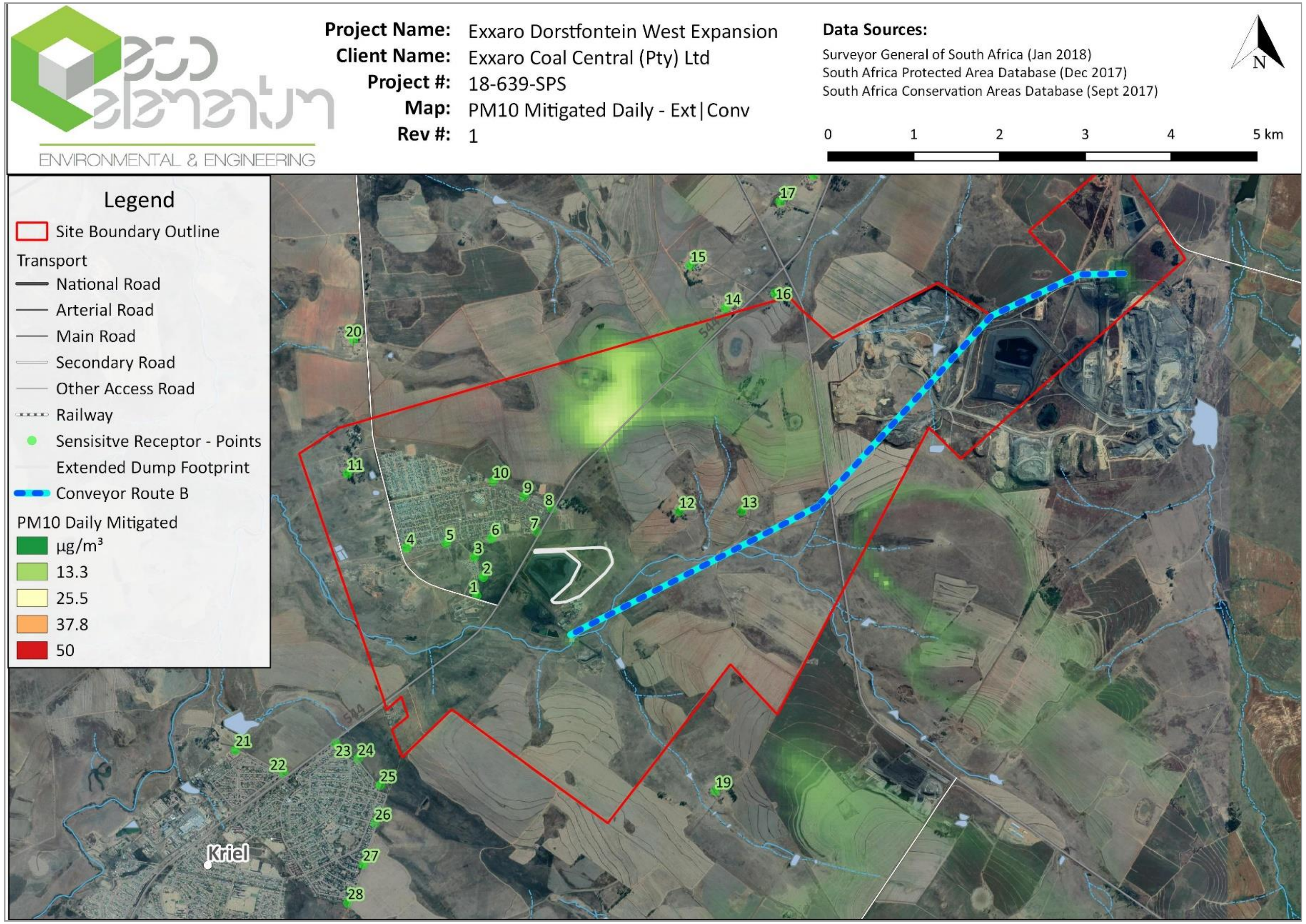


Figure 19: Predicted 2nd Highest daily concentrations for PM10 for the proposed Conveyor and Discard Dump Extension operations when mitigated.

11. IMPACT ASSESSMENT

11.1 Impact Assessment Methodology

The level of detail as depicted in the EIA regulations were fine-tuned by assigning specific values to each impact. In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes each aspect was assigned a value, ranging from one (1) to five (5), depending on its definition. This assessment is a relative evaluation within the context of all the activities and the other impacts within the framework of the project.

The impact assessment criteria used to determine the impact of the proposed development are as follows:

1. ***Nature*** of the impact;
2. The ***Source*** of the Impact;
3. ***Extent*** - The physical and spatial scale of the impact;
4. ***Duration*** - The lifetime of the impact, measured in relation to the lifetime of the proposed development;
5. ***Intensity*** - The intensity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functioning, or slightly alters the environment itself;
6. ***Probability*** - This describes the likelihood of the impacts actually occurring. The impact may occur for any length of time during the life cycle of the activity, and not at any given time;
7. ***Mitigation*****:** The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.
8. ***Determination of Significance – Without Mitigation****:* Significance is determined through a synthesis of impact characteristics as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact "without mitigation" is the prime determinant of the nature and degree of mitigation required.
9. ***Determination of Significance – With Mitigation***: Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the identified mitigation measures.

Previous experience has shown that it is often not feasible or practical to only identify and address possible impacts. The rating and ranking of impacts is often a controversial aspect because of the subjectivity involved in attaching values to impacts. Therefore, the assessment will concentrate on addressing key issues.

The methodology employed will involve a circular route, which will allow for the evaluation of the efficiency of the process itself. The project will be divided into three phases in order to assess impacts related to the Constructional, Operational and Decommissioning & Closure Phases. The assessment of actions in each phase will be conducted in the following order:

a. Identification of key issues;
b. Analysis of the activities relating to the proposed development;
c. Assessment of the potential impacts arising from the activities, without mitigation; and
d. Investigation of the relevant mitigation measures, as well as an assessment of their effectiveness in alleviating impacts.

Table 17: Assessment criteria

EXTENT: GEOGRAPHICAL	
Footprint	The impacted area extends only as far as the activity, such as a footprint occurring within the total site area.
Site	The impact could affect the whole, or significant portion of the site.
Regional	The impact could affect the whole area including neighbouring properties, the transport routes and the adjoining towns.
National	The impact could have an effect that expands throughout the country (South Africa).
International	Where the impact has international ramifications that extent beyond the boundaries of South Africa.
DURATION	
Short Term	The impact would either disappear with mitigation or will be mitigated through natural processes in a period shorter than that of the construction phase.
Short – Medium Term	The impact will be relevant throughout the construction phase.
Medium Term	The impact will last up to the end of the development phases, where after it will be entirely negated.
Long Term	The impact will continue or last for the entire operational lifetime of the development, but will be mitigated by direct human action or by natural processes thereafter.
Permanent	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.
INTENSITY	
Low	The impact alters the affected environment in such a way that the natural processes or functions are not affected.
Medium	The affected environment is altered, but functions and processes continue, albeit in a modified way.
High	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.
PROBABILITY	
Impossible	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0%).
Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined as 25%.
Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined as 50%.
Highly likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75%.
Definite	The impact will take place regardless of any provisional plans, and or mitigating actions or contingency plans to contain the effect. The chance of this impact occurring is defined as 100%.

The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.

11.1.1 Determination of Significance – Without Mitigation

Significance is determined through a synthesis of impacts as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact "without mitigation" is the prime determinant of the nature and degree of mitigation required. Where the impact is positive, significance is noted as "positive". Significance is rated on the following scale:

a. **No significance**: The impact is not substantial and does not require any mitigation action.

b. **Low:** The impact is of little importance, but may require limited mitigation.

c. **Medium:** The impact is of importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impacts to acceptable levels.

d. **High:** The impact is of major importance. Failure to mitigate, with the objective of reducing the impact to acceptable levels, could render the entire development option or entire project proposal unacceptable. Mitigation is therefore essential.

11.1.2 Determination of Significance – With Mitigation

Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. Significance with mitigation is rated on the following scale:

a. **No significance:** The impact will be mitigated to the point where it is regarded as insubstantial.

b. **Low:** The impact will be mitigated to the point where it is of limited importance.

c. **Low to Medium**: The impact is of importance however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels.

d. **Medium:** Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw.

e. **Medium to High:** The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels.

f. **High:** The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.

11.1.3 Assessment Weighting

Each aspect within the impact description was assigned a series of quantitative criteria. Such criteria are likely to differ during the different stages of the project's life cycle. In order to establish a defined base upon which it becomes feasible to make an informed decision, it is necessary to weigh and rank all criteria.

11.1.4 Ranking, Weighting and Scaling

For each impact under scrutiny, a scale weighting factor is attached to each respective impact (refer to Table 18 below). The purposes of assigning such weights serve to highlight those aspects considered most critical to the various stakeholders and ensure that each specialist's element of bias is taken into account.

The weighting factor also provides a means whereby the impact assessor can successfully deal with the complexities that exist between the different impacts and associated aspects criteria.

Simply, such a weighting factor is indicative of the importance of the impact in terms of the potential effect that it could have on the surrounding environment. Therefore, the aspects considered to have a relatively high value will score a relatively higher weighting than that which is of lower importance.

Table 18: Assessment parameters and associated weightings

Extent	Duration	Intensity	Probability	Weighting Factor (WF)	Significance Rating (SR)	Mitigation Efficiency (ME)	Significance Following Mitigation (SFM)
Footprint 1	Short term 1	Low 1	Probable 1	Low 1	Low 0-19	High 0,2	Low 0-19
Site 2	Short to medium 2		Possible 2	Low to medium 2	Low to medium 20-39	Medium to high 0,4	Low to medium 20-39
Regional 3	Medium term 3	Medium 3	Likely 3	Medium 3	Medium 40-59	Medium 0,6	Medium 40-59
National 4	Long term 4		Highly Likely 4	Medium to high 4	Medium to high 60-79	Low to medium 0,8	Medium to high 60-79
International 5	Permanent 5	High 5	Definite 5	High 5	High 80-100	Low 1,0	High 80-100

11.2 Predicted Impacts

11.2.1 Summarised Impacts According To Development Phases

Table 19: Impacts according to Development Phases

PHASE	ACTIVITIES
Construction Phase	**Activity 1** - Site clearing, removal of topsoil and vegetation.
	Activity 2 - Construction of surface infrastructure (e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting).
	Activity 3 - General transportation, hauling and vehicle movement on site.
Operational Phase	As per Modelling
Closure and Decommissioning	**Activity 4** - Demolition & Removal of all infrastructure (incl. transportation off site); and
	Activity 5- Rehabilitation (spreading of soil, revegetation & profiling/contouring).

11.2.2 Construction Phase

The following activities during the Construction Phase are identified as possible fugitive emission sources and may impact on the ambient air quality at the relevant environmental sensitive receivers:

- **Activity 1** - Site clearing, removal of topsoil and vegetation.
- **Activity 2** - Construction of surface infrastructure (e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling blasting etc.).
- **Activity 3** - General transportation, hauling and vehicle movement on site.

Table 20: Activity 1: Site Clearing, removal of topsoil and vegetation

<table>
<tr><th>Mining Phase</th><th colspan="3">Construction Phase</th></tr>
<tr><td>Impact description</td><td colspan="3">During this activity, a number of operations take place such as land clearing, topsoil removal, loading of material, hauling, grading, stockpiling, bulldozing and compaction. Initially, topsoil and subsoil will be removed with large scrapers. The topsoil will be stockpiled for rehabilitation in the infrastructure area. It is anticipated that each of the above mentioned operations will have its own duration and potential for dust generation. Fugitive dust (containing TSP (total suspended particulate, will give rise to nuisance impacts as fallout dust), as well as PM10 and PM2.5 (dust with a size less than 10 microns, and dust with a size less than 2.5 microns giving rise to health impacts)) It is anticipated that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. This activity will be short-term and localised, seizing after construction activities. Material will be removed by using a bulldozer and then storing this material separately for use during rehabilitation at end of life of mine when the operation cease. These construction sites are ideal for dust suppression measures as land disturbance from clearing and excavation generates a large amount of soil disturbance and open space for wind to pick up dust particles and deposit it elsewhere (wind erosion). Issues with dust can also arise during the transportation of the extracted material, usually by truck and shovel methods, to the stock piles. The dust can further be created by the entrainment from the vehicle itself or due to dust blown from the back of the bin of the trucks during transportation of material to and from stockpiles.</td></tr>
<tr><td rowspan="4">Magnitude</td><td colspan="2">Extent [footprint(1); site(2); regional(3); national(4); international(5)]</td><td>FOOTPRINT</td></tr>
<tr><td colspan="2">Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]</td><td>SHORT</td></tr>
<tr><td colspan="2">Intensity [low(1); medium(3); high(5)]</td><td>LOW</td></tr>
<tr><td colspan="2">Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]</td><td>HIGHLY LIKELY</td></tr>
<tr><td>Weighting factor (WF)</td><td colspan="2">WF [low(1); low-medium(2); medium(3); medium-high(4); high(5)]</td><td>LOW-MEDIUM</td></tr>
<tr><td>Mitigation Efficiency (ME)</td><td colspan="2">ME [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]</td><td>MEDIUM-HIGH</td></tr>
<tr><td rowspan="2">Significance</td><td>Without mitigation (WOM)</td><td colspan="2">(Extent + Duration + Intensity + Probability) x WF = WOM
(1 + 1+ 1 + 4) x 2 = 14
LOW</td></tr>
<tr><td>With mitigation (WM)</td><td colspan="2">WOM x ME = WM
14 x 0.4 =5.6
LOW</td></tr>
<tr><td>Significance With Mitigation (WM)</td><td colspan="3">LOW</td></tr>
<tr><td>Mitigation Measures</td><td colspan="3">Various measures can be implemented to mitigate the impacts of construction activities on atmospheric environment.
- Topsoil should not be removed during windy months (August to January) due to associated wind erosion heightening dust levels in the atmosphere.
- Area of disturbance to be kept to a minimum and no unnecessary clearing of vegetation to occur.
- Topsoil should be re-vegetated to reduce exposure areas.
- During the loading of topsoil onto trucks or stockpiles, the dropping heights should be minimised.
- Water or binding agents such as (petroleum emulsions, polymers and adhesives) can be used for dust suppression on earth roads.</td></tr>
</table>

	- When using bulldozers and graders, minimise travel speed and distance and volume of traffic on the roads. - Stockpiles should not be left for prolonged periods as wind energy generates erosion and causes more dust to form. - Emissions generated by wind are dependent on the frequency of disturbance of erodible surfaces and by covering the stockpiles with vegetation would reduce the negative erosion effect. - Any crusting of the surface binds the erodible material. - All stockpiles to be damped down, especially during dry weather or re-vegetated (hydro seeding is a good option for slope revegetation). - Successful trialling of broad acre temporary rehabilitation of unshaped overburden emplacement areas by aerial sowing of a cover crop, providing an established vegetative stabilisation to minimise the potential for windblown dust generation. - Constricting the areas and time of exposure of pre-strip clearing in advance of mining development.

Table 21: Activity 2: Construction of surface infrastructure (e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, drilling blasting and development of box cut for mining, etc.)

Mining Phase	Construction Phase	
Impact description	During this phase, it is anticipated there will be construction of infrastructure. This will include, access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting and development of box cut for mining, etc. Activities of vehicles on access roads, levelling and compacting of surfaces, as well localised drilling and blasting will have implications on ambient air quality. The above mentioned activities will result in fugitive dust emissions containing TSP (total suspended particulate, giving rise to nuisance impacts as fallout dust). Underground mining will commence with the development of the decline shaft and stripping of the vegetation for the initial boxcut. Topsoil and overburden need to be removed and stockpiled separately by means of truck and shovel methods (front end loaders, excavators and haul trucks). Once the rock has been reached will blasting be required to further remove material to the point where the mineral can be extracted. Bulldozing, excavation, drilling and blasting operations will result in the emission of dust to atmosphere. The construction of roads take place through removing the topsoil and then grading the exposed surface in order to achieve a smooth finish for vehicles to move on. Temporary stockpiles will be created close to the edge of the road in order to be backfilled easily once the road has expired or need to be rehabilitated.	
Magnitude	Extent [footprint(1); site(2); regional(3); national(4); international(5)]	**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**SHORT-MED**
	Intensity [low(1); medium(3); high(5)]	**MEDIUM**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**HIGHLY LIKELY**
Weighting factor (WF)	WF [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**MEDIUM**
Mitigation Efficiency (ME)	ME [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]	**HIGH**
Significance	Without mitigation (WOM)	(Extent + Duration + Intensity + Probability) x WF = WOM (2 + 2+ 3 + 4) x 3 = 33 LOW-MEDIUM
	With mitigation (WM)	WOM x ME = WM 33 x 0.2 = 6.6 LOW

Significance With Mitigation (WM)	LOW
Mitigation Measures	- Dust emitted during bulldozing activity can be reduced by increasing soil dampness by watering the material being removed thus increasing the moisture content. - Another option would be to time the blasting with wind to ensure the dust will not be blown to the sensitive receptors or especially the community. - Blasting should also not take place when poor atmospheric dispersion is expected i.e. early morning and late evening. - Material need to be removed to dedicated stockpiles to be used during rehabilitation. - This hauling of materials should take place on roads which is being watered and/or sprayed with dust suppressant. - To reduce the amount of dust being blown from the load bin in the haul roads, the material being transported can be watered or the back of the vehicles can be covered with plastic tarpaulin covers. - Constricting the areas and time of exposure of pre-strip clearing in advance of construction to limit exposed soil surfaces.

Table 22: Activity 3: General transportation, hauling and vehicle movement on site.

Mining Phase	Construction Phase	
Impact description	Transportation of the workers and materials in and out of mine site will be a constant feature during the construction phase. This will however result in the production of fugitive dust (containing TSP, as well as PM10 and PM2.5) due to suspension of friable materials from earth roads. It is anticipated this activity will be short-term and localised and will seize once the construction activities are finalised. Haul trucks generate the majority of dust emissions from surface operations. Observations of dust emissions from haul trucks show that if the dust emissions are uncontrolled, they can be a safety hazard by impairing the operator's visibility. Substantial secondary emissions may be emitted from material moved out from the site during grading and deposited adjacent to roads. Passing traffic can thus loosen and re-suspend the deposited material again into the air. In order to minimize these impacts the stockpiles should be vegetated for the duration that it is exposed.	
Magnitude	Extent [footprint(1); site(2); regional(3); national(4); international(5)]	**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**SHORT-MED**
	Intensity [low(1); medium(3); high(5)]	**MEDIUM**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**DEFINITIVE**
Weighting factor (WF)	WF [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**MEDIUM**
Mitigation Efficiency (ME)	ME [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]	**MEDIUM-HIGH**
Significance	Without mitigation (WOM)	(Extent + Duration + Intensity + Probability) x WF = WOM (2 + 2 + 3 + 5) x 3 = 36 LOW - MEDIUM
	With mitigation (WM)	WOM x ME = WM 36 x 0.4 = 14.1 LOW
Significance With Mitigation (WM)	LOW	

Mitigation Measures	- Hauling of materials and transportation of people should take place on roads which is being watered and/or sprayed with dust suppressant. - To reduce the amount of dust being blown from the load bin in the haul roads, the material being transported can be watered or the back of the vehicles can be covered with plastic tarpaulin covers. - In order to mitigate the impacts of the activity, the speed limit should be kept to the low as more dust will be generated at higher wind speeds. - Speed limits need to be observed and adhered to. - Management should fit roads with speed humps to ensure adherence. - Application of wetting agents or application of dust suppressant to bind soil surfaces to avoid soil erosion. - The drop heights should be minimised when depositing materials to the ground. - Encourage car-pool and bulk delivery of materials in order to reduce the number of trips generated daily.

11.2.3 Operational Phases

1. Un-mitigated - material being handled dry;
   a. Using the Haul Road
      i. Discard Dump Extension
      ii. Discard Dump Site 1
      iii. Discard Dump Site 2
      iv. Discard Dump Site 3
   b. Using the Conveyor
      i. Discard Dump Extension
      ii. Discard Dump Site 1
      iii. Discard Dump Site 2
      iv. Discard Dump Site 3
2. Mitigated – As Specified in Table 16.
   a. Using the Haul Road
      i. Discard Dump Extension
      ii. Discard Dump Site 1
      iii. Discard Dump Site 2
      iv. Discard Dump Site 3
   b. Using the Conveyor
      i. Discard Dump Extension
      ii. Discard Dump Site 1
      iii. Discard Dump Site 2
      iv. Discard Dump Site 3

11.2.3.1 PM10

Table 23 below show the predicted 2nd highest daily concentrations at the relevant sensitive receptors for all the modelled scenarios together with the average for all the receptors and a count of the minimum values. Looking at the PM10 2nd highest daily values, the preferred scenario is the mitigated Extension of the current discard dump with the lowest predicted average concentration at all the sensitive receptors and also the most sensitive receptors being predicted to have the lowest concentration compared to all the other scenarios.

Table 23: PM10 2nd Highest Daily Concentrations at the Sensitive Receptors.

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3
	µg/m³															
1	2324.6	2323.9	2323.9	2323.9	582.2	581.8	581.8	581.8	6.0	3.6	6.4	6.4	3.0	**1.8**	3.2	3.2
2	1303.7	1304.2	1306.3	1303.7	326.4	326.7	327.7	326.4	7.4	3.7	4.8	6.3	3.7	**1.8**	2.4	3.1
3	862.1	861.0	861.1	861.5	216.1	215.6	215.6	215.8	7.0	3.1	3.7	5.5	3.5	**1.5**	1.8	2.8
4	842.8	842.8	842.9	843.9	211.0	211.0	211.1	211.6	5.1	3.1	3.9	4.4	2.6	**1.5**	1.9	2.2
5	925.8	925.8	925.8	925.9	231.8	231.8	231.8	231.8	6.3	3.1	4.1	6.4	3.2	**1.5**	2.0	3.2
6	782.3	782.3	782.3	782.4	195.9	195.9	195.9	195.9	8.1	2.8	18.9	41.8	4.1	**1.4**	9.5	20.9
7	816.1	816.1	816.1	818.1	204.4	204.3	204.3	205.3	6.7	3.6	29.4	24.1	3.3	**1.8**	14.7	12.1
8	672.5	674.7	673.4	671.6	169.0	170.1	169.4	168.5	4.7	12.4	20.4	9.5	**2.3**	6.2	10.2	4.8
9	596.2	596.2	596.2	596.2	149.3	149.3	149.3	149.3	4.8	21.2	9.6	4.3	2.4	10.6	4.8	**2.2**
10	555.7	555.7	555.7	555.7	139.1	139.1	139.1	139.1	5.6	19.1	7.7	3.2	2.8	9.6	3.9	**1.6**
11	746.9	748.2	747.2	746.9	187.0	187.7	187.1	187.0	3.4	2.5	2.8	3.0	1.7	**1.2**	1.4	1.5
12	2268.9	2268.8	2272.4	2275.1	568.1	568.0	569.8	571.2	1.9	1.6	6.7	22.0	0.9	**0.8**	3.3	11.0

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3
13	4382.5	4382.5	4382.4	4382.4	1097.2	1097.2	1097.2	1097.2	1.8	1.3	2.4	8.9	0.9	**0.6**	1.2	4.4
14	1038.8	1040.4	1038.8	1037.4	260.5	261.3	260.5	259.8	2.3	9.7	3.0	1.6	1.1	4.9	1.5	**0.8**
15	807.0	808.0	810.5	806.5	202.2	202.7	204.0	202.0	1.5	8.9	4.4	1.5	**0.7**	4.5	2.2	0.8
16	1460.1	1460.1	1460.8	1463.7	365.6	365.6	365.9	367.4	1.6	2.1	8.8	16.9	**0.8**	1.0	4.4	8.5
17	1002.0	1003.1	1012.0	1014.1	250.9	251.4	255.9	256.9	1.6	2.1	5.7	12.2	**0.8**	1.0	2.9	6.1
18	1329.1	1329.1	1329.4	1330.9	332.8	332.8	332.9	333.7	1.4	2.1	2.6	5.5	**0.7**	1.0	1.3	2.8
19	501.1	501.1	501.1	501.1	125.5	125.5	125.5	125.5	2.5	1.9	11.1	16.8	1.2	**0.9**	5.5	8.4
20	544.7	544.8	545.8	563.0	136.4	136.4	136.9	145.5	2.9	2.5	4.5	18.3	1.5	**1.3**	2.2	9.2
21	792.3	792.3	792.3	792.3	198.4	198.4	198.4	198.4	2.7	4.3	2.7	2.9	**1.4**	2.1	**1.4**	1.5
22	568.6	568.6	568.6	568.6	142.4	142.4	142.4	142.4	2.7	4.9	3.4	4.1	**1.3**	2.4	1.7	2.1
23	634.4	634.4	634.4	634.4	158.8	158.8	158.8	158.8	3.2	6.8	3.8	4.1	**1.6**	3.4	1.9	2.0
24	1206.6	1206.8	1206.7	1206.6	302.1	302.2	302.1	302.1	3.9	6.6	3.8	3.9	**1.9**	3.3	1.9	2.0
25	1013.5	1013.9	1013.6	1013.9	253.8	254.0	253.8	254.0	3.3	7.6	4.3	4.8	**1.7**	3.8	2.2	2.4
26	701.5	701.5	701.5	701.5	175.6	175.6	175.6	175.6	2.4	7.1	5.6	4.6	**1.2**	3.5	2.8	2.3
27	433.6	433.6	433.6	433.6	108.6	108.6	108.6	108.6	1.7	8.0	4.7	3.9	**0.9**	4.0	2.4	2.0
28	368.1	372.7	370.3	369.7	92.5	94.8	93.6	93.3	1.6	5.5	4.6	4.0	**0.8**	2.8	2.3	2.0
29	648.5	648.5	648.4	648.4	162.4	162.4	162.4	162.4	0.6	0.7	0.6	0.7	**0.3**	0.4	0.3	0.4

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**
30	673.0	673.0	673.0	673.0	168.5	168.5	168.5	168.5	0.5	0.9	0.8	0.8	**0.2**	0.4	0.4	0.4
31	563.2	563.2	563.2	563.2	141.0	141.0	141.0	141.0	0.5	0.9	0.7	0.8	**0.2**	0.5	0.3	0.4
32	98.5	98.5	98.5	98.5	24.7	24.7	24.7	24.7	1.8	0.4	0.2	0.4	0.9	0.2	**0.1**	0.2
Average	*983.3*	*983.6*	*984.0*	*984.6*	*246.2*	*246.4*	*246.6*	*246.9*	*3.4*	*5.1*	*6.1*	*7.9*	*1.7*	*2.6*	*3.1*	*4.0*
											Minimum Count		**16**	**12**	**2**	**3**

Table 24 below show the predicted annual average concentrations at the relevant sensitive receptors for all the modelled scenarios together with the average for all the receptors and a count of the minimum values. Looking at the PM10 annual average values, the preferred scenario is the mitigated Extension of the current discard dump with a combined lowest predicted average concentration at all the sensitive receptors and also the most sensitive receptors being predicted to have the lowest concentration compared to all the other scenarios.

Table 24: PM10 Annual Average Concentrations at the Sensitive Receptors.

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**
	µg/m³															
1	126.4	125.6	125.7	126.0	31.9	31.5	31.6	31.7	1.0	0.2	0.4	0.6	0.5	**0.1**	0.2	0.3
2	127.3	126.5	126.5	126.8	32.1	31.7	31.7	31.9	1.0	0.2	0.3	0.5	0.5	**0.1**	0.1	0.3
3	92.7	92.0	92.1	92.4	23.4	23.1	23.1	23.3	0.9	0.2	0.2	0.6	0.4	**0.1**	0.1	0.3
4	68.2	67.9	68.0	68.1	17.2	17.0	17.1	17.2	0.5	0.2	0.3	0.4	0.3	**0.1**	0.1	0.2
5	72.0	71.6	71.7	72.0	18.2	18.0	18.0	18.2	0.7	0.2	0.3	0.7	0.3	**0.1**	0.1	0.3

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3
6	74.7	74.0	74.6	75.5	18.9	18.6	18.9	19.3	0.9	0.2	0.8	1.7	0.4	**0.1**	0.4	0.9
7	83.5	82.8	83.7	83.9	21.1	20.8	21.2	21.3	0.9	0.2	1.1	1.3	0.5	**0.1**	0.6	0.6
8	75.5	75.5	75.8	75.6	19.0	19.0	19.1	19.1	0.5	0.5	0.7	0.5	0.2	**0.2**	0.4	0.3
9	60.1	60.5	60.1	60.0	15.1	15.3	15.2	15.1	0.4	0.8	0.4	0.3	0.2	0.4	**0.2**	0.2
10	50.7	51.1	50.6	50.6	12.8	13.0	12.7	12.7	0.4	0.8	0.3	0.3	0.2	0.4	0.2	**0.1**
11	54.3	54.1	54.2	54.2	13.7	13.6	13.6	13.6	0.3	**0.1**	0.2	0.3	**0.1**	**0.1**	**0.1**	**0.1**
12	305.8	305.8	306.0	307.0	76.6	76.6	76.7	77.2	0.1	0.1	0.3	1.3	0.1	**0.0**	0.1	0.7
13	822.7	822.7	822.8	823.2	206.0	206.0	206.0	206.2	0.1	0.1	0.2	0.6	**0.0**	**0.0**	0.1	0.3
14	72.9	73.1	72.9	72.8	18.3	18.4	18.3	18.3	0.1	0.3	0.1	0.1	0.1	0.2	0.1	**0.0**
15	53.5	53.7	53.6	53.5	13.4	13.5	13.5	13.4	0.1	0.3	0.2	0.1	**0.1**	**0.1**	**0.1**	**0.1**
16	109.3	109.3	109.5	109.7	27.4	27.4	27.5	27.6	0.1	0.1	0.3	0.5	**0.0**	0.1	0.1	0.3
17	69.6	69.6	69.7	70.0	17.4	17.5	17.5	17.6	0.1	0.1	0.2	0.4	**0.0**	0.1	0.1	0.2
18	76.4	76.4	76.4	76.5	19.1	19.1	19.2	19.2	0.1	0.1	0.1	0.2	**0.0**	**0.0**	**0.0**	0.1
19	37.3	37.3	37.6	37.7	9.4	9.4	9.5	9.6	0.2	0.1	0.4	0.5	**0.1**	**0.1**	0.2	0.3
20	46.2	46.1	46.6	47.4	11.6	11.6	11.8	12.2	0.3	0.2	0.6	1.4	**0.1**	**0.1**	0.3	0.7
21	29.7	29.9	29.7	29.7	7.5	7.6	7.5	7.5	0.3	0.5	0.3	0.3	**0.1**	0.2	0.2	0.2
22	28.4	28.8	28.6	28.5	7.2	7.4	7.3	7.3	0.3	0.7	0.5	0.4	**0.1**	0.4	0.2	0.2

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3
23	34.3	34.8	34.4	34.4	8.7	8.9	8.8	8.7	0.3	0.9	0.5	0.5	**0.2**	0.4	0.3	**0.2**
24	40.0	40.8	40.3	40.2	10.1	10.5	10.2	10.2	0.3	1.1	0.6	0.5	**0.2**	0.5	0.3	0.3
25	42.8	43.7	43.3	43.1	10.8	11.2	11.0	10.9	0.3	1.2	0.7	0.6	**0.1**	0.6	0.4	0.3
26	34.9	35.6	35.5	35.2	8.8	9.1	9.1	8.9	0.2	0.9	0.8	0.5	**0.1**	0.4	0.4	0.3
27	28.0	28.5	28.4	28.2	7.1	7.3	7.3	7.2	0.2	0.7	0.6	0.4	**0.1**	0.4	0.3	0.2
28	23.9	24.3	24.3	24.1	6.0	6.2	6.2	6.1	0.2	0.5	0.5	0.4	**0.1**	0.3	0.3	0.2
29	15.1	15.1	15.1	15.1	3.8	3.8	3.8	3.8	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0**
30	11.2	11.2	11.2	11.2	2.8	2.8	2.8	2.8	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0**
31	12.6	12.6	12.6	12.6	3.2	3.2	3.2	3.2	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0**
32	4.7	4.7	4.7	4.7	1.2	1.2	1.2	1.2	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0**
Average	*87.0*	*87.0*	*87.1*	*87.2*	*21.9*	*21.9*	*21.9*	*22.0*	*0.3*	*0.4*	*0.4*	*0.5*	***0.2***	***0.2***	***0.2***	*0.3*
											Minimum Count		**20**	**19**	**8**	**9**

11.2.3.2 Total Dust Fallout

Table 25 below show the predicted highest monthly concentrations at the relevant sensitive receptors for all the modelled scenarios together with the average for all the receptors and a count of the minimum values. Looking at the TSP highest monthly values, the preferred scenario is the mitigated Discard Dump Site 1 with the also the most sensitive receptors being predicted to have the highest count of lowest deposition level at a sensitive receptor compared to all the other scenarios.

Table 25: TSP Highest Monthly Concentrations at the Sensitive Receptors.

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3
	mg/m²/day															
1	1132	1098	1096	1103	293	276	275	278	39	11	12	18	20	**5**	6	9
2	1092	1055	1054	1059	284	265	265	267	59	8	8	16	30	**4**	**4**	8
3	1001	929	930	938	269	233	233	237	73	5	5	10	36	**2**	3	5
4	621	596	597	602	162	150	150	153	26	3	6	7	13	**2**	3	4
5	804	755	755	762	214	189	189	193	50	3	5	7	25	**2**	**2**	4
6	1104	1021	1021	1028	297	256	256	259	84	4	3	10	42	**2**	**2**	5
7	1524	1439	1440	1447	403	360	361	364	85	4	4	12	42	**2**	**2**	6
8	1363	1334	1335	1339	348	334	334	336	41	3	2	9	20	**1**	**1**	4
9	1056	1037	1037	1039	269	260	260	261	25	2	2	8	13	**1**	**1**	4
10	843	832	832	834	214	208	208	209	17	2	2	6	9	**1**	**1**	3
11	477	471	471	472	121	118	118	119	6	1	1	1	3	**0**	1	1
12	6524	6522	6521	6523	1634	1633	1632	1633	11	1	3	11	6	**1**	**1**	5
13	16709	16708	16708	16711	4183	4183	4183	4184	6	1	2	10	3	**1**	**1**	5
14	1018	1018	1018	1018	255	255	255	255	1	0	1	1	1	**0**	**0**	**0**
15	802	802	802	802	201	201	201	201	1	0	0	1	**0**	**0**	**0**	**0**
16	1113	1113	1113	1113	279	279	279	279	1	0	0	1	**0**	**0**	**0**	**0**

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3
17	652	652	652	652	163	163	163	163	0	0	0	1	0	0	0	0
18	544	544	544	544	136	136	136	136	0	0	0	0	0	0	0	0
19	460	459	459	459	115	115	115	115	1	0	0	1	1	0	0	0
20	495	496	510	515	126	126	134	136	9	9	27	28	5	4	13	14
21	208	218	211	209	52	57	54	53	1	11	3	2	1	6	2	1
22	207	218	209	208	52	58	53	53	1	15	4	2	0	8	2	1
23	273	293	279	276	69	79	71	70	1	24	10	3	1	12	5	2
24	238	263	245	241	60	72	63	61	1	31	14	3	1	16	7	2
25	210	240	218	212	53	68	57	54	1	36	12	3	0	18	6	1
26	146	159	151	148	37	43	39	37	1	13	7	2	0	7	4	1
27	109	114	112	110	27	30	29	28	1	6	3	1	0	3	2	0
28	85	88	87	86	21	23	22	22	0	3	2	0	0	1	1	0
29	102	102	102	102	26	26	26	26	0	0	0	0	0	0	0	0
30	124	124	124	124	31	31	31	31	0	0	0	0	0	0	0	0
31	104	104	104	104	26	26	26	26	0	0	0	0	0	0	0	0
32	153	153	153	153	38	38	38	38	0	0	0	0	0	0	0	0
Average	*1290.4*	*1280.0*	*1277.9*	*1279.1*	*326.8*	*321.6*	*320.5*	*321.1*	*17.0*	*6.2*	*4.3*	*5.5*	*8.5*	*3.1*	*2.2*	*2.7*
											Minimum Count		**15**	**24**	**19**	**10**

Table 26 below show the predicted annual average deposition levels at the relevant sensitive receptors for all the modelled scenarios together with the average for all the receptors and a count of the minimum values. Looking at the TSP annual average values, the preferred scenario is the mitigated Discard Dump Site 2 with a combined lowest predicted average deposition level at all the sensitive receptors and also the most sensitive receptors being predicted to have the lowest deposition levels compared to all the other scenarios.

Table 26: TSP Annual Average Concentrations at the Sensitive Receptors.

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3
	mg/m²/day															
1	526	512	512	512	136	130	129	130	19	5	5	5	10	3	**2**	3
2	577	555	555	557	151	140	140	141	25	4	3	5	13	2	**2**	2
3	519	500	500	501	135	126	126	126	21	3	2	4	11	**1**	**1**	2
4	300	294	294	294	77	74	74	74	7	1	2	2	4	**1**	**1**	1
5	397	387	387	388	103	97	97	98	12	2	1	2	6	**1**	**1**	1
6	574	552	551	553	150	139	138	139	24	2	1	4	12	**1**	**1**	2
7	797	765	765	769	208	192	192	194	34	2	1	5	17	**1**	**1**	3
8	724	707	707	709	186	177	177	178	19	2	1	3	9	**1**	**1**	2
9	551	540	539	541	141	135	135	136	12	1	1	2	6	1	**0**	1
10	421	415	414	416	107	104	104	104	7	1	1	2	4	**0**	**0**	1
11	200	198	198	199	51	50	50	50	2	0	0	1	1	**0**	**0**	0
12	3244	3238	3239	3243	814	811	811	813	6	1	1	5	3	**0**	1	3
13	10331	10328	10329	10332	2587	2586	2586	2588	3	0	1	5	2	**0**	**0**	2

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3	Extension	Site 1	Site 2	Site 3
14	476	476	476	476	119	119	119	119	0	0	0	0	**0**	**0**	**0**	**0**
15	332	331	331	332	83	83	83	83	0	0	0	0	**0**	**0**	**0**	**0**
16	515	515	515	515	129	129	129	129	0	0	0	0	**0**	**0**	**0**	**0**
17	291	291	291	291	73	73	73	73	0	0	0	0	**0**	**0**	**0**	**0**
18	264	264	264	264	66	66	66	66	0	0	0	0	**0**	**0**	**0**	**0**
19	159	158	158	159	40	40	40	40	0	0	0	0	**0**	**0**	**0**	**0**
20	265	265	277	272	68	68	74	71	5	5	17	11	**2**	**2**	8	6
21	83	86	84	83	21	22	21	21	0	3	1	0	**0**	1	1	**0**
22	86	91	87	86	22	24	22	22	0	5	1	1	**0**	3	1	**0**
23	115	126	118	116	29	35	30	29	0	12	3	1	**0**	6	1	**0**
24	105	119	108	105	26	33	28	27	0	14	4	1	**0**	7	2	**0**
25	94	109	97	94	24	31	25	24	0	15	4	1	**0**	8	2	**0**
26	71	78	73	72	18	21	19	18	0	7	2	0	**0**	3	1	**0**
27	53	56	54	53	13	15	14	13	0	3	1	0	**0**	1	1	**0**
28	41	42	41	41	10	11	11	10	0	1	1	0	**0**	1	**0**	**0**
29	52	52	52	52	13	13	13	13	0	0	0	0	**0**	**0**	**0**	**0**
30	53	53	53	53	13	13	13	13	0	0	0	0	**0**	**0**	**0**	**0**

	Haul Road								Conveyor							
	Unmitigated				Mitigated				Unmitigated				Mitigated			
	Extension	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**	**Extension**	**Site 1**	**Site 2**	**Site 3**
31	49	49	49	49	12	12	12	12	0	0	0	0	**0**	**0**	**0**	**0**
32	92	92	92	92	23	23	23	23	0	0	0	0	**0**	**0**	**0**	**0**
Average	*698.6*	*695.2*	*694.1*	*694.3*	*176.5*	*174.7*	*174.2*	*174.3*	*6.3*	*2.8*	*1.7*	*2.0*	*3.1*	*1.4*	*0.9*	*1.0*
											Minimum Count		**19**	**21**	**23**	**18**

11.2.4 Decommissioning and Closure Phase

It is assumed that the decommissioning activities will only take place during daylight hours. The following activities during the Decommissioning and Closure phase are identified as possible air impacting sources and may impact on the ambient air quality at the relevant sensitive receivers:

1. **Activity 4 -** Demolition & Removal of all infrastructure (incl. transportation off site).
2. **Activity 5 -** Rehabilitation (spreading of soil, revegetation & profiling/contouring).

The decommissioning phase is associated with activities related to the demolition of infrastructure and the rehabilitation of disturbed areas. The following activities are associated with the decommissioning phase (US-EPA, 1996):

- Existing buildings and structures demolished, rubble removed and the area levelled;
- Remaining exposed excavated areas filled and levelled using overburden recovered from stockpiles;
- Stockpiles to be smoothed and contoured;
- Topsoil replaced using topsoil recovered from stockpiles; and
- Disturbed land prepared for revegetation.

Possible sources of fugitive dust emission during the closure and post-closure phase include:

- Smoothing of stockpiles by bulldozer;
- Grading of sites;
- Transport and dumping of overburden for filling;
- Infrastructure demolition;
- Infrastructure rubble piles;
- Transport and dumping of building rubble;
- Transport and dumping of topsoil; and
- Preparation of soil for revegetation – ploughing and addition of fertiliser, compost etc.

Exposed soil is often prone to erosion by water. The erodibility of soil depends on the amount of rainfall and its intensity, soil type and structure, slope of the terrain and the amount of vegetation cover (Brady, 1974). Revegetation of exposed areas for long-term dust and water erosion control is commonly used and is the most cost-effective option. Plant roots bind the soil, and vegetation cover breaks the impact of falling raindrops, thus preventing wind and water erosion. Plants used for revegetation should be indigenous to the area, hardy, fast-growing, nitrogen-fixing, provide high plant cover, be adapted to growing on exposed and disturbed soil (pioneer plants) and should easily be propagated by seed or cuttings.

Table 27: Activity 4: Demolition & Removal of all infrastructure (incl. transportation off site)

Mining Phase	Closure and Decommissioning Phase	
Impact description	During this activity, there is demolition of buildings and foundation and subsequent removal of rubbles generated. There is cleaning-up of workshops, fuels and reagents, removal of power and water supply, removal of haul and access roads. Potential for impacts during this phase will depend on the extent of demolition and rehabilitation efforts during closure as well as features which will remain. The impacts on the atmospheric environment during the decommissioning phase will be similar to the impacts during the construction phase. The process includes dismantling and demolition of existing infrastructure, transporting and handling of topsoil on unpaved roads in order to bring the site to its initial/rehabilitated state. Demolition and removal of all infrastructures will cause fugitive dust emissions. The impacts will be short-term and localised. Any implication or implications this phase will have on ambient air quality will seize once the activities are finalised.	
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]	**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**SHORT-MEDIUM**
	Intensity [low(1); medium(3); high(5)]	**HIGH**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**HIGHLY LIKELY**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**MEDIUM**
Mitigation Efficiency (ME)	**ME** [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]	**MEDIUM**
Significance	**Without mitigation (WOM)**	**(Extent + Duration + Intensity + Probability) x WF = WOM** **(2 + 2 + 5 + 4) x 3 = 39** **LOW-MEDIUM**
	With mitigation (WM)	**WOM x ME = WM** **39 x 0.6 = 23.4** **LOW-MEDIUM**
Significance With Mitigation (WM)	**LOW-MEDIUM**	
Mitigation Measures	- Demolition should not be performed during windy periods (August, September and October), as dust levels and the area affected by dust fallout will increase. - The area of disturbance must be kept to a minimum, as demolition should be done judiciously avoid the exposure of larger areas to wind erosion. - Speed restrictions should be imposed and enforced. - Cabs of machines should be swept or vacuumed regularly to remove accumulated dust. - Exhaust pipes of vehicles should be directed so that they do not raise dust. - Engine cooling fans of vehicles should be shrouded so that they do not raise dust. - Hard surfaced haul roads or standing areas should be washed down and swept to remove accumulated dust. - Dust suppression of roads being used during rehabilitation should be enforced.	

Table 28: Activity 5: Rehabilitation (spreading of soil, revegetation & profiling/contouring)

Mining Phase	Closure and Decommissioning Phase		
Impact description	During this activity, there is the reshaping and restructuring of the landscape. Since this is an opencast operation mainly, the area to be reconstructed will be limited to the opencast areas. Topsoil can be imported to reconstruct the soil structure. There is less transfer of soil from one area to other therefore negligible chances of dust through wind erosion. Profiling of dumps and waste rock dump to enhance vegetation cover and reduce wind erosion from such surfaces post mining.		
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]		**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]		**SHORT-MEDIUM**
	Intensity [low(1); medium(3); high(5)]		**LOW**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]		**HIGHLY LIKELY**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]		**LOW-MEDIUM**
Mitigation Efficiency (ME)	**ME** [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]		**MEDIUM-HIGH**
Significance	**Without mitigation (WOM)**	**(Extent + Duration + Intensity + Probability) x WF = WOM** (2 + 2 + 1 + 4) x 2 = 18 **LOW**	
	With mitigation (WM)	**WOM x ME = WM** 18 x 0.4 = 7.2 **LOW**	
Significance With Mitigation (WM)	**LOW**		
Mitigation Measures	- Revegetation of exposed areas for long-term dust and water erosion control is commonly used and is the most cost-effective option. - Plants with roots that bind the soil, and vegetation cover should be used that breaks the impact of falling raindrops, thus preventing wind and water erosion. - Plants used for revegetation should be indigenous to the area, hardy, fast-growing, nitrogen-fixing, provide high plant cover, be adapted to growing on exposed and disturbed soil (pioneer plants) and should easily be propagated by seed or cuttings. - The area of disturbance must be kept to a minimum, as demolition should be done judiciously avoid the exposure of larger areas to wind erosion. - Spreading of soil must be performed on less windy days. - The bare soil will be prone to erosion and therefore there is need to reduce the velocity near the surface of the soil by re-vegetation. - Leaving the surface of soil in a coarse condition reduces wind erosion and ultimately reduces dust levels. - Additional mitigation measures include keeping soil moist using sprays or water tanks, using wind breaks. - The best time to re-vegetate the area must be linked to the distribution and reliability of rainfall. - Speed restrictions should be imposed and enforced. - Cabs of machines should be swept or vacuumed regularly to remove accumulated dust. - Exhaust pipes of vehicles should be directed so that they do not raise dust. - Engine cooling fans of vehicles should be shrouded so that they do not raise dust. - Hard surfaced haul roads or standing areas to be washed down and swept to remove accumulated dust. - Dust suppression of roads being used during rehabilitation should be enforced. - It is recommended that the rehabilitation by vegetating should begin during the operational phase already as the objective is to minimise the erosion. - These measures should be aimed to reduce the potential for fugitive dust generation and render the impacts on ambient air quality negligible.		

11.3 Cumulative Impacts

The proposed Exxaro Dorstfontein Expansion project area surrounded by other mining areas. These mining operations will also generate fugitive dust and particulate matter emissions. The Exxaro Dorstfontein Expansion project will contribute to the cumulative air quality impacts of the region.

The impacts of projects are often assessed by comparing the post-project situation to a pre-existing baseline. Where projects can be considered in isolation this provides a good method of assessing a project's impact. However, in areas where baselines have already been affected, or where future development will continue to add to the impacts in an area or region, it is appropriate to consider the cumulative effects of development. This is similar to the concept of shifting baselines, which describes how the environmental baseline at a point in time may represent a significant change from the original state of the system. Cumulative impacts refer to the incremental effect of several projects that may have an individually minor, but collectively significant, impact on air quality.

Cumulative impact can be defined as:

- Two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts, and
- The change in the environment which results from the incremental impact of the project when added to other closely related past, present, or reasonably foreseeable future projects, and can result from individually minor, but collectively significant, projects taking place over a period of time.

This section describes the potential impacts of the project that are cumulative. There are three separate levels of cumulative impacts considered: project site localised cumulative impacts; regional cumulative impacts; and global cumulative impacts.

- **Project site localised cumulative impacts**

These are the cumulative impacts that result from mining operations in the immediate vicinity of the project site. Project site localised cumulative impacts include the cumulative effects from operations that are close enough to potentially cause additive effects on the environment or sensitive receivers. These include mainly dust deposition. From this air impact assessment conducted for the proposed project the modelling indicates the cumulative pollution plume emanating from this site as a combination of activities and shows that the impacts will be mainly localised around and in the vicinity of the operations.

- **Regional cumulative impacts**

Regional cumulative impacts include the project's contribution to impacts that are caused by mining operations throughout the region. Each mining operation in itself may not represent a substantial impact, however the cumulative effect on air quality in the region may warrant consideration. The coal mining sector in South Africa is growing steadily as the requirement for electricity also grows and therefore this project will also contribute to the larger regional impact that will be experienced.

- **Global cumulative impacts**

The only impact from the project that is potentially global is the generation of potential greenhouse gas emissions. However, the level of emissions from the project represents a very minor and insignificant contribution at this scale.

Recommendations to limit cumulative impacts:

Adoption of a combination of engineering controls, dust suppression measures, rehabilitation of exposed surfaces, operational procedures, and measurement of ambient air quality is expected to result in adequate management of dust emissions from the project, and the cumulative impacts from these emissions. An ambient air monitoring program has been developed to monitor the impact of dust-generating emission sources at sensitive receptor locations around the project site. The information obtained from the monitoring program will feed into the operational management of site-based dust emission sources.

Therefore, the overall impact on the air quality as a result of the project would not be cumulatively considerable, and would be less than significant if the sound implementation of mitigation measures identified reducing emissions are implemented. If emissions are kept below the relevant threshold levels by ensuring the management and mitigation measures prescribed are adhered to there is no significant cumulative impacts expected as the air quality impacts would be limited to the site level.

11.4 Climate Change

During an assessment in 2016 of South Africa's coal mining sectors' response to climate change adaption demands undertaken by B. Chavalala from UNISA, Climate change adaptation has received limited attention compared to mitigation across all spatial levels. This is besides the documented adverse impacts of climate change in different sectors of societies including mining in general and coal mining specifically. Against this background, the study set three objectives. The first objective was to identify current and possible future climate change impacts that may affect selected coal mines in South Africa. The second objective was to establish the nature and extent to which these mines were ready to address and implement adaptation measures. The last objective was to determine and document existing climate change adaptation practices in selected mines. Employing the mixed methods approach, the research engaged five coal mines located in Mpumalanga, Free State and Kwa Zulu-Natal, gathering both the qualitative and quantitative data. This data was analysed thematically.

The research made three major findings. The first finding was that the climatic conditions in the research areas have been changing over the observed period. In general, rainfall has been declining and temperatures have been increasing, leading to increased cases of extreme fog, mist and heatwaves. The second finding was that there has been an increase in frequency and intensity of extreme weather events, most notably, floods and droughts. These changes in the climate and associated weather events have frequently affected mine operations particularly at the production sub-chain of the coal mining value chain. The third major finding was that despite this evidence of adverse impact of climate change on the production sub-chain of the South African coal mining value chain, adaption responses in all the studied mines showed reactive adaptation to extreme events instead of proactive adaptation planning and implementation. South Africa depends on coal-derived energy, electricity in particular and the coal mines are implicitly exposed and vulnerable to the adverse impacts of climate change. Reducing this exposure and vulnerability dictates the urgent need to implement anticipatory adaptation measures in all the sub-chains of the coal mining value chain.

Coal is the world's most abundant and widely distributed fossil fuel source, and will remain so well into the future. At present approximately 23% of primary global energy needs are met by coal and 40% of electricity is generated from coal. About 70% of world steel production depends on coal feedstock.

The combustion of coal is the largest contributor to the human-made increase of CO_2 in the atmosphere. Electric generation using coal burning produces approximately twice the greenhouse gasses per kilowatt compared to generation using natural gas.

Coal mining releases methane, a potent greenhouse gas. Methane is the naturally occurring product of the decay of organic matter as coal deposits are formed with increasing depths of burial, rising temperatures, and rising pressure over geological time. A portion of the methane produced is absorbed by the coal and later released from the coal seam (and surrounding disturbed strata) during the mining process. Methane accounts for 10.55% of greenhouse-gas emissions created through human activity. According to the Intergovernmental Panel on Climate Change, methane has a global warming potential 21 times greater than that of carbon dioxide over a 100-year timeline. The process of mining can release pockets of methane, and these gases may pose a threat to coal miners, as well as being a source of air pollution. This is due to the relaxation of pressure and fracturing of the strata during mining activity, which gives rise to safety concerns for the coal miners if not managed properly. The build-up of pressure in the strata can lead to explosions during (or after) the mining process if prevention methods, such as "methane draining", are not taken.

In 2008 James E. Hansen and Pushker Kharecha published a peer-reviewed scientific study analysing the effect of a coal phase-out on atmospheric CO_2 levels. Their baseline mitigation scenario was a phase-out of global coal emissions by 2050. Under the *Business as Usual* scenario, atmospheric CO_2 peaks at 563 parts per million (ppm) in the year 2100. Under the four coal phase-out scenarios, atmospheric CO_2 peaks at 422–446 ppm between 2045 and 2060 and declines thereafter.

Climate change is unlikely to have a major direct impact on the mining industry, for which regulations and management strategies are already in place to manage factors such as water usage, water conservation and demand strategies and environmental issues relating to rehabilitation and the provision of rehabilitation guarantees. While a lack of access to water may affect some mining projects, most mining processes do not generally require potable water. Where high-quality water is required, some mines are already installing water treatment units.

Changes in the frequency and intensity of storm events have the potential to impact on mining operations (e.g. tailing dams, sediment and erosion control); however, these impacts can normally be addressed as part of the mine's storm water management plan.

The highest risk to the mining industry from climate change is most likely to come from meeting growing community concerns over environmental issues. This is likely to increase the difficulty in obtaining approvals for mining projects (particularly for coal). Additional constraints on mining may also affect the economic viability of individual mines, leading to flow-on effects to communities, through job losses and a decline in regional revenue. Work to develop clean coal technologies may ameliorate this risk to some extent; however, the actual process of mining is likely to face increasing community pressure.

Clean Coal technologies not only limited to the mining operations but also the end users of the coal will be a key factor in adapting to climate change and a carbon constrained future. Such technologies include:

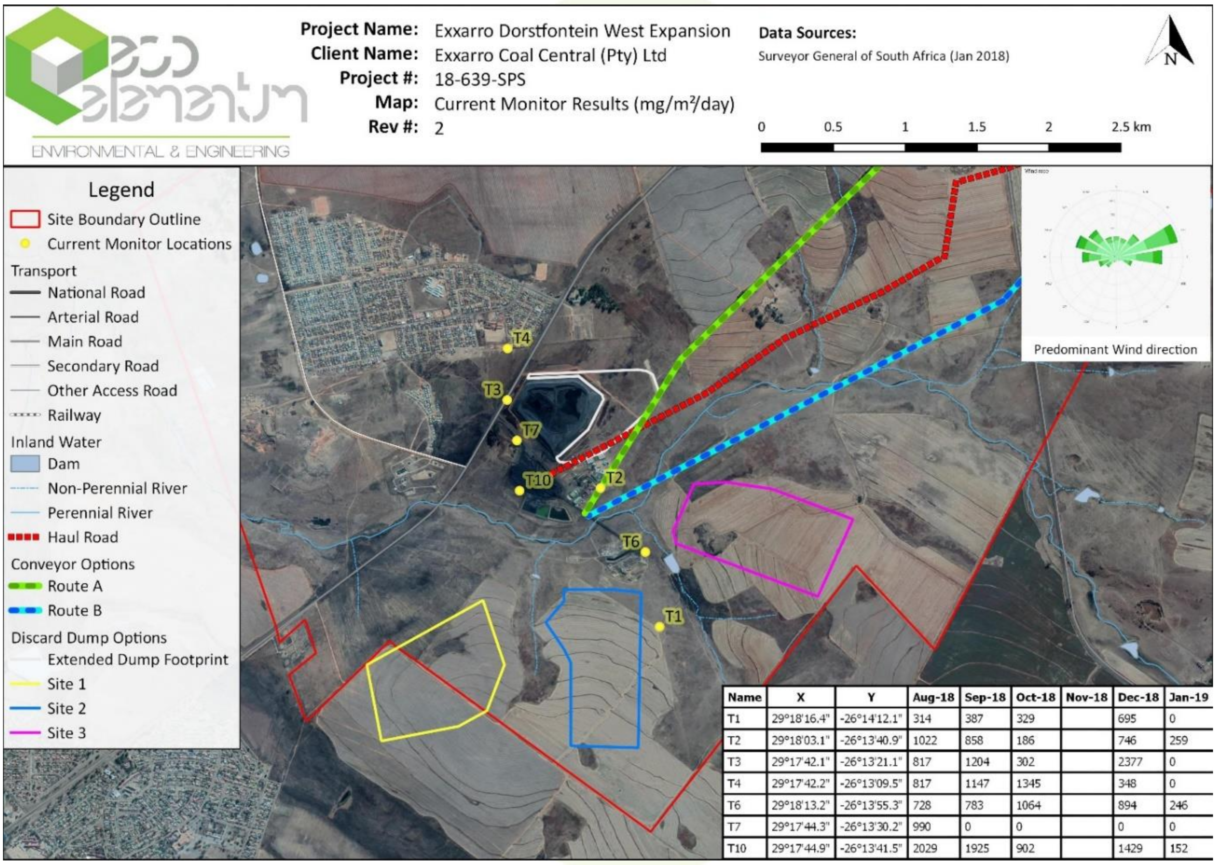
- Pre and post carbon capture and storage technologies.
- New pollution control devices - like advanced scrubbers - that clean pollutants from flue gases before they exit a plant's smokestack.
- Chemical looping combustion technology to concentrate CO_2 levels in exhaust.
- Production of ultra clean coal which reduces ash from the coal allowing it to be directly fired in gas turbines at higher efficiency and lower greenhouse gas emissions.
- Efficiency upgrades and co-firing with less greenhouse intensive fuels in coal fired power stations.
- Low – NOx burners which allow coal-fired plants to reduce nitrogen oxide emissions.
- High temperature solar thermal applications integrated into coal fired power generation.
- Stack Gas Treatment - applied to gaseous emissions from Pulverised Fuel (PF) Combustion.
- Advanced Pulverised Fuel Combustion (PF).
- Fluidised Bed Combustion (FBC).
- Gasification and Integrated Coal Gasification Combined Cycle Systems.
- Hybrid and advanced systems.
- Fuel cell technologies utilising gas from coal.
- Oxy-firing technology to raise the concentration of CO_2 in flue gases to better enable its capture.
- Coal Gasification including underground gasification in situ.
- Capture and utilisation of fugitive emissions from coal mines.

12. MONITORING PROGRAMME

Currently a monitoring campaign exists for the proposed Exxaro Dorstfontein Expansion project. It is recommended to expand the passive sampling campaign to include all wind directions and the outskirts of the town of Kriel. The campaign is to continue for the life of mine in order to establish historical repository of data needed to fully understand/address fugitive and airborne dust emissions from the construction, operation and closure activities. Managing dust fallout effectively will result in the reduction of respiratory diseases that are as a result of air pollution, reduced risk of damage to property, improved visibility, and fewer disturbances to existing flora and fauna habitats.

12.1 GRAVIMETRICAL DUST FALLOUT – (MILLIGRAM/SQUARE METER/DAY) OR (MG/M²/DAY) (MONTHLY 8 SAMPLES)

12.1.1 Current Monitoring Program



Name	X	Y	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19
T1	29°18'16.4"	-26°14'12.1"	314	387	329		695	0
T2	29°18'03.1"	-26°13'40.9"	1022	858	186		746	259
T3	29°17'42.1"	-26°13'21.1"	817	1204	302		2377	0
T4	29°17'42.2"	-26°13'09.5"	817	1147	1345		348	0
T6	29°18'13.2"	-26°13'55.3"	728	783	1064		894	246
T7	29°17'44.3"	-26°13'30.2"	990	0	0		0	0
T10	29°17'44.9"	-26°13'41.5"	2029	1925	902		1429	152

Figure 20 Current Monitor Locations and Results

Table 29: Current Dust Deposition Monitor Results at the Exxaro Dorstfontein Project in mg/m²/day

Name	X	Y	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19
T1	29°18'16.4"	-26°14'12.1"	314	387	329		695	
T2	29°18'03.1"	-26°13'40.9"	1022	858	186		746	259
T3	29°17'42.1"	-26°13'21.1"	817	**1204**	302		**2377**	
T4	29°17'42.2"	-26°13'09.5"	***817***	***1147***	**1345**		348	
T6	29°18'13.2"	-26°13'55.3"	728	783	1064		894	246
T7	29°17'44.3"	-26°13'30.2"	990					
T10	29°17'44.9"	-26°13'41.5"	**2029**	**1925**	902		**1429**	152

For the current operation there are exceedances at the monitor locations that fall outside of the allowable exceedances. Bucket T4 is situated in a residential area and exceeded the residential limit of 600 mg/m²/day for 3 consecutive months. Bucket T10 also exceeded the industrial limit for 2 consecutive months during the monitoring period. It should be noted that due to the nature of the sampling method, it may show exceedances due to other source contributions that are not part of the current operations. It is however highly recommended to further investigate the locations of the exceedances to determine the sources of the dust fallout.

12.1.2 Proposed expansion of the monitoring Program

It is recommended to expand the passive sampling campaign to include all wind directions and the outskirts of the town of Kriel.

Site layout for sampling points must be carried out according to the eight main compass directions; the site layout and equipment placement must be done in accordance with the ASTM standard, D 1739 – 2010, thereafter relevant sampling reference numbers will be allocated to the receptors accordingly. At each gravimetric dust fallout gauge/receptor point there is a stand built according to specification containing the dust sample collection bucket. Samples will be collected after a 1 month running period (+-30 day's exposure). After sample collection, the samples are taken to a SANAS accredited laboratory as required. A visual site investigation is done where after correlations are drawn and findings are identified and reported on.

Dust buckets of a standard size and shape are prepared and set up at locations related to the eight main compass points on the borders of the property so that dust can settle in them for periods of 30+/-2 days. The dust buckets are then sealed and replaced with new empty ones and send away to the SANAS accredited laboratory for analysis. The masses of the water-soluble and –insoluble components of the material collected are then determined and results are reported as mg/m²/day. This methodology is described according to South African National Standards 1929:2004 and the American Society for Testing and Materials (ASTM) Designation: D 1739-98 (2010). The results for this method of testing are obtained by gravimetrical weighing. The apparatus required include open top buckets/containers not less than 150 mm in diameter with a height not less than twice its diameter. The buckets must be placed on a stand at a height of 2 +/-0.2 m above the ground.

12.2 Particulate Matter PM10 (Monthly 8 Samples)

It is recommended that the client should establish a fine particulate monitoring programme, which should include one particulate instrument to monitor PM10 and preferably PM2.5 specifically at the problem areas shown by the passive sampling campaign at the residential areas. Handheld sampling instruments not only allows for sampling in the 8 main wind directions, but also on-site sampling down-wind of potential dust sources to quantify and determine impacts that need to be managed. It is advised to conduct this sampling on a monthly basis but also when the need arise during periods of elevated dust concentrations being emanated from the site.

New technology to perform cost effective real-time dust and particulate matter is currently becoming a cost effective option. This type of technology can record real-time wind speed and direction together with particulate concentrations. It can thus be used more effectively for management purposes. Actionable intelligence is generated on dust and particulate matter emissions, which in turn can then be used to determine the origin of the particulate emissions. In a scenario where mining operations are situated in such close proximity to each other and residential areas, this type of technology can become instrumental in decision making on the management of dust for a mining operation.

13. CONCLUSION

The air quality impact assessment undertaken for the project includes a meteorological overview of the area.

An emissions inventory was undertaken with the aim of quantifying emissions associated with the activities involved in the mining and processing of coal. The emissions for specific activities such as conveyor transport, haul road transport, wind erosion and materials handling activities were calculate and the cumulative impacts were compared to the relevant ambient air quality standards to determine legal compliance.

The findings reported here is therefore a combination of historical, observed and previously modelled data and provided the background and predicted scenario of various pollutants in the proposed Exxaro Dorstfontein West Expansion project mining area. The operational phases were assessed. Based on the dispersion modelling simulations, the following conclusions can be summarised as follows:

Table 30: Summary of all predicted Values

Average Value from all Receptors				
	Conveyor Mitigated			
	Extension	**Site 1**	**Site 2**	**Site 3**
PM10 Daily	**1.68**	2.56	3.06	3.96
PM10 Annual	**0.17**	0.18	0.19	0.25
TSP Monthly	8.50	3.09	**2.18**	2.73
TSP Annual	3.14	1.40	**0.87**	0.98

The **Expansion of the current Discard Dump** or building a new Discard Dump at the proposed location of **Site 2** while using a conveyor system to transport the ROM, are predicted to have the least impact in terms of Air quality on the sensitive receptors when comparing the PM10 predicted concentrations and TSP dust fallout.

Table 31: Summary of the count of minimum predicted Values

Count of minimum Values at all Receptors				
	Conveyor Mitigated			
	Extension	**Site 1**	**Site 2**	**Site 3**
PM10 Daily	16	**12**	2	3
PM10 Annual	**20**	19	8	9
TSP Monthly	15	**24**	19	10
TSP Annual	19	21	**23**	18

When comparing the amount of receptors that are predicted to have the lowest value for all the relevant scenarios, the **Expansion of the current Discard Dump** or building a new Discard Dump at the proposed location of **Site 1** while using a conveyor system to transport the ROM, are predicted to have the least impact in terms of Air quality on the sensitive receptors when comparing the PM10 predicted concentrations and TSP dust fallout.

Based on the results presented the following recommendations are outlined:

- **Conveyor Transport** is the **preferred option**.
- Although the **Expansion of the Discard dump** and **Site 1** are predicted to have the least air quality impact at the sensitive, when mitigated and using a conveyor system to transport the material, **all discard dump options** fall within the relevant air quality limits.

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