ENVIRONMENTAL & ENGINEERING

REPORT

VANDABYTE (PTY) LTD

AIR QUALITY IMPACT ASSESSMENT (AQIA)

REPORT REF: 18-695-SPS

(PORTIONS 1, 2 AND THE REMAINING EXTENT OF THE FARM DUNBAR 189 IS, PORTION 1 OF THE FARM MIDDELKRAAL 50 IS, PORTION 6 OF THE FARM HALFGEWONNEN 190 IS. - MPUMALANGA PROVINCE.)

2019/09/30

VERSION CC

Document and Quality Control:

Document No:	18-695-SPS (Dunbar AQIA)			
AA – draft	30/09/2019	Neel Breitenbach	[signature]	First draft for review / comments
BB – draft		Henno Engelbrecht	[signature]	Technical Review
CC– draft	30/09/2019	Leoni le Roux	[signature]	Quality review
DD– draft				Client review
EE - draft				Final Review
Approved for Distribution:				
0.0				Final report

Quality Control BY:

Nature of Signoff	Responsible Person	Role / Responsibility	Qualification
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Quality Reviewer	Leoni le Roux	Administrator	Professional Secretary and Personal Assistant
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Client			

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EXPERTISE OF THE REVIEWER

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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

Vandabyte (Pty) Ltd (hereafter the applicant) has appointed Enviro-Insight CC as the Environmental Assessment Practitioner (EAP) to undertake environmental authorisations (EAs) associated with the proposed Dunbar Coal Mine. The applicant has obtained a Prospecting Right (reference number MP 30/5/1/1/2/10737 PR) on 22 May 2014 from the Mpumalanga Department of Mineral Resources (DMR) to prospect for coal in an area of 1 797 ha on a Portion of Portion 1, Portion 2 and the remaining extent of the Farm Dunbar 189 IS, Portion 1 of the Farm Middelkraal 50 IS and Portion 6 of the Farm Halfgewonnen 190 IS located in the Mpumalanga Province. The mining right application lodged on 9 May 2019 to the DMR (reference number MP30/5/1/2/2/10237MR) includes the abovementioned properties and extent.

Enviro-Insight CC appointed Eco-Elementum (Pty) Ltd to undertake the Air Quality Impact Assessment for the Dunbar Coal project.

The proposed project involves the development of two new open pit coal mines and the associated supporting infrastructure. The coal resource will be mined using open pit methods due to the seemly depth of the coal reserve. For this specific project the mining of coal by means of surface mining methods are viable due to the fact that the resource is situated close enough to the surface to make it economically mineable. Typical surface mining methods include: strip mining and open pit mining, as well as dredge, placer and hydraulic mining in riverbeds, terraces and beaches. These activities always disrupt the surface and this, in turn, affects soils, surface water and near-surface ground water, fauna, flora and all alternative types of land-use.

The generally low strip ratios and wide surface area of the project area makes it ideal for the opencast truck and shovel mining method. Also, the mining method applicability is driven by technical applicability, economic viability, safety, equipment and infrastructure.

The proposed mining method and sequence comprised of the following main mining activities for both waste and coal:

1. Initial topsoil and soft overburden removal which will be stockpiled to ensure it can be replaced back in the initial box cut;
2. The physical mining of the coal seam which includes drilling of hard overburden material, charging and blasting;
3. The coal is loaded into trucks and hauled to the crushing and screening facility;
4. Discard coal will be extracted and replaced in the bottom of the opencast pit, while the product will be taken to the weighbridge via trucks and then removed off site;
5. The overburden is replaced back into the pit as mining progresses leaving a minimum area open at a single time;
6. The topsoil which was stripped and stockpiled separately before mining commenced is then replaced. The findings of the land capability study will determine the optimal composition to ensure pre-mining conditions for utilisation.

The proposed mining layout is based on a 100 m x 50 m mining block size. The purpose of a square mining layout is to increase the ease of strategic mine scheduling. The start of the mining block layout was based on the mining boundary. The size and scale of the open-pit mine entails that small and conventional truck and shovel mining equipment is used to mine both waste material and coal.

Key infrastructure includes:

1. Access & Haul roads (with necessary security) including the upgrading of the access point to the gravel road;
2. Contractor's Yard with septic/chemical ablution facilities;
3. Offices;
4. Weighbridge, workshop and stores (with septic/chemical ablution facilities);
5. Rail Siding;
6. Diesel facilities and a hardstand;
7. Power and Water;
8. Box cut;
9. Stockpiles (topsoil, overburden, subsoil/softs, ROM);
10. Surface water management measures (stormwater diversion berms and trenches, pollution control dams etc.);
11. Crushing & screening facility.

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 of coal. The emissions for specific activities such as bulldozing, blasting, tipping, wind erosion and materials handling activities were calculated 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 Dunbar Coal project mining area. The construction and operational phases were assessed. Based on the dispersion modelling simulations, the following conclusions can be summarised as follows:

PM10

For the unmitigated Daily PM10 concentrations it was predicted to be higher than the 75 µg/m³ limit for 11 of the 12 sensitive receptors with major exceedances at most of the receptors.

When comparing the Daily Mitigated PM10 modelled concentrations for the Haul Roads at 75% mitigation, the sensitive receptors exceeding the 75 µg/m³ limit drop to 6 out of the 12 identified sensitive receptors. With the Haul Roads at 90% mitigation only 1 identified sensitive receptor are predicted to exceed the 75µg/m³ limit. It should be noted that this is the2nd highest levels predicted for a 24 hour period within the period. Due to site specific atmospheric conditions these exceedances may still occur within the limit of 4 per year.

The annual average PM10 limit of 40 µg/m³ are not predicted to exceed at any of the identified sensitive receptors for any of the modelled scenarios.

TSP

In the mitigated and unmitigated scenarios none of the sensitive receptors are predicted to exceed the monthly dust fallout for the highest month residential limit of 600 mg/m²/day.

The predicted annual dust fall out for the mitigated and unmitigated scenarios are not predicted to exceed the annual limit of 300 mg/m²/day at any of the sensitive receptors.

Mitigation Measures

2 Different mitigation scenarios were modelled. Based on the results the following mitigation measures are recommended at the various sources:

Operation	Reduction	Method
Excavator ROM	50%	Water Sprays
Excavator Overburden	50%	Water Sprays
Wind Erosion	50%	Water Sprays
	90%	Revegetation on OB and Topsoil
Access Haul Road	75%	Level 2 Watering (>2 liters/m²/h)
Pit Haul Road	75%	Level 2 Watering (>2 liters/m²/h)
Truck Dumping (Overburden)	50%	Water Sprays
Truck Dumping (ROM)	50%	Water Sprays
Inpit Operations	50%	Inpit
Loading Stockpiles	50%	Water Sprays

Based on the results presented the following further recommendations are outlined:

- It is recommended that ambient air quality monitoring be established to get a baseline condition prior to the onset of the operations and in order to establish the level at which the proposed operations are noted to impact on the ambient air quality.

- Fallout monitoring should be continued for the life of mine to better assess the level of nuisance dust associated with both mining and process related operations. Sampling of fallout should be undertaken within the neighbouring areas as well as on-site. Dust fallout monitoring is recommended at the locations as shown in Figure 30.
- PM10 and PM2.5 dust monitoring must also be undertaken at the same sites as mentioned under the previous bullet but also in and around potential fugitive emission sources to determine mitigation measures and focus management efforts.
- Further mitigation measures that should be applied, if it is found that dust and PM10 levels are measured to be exceeding the limits are:
    - Reducing the speed of the Haul Trucks on the Pit and Access Haul Roads.
    - Fully sealed Pit and Access Haul Road to achieve 90-100% mitigation on these roads.

The impacts from dust fallout and Particulate matter can be reduced by implementing dust control measures. The highest intensity of the construction work should be carried out during the summer months and not over the harsh winter months as can result in increased dispersion of fugitive dust. The mine should ensure that unpaved roads are continuously watered and treated with dust binding additive products to reduce the volume of fugitive dust emitted from unpaved roads.

The mitigation and management measures for mining operation and discussed in this report should be sufficient to ensure the mining operation can be conducted with minimal impact on the receiving environment and therefore not have a detrimental effect and can go ahead.

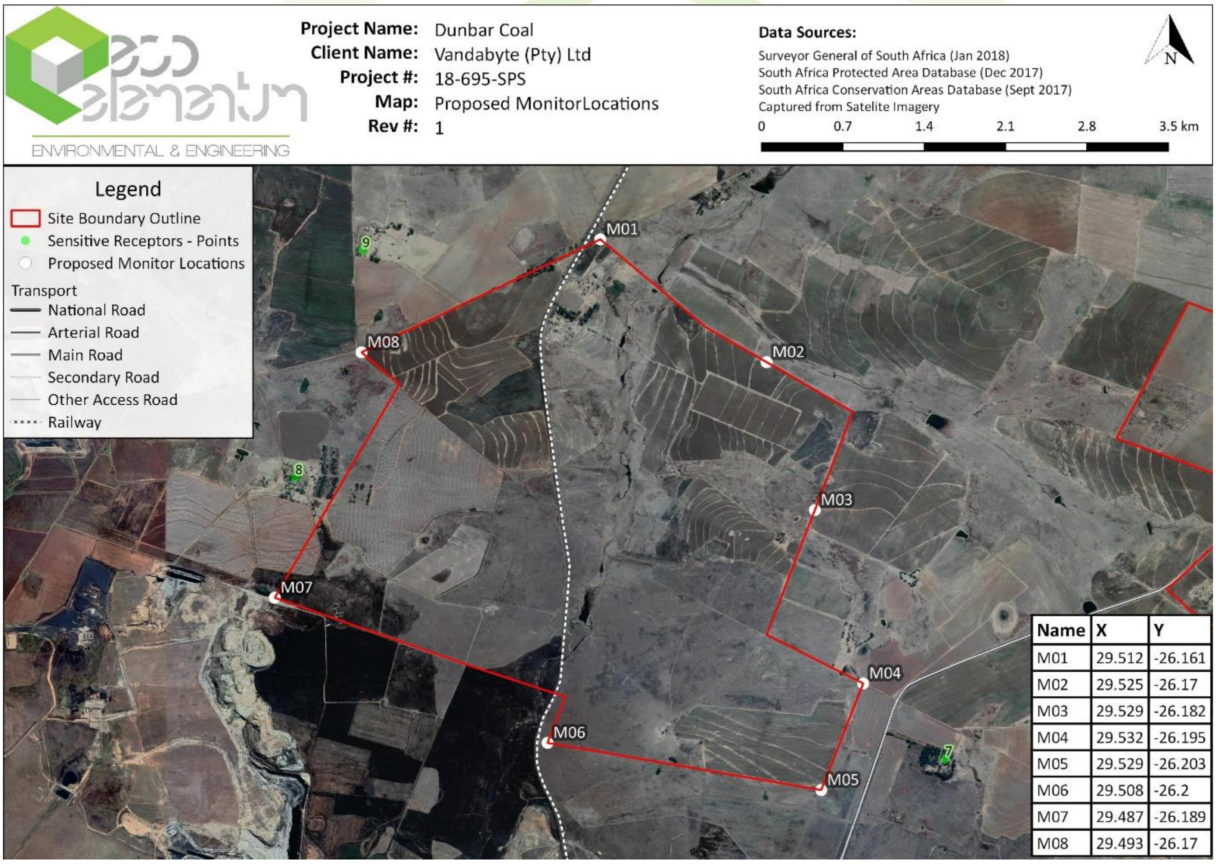

Figure 1: Proposed Monitor Locations

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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 1: Applicant Details

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File Reference Number DMR:	MP 30/5/1/12/2/ 10237MR

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Table 3: Specialist Details

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Contact Person:	Henno Engelbrecht
Contact Number:	082 690 9105
Email:	henno@ecoe.co.za info@ecoe.co.za
Website:	www.ecoelementum.co.za

SPECIALIST DECLARATION OF INDEPENDENCE

In support of an application in terms of the National Environmental Management Act 107 of 1998 (GNR983, GNR984 and GNR985, GG38282 of 4 December 2014 ("Listed Activities") that will require an environmental authorisation if triggered. As amended by GNR 327, GNR 325 and GNR 324.

I, **Neel Breitenbach** as specialist, has been appointed in terms of regulation 12(1) or 12(2), and can confirm that I shall —

a. Be independent;
b. have expertise in undertaking specialist work as required, including knowledge of the Act, these Regulations and any guidelines that have relevance to the proposed activity;
c. ensure compliance with these Regulations;
d. perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the application'
e. take into account, to the extent possible, the matters referred to in regulation 18 when preparing the application and any report, plan or document relating to the application; and
f. disclose to the proponent or applicant, registered interested and affected parties to the proponent or applicant, registered interested and affected parties and the competent authority all material information in the possession of the EAP and, where applicable, the specialist, that reasonably has or may have the potential of influencing –
g. any decision to be taken with respect to the application by the competent authority in terms of these Regulations; or
h. the objectivity of any report, plan or document to be prepared by the EAP or specialist, in terms of these Regulations for submission to the competent authority;
i. Unless access to that information is protected by law, in which case it must be indicated that such protected information exists and is only provided to the competent authority.

Neel Breitenbach	[signature]
Name and Surname	Signature
30-09-2019	**George**
Date	Signed at

1. INTRODUCTION

Vandabyte (Pty) Ltd (hereafter the applicant) has appointed Enviro-Insight CC as the Environmental Assessment Practitioner (EAP) to undertake environmental authorisations (EAs) associated with the proposed Dunbar Coal Mine. The applicant has obtained a Prospecting Right (reference number MP 30/5/1/1/2/10737 PR) on 22 May 2014 from the Mpumalanga Department of Mineral Resources (DMR) to prospect for coal in an area of 1797 ha on a Portion of Portion 1, Portion 2 and the remaining extent of the Farm Dunbar 189 IS, Portion 1 of the Farm Middelkraal 50 IS and Portion 6 of the Farm Halfgewonnen 190 IS located in Mpumalanga Province. The mining right application lodged on 9 May 2019 to the DMR (reference number MP30/5/1/2/2/10237MR) includes the abovementioned properties and extent.

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The Integrated Environmental Authorisation (IEA) application includes the above-mentioned properties where the proposed mining blocks identified and associated infrastructure will be located on Portion 2 of the Farm Dunbar 189 IS. Further invasive drilling and exploration activities on the remainder of the prospecting right is still required and based on new geological information becoming available will likely result in the mining layouts to be updated to ensure optimal mining and utilisation of the available coal resources throughout the proposed mining right area.

There is sufficient data available for Dunbar West to make an initial assessment of its potential. Both Seams 4 and 2 occur on the PR area with Seam 4 reaching a maximum thickness of 5.89 m and Seam 2 a maximum of 9.95 m. In the shallowest parts, Seam 4 starts at a depth of 2.45 m and goes as deep as 100.9 m with Seam 2 at depths from 29.80 to 122.70 m. Seam 5 is thin and not regarded as economical. A low-quality thermal coal will be produced from the different coal seams that are proposed to be mined. Open cast coal mining is the preferred method in this case from an economical view as it will recover a greater proportion of the coal deposit than underground methods, as more of the coal seams in the strata may be exploited

The proposed project involves the development of two new open pit coal mines and the associated supporting infrastructure. The coal resource will be mined using open pit methods due to the seemly depth of the coal reserve. For this specific project the mining of coal by means of surface mining methods are viable due to the fact that the resource is situated close enough to the surface to make it economically mineable. Typical surface mining methods include: strip mining and open pit mining, as well as dredge, placer and hydraulic mining in riverbeds, terraces and beaches. These activities always disrupt the surface and this, in turn, affects soils, surface water and near-surface ground water, fauna, flora and all alternative types of land-use.

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Key infrastructure includes:

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- Weighbridge, workshop and stores (with septic/chemical ablution facilities);
- Rail Siding;
- Diesel facilities and a hardstand;
- Power and Water;
- Box cut;
- Stockpiles (topsoil, overburden, subsoil/softs, ROM);
- Surface water management measures (stormwater diversion berms and trenches, pollution control dams etc.); and
- Crushing & screening facility.

Table 4: Project Locality

Farm Name:	**PORTIONS 1, 2 AND THE REMAINING EXTENT OF THE FARM DUNBAR 189 IS** **PORTION 1 OF THE FARM MIDDELKRAAL 50 IS** **PORTION 6 OF THE FARM HALFGEWONNEN 190 IS** **MPUMALANGA PROVINCE**
Application Area:	1 797 ha for the mining right of which approximately 200 ha identified for current mining operations.
Magisterial District:	- Nkangala District Municipality, - Steve Tshwete Local Municipality, - Gert Sibande District Municipality, - Govan Mbeki Local Municipality; - Mpumalanga Province; South Africa
Distance and direction from nearest town:	The Project Area is ~ 4 km south of Meerlus, ~ 9 km south-east of Komati and ~ 13 km west of Hendrina.

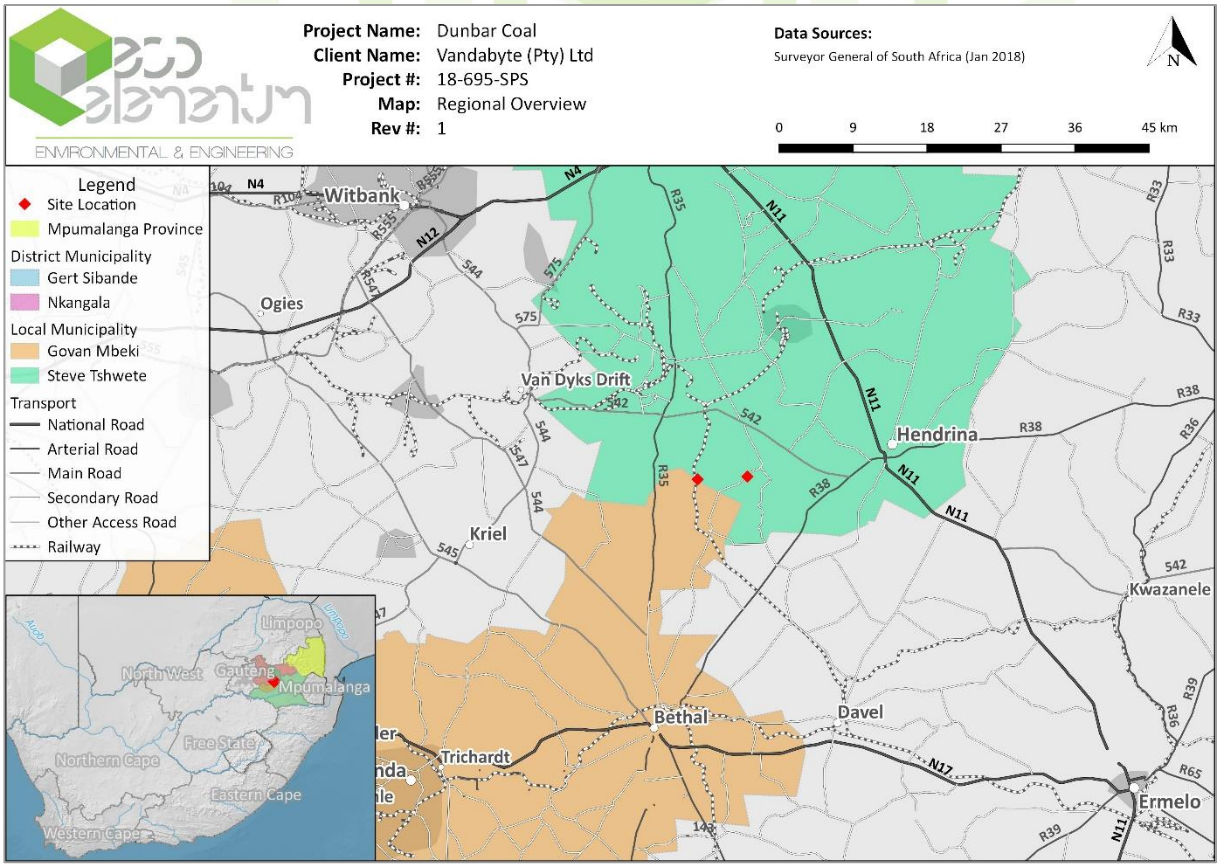


Figure 2: Map indicating the regional overview of the proposed Dunbar Coal project.

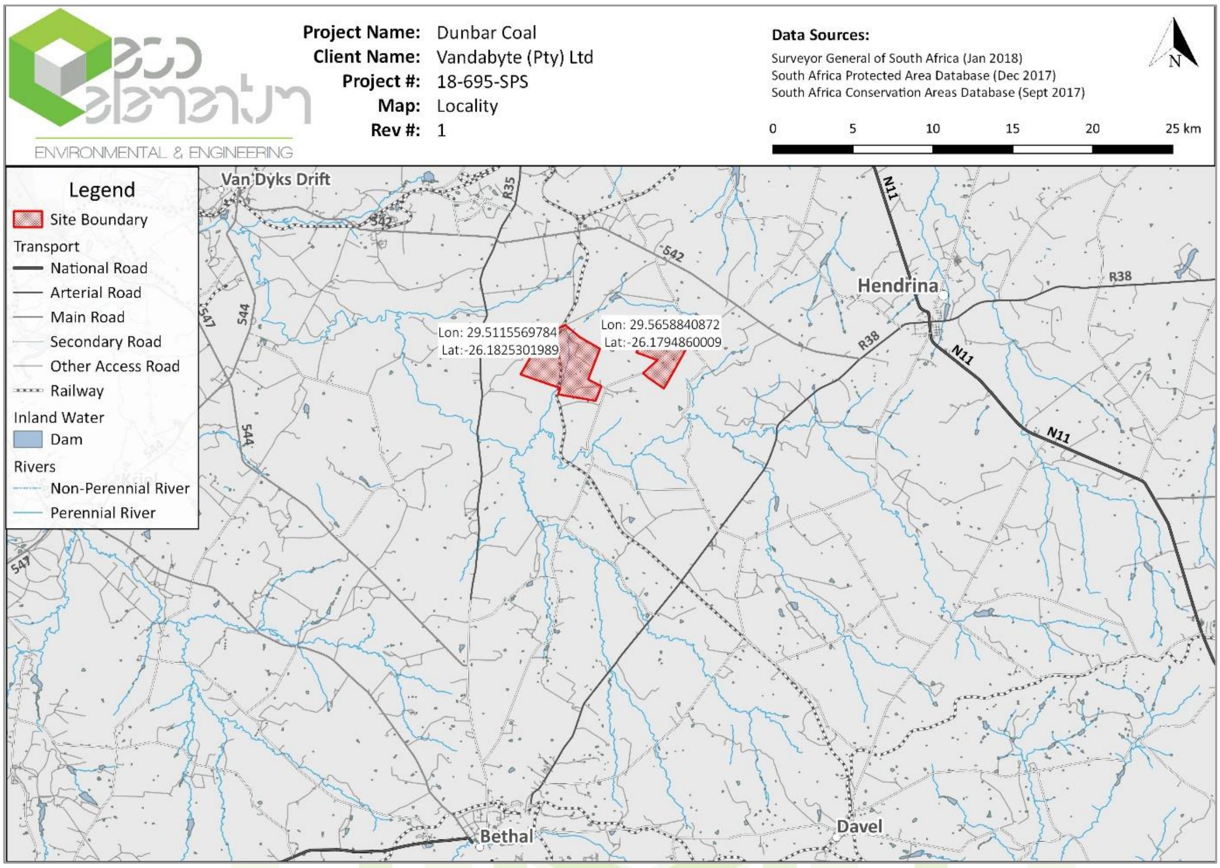


Figure 3: Locality map of the proposed Dunbar Coal project.

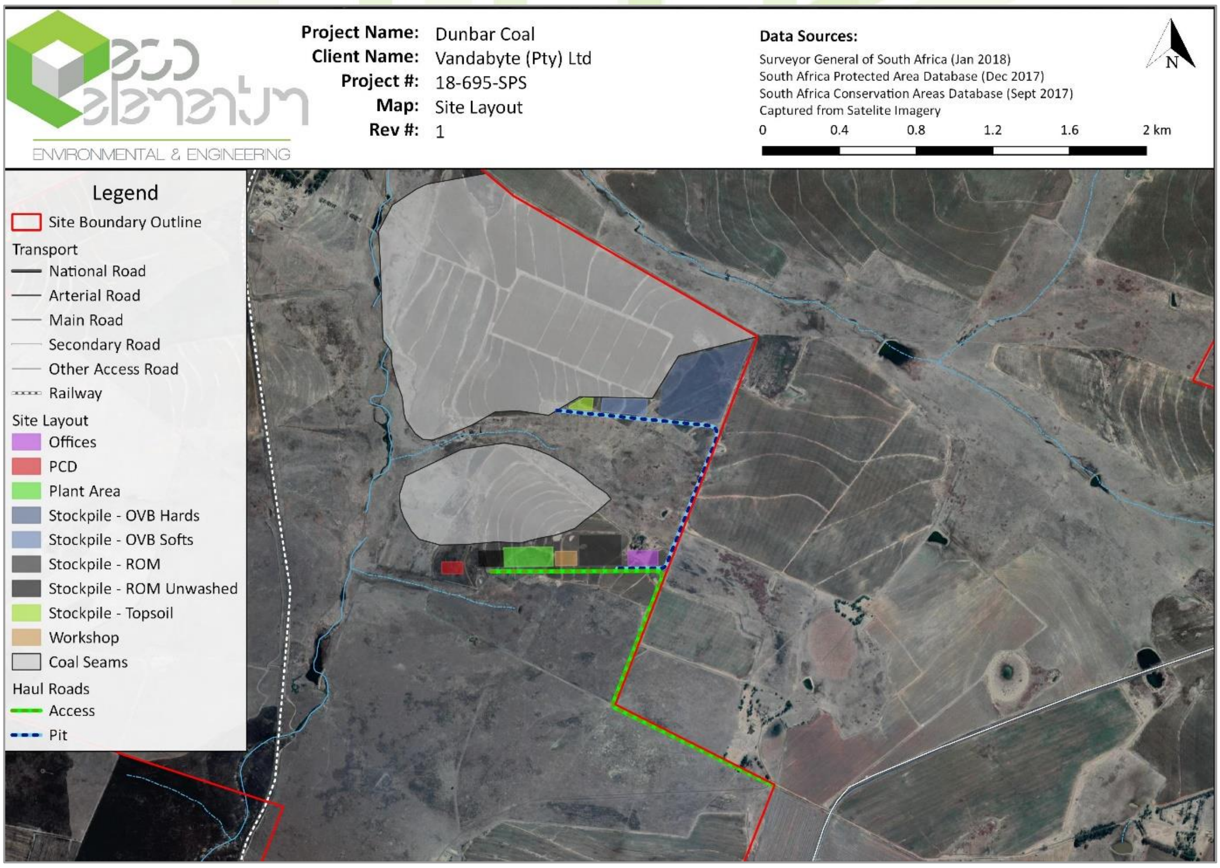


Figure 4: Proposed Site Layout for the proposed Dunbar Coal project.

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;
6. Consider, evaluate and rate the potential air quality impacts; and
7. Propose relevant management and mitigation measures to lessen the anticipated impacts.

3. STUDY AREA

3.1 Location

3.1.1 Industries

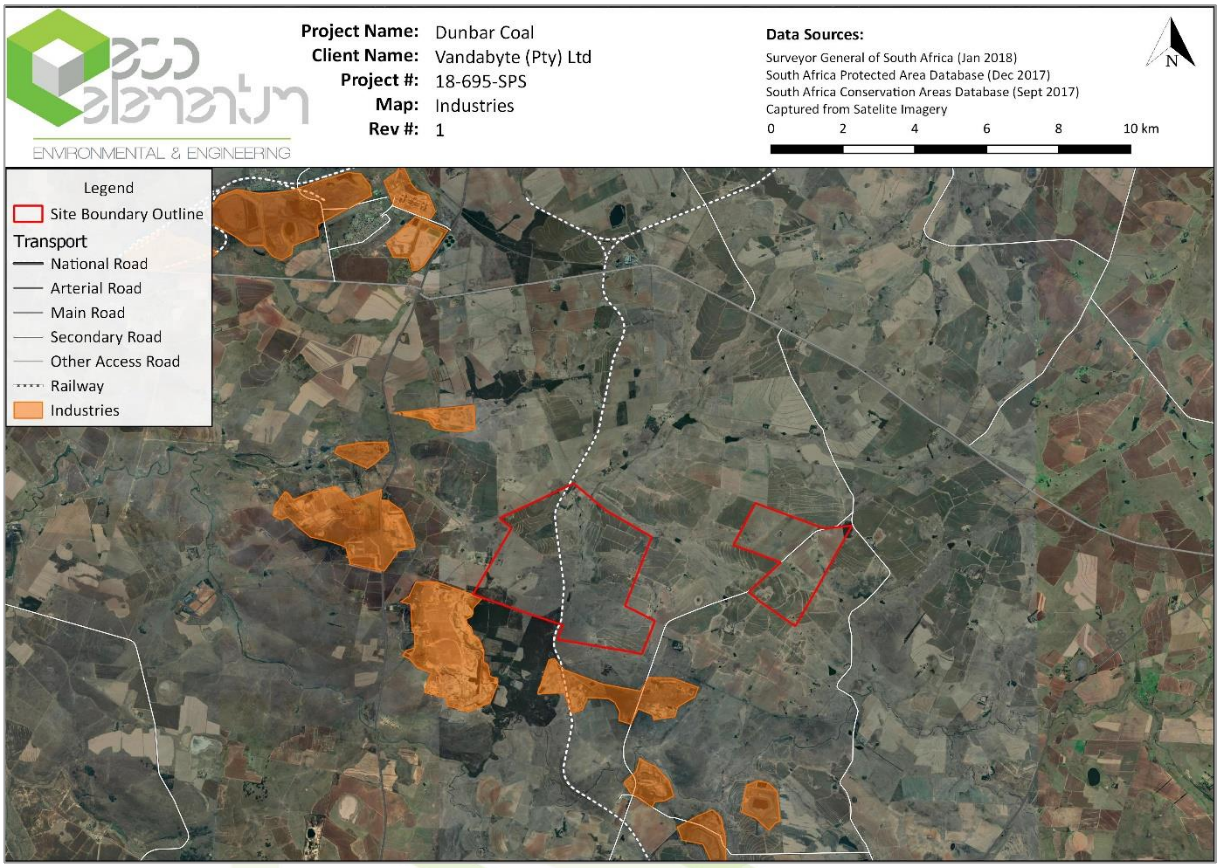


Figure 5: Other industries in the immediate vicinity of the proposed Dunbar Coal project.

From a desktop study of satellite imagery, industrial operations, including other mining operations, and other industries were identified in the immediate vicinity of the proposed Dunbar Coal project. The current operations is included in the identification. The industries is found to the north, west and south of the proposed project area.

3.1.2 Population

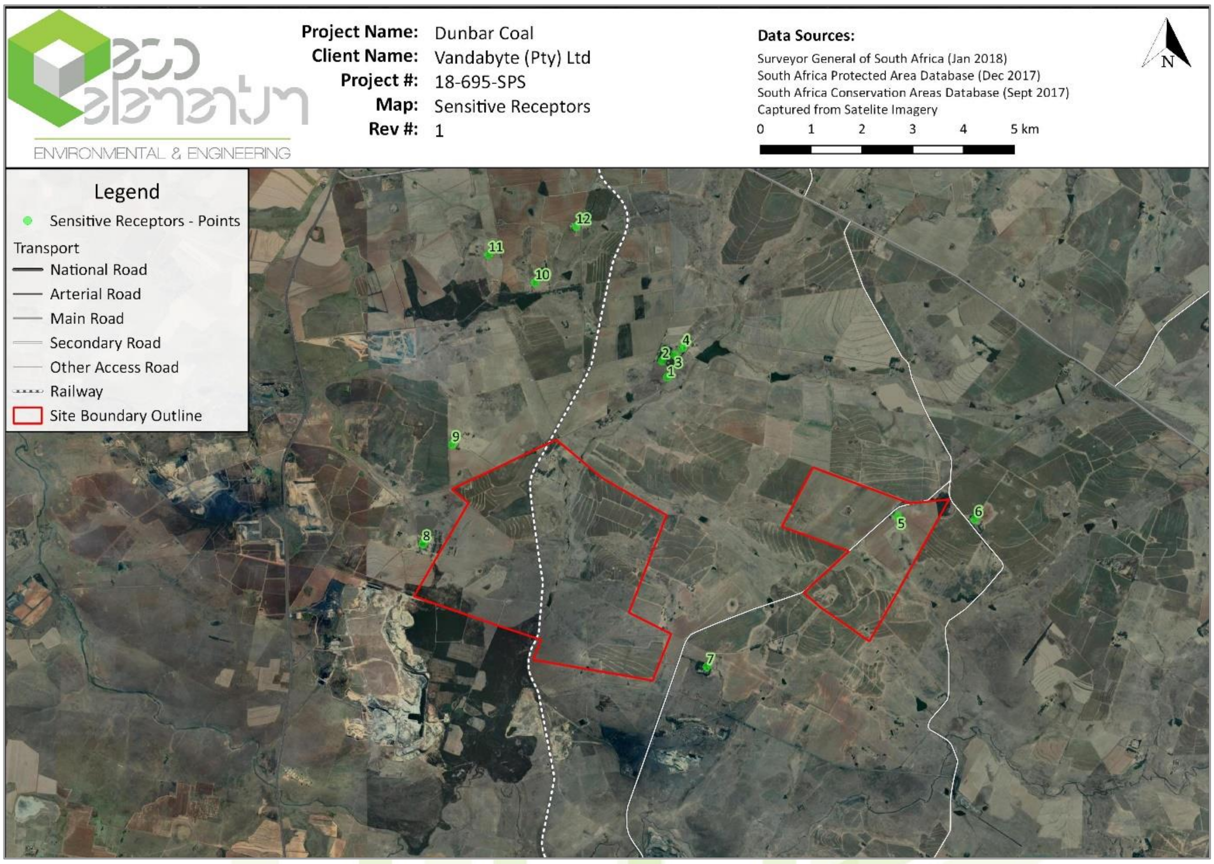


Figure 6: Population areas within the immediate vicinity of the proposed Dunbar Coal project.

From a desktop study of satellite imagery various sensitive receptors in the form of human habitation areas, consisting of dispersed farm houses mainly to the north and east 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

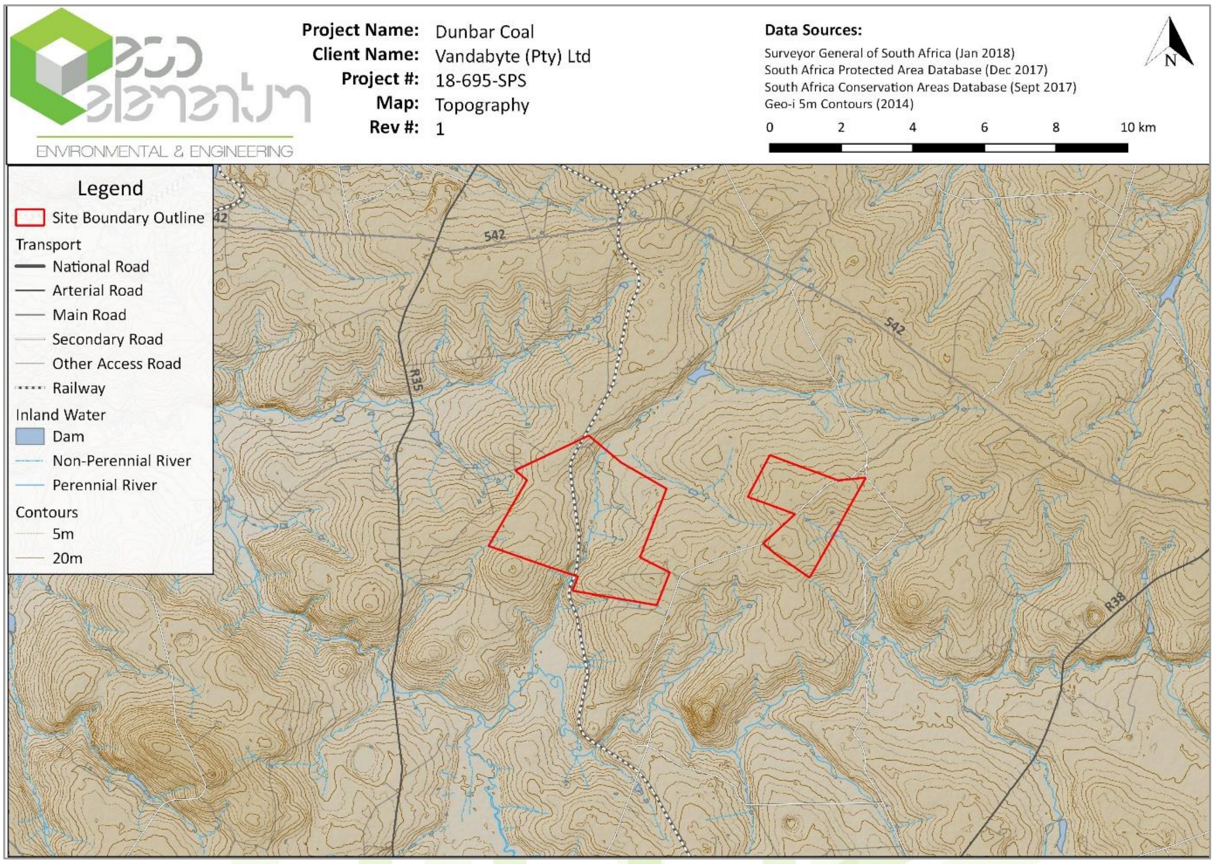


Figure 7: 3D map showing the terrain relief of the area around the proposed Dunbar Coal project.

The proposed mining operation area is situated in undulated terrain as can be seen in Figure 7 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 Dunbar Coal 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 9 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 9 below, the predominant wind direction is predicted to occur mainly from the east-north-east more than 1100 hours per year, with wind speeds higher than 5 km/h.

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 9-17 days per year on average.

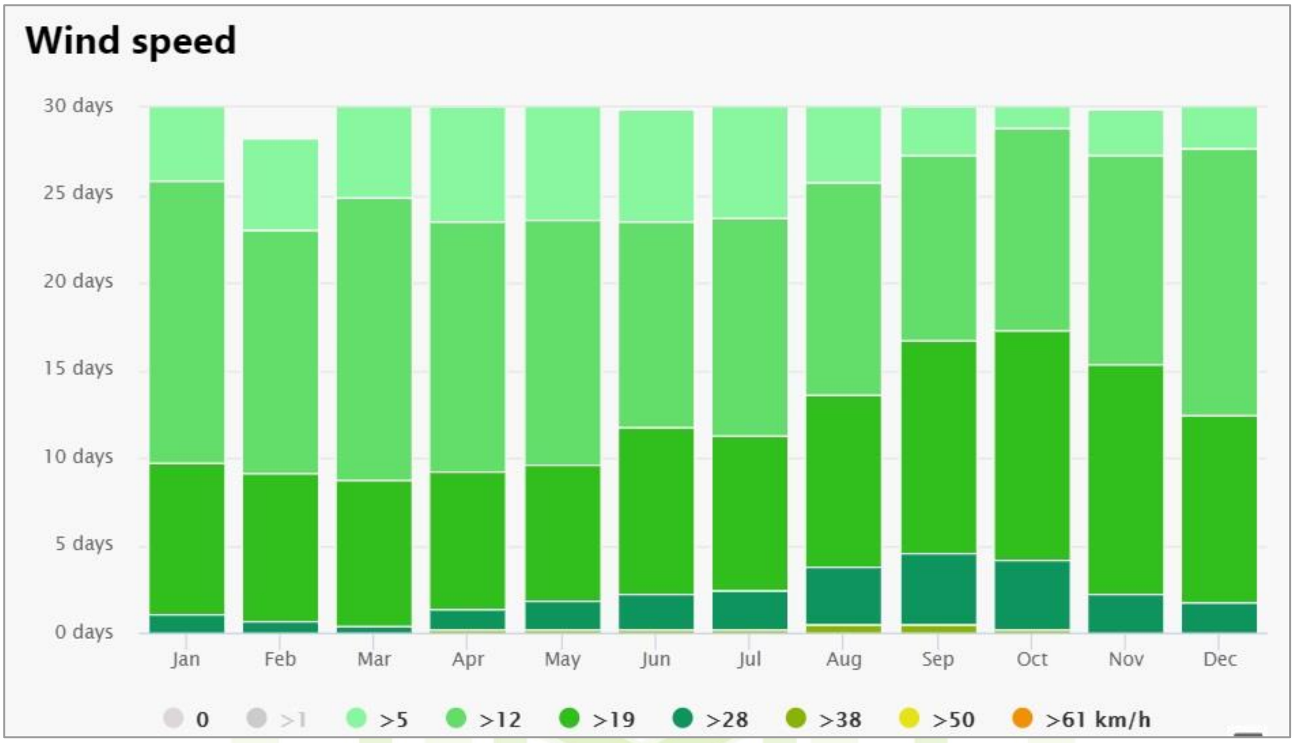


Figure 8: Wind Class Frequency Distribution per month.

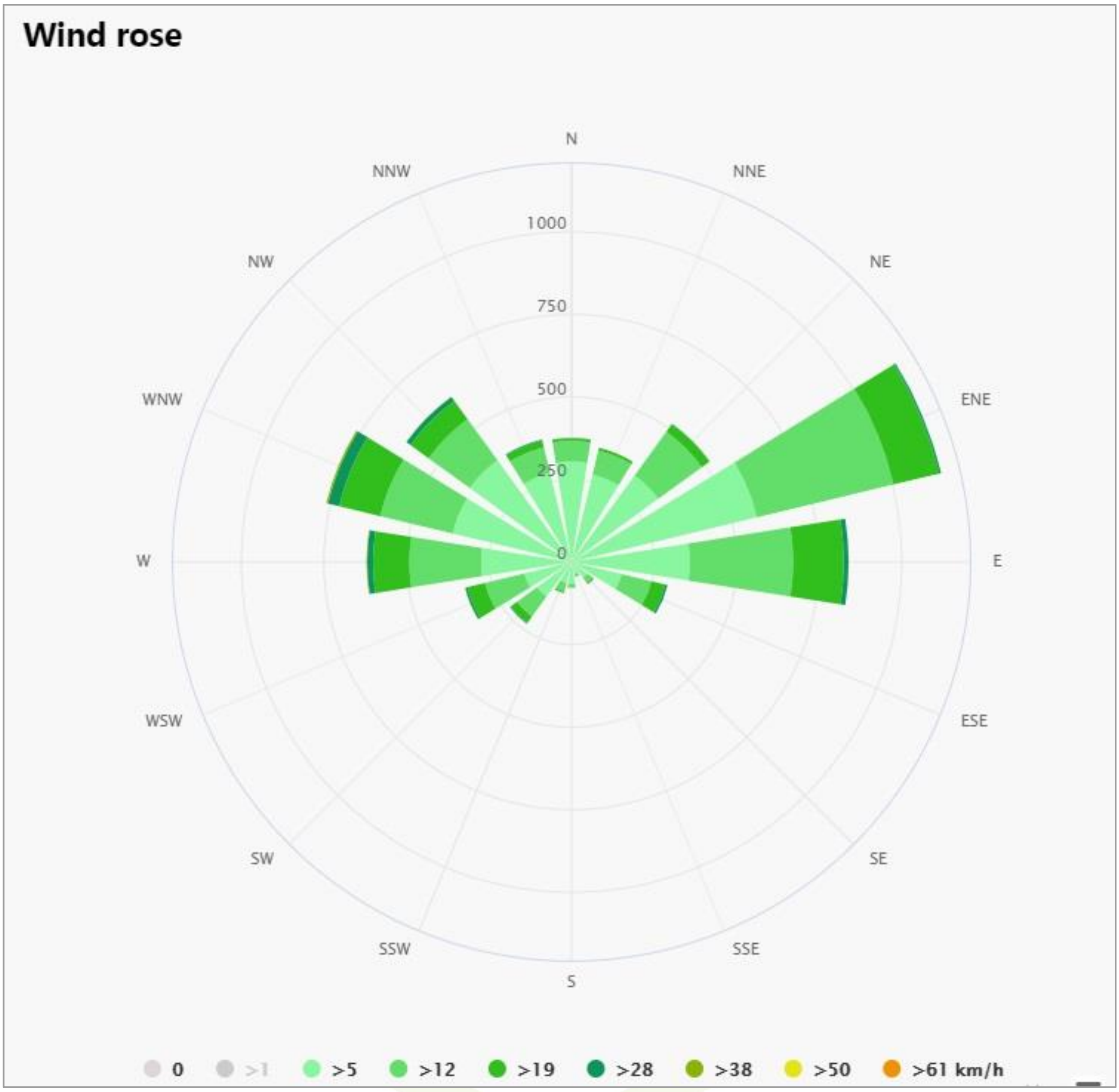


Figure 9: NEMS 30 km simulation model wind rose for the proposed Dunbar Coal project area for the period 1985 to current.

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 5 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 5: 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 23°C to 26°C on average with a maximum of 32°C possible during hot days, dropping to a predicted 9°C to 13°C on average at night and 4°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. October to January are predicted the highest rainfall months with between 76 mm to 107 mm predicted per month during these months. February and March is predicted to receive 54 mm to 55 mm precipitation. All other months are predicted to receive less than 26 mm precipitation on average during the month.

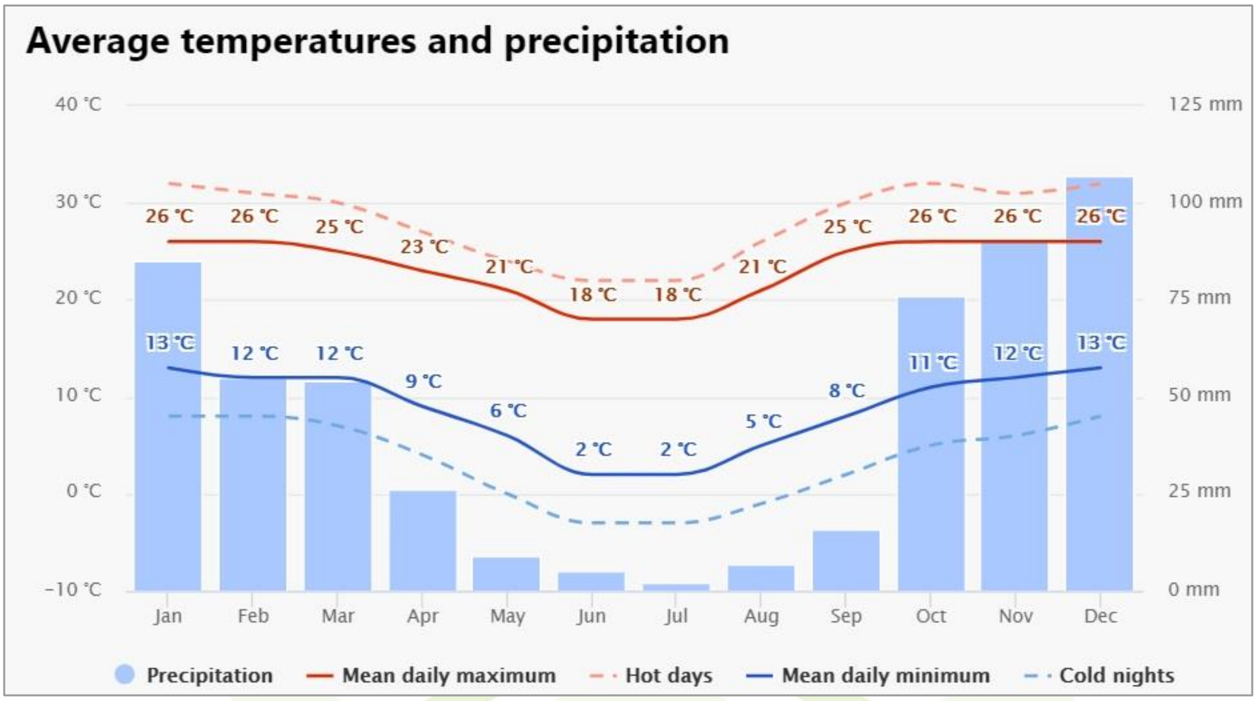


Figure 10: Temp and precipitation simulation results from the NEMS model for the Dunbar Coal project area (1985 - current).

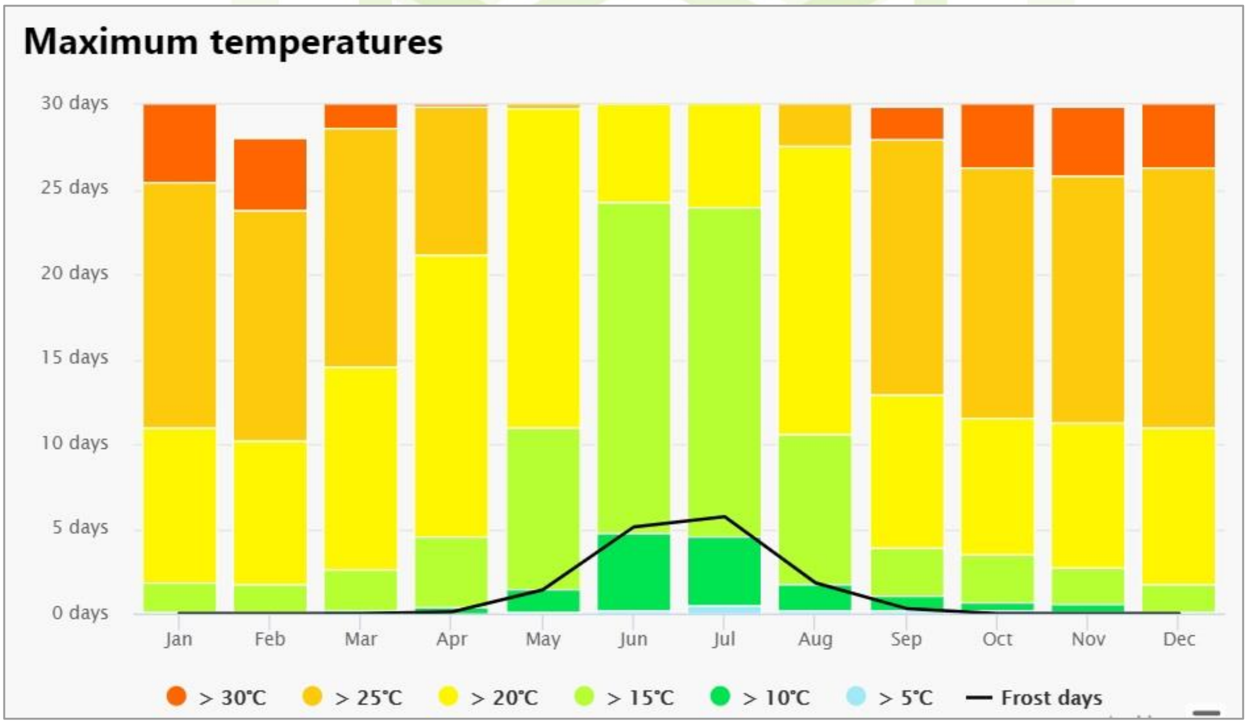


Figure 11: Maximum temperatures as simulated from the NEMS 30 km model for the proposed Dunbar Coal project area (1985 – current).

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 Dunbar Coal project area is shown in Figure 12 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.

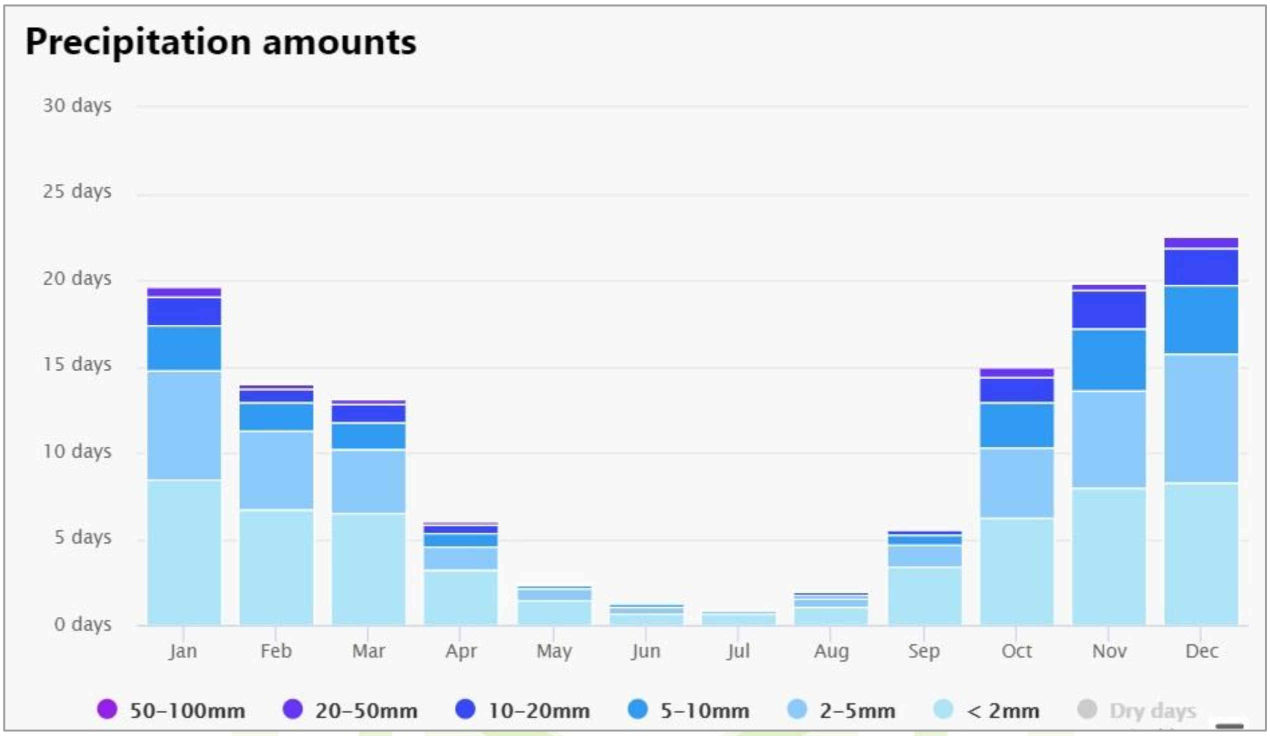


Figure 12: Day count of total daily precipitation per month for the proposed Dunbar Coal project area for the period 1985 – current.

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 13 below show the closest station to the proposed Dunbar Coal project area that fall within the validation criteria as stated above, in this case Ermelo, 58 km away and at a similar altitude. The recorded data show good correlation in respect to temperature and wind speed. No precipitation comparison was made.

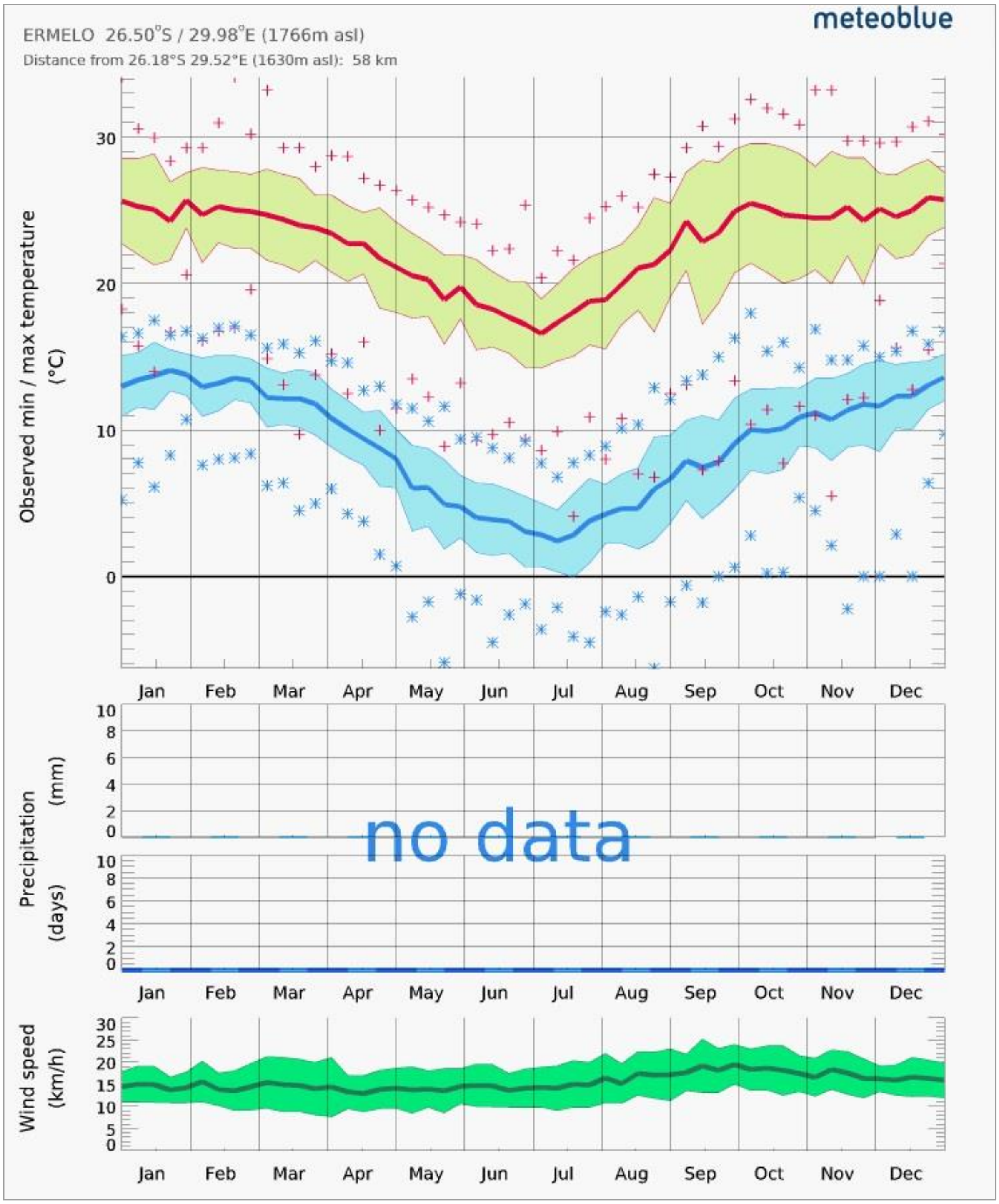


Figure 13: Measurement data for the closest measurement location with enough data to verify the NEMS model result.

3.3 Description Of The activities To Be Undertaken

3.3.1 Description of Mining Method

The mining method that will be used to exploit the different coal seams will be Roll-over Strip mining concurrently with rehabilitation. The roll over mining will make use of dozer and truck and shovel teams to remove the waste material, after drilling and blasting when required, to expose either the seam. Once the coal seam is exposed, it will be mined by truck and shovel operation and hauled via haul road to the crushing and screening plant for further processing. The block size is planned at 100 x 50 m.

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 Dunbar Coal project:

1. Site preparation;
2. Opencast mining;
3. Wind-blown emissions from Discard dumps;
4. Materials handling;
5. Crushing and Screening
6. Hauling of Coal
7. 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)

The National Dust Control Regulations, published on 1 November 2013, in terms of the National Environmental Management Air Quality Act, which prescribes general measures for the control of dust.

Table 6: 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 7 below.

5.2 South African National Standard (Department Environmental Affairs) DEA, 2012

5.2.1 Ambient Air Quality – Limits for Common Pollutants

Table 7, show the published PM10 limits. Table 8 and Table 9 below show the dust deposition evaluation scale and threshold levels respectively.

Table 7: Limits for PM10 in ug/m³

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

Table 8: 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 9: 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. METHODOLOGY

The Dunbar Coal project is a Greenfields project thus it is recommended that at least a baseline dust monitoring campaign be run before the commencement of the project. The samples can then be compared to the guidelines and standards as well as the modelling results while giving attention to the relevant referencing sites of a similar nature in the vicinity of the proposed project area to determine the impacts that have been experienced before. Passive and active sampling techniques to be used for the baseline determination as explained below.

6.1 Passive Sampling

At the time of this report, no passive sampling campaign exist for the proposed Dunbar Coal project. It is highly recommended that a passive sampling campaign be run before the commencement of the project. 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.

6.2 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.

6.2.1 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.

6.2.2 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 10: 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

6.3 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.

6.3.1 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.

6.3.2 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 2017 to 31 December 2018.

6.3.3 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.

6.3.4 Sensitive Receptor Grid

The pollutant dispersion is setup for a modelled domain of 15 km (north-south) by 15 km (east-west) with the centre of the proposed project area in the centre of the modelling domain. The area was divided into a variable grid with the following resolutions:

- 1 km from Centre:
    - 50 m (north-south) by 50 m (east-west).
- 2.5 km from boundary of first grid box:
    - 100 m (north-south) by 100 m (east-west).
- 4 km from the boundary of the second grid box:

200 m (north-south) by 200 m (east-west).

6.3.5 Modelling Runs

Modelling was undertaken for the operational phase scenarios.

1. Un-mitigated - material being handled dry;
2. Mitigated 75% – Sources as Specified with Haul roads at 90% Mitigation.

The construction and decommissioning phases were qualitatively assessed.

6.3.6 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.

7. BASELINE AIR QUALITY MEASUREMENT RESULTS

7.1 Discussion Of The Baseline Air Quality

7.1.1 Sensitive Receptors

Sensitive receptors, Figure 15, identified in the immediate vicinity of the study area and proposed project area have been listed below:

- Farm steads.

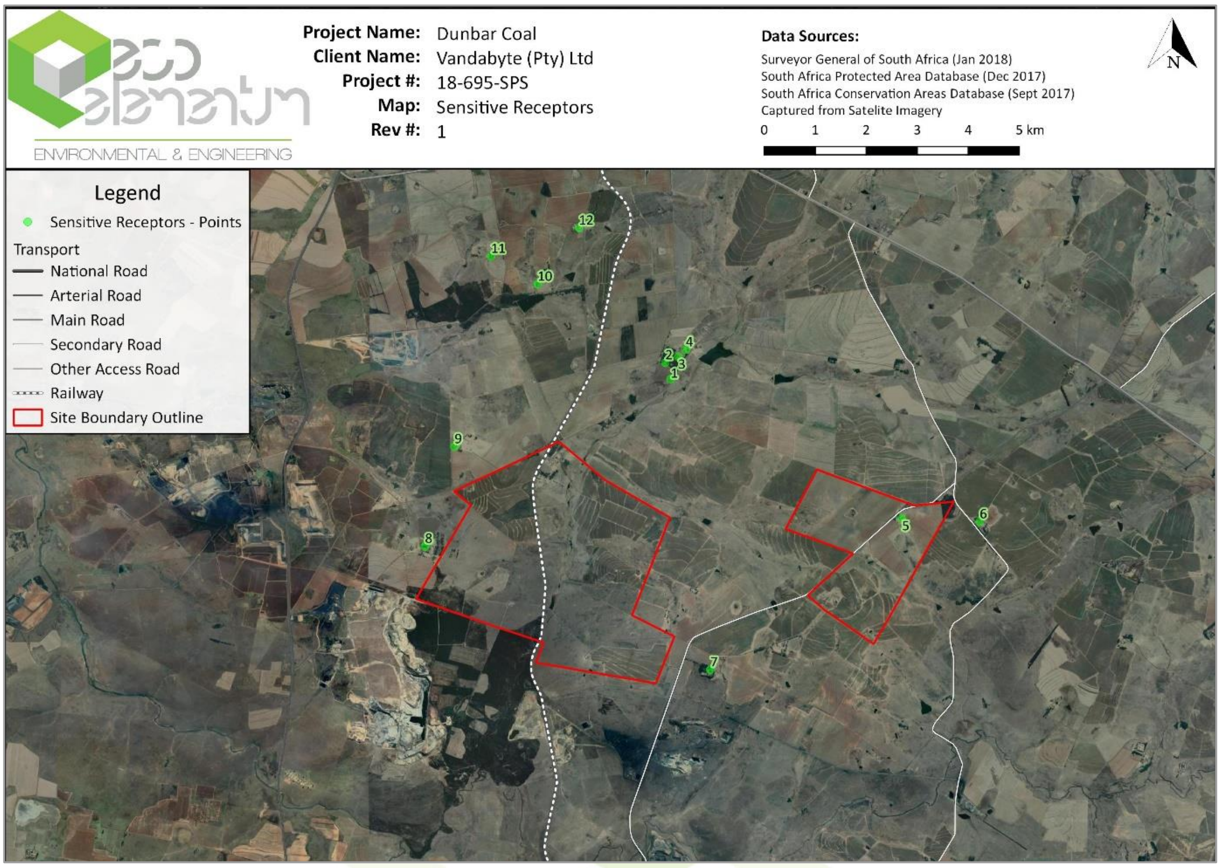


Figure 15: Sensitive receptors in the immediate area of the mining boundary.

7.1.2 Sources of Emissions

7.1.2.1 Vehicle Exhaust Gases

Vehicle exhausts contain a number of pollutants including carbon dioxide (CO^2), 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.

7.1.2.2 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).

7.1.2.3 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.

7.1.2.4 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.

7.1.2.5 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.

7.1.2.6 Agriculture Activities

Little information is available with respect to the emissions generated due to the growing of crops. The activities responsible for the release of particulates and gasses to atmosphere would however include:

- Particulate emissions generated due to wind erosion from exposed areas;
- Particulate emissions generated due to the mechanical action of equipment used for tilling and harvesting operations;
- Vehicle entrained dust on paved and unpaved road surfaces.

7.1.2.7 Plant – Crushing and Screening (Other Mining operations in the Area)

There are two basic methods of crushing, either compressive or impact. The main types within these categories are:

- Compressive; jaw crushers, single and double toggles, gyratory crushers, cone crushers, roll crushers, ball mills and rod mills.
- Impact; rotary or vertical shaft impactors (e.g. Barmac), hammer mills (fixed or swing hammers).

Compressive crushing produces dust but does not in itself produce a great deal of air movement, but rather the material passing through the crusher causes the dust from the process and the processed material to become airborne. Excessive clearance under the crusher can cause a lot of dust generation in the same way as a high discharge point. Impact-type crushers, for example hammer mills, act as powerful fans and not only produce dust from the impact of hammer on rock, but also blow the dust out.

Screening provides the most difficult dust control problem in mining operations, particularly if dry screening is taking place. Very careful planning of screen layout has to be undertaken to take out the fine cut as early as possible to lessen the dust carried through the screening process, and allow the use of water to both clean chip and allay dust, as water is the cheapest form of dust suppression there is. In most cases, the crushing and screening process represents a significant source of fugitive dust with high quantities of respirable fractions released to the atmosphere. Dust sources around the plant, apart from crushing and screening, include discharge into hoppers, long open chutes, and from conveyors and transfer points. High discharge heights produce an air pressure blast effect and create turbulence, which carries dust into the air. This also causes particle fracture, and free fall allows the wind to pick up and carry the dust for a long distance from the discharge point.

8. DISPERSION MODEL

8.1 Process Flow

The high level process flow of the proposed mining operation is illustrated in Figure 16 below.

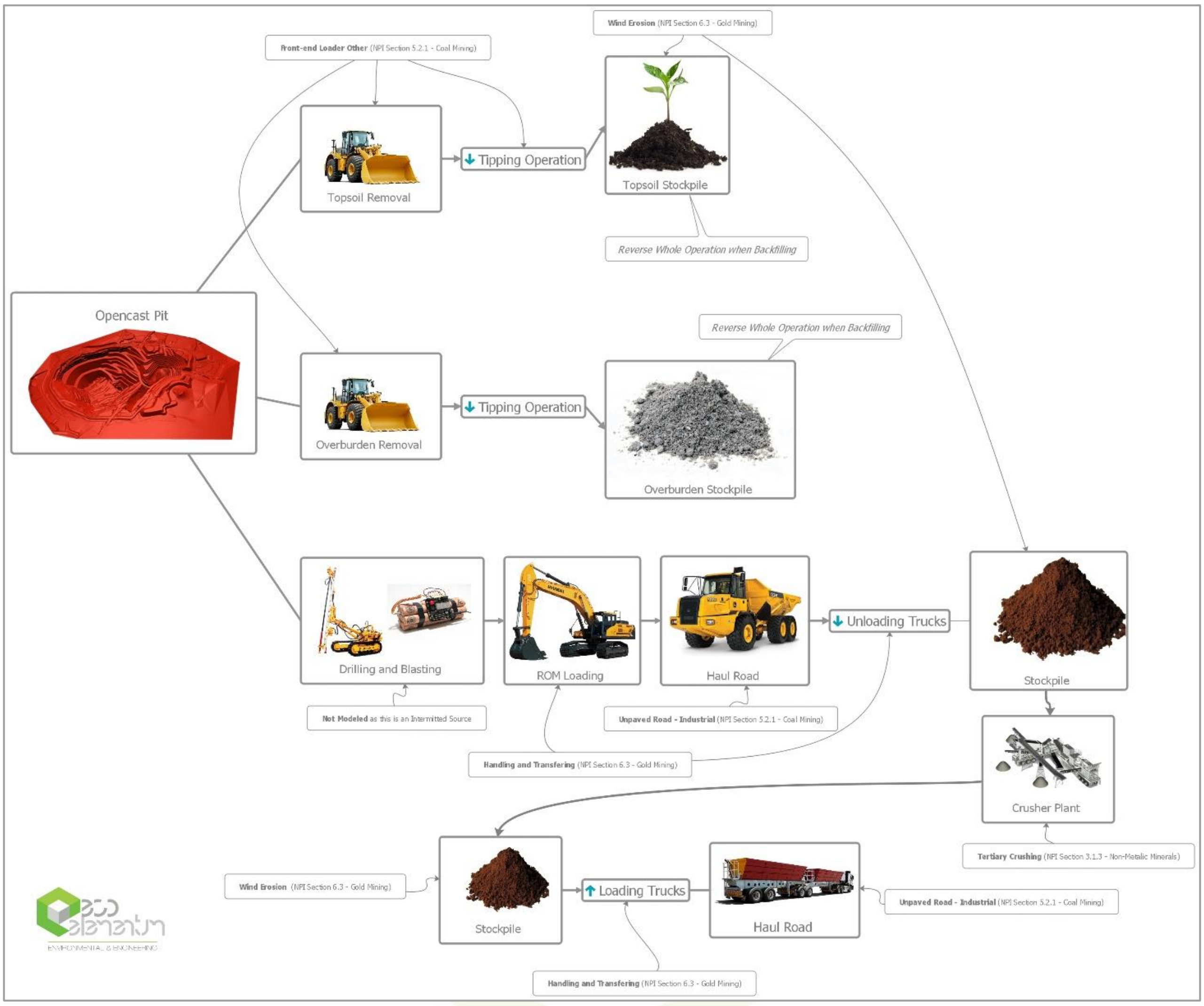


Figure 16: High level Mining Process Flow of the Rondevly Coal project.

8.2 Emissions Inventory

Table 11 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 11: Modelling Parameter Summary

Project Specific Information			
Type	**Spec**	**Quantity**	**Unit**
Material	ROM	14 5643	tpm
	Topsoil	19 154	tpm
	OVB	655 393	tpm

Project Specific Information			
Material Bulk Density	ROM	1.4	g/cm^3
	Topsoil*	1.5	g/cm^3
Note: Sandstone	OVB*	2.65	g/cm^3
Operations	Hours (Pit)*	20	
	Hours (Plant)*	24	
	Days*	31	
Stockpile - ROM	Height*	15	m
Stockpile - Topsoil	Height*	15	m
Stockpile - OVB	Height*	30	m
Haul Road	Width*	9	m
	Length*	1.8	km
Access Road	Width*	9	m
	Length*	2.6	km
Haul Trucks - ROM	Type	Bell B40D	
	Height	4.2	m
	Width	3.8	m
	Payload	37	t
	Trips	12.70	per h
	VKT	22.86	per h
Commercial Trucks	Type*	Side Tipper Interlink	
	Height*	3.1	m
	Width*	2.6	m
	Payload	38	t
	Trips	12.36	per h
	VKT	32.15	per h
Note:	** Assumed*		

Table 12: NPI Emission Factors

NPI Emission Factors				
Operation	**TSP**	**PM_{10}**	**Units**	**Rating**
Excavators				
Shovels				
Front-end Loaders				
(Overburden)	0.025	0.012	kg/t	U
Excavators				
Shovels				

NPI Emission Factors				
Front-end Loaders				
(ROM)"	0.029	0.014	kg/t	C
Wind Erosion	0.4	0.2	kg/ha/h	U
Haul Road	4.23	1.25	kg/VKT	B
Truck Dumping (Overburden)	0.012	0.0043	kg/t	U
Note:	Controlled = Water Sprays used			

Many published emission factors have and associated emission factor rating (EFR) code. These EFR codes are based on rating systems developed by the USEPA and by the European Environmental Agency. See Table 13 below.

Table 13: Emission Factor Ratings

Factor Ratings	
A	Excellent
B	Above Average
C	Average
D	Below Average
E	Poor
U	Unrated

8.2.1 Mitigation Measures

Mitigation measures proposed are discussed below.

8.2.1.1 Opencast Pit

50% mitigation on the various operations can be achieved using water sprays according to the Australian NPI.

8.2.1.2 Crusher

Crushing represents significant dust-generating sources. Dust fallout in the vicinity of crushers increase the potential for re-entrainment of dust by vehicles or wind. The large percentage of fines in the deposited material enhances the potential for it to become airborne. According to the Australian NPI, dust generation at Crushers can be mitigated by 50% with water sprays to keep the ore wet. When using hooding with fabric filters emissions can be reduced by 83%.

8.2.1.3 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.

8.2.1.4 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.)

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.

8.2.1.5 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.

The 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:

- measures aimed at reducing the extent of unpaved roads, e.g. paving,
- traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds, and
- 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:

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

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)

Table 14: Calculated Source Emission Rates Summary

Emissions Released								
Operation	Unmitigated			Mitigated				
	TSP	PM10	Unit	TSP	PM10	Unit	Reduction	Method
Excavator ROM	1.892	0.914	g/s	0.946	0.457	g/s	50%	Water Sprays
Excavator Overburden	7.341	3.524	g/s	3.670	1.762	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
				1.11E-06	5.56E-07	g/s/m²	90%	Revegetation on OB and Topsoil
Access Haul Road	4.20E-03	1.24E-03	g/s/m²	1.05E-03	3.10E-04	g/s/m²	75%	Level 2 Watering (>2 liters/m²/h)
				4.20E-04	1.24E-04		90%	Encrusting (Dust Aside or Similar)
Pit Haul Road	2.98E-03	8.82E-04	g/s/m²	7.46E-04	2.20E-04	g/s/m²	75%	Level 2 Watering (>2 liters/m²/h)
				2.98E-04	8.82E-05		90%	Encrusting (Dust Aside or Similar)
Truck Dumping (Overburden)	3.524	1.263	g/s	1.762	0.631	g/s	50%	Water Sprays
Truck Dumping (ROM)	0.653	0.274	g/s	0.326	0.137	g/s	50%	Water Sprays
Inpit Operations	12.757	5.700	g/s	6.378	2.850	g/s	50%	Inpit
Loading Stockpiles	0.261	0.111	g/s	0.131	0.055	g/s	50%	Water Sprays

8.3 Modelling Results

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

1. Un-mitigated - material being handled dry;
2. Mitigated 75% – Sources as Specified with Haul roads at 90% Mitigation.

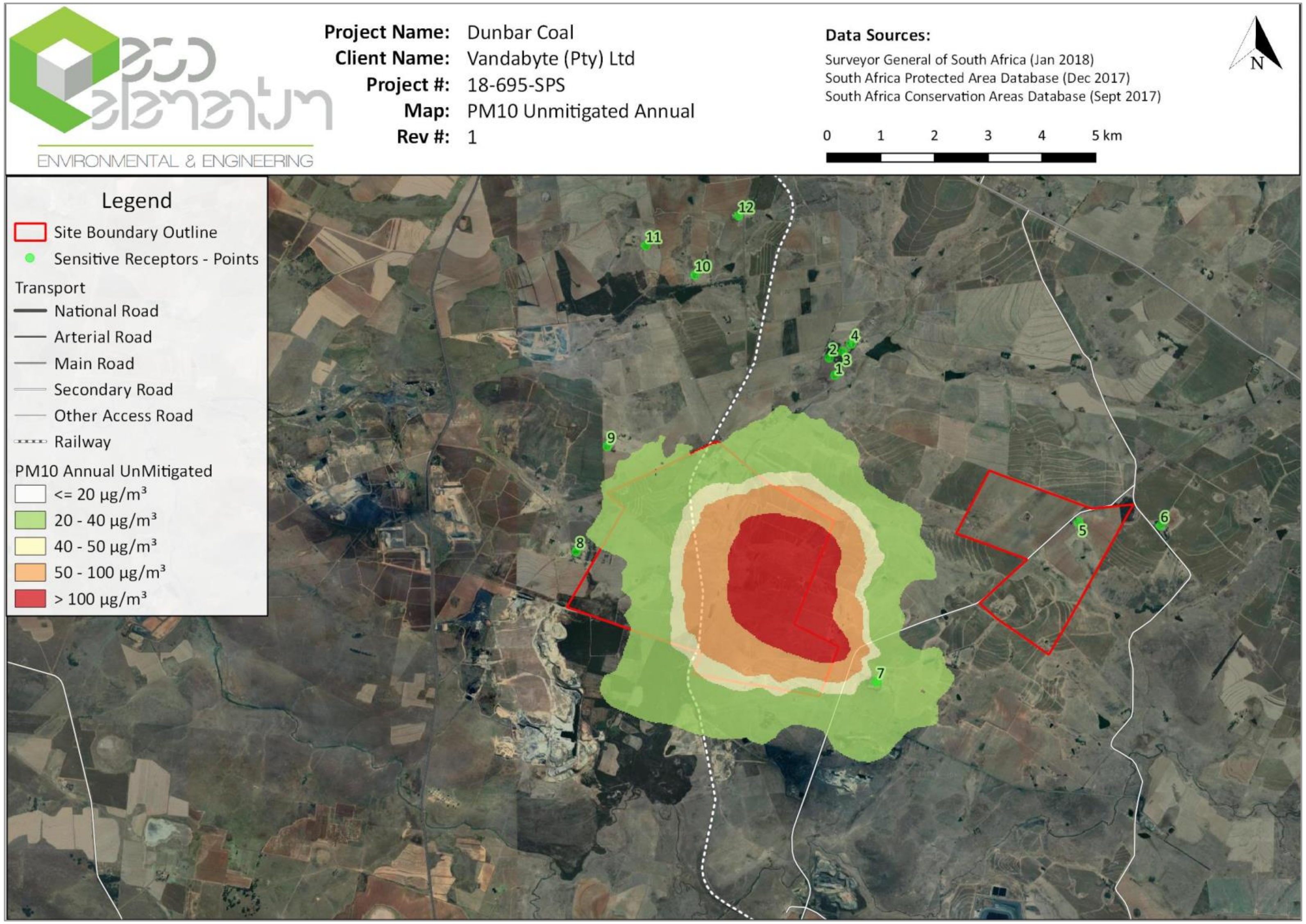


Figure 17: Predicted average annual concentrations for PM10 for the proposed Dunbar Coal project when unmitigated.

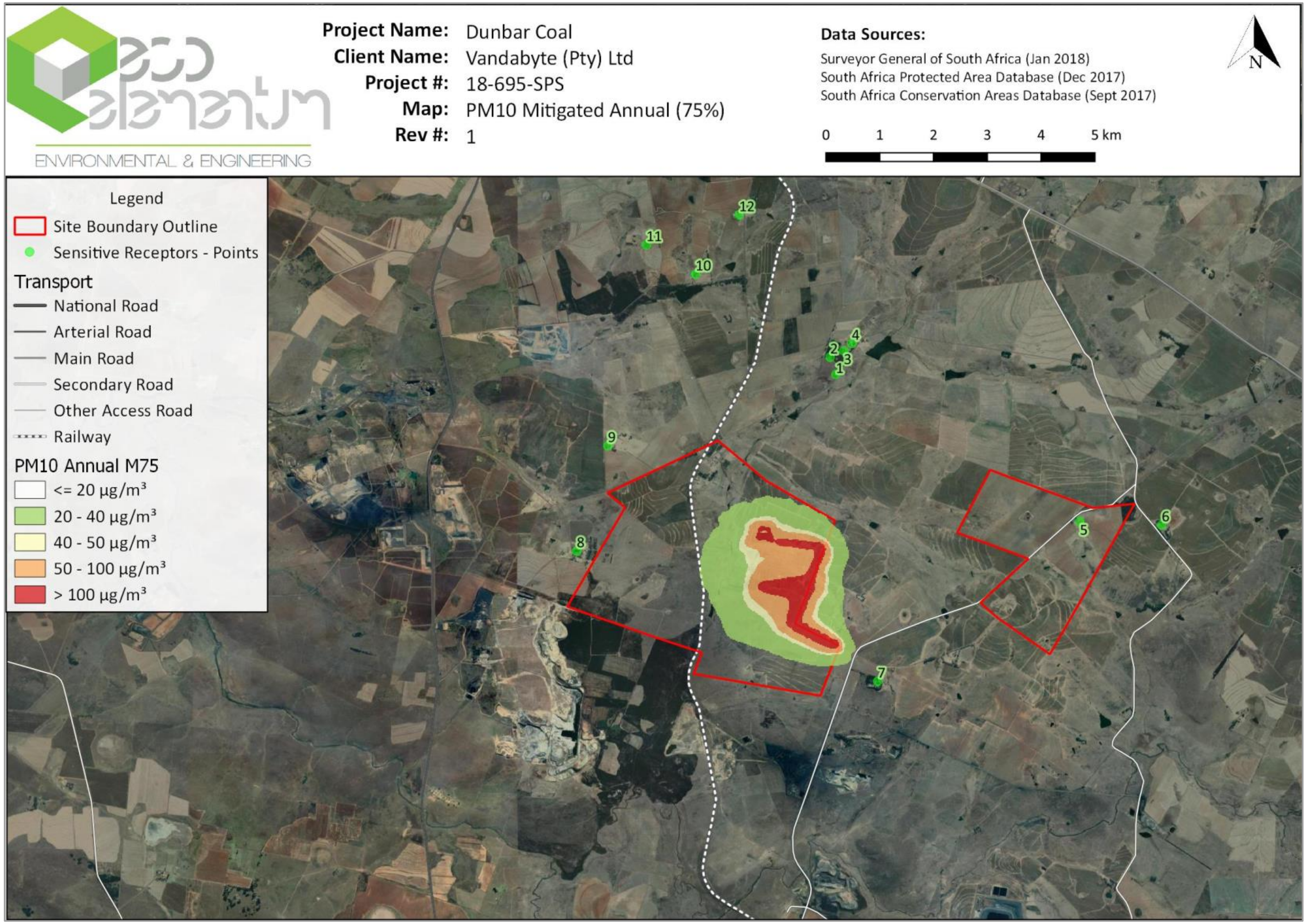


Figure 18: Predicted average annual concentrations for PM10 for the proposed Dunbar Coal project operations when mitigated with Haul Roads at 75%.

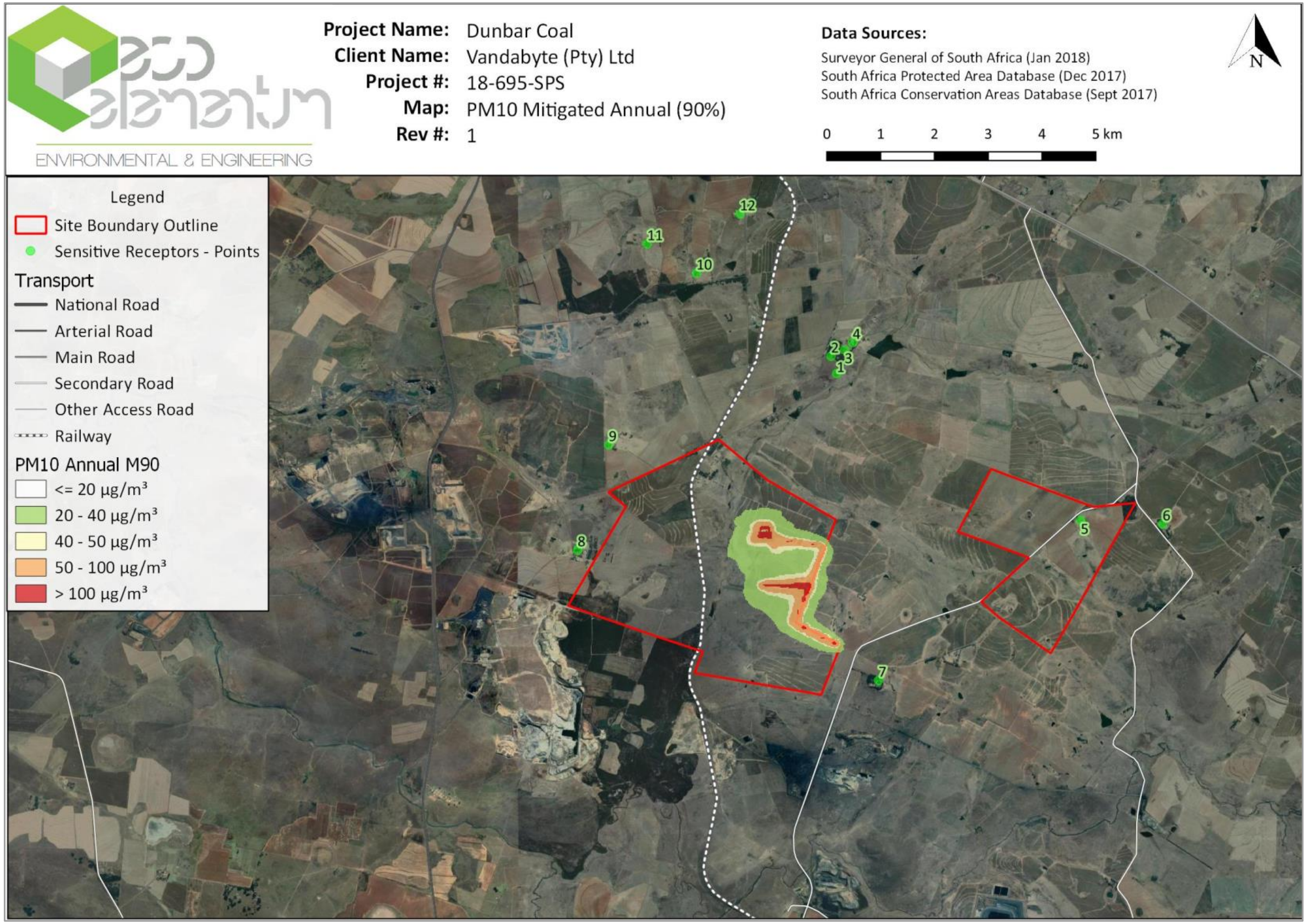


Figure 19: Predicted average annual concentrations for PM10 for the proposed Dunbar Coal project operations when mitigated with Haul Roads at 90%.

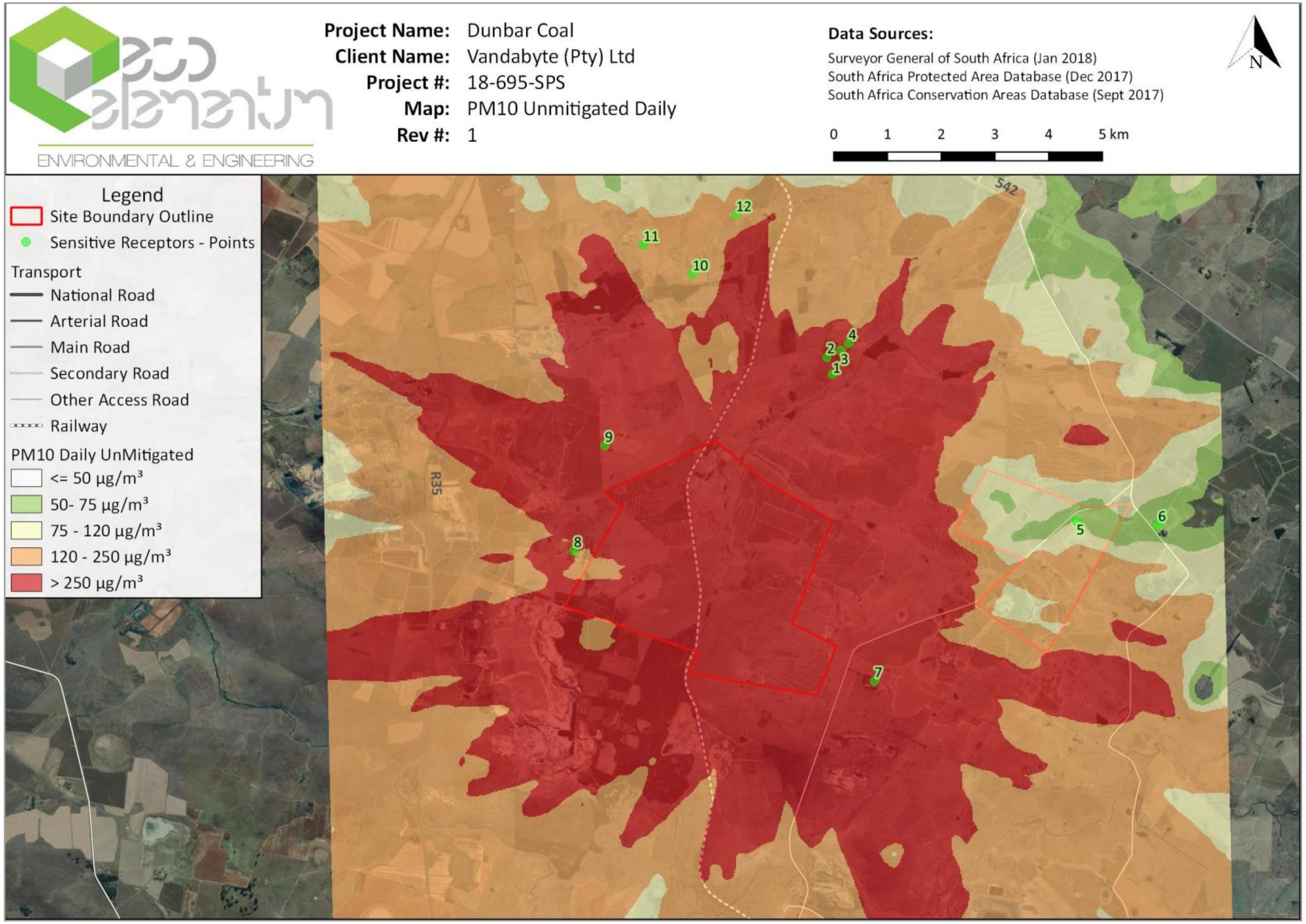


Figure 20: Predicted 2nd Highest daily concentrations for PM10 for the proposed Dunbar Coal project operations when unmitigated.

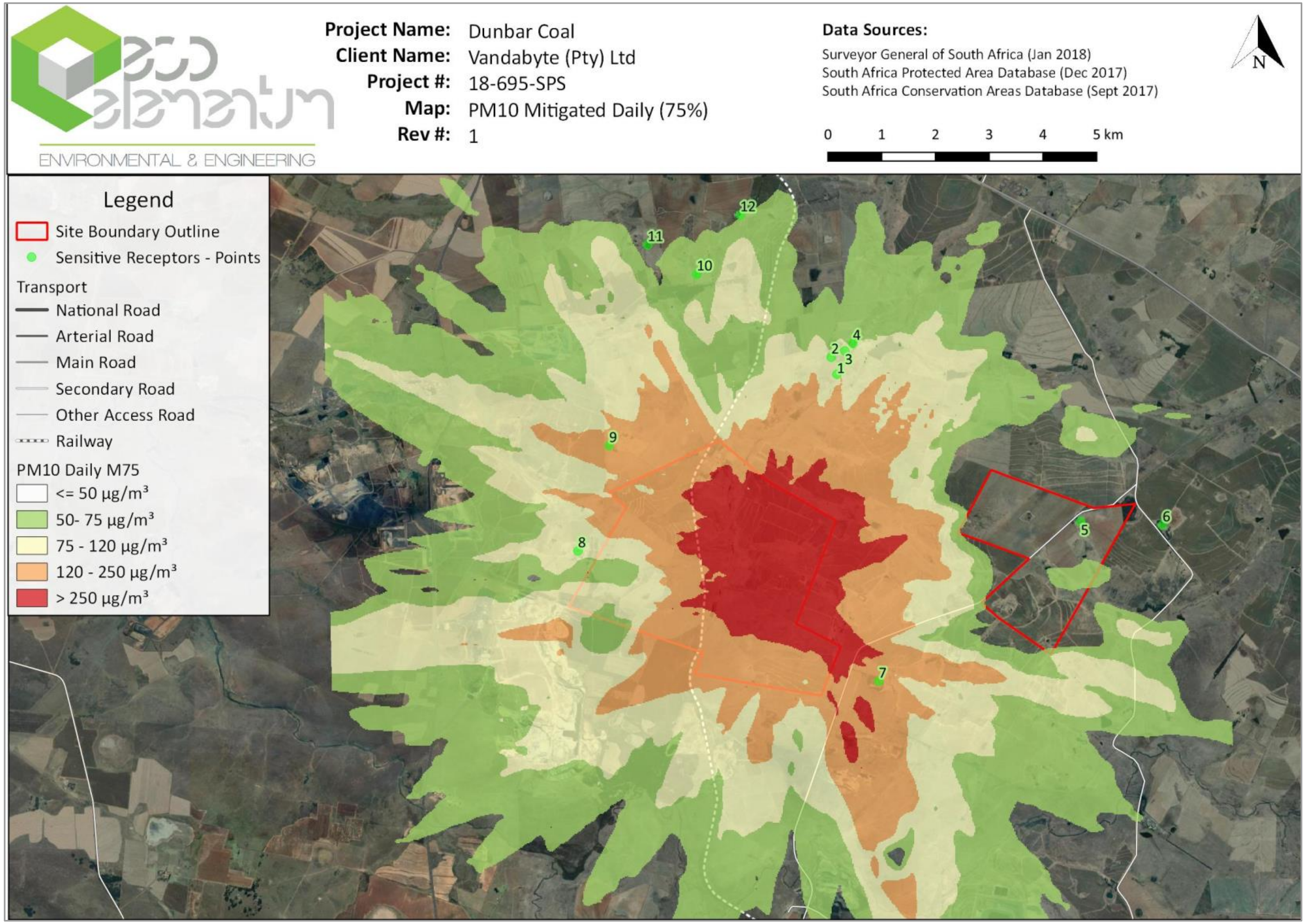


Figure 21: Predicted 2nd Highest daily concentrations for PM10 for the proposed Dunbar Coal project operations when mitigated with Haul Roads at 75%

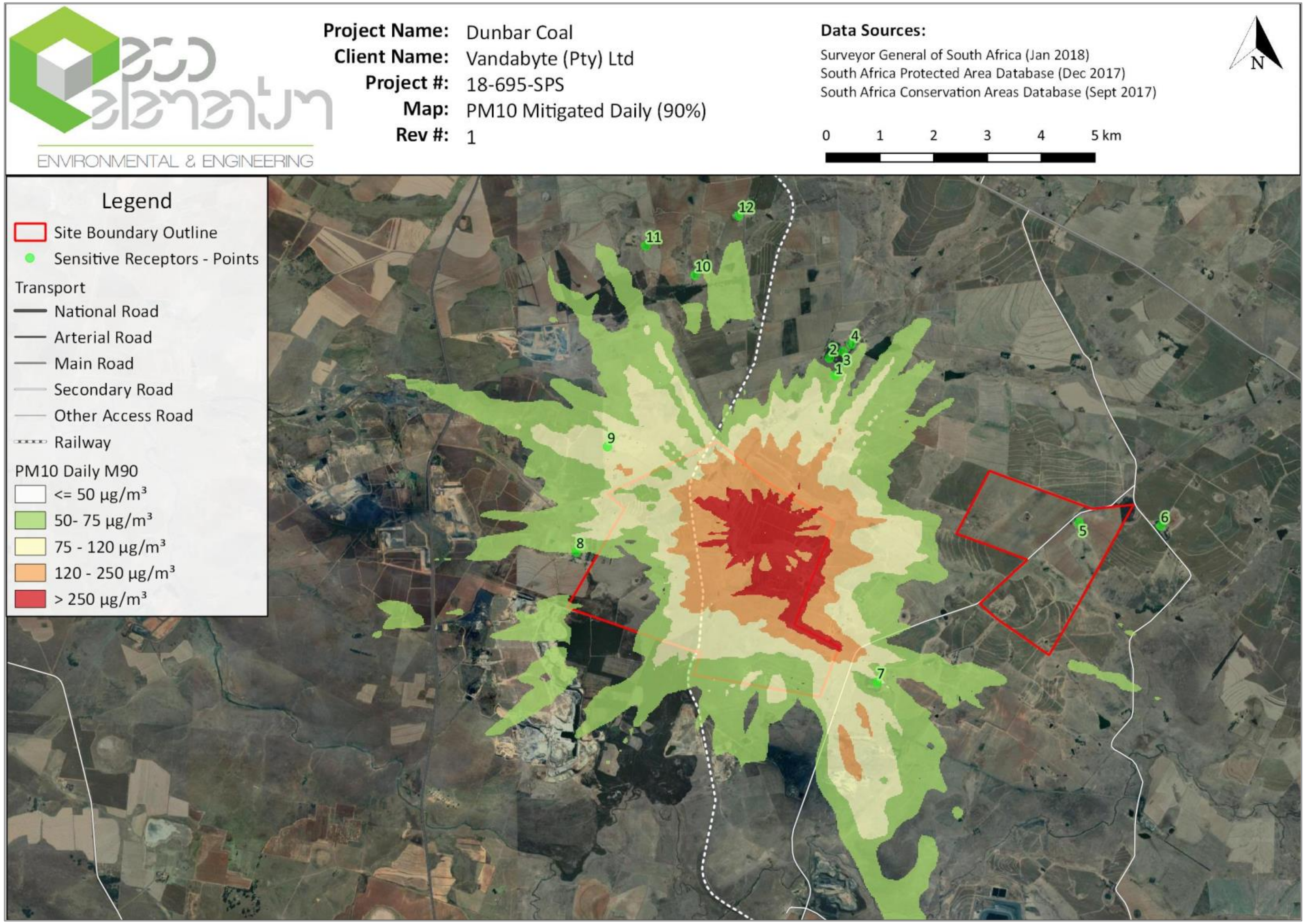


Figure 22: Predicted 2nd Highest daily concentrations for PM10 for the proposed Dunbar Coal project operations when mitigated with Haul Roads at 90%

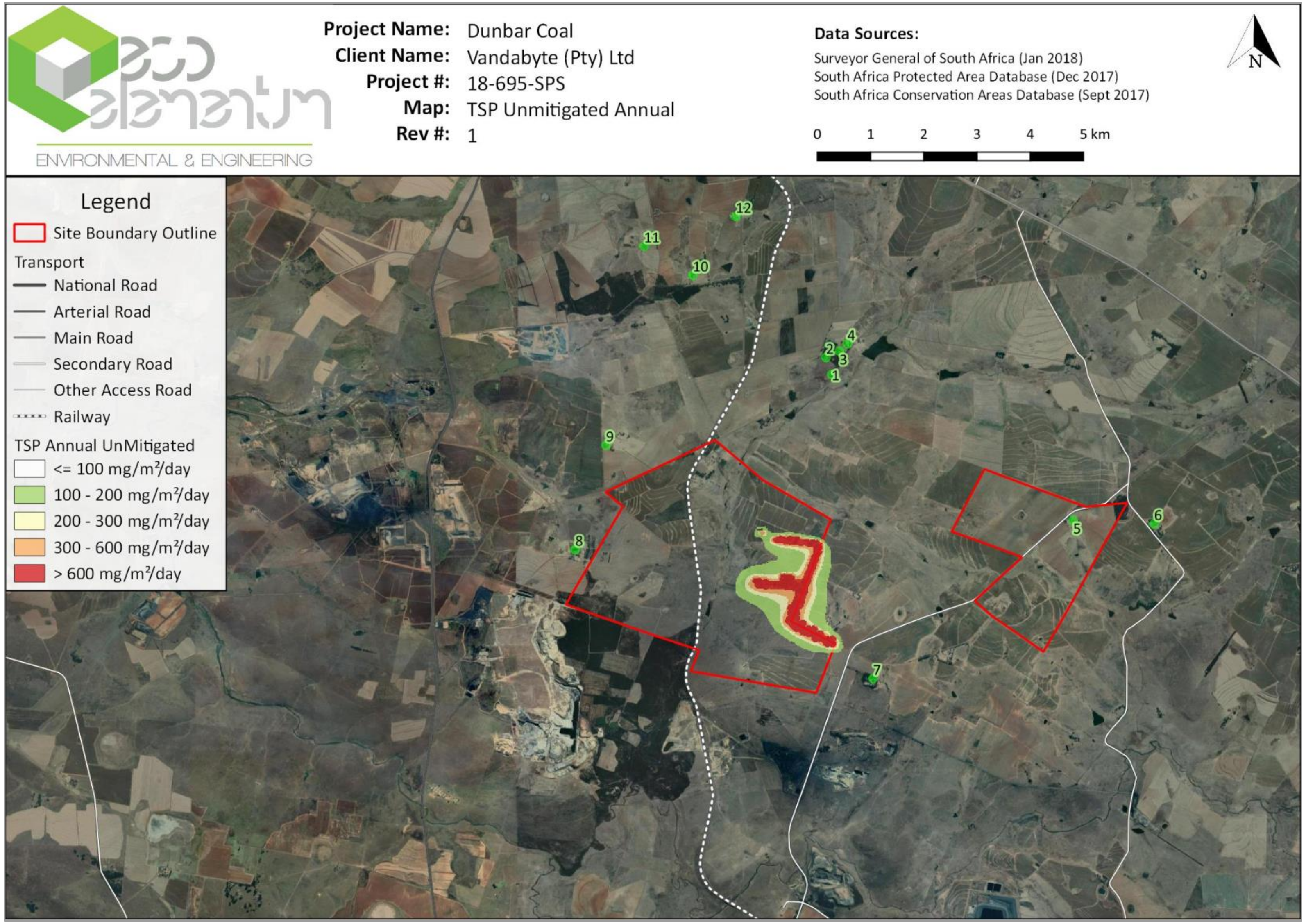


Figure 23: Predicted average annual concentrations for TSP for the proposed Dunbar Coal project when unmitigated.

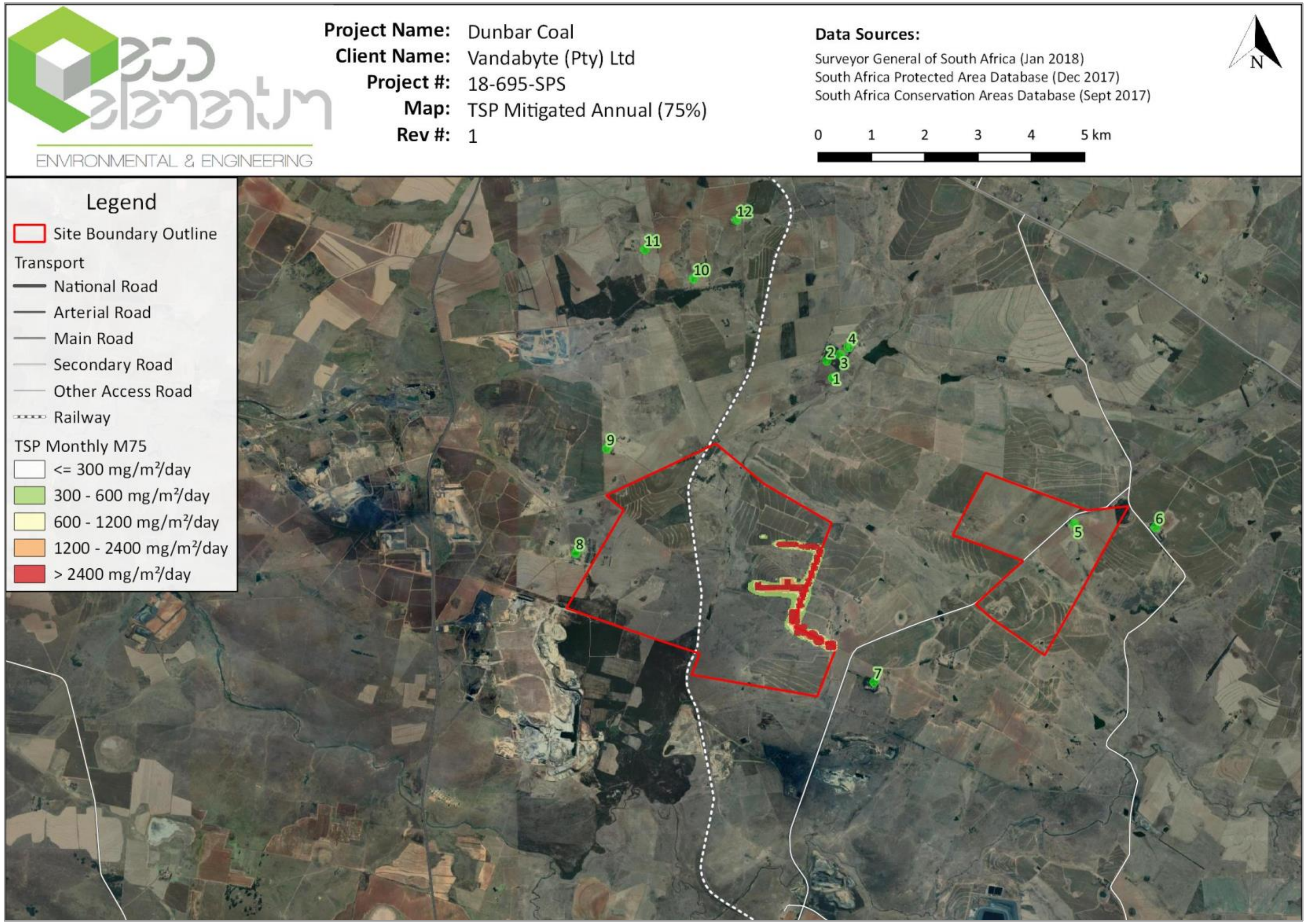


Figure 24: Predicted average annual concentrations for TSP for proposed Dunbar Coal project operations when mitigated with Haul Roads at 75%.

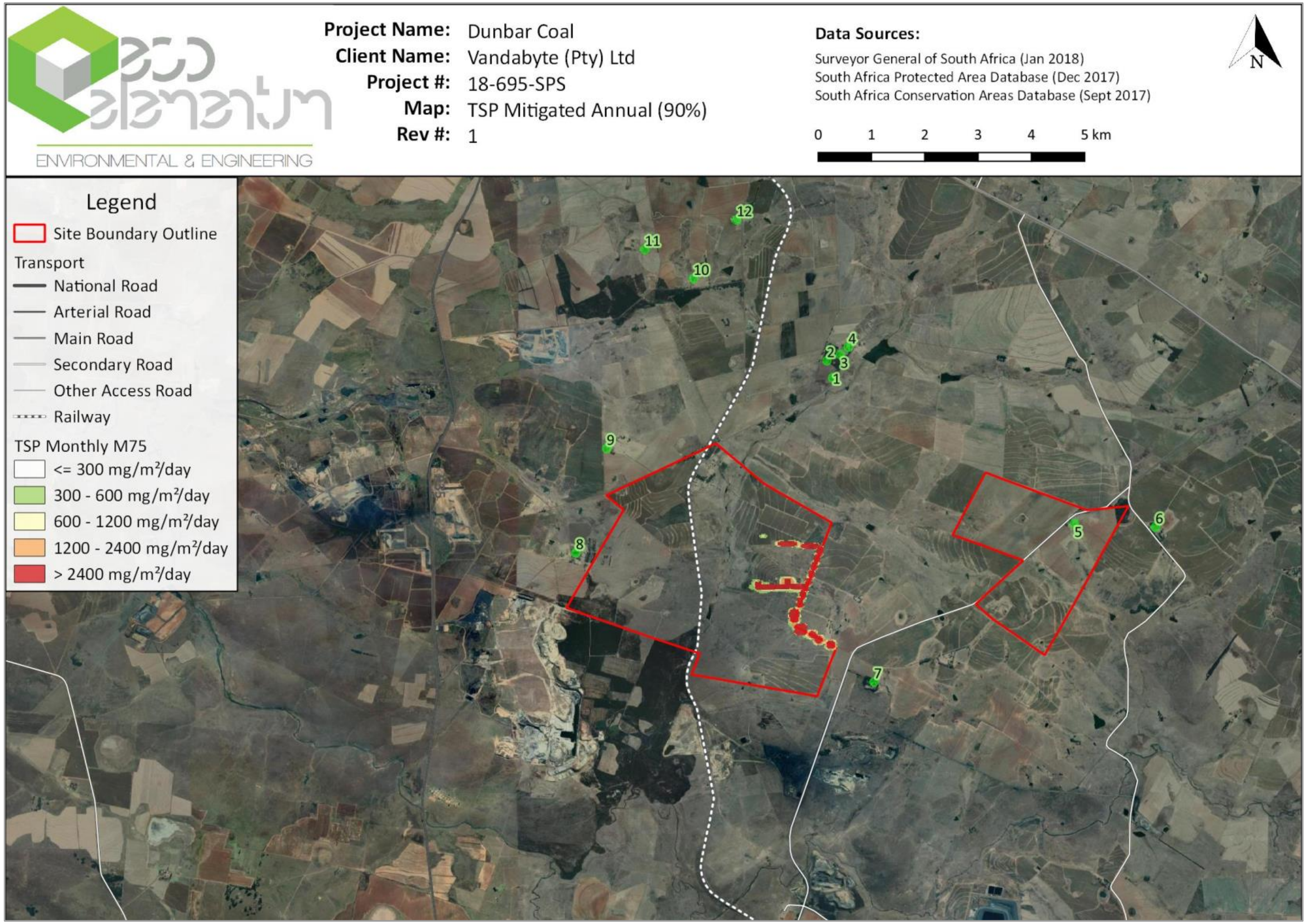


Figure 25: Predicted average annual concentrations for TSP for proposed Dunbar Coal project operations when mitigated with Haul Roads at 90%.

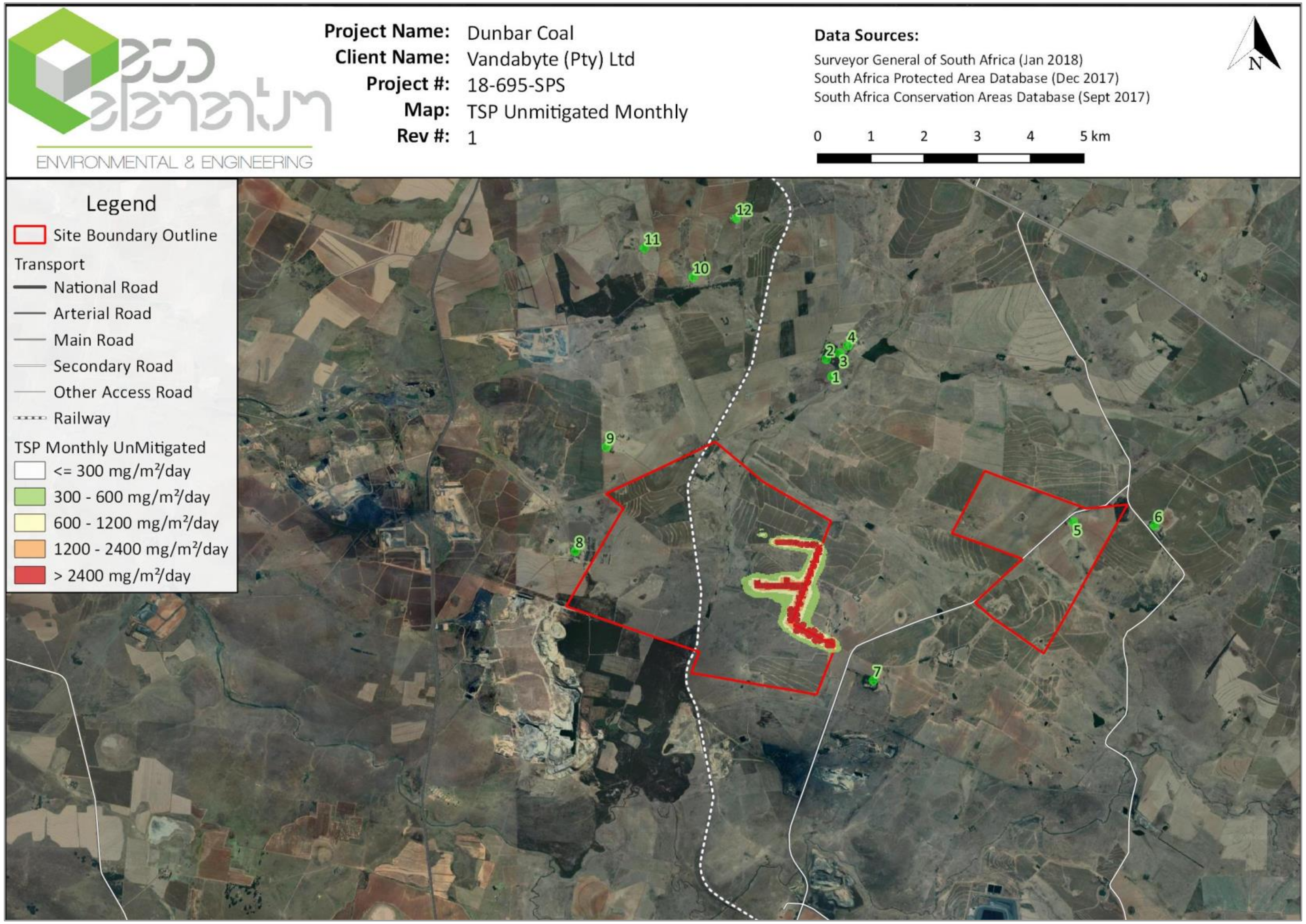


Figure 26: Predicted Highest Monthly concentrations for PM10 for proposed Dunbar Coal project operations when unmitigated.

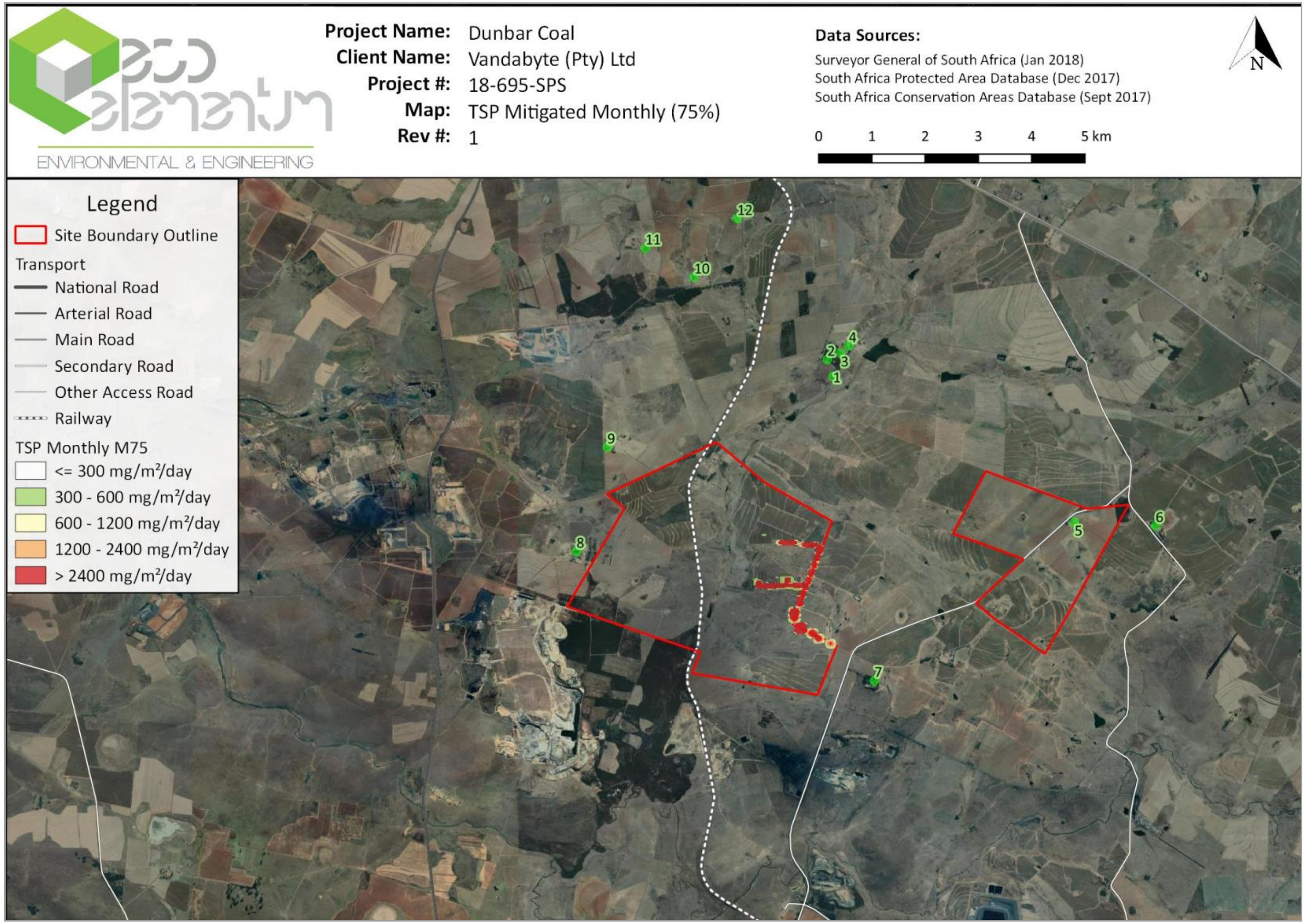


Figure 27: Predicted Highest Monthly concentrations for PM10 for proposed Dunbar Coal project operations when mitigated with Haul Roads at 75%

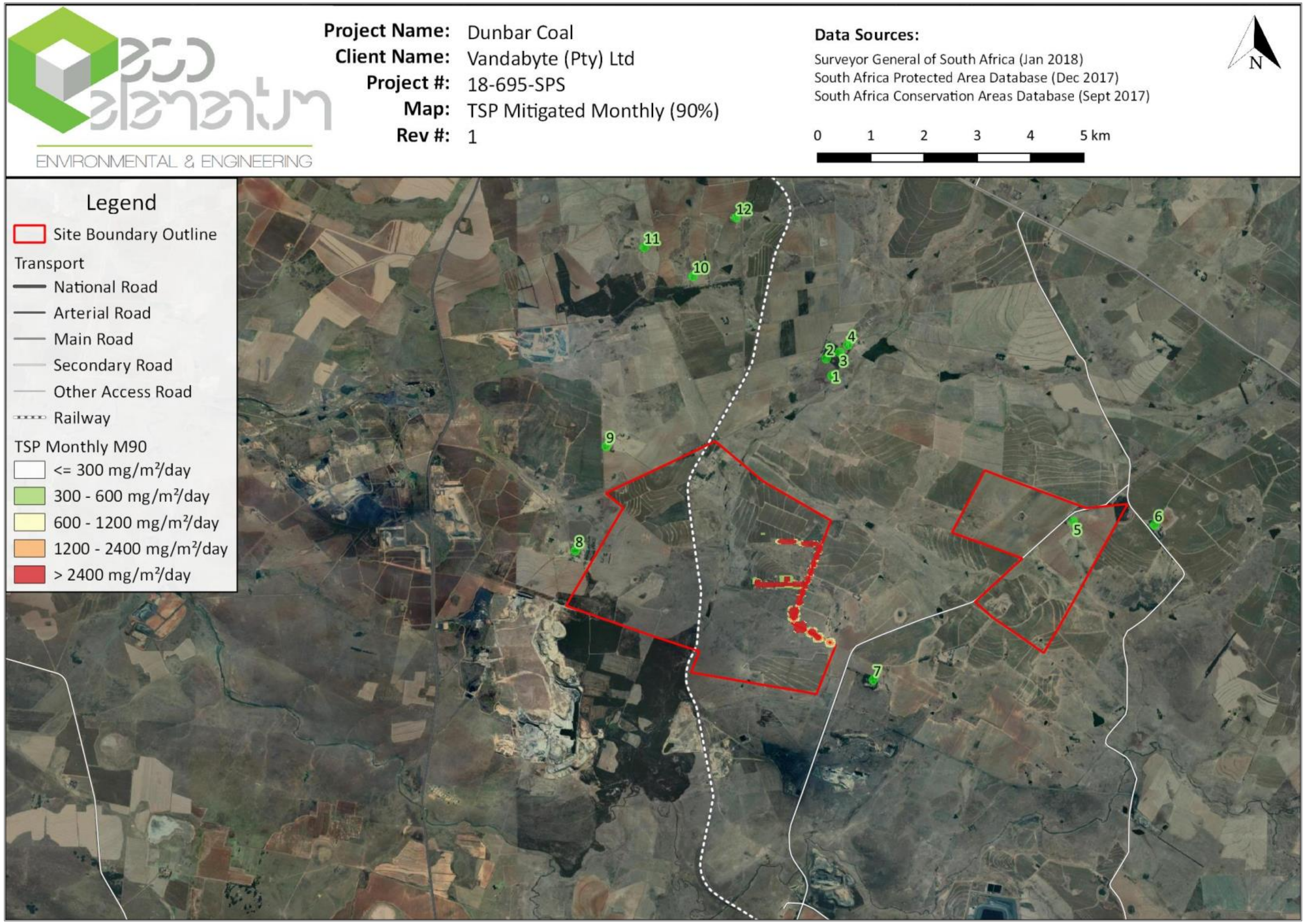


Figure 28: Predicted Highest Monthly concentrations for PM10 for proposed Dunbar Coal project operations when mitigated with Haul Roads at 90%

9. IMPACT ASSESSMENT

9.1 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. ***Severity*** of the impact;
2. **Spatial Scale** - The physical and spatial scale of the impact;
3. ***Duration*** - The lifetime of the impact, measured in relation to the lifetime of the proposed development;
4. ***Frequency of the Activity*** – How often do the activity take place;
5. ***Frequency of the incident/impact*** – How often does the activity impact on the environment;
6. ***Legal Issues*** – How is the activity governed by legislation;
7. ***Detection*** – How quickly/easily the impacts/risks of the activity be detected on the environment, people and property;

To ensure uniformity, the assessment of potential impacts will be addressed in a standard manner so that a wide range of impacts is comparable. For this reason a clearly defined rating scale will be provided to the specialist to assess the impacts associated with their investigation.

Table 15: Assessment criteria

SEVERITY	
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful / within a regulated sensitive area	5
SPATIAL SCALE	
Area specific (at impact site)	1
Whole site (entire surface right)	2
Local (within 5 km)	3
Regional / neighboring areas (5 km to 50 km)	4
National	5
DURATION	
One day to one month (immediate)	1
One month to one year (Short term)	2
One year to 10 years (medium term)	3
Life of the activity (long term)	4
Beyond life of the activity (permanent)	5
FREQUENCY OF THE ACTIVITY	
Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5
FREQUENCY OF THE INCIDENT/IMPACT	
Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5
LEGAL ISSUES	
No legislation	1
Fully covered by legislation	5

DETECTION	
Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5
Immediately	1

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.

9.1.1 Consequence

Consequence is determined by the following equation after the assessment of each impact.

Consequence = Severity + Spatial Scale + Duration

9.1.2 Likelihood

The Likelihood of the activity is then calculated based on frequency of the activity and impact, how easily it can be detected and whether the activity is governed by legislation. Thus:

Likelihood = Frequency of activity + frequency of impact + legal issues + detection

9.1.3 Risk

The risk is then based on the consequence and likelihood.

Risk = Consequence x likelihood

9.1.4 Impact Ratings

The impact is then rated according to the following table:

Table 16: Impact Rating Table

Rating	Class
1-55	(L) Low Risk
56-169	(M) Moderate Risk
170-600	(H) High Risk

9.2 PREDICTED IMPACTS

9.2.1 Summarised Impacts According To Development Phases

Table 17: 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).

9.2.2 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 18: Activity 1: Site Clearing, removal of topsoil and vegetation

Mining Phase	Construction Phase		
Impact description	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.		
		Unmitigated	**Mitigated**
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	**2**	**2**
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5km to 50km) (4); National (5)]	**1**	**1**
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	**2**	**2**
	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	**4**	**4**
	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	**4**	**3**
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	**5**	**5**
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	**2**	**2**
Consequence	Severity + Spatial Scale + Duration	**5**	**5**
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	**15**	**14**
Risk	Consequence * Likelihood	**MODERATE (75)**	**MODERATE (70)**
Mitigation Measures	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.		

Mining Phase	Construction Phase
	- 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. - 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 19: 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). Opencast mining will commence with the stripping of the vegetation for the initial box cut. 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.		
		Unmitigated	**Mitigated**
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	**2**	**2**
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5km to 50km) (4); National (5)]	**1**	**1**
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	**2**	**2**
	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	**4**	**4**

	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	**4**	**3**
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	**5**	**5**
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	**2**	**2**
Consequence	Severity + Spatial Scale + Duration	**5**	**5**
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	**15**	**14**
Risk	Consequence * Likelihood	**MODERATE (75)**	**MODERATE (70)**
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 20: 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.		
		Unmitigated	**Mitigated**
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	**2**	**2**
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5km to 50km) (4); National (5)]	**1**	**1**
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	**2**	**2**

	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	**4**	**4**
	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	**4**	**3**
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	**5**	**5**
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	**2**	**2**
Consequence	Severity + Spatial Scale + Duration	**5**	**5**
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	**15**	**14**
Risk	Consequence * Likelihood	**MODERATE (75)**	**MODERATE (70)**
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.		

9.2.3 Operational Phases

1. Un-mitigated - material being handled dry;
2. Mitigated 75% – Sources as Specified with Haul roads at 90% Mitigation;

Year 5 of the proposed operation throughput where used as this is the highest throughput rates, thus maximum impact on air quality is expected during this period.

9.2.3.1 PM10

For the unmitigated Daily PM10 concentrations it was predicted to be higher than the 75 µg/m³ limit for 11 of the 12 sensitive receptors with major exceedances at most of the receptors.

When comparing the Daily Mitigated PM10 modelled concentrations for the Haul Roads at 75% mitigation, the sensitive receptors exceeding the 75 µg/m³ limit drop to 6 out of the 12 identified sensitive receptors. With the Haul Roads at 90% mitigation only 1 identified sensitive receptor are predicted to exceed the 75µg/m³ limit. It should be noted that this is the2nd highest levels predicted for a 24 hour period within the period. Due to site specific atmospheric conditions these exceedances may still occur within the limit of 4 per year.

The annual average PM10 limit of 40 µg/m³ are not predicted to exceed at any of the identified sensitive receptors for any of the modelled scenarios.

Table 21: PM Concentrations at sensitive receptors

Receptor	PM10 2nd Highest Daily (µg/m³)			PM10 Annual Average (µg/m³)		
	Unmitigated	Mitigated 75%	Mitigated 90%	Unmitigated	Mitigated 75%	Mitigated 90%
1	**428.64**	**108.78**	48.07	13.28	3.65	1.87
2	**300.18**	**75.34**	34.41	10.56	2.86	1.42
3	**358.32**	**89.78**	36.31	9.14	2.44	1.17
4	**279.22**	70.91	29.38	7.86	2.13	1.05
5	**78.80**	19.70	8.62	2.07	0.55	0.26
6	53.03	13.26	6.35	1.60	0.42	0.20
7	**729.25**	**183.29**	73.34	37.48	9.65	4.21
8	**240.60**	**82.28**	51.04	15.85	4.46	2.39
9	**433.33**	**133.14**	**86.41**	16.99	4.82	2.63
10	**206.33**	60.51	38.57	7.49	2.19	1.27
11	**126.72**	31.98	18.80	4.17	1.13	0.57
12	**191.55**	49.77	22.30	4.72	1.31	0.69

9.2.3.1.1 Total Dust Fallout

In the mitigated and unmitigated scenarios none of the sensitive receptors are predicted to exceed the monthly dust fallout for the highest month residential limit of 600 mg/m²/day.

The predicted annual dust fall out for the mitigated and unmitigated scenarios are not predicted to exceed the annual limit of 300 mg/m²/day at any of the sensitive receptors.

Table 22: TSP Deposition rates at the sensitive receptors

Receptor	TSP Highest Monthly (mg/m²/day)			TSP Annual Average (mg/m²/day)		
	Unmitigated	Mitigated 75%	Mitigated 90%	Unmitigated	Mitigated	
1	6.83	1.87	0.94	2.07	0.58	0.30
2	6.04	1.65	0.84	1.80	0.49	0.25
3	5.70	1.55	0.77	1.67	0.45	0.23
4	5.33	1.45	0.72	1.56	0.42	0.21
5	4.53	1.21	0.57	1.78	0.48	0.24
6	2.88	0.75	0.33	1.23	0.33	0.16
7	37.00	11.01	6.61	19.73	5.69	3.23
8	13.89	4.04	2.30	4.67	1.43	0.89
9	6.20	1.68	0.95	2.68	0.78	0.45
10	2.54	0.71	0.37	0.80	0.22	0.11
11	2.01	0.53	0.25	0.61	0.16	0.08
12	1.78	0.47	0.23	0.61	0.16	0.08

9.2.4 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 23: 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.		
		Unmitigated	**Mitigated**
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	3	3

Mining Phase	Closure and Decommissioning Phase		
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5km to 50km) (4); National (5)]	**2**	**2**
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	**2**	**2**
	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	**4**	**4**
	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	**4**	**3**
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	**5**	**5**
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	**2**	**2**
Consequence	Severity + Spatial Scale + Duration	**7**	**7**
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	**15**	**14**
Risk	Consequence * Likelihood	**MODERATE (105)**	**MODERATE (98)**
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 24: 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.		
		Unmitigated	**Mitigated**
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	4	3
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5km to 50 km) (4); National (5)]	2	2
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	2	2
	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	5	5
	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	5	4
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	5	5
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	2	2
Consequence	Severity + Spatial Scale + Duration	8	7
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	17	16
Risk	Consequence * Likelihood	MODERATE (136)	MODERATE (112)

Mining Phase	Closure and Decommissioning Phase
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.

9.3 Cumulative Impacts

The proposed Dunbar Coal project area surrounded by other mining areas. These mining operations will also generate fugitive dust and particulate matter emissions. The Dunbar Coal 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.

9.4 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:

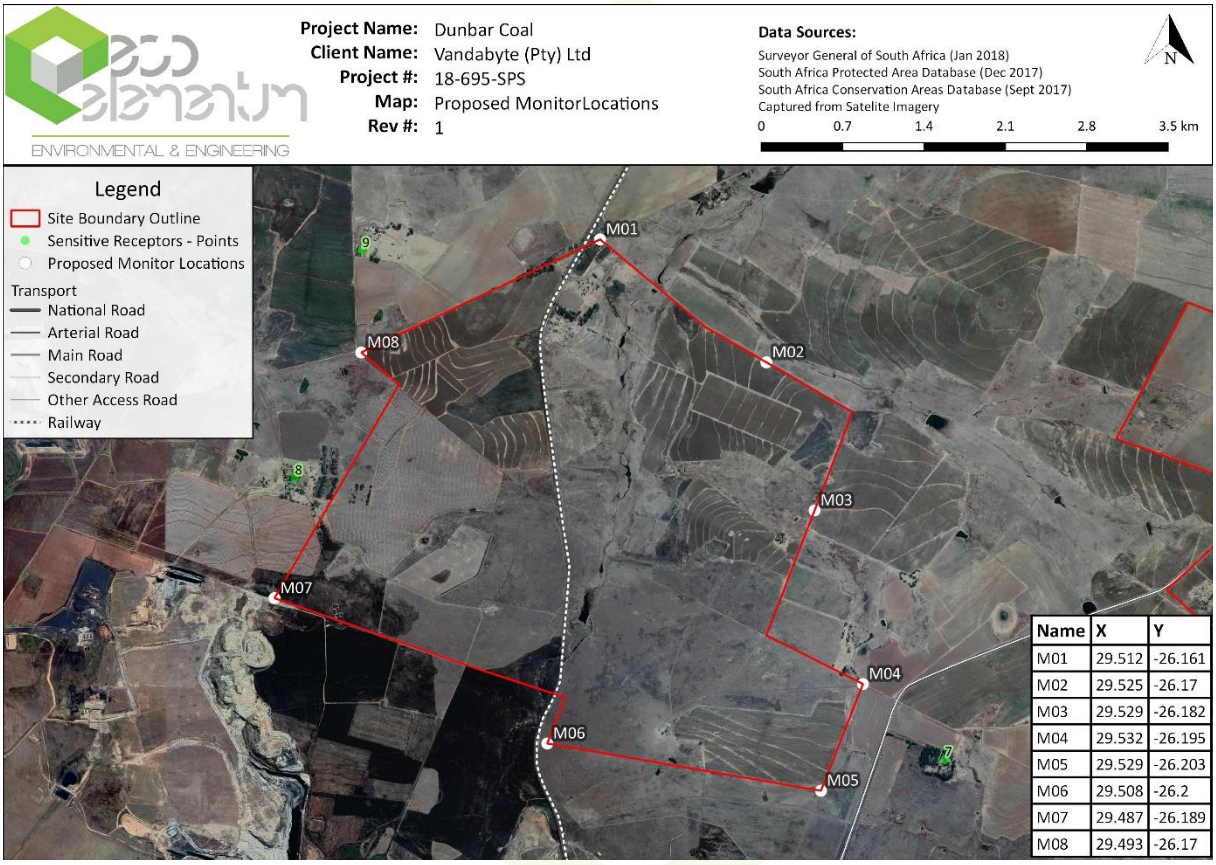
- Pre and post carbon capture and storage technologies.
- New pollution control devices - like advanced scrubbers - that clean pollutants from flue gases before they exit a plant's smokestack.
- Chemical looping combustion technology to concentrate CO_2 levels in exhaust.
- Production of ultra clean 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.

10. MONITORING PROGRAMME

As reported previously, no current monitoring campaign exists. It is highly recommended that a dust monitoring campaign be conducted prior to the proposed mining operations commence and then 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.

10.1 Gravimetrical Dust Fallout – (Milligram/Square Meter/Day) Or (Mg/M²/Day) (Monthly 8 Samples)

10.1.1 Proposed Monitor Locations



Name	X	Y
M01	29.512	-26.161
M02	29.525	-26.17
M03	29.529	-26.182
M04	29.532	-26.195
M05	29.529	-26.203
M06	29.508	-26.2
M07	29.487	-26.189
M08	29.493	-26.17

Figure 29 Proposed Monitor Locations

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.

10.2 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.

11. 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 of coal. The emissions for specific activities such as bulldozing, blasting, tipping, wind erosion and materials handling activities were calculated 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 Dunbar Coal project mining area. The construction and operational phases were assessed. Based on the dispersion modelling simulations, the following conclusions can be summarised as follows:

PM10

For the unmitigated Daily PM10 concentrations it was predicted to be higher than the 75 µg/m³ limit for 11 of the 12 sensitive receptors with major exceedances at most of the receptors.

When comparing the Daily Mitigated PM10 modelled concentrations for the Haul Roads at 75% mitigation, the sensitive receptors exceeding the 75 µg/m³ limit drop to 6 out of the 12 identified sensitive receptors. With the Haul Roads at 90% mitigation only 1 identified sensitive receptor are predicted to exceed the 75µg/m³ limit. It should be noted that this is the2nd highest levels predicted for a 24 hour period within the period. Due to site specific atmospheric conditions these exceedances may still occur within the limit of 4 per year.

The annual average PM10 limit of 40 µg/m³ are not predicted to exceed at any of the identified sensitive receptors for any of the modelled scenarios.

TSP

In the mitigated and unmitigated scenarios none of the sensitive receptors are predicted to exceed the monthly dust fallout for the highest month residential limit of 600 mg/m²/day.

The predicted annual dust fall out for the mitigated and unmitigated scenarios are not predicted to exceed the annual limit of 300 mg/m²/day at any of the sensitive receptors.

Mitigation Measures

2 Different mitigation scenarios were modelled. Based on the results the following mitigation measures are recommended at the various sources:

Operation	Reduction	Method
Excavator ROM	50%	Water Sprays
Excavator Overburden	50%	Water Sprays
Wind Erosion	50%	Water Sprays
	90%	Revegetation on OB and Topsoil
Access Haul Road	75%	Level 2 Watering (>2 liters/m²/h)
Pit Haul Road	75%	Level 2 Watering (>2 liters/m²/h)
Truck Dumping (Overburden)	50%	Water Sprays
Truck Dumping (ROM)	50%	Water Sprays
Inpit Operations	50%	Inpit
Loading Stockpiles	50%	Water Sprays

Based on the results presented the following further recommendations are outlined:

- It is recommended that ambient air quality monitoring be established to get a baseline condition prior to the onset of the operations and in order to establish the level at which the proposed operations are noted to impact on the ambient air quality.
- Fallout monitoring should be continued for the life of mine to better assess the level of nuisance dust associated with both mining and process related operations. Sampling of fallout should be undertaken within the neighbouring areas as well as on-site. Dust fallout monitoring is recommended at the locations as shown in Figure 30.
- PM10 and PM2.5 dust monitoring must also be undertaken at the same sites as mentioned under the previous bullet but also in and around potential fugitive emission sources to determine mitigation measures and focus management efforts.
- Further mitigation measures that should be applied, if it is found that dust and PM10 levels are measured to be exceeding the limits are:
    - Reducing the speed of the Haul Trucks on the Pit and Access Haul Roads.
    - Fully sealed Pit and Access Haul Road to achieve 90-100% mitigation on these roads.

The impacts from dust fallout and Particulate matter can be reduced by implementing dust control measures. The highest intensity of the construction work should be carried out during the summer months and not over the harsh winter months as can result in increased dispersion of fugitive dust. The mine should ensure that unpaved roads are continuously watered and treated with dust binding additive products to reduce the volume of fugitive dust emitted from unpaved roads.

The mitigation and management measures for mining operation and discussed in this report should be sufficient to ensure the mining operation can be conducted with minimal impact on the receiving environment and therefore not have a detrimental effect and can go ahead.

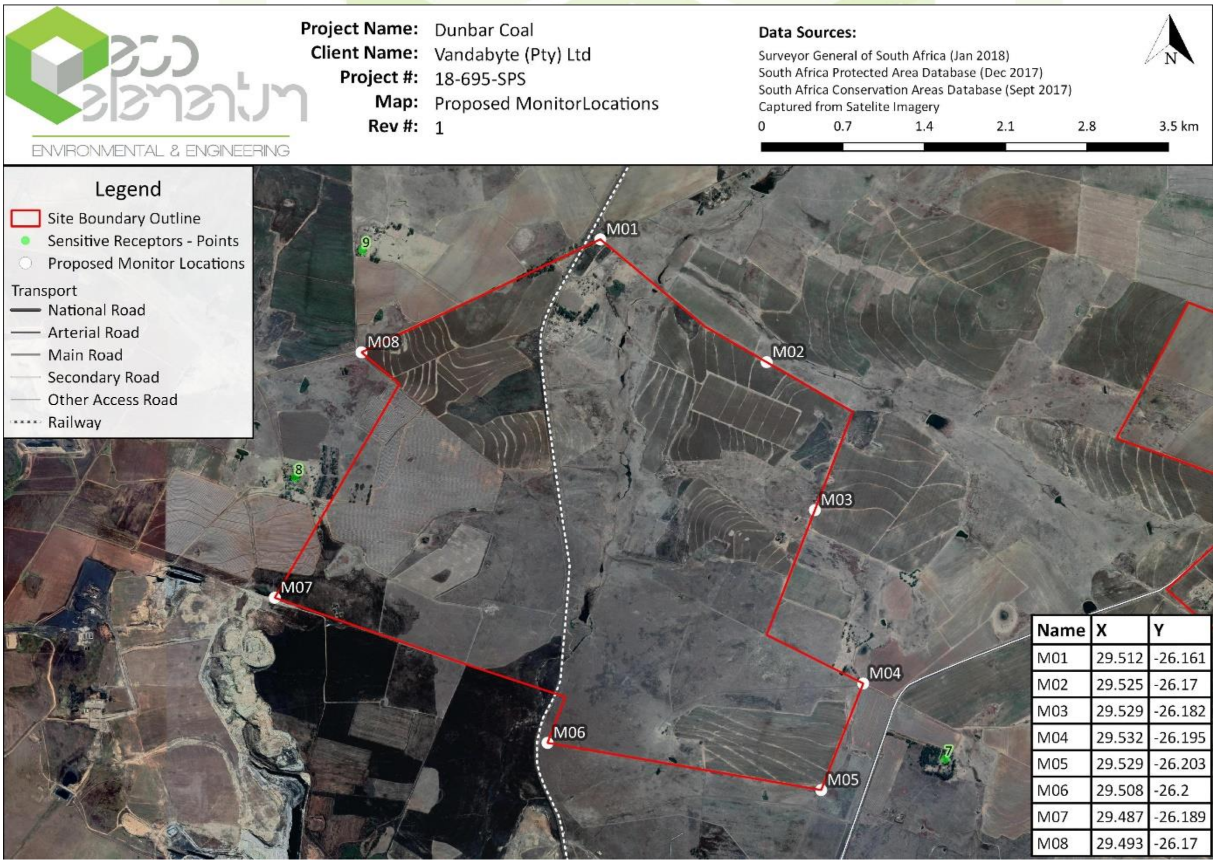


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Figure 30 Proposed Monitor Locations

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