# Air Quality Impact Assessment

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# AIR QUALITY IMPACT ASSESSMENT

## Proposed Yzermyn Underground Coal Mine

2013/08/15

# Quality Management

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| Signature |  | | | |
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# Air Quality Impact Assessment

## Proposed Yzermyn Underground Coal Mine

2013/08/15

## Client


Atha Africa Ventures (Pty) Ltd
8th Floor
Sinosteel Plaza
159 Rivonia Road
Sandton
2144


## Consultant


Kirsten Collett
WSP House
Bryanston Place, 199 Bryanston Drive
Bryanston
2191
South Africa

Tel: +27 11 361 1372
Fax: +27 86 556 7189

www.wspenvironmental.co.za


## Registered Address


WSP Environmental (Pty) Ltd
1995/008790/07
WSP House, Bryanston Place, 199 Bryanston Drive, Bryanston, 2191, South Africa


## WSP Contacts


Kirsten Collett
Kirsten.Collett@WSPgroup.co.za
+27 11 361 1372

Bradley Keiser
Bradley.Keiser@WSPgroup.co.za
+27 11 361 1377

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# Abbreviations

| | |
|---|---|
| *APPA* | Atmospheric Pollution Prevention Act (Act 45 of 1965) |
| *AQIA* | Air Quality Impact Assessment |
| *CO* | Carbon monoxide |
| *EIA* | Environmental Impact Assessment |
| *GIS* | Geographic Information System |
| *GNR* | Government Notice Regulations |
| *NEM:AQA* | National Environmental Management: Air Quality Act (Act 39 of 2004) |
| $NO_2$ | Nitrogen dioxide |
| $NO_x$ | Nitrogen oxides |
| *PM* | Particulate matter |
| $PM_{10}$ | Particulate matter with an aerodynamic diameter less than 10 µm |
| $PM_{2.5}$ | Particulate matter with an aerodynamic diameter less than 2.5 µm |
| *SANS* | South African National Standards |
| *SAWS* | South African Weather Service |
| $SO_2$ | Sulphur dioxide |
| *TSP* | Total suspended particulates |
| *US EPA* | United States Environmental Protection Agency |
| *VOC* | Volatile organic compound |

# Executive Summary

Atha Africa Ventures (Pty) Ltd plan to construct and operate an underground coal mine near Wakkerstroom in the Mpumalanga Province and require environmental authorisation to do so. As part of this authorisation, a specialist air quality impact assessment is required to quantify all sources of emissions at the proposed Yzermyn Underground Coal Mine during both the construction and operational phase and determine how these emissions will impact on the existing air quality of the region. This report details the findings of the air quality impact assessment.

The assessment comprised onsite ambient air quality monitoring in order to assess the existing air quality in the region as well as dispersion modelling to determine the predicted impacts that the proposed mine will have on the existing air quality. A comprehensive emissions inventory was developed to account for all emission sources at the proposed Yzermyn Underground Coal Mine during both the construction and operational phases. Calculated emission rates were then used as input into ADMS (v5) dispersion modelling software. Included into the model was Unified Model (UM) meteorological data generated for the site co-ordinates; background pollutant concentration (monitored) data; and a complex terrain file to account for the influence of the undulating regional topography on the dispersion of pollutants. Predicted particulate matter ($PM_{10}$ and $PM_{2.5}$), sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), carbon monoxide (CO) and volatile organic compound (VOC) concentrations were assessed against the National Environmental Management: Air Quality Act 39 of 2004 (NEM:AQA) ambient air quality standards to assess compliance, whilst dust fallout was assessed against the SANS 1929:2005 guidelines.

From the onsite monitoring, it was identified that dust fallout rates and particulate emissions in the region are low, particularly in the wet summer season. The region is characterised by a background $PM_{10}$ concentration of 8.97 µg/m$^3$ and a $PM_{2.5}$ concentration of 2.75 µg/m$^3$, which were subsequently utilised as background in the dispersion model. $NO_2$ and $SO_2$ concentrations were significantly low, with monitored summer and winter concentrations indicating compliance with the NEM:AQA standards.

From the dispersion modelling and the meteorological input data, emissions from the proposed Yzermyn Underground Coal Mine will disperse towards the east and the west, with local plume dispersion being dictated by the topography. Main sources of particulate emissions during the construction phase include materials handling activities; general construction activities and activities along the mine access road. During the first three years of operation the main source of particulates is from vehicular activity on the unpaved mine access road, whilst after three years (when the road is paved) the main sources include materials handling (in the form of bulldozing / FEL activity at the stockpiles and discard dump; truck loading; and drop operations at tips and bins) and wind erosion of exposed areas and stockpiles.

Long term $PM_{10}$ concentrations during the construction phase are predicted to be generally low, with concentrations only exceeding the annual standard (50 µg/m$^3$) at receptors in close proximity to the construction activities and at receptors in closest proximity to the mine access road. Numerous exceedences of the 24 hour average standard are also predicted at these receptors. The highest number of daily $PM_{10}$ exceedences is predicted within the mine boundary; however, a number of exceedences are predicted along the mine access road, with the maximum permitted frequency being exceeded up to 600 m from the road. Emissions from the construction phase are not a key concern due to the temporary nature of this phase, however, various mitigation methods can be employed to minimise emissions from construction sources. These methods include dust suppression on roads through wetting or the use of dust suppressants such as dust-a-side; and the erection of wind breaks to minimise wind-blown dust from exposed areas.

Predicted long term $PM_{2.5}$ concentrations during the construction phase are low and no exceedences of the annual $PM_{2.5}$ standard are predicted at any of the sensitive receptors. Worst case daily concentrations are also low, with the farm house receptor, FH 04 being the only receptor to exceed the daily standard, due to its close proximity to the construction activities. From this it is evident that dust in the form of $PM_{2.5}$ is not a key emission from the construction phase of the proposed Yzermyn Underground Coal Mine and will not negatively impact on surrounding receptors.

Annual average dust fallout rates during the construction phase are low and are compliant with the SANS Residential Guideline at all receptors. It must be noted, that although low rates are predicted offsite, onsite fallout rates in the direct vicinity of the construction activities are predicted to be significantly elevated as would be expected.

Predicted long term $PM_{10}$ concentrations during the first three years of operation are significantly elevated if no mitigation is applied, with concentrations exceeding the annual standard at nine of the 13 receptor points. All of these receptors are in close proximity to the unpaved mine access road, that generates high dust levels as a result of the high vehicle numbers travelling on the road on a daily basis. Exceedences of the 24 hour standard are predicted at all receptors, except FH 02, with the highest number of exceedences predicted at receptors in close proximity to the mine access road. Similarly, predicted long term $PM_{2.5}$ concentrations during the first three years of operation are high with exceedences of the annual standard (25 µg/m³) being predicted at five of the 13 receptors. Worst case daily concentrations at these receptors also indicate non-compliance with the 24 hour standard. Highest concentrations are evident in the direct vicinity of the mine access road, with exceedences of the annual average standard predicted up to 400 m from the road and exceedences of the daily standard up to 600 m from the road. Mitigation in the form of dust palliatives and suppressants on the haul road will be required to address these predicted exceedences during the first three years of operation.

After three years of operation, the mine access road will be paved and an increase in vehicle numbers is envisaged. Predicted long term $PM_{10}$ concentrations at this time are low and are compliant with the annual standard at all receptors except at the farm house receptor, FH 04. This receptor is in closest proximity to the mine and is impacted by emissions from the handling of materials in the form of bulldozers, conveyors and tips. Exceedences of the daily $PM_{10}$ standard are predicted in the direct vicinity of the mining operations, impacting on three receptors that are in closest proximity to the mine. In order to decrease the impacts of such emissions, certain mitigation techniques can be employed. These include erection of wind breaks to limit wind erosion of exposed areas; the enclosing of conveyors; the covering of stockpiles; and the regular maintenance of equipment to avoid unnecessary emissions.

Predicted long term $PM_{2.5}$ concentrations are low, with no exceedences of the annual standard at any of the receptor points. Only one exceedence of the daily standard is predicted at receptor FH 04. Daily $PM_{2.5}$ exceedences are predicted around the direct vicinity of the mine where the loading of material from the export and middlings stockpiles occur. No offsite exceedences are predicted.

Predicted annual average dust fallout rates after three years of operation are compliant with the SANS Residential Guideline at all receptors. Although compliance at receptors is noted, dust fallout rates within the mine boundary itself will be significantly elevated and mitigation measures as indicate above are recommended.

$SO_2$, $NO_2$, CO and VOC emissions from vehicles travelling on the mine access road during both the first three years of operation and after three years of operation are low, indicating compliance with the NEM:AQA annual standards at all receptors. The contribution from activities during the first three years and after three years is minimal, contributing between 0.01 to 1.33 µg/m³ and 0.01 to 2.66 µg/m³ to $NO_x$ emissions at receptors respectively. $SO_2$ emissions from activities at the mine are not predicted to result in any detectable increase at receptor locations. From this it is evident that emissions of CO, $NO_x$, $SO_2$ and VOCs from vehicles travelling on the mine access road during the operational phase will not negatively impact on the surrounding environment.

# 1 Introduction

Atha Africa Ventures (Pty) Ltd (hereafter referred to as Atha), plan to construct and operate an underground coal mine near Wakkerstroom in the Mpumalanga Province. WSP Environmental (Pty) Ltd (WSP) has been appointed by Atha to undertake a comprehensive environmental and social impact assessment (ESIA) for the proposed Yzermyn mine. The ESIA has been undertaken in two phases, namely the scoping phase and environmental social impact assessment (ESIA) phase. As part of the ESIA phase, a specialist air quality impact assessment (AQIA) is required to assess the impact of activities at the mine on air quality in the region.

This report details the findings of the AQIA conducted by WSP. Included in this report is background to the project; key atmospheric emissions associated with the mine; an overview of the regulatory framework for air quality; discussions on the emissions inventory development; a meteorological overview; a discussion on the ambient regional and local air quality; sensitive receptor identification; and dispersion modelling outputs and results.

## 1.1 Scope of Work

Below is a summary of the scope of work performed by WSP in fulfilment of the requirements of the air quality specialist study:

- Literature review of proposed activities at the mine, as well as emissions associated with these activities;
- Description of receiving environment, specifically relating to sensitive receptors;
- Baseline air quality characterisation through the review of onsite monitoring performed at the site during a summer and winter campaign during 2012;
- Compilation of a site specific emissions inventory for both the construction and operational phases of the proposed Yzermyn Underground Coal Mine;
- Dispersion modelling simulations of activities at the site during both the construction and operational phases of the proposed Yzermyn Underground Coal Mine; and
- Compilation of an air quality assessment report, inclusive of all information listed above.

## 1.2 Rational for the Study

As part of the environmental authorisation process for the proposed Yzermyn Underground Coal Mine, an AQIA is required in order to identify potential impacts of the proposed Yzermyn Underground Coal Mine on the air quality in the region. Such an operation has the potential to emit significant amounts of pollutants (especially particulates / dust) which can impact on surrounding receptors (communities), so such a study is a requirement of the ESIA.

## 1.3 Air Quality Consultant

Kirsten Collett is an air quality specialist with a Master of Science (Atmospheric Sciences) degree obtained from the University of the Witwatersrand. For four years she worked at the Climatology Research Group at the University of Witwatersrand and was involved in various air quality projects with both local and international associations. She is currently employed by WSP and has worked on air quality impact assessments, monitoring and modelling for a variety clients over the past two years. She has provided consulting support to various client industries including mining, petrochemical, power generation, metallurgical and local government bodies.

## 1.4 Declaration of Independence

I hereby declare that I am fully aware of my responsibilities in terms of the National Environmental Management Act 2006 EIA Regulations and that I have no financial or other interest in the undertaking of the proposed activity other than the imbursement of consultants fees.

Name: Kirsten Collett

Company: WSP Environmental (Pty) Ltd

Signature:

# 2 Project Background

## 2.1 Locality and Study Area

Atha has obtained the prospecting rights for an area of 8,360 ha in the Pixley ka Seme Local Municipality within the Mpumalanga Province, some 58 km southwest of Piet Retief in the Mpumalanga Province. A target area has been identified within the eastern section of the prospecting rights boundary where the proposed Yzermyn mine is to be located (Figure 1). The region has very undulating, hilly topography and the surrounding land use is predominantly natural bush, agricultural and wetlands with scattered rural settlements.

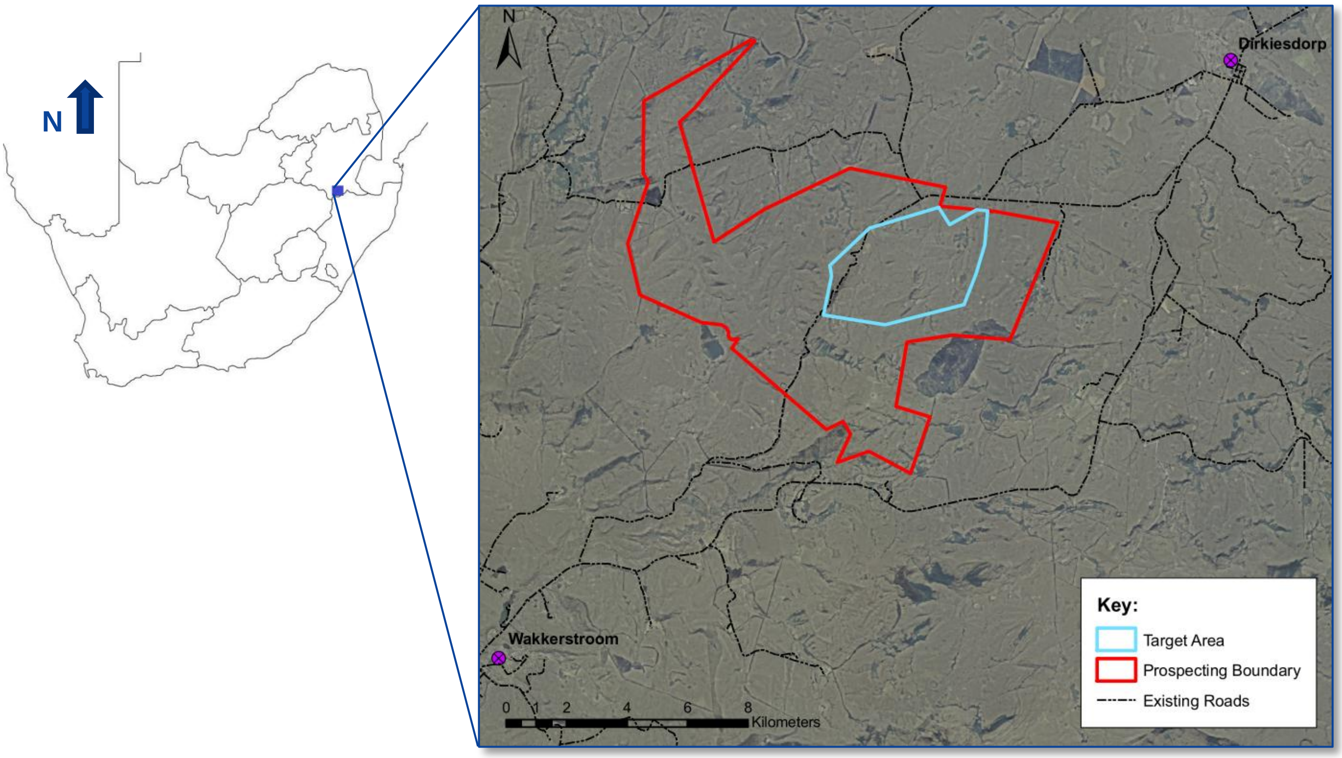


**Figure 1: Location of the proposed Yzermyn Underground Coal Mine in the Mpumalanga province**

## 2.2 Process Description

### 2.2.1 Construction Phase

A construction phase of six months is envisaged for the proposed Yzermyn Underground Coal Mine. Construction will include land clearing of the construction footprint; general construction activities (i.e. earthworks, brickworks infrastructure development etc. for the plant, buildings, dams, onsite roads and parking lots); drilling of the boxcut highwall; blasting of the boxcut highwall and declines to the Alfred and Dundas seams; bulldozing, truck unloading and grading activities at the boxcut platform; and grading of the mine access road from the town of Dirkiesdorp to the proposed Yzermyn Underground Coal Mine site.

### 2.2.2 Operational Phase

Either drill and blast or continuous miner methods will be utilised to extract approximately 200,000 tons of run of mine (ROM) coal per month at the proposed Yzermyn Underground Coal Mine. This ROM will be brought to the surface via conveyors transferring it to an open ROM stockpile ahead of the coal handling and preparation plant (CHPP). The ROM will be drawn from the bottom of the ROM stockpile via vibratory feeders and fed onto a vibratory screen where larger material will be crushed to a nominal size of 50 mmm as the CHPP is not equipped to handle oversized material. The ROM will then enter the CHPP for further crushing, screening and treatment.

Discard material will be sent via conveyer to the discard bin where it will be loaded into trucks and deposited at the discard dump to the north of the proposed mine. It is estimated that 38,000 tons of discard will be sent to the dump per month where bulldozers and graders will be responsible for the levelling of the discard material. Approximately 110,000 tons of primary, export quality coal will be transferred via conveyor to the export stockpile, whilst 52,000 tons per month of secondary grade coal will be transferred to the middlings stockpile. Coal from both stockpiles will be loaded via front end loaders (FELs) to 30 ton haul trucks and transported to the Piet Retief Rail Siding for dispatch to export and local markets.

## 2.3 Atmospheric Emissions and Impacts

### 2.3.1 Key Atmospheric Pollutants

The main pollutant of concern at the proposed Yzermyn mine is particulate matter (PM) in the form of dust. Dust originates from a variety of sources onsite including: conveyors; truck loading and unloading; crushing and screening activities; wind erosion; and vehicles travelling on unpaved roads.

During various underground mining processes and stockpiling of coal, the coal may come into contact with oxygen. If poorly ventilated (i.e. compressed), heating may result. The combination of the oxygen, fuel (coal) and heat results in oxidation, which leads to the spontaneous combustion of the coal. Spontaneous combustion produces emissions of various toxic, explosive and flammable gases including sulphur dioxide ($SO_2$), nitrogen oxides ($NO_x$), hydrogen sulphide ($H_2S$), carbon monoxide (CO), methane ($CH_4$) and a large variety of hydrocarbons which are produced in such small amounts that they are unlikely to reach toxic levels (Phillips, Uludag and Chabedi, 2011).

### 2.3.2 Health and Environmental Impacts

#### 2.3.2.1 Particulate Matter (PM)

Particulate matter (PM) refers to solid or liquid particles suspended in the air. PM varies in size from particles that are only visible under an electron microscope to soot or smoke particles that are visible to the human eye. PM contributes greatly to deteriorations in visibility, as well as posing major health risks, as small particles ($PM_{10}$) can penetrate deep into lungs, while even smaller particle sizes ($PM_{2.5}$) can enter the bloodstream via capillaries in the lungs, with the potential to be laid down as plaques in the cardiovascular system or brain. Health effects include: respiratory problems, lung tissue damage, cardiovascular problems, cancer and premature death. Acidic particles may damage buildings, vegetation and acidify water sources (US EPA, 2011).

#### 2.3.2.2 Sulphur Dioxide ($SO_2$)

$SO_2$ is produced via the combustion of sulphur rich fuel. $SO_2$ is a major respiratory irritant, resulting in respiratory illnesses, alterations in pulmonary defences and aggravation of existing cardiovascular disease. $SO_2$ may also create sulphuric acid as a result of its water solubility, producing acid rain. Once emitted, $SO_2$ may oxidize in the atmosphere to produce sulphate aerosols, which are harmful to human health, limit visibility and in the long term have an effect on global climate (Seinfeld and Pandis, 1998; Fenger, 2002; US EPA, 2011).

#### 2.3.2.3 Nitrogen Oxides ($NO_x$)

Under high temperature conditions nitrogen and oxygen atoms in the air react to form nitric oxide (NO). NO is a colourless gas that is non-toxic, but is transformed into $NO_2$ when it is oxidised in the atmosphere. Elevated $NO_2$ concentrations may lead to asthma, emphysema, bronchitis, damage to lung tissue and even premature death. $NO_x$ may lead to biological imbalances and mutations in vegetation, limits visibility and contributes to the formation of acid rain via the production of nitric acid ($HNO_3$). Further oxidation of $NO_2$ may lead to the formation of nitrate aerosols, which further limit visibility and affect the natural environment. Most importantly, however, $NO_x$ contributes to the formation of tropospheric $O_3$, an important atmospheric oxidant, a major air pollutant and a key greenhouse gas (Seinfeld and Pandis, 1998; Fenger, 2002; US EPA, 2011).

#### 2.3.2.4 Carbon Monoxide (CO)

CO is a product of incomplete combustion of carbon in fuels and is a colourless, odourless, and toxic gas at high concentrations. When CO enters the bloodstream, it reduces the flow of oxygen to various organs and tissue, and is particularly dangerous to individuals who suffer from cardiovascular disease. Really high concentrations of CO may affect healthy individuals through impaired vision and a reduction in brain activity. These concentrations tend only to be reached in indoor environments (Fenger, 2002; US EPA, 2011).

#### 2.3.2.5 Hydrogen Sulphide ($H_2S$)

Hydrogen sulphide ($H_2S$) has both natural and anthropogenic origins. It is a colourless, flammable gas that has a distinctive rotten egg smell which is detectable even at low concentrations. Long term exposure to $H_2S$ at low concentrations results in eye irritation, headache, fatigue, respiratory irritation, dizziness, nausea and vomiting. Exposure to higher concentrations can lead to convulsions, inability to breathe, coma and even death (OSHA, 2005; ATSDR, 2006)

#### 2.3.2.6 Methane ($CH_4$)

Methane ($CH_4$) is a key greenhouse gas that can remain in the atmosphere for up to 15 years, leading to implications on climate. $CH_4$ exists naturally in the atmosphere, but in very low concentrations. In a more concentrated form, $CH_4$ can have implications on human health. At high concentrations, $CH_4$ can cause agitation, slurred speech, nausea, vomiting and headaches. At highly elevated concentrations, $CH_4$ can cause respiratory and pulmonary complications, coma and even death (Health Protection Agency, 2010).Methane is emitted from a variety of natural and anthropogenic sources. Anthropogenic sources include landfills, natural gas and petroleum systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial process. In South Africa underground coal mines contribute up to 40.8 Giga grams per annum of methane released to the atmosphere via the ventilation of underground mines (Lloyd & Cook, 2008).

# 3 The Regulatory Framework for Air Quality

The new National Environmental Management: Air Quality Act 39 of 2004 (NEM:AQA), which repeals the Atmospheric Pollution Prevention Act of 1965, came into effect on 11 September 2005, with the promulgation of regulations in terms of certain sections resulting in the APPA being repealed entirely on 1 April 2010. Key features of the current legislation include:

- a decentralisation of air quality management responsibilities;
- the identification and quantification of significant emission sources that then need to be addressed;
- the development of ambient air quality targets as goals for driving emission reductions;
- the use of source-based (command-and-control) measures in addition to alternative measures, including market incentives and disincentives, voluntary programmes, and education and awareness;
- the promotion of cost-optimized mitigation and management measures;
- stipulation of air quality management planning by authorities, and emission reduction and management planning by sources; and
- access to information and public consultation.

The NEM:AQA introduced a management system based on ambient air quality standards and corresponding emission limits to achieve them. Two significant regulations stemming from NEM:AQA have been promulgated recently, which are:

- **GNR 1210** on 24 December 2009 (Government Gazette 32816) National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Ambient Air Quality Standards.
- **GNR 248** on 31 June 2010 (Government Gazette 33064) National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) List of Activities Which Result in Atmospheric Emissions Which Have or May Have a Significant Detrimental Effect on the Environment, Including Health, Social Conditions, Economic Conditions, Ecological Conditions or Cultural Heritage.

The new national ambient standards for air quality were based primarily on guidance offered by two standards set by the South African National Standards (SANS), namely:

- **SANS 69:2004** Framework for implementing national ambient air quality standards.
- **SANS 1929:2005** Ambient air quality – Limits for common pollutants.

**SANS 69:2004** makes provision for the establishment of air quality objectives for the protection of human health and the environment as a whole. Such air quality objectives include limit values, alert thresholds and target values.

**SANS1929:2005** uses the provisions in SANS 69 to establish air quality objectives for the protection of human health and the environment, and stipulates that limit values are initially set to protect human health. The setting of such limit values represents the first step in a process to manage air quality and initiate a process to ultimately achieve acceptable air quality nationally. The limit values presented in this standard are to be used in air quality management but have only become enforceable as revised under **GNR 1210** since 24 December 2009. National ambient air quality standards for criteria pollutants generally have specific averaging periods; compliance timeframes, permissible frequencies of exceedence and reference methods.

## 3.1 Particulate Matter

With regard to the setting of limit values for particulate matter, SANS 1929:2005 recognises the following:

- different types of particles can have different harmful effects on human health;
- there is evidence that risks to human health associated with exposure to man-made $PM_{10}$ are higher than risks associated with exposure to naturally occurring particles in ambient air; and
- as far as they relate to $PM_{10}$, action plans and other reduction strategies should aim to reduce concentrations of fine particles as part of the total reduction in concentrations of particulate matter.

Stringent Limit and Target Values for particulate matter (expressed in µg/m³) have been suggested as guidelines in SANS 1929:2005, and revised 2009. These were developed by a panel of experts on the basis of best international practice. However, the latest regulations emanating from NEM:AQA (GNR 1210) were promulgated in late 2009 and stipulate a phased approach towards the implementation of national ambient air quality standards as tabulated below (Table 1). A similar approach was adopted and ratified in June 2012, setting limit values for $PM_{2.5}$ particles. These standards are also presented in Table 1

**Table 1: Rollout of National Ambient Air Standards for Particulate Matter ($PM_{10}$ and $PM_{2.5}$)**

| Particulate Matter ($PM_{10}$) | | | |
|---|---|---|---|
| **Averaging Period** | **Concentration (µg/m$^3$)** | **Frequency of Exceedence** | **Compliance Date** |
| **Daily** | 120 | 4 | Immediate – 31/12/2014 |
| | 75 | 4 | 1 January 2015 |
| **Annual** | 50 | 0 | Immediate – 31/12/2014 |
| | 40 | 0 | 1 January 2015 |
| **Particulate Matter ($PM_{2.5}$)** | | | |
| **Averaging Period** | **Concentration (µg/m$^3$)** | **Frequency of Exceedence** | **Compliance Date** |
| **Daily** | 65 | 4 | Immediate – 31/12/2015 |
| | 40 | 4 | 01/01/2015 -31/12/2029 |
| | 25 | 4 | 1 January 2030 |
| **Annual** | 25 | 0 | Immediate – 31/12/2015 |
| | 20 | 0 | 01/01/2015 -31/12/2029 |
| | 15 | 0 | 1 January 2030 |

It must be noted that from a legal standpoint, only standards promulgated under the National Environmental Management: Air Quality Act (Act 39 of 2004) are applicable during the relevant timeframes as stipulated above. In addition, the ambient air quality standards are to be used to identify priority areas which require the attention of the regulatory authorities. It needs to be stressed that the ambient air quality standard will not be used for prosecution, but as a guide for action by the relevant local authorities.

## 3.2 Dust Deposition

Dust deposition, commonly referred to as fallout or nuisance dust, is of major concern to mining and related operations. Importantly, it should be noted that dust fallout is not considered a priority pollutant according to the NEMA:AQA, and therefore no legislated limits or standards for assessing dust fallout impacts exist, though the Draft National Dust Control Regulations were published in the Government Gazette, Notice 309 of 2011. Until its final acceptance however, standards for the evaluation and assessment of dust fallout impacts as found in SANS 1929:2005 will be applied in the AQIA for the Yzermyn mine. SANS 1929:2005 also sets out dust deposition rates, expressed in units of mg/m$^2$/day over a typical 30-day averaging period. Dust deposition must be evaluated against a four-band scale as presented in Table 2.

**Table 2: Dust Deposition Rates (SANS 1929:2005)**

| Band Description Label | Dust Fallout Rate (D), ($mg/m^2/day$) | Comment |
|---|---|---|
| **Residential** | D < 600 | Permissible for residential and light commercial. |
| **Industrial** | 600 < D < 1 200 | Permissible for heavy commercial and industrial. |
| **Action** | 1 200 < D < 2 400 | Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year. |
| **Alert** | 2 400 > D | Immediate action and remediation required following the first incidence of dust fall rate being exceeded. Incident report to be submitted to relevant authority. |

According to the proposed dust fallout limits, an enterprise may submit a request to the authorities to operate within Band 3 (Action) for a limited period, providing that this is essential in terms of the practical operation of the enterprise (for example the final removal of a tailings deposit) and provided that the best available control technology is applied for the duration. No margin of tolerance will be granted for operations that result in dust fallout rates in Band 4 (Alert).

## 3.3 Sulphur Dioxide ($SO_2$), Nitrogen Dioxide ($NO_2$), Carbon Monoxide (CO) and Volatile Organic Compounds (VOCs)

Emissions of $SO_2$, $NO_2$, CO and VOCs (in the form of benzene) are regulated under NEM:AQA in the form of national ambient air quality standards. Such limit values against which onsite monitored concentrations as well as predicted (modelled) concentrations are assessed are presented in Table 3. Note, concentrations of VOCs are assessed against the benzene standard, as compliance of total VOC concentrations with the standard essentially indicates compliance of the benzene itself with the standard.

**Table 3: South African ambient air quality standards for $SO_2$, $NO_2$, CO and benzene**

| Sulphur Dioxide ($SO_2$) | | | |
|---|---|---|---|
| **Averaging Period** | **Concentration ($\mu g/m^3$)** | **Frequency of Exceedence** | **Compliance Date** |
| **Hourly** | 350 | 88 | Immediate |
| **Daily** | 125 | 4 | Immediate |
| **Annual** | 50 | 0 | Immediate |
| **Nitrogen Dioxide ($NO_2$)** | | | |
| **Averaging Period** | **Concentration ($\mu g/m^3$)** | **Frequency of Exceedence** | **Compliance Date** |
| **Hourly** | 200 | 88 | Immediate |
| **Annual** | 40 | 0 | Immediate |
| **Carbon Monoxide (CO)** | | | |
| **Averaging Period** | **Concentration ($\mu g/m^3$)** | **Frequency of Exceedence** | **Compliance Date** |
| **Hourly** | 30 000 | 88 | Immediate |
| **8 Hourly** | 10 000 | 11 | Immediate |
| **Benzene ($C_6H_6$)** | | | |
| **Averaging Period** | **Concentration ($\mu g/m^3$)** | **Frequency of Exceedence** | **Compliance Date** |
| **Annual** | 10 | 0 | Immediate to December 2014 |
| **Annual** | 5 | 0 | 1 January 2015 |

## 3.4 Onsite Storage Tanks

In accordance with the NEM:AQA listed activities, VOC emissions from onsite diesel storage tanks are regulated under subcategory 2.2: The Storage and Handling of Petroleum Products (Table 4). At the proposed Yzermyn Underground Coal Mine, diesel will be stored in ten 15 $m^3$ storage tanks for use by vehicles and onsite generators. Since this capacity does not exceed the stipulated cumulative tankage capacity of 500 $m^3$, an Atmospheric Emission Licence (AEL) will not be required for the facility. However, as stipulated in the listed activities it must be noted that should a throughput of more than 50,000 $m^3$ per annum occur at the mine, all installations will need to be fitted with a vapour recovery unit and an AEL may be required.

**Table 4: Minimum emission standards associated with the storage and handling of petroleum products (NEM:AQA, listed activities, Category 2: Petroleum Industry, Subcategory 2.2)**

| Description: | Petroleum product storage tanks and product transfer facilities, except those used for liquefied petroleum gas. | | |
|---|---|---|---|
| Application: | All permanent immobile liquid storage tanks larger than 500 cubic meters cumulative tankage capacity at a site. | | |
| Substance or mixture of substances | | Plant status | $mg/Nm^3$ under normal conditions of 273 Kelvin and 101.3kPa (daily average). |
| Common name | Chemical symbol | | |
| Total volatile organic compounds from vapour recovery/destruction units (Thermal treatment) | N/A | New | 150 |
| | | Existing | 150 |
| Total volatile organic compounds from vapour recovery/destruction units (Non-thermal treatment) | N/A | New | 40,000 |
| | | Existing | 40,000 |

# 4 Ambient Air Quality

## 4.1 Regional Air Quality

The proposed Yzermyn mine is located within the Highveld Priority Area (HPA); an air pollution hotspot area prioritised in Section 18(1) of the NEM:AQA as an area associated with poor air quality and elevated concentrations of criteria pollutants (such as $NO_x$, $SO_2$ and $PM_{10}$) (DEA, 2010). Potential air pollution sources within the Pixley Ka Seme local municipality, surrounding the proposed mine include: three coal fired power stations (Majuba and Tutuka, located 45 km and 95 km north west of the mining area respectively and Camden, located 60km to the north); domestic burning emissions from surrounding communities; biomass burning emissions (during late winter and early spring); particulate matter and dust fallout from agricultural activities; vehicular emissions; and emissions from small scale industries in surrounding towns.

## 4.2 Local Air Quality

In order to assess the local air quality in the vicinity of the proposed Yzermyn mine, ambient air quality monitoring was performed during 2012. Results from the monitoring campaigns for dust fallout (DFO), particulate matter (PM), sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) are presented here:

### 4.2.1 Dust Fallout

To determine the concentration of dust that falls to the surface on a daily basis, dust fallout monitoring was performed onsite at eight monitoring locations during a winter and summer campaign (Figure 2). Since deposition of large (>10 µm) solid particles is a function of airborne concentrations and particle gravitational speed, fugitive dust is principally monitored using passive dust deposition gauges. These comprise an open-mouthed container partially filled with distilled water and exposed for a designated period of time.

The sampling equipment consists of a non-directional fallout bucket with a circular opening of 19 cm and a depth of 33 cm. The specifications are as close as possible to those recommended by the International Standards Organisation using available materials. The low aspect ratio (i.e. the height to width ratio) is required to keep collected particulates in the bucket before they settle in the sample water that is treated with a small quantity of algaecide to prevent algal growth. The ASTM method stipulates that the stand that supports the container is two meters above ground as there is a large variability in the concentration of particles subject to settling at heights less than two meters. As per the ASTM method, a simple aerodynamic wind shield to obtain improved precision in measured dust fallout was also installed (Figure 3).

The dust buckets were exposed for approximately 30 days during June, July and August and again in October, November and December, in accordance with the South African National Standards (SANS) 1929:2005 prescribed methodology, ASTM D1739. The buckets were collected on a monthly basis, sealed and sent to a South African National Accreditation System (SANAS) accredited laboratory for analysis. In the laboratory, the insoluble particles are first removed by filtering the water and weighing, whilst the soluble particle mass is determined after evaporation of a sample of the filtered solution. This is a standardised sampling technique in South Africa, commonly referred to as ‘bucket-monitoring’ that was originally derived from the ASTM standard method for collection and analysis of dust fallout (ASTM D1739). It has now been defined in the local context as a South African National Standard (SANS1929:2005/2009).

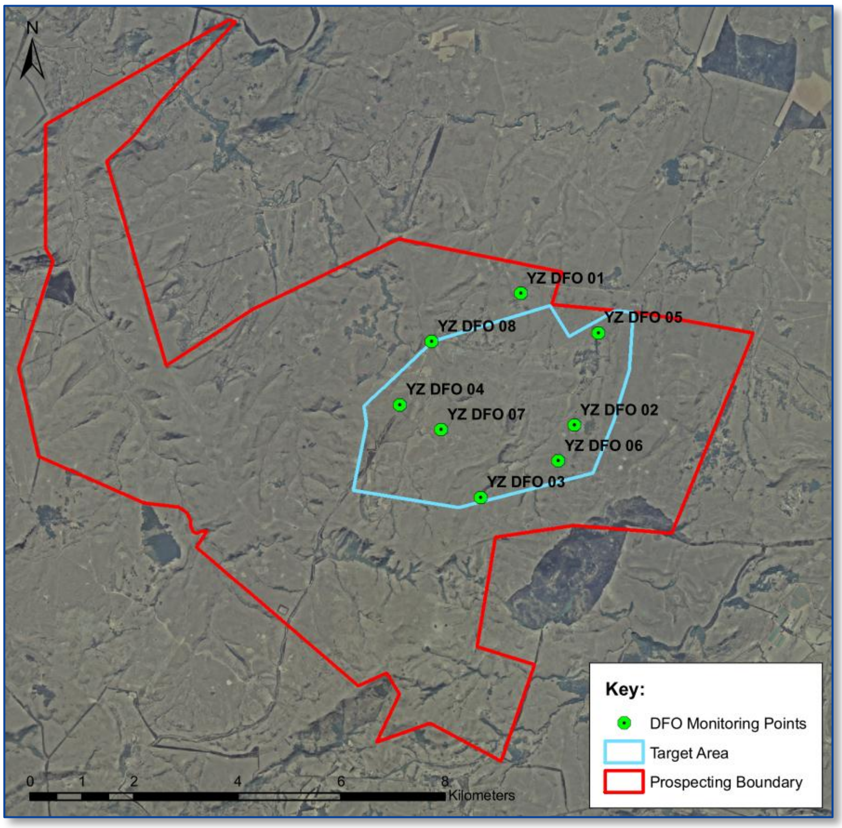


**Figure 2: Location of dust fallout (DFO) monitoring points at the proposed Yzermyn Underground Coal Mine site**

**Figure 3: Photograph of dust bucket installed at location YZ DFO 04**

The results from the three month winter and summer monitoring campaigns are presented in Figure 4. Dust fallout rates at all monitoring locations were compliant with the SANS residential standard except for YZ DFO 04 during July 2012. Since this unit was located alongside a sand road, the higher rates recorded at this site may be attributable to road dust and may not be an accurate representation of the dust climate in the region. DFO rates at all other units remain low, with the lowest rates being recorded at YZ DFO 03, which is remotely situated away from any roads with the only visible dust sources being the trampling of grazing cattle.

The elevated dust fallout rates during July at most sites could indicate an increase in vehicular activities related to the proposed Yzermyn Underground Coal Mine project on roads at the site, creating more airborne dust. The higher rates may also be influenced by deposition of particles from increased biomass burning activities which were evident within the region at this time.

As the Yzermyn area is situated in a summer rainfall region, dust fallout rates recorded during October, November and December are substantially lower than those recorded during June, July and August as rainfall supresses the amount of dust that becomes airborne.

Intermittent missing data at some locations is a result of units being stolen and inaccessibility at times due to weather conditions and unnavigable terrain.

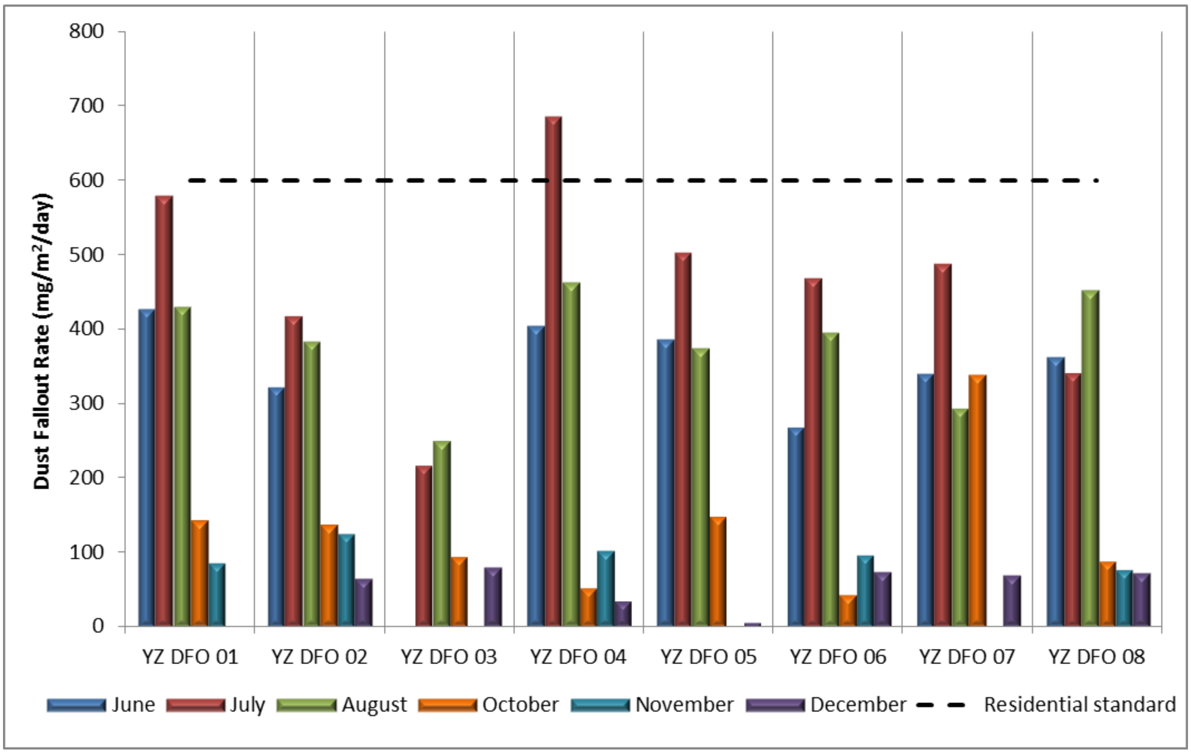


**Figure 4: Dust fallout results for the proposed Yzermyn Underground Coal Mine site for the winter (June, July and August) and summer (October, November and December) campaigns**

### 4.2.2 Particulate Matter

To establish baseline particulate matter concentrations, measurements were undertaken using an Osiris™ continuous dust monitor. The Osiris™ analyser is capable of measuring a number of size fractions simultaneously, including total suspended particulates (TSP), particles with a diameter less than 10 µm ($PM_{10}$), particles with a diameter less than 2.5 µm ($PM_{2.5}$) and particles with a diameter less than 1 µm ($PM_1$). The instrument is also equipped with a wind monitor that allows for emissions to be correlated with wind speed and direction data, making it possible for recorded dust emissions to be traced back to the probable source of the emissions.

The Osiris™ was installed ~ 900 m north-east of YZ DFO 05, within the boundaries of a camp set up by onsite drillers, performing core drilling for the Yzermyn project (Figure 6).


**Figure 5: Osiris™ analyser installed at the proposed Yzermyn Underground Coal Mine site**

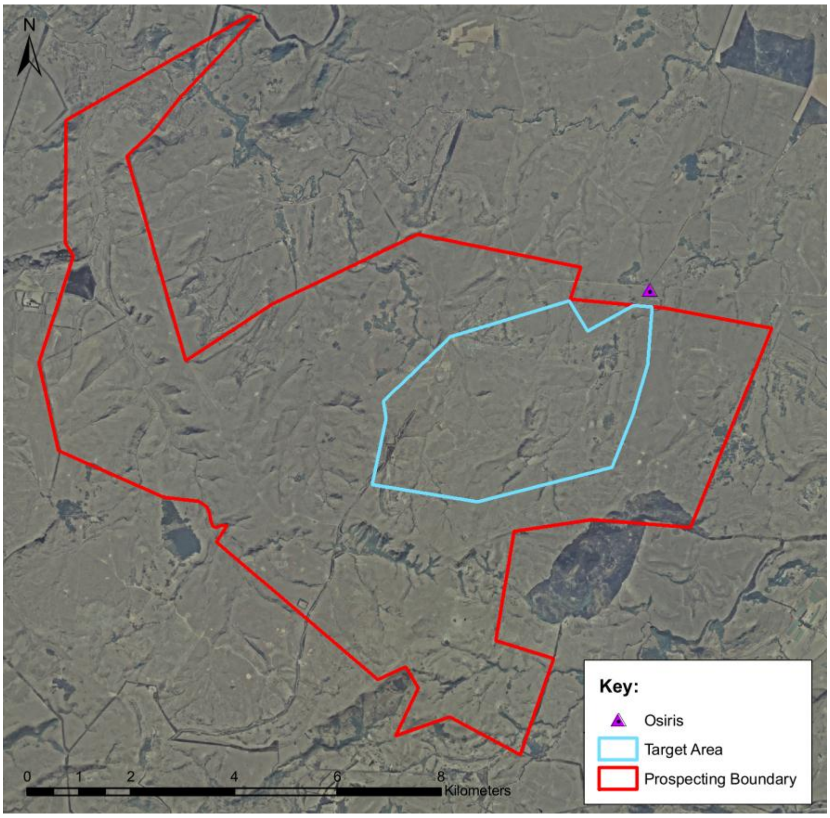


**Figure 6: Location of the Osiris™ analyser at the proposed Yzermyn Underground Coal Mine site**

Particulate matter concentrations are very low for the region with an average $PM_{10}$ concentration of 8.97 µg/m$^3$ and an average $PM_{2.5}$ concentration of 2.75 µg/m$^3$. Concentrations are well below the NEM:AQA daily standard (120 µg/m$^3$ ($PM_{10}$) and 65 µg/m$^3$ ($PM_{2.5}$)) and annual standard (50 µg/m$^3$ ($PM_{10}$) and 25 µg/m$^3$ ($PM_{2.5}$))

Figure 7 presents a $PM_{10}$ pollution rose for the region. The highest concentrations originate from the south-west, where the proposed Yzermyn Underground Coal Mine site will be located.

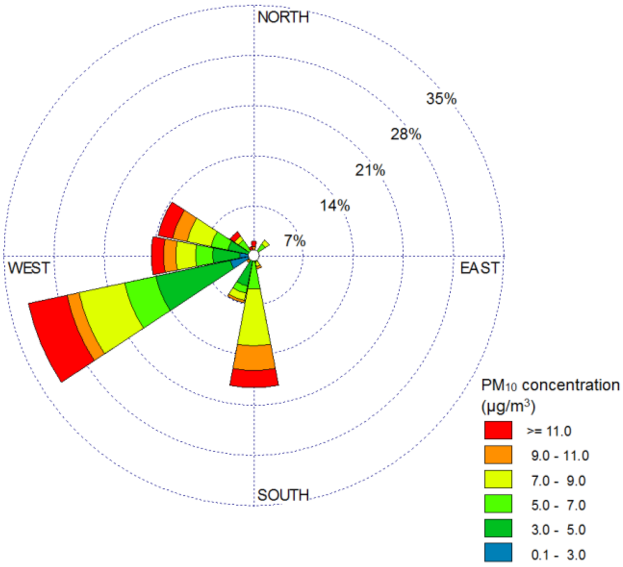


**Figure 7: $PM_{10}$ pollution rose for the proposed Yzermyn Underground Coal Mine area**

### 4.2.3 Sulphur Dioxide ($SO_2$) and Nitrogen Dioxide ($NO_2$)

$SO_2$ and $NO_2$ concentrations in the region were measured using Radiello passive samplers. Radiello passive diffusive samplers consist of three components: a support plate, a blue diffusive body in the case of $SO_2$ and $NO_2$ and a chemical absorbing cartridge. The chemical absorbing cartridge is placed within the diffusive body and then attached to the support plate. The support plate was then attached to a shelter to protect the samples from the elements.

The chemical absorbing cartridge consists of microporous polyethylene and is coated with triethanolamine (TEA) which absorbs chemicals from the air. The chemical absorbing cartridge consists of carbon and is analysed for $SO_2$ and $NO_2$ by spectrophotometry and ion chromatography.

Six passive samplers were placed at various locations on the Yzermyn site (Figure 8). These monitoring points were placed with six of the dust fallout monitoring points. Since the shelters containing the passive samplers need to be mounted above the ground, they were attached to the dust fallout units (Figure 9). Samplers were exposed for 28 days after which they were collected, sealed, kept in a temperature controlled environment and sent to a SANAS accredited laboratory for analysis.

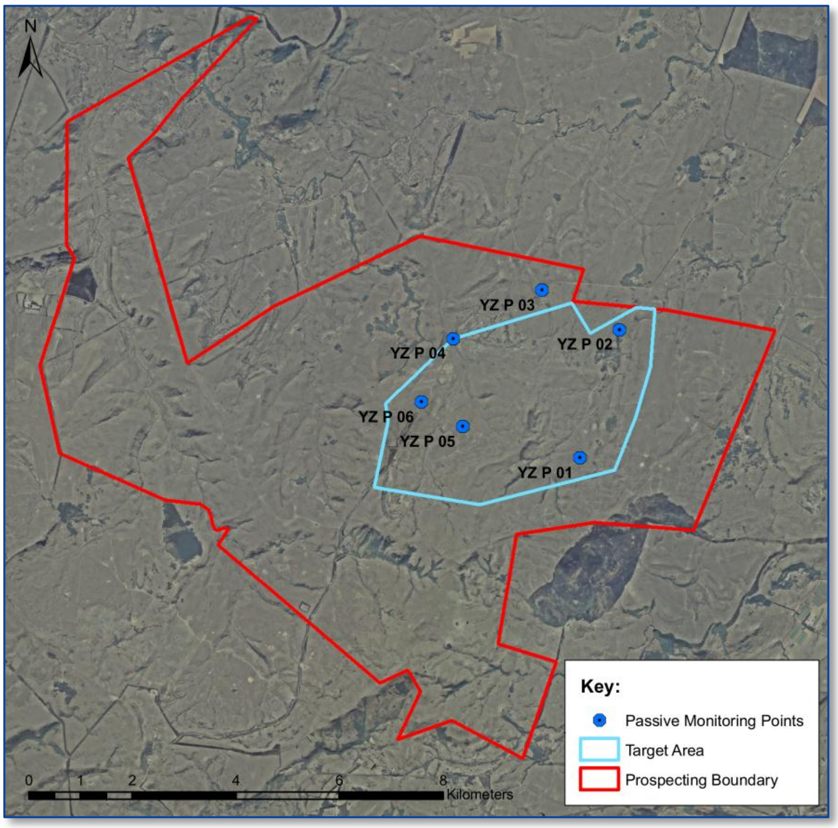


**Figure 8: Location of passive monitoring points at the Yzermyn site**

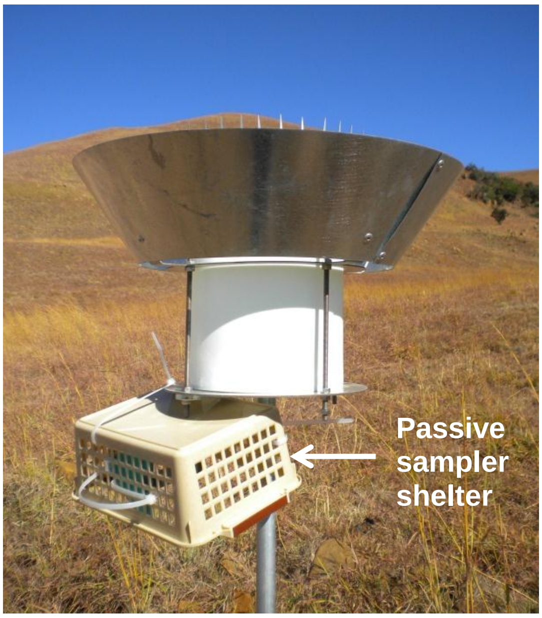


**Figure 9: Passive sampler shelter attached to dust fallout unit at location YZ P01**

The results from the $NO_2$ and $SO_2$ winter and summer monitoring campaigns are presented in Figure 10 and Figure 11. Both $SO_2$ and $NO_2$ concentrations remain low during the both the winter and summer campaigns, with concentrations remaining well below the NEM:AQA standards.

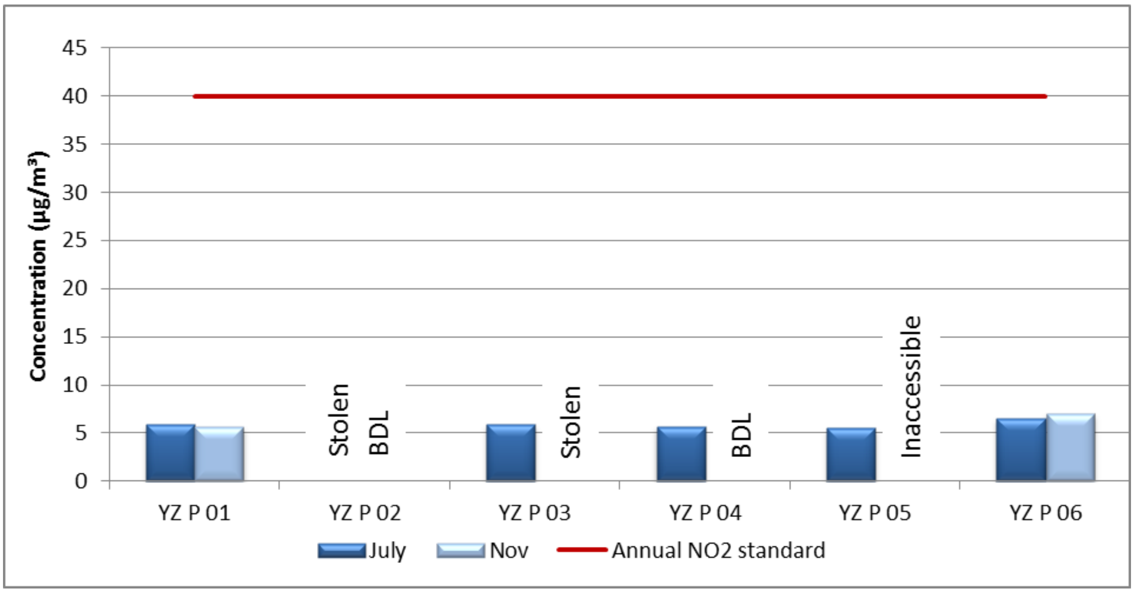


**Figure 10: Results from the $NO_2$ winter (July 2012) and summer (November 2012) monitoring campaigns at the proposed Yzermyn Underground Coal Mine site (BDL = Below Detectable Limit)**

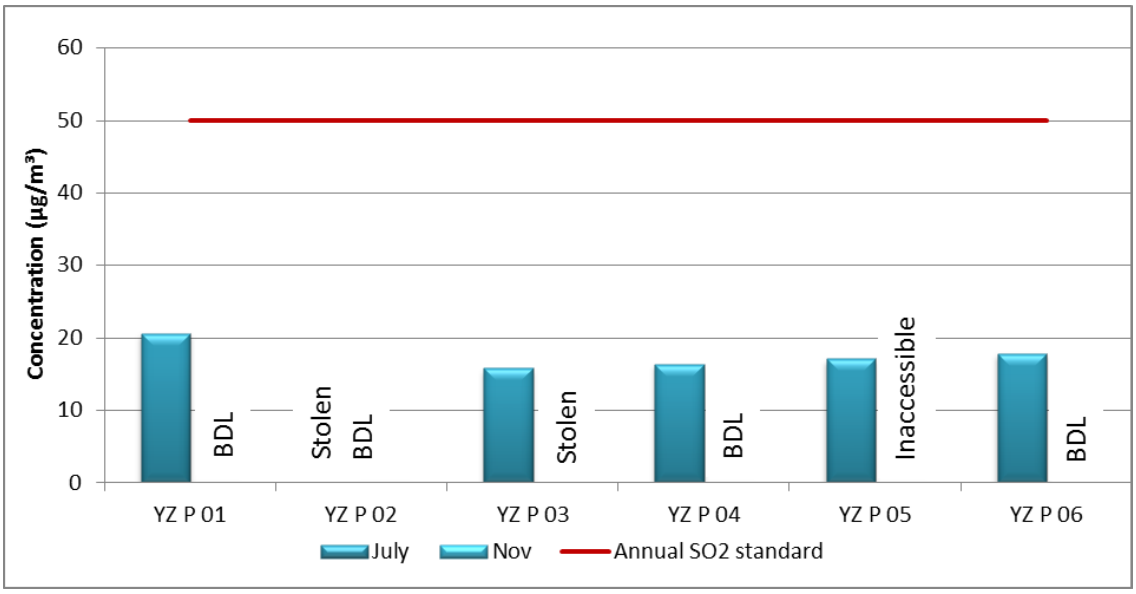


**Figure 11: Results from the $SO_2$ winter (July 2012) and summer (November 2012) monitoring campaigns at the proposed Yzermyn Underground Coal Mine site (BDL = Below Detectable Limit)**

# 5 Methodology

## 5.1 Emission Estimation

Emissions from the proposed Yzermyn Underground Coal Mine were calculated using the US EPA's AP42 and Australian National Pollutant Inventory (NPI) emission factors. An emission factor is a value representing the relationship between an activity and the rate of emission of a specified pollutant. The AP42 emission factors have been compiled since 1972 and contain emission factors and process information for over 200 air pollution source categories. These emission factors have been developed based on test data, material mass balance studies and engineering estimates.

Emissions estimates for the proposed Yzermyn Underground Coal Mine were based on the AP42 sections: 11.9: Western Surface Coal Mining; 13.2.2: Unpaved Roads; 13.2.3: Heavy Construction Operations; and 13.2.4: Aggregate Handling and Storage Piles; as well as the NPI Emission Estimation Technique Manual for Mining; Mining and Processing of Non-Metallic Minerals; and Combustion Engines. Calculations were applied to individual processes to obtain an emission to air estimate, based on mass balance information provided by the client. The specific processes and emission calculations are discussed in detail below.

Emissions of total suspended particulates (TSP), $PM_{10}$ and $PM_{2.5}$ were calculated for each mining location. Where calculations of $PM_{10}$ were not available, a factor of 50% was applied to the calculated TSP emission rates according to best international practice and as specified in the US EPA's AP42 documentation (US EPA, 1998). Where calculations of $PM_{2.5}$ were not available the generalised particle size distributions in the AP42 Appendix B.2 were utilised.

### 5.1.1 Construction Phase

The construction phase is envisaged to last six months, so all calculated emission rates were applied for a worst case duration of six months. A map indicating the layout of the proposed Yzermyn Underground Coal Mine and the relevant sources of emissions during the construction phase is indicated in Figure 12.

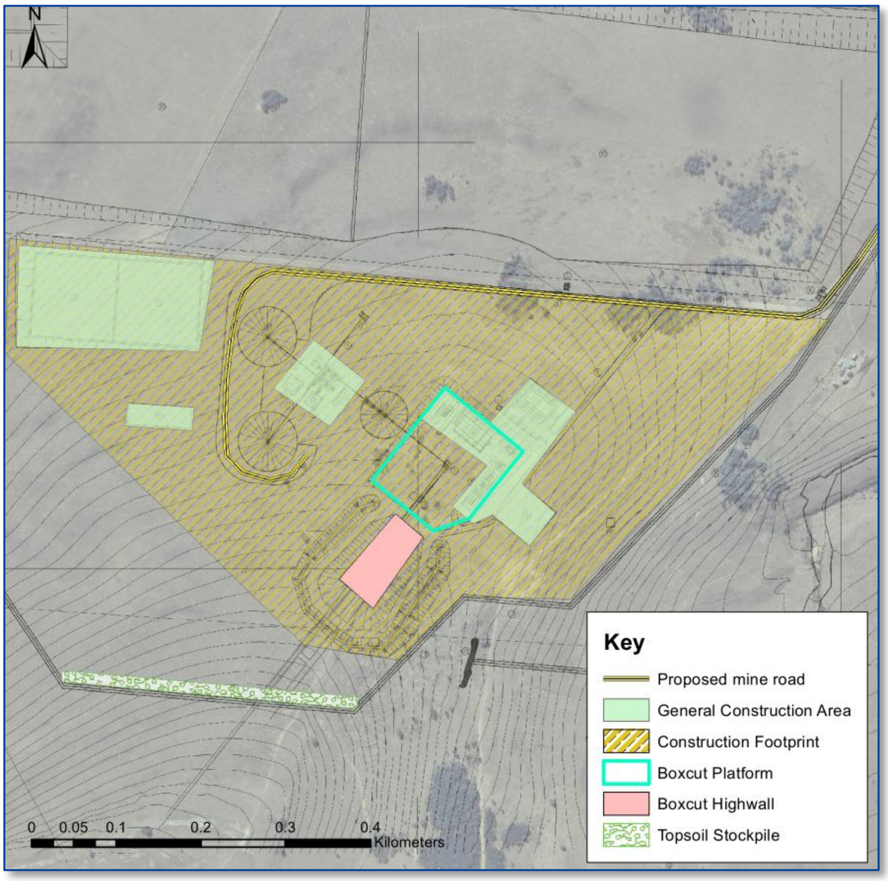


**Figure 12: Site layout of the proposed Yzermyn Underground Coal Mine and related construction phase emission sources**

#### 5.1.1.1 Topsoil Removal

To determine the amount of particulate matter (expressed as total suspended particulates (TSP)) emitted during the removal of topsoil from the construction footprint, a generic emission factor was used, based on the tons of topsoil removed over a specified time period. The emission factor utilised was:

$$E = 0.029\ kg/ton \qquad (1)$$

Equation 1 relates the kilograms of TSP emitted per ton of topsoil that is removed from the site. The calculated emission rate for the proposed Yzermyn Underground Coal Mine was based on the topsoil statistics depicted in Table 5.

**Table 5: Topsoil removal statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Area (m²) | Tons of topsoil removed per month | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|---|
| **Whole Construction Footprint** | 286,007 | 361,650 | $1.41 \times 10^{-5}$ | $4.53 \times 10^{-6}$ | $6.62 \times 10^{-7}$ |

The tons of topsoil removed were calculated based on the area calculated using GIS as specified in Table 5; a topsoil depth of 0.7 m (obtained from the soil specialist on the project); and a topsoil density of 1,806.4 kg/m³ obtained from a previous mining project in the Mpumalanga Province.

#### 5.1.1.2 Topsoil Unloading

The topsoil that will be removed from the whole construction footprint will be stockpiled in a berm to the south of the mine. To determine the amount of TSP emitted during the unloading of topsoil at this stockpile, the following emission factor was utilised:

$$E = 0.02\ kg/ton \qquad \text{(for TSP)} \qquad (2)$$

This calculation relates the amount of TSP emitted per ton of topsoil unloaded. The calculated emission rates, utilised in the dispersion model are presented in Table 6.

**Table 6: Topsoil unloading statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Area (m²) | Tons of topsoil unloaded per month | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|---|
| **Topsoil berm / stockpile** | 4,863 | 361,650 | $5.74 \times 10^{-4}$ | $1.84 \times 10^{-4}$ | $2.69 \times 10^{-5}$ |

#### 5.1.1.3 Grading

Particulate emissions from grading activities onsite were determined based on the following equations:

$$E = 0.0034\ (S)^{2.5}\ kg/VKT \qquad \text{(for TSP)} \qquad (3)$$

$$E = 0.60 \times (0.0056(S)^{2.0})\ kg/VKT \qquad \text{(for } PM_{10}\text{)} \qquad (4)$$

*Where S represents the mean vehicle speed*

This calculation relates the kilograms of particulates emitted per vehicle kilometre travelled (VKT) by each grader. Calculations at the proposed Yzermyn Underground Coal Mine were based on the grader statistics presented in Table 7.

**Table 7: Grader statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Mean grader speed (km/h) | No. of graders | VKT per year | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|---|---|
| **Roads** | 4 | 1 | 14,400 | $6.28 \times 10^{-6}$ | $3.10 \times 10^{-6}$ | $1.95 \times 10^{-7}$ |
| **Boxcut Platform** | 4 | 1 | 255.6 | $2.10 \times 10^{-8}$ | $1.04 \times 10^{-8}$ | $6.51 \times 10^{-10}$ |

Calculated emission rates were applied as a worst case for 20 hours of operation, seven days a week on the boxcut platform and twice a month on the roads.

#### 5.1.1.4 General Construction

TSP emissions generated as a result of general construction activities, which includes land clearing, ground excavation, earth moving and construction itself, were calculated using the following equation:

$$E = 2.69\ tons/\text{ha/month of activity} \qquad (5)$$

The emission factor relates the tons of TSP emitted per hectare covered by construction activities per month of activity. Since this is a fairly generalised emission factor, for the proposed Yzermyn Underground Coal Mine this emission factor was applied to areas where general construction will be prevalent (workshops, stores, offices and plant). For the boxcut, a combination of specific factors were utilised and are discussed further below. Calculations were based on the statistics presented in Table 8.

**Table 8: General construction statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Area ($m^2$) | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|
| **Areas of general construction** | 50,186 | $1.04 \times 20^{-4}$ | $5.19 \times 10^{-5}$ | $1.56 \times 10^{-5}$ |

#### 5.1.1.5 Drilling

To determine the TSP emissions from drilling activities onsite during the excavation of the boxcut highwall, an emission factor was applied based on the number of holes that are drilled over a specified time period.

The following calculation was applied for overburden drilling:

$$E = 0.59\ kg/hole \qquad (6)$$

The calculation relates the amount of TSP emitted (in kilograms) per hole that is drilled. Emission calculations for drilling activities at the proposed Yzermyn Underground Coal Mine were based on drilling statistics provided in Table 9.

**Table 9: Drilling statistics for the proposed Yzermyn Underground Coal Mine**

| Location | No. of holes in overburden/month | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|
| **Boxcut Highwall** | 155.6 | $1.26 \times 10^{-5}$ | $6.32 \times 10^{-6}$ | $3.79 \times 10^{-7}$ |

The number of holes drilled was based on a 3 m spacing over the area of the boxcut highwall.

#### 5.1.1.6 Blasting

The emission factor utilised to estimate TSP emissions from blasting activities during the excavation of the boxcut highwall and declines to the Alfred and Dundas seams, is presented below:

$$E = 0.00022(A)^{1.5}\ kg/blast \qquad (7)$$

Where A represents the horizontal area ($m^2$) to be blasted (with a blasting depth of ≤ 21 m)

The emission factor relates the amount of particulate matter emitted (in kg) to the surface area that is blasted. The calculations were based on the blasting statistics presented in Table 10.

**Table 10: Blasting statistics for the proposed Yzermyn Underground Coal Mine**

| Location | No. of blasts in overburden/month | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|
| **Boxcut Highwall** | 4 | $1.80 \times 10^{-5}$ | $8.98 \times 10^{-6}$ | $5.39 \times 10^{-7}$ |
| **Decline 1** | 30 | $1.17 \times 10^{-5}$ | $5.83 \times 10^{-6}$ | $3.50 \times 10^{-7}$ |
| **Decline 2** | 30 | $1.17 \times 10^{-5}$ | $5.83 \times 10^{-6}$ | $3.50 \times 10^{-7}$ |

#### 5.1.1.7 Bulldozing

Emissions from the bulldozing of overburden during the construction of the boxcut were calculated using the following equations:

$$E = \frac{2.6(s)^{1.2}}{(M)^{1.3}}\ kg/hr \qquad \text{(for TSP)} \qquad (8)$$

$$E = \left(\frac{0.45(s)^{1.5}}{(M)^{1.4}}\right)(0.75)\ kg/hr \qquad \text{(for } PM_{10}\text{)} \qquad (9)$$

Where s represents the material silt content (%) and M represents the material moisture content (%)

These emission factors relate the amount of particulate matter emitted (in kg) to the number of hours that the bulldozers operate over an area during a specified timeframe. A silt content of 14% and moisture content of 6.7% was used, based on a soil analysis performed for previous mining project in the Mpumalanga Province. For the proposed Yzermyn Underground Coal Mine, the calculations were based on the bulldozing statistics provided in Table 11.

**Table 11: Overburden bulldozing statistics for the proposed Yzermyn Underground Coal Mine**

| Location | No. of bulldozers | Hours of operation per year per bulldozer | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|---|
| **Boxcut Highwall** | 1 | 3,600 | $2.44 \times 10^{-4}$ | $5.79 \times 10^{-5}$ | $2.57 \times 10^{-5}$ |
| **Boxcut Platform** | 1 | 3,600 | $7.51 \times 10^{-5}$ | $1.78 \times 10^{-5}$ | $7.88 \times 10^{-6}$ |

Emission rates were applied for a worst case of 20 hours of operation for seven days a week.

#### 5.1.1.8 Unloading of Material from Trucks

To determine the amount of particulate matter emitted during the unloading of overburden at the box cut platform, the following equations from the Australian NPI emission factors for coal mines were utilised:

*Truck dumping of overburden:*

$$EF_{TSP} = 0.012\ kg/ton \qquad (10)$$

$$EF_{PM10} = 0.0043\ kg/ton \qquad (11)$$

The emission factors relate the amount of particulate matter emitted (in kg) to the amount of material unloaded during a specified timeframe. Calculations were performed based on the truck unloading statistics depicted in Table 12.

**Table 12: Truck unloading statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Material Type | Material handled (tons/month) | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|---|
| **Boxcut Platform** | Overburden | 20,674 | $5.96 \times 10^{-6}$ | $5.96 \times 10^{-6}$ | $6.26 \times 10^{-7}$ |

#### 5.1.1.9 Unpaved Roads

Particulate emission estimates from vehicles travelling on the unpaved mine access road from the town of Dirkiesdorp to the mine are presented here. The equation used to determine particulate emissions from vehicles travelling on unpaved roads at industrial sites is presented below:

$$E = \left(k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}\right)(281.9)\ \ g/VKT \qquad (12)$$

Where s is the surface material silt content (%), W is the mean vehicle weight; and a, b and k are empirical constants

These emission factors relate the amount of particulate emissions (in grams) to the number of kilometres travelled by all vehicles on site (VKT). Table 13 presents the empirical constants used in the equation for different particle sizes; and Table 14 presents the vehicular statistics at the proposed Yzermyn Underground Coal Mine, used in the calculations. The lengths of the roads used in the calculations and modelling as well as the calculated emission rates are presented in Table 15.

**Table 13: Empirical constants for different particle sizes**

| Constant | $PM_{10}$ | TSP |
|---|---|---|
| **a** | 0.9 | 0.7 |
| **b** | 0.45 | 0.45 |
| **k** | 1.5 | 4.9 |

**Table 14: Vehicular statistics at the proposed Yzermyn Underground Coal Mine**

| Location | No. of construction vehicles | No. of LDVs per day | Average weight of vehicles (tons) | VKT by all vehicles per year |
|---|---|---|---|---|
| **Mine access road** | 18 | 20 | 15.8 | 77,061 |

Construction vehicles will only travel on the road twice during the construction phase (once on entry and once on exit). It was assumed that 20 LDVs/delivery trucks will visit the site per day. The average weight of the vehicles is based on a weighted mean of all light (3 ton) and heavy duty (30 ton) vehicles frequenting the site on a daily basis.

**Table 15: Lengths of unpaved roads at the proposed Yzermyn Underground Coal Mine and calculated unpaved road emission rates**

| Location | Length of unpaved roads (m) | Calculated TSP emission rate (g/m/s) | Calculated $PM_{10}$ emission rate (g/m/s) | Calculated $PM_{2.5}$ emission rate (g/m/s) |
|---|---|---|---|---|
| **Mine access road** | 10,649.7 | $2.76 \times 10^{-7}$ | $9.69 \times 10^{-5}$ | $9.69 \times 10^{-6}$ |

### 5.1.1.10 Wind Erosion

Particulate matter emissions from the wind erosion of exposed ground were calculated using the following equations:

$$E_{TSP} = 0.4\ kg/ha\ /hr \qquad (13)$$

$$E_{PM10} = 0.2\,kg/ha\ /hr \qquad (14)$$

The equations relate the amount of particulate matter (in kg) emitted per hectare of exposed ground per hour. The calculated emission rate was applied to the exposed areas were general construction occurs, at the boxcut highwall and platform and at the topsoil stockpile. Emission rates are presented in Table 16.

**Table 16: Exposed ground wind erosion emission rates**

| Location | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|
| **General construction areas** | $2.70 \times 10^{-6}$ | $1.35 \times 10^{-6}$ | $1.35 \times 10^{-7}$ |
| **Boxcut highwall** | $2.70 \times 10^{-6}$ | $1.35 \times 10^{-6}$ | $1.35 \times 10^{-7}$ |
| **Box cut platform** | $2.70 \times 10^{-6}$ | $1.35 \times 10^{-6}$ | $1.35 \times 10^{-7}$ |
| **Topsoil stockpile** | $2.70 \times 10^{-6}$ | $1.35 \times 10^{-6}$ | $1.35 \times 10^{-7}$ |

## 5.1.2 Operational Phase

Operations at the proposed Yzermyn underground coal mine will sustain for 24 hours a day. Emissions from the mine itself calculated during the first three years of operation are a worst case representation of emissions, based on maximum capacity, which will only occur after three years of operation. Direct mine emissions after the first three years are therefore the same as during the first three years and are modelled as such in the dispersion model.

A map indicating the layout of the proposed Yzermyn Underground Coal Mine and the relevant sources during the operational phase is indicated in Figure 13.

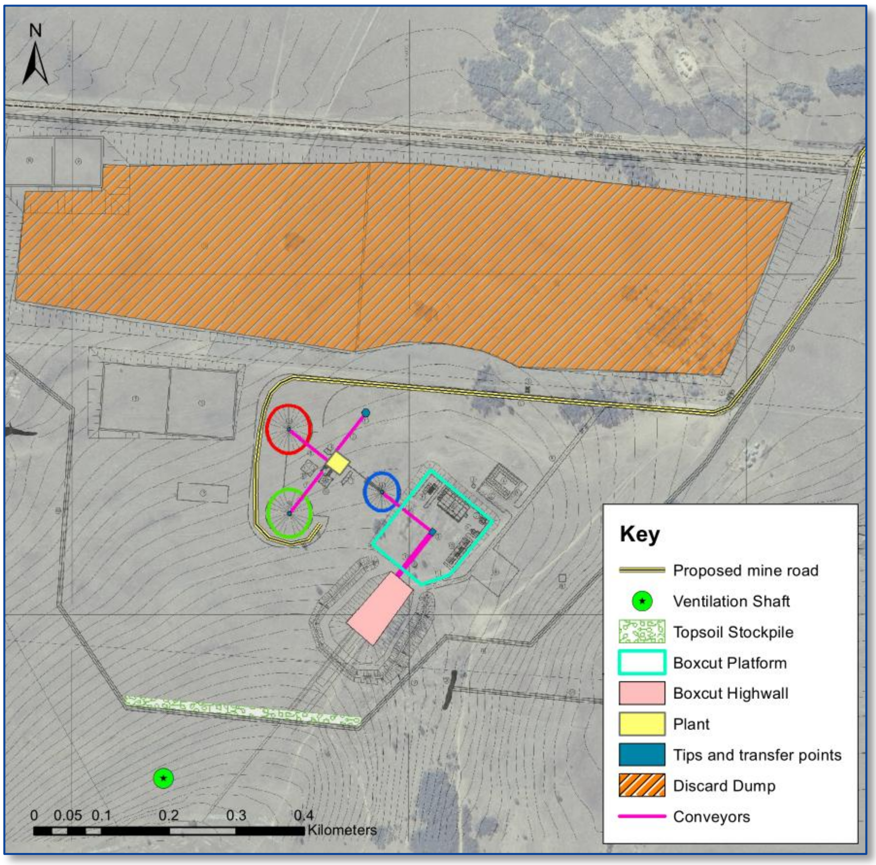


**Figure 13: Site layout of the proposed Yzermyn Underground Coal Mine and related emission sources during the operational phase**

### 5.1.2.1 Conveyor Drop Operations

To determine the amount of particulate matter emitted during the continuous and batch drop of material from the conveyor system onto stockpiles, including the batch drop of waste rock onto transport trucks, the AP42 aggregate handling equation was utilised. This equation relates the amount of particulate matter generated (in kg) per ton of material (ROM or waste rock) transferred by any type of drop operation:

$$EF_{(kg/t)} = k \cdot (0.0016) \cdot \left( \frac{\left(\frac{u}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad (15)$$

Where u is the mean wind speed, M is the material moisture content (%) and k is particle size multiplier (k = 0.74 for TSP and k = 0.35 for $PM_{10}$)

Calculations were performed for the proposed Yzermyn Underground Coal Mine, based on the materials handling statistics presented in Table 17. A moisture content of 4.25% was utilised in calculations.

**Table 17: Material handling statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Material handled (tons/month) | Height (m) | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|---|
| **Boxcut transfer point** | 200,000 | 10 | $6.83 \times 10^{-3}$ | $3.23 \times 10^{-3}$ | $4.88 \times 10^{-4}$ |
| **ROM tip** | 200,000 | 19 | $2.51 \times 10^{-2}$ | $1.19 \times 10^{-2}$ | $1.80 \times 10^{-3}$ |
| **Export tip** | 110,000 | 15 | $1.37 \times 10^{-2}$ | $6.50 \times 10^{-3}$ | $9.84 \times 10^{-4}$ |
| **Middlings tip** | 52,000 | 15 | $6.50 \times 10^{-3}$ | $3.07 \times 10^{-3}$ | $4.65 \times 10^{-4}$ |
| **Discard bin tip** | 38,000 | 8 | $9.42 \times 10^{-4}$ | $4.46 \times 10^{-4}$ | $6.75 \times 10^{-5}$ |

### 5.1.2.2 Crushing and Screening

To determine the particulate emissions from the crushing and screening of coal in the coal handling and preparation plant (CHPP), emission factors for crushing operations at mines from the NPI Emission Estimation Technique Manual for Mining and Processing of Non-metallic Minerals were utilised. Emissions from the Yzermyn mine were based on primary crushing of low moisture content ore (< 4%). Primary crushing activities include emissions from screens, the crusher, the surge bin, the apron feeder, and conveyor belt transfer points that are integral to the crusher. The following equations were used to calculate TSP and $PM_{10}$ emissions from such activities:

$$E_{TSP} = 0.2\ kg/ton \qquad (16)$$

$$EF_{PM10} = 0.02\ kg/ton \qquad (17)$$

The resultant emission rates are based on the amount of particulates emitted (in kg) per ton of ore that is crushed. The crushing statistics used in the calculations are presented in Table 18 below.

**Table 18: Crushing statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Tons of ore crushed per month | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|
| **Coal handling and preparation plant** | 200,000 | $1.14 \times 10^{-3}$ | $4.54 \times 10^{-4}$ | $1.70 \times 10^{-4}$ |

### 5.1.2.3 Front End Loader (FEL) activity

Particulate matter emissions from the loading of coal using FELs were estimated using the following equations:

$$\mathrm{E} = \frac{35.6\,(\mathrm{s})^{1.2}}{(\mathrm{M})^{1.3}}\ \mathrm{kg/hr} \qquad \text{(for TSP)} \qquad (18)$$

$$\mathrm{E} = \left(\frac{8.44(\mathrm{s})^{1.5}}{(\mathrm{M})^{1.4}}\right)(0.75)\ \mathrm{kg/hr} \qquad \text{(for } PM_{10}\text{)} \qquad (19)$$

Where s represents the material silt content (%) and M represents the material moisture content (%)

These emission factors relate the amount of particulate matter emitted (in kg) to the number of hours that the FELs operate over an area during a specified timeframe. A moisture content of 4.25% was used in the calculations and a silt content of 6.2%, an average coal value obtained from the AP42 documentation, was utilised. For the proposed Yzermyn Underground Coal Mine the calculations were based on the statistics presented in Table 19.

**Table 19: Coal bulldozing statistics for the proposed Yzermyn Underground Coal Mine**

| Location | No. of bulldozers | Hours of operation per year per bulldozer | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|---|
| **Export stockpile** | 2 | 8,640 | $7.52 \times 10^{-3}$ | $2.00 \times 10^{-3}$ | $1.65 \times 10^{-4}$ |
| **Middlings stockpile** | 2 | 8,640 | $7.52 \times 10^{-3}$ | $2.00 \times 10^{-3}$ | $1.65 \times 10^{-4}$ |

Calculations were based on a worst case of 24 hour operation of FELs.

#### 5.1.2.4 Bulldozing

Emissions from the bulldozing of waste rock that is dumped at the discard dump were calculated using the following equations:

$$E = \frac{2.6(s)^{1.2}}{(M)^{1.3}}\ kg/hr \qquad \text{(for TSP)} \qquad (20)$$

$$E = \left(\frac{0.45(s)^{1.5}}{(M)^{1.4}}\right)(0.75)\ kg/hr \qquad \text{(for } PM_{10}\text{)} \qquad (21)$$

Where s represents the material silt content (%) and M represents the material moisture content (%)

These emission factors relate the amount of particulate matter emitted (in kg) to the number of hours that the bulldozers operate over an area during a specified timeframe. A moisture content of 4.25% was used in the calculations and a silt content of 6.2%, an average coal value obtained from the AP42 documentation, was utilised. For the proposed Yzermyn Underground Coal Mine the calculations were based on the statistics presented in Table 20

**Table 20: Overburden bulldozing statistics for the proposed Yzermyn Underground Coal Mine**

| Location | No. of bulldozers | Hours of operation per year per bulldozer | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|---|
| **Discard dump** | 2 | 8,640 | $9.54 \times 10^{-5}$ | $2.54 \times 10^{-5}$ | $2.10 \times 10^{-6}$ |

Calculations were based on a worst case of 24 hour bulldozer operation.

#### 5.1.2.5 Loading of Coal

The quantity of particulate emissions generated from the loading of coal onto trucks is estimated using the equations below:

*Truck loading of coal:*

$$E_{TSP} = \frac{0.580}{(M)^{1.2}}\ \ kg/ton \qquad (22)$$

$$E_{PM10} = \left(\frac{0.0596}{(M)^{0.9}}\right)(0.75)\ \ kg/ton \qquad (23)$$

The emission factors relate the amount of particulate matter emitted (in kg) to the amount of material loaded during a specified timeframe. Calculations utilised a moisture content of 4.25% and were based on the truck loading statistics presented in Table 21.

**Table 21: Truck loading statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Tons of coal per month | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|
| **Product Stockpile** | 110,000 | $1.23 \times 10^{-3}$ | $1.46 \times 10^{-4}$ | $2.33 \times 10^{-5}$ |
| **Middlings Stockpile** | 52,000 | $5.80 \times 10^{-4}$ | $6.91 \times 10^{-5}$ | $1.10 \times 10^{-5}$ |

Calculations were based on a worst case of 24 hour operation.

#### 5.1.2.6 Truck Unloading

To determine the amount of particulate matter emitted during the unloading of discard material at the discard dump, the following equation from the Australian NPI emission factors for coal mines were utilised:

$$EF_{TSP} = 0.012\ kg/t \qquad (24)$$

$$EF_{TSP} = 0.0043\ kg/t \qquad (25)$$

The emission factors relate the amount of particulate matter emitted (in kg) to the amount of material unloaded during a specified timeframe. Calculations were performed based on the truck unloading statistics depicted in Table 22.

**Table 22: Truck unloading statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Material handled (tons/month) | Calculated TSP emission rate ($g/m^2/s$) | Calculated $PM_{10}$ emission rate ($g/m^2/s$) | Calculated $PM_{2.5}$ emission rate ($g/m^2/s$) |
|---|---|---|---|---|
| **Discard Dump** | 38,000 | $6.32 \times 10^{-7}$ | $6.32 \times 10^{-7}$ | $6.64 \times 10^{-8}$ |

#### 5.1.2.7 Grading

Roads will remain unpaved for the first three years of operation. Particulate emissions from grading activities at the discard dump and on roads during the first three years of operation were determined based on the following equations:

$$E = 0.0034\ (S)^{2.5}\ kg/VKT \qquad \text{(for TSP)} \qquad (26)$$

$$E = 0.60 \times (0.0056(S)^{2.0})\ kg/VKT \qquad \text{(for } PM_{10}\text{)} \qquad (27)$$

*Where S represents the mean vehicle speed*

This calculation relates the kilograms of particulates emitted per vehicle kilometre travelled (VKT) by each grader. Calculations at the proposed Yzermyn Underground Coal Mine were based on the grader statistics presented in Table 23.

**Table 23: Grader statistics for the proposed Yzermyn Underground Coal Mine**

| Location | Mean grader speed (km/h) | No. of graders | VKT per year (all graders) | Calculated TSP emission rate (g/m/s) | Calculated $PM_{10}$ emission rate (g/m/s) | Calculated $PM_{2.5}$ emission rate (g/m/s) |
|---|---|---|---|---|---|---|
| **Discard Dump** | 4 | 2 | 50,688 | $6.28 \times 10^{-7}$ | $3.10 \times 10^{-7}$ | $1.95 \times 10^{-8}$ |
| **Roads (first 3 years)** | 4 | 2 | 1,022 | $4.14 \times 10^{-8}$ | $2.05 \times 10^{-8}$ | $1.28 \times 10^{-9}$ |

Calculated emission rates were applied as a worst case for 24 hours of operation, seven days a week on the discard dump and twice a month on the roads.

#### 5.1.2.8 Wind Erosion

To quantify the particulate emissions created as a result of wind erosion of active coal storage piles, the following equation was utilised:

$$E = 0.85\ \frac{Mg}{(hectare)(yr)} \qquad (28)$$

This emission factor relates the amount of TSP emitted, to the area covered by the stock piles. The calculated emission rate was applied to the ROM and product stockpiles as well as the conveyors, as these are not enclosed and may be exposed to wind erosion. Emissions are presented in Figure 24.

**Table 24: Coal stockpiles affected by wind erosion**

| Location | Height (m) | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|
| **ROM Stockpile** | 18 | $1.42 \times 10^{-4}$ | $7.08 \times 10^{-5}$ | $7.08 \times 10^{-6}$ |
| **Export Stockpile** | 14 | $1.42 \times 10^{-4}$ | $7.08 \times 10^{-5}$ | $7.08 \times 10^{-6}$ |
| **Middlings Stockpile** | 14 | $1.42 \times 10^{-4}$ | $7.08 \times 10^{-5}$ | $7.08 \times 10^{-6}$ |
| **Conveyors** | 1 | $1.42 \times 10^{-4}$ | $7.08 \times 10^{-5}$ | $7.08 \times 10^{-6}$ |

Particulate matter emissions from the wind erosion of exposed ground were calculated using the following equations:

$$E_{TSP} = 0.4\ kg/ha\ /hr \qquad (29)$$

$$E_{PM10} = 0.2\,kg/ha\ /hr \qquad (30)$$

The equations relate the amount of particulate matter (in kg) emitted per hectare of exposed ground per hour. The calculated emission rate was applied to the exposed areas around the boxcut highwall and platform; the topsoil stockpile/berm; and the discard dump. Emission rates are presented in Table 25.

**Table 25: Exposed ground wind erosion emission rates**

| Location | Height (m) | Calculated TSP emission rate (g/m²/s) | Calculated $PM_{10}$ emission rate (g/m²/s) | Calculated $PM_{2.5}$ emission rate (g/m²/s) |
|---|---|---|---|---|
| **Discard Dump** | 30 | $2.70 \times 10^{-6}$ | $1.35 \times 10^{-6}$ | $1.35 \times 10^{-7}$ |
| **Boxcut Highwall** | 0 | $2.70 \times 10^{-6}$ | $1.35 \times 10^{-6}$ | $1.35 \times 10^{-7}$ |
| **Boxcut Platform** | 0 | $2.70 \times 10^{-6}$ | $1.35 \times 10^{-6}$ | $1.35 \times 10^{-7}$ |
| **Topsoil Stockpile** | 2 | $2.70 \times 10^{-6}$ | $1.35 \times 10^{-6}$ | $1.35 \times 10^{-7}$ |

### 5.1.2.9 Unpaved Roads

During the first three years of operation, the mine access road will be unpaved. Particulate emission estimates from vehicles travelling on the unpaved mine access road from the town of Dirkiesdorp to the mine are presented here. The equation used to determine particulate emissions from vehicles travelling on unpaved roads at industrial sites is presented below:

$$E = \left(k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}\right)(281.9)\ \ g/VKT \qquad (31)$$

Where s is the surface material silt content (%), W is the mean vehicle weight; and a, b and k are empirical constants

These emission factors relate the amount of particulate emissions (in grams) to the number of kilometres travelled by all vehicles on site (VKT). The empirical constants used in the equation for different particle sizes are presented in Table 13. Table 26 presents the vehicular statistics at the proposed Yzermyn Underground Coal Mine during the first three years of operation, used in the calculations. A road length of 10.65 km was utilised and the emission rates calculated represent a worst case scenario of emissions, as it was assumed that all trucks frequenting the mine travel on all of the roads onsite. The calculated emission rates are presented in Table 27.

**Table 26: Vehicular statistics at the proposed Yzermyn Underground Coal Mine during the first three years of operation**

| Location | No. of haul trucks per day | No. of LDVs per day | Average weight of vehicles (tons) | VKT by all vehicles per year |
|---|---|---|---|---|
| **Mine access road** | 139 | 45 | 46.1 | 1,430,468 |

It was assumed that 45 LDVs will enter the site per day, based on the personnel numbers depicted in the Mine Works Programme. The average weight of the vehicles is based on a weighted mean of all light (3 ton) and heavy duty (60 ton - loaded) vehicles frequenting the site on a daily basis.

**Table 27: Calculated unpaved road emission rates for the proposed Yzermyn Underground Coal Mine**

| Location | Calculated TSP emission rate (g/m/s) | Calculated $PM_{10}$ emission rate (g/m/s) | Calculated $PM_{2.5}$ emission rate (g/m/s) |
|---|---|---|---|
| **Mine access road** | $4.08 \times 10^{-3}$ | 1.44 x 10-3 | $1.06 \times 10^{-4}$ |

### 5.1.2.10 Vehicle Emissions

Emissions from vehicle engines travelling onsite were estimated using the NPI Emissions Estimation Technique Manual for Combustion Engines. The emission factors estimate pollutant emissions from vehicles in kilograms per year of activity onsite. The following equation is used to determine such emissions:

$$Ei = LY \times EFi \quad kg/y \qquad (32)$$

Where LY is the distance travelled in a reporting year, EFi is the emission factor of the substance and i is the substance.

For all calculations a fuel consumption of 25 L/100 km based on a generic diesel truck was utilised. The calculations were based on 36,718 trucks operating at the mine during the first three years of operation and 63,259 trucks operating at the mine after the first three years of operation. A road length of 10.65 km was utilised and it was assumed, as a worst case that all trucks travel on all roads at the facility. The calculated emission rates are presented in Table 28.

**Table 28: Calculated vehicle emission rates for the operational phase of the proposed Yzermyn Underground Coal Mine**

| Pollutant | Emission Factor (kg/km) | First Three Years Calculated Emission Rate (g/m/s) | After Three Years Calculated Emission Rate (g/m/s) |
|---|---|---|---|
| **CO** | 8.5 | $6.19 \times 10^{-7}$ | $1.07 \times 10^{-6}$ |
| **$NO_x$** | 22 | $1.60 \times 10^{-6}$ | $2.76 \times 10^{-6}$ |
| **$SO_2$** | 0.017 | $1.24 \times 10^{-9}$ | $2.13 \times 10^{-9}$ |
| **$PM_{10}$** | 1.2 | $8.73 \times 10^{-8}$ | $1.50 \times 10^{-7}$ |
| **VOC** | 1 | $7.28 \times 10^{-8}$ | $1.25 \times 10^{-7}$ |

### 5.1.2.11 Underground Ventilation System

Emission factors for release of particulate matter from underground vent shafts are not available, so particulate emissions obtained from a BHP Billiton study performed for the Illwarra Coal Mine were utilised. The vent shaft dimensions and emission rates applied in the dispersion model are presented in Table 29. The exit temperature of the vent was assumed as ambient.

**Table 29: Vent dimensions and emission rates from the underground ventilation shaft**

| Location | Height of release (m) | Vent Diameter (m) | Exit Velocity (m/s) | Calculated TSP emission rate (g/s) | Calculated $PM_{10}$ emission rate (g/s) | Calculated $PM_{2.5}$ emission rate (g/s) |
|---|---|---|---|---|---|---|
| **Upcast shaft** | 3 | 6 | 8 | 0.9 | 0.5 | 0.1 |

### 5.1.2.12 Storage Tanks

From previous project experience, VOC emissions from the ten 15m³ onsite diesel storage tanks at the proposed Yzermyn Underground Coal Mine will be minimal and have subsequently been excluded from this assessment.

### 5.1.3 Source Contributions

Figure 14 illustrates the contribution of $PM_{10}$ emissions from the main activities at the proposed Yzermyn Underground Coal Mine during the construction phase. The largest source of particulate emissions during the construction phase is associated with handling of materials in the form of topsoil removal and unloading; bulldozing; and truck unloading at the boxcut platform, constituting 48.5% of all $PM_{10}$ emissions. General construction activities (which includes land clearing, ground excavation, earth moving and construction itself) constitutes 32.2% of $PM_{10}$ emitted during the construction phase, followed by activities operating along the mine access road (vehicle movement and grading), which constitutes 12.8% of emissions. Smaller contributions from wind erosion as well as drilling and blasting are also noted. Since construction activities are only envisaged to endure for six months, emissions from these sources are not permanent in nature and may not require such strict mitigation techniques.

During the first three years of operation the mine access road leading from Dirkiesdorp will not be paved, leading to elevated $PM_{10}$ emissions from the 139 trucks and 45 light duty vehicles that will frequent the mine on a daily basis, together with grading activities on the road. Emissions from the unpaved road will contribute up 99.9% of emissions from the proposed Yzermyn Underground Coal Mine, with the next highest source being materials handling, constituting only 0.002%. From this, together with the model outputs presented in section 7.2, drastic mitigation methods will need to me employed to decrease emissions from this source. These methods are discussed further in section 10. Such elevated $PM_{10}$ contributions from unpaved roads have also been noted in previous mining projects, where a key management and mitigation focus was the employment of the correct methods to minimise emissions from such a source.

Figure 15 illustrates the contribution of $PM_{10}$ from various activities at the proposed Yzermyn Underground Coal Mine during the operational phase (after three years). The largest source of $PM_{10}$ is the handling of materials in the form of bulldozing / FEL activity at the stockpiles and discard dump; truck loading; and drop operations at tips and bins. This source constitutes 95.7% of $PM_{10}$ emissions during the operational phase. The second highest contributor is wind erosion of stockpiles and exposed areas, constituting 2.4% of emissions. Such sources have various mitigation options available, all of which are discussed in section 9.

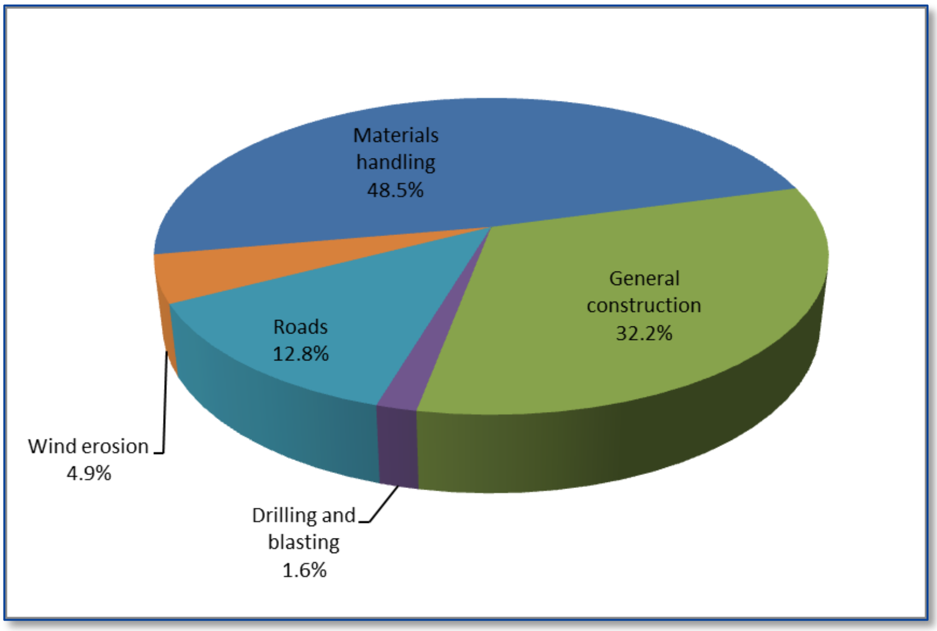


**Figure 14: $PM_{10}$ source apportionment for the Yzermyn mine during construction phase**

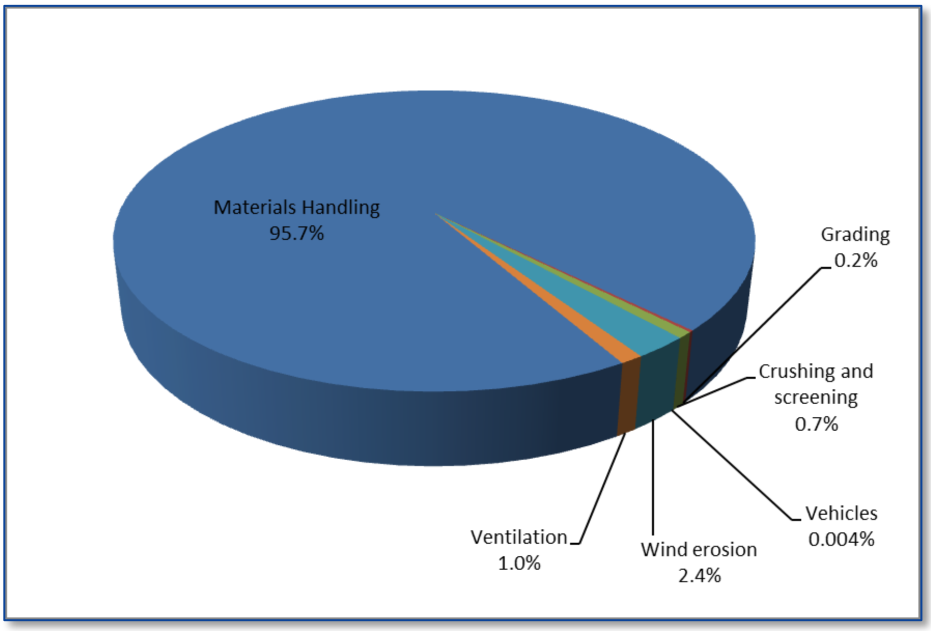


**Figure 15: $PM_{10}$ source apportionment for the Yzermyn mine during operational phase (after three years)**

### 5.1.4 Greenhouse Gases

Fugitive emissions from underground mines are a result of ventilation and degasification systems. The ventilation system from an underground mine is crucial in extracting ultimately toxic pollutants from the mining area in which workers operate. Underground coal mines are ventilated by flushing surface air through the underground tunnels. This ventilation air collects methane ($CH_4$), carbon dioxide ($CO_2$) and hydrogen sulphide ($H_2S$) released from the coal seams and transports it to the surface where it is emitted into the atmosphere. The concentration of methane in the ventilation air is normally low; however, the flow rate of the ventilation air is generally high and can therefore result in significant methane releases (Carras and Picard, 2006). This is such that underground mining activities in South Africa have been found to contribute to the majority of methane released into the atmosphere (Lloyd and Cook, 2004). In addition to $CH_4$, $CO_2$ and $H_2S$; emissions of nitrogen dioxide ($NO_2$), sulphur dioxide ($SO_2$) and carbon monoxide (CO) as a result of vehicles and machinery that operate within the tunnels, are also expelled from the ventilation system.

In order to assess the contribution of $CH_4$ emissions from the proposed Yzermyn Underground Coal Mine to South Africa's total methane emissions, the Intergovernmental Panel on Climate Change (IPCC) guidelines for greenhouse gas inventories was utilised. From this, the following equation was utilised to calculate annual average $CH_4$ emissions from the proposed Yzermyn Underground Coal Mine:

$$CH_4\ emissions(\mathrm{Gg/y})\ = CH_4\ emission\ factor\ (m^3/\mathrm{t}) \times underground\ coal\ production(\mathrm{t/y})\ \times conversion\ factor\ (\mathrm{Gg}/m^3)$$

It was calculated that 0.16 tons per annum of $CH_4$ will be emitted from the proposed Yzermyn Underground Coal Mine, based on a coal production statistic of 2,400,000 tons/year. From the International Energy Agency's statistics, the total amount of $CH_4$ emitted in South Africa per year is 3,110,048 tons (International Energy Agency, 2010). Yzermyn's contribution to this total will be 0.0000005%. The total $CH_4$ emissions from mining activities are estimated at 72,000 tons/year (Lloyd and Cook, 2004). Yzermyn's contribution to this total will be 0.00002%.

From research, no emission factors for $CO_2$ were available and it was found that $CO_2$ is not as significant as $CH_4$ in terms of the coal mining industry. For these reasons $CO_2$ statistics have not been provided here.

## 5.2 Dispersion Modelling

Atmospheric dispersion modelling mathematically simulates the transport and fate of pollutants emitted from a source into the atmosphere. Sophisticated software with algorithms that incorporate source quantification, surface contours and topography, as well as meteorology can reliably predict the downwind concentrations of these pollutants.

The latest version (v5) of the ADMS dispersion model was chosen for this assessment based on previous experience. Cambridge Environmental Research Consultants (CERC) have developed ADMS to offer a practical dispersion model that simulates a wide range of buoyant and passive releases to the atmosphere, whether individually or in combination. It draws on the latest plume dispersion mathematics and integrates a solid GIS platform (ArcView 3.3 & ArcGIS 10.1). The model handles multiple point, line, area and volume sources to produce long- and short-term scenarios for comparison with measured values, guidelines, standards and objectives. The interface requires detailed geographic data, sequential meteorological data, efflux and emission parameters to produce optimal output.

ADMS is recognised as a leading dispersion model in the United Kingdom (UK), European Union (EU), Asia, Australasia, the Middle East and South Africa, The software is currently endorsed by the Climate Research Group (operating from the University of the Witwatersrand, University of KwaZulu-Natal & University of Cape Town) and is used by most metro councils in South Africa. Output for criteria pollutants has been extensively validated against field data sets in the EU and against the American Standard Test Methods.

### 5.2.1 Modelling Scenarios

To calculate emissions from the proposed Yzermyn Underground Coal Mine, three emissions scenarios were separately modelled. The first scenario included emissions from all sources during the construction phase, the second scenario modelled all sources during the first three years of the operational phase and the third scenario modelled the emissions after the first three years of operation.

#### 5.2.1.1 Statistical Modelling Descriptions

For the purposes of this investigation, various statistical outputs were generated, as described below:

- Long-term scenario

  The long-term scenario refers to an annual concentration, which is calculated by averaging all hourly concentrations. The calculation is conducted for each grid point within the modelling domain. The long-term concentration for each receptor point is presented in a results table.

- Worst-case scenario

  The worst-case scenario refers to the 100$^{th}$ percentile concentration (P100), which is the maximum concentration predicted at any grid point within the modelling domain. The worst case concentration at a point usually occurs only once per annum. The P100 results are graphically presented as concentration isopleths, indicating the worst-case concentrations at each grid point. However, in practice, the worst-case concentrations do not tend to occur simultaneously across the model domain and hence the P100 images do not depict a 'worst-case contaminant plume' but rather a distribution of worst case concentrations.

- Predicted number of exceedences

  This prediction is not a worst-case scenario, but rather indicates the total number of times that the standard is exceeded at a given point (grid cell). As an example, an hourly exceedence prediction considers all hourly concentrations (8,760 values when using a single year of met data) at a single point, and predicts the number of hours that would exceed the hourly standard.

### 5.2.2 GIS Input

ArcGIS 10 was used as a mapping interface for this study. ArcGIS includes a suite of integrated applications that provide for several GIS tasks, from simple to advanced, including mapping, geographic analysis, data editing and compilation, data management, visualisation and geo-processing.

The proposed Yzermyn Underground Coal Mine is located in an area of complex terrain with steeply undulating hills and valleys. Steep valley terrain has the potential to inhibit the dispersion of pollutants, especially during periods of stable conditions. The formation of temperature inversions during episodes of calm conditions limit the vertical dispersion of pollutants, resulting in fumigation episodes. A complex terrain file was created as input into the dispersion model to account for these effects.

The terrain domain selected for this campaign is 35,000 m x 35,000 m, covering an approximate area of 122,500 ha, with the modelling domain at the centre. A regular grid was compiled consisting of approximately 31,500 points for input to the model. Attributes at each point included x and y coordinates and elevation (denoted as z). Table 30 presents the terrain domain coordinates (in meters using the LO31 projection), while Figure 16 illustrates the complex terrain surrounding the proposed Yzermyn Underground Coal Mine.

**Table 30: Terrain domain coordinates**

| Domain Point | x Coordinate (m) | y Coordinate (m) |
|---|---|---|
| **North-Western Point** | -81,982 | -2,993,785 |
| **North-Eastern Point** | -46,982 | -2,993,785 |
| **South-Western Point** | -81,982 | -3,028,785 |
| **South-Eastern Point** | -46,982 | -3,028,785 |

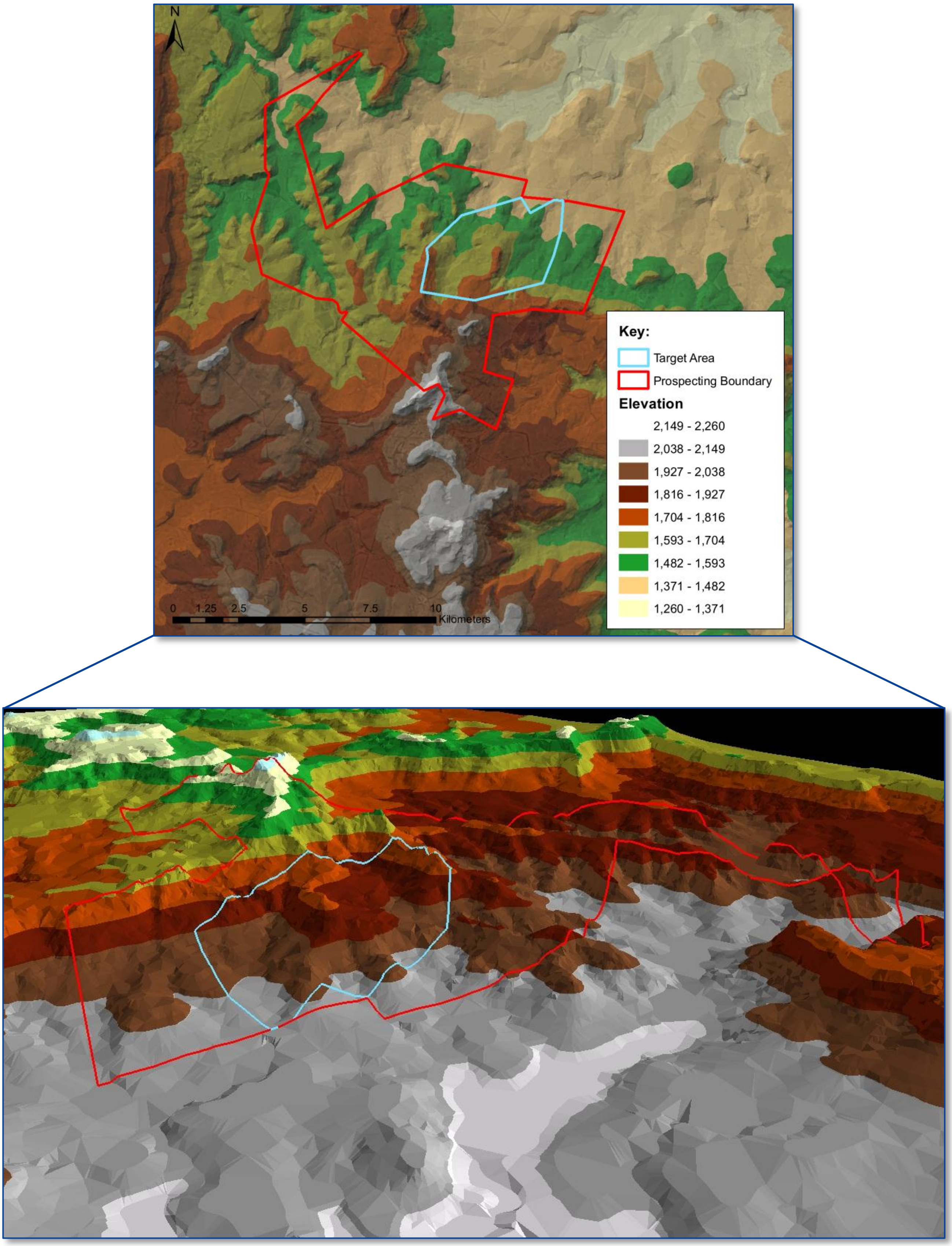


**Figure 16: Complex terrain surrounding the proposed Yzermyn Underground Coal Mine site**

The modelling domain selected for this campaign is 20,000 m x 20,000 m, with the proposed Yzermyn Underground Coal Mine mining area at the centre; covering an approximate area of 40,000 ha. Table 31 presents the modelling domain coordinates.

**Table 31: Modelling Domain coordinates**

| Domain Point | x Coordinate (m) | y Coordinate (m) |
|---|---|---|
| **North-Western Point** | -74,124 | -3,001,127 |
| **North-Eastern Point** | -54,124 | -3,001,127 |
| **South-Western Point** | -74,124 | -3,021,127 |
| **South-Eastern Point** | -54,124 | -3,021,127 |

### 5.2.3 Meteorological Input

Due to the irregular topography of the area surrounding the proposed Yzermyn site, meteorological conditions at the site are localised and may differ greatly over a short distance. The closest available South African Weather Services (SAWS) meteorological station is located ~50 km from the site and clearly would not be representative of conditions at the site. Instead, Unified Model (UM) data generated for 27.2371 °S and 30.2953° E was obtained from the South African Weather Service (SAWS) and utilised in this assessment.

The UM is a numerical weather prediction and climate modelling software suite developed in the UK and is utilised in various weather forecasting agencies around the world. It models across a broad range of timescales and spatial scales (convective scale to climate system earth modelling). The atmospheric prediction component makes use of a set of equations that describe the time evolution of the atmosphere. Input data is obtained from observations from satellites, automatic weather stations, ground measurements, radar, weather balloons, wind profilers, aircraft and previous model runs (Dando, 2004).

### 5.2.4 Background Ambient Concentrations

In accordance with the Draft Dispersion Modelling Guidelines for South Africa (DEA, 2012), cumulative models need to simulated taking into account neighbouring emission sources or background pollutant concentrations together with predicted emissions from the proposed activity. In this case, since there are no anthropogenic sources surrounding the proposed Yzermyn Underground Coal Mine site, background $PM_{10}$, $PM_{2.5}$, $SO_2$ and $NO_2$ concentrations obtained from onsite monitoring were utilised in the dispersion model.

Based on the monitoring presented in section 4.2, the following background concentrations were included in the model: 8.97 µg/m³ ($PM_{10}$); 2.75 µg/m³ ($PM_{2.5}$); 4.55 µg/m³ ($NO_2$); and 8.74 µg/m³ ($SO_2$).

## 5.3 Receptor Identification

Receptors are identified as areas that may be impacted negatively due to emissions from the Yzermyn mine. Examples of receptors include, but are not limited to, schools, shopping centres, hospitals, office blocks and residential areas. The sensitive receptors identified in the area surrounding the Yzermyn mine are presented in Table 32 and Figure 17.

**Table 32: Location of sensitive receptors surrounding the proposed Yzermyn Underground Coal Mine**

| Receptor | Description | Direction mine offices | Distance from mine offices (km) |
|---|---|---|---|
| **FH 01** | Farm House | WSW | 3.5 |
| **FH 02** | Farm House | SW | 3.6 |
| **FH 03** | Farm House | S | 2.5 |
| **FH 04** | Farm House | E | 0.35 |
| **FH 05** | Farm House | NNE | 0.68 |
| **FH 06** | Farm House | NE | 1.1 |
| **FH 07** | Farm House | NW | 2.3 |
| **FH 08** | Farm House | SE | 3.1 |
| **FH 09** | Farm House | NE | 4.3 |
| **FH 10** | Farm House | NE | 5.4 |
| **FH 11** | Farm House | NE | 7.8 |
| **School** | School | NE | 8.5 |
| **Dirkiesdorp** | Town | NE | 9.5 |

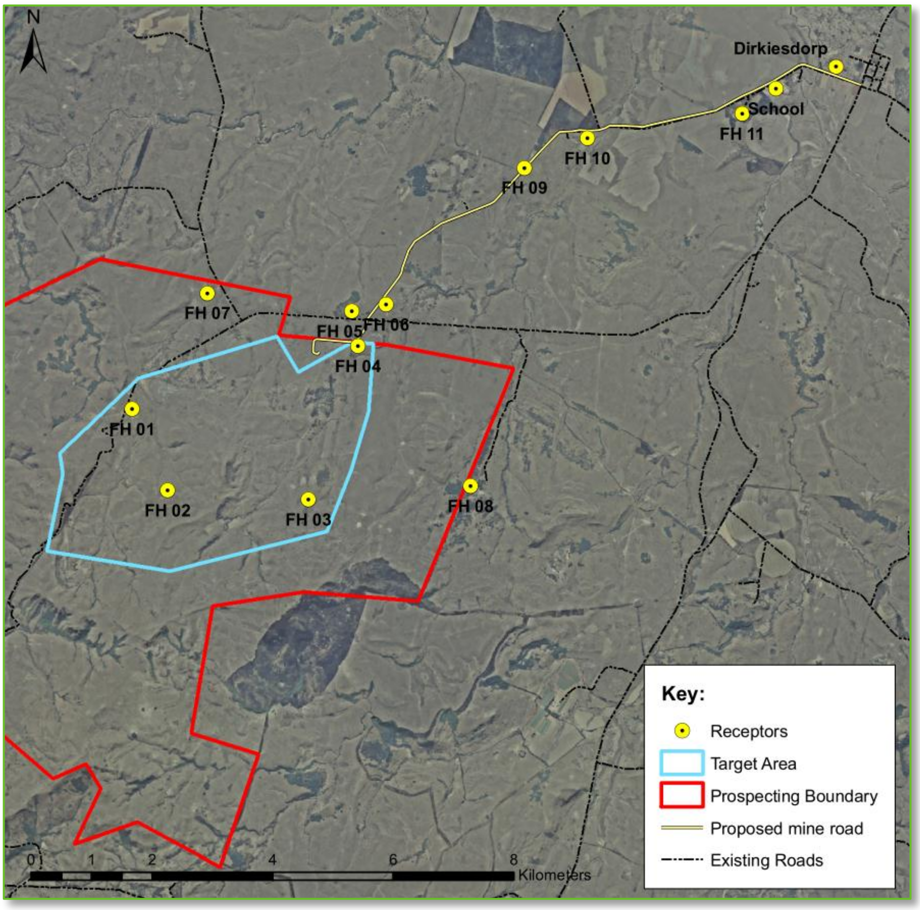


**Figure 17: Map indicating location of sensitive receptors**

# 6 Climate and Meteorology

## 6.1 Climate

The proposed Yzermyn underground coal mine is located within the Pixley Ka Seme local municipality that falls under the Gert Sibande district municipality in the Mpumalanga province. The Pixley Ka Seme municipality as a whole has a subtropical climate that receives predominantly summer rainfall. The eastern parts of the region experience generally higher rainfall than the western parts. Summer rainfall events are generally associated with severe thunderstorms. Temperatures in the region range from very cold in winter with severe frost and even snow in some parts, to warm to hot during summer, especially in the parts below the escarpment (Pixley Ka Seme Local Municipality, 2010).

Atmospheric transport within the area occurs both vertically and horizontally. Vertical transport is primarily due to deep convection. This convection transports air and any air pollutants contained therein from the surface into the upper atmosphere. Vertical motion is eventually inhibited due to the absolutely stable layers found preferentially at ~700hPa, ~500hPa and ~300hPa on no-rain days. These stable layers trap pollutants at lower atmospheric levels and so influence the transport of pollutants over the whole of southern Africa (Cosijn and Tyson, 1996; Garstang et al., 1996)

On a more local scale, like that of the Pixley Ka Seme local municipality, vertical motion and hence dispersion of pollutants is inhibited by surface inversions that form during the night. These inversions are a result of radiational cooling at the surface and are most pronounced just before sunrise. In the presence of sunlight the inversions begin to break down through convective heating and the height of the mixed layer is increased (Cosijn and Tyson, 1996; Tyson and Preston-Whyte, 2000).

In terms of horizontal transport, local winds may transport pollutants within the vicinity of their source. These include: anabatic and katabatic winds, valley and mountain winds, and mountain-plain and plain-mountain winds (Tyson and Preston-Whyte, 2000). On a larger scale, various synoptic systems affect atmospheric circulation over the Pixley Ka Seme local municipality as well as circulation over the whole of southern Africa. These systems include: continental highs, ridging highs, westerly lows, westerly waves and easterly waves, which transport air and any pollutants contained within over larger distances (Garstang et al., 1996; Tyson et al., 1996).

In the Pixley Ka Seme region, transport associated with continental highs occurs all year round, but with greater frequency during winter. Easterly waves show an annual cycle, peaking in summer, with extremely seldom occurrences in winter. Transport associated with ridging highs and westerly waves dominates during winter (Garstang et al., 1996; Tyson and Preston-Whyte, 2000).

Recirculation is also important in the transport of pollutants and occurs frequently over southern Africa due to the high frequency of anticyclonic circulations (Garstang et al., 1996; Freiman and Piketh, 2003). Recirculation occurs when air is transported away from its source and returns in the opposite direction after rotating cyclonically or anticyclonically. Recirculation can occur at a number of scales from sub-continental to regional, and an interaction between different scales of wind systems results in further recirculation (Tyson et al., 1996; Tyson and Preston-Whyte, 2000; Freiman and Piketh, 2003).

## 6.2 Meteorological Overview

### 6.2.1 Local Wind Field

The UM data discussed in section 5.2.3 was used to create wind roses using the Lakes Environmental Wind Rose Plot Software. Wind roses are useful for illustrating local wind speeds and directional frequency distributions. In the following wind roses, the colour of the bar indicates the wind speed while the length of the bar represents the frequency of winds *blowing from* a certain direction (as a percentage). As evident in Figure 18 below, winds at the proposed mining site are predominantly from the west (18% of the time) and east (16% of the time). Wind speeds are strongest from the west with wind speeds ranging from 0.1 m/s to greater than 6 m/s.

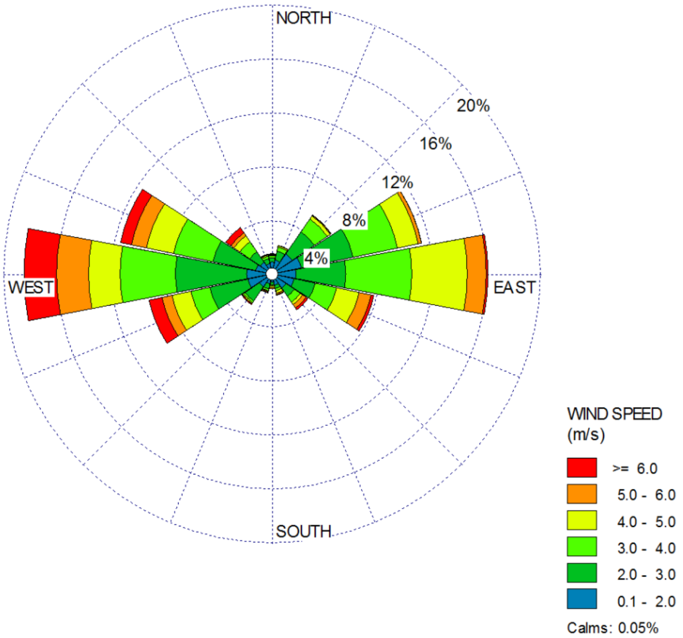


**Figure 18: Wind rose plot for the Yzermyn area for the 2011 period**

Seasonal variations in winds at the Yzermyn site are depicted in Figure 19. During summer (December to February), winds predominantly originate from an easterly direction. This dominant easterly flow is a result of easterly waves that impact South Africa during summer, bringing rainfall to the eastern parts of the country. During autumn (March to May) and winter (June to August), there is a definite shift in wind direction. Winds still originate from the east, although a much stronger westerly component is introduced. Winds of over 6 m/s are experienced from the west. This westerly wind direction during winter is a result of westerly waves, in the form of cold fronts that move over the country during this time. During spring (September to November), both westerly and easterly wind components are experienced, with the strongest winds (reaching speeds over 6 m/s) originating from the west.

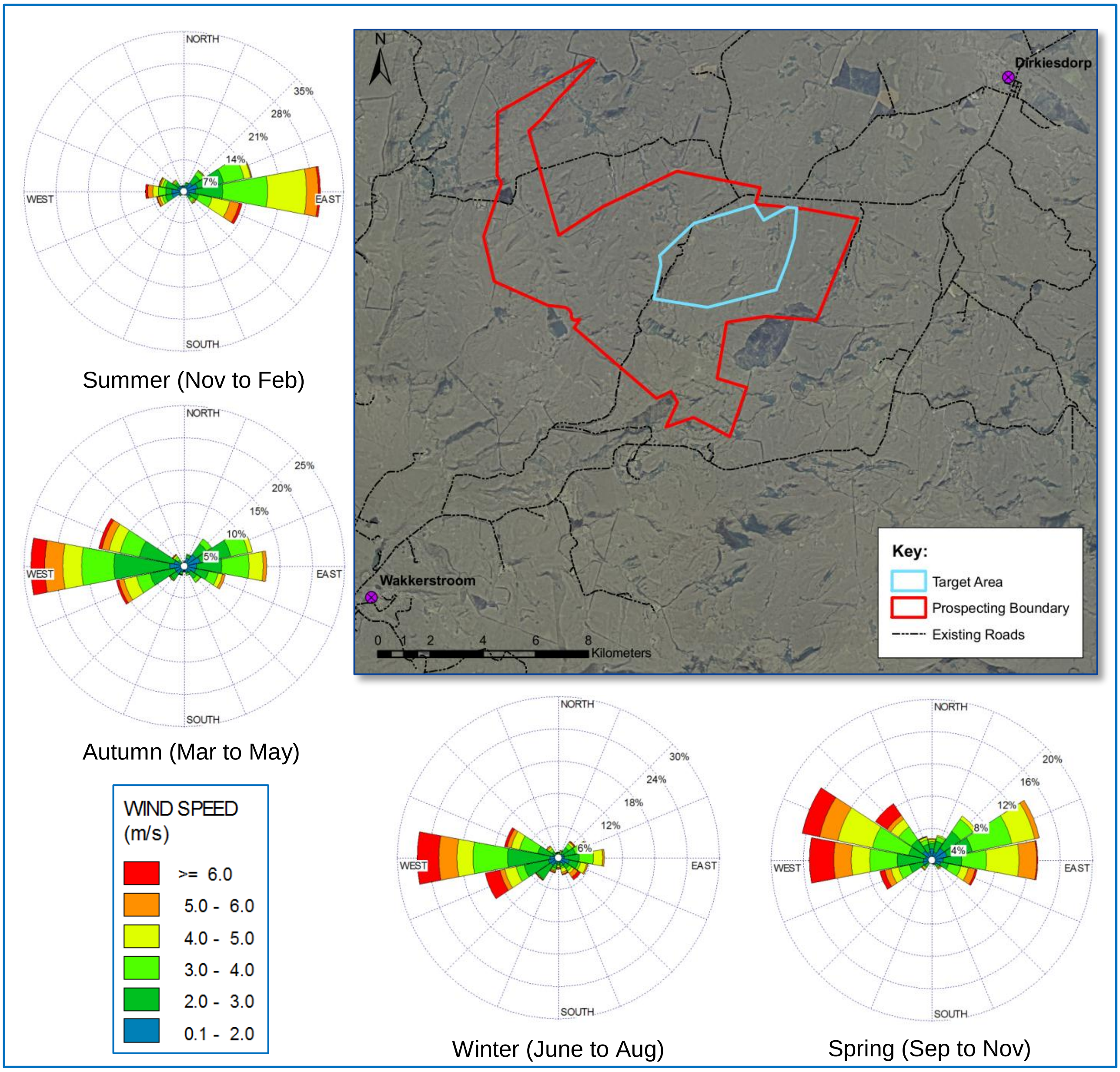


**Figure 19: Seasonal wind rose plots for the Yzermyn area**

Diurnal variations in wind at the Yzermyn site are depicted in Figure 20. From 00:00 to 06:00 westerly flow dominates, followed by smaller west-north-westerly and east-north-easterly components. Winds are calm to moderate, with wind speeds reaching levels greater than 6 m/s from the west and west-south-west. Similar wind directions are experienced after sunrise (06:00 to 12:00) but with clear increases in average wind speeds. After midday (12:00 to 18:00) easterly and westerly winds predominate, with further strengthening of the westerly component. In the evening (18:00 to 24:00) the westerly wind component diminishes and winds are predominantly easterly.

The dispersion of emissions will be lower during the early morning hours as a result of calmer wind speeds. During winter the concentrations of pollutants experienced at the surface at this time is likely to be augmented by surface temperature inversions, which trap pollutants and by preventing vertical dispersion into the atmosphere. After sunrise, convective mixing is initiated and any pollutants that are trapped at ground level are dispersed into the atmosphere.

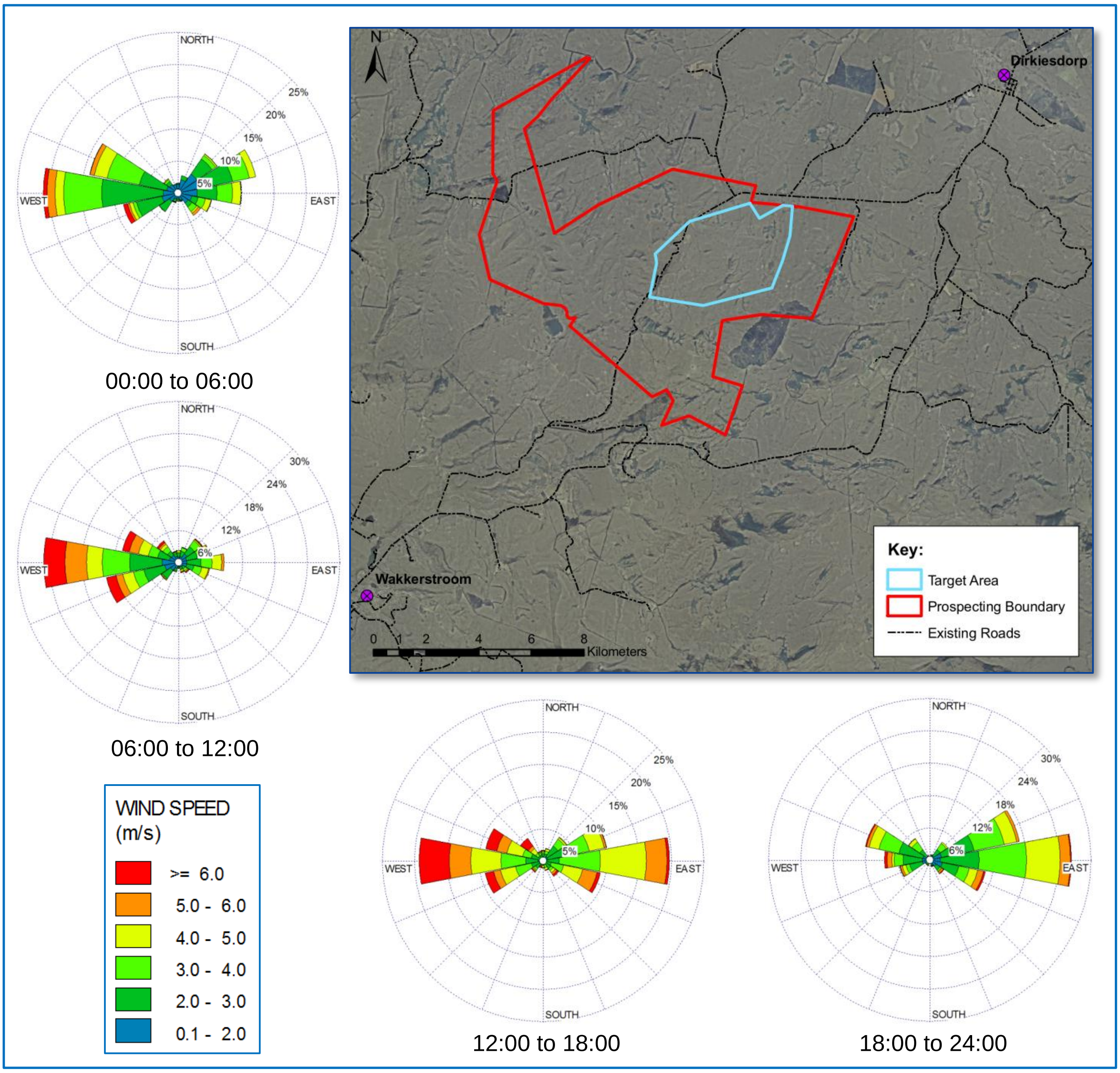


**Figure 20: Diurnal wind rose plots for the Yzermyn area for 2011**

## 6.2.2 Temperature

Figure 21 represents the average, minimum and maximum temperatures for the Yzermyn area, calculated from the hourly average UM temperatures for the area. Maximum average monthly temperatures occur during October and November (33.2°C and 33.59°C respectively) while minimum average monthly temperatures are experienced during July and August (-4.81°C and -4.61°C respectively). Average temperatures range quite considerably between the summer and winter months, with an average summer temperature of about 18°C and an average winter temperature of about 5°C.

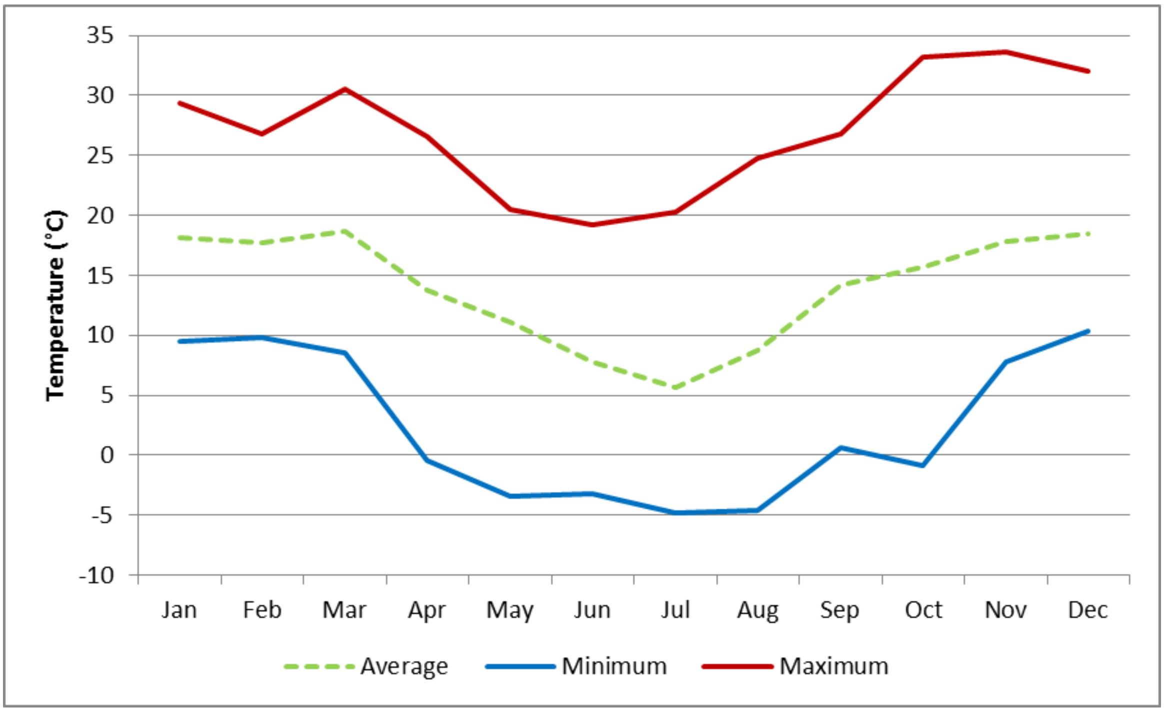


**Figure 21: Average, maximum and minimum temperatures for the Yzermyn area**

### 6.2.3 Rainfall

Monthly rainfall figures for the Yzermyn area are plotted in Figure 22, together with the monthly average humidity. Relative humidity in the region is generally high, with values ranging from ~60% during winter to ~80% during summer. The highest monthly average rainfall is experienced during late spring and early summer (October, November and December). The lowest monthly average rainfall occurs during May, June and August. Rainfall has the potential to remove pollutants from the air, especially particulates, thereby improving the air quality situation in high rainfall areas. During the spring and summer months, air quality in the area may improve due to the high rainfall experienced. Drier conditions, together with increased domestic fuel combustion and biomass burning in the region during winter, is likely to augment the concentration of ambient pollutants.

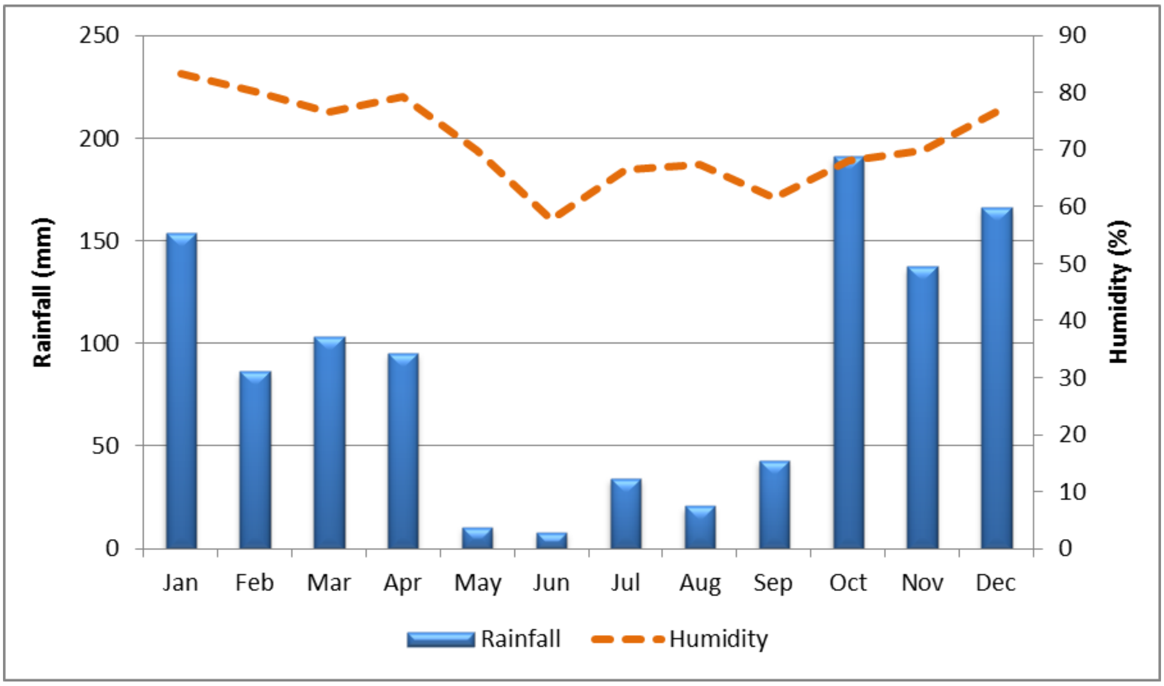


**Figure 22: Total monthly rainfall and average humidity for the Yzermyn area**

# 7 Results and Discussion

This section presents the results of the dispersion modelling performed for the proposed Yzermyn Underground Coal Mine. Long-term scenarios were run to predict the annual average concentrations of criteria pollutants, as health risks are primarily based on long-term exposure to pollutants. In addition, the long-term run also collates and calculates statistics for worst-case short-term (P100) concentrations, to assess the likely number of exceedences of standards over intervals of 1-hour and 24-hours, as applicable for various criteria pollutants.

## 7.1 Construction Phase

The predicted $PM_{10}$ concentrations at each specified receptor point during the construction phase of the proposed Yzermyn Underground Coal Mine are presented in Table 33. Long term concentrations are generally low with concentrations exceeding the annual $PM_{10}$ standard (50 µg/m³) at receptors in close proximity to the construction activities (FH 04 and FH 06) and at receptors in closest proximity to the mine access road (FH 09 and Dirkiesdorp). The highest concentrations (121.02 µg/m³) are predicted at the farmhouse receptor, FH04, located less than 100 m from the general construction activities. Numerous exceedences of the 24-hour standard are predicted, with exceedences predicted at FH 04, FH 05, FH 06, FH 09, FH 11 and Dirkiesdorp. The NEM:AQA standards stipulate that four exceedences of the 24 hour average standard are permitted within a calendar year. Based on model predictions, the number of exceedences at FH 05 and FH11 are within this frequency, so concentrations are essentially compliant. The worst-case (P100) 24-hour average concentrations are elevated at many of the receptors, although it must be recognised this is the absolute worst-case 24-hour concentration experienced at a receptor point should the wind be blowing directly toward that point. This represents the highest concentration predicted in a year, so does not represent the average.

**Table 33: $PM_{10}$ concentrations at specified receptor points during the construction phase of the proposed Yzermyn Underground Coal Mine**

| Receptor | Long Term $PM_{10}$ Concentration (µg/m³) | P100 24 Hr Average $PM_{10}$ Concentration (µg/m³) | Predicted No. of Exceedences Per Year of 24 Hr Standard (120 µg/m³) |
|---|---|---|---|
| **FH 01** | 11.10 | 36.30 | 0 |
| **FH 02** | 10.24 | 24.17 | 0 |
| **FH 03** | 9.72 | 22.18 | 0 |
| **FH 04** | 121.02 | 455.40 | 163 |
| **FH 05** | 31.63 | 126.63 | 4 |
| **FH 06** | 75.02 | 187.12 | 63 |
| **FH 07** | 12.89 | 34.57 | 0 |
| **FH 08** | 10.06 | 23.07 | 0 |
| **FH 09** | 106.33 | 361.99 | 149 |
| **FH 10** | 41.67 | 91.34 | 0 |
| **FH 11** | 33.50 | 122.71 | 2 |
| **School** | 41.25 | 118.03 | 0 |
| **Dirkiesdorp** | 63.67 | 215.58 | 32 |
| Long Term = Annual Concentrations | | | |
| P100 = 100th percentile concentrations (worst case) | | | |
| Highlighted concentrations indicate exceedences of $PM_{10}$ Annual Std (50 µg/m³) | | | |

Graphical outputs of the modelled long-term (annual) and worst case daily $PM_{10}$ concentrations are depicted in Figure 23 and Figure 24. Figure 25 illustrates the predicted number of exceedences of the $PM_{10}$ 24-hour average standard within a calendar year. Annual average concentrations indicate that emissions will disperse eastwards and westwards from the main construction area. Exceedences of the annual standard are predicted in the area directly surrounding the proposed Yzermyn Underground Coal Mine where construction activities will take place and along the mine access road. Worst case (P100) concentrations disperse towards the west and the east, with plume dispersion being dictated by the local topography. The highest number of daily $PM_{10}$

exceedences is predicted within the mine boundary; however, a number of exceedences are predicted along the mine access road, with the maximum permitted frequency being exceeded up to 600 m from the road.

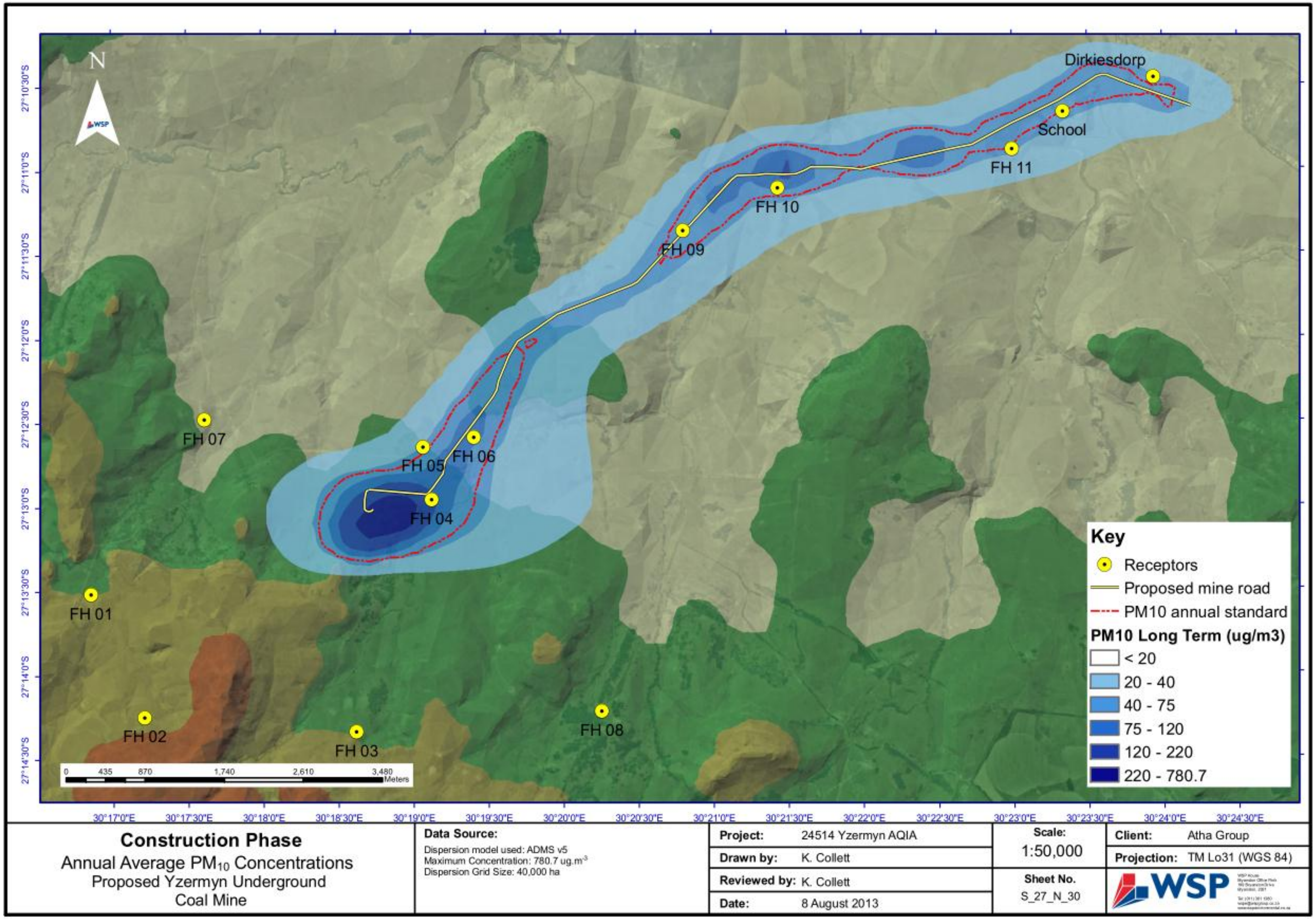


**Figure 23: Predicted annual average $PM_{10}$ concentrations associated with the construction phase of the proposed Yzermyn Underground Coal Mine**

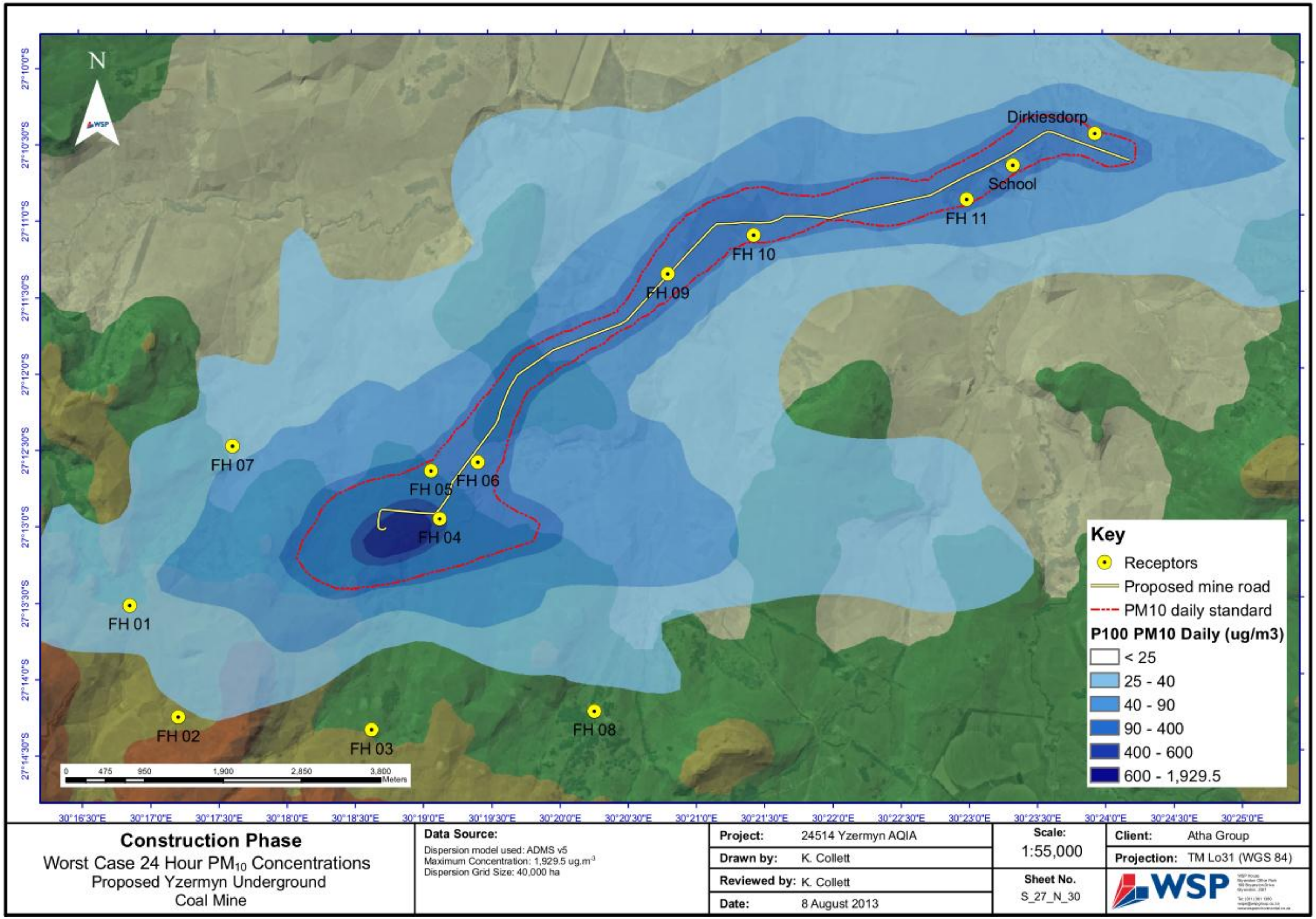


**Figure 24: Predicted worst case 24 hour $PM_{10}$ concentrations associated with the construction phase of the proposed Yzermyn Underground Coal Mine**

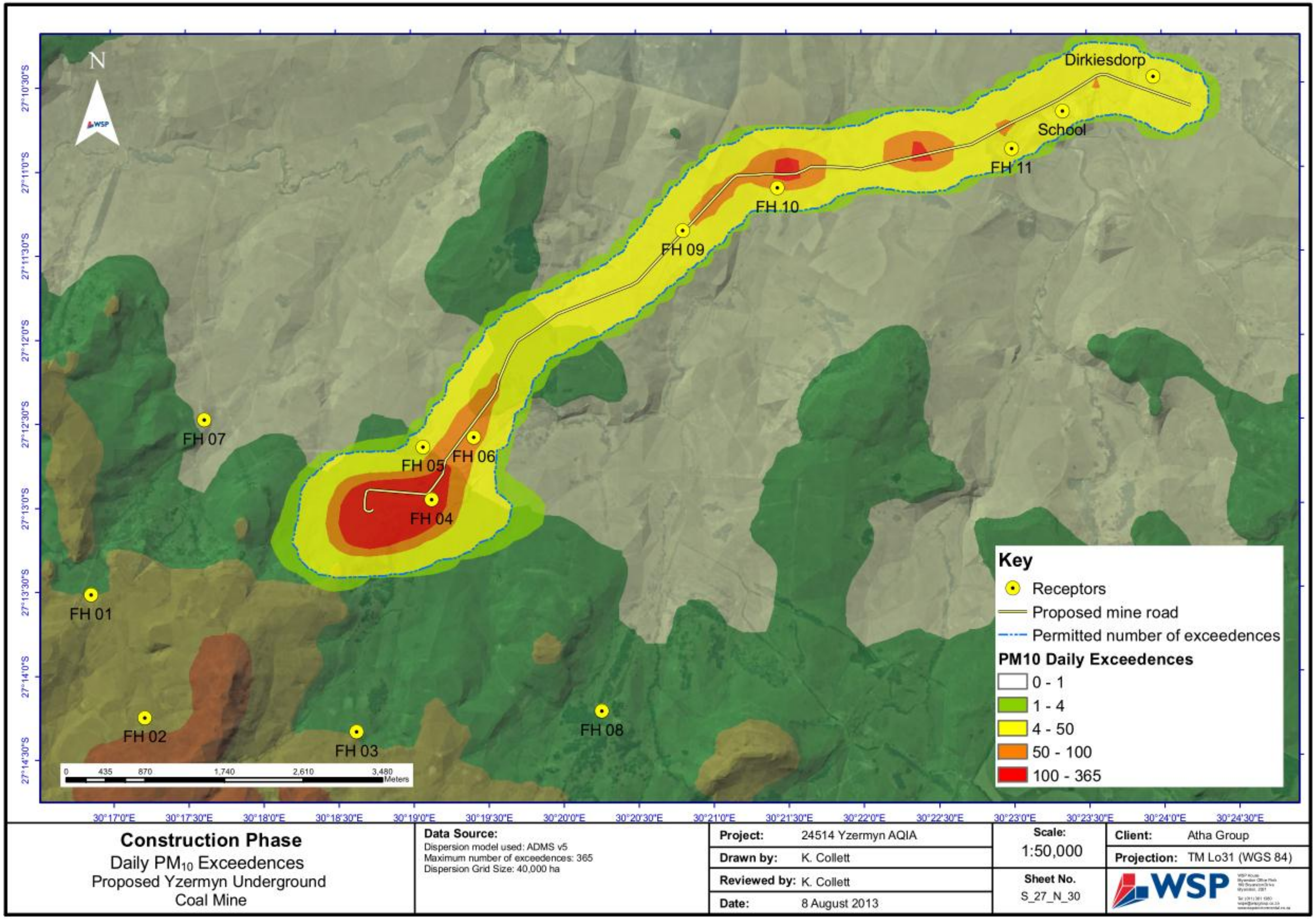


**Figure 25: Predicted number of exceedences of the 24 hour average $PM_{10}$ standard (120 µg/m³) during the construction phase**

The predicted $PM_{2.5}$ concentrations at each specified receptor point during the construction phase of the Yzermyn mine are presented in Table 34. Long term (annual average) concentrations at all receptors are low with no exceedences of the annual standard (25 µg/m³) being predicted. The highest $PM_{2.5}$ concentration (24.6 µg/m³) is predicted at the farm house receptor, FH 04 that is in closest proximity to the construction activities. FH 04 is also the only receptor predicted to experience exceedences of the daily standard (65 µg/m³). The worst-case (P100) 24-hour average concentrations are low at most receptors, with FH 04 being the only receptor to exceed the daily standard of 120 µg/m³. From this it is evident that dust in the form of $PM_{2.5}$ is not a key emission from the construction phase of the proposed Yzermyn Underground Coal Mine and will not negatively impact on surrounding receptors.

**Table 34: $PM_{2.5}$ concentrations at specified receptor points during the construction phase of the proposed Yzermyn Underground Coal Mine**

| Receptor | Long Term $PM_{2.5}$ Concentration (µg/m³) | P100 24 Hr Average $PM_{2.5}$ Concentration (µg/m³) | Predicted No. of Exceedences Per Year of 24 Hr Standard (65 µg/m³) |
|---|---|---|---|
| **FH 01** | 3.11 | 7.74 | 0 |
| **FH 02** | 2.96 | 5.34 | 0 |
| **FH 03** | 2.87 | 5.33 | 0 |
| **FH 04** | 24.60 | 89.38 | 16 |
| **FH 05** | 5.77 | 26.64 | 0 |
| **FH 06** | 10.09 | 26.75 | 0 |
| **FH 07** | 3.35 | 7.50 | 0 |
| **FH 08** | 2.94 | 5.54 | 0 |
| **FH 09** | 12.56 | 38.02 | 0 |
| **FH 10** | 6.08 | 10.99 | 0 |
| **FH 11** | 5.25 | 14.11 | 0 |
| **School** | 6.02 | 13.64 | 0 |
| **Dirkiesdorp** | 8.25 | 23.39 | 0 |
| Long Term = Annual Concentrations | | | |
| P100 = 100th percentile concentrations (worst case) | | | |
| No Exceedences of Annual $PM_{2.5}$ Std (25 µg/m³) | | | |

Graphical outputs of the modelled long-term (annual) and worst case daily $PM_{2.5}$ concentrations are depicted in Figure 26 and Figure 27. Figure 28 illustrates the predicted number of exceedences of the $PM_{2.5}$ 24-hour average standard within a calendar year. Annual average $PM_{2.5}$ emissions will disperse from the general construction area towards the east and the west. Exceedences of the annual standard (50 µg/m³) are only predicted within the direct vicinity of the mine. Very low $PM_{2.5}$ concentrations are associated with travel along the mine access road. Worst case (P100) concentrations disperse towards the west and the east, with plumes following the topography of the land. The highest number of daily $PM_{2.5}$ exceedences is predicted within the mine boundary, with no exceedences predicted along the mine access road.

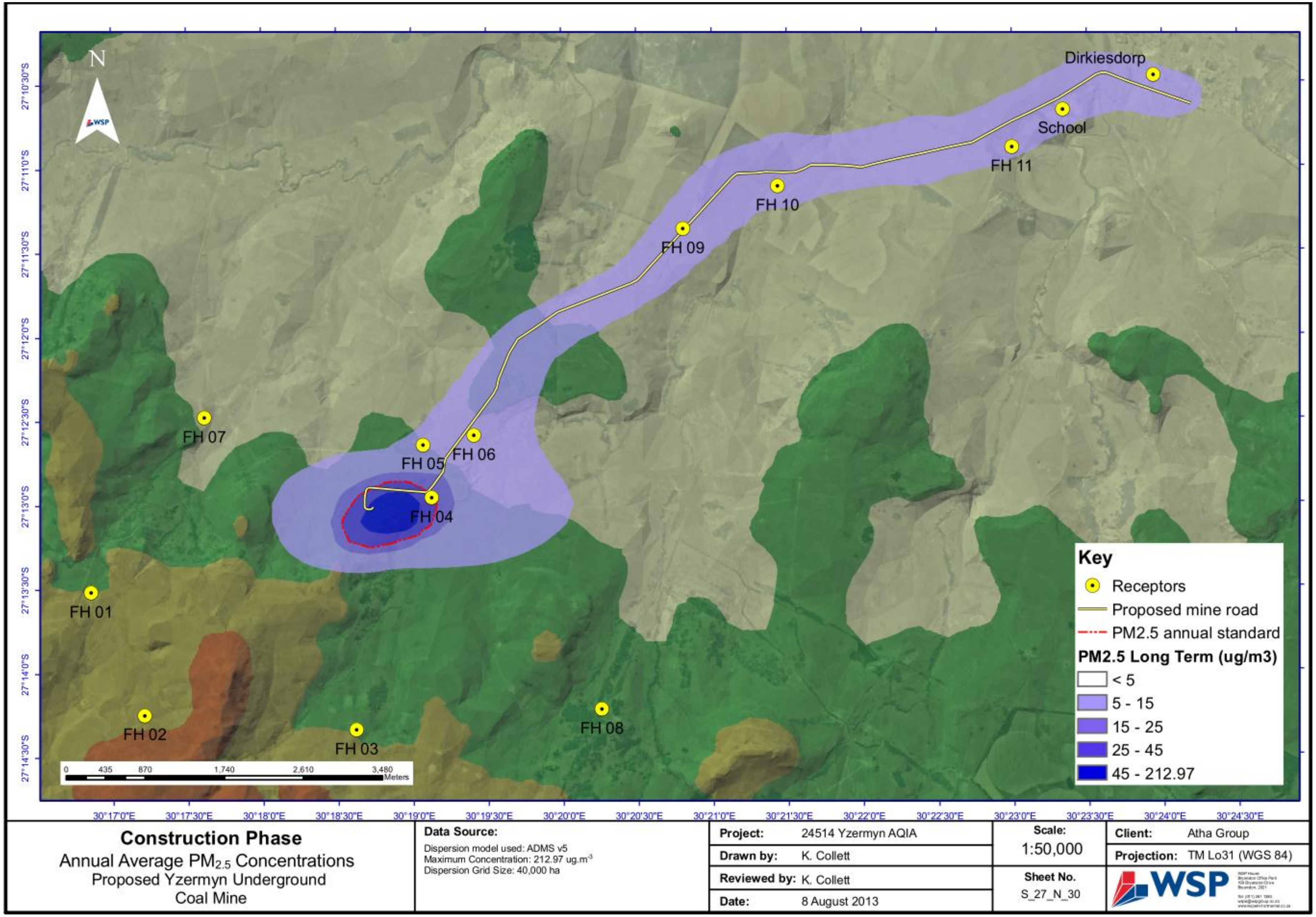


**Figure 26: Predicted annual average $PM_{2.5}$ concentrations associated with the construction phase of the proposed Yzermyn Underground Coal Mine**

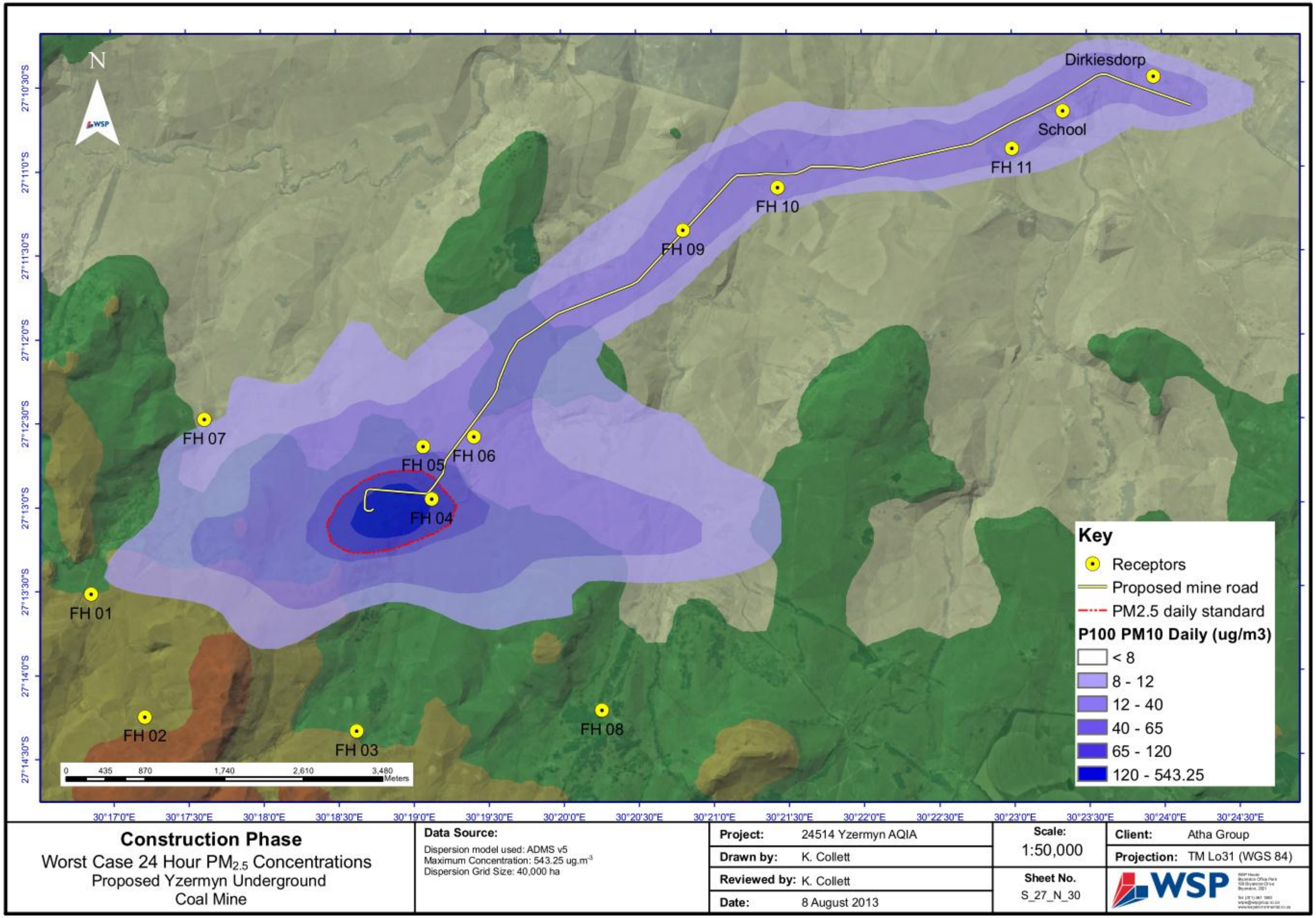


**Figure 27: Predicted worst case 24 hour $PM_{2.5}$ concentrations associated with the construction phase of the proposed Yzermyn Underground Coal Mine**

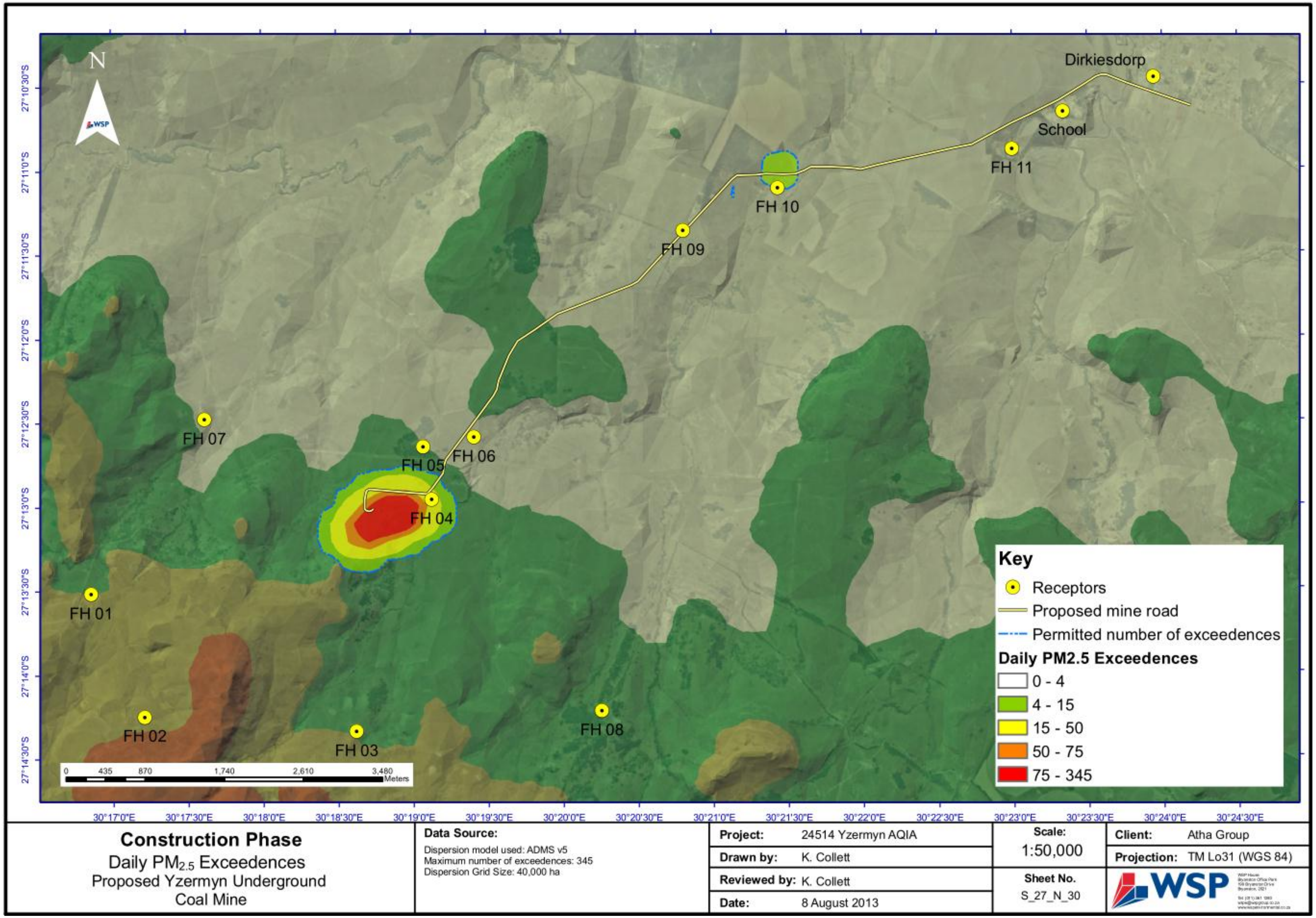


**Figure 28: Predicted number of exceedences of the 24 hour average $PM_{2.5}$ standard (65 µg/m³) during the construction phase**

Annual average dust fallout rates at each of the specified receptors during the construction phase of the proposed Yzermyn Underground Coal Mine are presented in Table 35. Dust fallout at all receptors is low and predicted fallout rates are compliant with the SANS Residential Guideline (600 mg/m²/day). It must be noted, that although low rates are predicted offsite, onsite fallout rates in the direct vicinity of the construction activities are predicted to be significantly elevated. Such elevated onsite values are common for construction activities of this nature.

**Table 35: Annual average dust fallout rates associated with the construction phase of the proposed Yzermyn Underground Coal Mine**

| Receptor | Annual Average Dust Fallout Rate (mg/m²/day) | Compliance with Residential Guideline (600 mg/m²/day) |
|---|---|---|
| **FH 01** | 0.58 | Yes |
| **FH 02** | 0.31 | Yes |
| **FH 03** | 0.19 | Yes |
| **FH 04** | 50.56 | Yes |
| **FH 05** | 7.95 | Yes |
| **FH 06** | 35.18 | Yes |
| **FH 07** | 1.04 | Yes |
| **FH 08** | 0.29 | Yes |
| **FH 09** | 69.85 | Yes |
| **FH 10** | 13.91 | Yes |
| **FH 11** | 9.91 | Yes |
| **School** | 14.38 | Yes |
| **Dirkiesdorp** | 28.48 | Yes |

## 7.2 Operational Phase (First Three Years)

The predicted $PM_{10}$ concentrations at each specified receptor point during the first three years of operation of the proposed Yzermyn Underground Coal Mine are presented in Table 36. Long term concentrations are elevated at most receptors, with predicted concentrations exceeding the annual standard (50 µg/m³) at FH 04, FH 05, FH 06, FH 07, FH 09, FH 10, FH 11, School and Dirkiesdorp, which are all located in close proximity to the mine access road. Unlike in the construction phase scenario, the dominant source of particulates in the first three years of operation is not activities at the mine itself, but rather activities occurring along the unpaved mine access road. Worst case (P100) concentrations are highly elevated at receptors in close proximity to the unpaved road. Exceedences of the 24 hour standard are predicted at all receptors, except FH 02, with the highest number of exceedences predicted at receptors in close proximity to the mine access road.

**Table 36: $PM_{10}$ concentrations at specified receptor points during the first three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receptor | Long Term $PM_{10}$ Concentration (µg/m³) | P100 24 Hr Average $PM_{10}$ Concentration (µg/m³) | Predicted No. of Exceedences Per Year of 24 Hr Standard (120 µg/m³) |
|---|---|---|---|
| **FH 01** | 29.32 | 153.61 | 2 |
| **FH 02** | 20.22 | 110.44 | 0 |
| **FH 03** | 17.74 | 266.53 | 3 |
| **FH 04** | 216.92 | 2,731.79 | 216 |
| **FH 05** | 286.83 | 919.88 | 252 |
| **FH 06** | 698.22 | 2,581.60 | 299 |
| **FH 07** | 50.04 | 222.05 | 21 |
| **FH 08** | 15.50 | 123.93 | 1 |
| **FH 09** | 1,606.31 | 4,910.44 | 289 |
| **FH 10** | 484.85 | 1,811.65 | 337 |
| **FH 11** | 287.93 | 2,380.24 | 263 |
| **School** | 402.81 | 1,550.27 | 309 |
| **Dirkiesdorp** | 539.04 | 2,803.65 | 280 |
| Long Term = Annual Concentrations | | | |
| P100 = 100$^{th}$ percentile concentrations (worst case) | | | |
| Highlighted concentrations indicate exceedences of $PM_{10}$ Annual Std (50 µg/m$^3$) | | | |

Graphical outputs of the modelled long-term (annual) and worst case daily $PM_{10}$ concentrations are depicted in Figure 29 and Figure 30. Figure 31 illustrates the predicted number of exceedences of the $PM_{10}$ 24-hour average standard within a calendar year. Emissions disperse toward the east and west as per the dominant wind direction with local dispersion of plumes being dictated by the topography. Highest annual average concentrations are associated with vehicle movement and grading activities along the unpaved mine access road. Elevated concentrations are predicted in the direct vicinity of the road, such that exceedences of the annual standard (50 µg/m³) are predicted up to 2 km from the road. Worst case (P100) daily concentrations disperse much further downwind being greatly influenced by the local topography. Daily exceedences of the 24 hour standard (120 µg/m³) are elevated in the direct vicinity of the road. Such elevated concentrations and excessive exceedences of the standards indicates that an unpaved road of such a great distance and without the application of mitigation techniques is not viable for the operation of the proposed Yzermyn Underground Coal Mine.

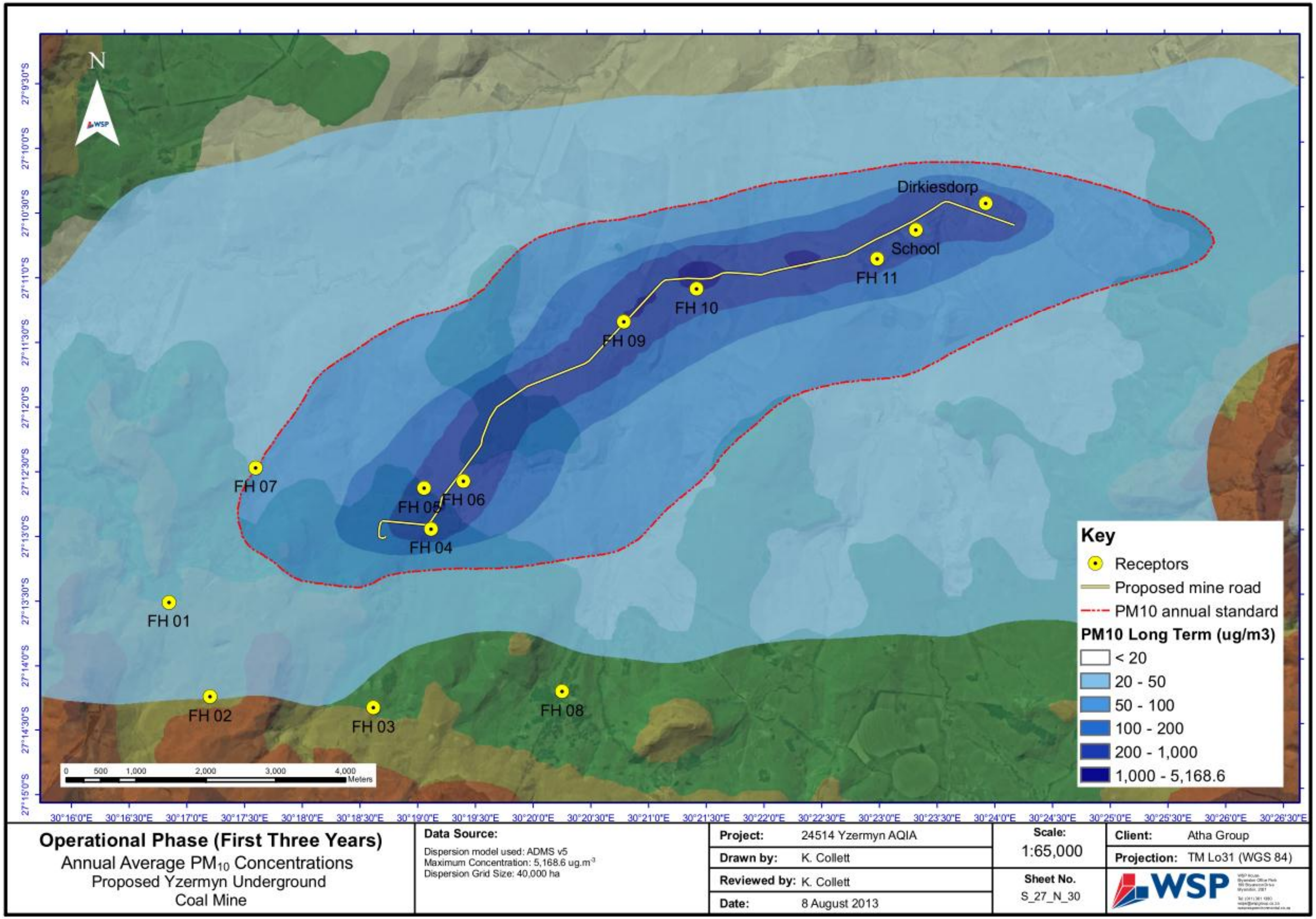


**Figure 29: Predicted annual average $PM_{10}$ concentrations associated with the first three years of operation of the proposed Yzermyn Underground Coal Mine**

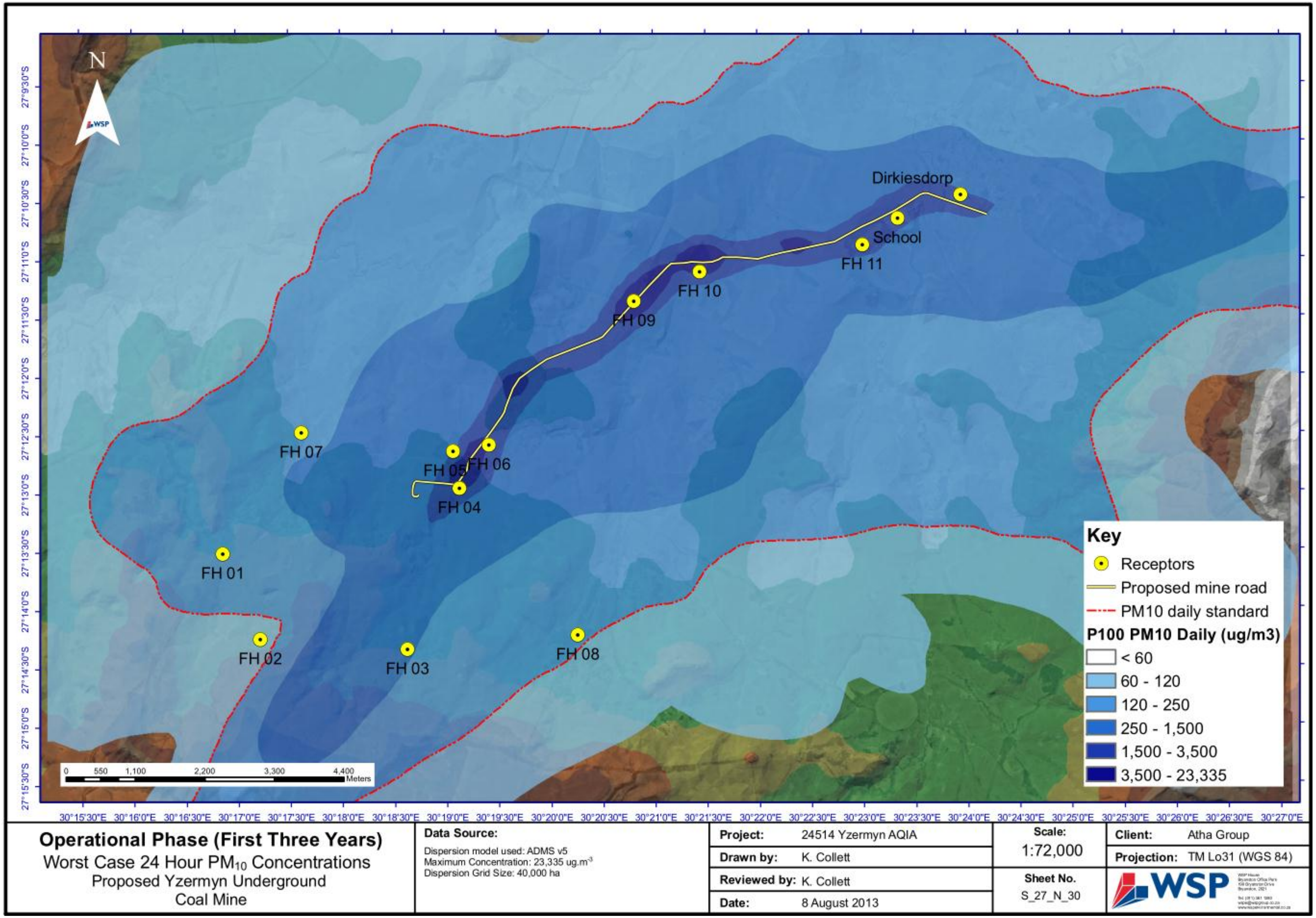


**Figure 30: Predicted worst case 24 hour $PM_{10}$ concentrations associated with the first three years of operation of the proposed Yzermyn Underground Coal Mine**

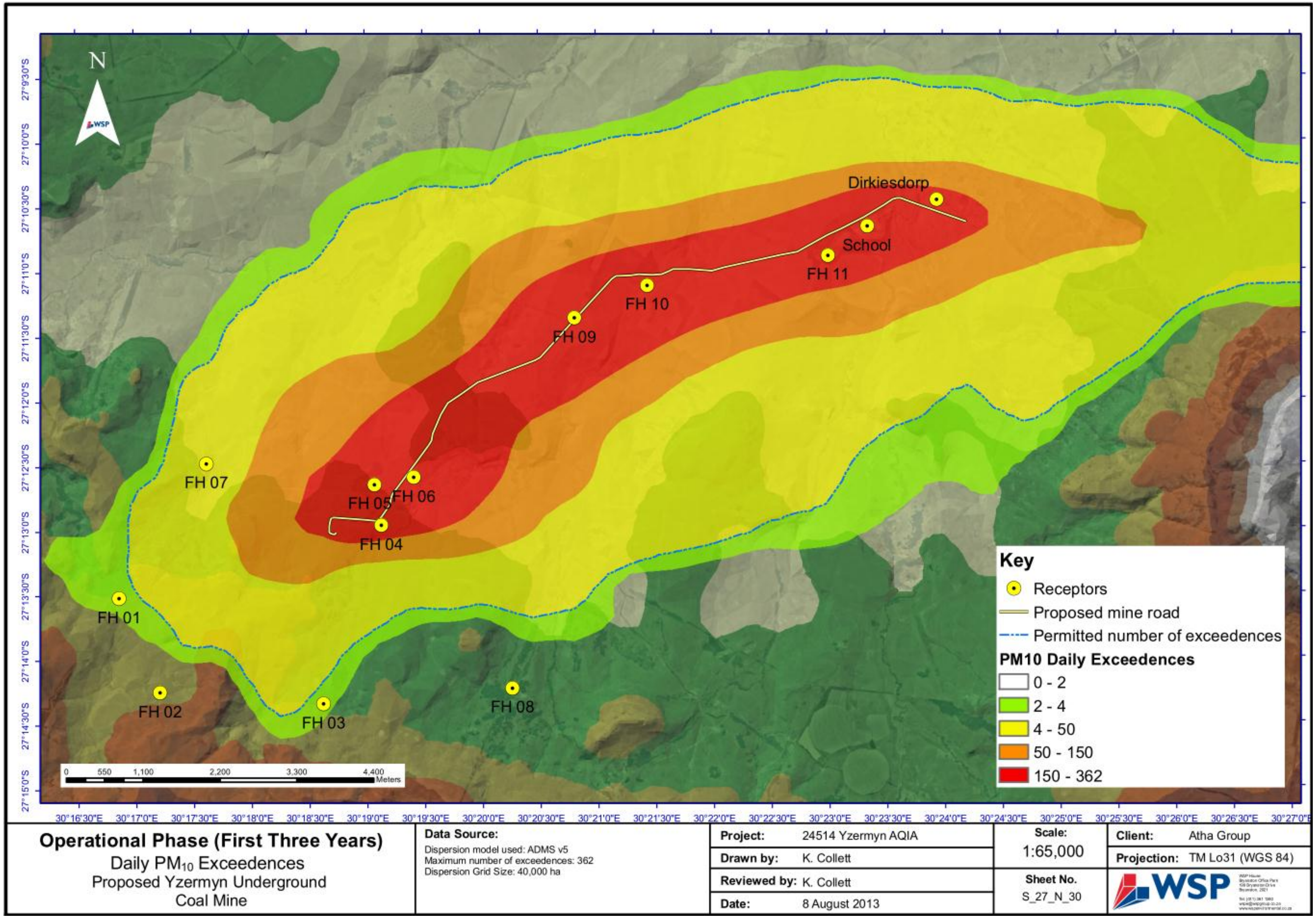


**Figure 31: Predicted number of exceedences of the 24 hour average $PM_{10}$ standard (120 µg/m³) during the first three years of operation**

The predicted $PM_{2.5}$ concentrations at each specified receptor point during the first three years of operation of the proposed Yzermyn Underground Coal Mine are presented in Table 37. Annual average concentrations are elevated at receptors in closest proximity to the mine access road, with exceedences of the annual standard (25 µg/m³) being predicted at FH 06, FH 09, FH 10, School and Dirkiesdorp. Worst case (P100) concentrations at these receptors as well as at FH 04 and FH 11 are elevated, all exhibiting exceedences of the daily standard (65 µg/m³). In terms of the number of predicted exceedences of the daily standard, only six of the 13 receptors are complaint.

**Table 37: $PM_{2.5}$ concentrations at specified receptor points during the construction phase of the proposed Yzermyn Underground Coal Mine**

| Receptor | Long Term $PM_{2.5}$ Concentration (µg/m³) | P100 24 Hr Average $PM_{2.5}$ Concentration (µg/m³) | Predicted No. of Exceedences Per Year of 24 Hr Standard (65 µg/m³) |
|---|---|---|---|
| **FH 01** | 4.43 | 14.42 | 0 |
| **FH 02** | 3.66 | 10.99 | 0 |
| **FH 03** | 3.44 | 21.73 | 0 |
| **FH 04** | 20.67 | 203.18 | 13 |
| **FH 05** | 23.52 | 69.80 | 1 |
| **FH 06** | 53.81 | 192.95 | 143 |
| **FH 07** | 5.91 | 18.46 | 0 |
| **FH 08** | 3.28 | 11.21 | 0 |
| **FH 09** | 120.37 | 363.55 | 246 |
| **FH 10** | 37.81 | 135.45 | 33 |
| **FH 11** | 23.31 | 177.30 | 10 |
| **School** | 31.77 | 116.21 | 26 |
| **Dirkiesdorp** | 41.79 | 208.47 | 88 |
| Long Term = Annual Concentrations | | | |
| P100 = 100th percentile concentrations (worst case) | | | |
| Highlighted concentrations indicate exceedences of $PM_{2.5}$ Annual Std (25 µg/m³) | | | |

Graphical outputs of the modelled long-term (annual) and worst case daily $PM_{2.5}$ concentrations are depicted in Figure 32 and Figure 33. Figure 34 illustrates the predicted number of exceedences of the $PM_{2.5}$ 24-hour average standard within a calendar year. As with the $PM_{10}$, dispersion of $PM_{2.5}$ is towards the east and west with local topography dictating local plume dispersal. Highest concentrations are evident in the direct vicinity of the mine access road, with exceedences of the annual average standard predicted up to 400 m from the road and exceedences of the daily standard up to 600 m from the road.

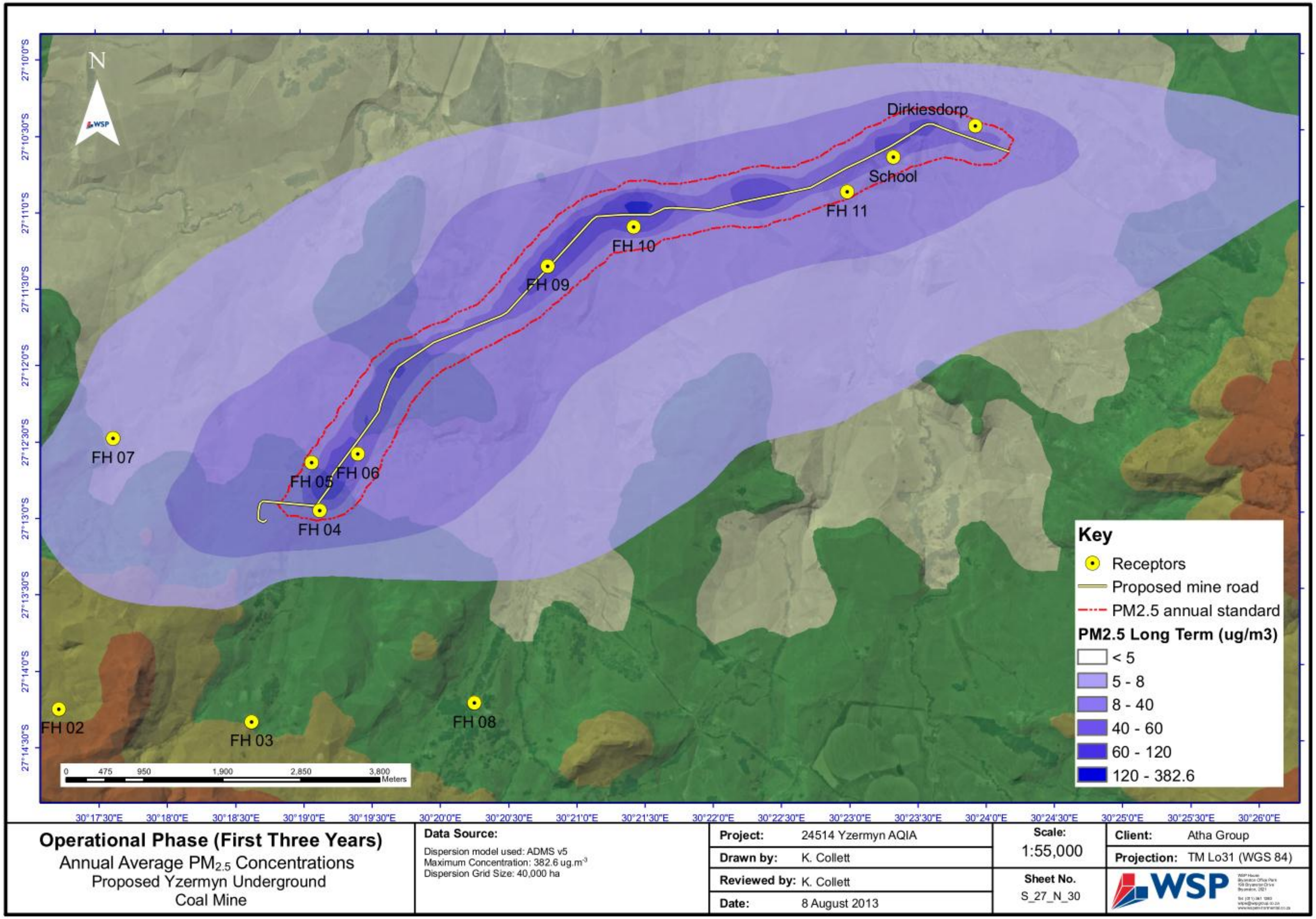


**Figure 32: Predicted annual average $PM_{2.5}$ concentrations associated with the first three years of operation of the proposed Yzermyn Underground Coal Mine**

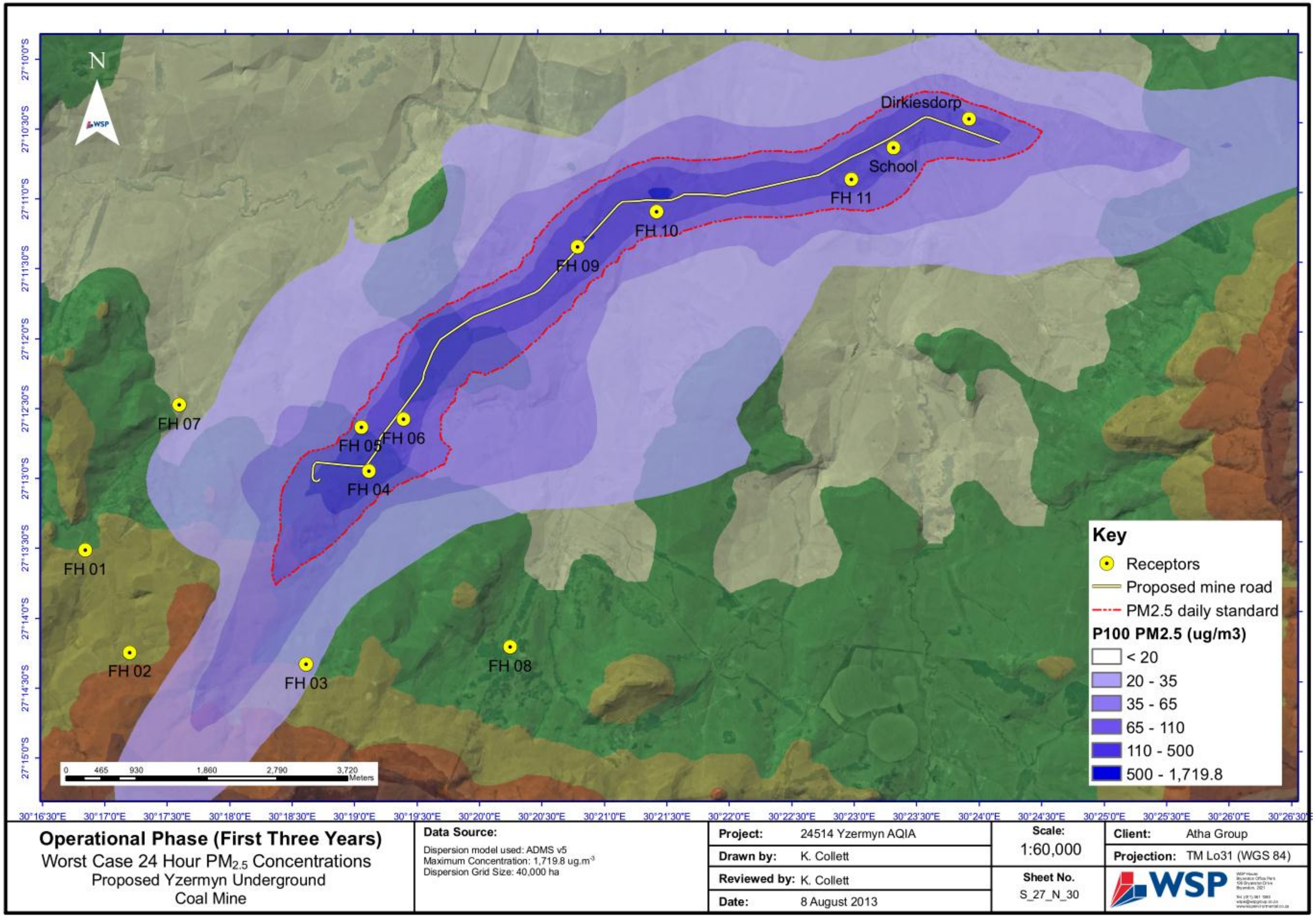


**Figure 33: Predicted worst case 24 hour $PM_{2.5}$ concentrations associated with the first three years of operation of the proposed Yzermyn Underground Coal Mine**

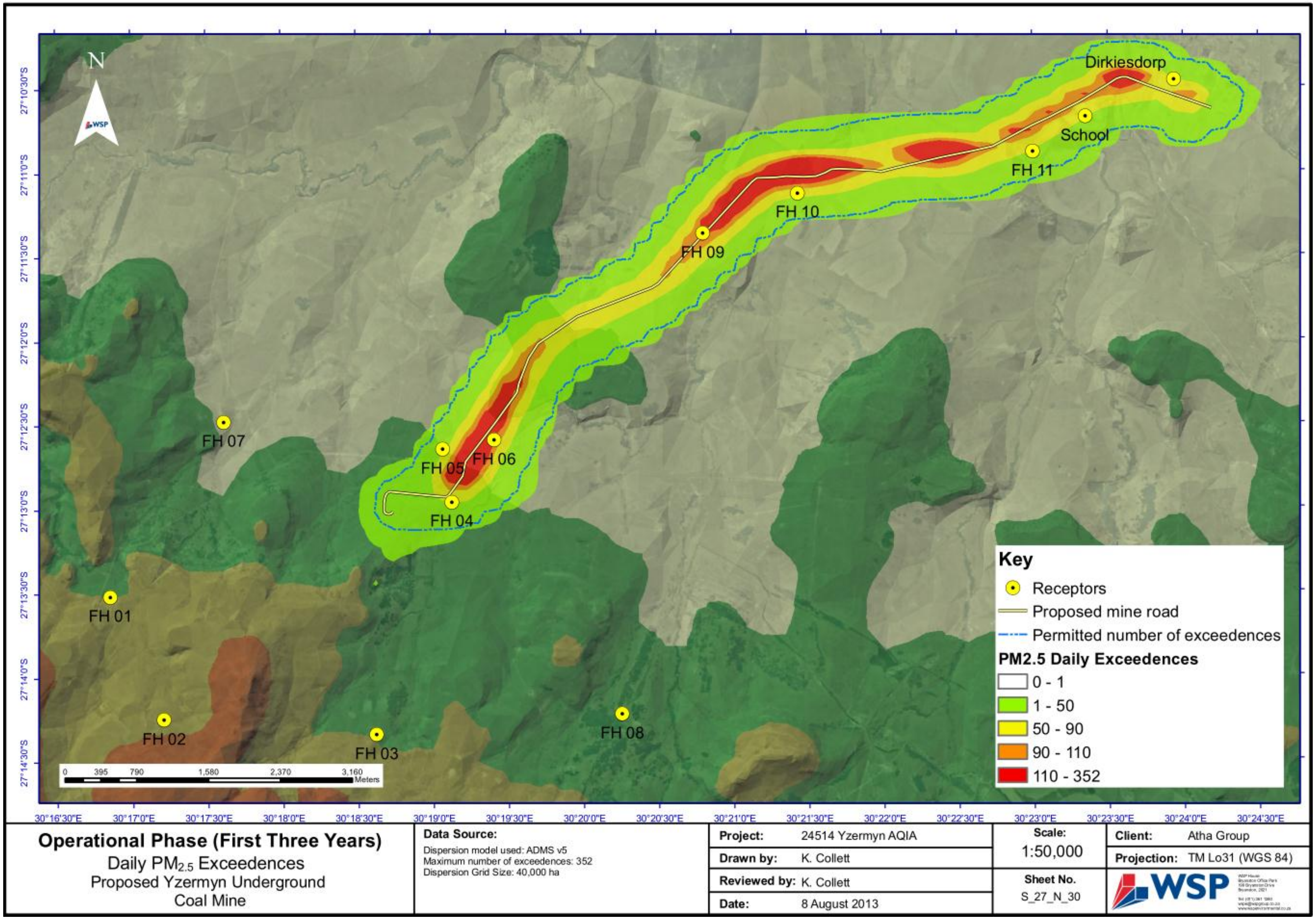


**Figure 34: Predicted number of exceedences of the 24 hour average $PM_{2.5}$ standard (65 µg/m³) during the first three years of operation**

Annual average dust fallout rates at each of the specified receptors during the first three years of operation of the proposed Yzermyn Underground Coal Mine are presented in Table 38. Predicted dust fallout rates are complaint with the SANS Residential Guideline (600 mg/m²/day), except at the farm house receptor, FH 09. Although compliance at receptors is noted, dust fallout rates along the road itself will be significantly elevated and mitigation measures should be employed. These recommendations are presented in section 10.

**Table 38: Annual average dust fallout rates associated with the first three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receptor | Annual Average Dust Fallout Rate (mg/m²/day) | Compliance with Residential Guideline (600 mg/m²/day) |
|---|---|---|
| **FH 01** | 7.62 | Yes |
| **FH 02** | 3.39 | Yes |
| **FH 03** | 2.40 | Yes |
| **FH 04** | 302.88 | Yes |
| **FH 05** | 219.73 | Yes |
| **FH 06** | 385.78 | Yes |
| **FH 07** | 15.15 | Yes |
| **FH 08** | 2.16 | Yes |
| **FH 09** | 1,265.45 | No |
| **FH 10** | 196.37 | Yes |
| **FH 11** | 109.37 | Yes |
| **School** | 170.52 | Yes |
| **Dirkiesdorp** | 269.52 | Yes |

Annual average CO, $NO_x$, $SO_2$ and VOC concentrations associated with vehicles travelling on the mine access road during the first three years of operation are presented in Table 39. Concentrations of all pollutants are low at all receptors, indicating compliance with the NEM:AQA annual standards (30,000 µg/m³ for CO; 40 µg/m³ for $NO_x$; 50 µg/m³ for $SO_2$; and 10 µg/m³ for VOCs (benzene)). With background $NO_2$ concentrations of 4.55 µg/m³, the contribution from activities at the Proposed Yzermyn Underground Coal Mine is minimal and contributes between 0.01 to 1.33 µg/m³ to $NO_x$ emissions at receptors. With background $SO_2$ concentrations of 8.74 µg/m³, emissions from activities at the mine are indiscernible. From this it is evident that emissions of CO, $NO_x$, $SO_2$ and VOCs from vehicles travelling on the mine access road during the first three years of operation will not negatively impact on the surrounding environment.

**Table 39: CO, $NO_x$, $SO_2$ and VOC concentrations at receptors during the first three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receptor | Annual Average CO Concentration (µg/m³) | Annual Average $NO_x$ Concentration (µg/m³) | Annual Average SO2 Concentration (µg/m³) | Annual Average VOC Concentration (µg/m³) |
|---|---|---|---|---|
| **FH 01** | 0.01 | 4.57 | 8.74 | 0.001 |
| **FH 02** | 0.01 | 4.56 | 8.74 | 0.001 |
| **FH 03** | 0.00 | 4.56 | 8.74 | 0.0004 |
| **FH 04** | 0.26 | 5.07 | 8.74 | 0.031 |
| **FH 05** | 0.10 | 4.74 | 8.74 | 0.011 |
| **FH 06** | 0.27 | 5.08 | 8.74 | 0.032 |
| **FH 07** | 0.02 | 4.58 | 8.74 | 0.002 |
| **FH 08** | 0.67 | 5.88 | 8.74 | 0.080 |
| **FH 09** | 0.00 | 4.56 | 8.74 | 0.0004 |
| **FH 10** | 0.14 | 4.82 | 8.74 | 0.016 |
| **FH 11** | 0.24 | 5.04 | 8.74 | 0.029 |
| **School** | 0.24 | 5.03 | 8.74 | 0.029 |
| **Dirkiesdorp** | 0.31 | 5.16 | 8.74 | 0.037 |

## 7.3 Operational Phase (After Three Years)

The predicted $PM_{10}$ concentrations at each specified receptor point after the first three years of operation are presented in Table 40. Long term concentrations at all receptors are low, except at the farm house receptor FH 04 which exhibits a concentration of 90.94 µg/m³, exceeding the annual standard (50 µg/m³). This receptor is in closest proximity to the mine and is impacted on by emissions from the handling of materials in the form of bulldozers, conveyors and tips. Worst case (P100) daily concentrations are elevated at FH 04, FH 05 and FH 06, which all exhibit exceedences of the 24 hour standard (120 µg/m³). All other receptors remain compliant.

In comparison with the first three years of operation, $PM_{10}$ concentrations predicted after three years are significantly lower, indicating compliance at all but one receptor. Although the number of vehicles operating on the mine access road after the first three years will increase substantially, the paving of the road will clearly aid in supressing particulate emissions from the road. The drastic decrease in concentrations between the first three years and after three years provides clear confirmation of the effectiveness a paved road has in mitigating particulate emissions.

**Table 40: $PM_{10}$ concentrations at specified receptor points after the first three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receptor | Long Term $PM_{10}$ Concentration (µg/m³) | P100 24 Hr Average $PM_{10}$ Concentration (µg/m³) | Predicted No. of Exceedences Per Year of 24 Hr Standard (120 µg/m³) |
|---|---|---|---|
| **FH 01** | 16.24 | 68.61 | 0 |
| **FH 02** | 11.97 | 42.56 | 0 |
| **FH 03** | 10.72 | 44.52 | 0 |
| **FH 04** | 90.94 | 820.30 | 120 |
| **FH 05** | 21.50 | 252.17 | 8 |
| **FH 06** | 23.50 | 187.01 | 7 |
| **FH 07** | 14.34 | 77.47 | 0 |
| **FH 08** | 10.54 | 36.29 | 0 |
| **FH 09** | 10.39 | 34.14 | 0 |
| **FH 10** | 10.27 | 30.90 | 0 |
| **FH 11** | 10.26 | 22.79 | 0 |
| **School** | 10.09 | 21.47 | 0 |
| **Dirkiesdorp** | 9.96 | 18.10 | 0 |
| Long Term = Annual Concentrations | | | |
| P100 = $100^{th}$ percentile concentrations (worst case) | | | |
| Highlighted concentrations indicate exceedences of $PM_{10}$ Annual Std (50 µg/m³) | | | |

Graphical outputs of the modelled long-term (annual) and worst case daily $PM_{10}$ concentrations are depicted in Figure 35 and Figure 36. Figure 37 illustrates the predicted number of exceedences of the $PM_{10}$ 24-hour average standard within a calendar year. The highest concentrations are predicted around the mine itself, with the highest contributing source being materials handling as discussed in section 5.1.2.12. Dispersion of $PM_{10}$ is towards the east and west as per the dominant wind direction with local dispersion of plumes being dictated by the topography, particularly in the P100 case. Exceedences of the annual standard are predominantly expected within the mine boundary, while the P100 daily exceedences are predicted to spread more towards the south. Daily $PM_{10}$ exceedences are predicted around the direct vicinity of the mine, with FH 04, FH 05 and FH 06 experiencing exceedences and all other receptors at some distance away indicating compliance with the daily standard.

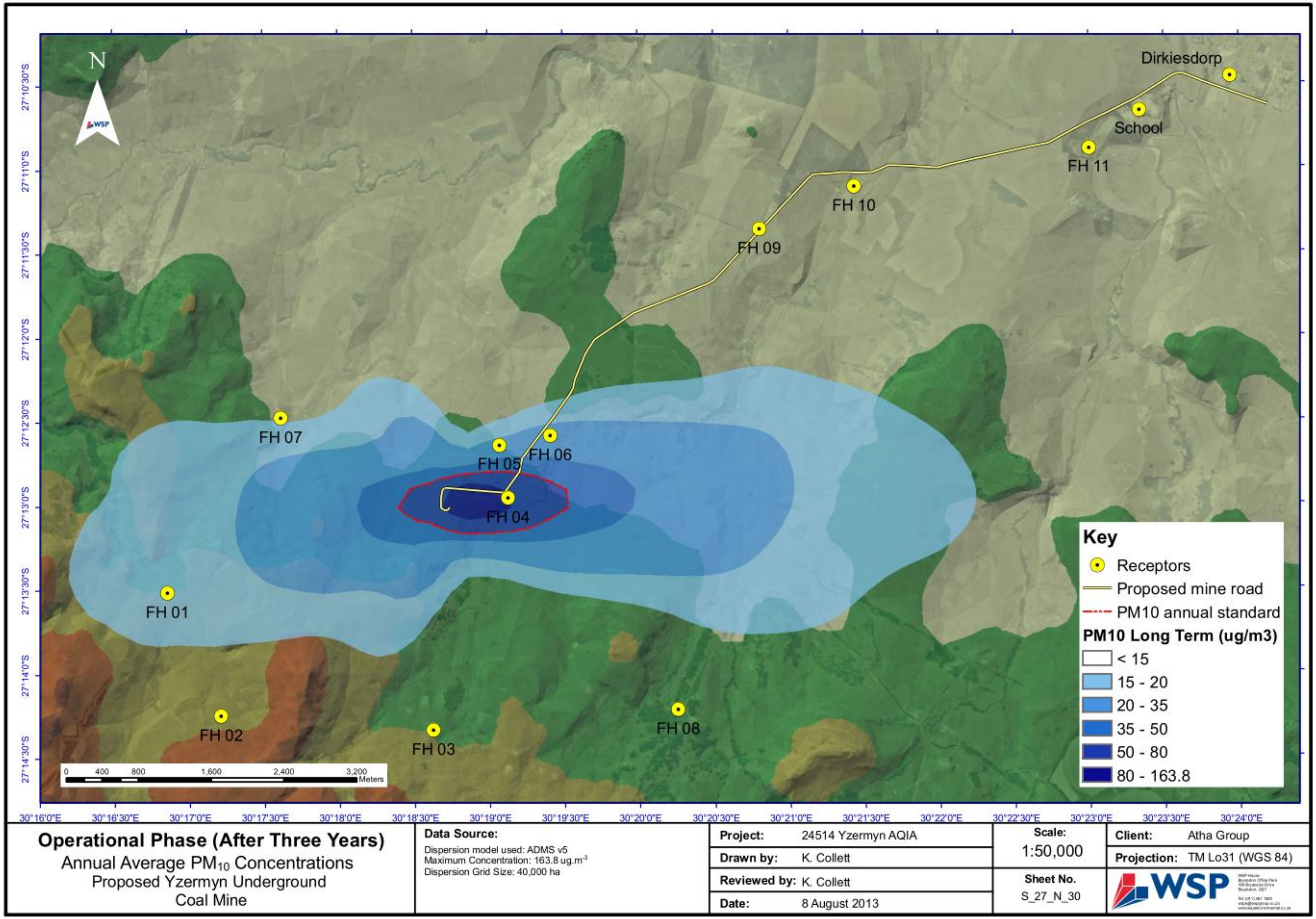


**Figure 35: Predicted annual average $PM_{10}$ concentrations associated after three years of operation at the proposed Yzermyn Underground Coal Mine**

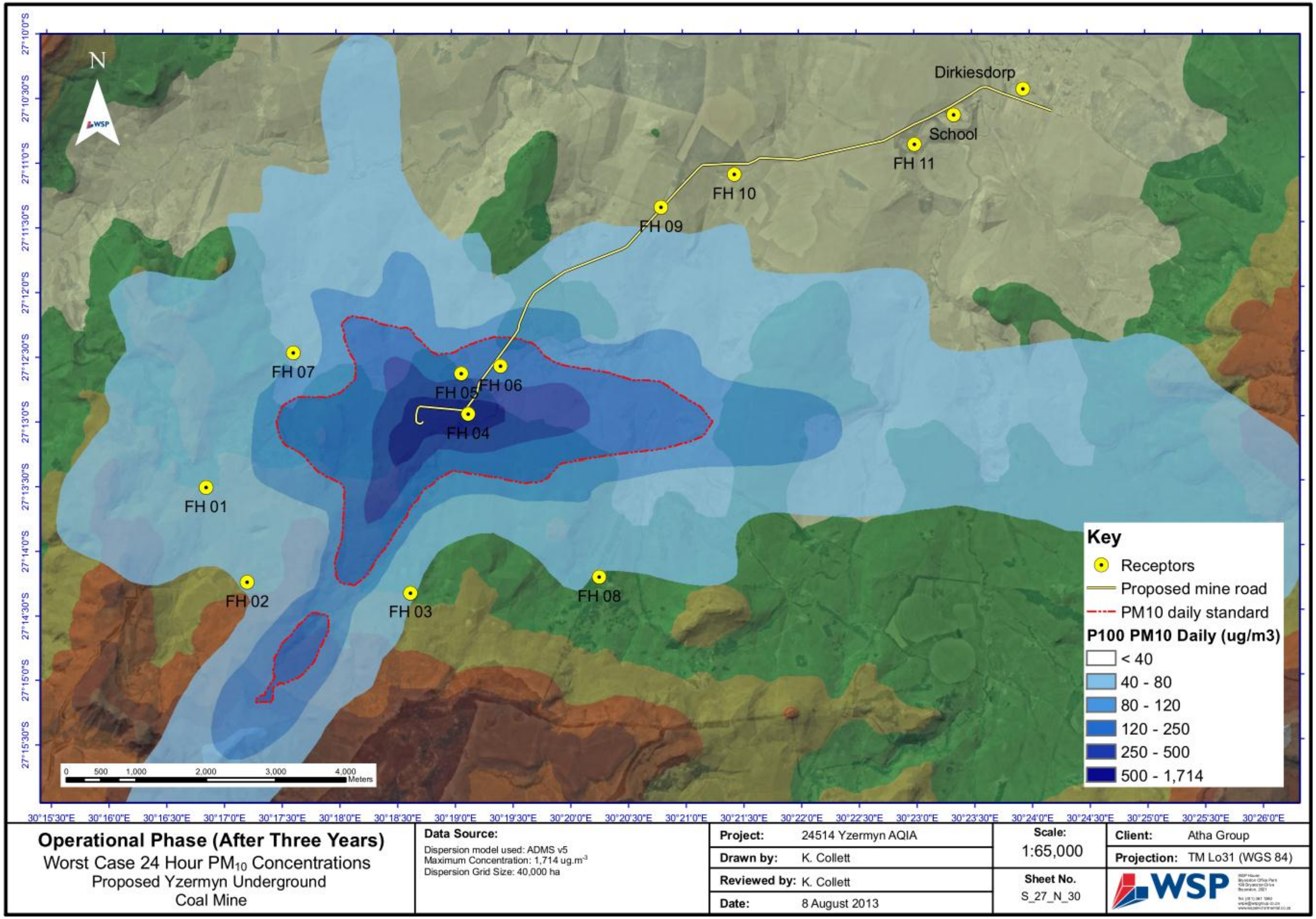


**Figure 36: Predicted worst case 24 hour $PM_{10}$ concentrations after three years of operation at the proposed Yzermyn Underground Coal Mine**

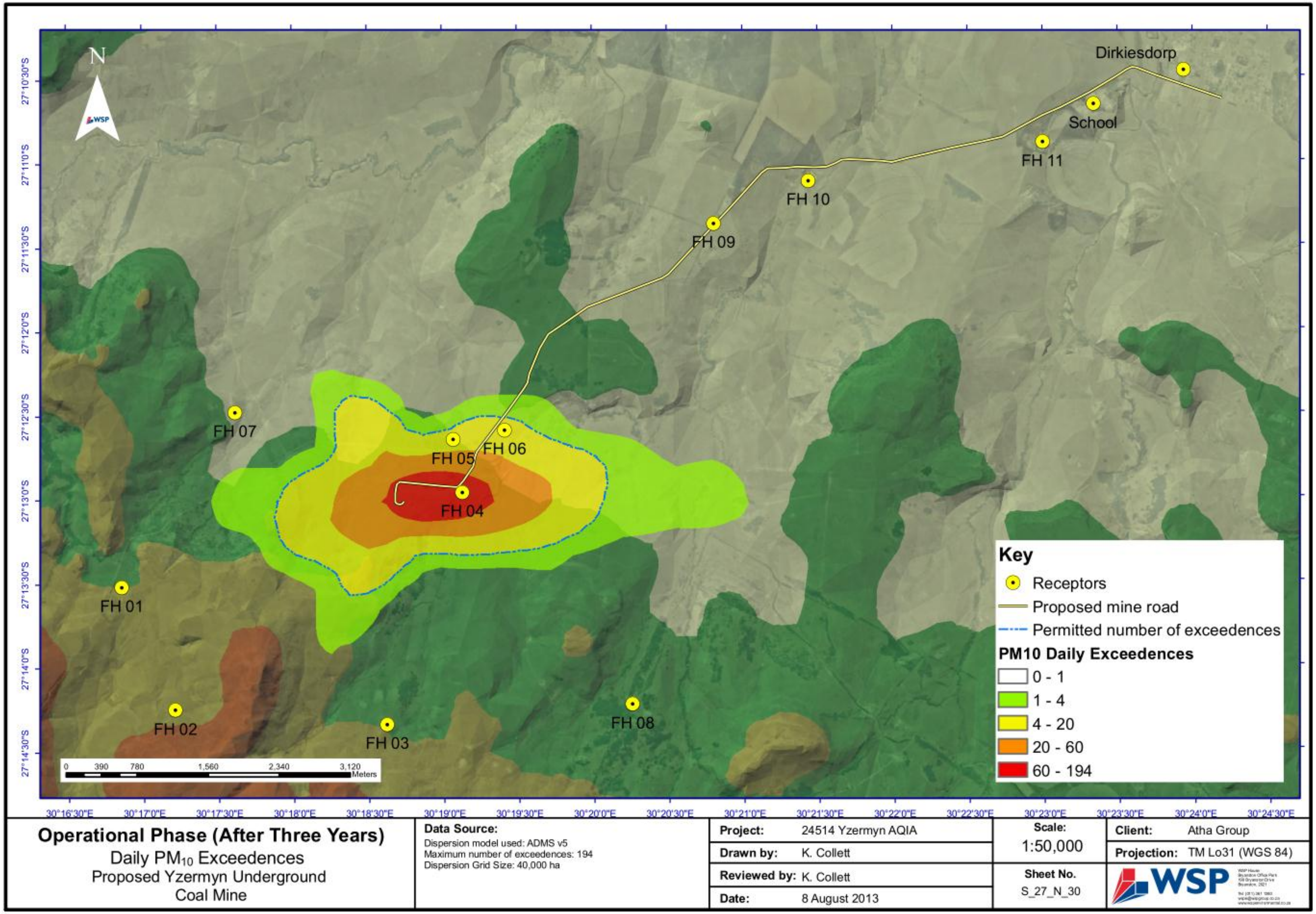


**Figure 37: Predicted number of exceedences of the 24 hour average $PM_{10}$ standard (120 µg/m³) after the first three years of operation**

The predicted $PM_{2.5}$ concentrations at each specified receptor point after the first three years of operation are presented in Table 41. Annual average concentrations at all receptors are low and are compliant with the annual standard (25 µg/m³). Worst case (P100) daily concentrations are low except at FH 04, which is in closest proximity to the mine and exceeds the daily standard (65 µg/m³). This receptor exhibits only one exceedence of the 24 hour standard. The NEM:AQA standards stipulate that four exceedences of the 24 hour average standard are permitted within a calendar year. Since concentrations at FH 04 indicate only one exceedence, concentrations are essentially compliant.

**Table 41: $PM_{2.5}$ concentrations at specified receptor points after three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receptor | Long Term $PM_{2.5}$ Concentration (µg/m³) | P100 24 Hr Average $PM_{2.5}$ Concentration (µg/m³) | Predicted No. of Exceedences Per Year of 24 Hr Standard (65 µg/m³) |
|---|---|---|---|
| **FH 01** | 3.47 | 8.75 | 0 |
| **FH 02** | 3.05 | 5.99 | 0 |
| **FH 03** | 2.92 | 6.11 | 0 |
| **FH 04** | 11.37 | 83.06 | 1 |
| **FH 05** | 3.99 | 28.35 | 0 |
| **FH 06** | 4.14 | 19.62 | 0 |
| **FH 07** | 3.28 | 9.34 | 0 |
| **FH 08** | 2.91 | 5.37 | 0 |
| **FH 09** | 2.89 | 5.14 | 0 |
| **FH 10** | 2.87 | 4.85 | 0 |
| **FH 11** | 2.87 | 4.08 | 0 |
| **School** | 2.86 | 3.96 | 0 |
| **Dirkiesdorp** | 2.84 | 3.63 | 0 |
| Long Term = Annual Concentrations | | | |
| P100 = 100th percentile concentrations (worst case) | | | |
| No exceedences of $PM_{2.5}$ Annual Std (25 µg/m³) | | | |

Graphical outputs of the modelled long-term (annual) and worst case daily $PM_{2.5}$ concentrations are depicted in Figure 38 and Figure 39. Figure 40 illustrates the predicted number of exceedences of the $PM_{2.5}$ 24-hour average standard within a calendar year. The highest annual average concentrations are predicted around the mine itself, although no exceedences of the annual standard (25 µg/m³) are predicted. Dispersion is towards the east and west as per the dominant wind direction with local dispersion of plumes being dictated by the topography, particularly in the P100 case. Daily $PM_{2.5}$ exceedences are predicted around the direct vicinity of the mine where the loading of material from the export and middlings stockpiles occur. No offsite exceedences are predicted.

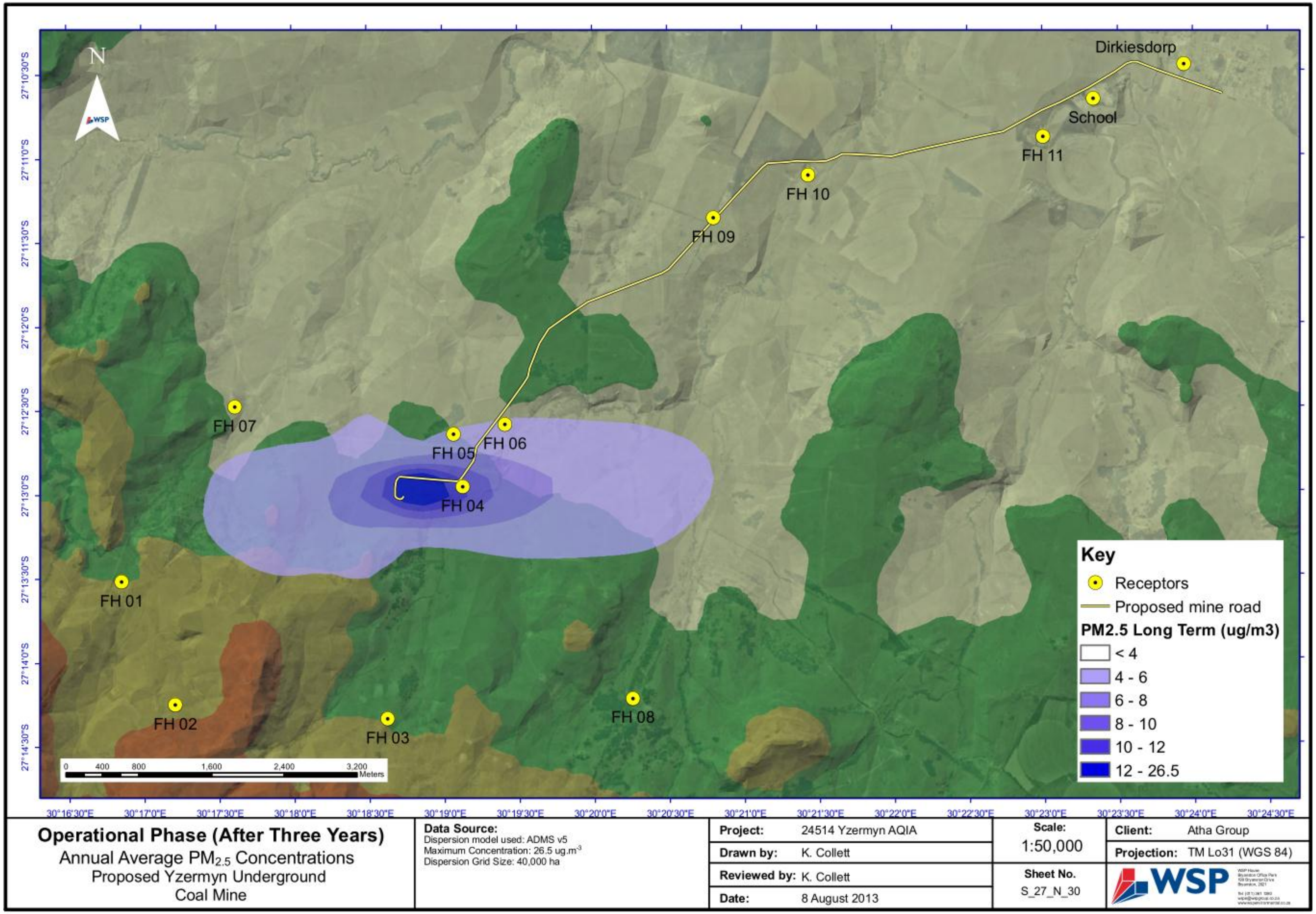


**Figure 38: Predicted annual average $PM_{2.5}$ concentrations after three years of operation at the proposed Yzermyn Underground Coal Mine**

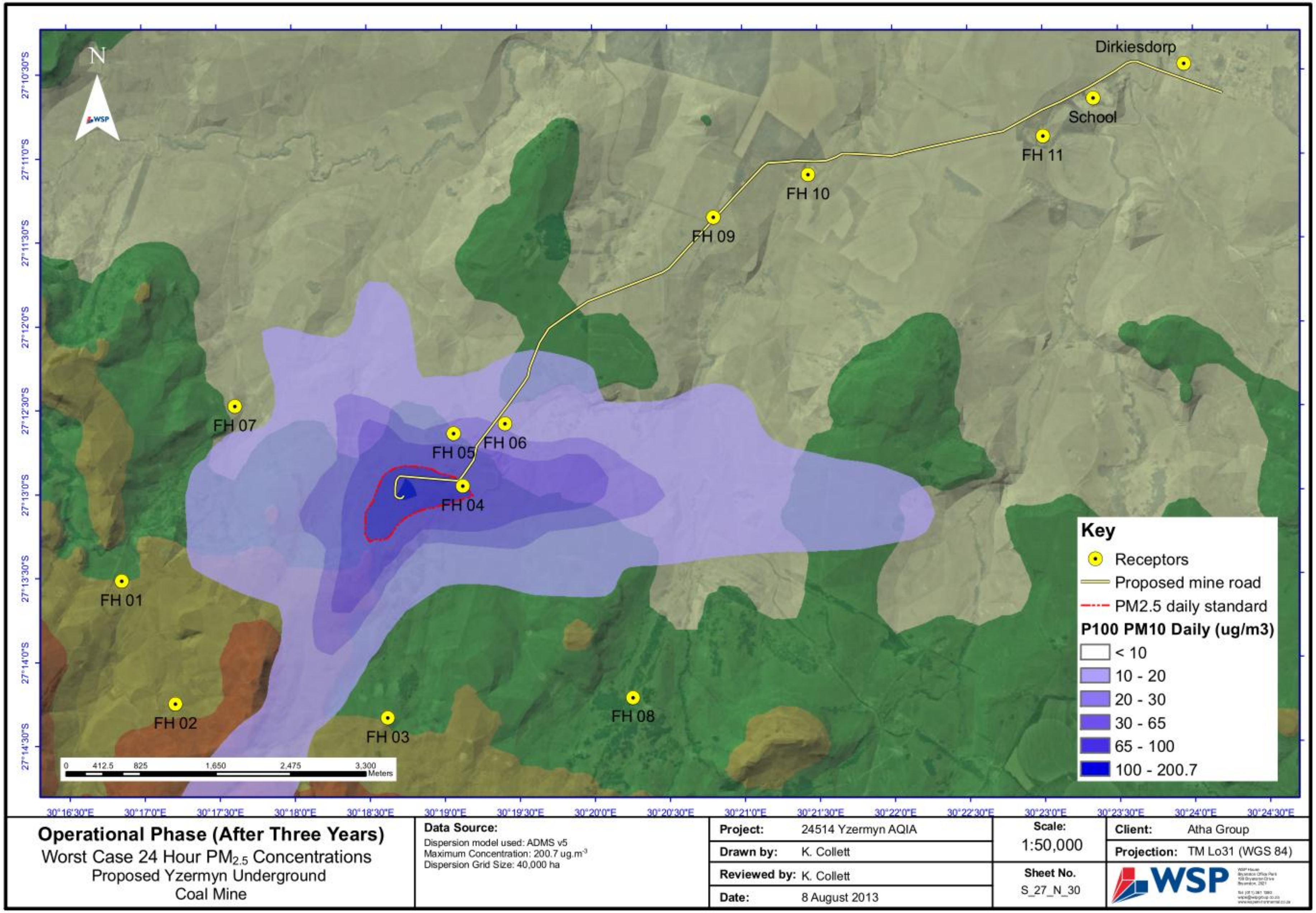


**Figure 39: Predicted worst case 24 hour $PM_{2.5}$ concentrations after three years of operation of the proposed Yzermyn Underground Coal Mine**

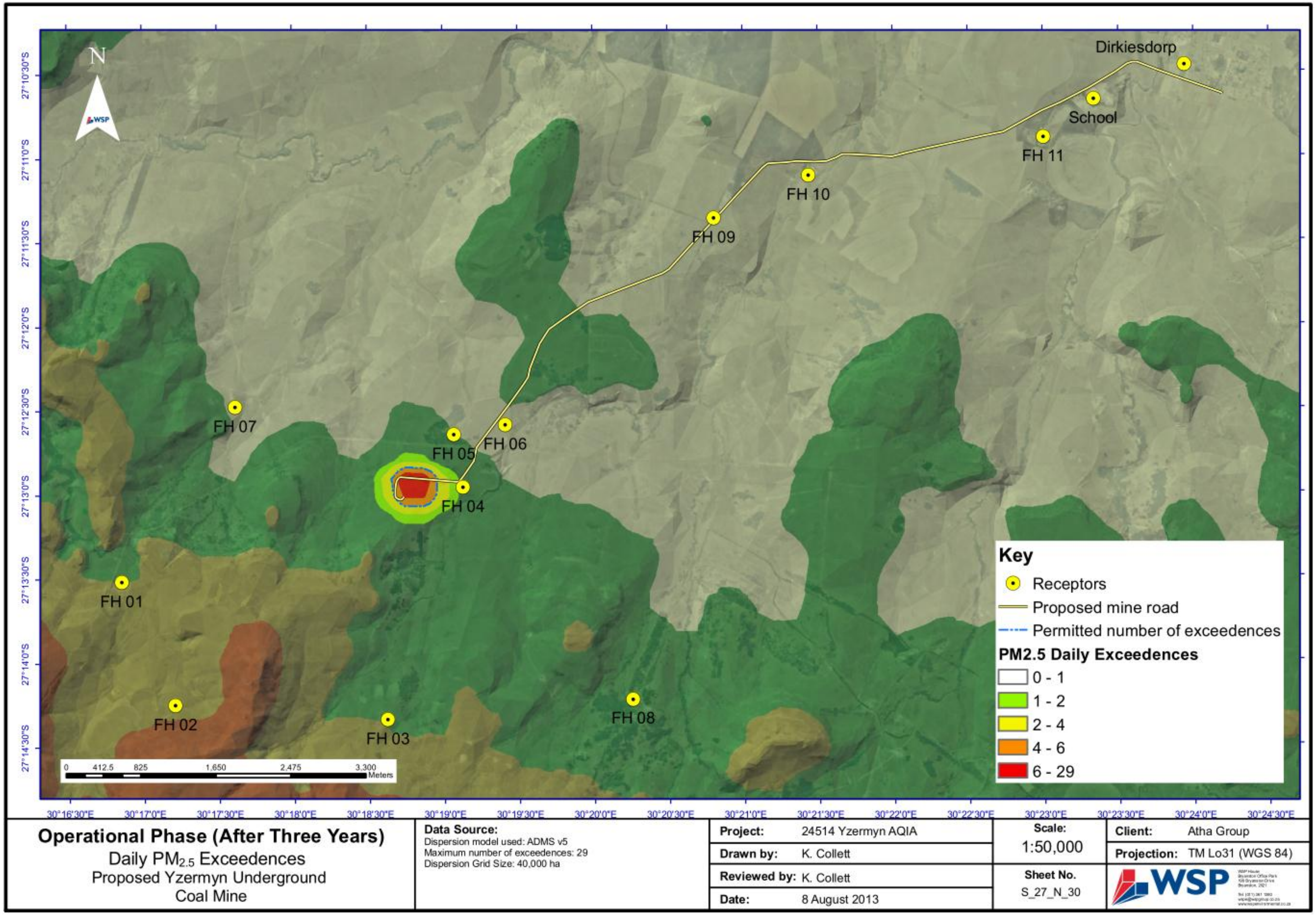


**Figure 40: Predicted number of exceedences of the 24 hour average $PM_{2.5}$ standard (65 µg/m³) after the first three years of operation**

Predicted annual average dust fallout rates after the first three years of operation of the proposed Yzermyn Underground Coal Mine are presented in Table 42. Predicted dust fallout rates at all specified receptors are low, indicating compliance with the SANS residential guideline (600 mg/m²/day). Although compliance at receptors is noted, dust fallout rates within the mine boundary itself will be significantly elevated and mitigation measures are recommended. These mitigation recommendations are discussed in section 10.

**Table 42: Annual average dust fallout rates after three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receptor | Annual Average Dust Fallout Rate (mg/m²/day) | Compliance with Residential Guideline (600 mg/m²/day) |
|---|---|---|
| **FH 01** | 4.81 | Yes |
| **FH 02** | 1.79 | Yes |
| **FH 03** | 1.07 | Yes |
| **FH 04** | 263.02 | Yes |
| **FH 05** | 110.47 | Yes |
| **FH 06** | 15.33 | Yes |
| **FH 07** | 5.56 | Yes |
| **FH 08** | 1.13 | Yes |
| **FH 09** | 0.71 | Yes |
| **FH 10** | 0.57 | Yes |
| **FH 11** | 0.55 | Yes |
| **School** | 0.48 | Yes |
| **Dirkiesdorp** | 0.42 | Yes |

Annual average CO, $NO_x$, $SO_2$ and VOC concentrations associated with vehicles travelling on the mine access road after the first three years of operation are presented in Table 43. Even with a significant increase in the number of vehicles from the first three years of operation, concentrations of all pollutants are low at all receptors, indicating compliance with the NEM:AQA annual standards. With background $NO_2$ concentrations of 4.55 µg/m³, the contribution from activities at the proposed Yzermyn Underground Coal Mine after three years of operation is minimal and contributes between 0.01 to 2.66 µg/m³ to $NO_x$ emissions at receptors. With background $SO_2$ concentrations of 8.74 µg/m³, emissions from activities at the proposed Yzermyn Underground Coal Mine are indiscernible. From this it is evident that emissions of CO, $NO_x$, $SO_2$ and VOCs from vehicles travelling on the mine access road after the first three years of operation will not negatively impact on the surrounding environment.

**Table 43: CO, $NO_x$, $SO_2$ and VOC concentrations at receptors during the first three years of operation**

| Receptor | Annual Average CO Concentration (µg/m³) | Annual Average $NO_x$ Concentration (µg/m³) | Annual Average SO2 Concentration (µg/m³) | Annual Average VOC Concentration (µg/m³) |
|---|---|---|---|---|
| **FH 01** | 0.02 | 4.59 | 8.74 | 0.002 |
| **FH 02** | 0.01 | 4.57 | 8.74 | 0.001 |
| **FH 03** | 0.01 | 4.56 | 8.74 | 0.001 |
| **FH 04** | 0.52 | 5.60 | 8.74 | 0.05 |
| **FH 05** | 0.19 | 4.93 | 8.74 | 0.02 |
| **FH 06** | 0.53 | 5.62 | 8.74 | 0.05 |
| **FH 07** | 0.03 | 4.61 | 8.74 | 0.003 |
| **FH 08** | 1.33 | 7.21 | 8.74 | 0.13 |
| **FH 09** | 0.01 | 4.56 | 8.74 | 0.001 |
| **FH 10** | 0.27 | 5.10 | 8.74 | 0.03 |
| **FH 11** | 0.49 | 5.53 | 8.74 | 0.05 |
| **School** | 0.48 | 5.51 | 8.74 | 0.05 |
| **Dirkiesdorp** | 0.61 | 5.78 | 8.74 | 0.06 |

# 8 Assumptions and Limitations

Various assumptions were made and limitations experienced in this assessment that may impact on the outcome of the results obtained in this report.

These assumptions include:

- The proposed site layout as provided by Mindset Mining Consultants is assumed to be representative of reality;
- All areas utilised in the emissions inventory calculations were calculated using ArcGIS 10, based on the site layout provided by Mindset Mining Consultants;
- It was assumed that the operational statistics provided by Atha and Mindset Mining Consultants is representative of reality;
- Topsoil density was assumed to be 1,806.4 kg/m³ based on experience from previous work undertaken in the area;
- The topsoil depth of 0.7 m obtained from the soil specialist was assumed to be representative of reality;
- The removed topsoil will be stockpiled in a berm to the south of the mine;
- The location of the topsoil stockpile / berm was assumed to be located towards the south of the mine;
- A height of 2 m for the topsoil stockpile / berm was assumed;
- Graders will operate twice a month on roads;
- The number of holes drilled was based on a 3 m spacing over the area of the boxcut highwall;
- It was assumed that the overburden moisture content of 6.7% and silt content of 14% from a previous mining study performed in the Mpumalanga province is representative for this study;
- 20 vehicles will frequent the site on a daily basis during the construction phase;
- The construction vehicles will only enter and exit the site once;
- Activities will operate for 20 hours a day during construction phase;
- Activities will operate for 24 hours a day during operational phase;
- Height of tips above stockpiles is 1 m;
- Emissions at stockpiles were applied to the entire surface area of the stockpile;
- It was assumed that trucks will transport discard from the discard bin to the discard dump;
- Fuel consumption of trucks was based on a generic Volvo diesel truck;
- The number of vehicles operating on the mine access road during the operational phase, calculated from the personnel numbers depicted in the Mine Works Programme, are assumed to be representative of reality;
- A height of 3.5 m for the Coal Handling and Preparation Plant was utilised in the model; and
- It was assumed that the topsoil stockpile will be grassed and will not impact on emissions in the operational phase (after three years) scenario.

The limitations include:

- The lack of site specific metrological data, where only UM model data was obtainable and subsequently utilised in the dispersion model.

# 9 Conclusions

This air quality impact assessment investigated emissions associated with the construction and operation of the proposed Yzermyn Underground Coal Mine near Wakkerstroom in the Mpumalanga Province. To assess the existing background local air quality of the region, baseline ambient air quality monitoring of dust fallout, particulate matter, sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) was performed during a summer and winter campaign in 2012. From this, it was identified that dust fallout rates and particulate emissions in the region are low, particularly in the wet summer season. The region is characterised by a background $PM_{10}$ concentration of 8.97 µg/m$^3$ and a $PM_{2.5}$ concentration of 2.75 µg/m$^3$, which were subsequently utilised as background in the dispersion model. $NO_2$ and $SO_2$ concentrations were significantly low, with monitored summer and winter concentrations indicating compliance with the NEM:AQA standards.

From the dispersion modelling and the meteorological input data, emissions from the proposed Yzermyn Underground Coal Mine will disperse towards the east and the west, with local plume dispersion being dictated by the topography. Main sources of particulate emissions during the construction phase include materials handling activities; general construction activities and activities along the mine access road. During the first three years of operation the main source of particulates is from vehicular activity on the unpaved mine access road, whilst after three years (when the road is paved) the main sources include materials handling (in the form of bulldozing / FEL activity at the stockpiles and discard dump; truck loading; and drop operations at tips and bins) and wind erosion of exposed areas and stockpiles.

Long term $PM_{10}$ concentrations during the construction phase are predicted to be generally low, with concentrations exceeding the annual standard (50 µg/m$^3$) at receptors in close proximity to the construction activities and at receptors in closest proximity to the mine access road. Numerous exceedences of the 24 hour average standard are also predicted at these receptors. The highest number of daily $PM_{10}$ exceedences is predicted within the mine boundary; however, a number of exceedences are predicted along the mine access road, with the maximum permitted frequency being exceeded up to 600 m from the road. Emissions from the construction phase are not a key concern due to the temporary nature of this phase, however, various mitigation recommendations are provided in the section that follows to further minimise the impacts from construction activities.

Predicted long term $PM_{2.5}$ concentrations during the construction phase are low and no exceedences of the annual $PM_{2.5}$ standard are predicted at any of the sensitive receptors. Worst case daily concentrations are also low, with the farm house receptor, FH 04 being the only receptor to exceed the daily standard, due to its close proximity to the construction activities. From this it is evident that dust in the form of $PM_{2.5}$ is not a key emission from the construction phase of the proposed Yzermyn Underground Coal Mine and will not negatively impact on surrounding receptors.

Annual average dust fallout rates during the construction phase are low and are compliant with the SANS Residential Guideline at all receptors. It must be noted, that although low rates are predicted offsite, onsite fallout rates in the direct vicinity of the construction activities are predicted to be significantly elevated as would be expected.

Predicted long term $PM_{10}$ concentrations during the first three years of operation are significantly elevated if no mitigation is applied, with concentrations exceeding the annual standard at nine of the 13 receptor points. All of these receptors are in close proximity to the unpaved mine access road, that generates high dust levels as a result of the high vehicle numbers travelling on the road on a daily basis. Exceedences of the 24 hour standard are predicted at all receptors, except FH 02, with the highest number of exceedences predicted at receptors in close proximity to the mine access road. Similarly, predicted long term $PM_{2.5}$ concentrations during the first three years of operation are high with exceedences of the annual standard (25 µg/m$^3$) being predicted at five of the 13 receptors. Worst case daily concentrations at these receptors also indicate non-compliance with the 24 hour standard. Highest concentrations are evident in the direct vicinity of the mine access road, with exceedences of the annual average standard predicted up to 400 m from the road and exceedences of the daily standard up to 600 m from the road. Mitigation in the form of dust palliatives and suppressants on the haul road (discussed in section 10) will be required to address these predicted exceedences during the first three years of operation.

After three years of operation, the mine access road will be paved and an increase in vehicle numbers is envisaged. Predicted long term $PM_{10}$ concentrations at this time are low and are compliant with the annual standard at all receptors except at the farm house receptor, FH 04. This receptor is in closest proximity to the mine and is impacted by emissions from the handling of materials in the form of bulldozers, conveyors and tips. Exceedences of the daily $PM_{10}$ standard are predicted in the direct vicinity of the mining operations, impacting on three receptors that are in closest proximity to the mine. In order to decrease the impacts of such emissions, certain mitigation techniques can be employed which are discussed in detail in the section that follows.

Predicted long term $PM_{2.5}$ concentrations are low, with no exceedences of the annual standard at any of the receptor points. Only one exceedence of the daily standard is predicted at receptor FH 04. Daily $PM_{2.5}$ exceedences are predicted around the direct vicinity of the mine where the loading of material from the export and middlings stockpiles occur. No offsite exceedences are predicted.

Predicted annual average dust fallout rates after three years of operation are compliant with the SANS Residential Guideline at all receptors. Although compliance at receptors is noted, dust fallout rates within the mine boundary itself will be significantly elevated and mitigation measures are recommended.

$SO_2$, $NO_2$, CO and VOC emissions from vehicles travelling on the mine access road during both the first three years of operation and after three years of operation are low, indicating compliance with the NEM:AQA annual standards at all receptors. The contribution from activities during the first three years and after three years is minimal, contributing between 0.01 to 1.33 µg/m³ and 0.01 to 2.66 µg/m³ to $NO_x$ emissions at receptors respectively. $SO_2$ emissions from activities at the mine are not predicted to result in any detectable increase at receptor locations. From this it is evident that emissions of CO, $NO_x$, $SO_2$ and VOCs from vehicles travelling on the mine access road during the operational phase will not negatively impact on the surrounding environment.

In accordance with WSP's impact rating methodology, the predicted air quality impacts of the proposed Yzermyn Underground Coal Mine project are expected to be low-medium (LM) to medium-high (MH) as depicted in Table 44.

**Table 44: Impacts rating table of environmental noise from the proposed Yzermyn Underground Coal Mine**

| | | | | A | B | C | D | E | F | G | (DxG) | (DxG) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ref.** | **Phase** | **Impact Description** | **Mitigation Measure** | **Severity** | **Duration** | **Extent** | **Consequence (A+B+C)/3** | **Frequency** | **Probability** | **Likelihood (E+F)/2** | **Environmental Significance** | **Impact** |
| | | | | **Air Quality** | | | | | | | | |
| 1 | Construction | Impact on neighbouring farm houses | Without mitigation | 3.0 | 2.0 | 3.0 | 2.7 | 5.0 | 2.0 | 3.5 | **9.3** | **LM** |
| | | | With mitigation | 2.0 | 2.0 | 3.0 | 2.3 | 5.0 | 2.0 | 3.5 | **8.2** | **LM** |
| 2 | Construction | Impact on sensitive receivers along the mine access road | Without mitigation | 3.0 | 2.0 | 3.0 | 2.7 | 5.0 | 2.0 | 3.5 | **9.3** | **LM** |
| | | | With mitigation | 2.0 | 2.0 | 3.0 | 2.3 | 5.0 | 2.0 | 3.5 | **8.2** | **LM** |
| 3 | Operational first three years | Impact on neighbouring farm houses | Without mitigation | 4.0 | 3.0 | 3.0 | 3.3 | 5.0 | 5.0 | 5.0 | **16.7** | **MH** |
| | | | With mitigation | 2.0 | 4.0 | 2.0 | 2.7 | 5.0 | 2.0 | 3.5 | **9.3** | **LM** |
| 4 | Operational first three years | Impact on sensitive receivers along the mine access road | Without mitigation | 4.0 | 3.0 | 3.0 | 3.3 | 5.0 | 5.0 | 5.0 | **16.7** | **MH** |
| | | | With mitigation | 2.0 | 4.0 | 2.0 | 2.7 | 5.0 | 2.0 | 3.5 | **9.3** | **LM** |
| 5 | Operational after three years | Impact on neighbouring farm houses | Without mitigation | 2.0 | 4.0 | 2.0 | 2.7 | 5.0 | 2.0 | 3.5 | **9.3** | **LM** |
| | | | With mitigation | 1.0 | 4.0 | 2.0 | 2.3 | 5.0 | 2.0 | 3.5 | **8.2** | **LM** |
| 6 | Operational after three years | Impact on sensitive receivers along the mine access road | Without mitigation | 2.0 | 4.0 | 2.0 | 2.7 | 5.0 | 2.0 | 3.5 | **9.3** | **LM** |
| | | | With mitigation | 1.0 | 4.0 | 2.0 | 2.3 | 5.0 | 2.0 | 3.5 | **8.2** | **LM** |

# 10 Recommendations

As indicated in the emissions inventory calculations and dispersion model results, emissions from unpaved roads (especially during the first three years of operation) are a significant concern and mitigatory measures will be required. The following mitigation techniques are recommended to minimise the impacts from unpaved roads and materials handling. Such techniques are in line with the IFC / World Bank recommendations.

## 10.1 Unpaved Roads

During the construction phase, unpaved roads are a dominant source of particulate emissions. Vehicle movement along unpaved roads manifests a range of dust emission mechanisms. Firstly, as the vehicle's tyres move across the road surface the frictional forces result in the soil and rock particles breaking down into smaller sized particles (which are more readily entrained into the air compared with larger, heavier particles). Air turbulence from the moving tyres, the bulk of the vehicle itself and even the exhaust can result in entrainment of dust which would have otherwise remained on the ground surface. The US EPA suggests that vehicle restrictions are one of three categories of mitigation efforts that may be employed to reduce dust emission from unpaved roads. Its recommendations include reducing vehicle speed, reducing vehicle weights and limiting the amount of traffic using the roads.

WSP recommends that the mine access road from Dirkiesdorp receive dust-a-side or another form of chemical suppressant (preferably an emulsion type which bonds the soil together) during the construction phase, having the benefit of:

- Reducing dust emissions by approximately 99% (dust-a-side);
- Improving safety through improved visibility; and
- Reducing costs associated with application of water to unpaved roads.

In the late 1990's the United States Department of Defence tested various emulsion types of chemical suppressants (polyvinyl acrylic polymer, soybean feedstock by-product, calcium ligno-sulphonate and a 38% calcium chloride solution) to determine the most efficient suppressant (Hough, 2012). Findings indicated:

- Within the first month, all four agents reduced dust emissions by 50%, providing protection to the road surfaces past 60 days, although the polyvinyl acrylic polymer indicated break-up of the surface due to heavy traffic after approximately 45 days (Hough, 2012).
- In a study conducted in California, the polyvinyl acrylic polymer agent indicated a 90% reduction in fine suspended dust, while a 20% reduction in this dust was noted using ligno-sulphonates and a 10% reduction using calcium chloride (Hough, 2012).

As indicated above, there are various chemical dust suppressants available on the international market, with a number of investigations into the efficiency of these having been conducted. Dust-a-side is a chemical suppressant widely used in South Africa with proven effectiveness and being readily available. WSP recommends that Atha investigate all these options, considering the cost of application, maintenance of the surface after application and efficiency of the suppressant. The application of the chemicals to the mine access road will result in a significant reduction of dust emissions associated with the road.

A second option to mitigate the generation of dust on the mine access road is wetting. The benefits of the application of water include:

- It is environmentally friendly; and
- It is effective in reducing dust emissions for the short-term, for example a large, temporary dust release can be effectively mitigated with the application of water.

The disadvantages of the application of water to unpaved roads include:

- Water is a scare resource and needs to be consumed with care;
- It is a short-term solution, with the road surfaces requiring approximately two applications per day to ensure continued dust suppression;

- On unpaved roads with a high gravel content, the formation of mud will force the gravel to the side of the road, often being lost and requiring replacement with new gravel, at significant costs (Hough, 2012);
- Water does not bind the road surface. Once surfaces are dry, gravel can be thrown up by vehicles causing damage to other vehicles, resulting in higher vehicle maintenance costs; and
- The application of water as a dust suppressant can be viewed negatively by the public as water is viewed as a limited resource.

The use of water as a dust suppressant can be a costly exercise, which is not efficient for the long-term. Alternatives to this suppressant should be investigated, such as those chemical suppressants discussed previously.

Key recommendations:

- Application of dust-a-side or similar chemical suppressant to the mine access road;
- Application of salts (calcium chloride, magnesium chloride, hydrated lime etc.) which as hygroscopic compounds increase the surface moisture content of the roads material by attracting moisture from the atmosphere;
- Application of surfactants (soaps/detergents) that decrease the surface tension of water allowing the available moisture to wet more particles per unit volume;
- Implement vehicle speed restrictions (approximately 10 – 20 km/hour) on the road; and
- Vehicles carrying any loose aggregates or materials should be covered with tarpaulins or sheets at all times.

## 10.2 Wind Blown Dust

Wind erosion contributes to overall particulate emissions in both the construction and operational phases of the proposed Yzermyn Underground Coal Mine. Areas of concern predominantly include exposed areas, coal stockpiles, conveyors, tips / feedbins, and fines around the CHPP.

Tips, Feedbins and Processing Plant

Improving general maintenance, specifically the cleaning of machinery to remove deposited dust as well as the removal of deposited coal fines on the ground surrounding the processing plant and feedbins. The coal fines deposited on the ground contribute the highest dust emissions in high wind speed events. Should these fines be removed, entrainment of dust in these areas will be significantly reduced. Mitigation methods in these areas that can be implemented to reduce dust emissions include:

- Tasking a team to be responsible for the removal of all deposited dust from machinery, enclosures and conveyors within the processing plant and tip area, resulting in less deposited dust available for wind entrainment.
- Deploy a dust sweeper to the processing plant and tip area, capable of collecting all deposited coal fines, reducing the amount of dust available for wind entrainment. An example of a dust sweeper is the Tennant 6200, available from Goscor Cleaning Equipment (www.goscorcleaning.co.za), which is petrol, battery or LP Gas operated. Atha should investigate dust sweeper options which would best suit the requirements for cleaning the processing plant and tip areas.
- Erecting porous wind breaks at the base of crushers, screens and conveyor transfer points, approximately 1 m high, completely enclosing the base of the structure. This method will ensure deposited coal fines from the activity are not entrained by winds. These areas can then be routinely cleaned.

Porous barriers are typically more effective in reducing dust transmission compared with solid wall structures (WeatherSolve Structures, 2010). In the case of a solid wall, moving air can only travel upwards and over the wall (with little speed reduction) (Figure 41). This in turn can result in additional scour of soil on the windward and leeward sides of the wall (induced vortex) (Pick, 1998).

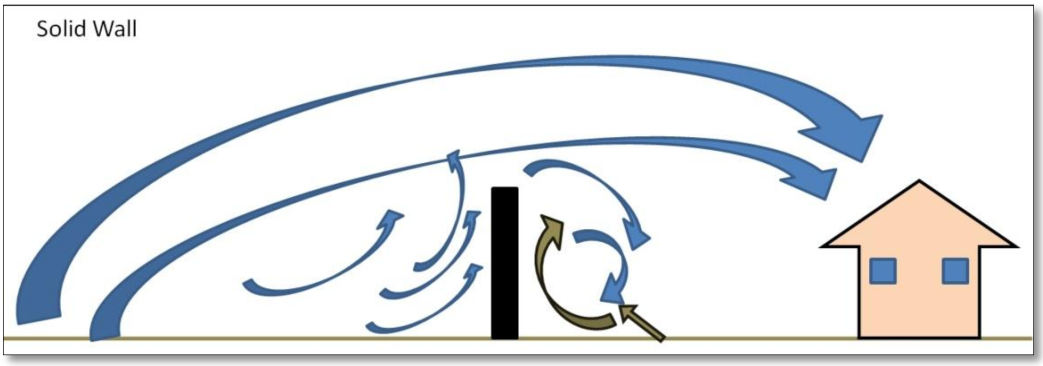


**Figure 41: Diagram indicating wind movements with a solid wall windbreak**

A porous wall (such as open-weave netting) will not cause as significant a pressure difference either side of the wall compared to a solid structure. Also, as the air moves through the wall, its velocity is decreased, which in turn decreases the energy available to transport dust particles (encouraging deposition) (Figure 42). It is estimated that an ideal porosity for the windbreak wall would be 40-50% (where 0% would be a solid wall).

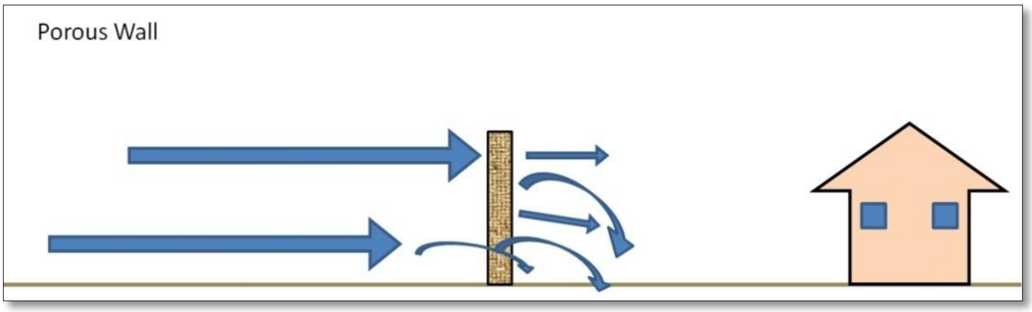


**Figure 42: Diagram indicating wind movements with a porous windbreak**

Stockpiles

Dust emissions from stockpiles can occur during the loading of the piles, when wind disturbs the stockpile surface and during reclamation (USEPA, 2006a). Smaller stockpiles can be covered using hessian sheets (Figure 43) or alternatively protected by a shade cloth windbreak (porous wall). Both of these techniques aim to reduce wind speed at the surface of the stockpile, in turn reducing the potential for dust scour and entrainment. An important characteristic about wind erosion is that each time a surface is disturbed, its erosion potential is restored (USEPA, 2006b).

In order to decrease the erosion potential of stockpiles at the proposed Yzermyn Underground Coal Mine, WSP suggest the following mitigation techniques:

- Permanent stockpiles be enclosed with concrete berms;
- Temporary stockpiles be enclosed by porous walls; and
- Small, temporary stockpiles can be covered with a porous sheet (preferably hessian).

**Figure 43: Soil stockpiles covered with hessian sheets**

<u>Exposed Areas</u>

Windbreaks in the form of shade cloth screens may be erected at exposed areas. The windbreaks aim to mitigate dust transportation by reducing the wind speed across the surface of the ground (higher wind speeds tend to scour the surface, leading to dust entrainment and subsequent transportation). Examples of such shade cloth windbreaks are illustrated in Figure 44.

**Figure 44: On-site windbreaks (left) and perimeter windbreaks (right)**

<u>Conveyor Belts</u>

Wind erosion of material on conveyor belts can cause large quantities of dust to become airborne, particularly if they are unenclosed. In order to decrease dust emissions from such a source, WSP recommend that all conveyors be enclosed. Should this not be possible for low lying / flat conveyors, it is suggested that these conveyors be fitted with side wind guards.

Carryback, the material that sticks to the belt instead of falling off at the head pulley, may also become airborne as the belt dries and passes over the return idlers. If a conveyor belt is not clean, dust can also be bumped from the belt as it passes over the idlers and pulleys, creating more potential for dust to become airborne and entrained in prevailing winds (Kissell, 2003). To prevent unnecessary airborne dust from the conveyors, it is recommended that the conveyor belts are cleaned on a regular basis through the use of belt scrapers or washers. Wetting of conveyor belts has also been found to greatly improve airborne dust concentrations around conveyors.

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**WSP Environmental (Pty) Ltd**
WSP House
Bryanston Place, 199 Bryanston Drive
Bryanston
2191
South Africa
Tel: +27 11 361 1372
Fax: +27 86  556 7189
www.wspenvironmental.co.za

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# Noise Impact Assessment

# ENVIRONMENTAL NOISE IMPACT ASSESSMENT

## Proposed Yzermyn Underground Coal Mine

2013/08/08

# Quality Management

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# Environmental Noise Impact Assessment

## Proposed Yzermyn Underground Coal Mine

2013/08/08

## Client

Atha Africa Ventures (Pty) Ltd
8th Floor
Sinosteel Plaza
159 Rivonia Road
Sandton
2144

## Consultant

Kirsten Collett
WSP House
Bryanston Place, 199 Bryanston Drive
Bryanston
2191
South Africa

Tel: +27 11 361 1372
Fax: +27 86 556 7189

www.wspenvironmental.co.za

## Registered Address

WSP Environmental (Pty) Ltd
1995/008790/07
WSP House, Bryanston Place, 199 Bryanston Drive, Bryanston, 2191, South Africa

## WSP Contacts

Kirsten Collett
Kirsten.Collett@WSPgroup.co.za
+27 11 361 1372

Bradley Keiser
Bradley.Keiser@WSPgroup.co.za
+27 11 361 1377

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# Glossary

| | |
|---|---|
| **Sound** | Sound is small fluctuations in air pressure (measured in N/m$^2$ or Pa) that are transmitted as vibrational energy via a medium (air) from the source to the receiver. The human ear is in essence a pressure transducer, which converts these small fluctuations in air pressure into electrical signals, which the brain then interprets as sound. |
| **Noise** | Noise is generally defined as unwanted sound. |
| **Sound or Noise level** | A sound or noise level is a sound measurement that is expressed in terms of dB or dBA. |
| **dB or dBA** | The human ear is a phenomenally sensitive instrument that can detect fluctuations in air pressure over an extremely wide range of amplitudes. This makes the handling of sound quantities in absolute terms, i.e. Pascal (Pa), very cumbersome. For this reason a sound measurement is expressed as ten times the logarithm of the ratio of the sound measurement to a reference value, 20 micro (millionth) Pa. This process converts a scale of constant increases to a scale of constant ratios and considerably simplifies the handling of sound measurement quantities. The attached ‘A’ indicates that the sound measurement has been A-weighted. |
| **A-weighting** | The human ear is not equally sensitive to sound of all frequencies, i.e. it is less sensitive to low pitched (or ‘bass’) than high pitched (or ‘treble’) sound. In order to compensate when making sound measurements, the measured value is passed through a filter that simulates the human hearing characteristic. Internationally this is an accepted procedure when working with measurements that relate to human responses to sound/noise. |
| **Ambient sound level** | According to the national Noise Regulations in terms of the Environment Conservation Act (South Africa, 1989), ambient sound level means the reading on an integrating impulse sound level meter taken at a measuring point in the absence of any alleged disturbing noise at the end of a total period of at least 10 minutes, after such a meter has been put into operation.<br><br>Brüell & Kjaer (2001) define ambient noise as “the noise from all sources combined − factory noise, traffic noise, birdsong, running water, etc.” while residual noise is referred to as the noise levels without the noise source of concern.<br><br>For the purposes of this study, ambient noise will be defined as the totally encompassing sound in a given situation at a given time, and is usually composed of sound from many sources, both near and far. |
| **Sound Pressure** | Sound pressure is the force of sound exerted on a surface area perpendicular to the direction of the sound and is measured in N/m$^2$ or Pa. The human ear perceives sound pressure as loudness and can also be expressed as the number of air pressure fluctuations that a noise source creates. |
| **Sound Pressure Level** | The sound pressure level is a relative quantity as it is a ratio between the actual sound pressure and a fixed reference pressure. The reference pressure is usually the threshold of hearing, namely 20 µPa. Sound pressure levels are expressed in dBA, as they are referenced to sound detected by the human ear (A-weighted). Sound pressure level is typically the component measured by a sound level meter. |
| **Sound Power** | Sound power is the rate of sound energy transferred from a noise source per unit of time (J/s or W). |
| **Sound Power Level** | The sound power level is a relative quantity as it relates the sound power of a source to the threshold of human hearing ($10^{-12}$ W). Sound power levels are expressed in dBA, as they are referenced to sound detected by the human ear (A-weighted). |

| | |
|---|---|
| **Noise nuisance** | Noise nuisance means any sound which disturbs or impairs or may disturb or impair the convenience or peace of any person. |
| **Nuisance** | A legal definition of a noise that offends or upsets the receiver because it is occurring at the wrong time in the wrong place or is of a character that annoys due to excessive tonal components or impulses. |
| **$L_{eq}$** | The equivalent sound pressure level. This is in essence a time-averaged sound measurement. Sound continuously fluctuates as a function of time. In order to effectively assess the effect of sound or noise on human beings it is very often necessary to obtain a measure of the average exposure to the sound or noise. |
| **$LA_{eq}$** | The equivalent A-weighted sound pressure level. This is internationally the most often used parameter to measure noise in relation to human responses. |
| **$LA_{max}$** | The maximum sound pressure level of a noise event, normally measured on an A-weighted decibel scale. |
| **$L_{R,dn}$** | The equivalent continuous day/night rating level. |
| **$L_{Req,d}$** | The equivalent continuous rating level for daytime. |
| **$L_{Req,n}$** | The equivalent continuous rating level for night-time. |
| **Octave Bands** | The Octave bands refer to the frequency groups that make a sound. The sound is divided in to 10 groups (Octave bands) ranging from 32 Hz to 8,000 Hz. The lower frequency ranges of a sound have a vibrating character were the higher frequency of sound has the character of high pitched sound. In viewing the total Octave bands scale from 32 Hz to 8 kHz the character of the sound can be described. |

# Executive Summary

Atha Africa Ventures (Pty) Ltd (Atha) plan to construct and operate an underground coal mine near Wakkerstroom in the Mpumalanga Province and require environmental authorisation to do so. As part of this authorisation, a specialist environmental noise impact assessment is required to quantify all noise sources at the mine during both construction and operational phase and determine how this noise will impact on the existing noise climate of the region. This report details the findings of the noise impact assessment.

The assessment comprised onsite environmental noise monitoring in order to obtain a baseline / existing noise climate for the region as well as acoustic modelling to determine the predicted impacts that the proposed mine will have on the existing noise climate. An inventory of all noise sources during the construction and operational phases was compiled with associated sound power levels for each source. These sources were then input into the Computer Aided Noise Abatement (CadnaA) acoustic model. Results were compared with the monitored (existing) noise levels as well as the SANS day and night-time guidelines to assess compliance.

From the onsite monitoring, it was identified that the region has a characteristic daytime noise level of 26.9 dBA and a night-time noise level of 25.7 dBA, which are both compliant with the SANS rural guidelines. The region is characterised as rural, with the dominant land use being natural bush and grazing land. Existing noise sources at the proposed site include insects, livestock, wind and the odd passing vehicle.

From the acoustic modelling, predicted daytime and night-time noise levels during the construction phase are elevated at receivers in close proximity to the construction activities, whilst receivers that are further away experience much lower noise levels. The highest noise levels are predicted at FH 04, a homestead that is in closest proximity to the mine. When the predicted noise levels are added (logarithmically) to the existing baseline daytime or night-time noise levels, cumulative noise levels at all receivers (except FH 04, FH 05 and FH 06) are compliant with the SANS day and night-time guidelines. Owing to the close proximity of these homesteads (FH 04, FH 05 and FH 06) to the main construction activities, such elevated noise levels would be expected. At night, noise levels at receivers in close proximity to construction activities decrease by an average of 3 dBA, whilst those receivers further away decrease by an average of 7.5 dBA. These decreases are a result of fewer construction hours at night; absence of grading and blasting activities at night and fewer vehicles frequenting the site at night.

During the construction phase the highest noise levels are associated with general construction activities, which include land clearing, earthworks, grading, bulldozing and unloading of material. Since blasting events at the boxcut/ high-wall are not continuous and will only occur once per day, impacts from this source are low. Noise levels emanating from the mine access road that runs from Dirkiesdorp to the mine are minimal as all construction vehicles will only use the access road twice during the construction phase (once on entry to the site and once on exit) and grader activity on the road will only occur twice a month. Noise from general traffic on the mine access road will slightly increase the noise levels experienced at FH 09 and the town of Dirkiesdorp, although these levels are still in compliance with the SANS guidelines.

Predicted noise levels at most receivers during the first three years of operation are higher than those noise levels predicted during the construction phase. The highest noise levels are predicted at FH 04. Cumulative noise levels at receivers are compliant with the respective SANS daytime guidelines except at FH 04, FH 05, FH06 and FH09. Night-time noise levels are identical to daytime levels as a result of 24 hour operations at the mine. Due to the stricter SANS night-time guideline, cumulative night-time noise levels exceed the guidelines at seven of the ten receivers. These non-compliant receivers are located in close proximity to the mine itself or along the access road from the town of Dirkiesdorp.

Predicted noise levels after the first three years of operation remain similar in the direct vicinity of the mine as no processes will have changed. With an increase in vehicular activity along the mine access road after three years, noise levels at the receivers adjacent to the road are predicted to increase substantially with noise levels exceeding the SANS daytime guideline at FH 09 and the SANS night-time guideline at FH 09, FH 10, FH 11, School and Dirkiesdorp.

During both operational phases dominant noise sources include conveyor belts; loading activities at the export and middlings stockpiles; the pollution control dam water pumps; and the dewatering pump located outside the adit. Noise associated with the mine access road from Dirkiesdorp impacts far more greatly on the adjacent receivers (FH 09, FH 10, FH 11, School and Dirkiesdorp) than noise during the construction phase. This is a

result of increased traffic flow on the roads. Such noise levels increase substantially after the first three years of operation as a result of increased traffic flow.

Based on this noise impact assessment, the proposed Yzermyn Underground Coal Mine can be considered for authorisation, however, due to the potential impacts during the operational phase of the project, it is recommended that the following mitigation techniques are implemented at the site:

- Installation of suitable mufflers on engine exhausts and compressor components;
- Selecting and installing equipment with lower sound power level specifications;
- Installation of silencers for fans;
- The enclosing of conveyors;
- Enclosing of continuous noise sources (i.e. pumps) within sound absorbing enclosures;
- Installation of acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m² in order to minimise the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective;
- Limiting the hours of operation of “noisy” equipment; and
- Regular maintenance of equipment to reduce the generation of additional unwanted noise.

# 1 Introduction

Atha Africa Ventures (Pty) Ltd (hereafter referred to as Atha), plan to construct and operate an underground coal mine near Wakkerstroom in the Mpumalanga Province. WSP Environmental (Pty) Ltd (WSP) has been appointed by Atha to undertake a comprehensive environmental and social impact assessment (ESIA) for the proposed Yzermyn Underground Coal Mine. The ESIA has been undertaken in two phases, namely the scoping phase and environmental and social impact assessment (ESIA) phase. As part of the ESIA phase, a specialist environmental noise impact assessment (NIA) is required to quantify all noise sources at the mine during both construction and operational phase and determine how this noise will impact on the existing noise climate of the region.

This report details the findings of the NIA conducted by WSP. Included in this report is background to the project; fundamentals and principles of environmental noise; an overview of the legal framework for environmental noise; discussions on the noise inventory development and identification of key noise sources at the mine; a meteorological overview, identification of sensitive receptors (noise receivers); and acoustic modelling outputs and results.

## 1.1 Scope of Work

Below is a summary of the scope of work performed by WSP in fulfilment of the requirements of the environmental noise specialist study:

- A baseline environmental noise characterisation through the evaluation of onsite monitoring performed at the site during 2012;
- Description of the receiving environment, specifically relating to sensitive receptors (noise receivers);
- Development of a comprehensive noise inventory detailing sound power levels of all proposed noise sources at the mine during both the construction and operational phases;
- Evaluation of the proposed noise climate during the construction and operational phase as well as the noise propagation potential using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software;
- An assessment of the impacts of the proposed mine on the surrounding communities; and
- Compilation of an environmental noise assessment report, inclusive of all information listed above.

## 1.2 Rational for the Study

As part of the environmental authorisation process for the proposed Yzermyn Underground Coal Mine, an NIA is required in order to identify the potential impacts that the mine may have on the existing noise climate of the region. Such an operation has the potential to produce significant noise levels from a variety of different sources which can impact on surrounding receivers (communities), so such a study is a requirement of the ESIA.

## 1.3 Environmental Noise Consultant

Kirsten Collett is an air quality and noise specialist with a Master of Science (Atmospheric Sciences) degree obtained from the University of the Witwatersrand. For four years she worked at the Climatology Research Group at the University of Witwatersrand and was involved in various projects with both local and international associations. She is currently employed by WSP and has worked on environmental noise impact assessments, monitoring and modelling for a variety clients over the past year. She has provided acoustic consulting support to various client industries including petrochemical, mining and production industries.

## 1.4 Declaration of Independence

I hereby declare that I am fully aware of my responsibilities in terms of the National Environmental Management Act 2006 EIA Regulations and that I have no financial or other interest in the undertaking of the proposed activity other than the imbursement of consultants fees.

Name: Kirsten Collett

Company: WSP Environmental (Pty) Ltd

Signature:

# 2 Project Background

## 2.1 Locality and Study Area

Atha has obtained the prospecting rights for an area of 8,360 ha in the Pixley ka Seme Local Municipality within the Mpumalanga Province, some 58 kilometres (km) southwest of Piet Retief in the Mpumalanga Province. A target area has been identified within the eastern section of the prospecting rights boundary where the proposed Yzermyn mine is to be located (Figure 1). The region has very undulating, hilly topography and the surrounding land use is predominantly natural bush, agricultural and wetlands, with scattered rural settlements.

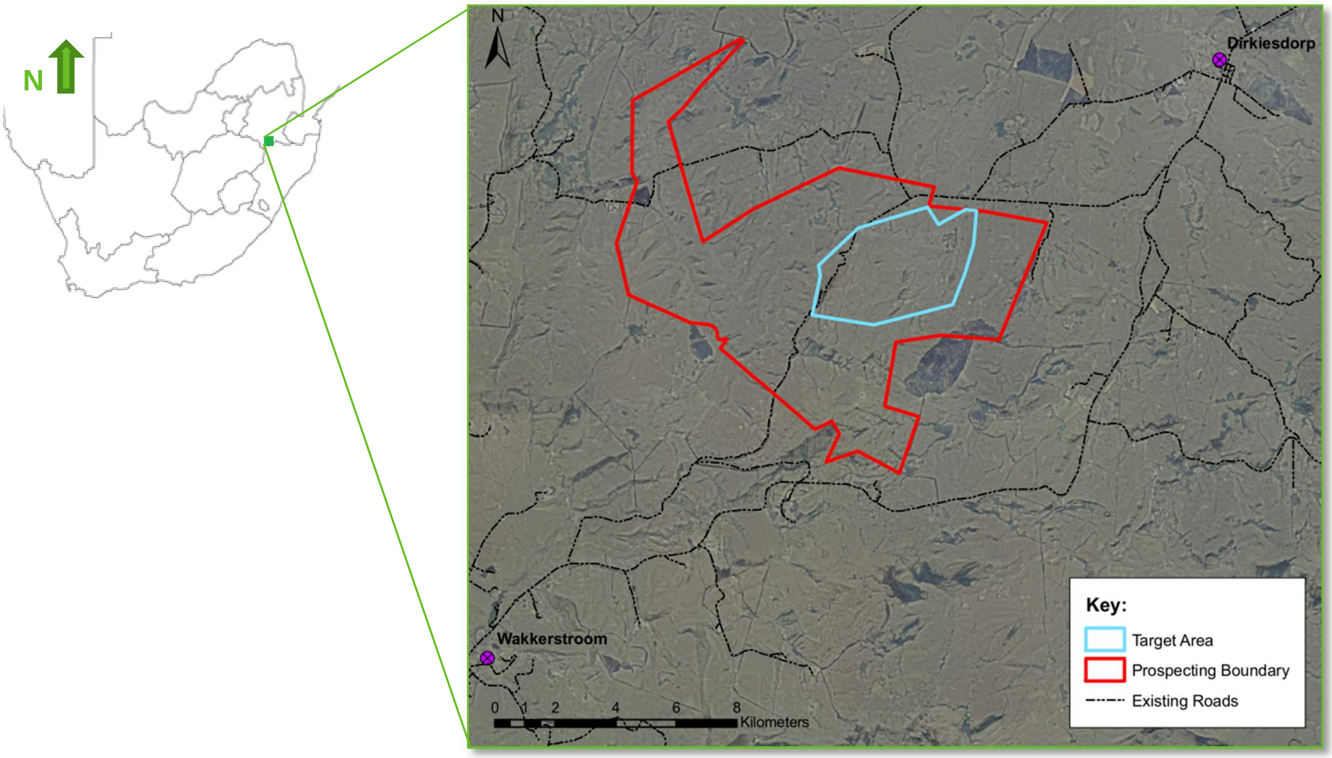


**Figure 1: Location of the proposed Yzermyn Underground Coal Mine in the Mpumalanga province**

## 2.2 Project Description

### 2.2.1 Construction Phase

A construction phase of six months is envisaged for the proposed Yzermyn Underground Coal Mine. Construction will include land clearing of the construction footprint; general construction activities (i.e. earthworks, brickworks infrastructure development etc. for the plant, buildings, dams, onsite roads and parking lots); drilling of the boxcut/ high-wall; blasting of the boxcut/ high-wall and declines to the Alfred and Dundas seams; bulldozing, truck unloading and grading activities at the boxcut platform; and grading of the mine access road from the town of Dirkiesdorp to the proposed Yzermyn Underground Coal Mine site.

### 2.2.2 Operational Phase

Either drill and blast or continuous miner methods will be utilised to extract approximately 200,000 tons of run of mine (ROM) coal per month at the proposed Yzermyn Underground Coal Mine. This ROM will be brought to the surface via conveyors transferring it to an open ROM stockpile ahead of the coal handling and preparation plant (CHPP). The ROM will be drawn from the bottom of the ROM stockpile via vibratory feeders and fed onto a vibratory screen where larger material will be crushed to a nominal size of 50 mm as the CHPP is not equipped to handle oversized material. The ROM will then enter the CHPP for further crushing, screening and treatment.

Discard material will be sent via conveyer to the discard bin where it will be loaded into trucks and deposited at the discard dump to the north of the proposed mine. It is estimated that 38,000 tons of discard will be sent to the dump per month where bulldozers and graders will be responsible for the levelling of the discard material. Approximately 110,000 tons of primary, export quality coal will be transferred via conveyor to the export stockpile, whilst 52,000 tons per month of secondary grade coal will be transferred to the middlings stockpile. Coal from both stockpiles will be loaded via front end loaders (FELs) to 30 ton haul trucks and transported to the Piet Retief Rail Siding for dispatch to export and local markets.

# 3 Noise Fundamentals

## 3.1 Principles

Sound may be defined as any pressure variation (in air, water or other medium) that the human ear can detect. Noise is defined as “unwanted sound”. Noise can lead to health impacts and can negatively affect the quality of life of people.

The annoyance due to a given noise source is subjective from person to person, and is also dependent upon many non-acoustic factors such as: the prominence of the source; its importance to the listener’s economy (wellbeing); and his or her personal opinion of the source.

Noise impact may be understood to mean one or a combination of negative physical, physiological or psychological responses experienced by individuals, whether consciously or unconsciously, caused by exposure to noise. The result of increased exposure to noise on individuals can have negative effects, both physiological (influence on communication, productivity and even impaired hearing) and psychological effects (stress, frustration and disturbed sleep).

Hearing impairment is typically defined as a decrease in the threshold of hearing. Severe hearing deficits may be accompanied by tinnitus (ringing in the ears). Noise-induced hearing impairment occurs predominantly in the higher frequency range of 3,000 to 6,000 Hz, with the largest effect at 4,000 Hz. With increasing $LA_{eq,8h}$ and increasing exposure time, noise-induced hearing impairment occurs even at frequencies as low as 2,000 Hz. However, hearing impairment is not expected to occur at $LA_{eq,8h}$ levels of 75 dBA or below, even for prolonged occupational noise exposure.

Annoyance is defined as the capacity of noise to induce annoyance depending upon its physical characteristics including the sound pressure level, spectral characteristics and variations of these properties with time. During daytime, few people are highly annoyed at $LA_{eq}$ levels below 55 dBA, and very few are moderately annoyed at $LA_{eq}$ levels below 50 dBA. Sound levels during the evening and night should be 5 to 10 dB lower than during the day (WHO, 1999).

Speech intelligibility is adversely affected by noise. Most of the acoustical energy of speech is in the frequency range of 100 to 6,000 Hz, with the most important cue-bearing energy being between 300 and 3,000 Hz. Speech interference is basically a masking process in which simultaneous interfering noise renders speech incapable of being understood. Environmental noise may also mask other acoustical signals that are important for daily life such as doorbells, telephone signals, alarm clocks, music, fire alarms and other warning signals.

Sleep disturbance is a major effect of environmental noise. It may cause primary effects during sleep and secondary effects that can be assessed the day after night-time noise exposure. Uninterrupted sleep is a prerequisite for good physiological and mental functioning and the primary effects of sleep disturbance are: (a) difficulty in falling asleep; and (b) awakenings and alterations of sleep stages or depth. The difference between the sound levels of a noise event and background sound levels, rather than the absolute noise level, may determine the reaction probability.

**Table 1: Typical noise levels**

| Sound Pressure Level (SPL – dBA) | Typical Source | Subjective Evaluation |
|---|---|---|
| **130** | Threshold of pain | Intolerable |
| **120**<br>**110** | Heavy rock concert<br>Grinding on steel | Extremely noisy |
| **100**<br>**90** | Loud car horn at 3m<br>Construction site with pneumatic hammering | Very noisy |
| **80**<br>**70** | Kerbside of busy street<br>Loud radio or television | Loud |
| **60**<br>**50** | Department store<br>General office | Moderate to quiet |
| **40**<br>**30** | Inside private office<br>Inside bedroom | Quiet to very quiet |
| **20** | Unoccupied recording studio | Almost silent |

## 3.2 Noise Propagation

Sound is a pressure wave that decreases over distance from the source. Noise attenuation is typically described as a set reduction in decibel level per doubling of distance from the source. Depending on the nature of the noise source, sound propagates at different rates. The two most common categories of noise are point sources and line sources.

The most important factors affecting noise propagation are:

- The type of source (point or line);
- Distance from source;
- Atmospheric absorption;
- Wind;
- Temperature and temperature gradient;
- Obstacles such as barriers and buildings;
- Ground absorption;
- Reflections;
- Humidity; and
- Precipitation.

Research has shown that a doubling in distance from a noise source results in a proportional decline in noise level. Sound propagation in air can be compared to ripples on a pond. The ripples spread out uniformly in all directions, decreasing in amplitude as they move further from the source.

For sound in air, when the distance doubles, the amplitude drops by approximately 6 dBA. Thus, if you are at a position one meter from the source and move one meter further away from the source, the sound pressure level will drop by 6 dBA, moving to 4 meters, the drop will be a further 6 dBA, and so on. This methodology is only applicable when there are no reflecting or blocking objects in the sound path. Such ideal conditions are termed free-field conditions.

With an obstacle in the sound path, part of the sound will be reflected, part absorbed and the remainder will be transmitted through the object. How much sound is reflected, absorbed or transmitted depends on the properties of the object, its size and the wavelength of the sound.

Noise mitigation can also result from the topography or shielding from trees or structures. When locations are not in the line of sight of the noise source, there is generally a 10+ dBA attenuation for broadband noise, with a further 10 dBA attenuation on the inside of an average residence, when the windows are open. The influences of vegetation, topography and atmospheric conditions as noise reduction factors can vary greatly and are often impossible to quantify.

When ground cover or normal unpacked earth (i.e. a soft site) exists between the source and receptor, the ground becomes absorptive to sound energy. Absorptive ground results in an additional noise reduction of 1.5 dBA per doubling of distance. Added to the standard reduction rate for soft site conditions, point source noise attenuates at a rate of 7.5 dBA per doubling of distance.

A hard site exists where sound travels away from the source over a generally flat, hard surface such as water, concrete, or hard-packed soil. These are examples of reflective ground, where the ground does not provide any attenuation. The standard attenuation rate for hard site conditions is 6 dBA per doubling of distance for point sources.

A break in the line of sight between the noise source and the receptor can result in a 5 dBA reduction. Dense vegetation can reduce noise levels by 5 dBA for every 30 m of vegetation, up to a maximum reduction of 10 dBA.

## 3.3 Characteristics of Noise (Frequency Character)

The human ear simultaneously receives sound (normal un-weighted sound or Z-weighting dBZ) at many frequencies (octave bands) at different amplitudes. The ear then shifts the sensibility based on the amplitude of the sound. This focuses the sound and makes it audible by adjusting the amplitude of the low, mid and high frequencies.

In order to analyse or measure how a person experiences sound, an electronic weighting adjusted to the Z-weighted sound was developed. With this research, there were three different weighting curves developed, namely A-weighting, B-weighting and C-weighting:

A-weighting – This measurement is often noted as dBA and this weighting curve attempts to make the dosimeter/noise level meter respond closely to the characteristics of a human ear. It attenuates the frequencies at low frequencies. Various national standards relate to measurements recorded in the A-weighting of sound pressure levels.

B-weighting – is similar to A-weighting but with less attenuation. The B-weighting is very seldom, if ever, used. The B-weighting follows the C-weighted trend.

C-weighting – is intended to represent how the ear perceives sound at high decibel levels. C-weighted measurements are often reported as dBC

Z-weighting – historically sound levels were read off a hand held meter and the noise levels were noted in dB (decibel), after the development of different weighting curves sound levels were noted as Z-weighting or dBZ to reduce the confusion with different type of weighting applied noise levels.

The weighting is employed by arithmetically adding a table of values (Table 2), listed by octave bands, to the measured sound pressure levels in dBZ for each specific octave band. The resulting octave band measurements are usually added (logarithmic method) to provide a single weighted value describing the sound, based on the applied weighting curve. Thus, if the A-weighted curve was applied to the sound, the noise level is noted as dBA.

**Table 2: Frequency weighting table for the different weighting curves**

| Frequency (Hz) | 32 Hz | 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1k Hz | 2k Hz | 4k Hz | 8k Hz |
|---|---|---|---|---|---|---|---|---|---|
| **A-weighting** | -39.4 | -26.2 | -16.1 | -8.6 | -3.2 | 0 | 1.2 | 1 | 1.1 |
| **B-weighting** | -17.1 | -9.3 | -4.2 | -1.3 | -0.3 | 0 | -0.1 | -0.7 | -2.9 |
| **C-weighting** | -3 | -0.8 | -0.2 | 0 | 0 | 0 | -0.2 | -0.8 | -3 |
| **Z-weighting** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |


**Figure 2: Different weighting curves**

# 4 Environmental Noise Standards and Guidelines

## 4.1 South African Noise Control Regulations

In South Africa, environmental noise control has been in place for three decades, beginning in the 1980s with codes of practice issued by the then South African Bureau of Standards (SABS) to address noise pollution in various sectors of the country. Under the previous generation of environmental legislation, specifically the Environmental Conservation Act (No. 108 of 1989) (ECA), provisions were made to control noise in different districts from a national level. In later years, the ECA was replaced by the up-to-date NEMA, from where the new National Environmental Management: Air Quality Act (No. 39 of 2004) (NEMAQA) originated. In the NEMAQA the noise control provisions are mentioned in Section 34.

> *"(1) The minister may prescribe essential national standards –*
>
> > *(a) for the control of noise, either in general or by specific machinery or activities or in specified places or areas; or*
> >
> > *(b) for determining –*
> >
> > > *(i) a definition of noise; and*
> > >
> > > *(ii) the maximum levels of noise.*
>
> *(2) When controlling noise the provincial and local spheres of government are bound by any prescribed national standards."*

From the ECA to the new NEMAQA the noise control regulations were updated and accepted by all the provinces. The noise control regulations give all the responsibilities of enforcement to the local provincial authority, where location specific by-laws can be created and applied to the locations with approval of the provincial government.

In the NEMAQA the act states that the minister should prescribe the maximum allowable noise levels for different districts and publish national noise standards, these goals have not been accomplished as yet and all monitoring and assessments are done in accordance with the South African National Standards (SANS) 10103 and SANS 10328.

## 4.2 South African Bureau of Standards (SABS/SANS)

The SANS 10328:2008 "Methods for environmental noise impact assessments" is in accordance with the current National Environmental Management Act (No. 107 of 1998) (NEMA) and prescribes the steps to follow in the process of conducting an Environmental Noise Impact Assessment. An ESIA is being conducted as part of the Yzermyn project and thus Section 8 should be followed "Environmental noise impact investigation and assessment", and the key points listed in Section 8.7 should be addressed in the report:

> *h) an explanation, either by a brief description or by brief reference, of all measuring and calculation procedures that were followed, as well as any possible adjustments to existing measuring methods that had to be made, together with the results of the calculations;*
>
> *i) an explanation, either by a brief description or by brief reference, of all measuring or calculation methods (or both) that were used to determine existing and predicting rating levels, as well as other relevant information, including a statement of how the data were obtained and applied to determine the rating level of the area in question;*

In terms of this noise assessment, the baseline (monitored) and predicted (modelled) noise levels are compared to the guidelines as stipulated in the SANS 10103:2008 - Typical Rating Levels for Noise in Districts, as presented in Table 3 below. These values should be viewed as guidelines of typical noise levels that are likely to be experienced in the various land use zones. Noise levels within the direct vicinity of the mine are assessed against the guideline for industrial districts, whilst the noise levels for the surrounding areas scattered with farm houses are assessed against the rural guideline. Noise levels in the town of Dirkiesdorp are assessed against the SANS suburban guideline.

**Table 3: Typical rating levels for noise in districts (adapted from SANS 10103:2008)**

| Type of District | Classification | Equivalent Continuous Rating level for Noise ($L_{Req,T}$) (dBA) | | |
|---|---|---|---|---|
| | | Outdoors | | |
| | | Day – Night ($L_{R,dn}$) | Day-time ($L_{req,d}$) | Night-time ($L_{req,n}$) |
| a) Rural | A | **45** | **45** | **35** |
| b) Suburban (with little road traffic) | B | **50** | **50** | **40** |
| c) Urban | C | 55 | 55 | 45 |
| d) Urban (with one or more of the following: workshops, business premises and main roads) | D | 60 | 60 | 50 |
| e) Central Business Districts | E | 65 | 65 | 55 |
| f) Industrial District | F | **70** | **70** | **60** |
| Those guidelines highlighted in red and bold are the guidelines applicable to this noise assessment | | | | |

**Table 4: Categories of community/group response (Adapted from SANS 10103:2008)**

| Excess ($\Delta L_{Req,T}$)[a] dBA | Estimated Community/Group response | |
|---|---|---|
| | Category | Description |
| 0 – 10<br>5 – 15<br>10 – 20<br>>15 | Little<br>Medium<br>Strong<br>Very Strong | Sporadic Complaints<br>Widespread Complaints<br>Threats of community/group action<br>Vigorous community/group action |

NOTE: Overlapping ranges for the excess values are given because a spread in the community reaction might be anticipated.
[a] $\Delta L_{Req,T}$ should be calculated from the appropriate of the following:
1) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS $L_{Req,T}$ of the residual noise (determined in the absence of the specific noise under investigation);
2) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the maximum rating level of the ambient noise given in Table 1 of the code;
3) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the typical rating level for the applicable district as determined from Table 2 of the code; or
4) $L_{Req,T}$ = Expected increase in $L_{Req,T}$ of ambient noise in the area because of the proposed development under investigation.

## 4.3 International Finance Corporation Guidelines

From the International Finance Corporation (IFC) Environmental, Health and Safety Guidelines, the impacts of noise beyond the property boundary of a facility are addressed in section 1.7 (IFC, 2007). The noise guidelines stipulated by the IFC are grouped into two categories, namely “Residential; institutional; educational” and “Industrial; commercial” (Table 5). Noise impacts should not exceed these levels or result in a maximum increase in background noise levels of 3 dBA at the nearest off site receptor location.

**Table 5: IFC Environmental Noise Level Guidelines**

| Receptor | One hour $LA_{eq}$ (dBA) | |
|---|---|---|
| | Daytime (07:00 – 22:00) | Night-time (22:00 – 07:00) |
| **Residential; institutional; educational** | 55 | 45 |
| **Industrial; commercial** | 70 | 70 |

The guideline also states that highly intrusive noise, such as noise from aircraft flyovers and passing trains should not be included when establishing background noise levels.

## 4.4 WHO Guidelines for Community Noise

The World Health Organisation (WHO) together with the Organisation for Economic Co-operation and Development (OECD) are the main international bodies that have collected data and developed assessments on the effects of exposure to environmental noise. This has provided the following summary of thresholds for noise nuisance in terms of outdoor daytime $LA_{eq}$ in residential districts:

- At 55 - 60 dBA noise creates annoyance.
- At 60 - 65 dBA annoyance increases considerably.
- Above 65 dBA constrained behaviour patterns, symptomatic of serious damage caused by noise

The World Health Organisation recommends a maximum outdoor daytime $LA_{eq}$ of 55 dBA in residential areas and schools in order to prevent significant interference with normal activities. It further recommends a maximum night-time $LA_{eq}$ of 45 dBA outside dwellings. No distinction is made as to whether the noise originates from road traffic, from industry, or any other noise source.

The WHO also lists that the guideline for industrial noise is set to 70 dBA over a period of 24 hours. This would cause hearing impairment, where the peak noise level of 110 dBA is allowable on a fast response measurement.

# 5 Study Methodology

In order to assess the environmental noise impacts of the proposed Yzermyn Underground Coal Mine both baseline (monitored) and proposed (modelled) noise levels were assessed. Comparisons of the existing and proposed noise levels at various specified sensitive receptors (noise receivers) enabled an assessment of changes in noise levels at these locations as a result of the construction and operation of the proposed project.

## 5.1 Environmental Noise Field Monitoring

Ambient sound level measurements were undertaken during the 28th and 29th May 2012 at eight locations within the proposed target area of the proposed Yzermyn Underground Coal Mine (Figure 3). All sound level measurement procedures were undertaken according to the relevant South African Code of Practice SANS 10103:2008 and IFC specifications. This included the selection of monitoring locations, microphone positioning and equipment specifications among others. Sound level measurements were taken with a SABS-calibrated Type 1 Integrating Sound Level Meter. The day- and night-time measurements were taken for 15 minutes, which allows for monitoring to be adequately representative of the reference period, as detailed in SANS 10103:2008. The monitoring was conducted during the relevant time-frame for day (06:00 to 22:00) and night (22:00 to 06:00).

The noise parameters recorded were:

- $LA_{eq}$ The equivalent continuous sound pressure level, normally measured (A-weighted);
- $LA_{max}$ The maximum sound pressure level of a noise event measured (A-weighted);
- $LZ_{peak}$ The peak noise level experienced during the measurement (Z-weighted); and
- $LA_{90}$ The average noise level the receptor is exposed to for 90% of the monitoring period.

The make and model as well as serial number and calibration validity of the sound level meter and calibrator are presented in Table 6.

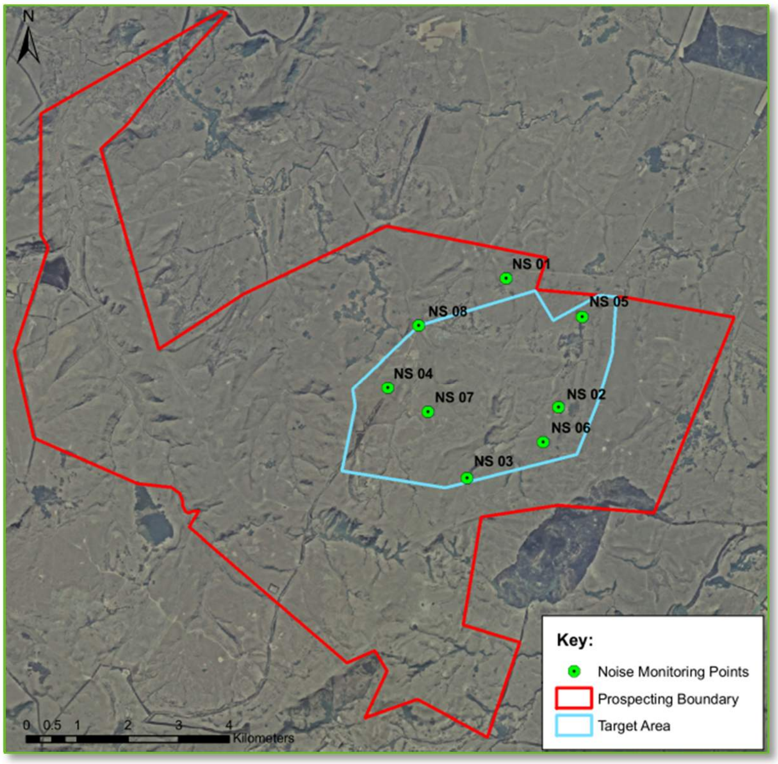


**Figure 3: Location of noise monitoring points within the proposed Yzermyn Underground Coal Mine Target Area**

**Table 6: Sound level meter and calibrator specifications**

| Sound Level Meter | | Calibrator | |
|---|---|---|---|
| Make & Model:<br>Serial No.:<br>Calibration valid until: | **CEL Instruments – CEL480**<br>**043303, 5184**<br>**August 2013** | Make & Model:<br>Serial No.:<br>Calibration valid until: | **CEL Instruments – CEL-284/2**<br>**4/03326337**<br>**August 2013** |

## 5.2 Noise Inventory

A detailed inventory of all noise sources during the construction and operational phases was compiled based on sound level data from the Noise Navigator™ sound level database (Berger *et al*., 2010) together with any relevant literature (OSHA, 2011; BHP Billiton, 2010; B.E.S. Inc, 2009; Flowserve, 2008; BHP Billiton, 2008). The sound level database provides sound (pressure) levels (SPL) of over 1,700 occupational and non-occupational noise sources.

The SPLs for each source were then converted into sound power levels (PWL), utilising equation 1, which were used as input for the acoustic model. Equation 1 calculates PWLs based on the hemispherical propagation of sound under free field conditions (i.e. it is assumed that the noise source is located in the vicinity of hard, reflecting surfaces). The r value represents the distance from the source that the SPL was recorded. A distance of 1 m was utilised for all proposed sources, unless otherwise stated in the Noise Navigator™ database.

$$PWL = SPL - 10\,log\frac{2}{4\pi r^2} \qquad (1)$$

Full descriptions of the noise sources and relevant sound power levels of each source during both construction and operational phases are presented below.

### 5.2.1 Construction Phase

The noise sources identified during the construction phase of the proposed Yzermyn Underground Coal mine are presented in Table 7, together with the location, height and sound power levels that were utilised in the acoustic model.

**Table 7: Construction phase noise sources and noise levels used in the acoustic model for the proposed Yzermyn Underground Coal Mine**

| Source | Location | Activity | Number in Operation | Sound Power Level (dBA) | Source Height above ground level (m) |
|---|---|---|---|---|---|
| **General Construction** | General construction footprint | All construction activities (including land clearing, earthworks, building etc.) | 1 | 127.524 | 1.5 |
| **Grading** | Boxcut platform | Levelling | 1 | 102.982 | 1.5 |
| **Grading** | Road | Clearing | 1 (twice a month) | 102.982 | 1.5 |
| **Drilling** | Boxcut highwall | Drill material | 155.6 holes / month | 100.982 | 2 |
| **Blasting** | Boxcut highwall | Blast material | 4 / month | 127.982 | 0 |
| **Blasting** | Decline 1 | Blast material | 1 / day | 127.982 | 0 |
| **Blasting** | Decline 2 | Blast material | 1 / day | 127.982 | 0 |
| **Bulldozing** | Boxcut highwall | Loading material | 1 | 109.982 | 1.5 |
| **Bulldozing** | Boxcut platform | Unloading and compacting material | 1 | 109.982 | 1.5 |
| **Trucks** | Boxcut platform | Unloading material | 2 | 120.064 | 1.5 |
| **Traffic** | Mine access road from Dirkiesdorp | Trucks and light duty vehicles (LDVs) on roads | 18 construction vehicles once off + 20 LDVs a day | Calculated in CadnaA model | |
| **Generators** | See figure 4 | Providing 10MVA power supply | 5 | 99.961 | 1.5 |

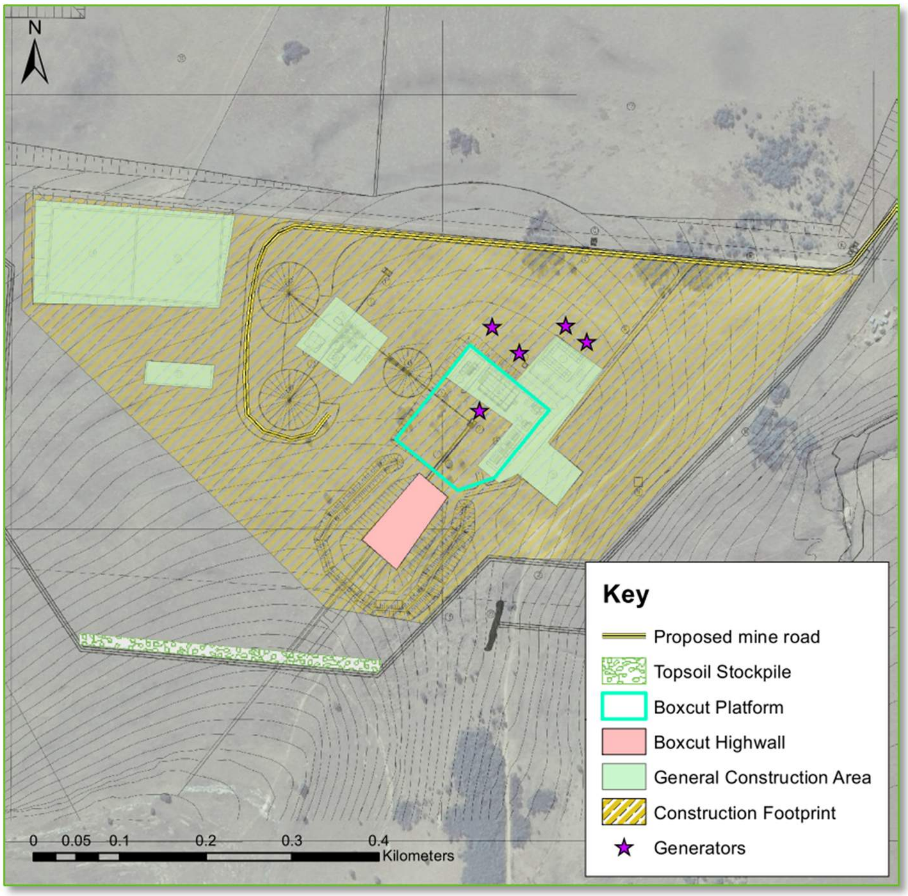


**Figure 4: Location of noise sources during the construction phase of the proposed Yzermyn Underground Coal Mine**

### 5.2.2 Operational Phase

Table 8 presents the noise sources identified during the first three years of the operational phase of the proposed Yzermyn Underground Coal Mine, together with the associated sound power levels, locations and heights utilised in the model.

**Table 8: Operational phase noise sources and noise levels used in the acoustic model for the proposed Yzermyn Underground Coal Mine**

| Source | Location | Activity | Number in Operation | Sound Power Level (dBA) | Source Height above ground level (m) |
|---|---|---|---|---|---|
| **Ventilation Shaft** | Upcast Shaft | Fans venting air | 1 | 114.982 | 3 |
| **Conveyors** | To ROM stockpile, to plant, to middlings stockpile, to export stockpile, to discard dump | Transferring ROM and product | 5 | 100.982 | 1 |
| **Vibratory feeders** | ROM stockpile | Draw coal from ROM stockpile | 2 | 86.504 | 0 |
| **Crusher** | Coal handling and preparation plant (CHPP) | Crushing and screening | 1 | 103.982 | 3 |
| **Conveyors** | De-sliming (inside CHPP) | Transferring material | 2 | 100.982 | 1 |
| **Pump** | De-sliming (inside CHPP) | Pump slurry | 1 | 89.982 | 1 |
| **Pumps** | Spiral Plant (inside CHPP) | Pump slurry | 3 | 89.982 | 1 |
| **Dewatering cyclones** | Spiral Plant (inside CHPP) | | 3 | 103.982 | 1 |
| **Screenbowl centrifuges** | Spiral Plant (inside CHPP) | | 2 | 72.982 | 1 |
| **Pumps** | Ultra-fines (CHPP) | Underflow and process water | 2 | 89.982 | 1 |
| **Pumps** | DMS Cyclone plant (CHPP) | Cyclone feed pumps, heavy media pumps, spillage pump | 5 | 89.982 | 1 |
| **DMS Cyclones** | DMS Cyclone plant (CHPP) | | 2 | 103.982 | 1 |
| **Centifuges** | DMS Cyclone plant (CHPP) | | 2 | 72.982 | 1 |
| **Generators** | See figure 5 | Providing 10MVA | 5 | 99.961 | 1.5 |
| **Pumps** | Pollution Control Dams | | 7 | 128.002 | 1.5 |
| **Pump** | Water treatment plant | | 1 | 89.982 | 1 |
| **Pump** | See figure 5 | Dewatering pump | 1 | 89.982 | 1 |
| **Pump** | Bulk magnetite pump and sump | | 1 | 89.982 | 1 |
| **Pump** | Sewerage Plant | | 1 | 89.982 | 1 |
| **FEL** | Export and Middlings stockpile | Loading | 4 | 109.982 | 1.5 |
| **FEL** | Discard dump | Levelling | 2 | 109.982 | 1.5 |
| **Trucks** | Export and Middlings stockpile | Loading | 139 / day | 116.982 | 3 |
| **Trucks** | Discard dump | Unloading | 5 | 107.982 | 3 |
| **Grading** | Discard dump | Levelling | 2 | 105.982 | 1.5 |

| Source | Location | Activity | Number in Operation | Sound Power Level (dBA) | Source Height above ground level (m) |
|---|---|---|---|---|---|
| **Grading** | Roads | Clearing / levelling | 2 | 105.982 | 1.5 |
| **Trucks** | Unpaved roads | Travelling | 139 / day | Calculated in CadnaA model | |
| **Road traffic** | Unpaved roads | Travelling | Mean Daily Traffic Density (MDTD): 45 per day | | |

After three years of operation, it is envisaged that the mine will be operating at full capacity and the mine access road will be paved. Noise sources identified at this time are identical to those presented in Table 8 above, however, no grading of roads will occur and the number of vehicles in operation will increase, as presented in Table 9.

**Table 9: Vehicle statistics at the proposed Yzermyn Underground Coal Mine after three years of operation**

| Source | Location | Activity | Number in Operation | Sound Power Level (dBA) | Source Height above ground level (m) |
|---|---|---|---|---|---|
| **Trucks** | Paved roads | Travelling | 240 / day | Calculated in CadnaA model | |
| **Road traffic** | Paved roads | Travelling | Mean Daily Traffic Density (MDTD): 59 per day | | |

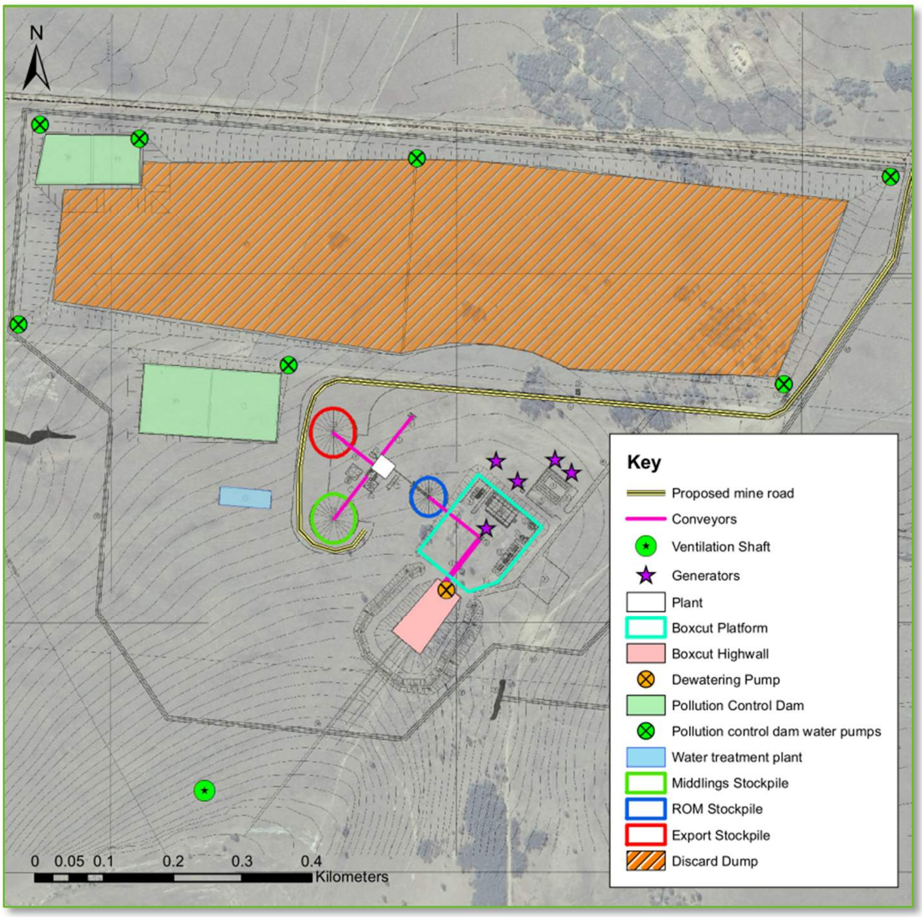


**Figure 5: Location of noise sources during the operational phase of the proposed Yzermyn Underground Coal Mine**

No underground noise sources have been included in this assessment as this is an environmental noise assessment and such noise sources would be included in an occupational noise assessment. In addition, with the 107 m depth of the proposed mine together with the logarithmic nature of noise, any noise from underground sources is assumed to be minimal.

## 5.3 CADNA Noise Modelling Software

Acoustic modelling was used to calculate the noise levels within a specified grid area as well as the noise level at specific modelling receivers. The acoustic modelling software used in this study is the internationally recognised package CadnaA. The CadnaA software provides an integrated environment for noise predictions under varying scenarios and calculates the cumulative effects of various sources. The model uses ground elevations in the calculation of the noise levels in a grid and uses meteorological parameters that have an effect on the propagation of noise. CadnaA has been utilised in many countries across the globe for the modelling of environmental noise and town planning. It is comprehensive software for 3-dimensional calculations, presentation, assessment and prediction of environmental noise emitted from industrial plants, parking lots, roads, railway schemes or entire towns and urbanized areas.

### 5.3.1 Meteorological Input

Meteorology is an important aspect of environmental noise assessments, as prevailing conditions determine how noise propagates from a source. Wind speed and direction determine how far and to where noise will travel from its source. Phenomena like temperature inversions cause sound energy to curve downwards and increase sound levels experienced at ground level below the inversion layer while normal mid-day type of temperature lapse conditions on clear, sunny days create a shadow zone around noise sources, usually below the noise source resulting in the majority of sound energy being directed in a more upward angle.

Due to the irregular topography of the area surrounding the proposed Yzermyn mine, meteorological conditions at the site are localised and may differ greatly over a short distance. The closest available South African Weather Services (SAWS) meteorological station is located ~50 km from the site and would therefore not be representative of conditions at the site. Instead, Unified Model (UM) data generated for 27.2371 °S and 30.2953° E was obtained from the SAWS and utilised in this assessment.

The UM is a numerical weather prediction and climate modelling software suite developed in the UK and is utilised in various weather forecasting agencies around the world. It models across a broad range of timescales and spatial scales (convective scale to climate system earth modelling). The atmospheric prediction component makes use of a set of equations that describe the time evolution of the atmosphere. Input data is obtained from observations from satellites, automatic weather stations, ground measurements, radar, weather balloons, wind profilers, aircraft and previous model runs (Dando, 2004).

The CadnaA model allows for the assignment of wind vector values, $C_0$. These values were determined from the wind direction statistics from the SAWS data. Together with this, the model allows for a humidity input value (50%, 70% or 90%) and temperature input value (0°C, 10°C or 20°C). Average humidity and temperature values from the SAWS data were 71.3% and 14°C respectively, so values of 70% and 10°C were utilised in the model.

### 5.3.2 Terrain

The proposed Yzermyn mine is located in an area of complex terrain with steeply undulating hills and valleys (Figure 6). Such terrain impacts on the propagation of noise from a source, with hills acting as obstacles around which noise is refracted, reflected or absorbed. For this reason, site specific terrain needs to be incorporated into the CadnaA model. ArcGIS-generated 5 m contour lines where imported into the model to account for the undulating terrain.

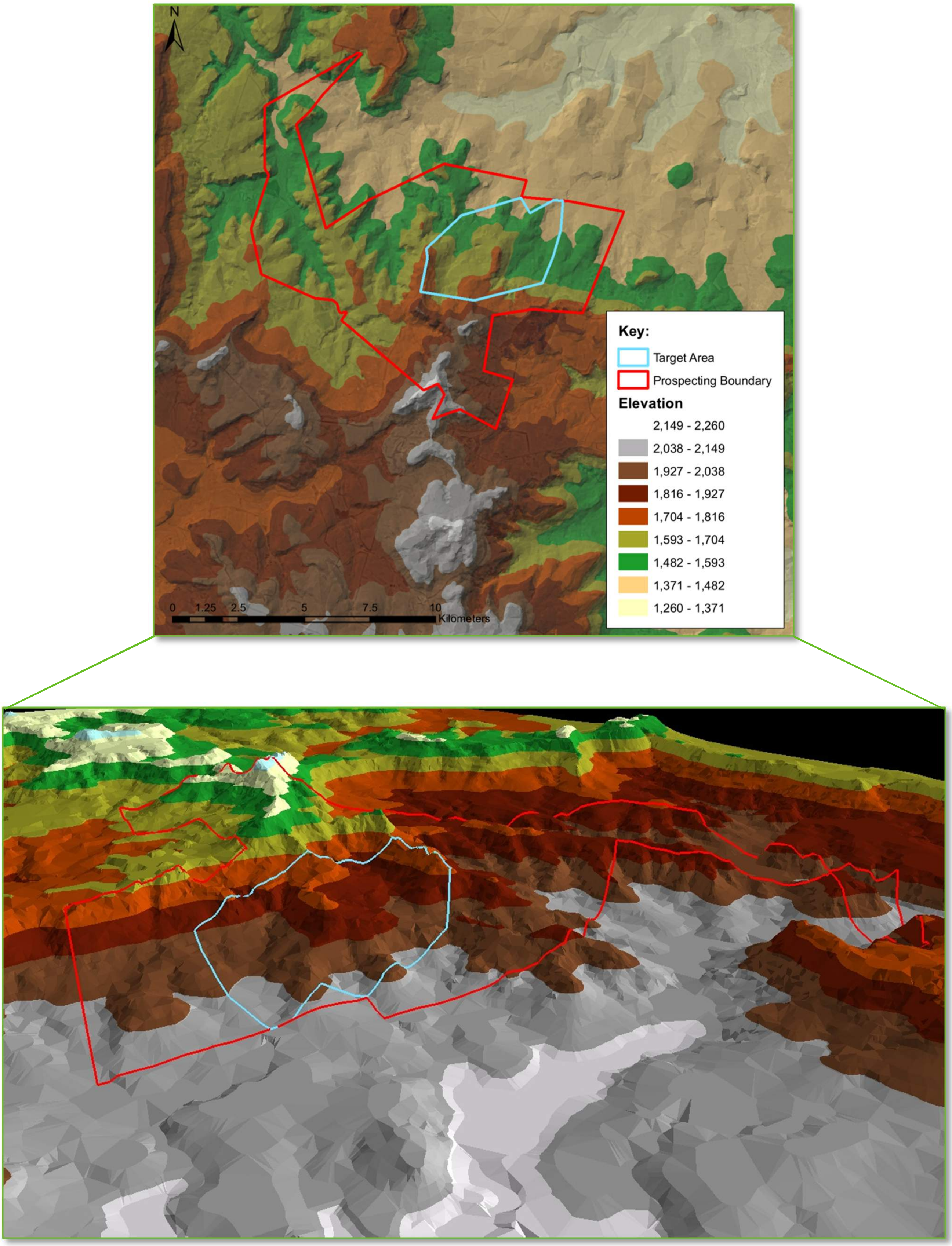


**Figure 6: Complex terrain surrounding the proposed Yzermyn Underground Coal Mine site**

### 5.3.3 Modelling Scenarios

In order to assess changes in the noise levels in the region with the construction and operation of the proposed Yzermyn Underground Coal Mine, three scenarios were modelled, namely construction phase; operational phase during the first three years; and operational phase after three years. Since it is envisaged that the mine will only be operating at full capacity after three years, two operational phase scenarios where modelled to account for the increase in vehicles and the upgrade to a paved road after the first three years of operation.

## 5.4 Noise Receivers

In order to assess the impact of the construction and operation of the proposed Yzermyn Underground Coal Mine on the existing noise climate in the region, several noise receivers in the area surrounding the proposed project location were identified, where baseline and modelled noise levels could be compared. The locations of these receivers are presented in Table 10 and Figure 7.

**Table 10: Noise receivers surrounding the proposed Yzermyn Underground Coal Mine**

| Receiver | Description | Direction mine offices | Distance from mine offices (km) | Classification |
|---|---|---|---|---|
| **FH 01** | Farm House | WSW | 3.5 | Rural |
| **FH 02** | Farm House | SW | 3.6 | Rural |
| **FH 03** | Farm House | S | 2.5 | Rural |
| **FH 04** | Farm House | E | 0.35 | Rural |
| **FH 05** | Farm House | NNE | 0.68 | Rural |
| **FH 06** | Farm House | NE | 1.1 | Rural |
| **FH 07** | Farm House | NW | 2.3 | Rural |
| **FH 08** | Farm House | SE | 3.1 | Rural |
| **FH 09** | Farm House | NE | 4.3 | Rural |
| **FH 10** | Farm House | NE | 5.4 | Rural |
| **FH 11** | Farm House | NE | 7.8 | Rural |
| **School** | School | NE | 8.5 | Rural |
| **Dirkiesdorp** | Town | NE | 9.5 | Suburban |

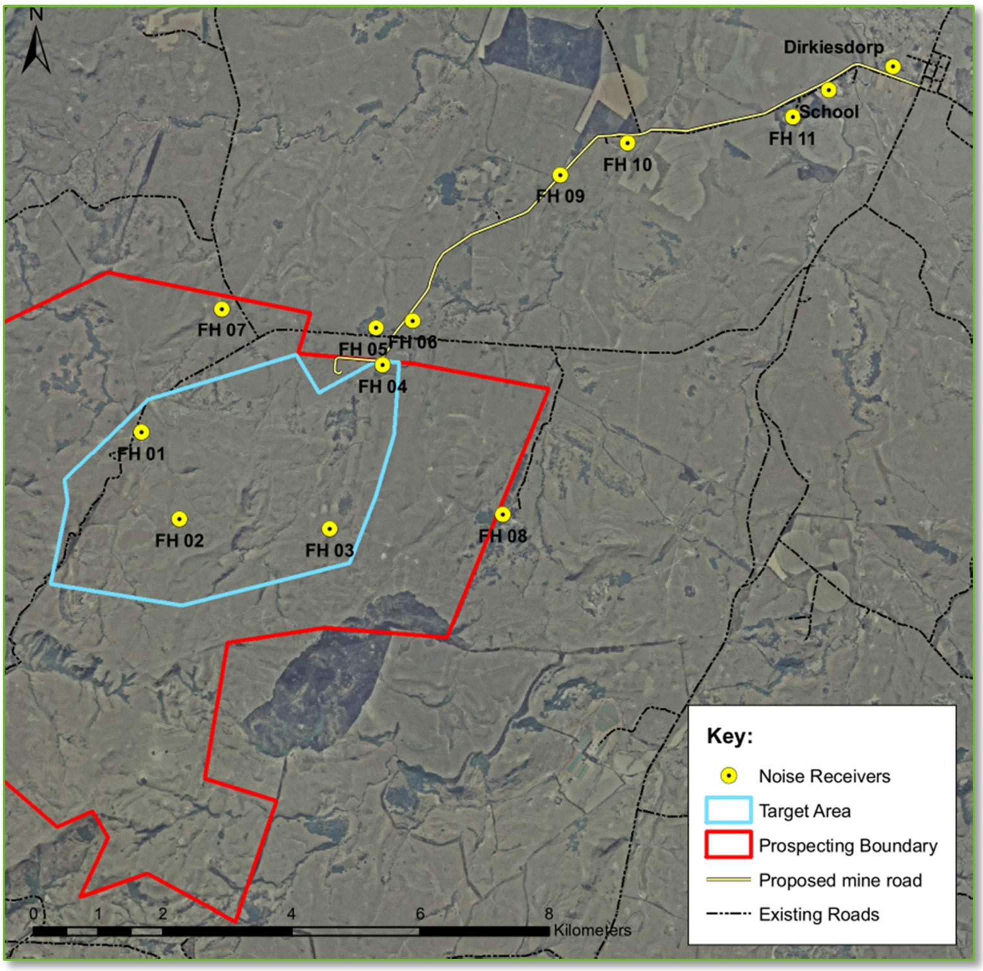


**Figure 7: Map indicating the location of the noise receivers surrounding the proposed Yzermyn Underground Coal Mine**

# 6 Meteorological Overview

## 6.1 Local Wind Field

Wind roses were generated using the Lakes Environmental Wind Rose Plot Software using the UM data described in Section 5.3.1 (of this report). Wind roses are useful for illustrating the prevailing meteorological conditions of an area, indicating wind speeds and directional frequency distributions. In the following wind rose, the colour of the bar indicates the wind speed while the length of the bar represents the frequency of winds *blowing from* a certain direction (as a percentage).

In the area of the proposed mine, winds are predominantly from the west (18% of the time) and east (16% of the time). Wind speeds are strongest from the west with wind speeds ranging from 0.1 m/s to greater than 6 m/s.

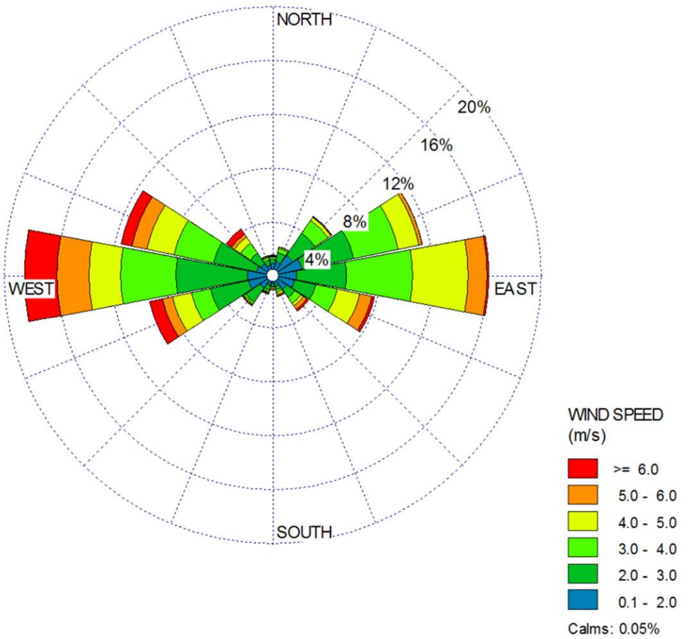


**Figure 8: Wind rose plot for the project area for the 2011 period**

Seasonal variations in winds at the proposed Yzermyn Underground Coal Mine site are depicted in Figure 9. During summer (December to February), winds predominantly originate from an easterly direction. This dominant easterly flow is a result of easterly waves that impact South Africa during summer, bringing rainfall to the eastern parts of the country. During autumn (March to May) and winter (June to August), there is a definite shift in wind direction. Winds still originate from the east, although a much stronger westerly component is introduced. Winds of over 6 m/s are experienced from the west. This westerly wind direction during winter is a result of westerly waves, in the form of cold fronts that move over the country during this time. During spring (September to November), both westerly and easterly wind components are experienced, with the strongest winds (reaching speeds over 6 m/s) originating from the west.

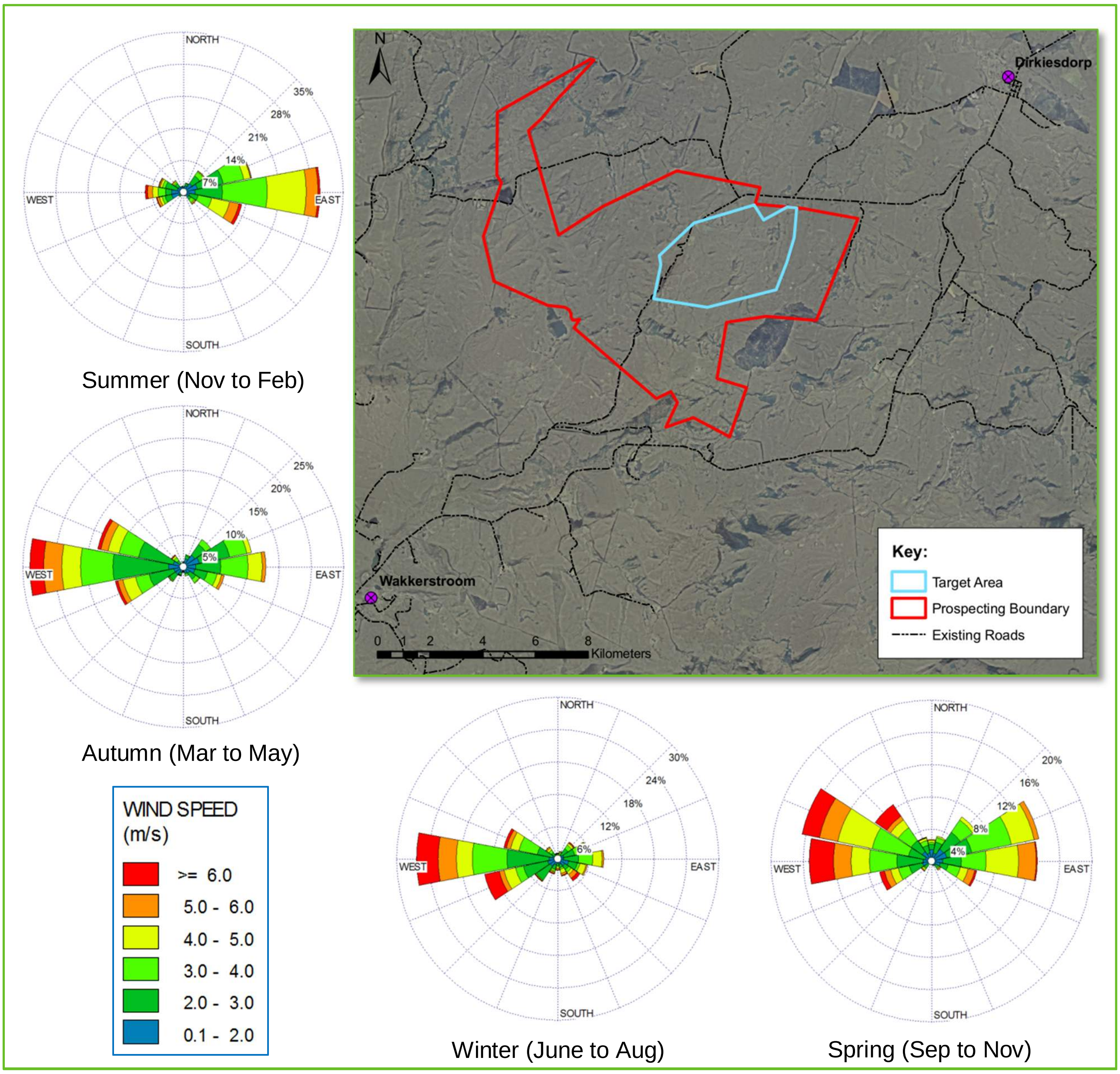


**Figure 9: Seasonal wind rose plots for the proposed Yzermyn Underground Coal Mine area**

Diurnal variations in wind at the Yzermyn site are depicted in Figure 10. From 00:00 to 06:00 westerly flow dominates, followed by smaller west-north-westerly and east-north-easterly components. Winds are calm to moderate, with wind speeds reaching levels greater than 6 m/s from the west and west-south-west. Similar wind directions are experienced after sunrise (06:00 to 12:00) but with clear increases in average wind speeds. After midday (12:00 to 18:00) easterly and westerly winds predominate, with further strengthening of the westerly component. In the evening (18:00 to 24:00) the westerly wind component diminishes and winds are predominantly easterly.

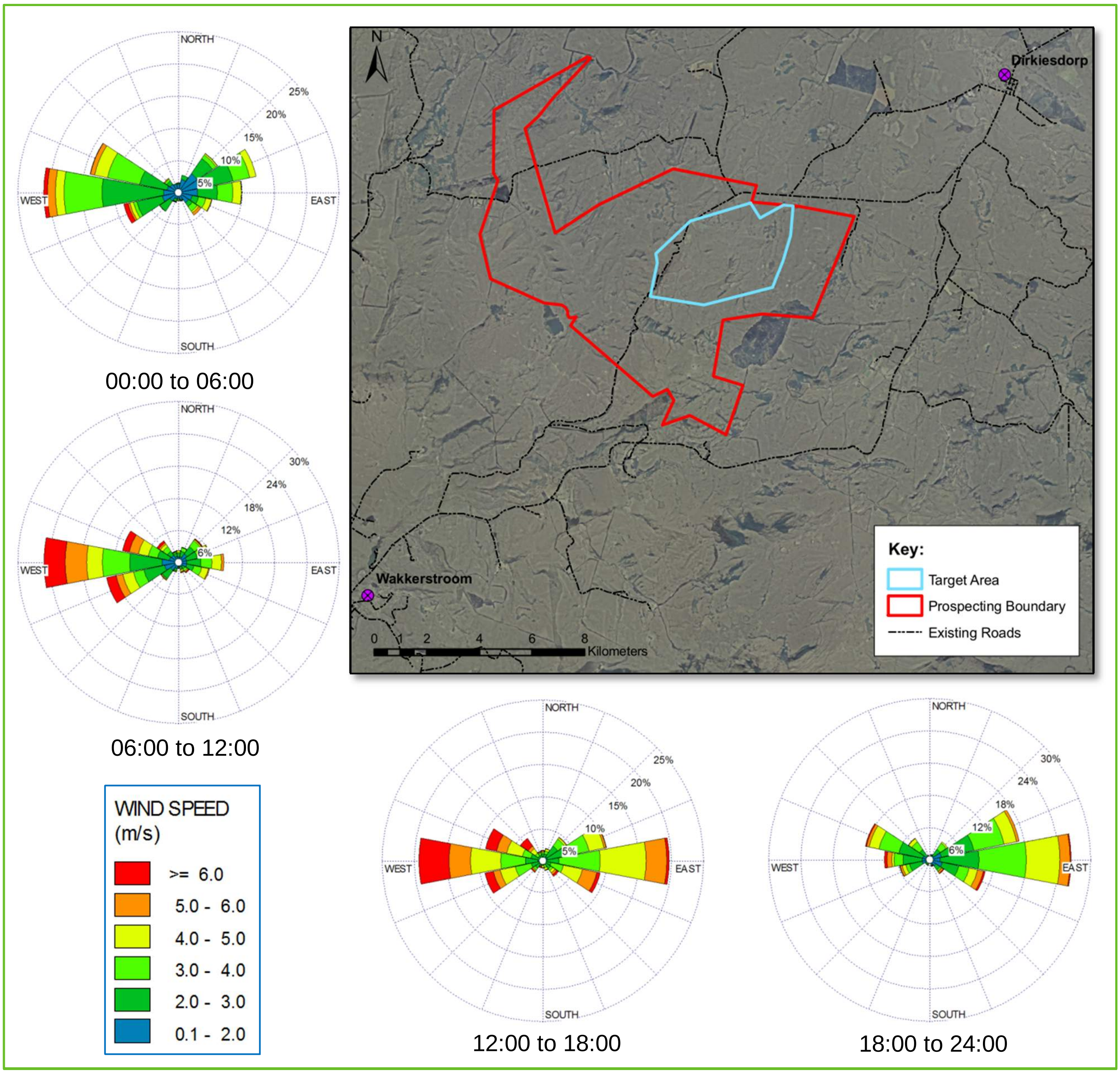


**Figure 10: Diurnal wind rose plots for the proposed Yzermyn Underground Coal Mine area for 2011**

## 6.2 Temperature

Figure 11 represents the average, minimum and maximum temperatures for the area, calculated from the hourly average UM temperatures for the area. Maximum average monthly temperatures occur during October and November (33.2°C and 33.59°C respectively) while minimum average monthly temperatures are experienced during July and August (-4.81°C and -4.61°C respectively). Average temperatures range quite considerably between the summer and winter months, with an average summer temperature of about 18°C and an average winter temperature of about 5°C.

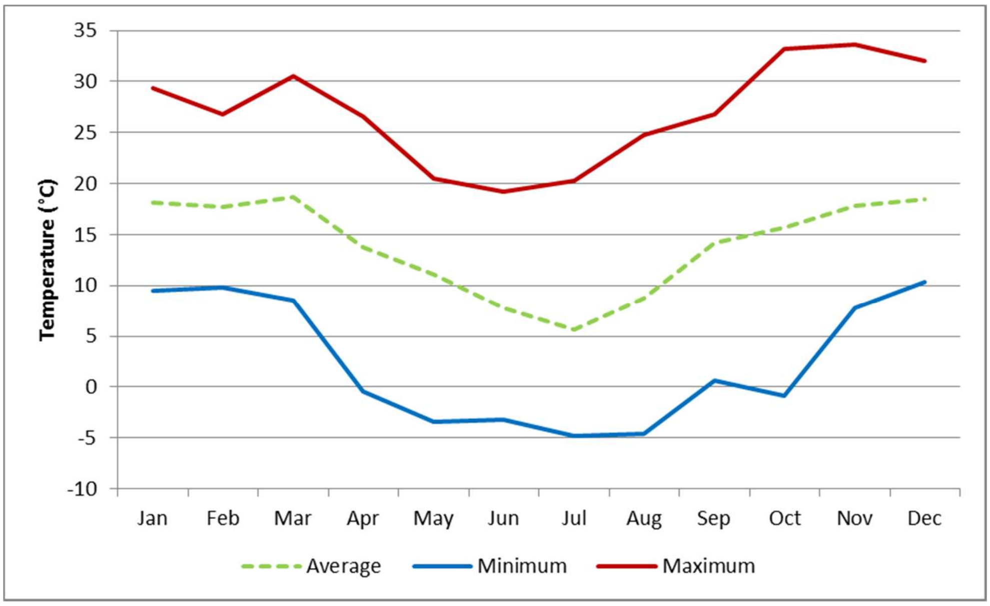


Figure 11: Average, maximum and minimum temperatures for the proposed Yzermyn Underground Coal Mine area

## 6.3 Rainfall

Monthly rainfall figures for the Yzermyn area are plotted in Figure 12, together with the monthly average humidity. Relative humidity in the region is generally high, with values ranging from ~60% during winter to ~80% during summer. The highest monthly average rainfall is experienced during late spring and early summer (October, November and December).

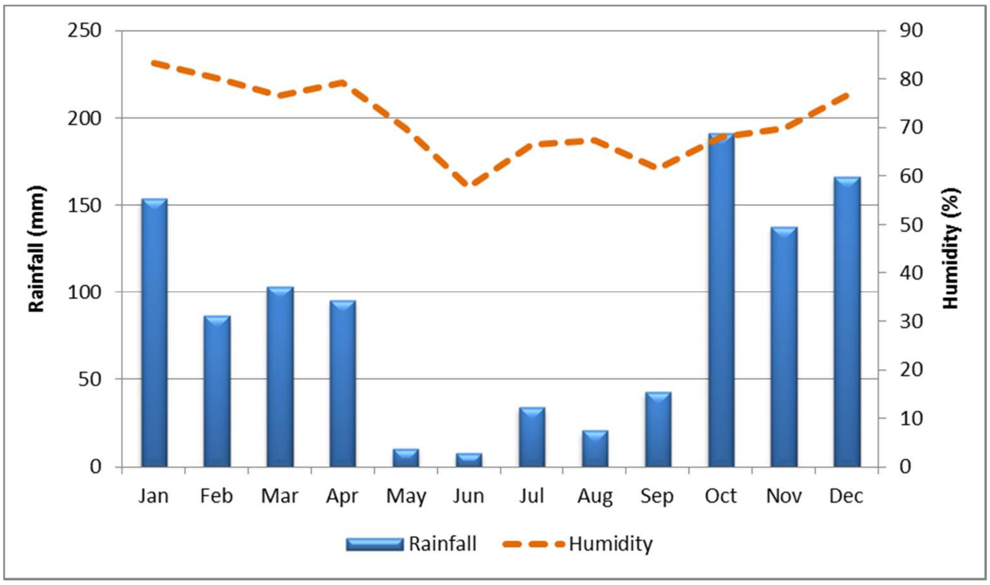


Figure 12: Total monthly rainfall and average humidity for the proposed Yzermyn Underground Coal Mine area

# 7 Results and Discussion

## 7.1 Existing / Baseline Conditions

### 7.1.1 Daytime Noise Monitoring

The results from the daytime noise monitoring performed at the proposed Yzermyn Underground Coal Mine on the 28th and 29th May 2012 are presented in Table 11 and Figure 13. Noise levels at all locations are assessed against the SANS typical rating level for noise in *rural* areas (45 dBA).

The daytime noise levels ranged from 26.9 dBA to 50.8 dBA with the highest noise levels being recorded at NS 04 and NS 08. Noise levels exceeded the SANS rural guideline at four of the eight monitoring locations. During the monitoring period moderate winds were evident throughout the day, resulting in wind interference noise with the microphone causing elevated noise levels at many of the monitoring locations. The proposed project site is located in a rural area with no anthropogenic noise sources, hence such elevated noise levels are not a realistic representation of the daytime noise levels in the region as the measurements are skewed as a result of wind noise. The noise levels at NS 01, NS 02, NS 05 and NS 06 are therefore more representative of the region, being less impacted on by wind interference.

**Table 11: Daytime 15-minute sound levels for the proposed Yzermyn Underground Coal Mine area**

| Site ID | LAeq (dBA) | LAmax (dBA) | LAmin (dBA) | LA90 (dBA) | LZpk (dBA) |
|---|---|---|---|---|---|
| **NS 01** | 28.30 | 39.90 | 24.30 | 32.30 | 86.00 |
| **NS 02** | 30.50 | 40.70 | 25.10 | 33.60 | 93.70 |
| **NS 03** | 46.50 | 72.10 | 24.50 | 59.70 | 86.00 |
| **NS 04** | 50.80 | 72.90 | 21.80 | 63.60 | 86.00 |
| **NS 05** | 26.90 | 45.30 | 24.20 | 32.50 | 80.70 |
| **NS 06** | 38.30 | 61.90 | 30.30 | 45.20 | 93.50 |
| **NS 07** | 49.20 | 73.80 | 23.90 | 62.10 | 86.00 |
| **NS 08** | 50.00 | 72.80 | 23.90 | 62.20 | 86.00 |

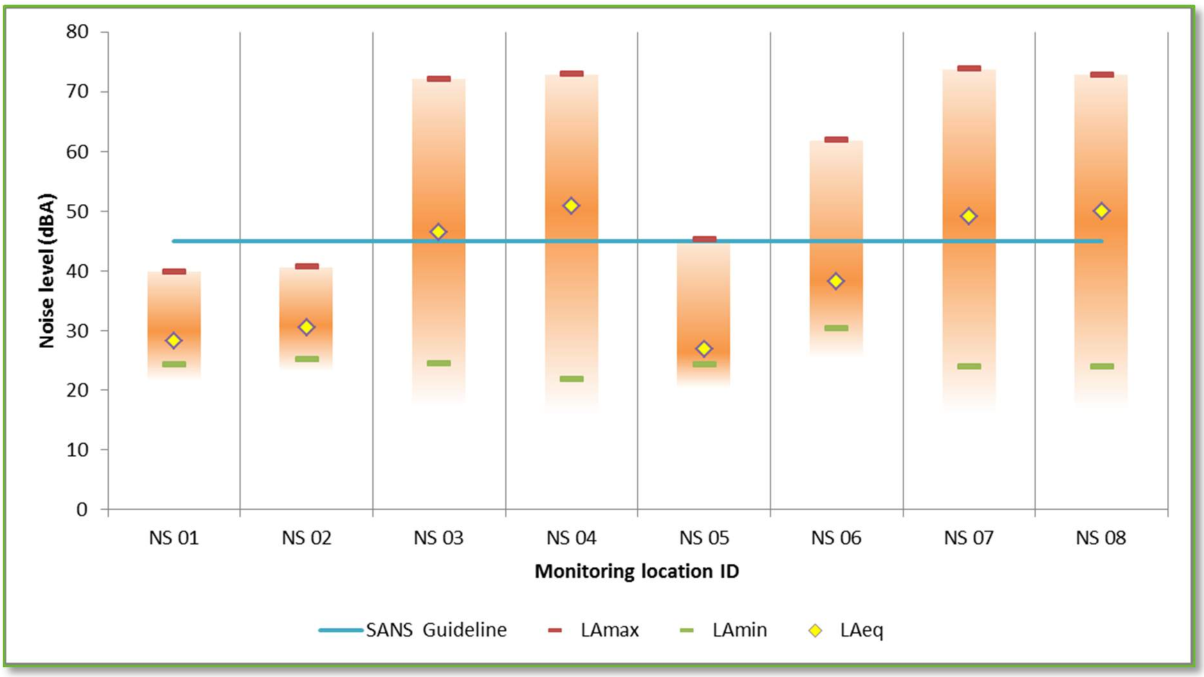


**Figure 13: Daytime noise monitoring results. $LA_{eq}$ is compared with the SANS 10103 guideline.**

### 7.1.2 Night-time Noise Monitoring

The results from the night-time noise monitoring performed on 28th May 2012 are presented in Table 12 and Figure 14. Due to safety issues, as a result of the rugged terrain and poor visibility at night, access to NS 02, NS 03 and NS 06 was not possible and hence no measurements at these locations were undertaken. Night-time noise levels at all remaining locations were low, with recorded levels well below the SANS rural night-time guideline (35 dBA). The only discernible noise source at night was from insects in the region, so such noise levels can be viewed as an accurate representation of the existing night-time noise climate of the region.

**Table 12: Night-time 15-minute sound levels for the proposed Yzermyn Underground Coal Mine area**

| Site ID | LAeq (dBA) | LAmax (dBA) | LAmin (dBA) | LA90 (dBA) | LZpk (dBA) |
|---|---|---|---|---|---|
| **NS 01** | 26.8 | 36.7 | 24.2 | 31.1 | 74.0 |
| **NS 02** | - | - | - | - | - |
| **NS 03** | - | - | - | - | - |
| **NS 04** | 26.3 | 38.7 | 24.8 | 30.5 | 73.7 |
| **NS 05** | 25.0 | 29.0 | 24.3 | 25.9 | 60.3 |
| **NS 06** | - | - | - | - | - |
| **NS 07** | 25.4 | 43.4 | 24.0 | 30.7 | 73.1 |
| **NS 08** | 24.8 | 34.9 | 23.6 | 25.2 | 58.0 |

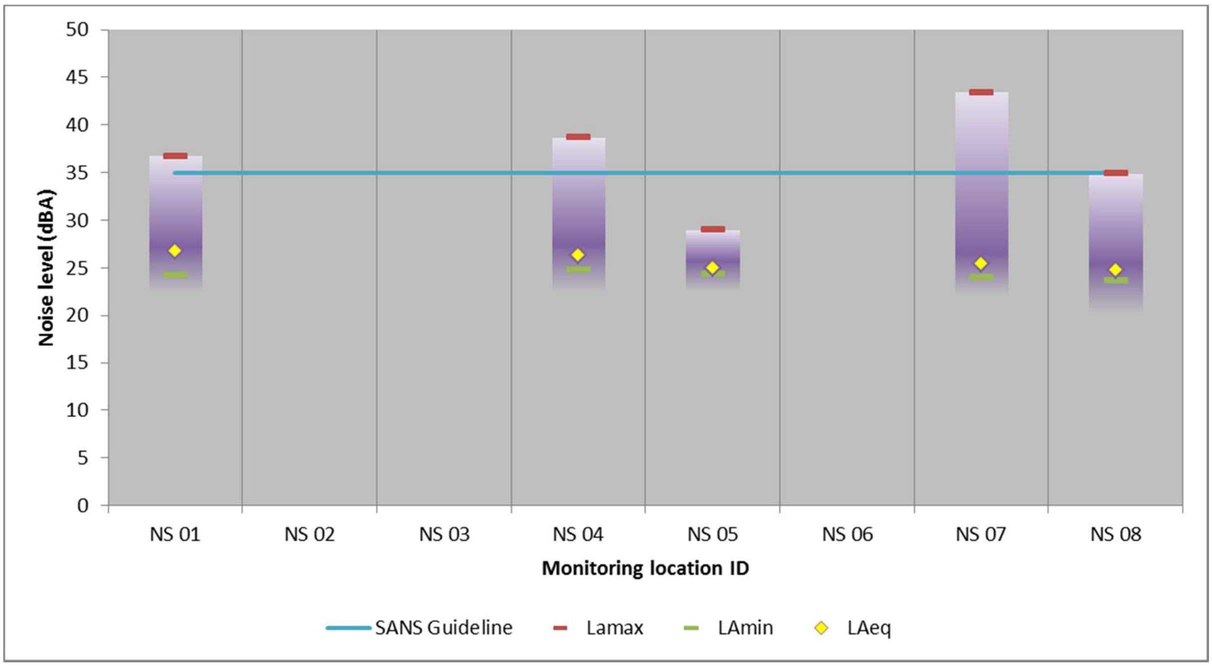


**Figure 14: Night-time noise monitoring results. $LA_{eq}$ is compared with the SANS 10103 guideline.**

Since the proposed Yzermyn Underground Coal Mine site is located in an area with little to no human activities, the baseline noise levels during both day and night should be similar, with noise sources including insects, livestock, wind and the odd passing vehicle. Based on this, the most representative daytime measurement is at NS 05 (26.9 dBA) and therefore this value was applied as an existing daytime baseline noise level value at all receivers. A night-time noise level of 25.7 dBA, the calculated average for all night-time measurements, was applied to all receivers as the baseline / existing noise level value. From these existing levels, it was then possible to determine the changes in noise levels at each receiver during both day and night as a result of the construction and operational activities of the proposed Yzermyn Underground Coal Mine. These results are discussed in the section that follows.

## 7.2 Predicted Noise Climate

Predicted noise level results from the CadnaA acoustic model for the proposed Yzermyn underground coal mine during construction phase; operational phase during the first three years; and operational phase after three years are presented here. Since construction activities will not be continuous, with construction occurring for 20 hours a day, the daytime and night-time noise levels will differ. For this reason, daytime and night-time scenarios were modelled. During the operational phase, modelled results during night-time conditions and daytime conditions are similar, as the mine will be operating on a continuous basis (24/7). For this reason, only one output plot for each operational phase is presented which is representative of both day and night-time noise levels.

It must be noted that the outputs presented here are for the proposed operations only and are not cumulative (i.e. taking the existing background noise levels into account). For each receiver point, the current sound levels (monitored) are evaluated against the predicted sound levels (modelled) for each point to assess the change in sound levels as a result of the proposed Yzermyn Underground Coal Mine. Cumulative sound levels (current and predicted together) are also presented for each receiver, however, it must be noted that since sound levels are represented in logarithmic units, simple addition cannot be applied to obtain the cumulative sound levels, but rather logarithmic addition.

### 7.2.1 Construction Phase

Table 13 presents the predicted daytime sound levels at each of the specified receiver points during the construction phase of the Yzermyn mine, assessed against the baseline daytime sound levels as well as the SANS rural and suburban guidelines to evaluate compliance.

Predicted daytime noise levels at receivers in close proximity to the mine are slightly elevated, whilst receivers that are further away experience much lower noise levels. The highest daytime noise level (57 dBA) is predicted at FH 04, which is in closest proximity to the proposed mining operations. When the predicted noise levels are added (logarithmically) to the existing baseline daytime noise levels, cumulative noise levels at all receivers (except FH 04, FH 05 and FH 06) are compliant with the rural SANS guideline and the suburban guideline (Dirkiesdorp). Owing to the close proximity of these farm houses (FH 04, FH 05 and FH 06) to the main construction activities, such elevated noise levels would be expected.

Graphical outputs of the modelled results of the daytime construction phase activities are presented in Figure 15 and Figure 16. Highest noise levels are predicted around the areas of general construction where land clearing, earthworks, grading, bulldozing and unloading of material will occur. Since blasting events at the boxcut/ high-wall are not continuous and will only occur once per day, impacts from this source are low. As all construction vehicles will only use the access road twice during the construction phase (once on entry to the site and once on exit) and grader activity on the road will only occur twice a month, noise levels emanating from the road are minimal and will not negatively impact on surrounding receivers. Noise from general traffic (light duty vehicles (LDVs) and delivery trucks) on the mine access road will slightly increase the noise levels experienced at FH 09 and Dirkiesdorp, although these levels are still in compliance with the SANS daytime guidelines.

**Table 13: Daytime predicted and background sound levels at receivers during the construction phase of the proposed Yzermyn Underground Coal Mine**

| Receiver | ID | Predicted Sound Level (dBA) | Background Daytime Sound Level (dBA) | Cumulative Sound Level (dBA) | Daytime Guideline (dBA) | Compliant |
|---|---|---|---|---|---|---|
| **Farm House 01** | FH 01 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 02** | FH 02 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 03** | FH 03 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 04** | FH 04 | 57.0 | 26.9 | 57.0 | 45 | No |
| **Farm House 05** | FH 05 | 52.5 | 26.9 | 52.5 | 45 | No |
| **Farm House 06** | FH 06 | 47.6 | 26.9 | 47.6 | 45 | No |
| **Farm House 07** | FH 07 | 23.7 | 26.9 | 28.6 | 45 | Yes |
| **Farm House 08** | FH 08 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 09** | FH 09 | 40.5 | 26.9 | 40.7 | 45 | Yes |
| **Farm House 10** | FH 10 | 26.3 | 26.9 | 29.6 | 45 | Yes |
| **Farm House 11** | FH 11 | 21.5 | 26.9 | 28.0 | 45 | Yes |
| **School** | School | 26.2 | 26.9 | 29.6 | 45 | Yes |
| **Dirkiesdorp** | Dirkiesdorp | 30.6 | 26.9 | 32.1 | 50 | Yes |

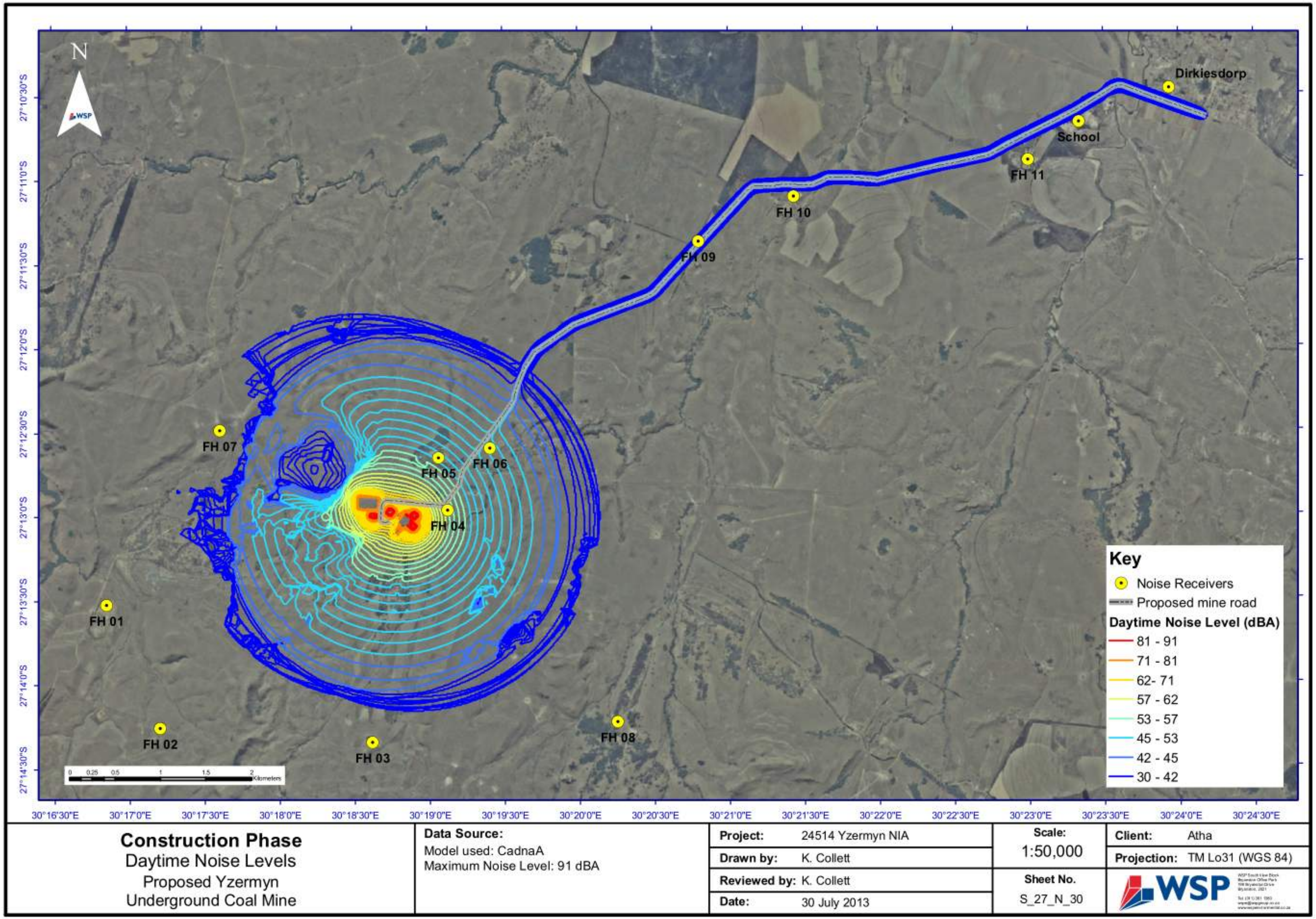


**Figure 15: Predicted daytime noise levels at the proposed Yzermyn Underground Coal Mine during the construction phase**

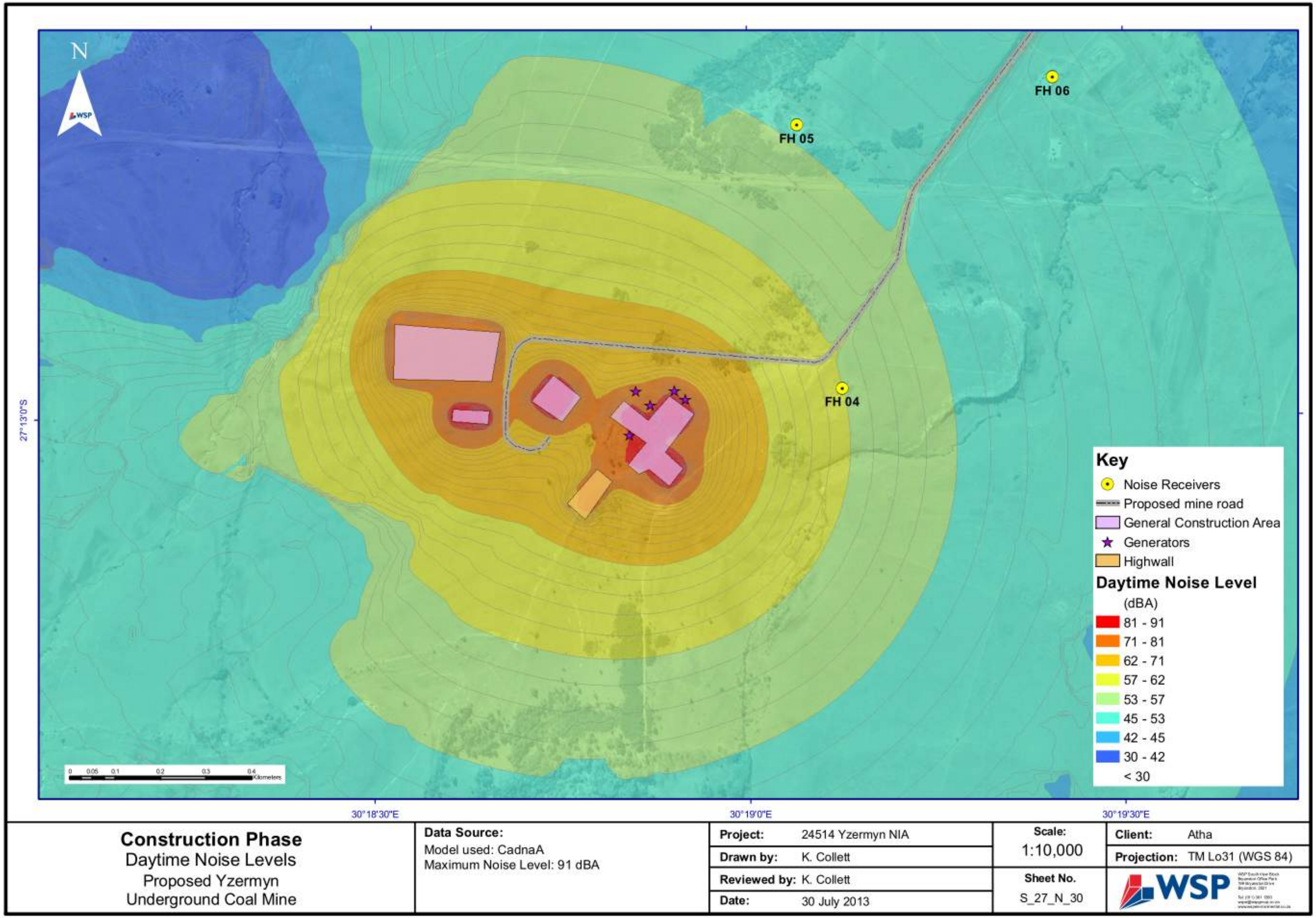


**Figure 16: Predicted daytime noise levels at the proposed Yzermyn Underground Coal Mine during the construction phase (zoomed)**

Table 14 presents the predicted night-time sound levels at each of the specified receiver points during the construction phase of the proposed Yzermyn Underground Coal Mine, assessed against the baseline night-time sound levels as well as the SANS rural and suburban guidelines to evaluate compliance.

At night, noise levels at receivers in close proximity to construction activities decrease by an average of 3 dBA, whilst those receivers further away decrease by an average of 7.5 dBA. These decreases in noise levels are a result of fewer construction hours at night than during the day; absence of road grading and blasting activities at night; and fewer LDV's and delivery trucks frequenting the site at night. The highest noise levels (54 dBA) are once again predicted at receiver FH 04, which is in closest proximity to the construction site. Cumulative night-time noise levels at all receivers (except FH 04, FH 05 and FH 06) are compliant with the respective SANS guidelines.

Graphical outputs of the modelled results of the night-time construction phase activities are presented in Figure 17 and Figure 18. The highest noise levels are predicted around the general construction areas, as in the daytime scenario. Noise propagation to the receivers at night is less due to the shorter construction timeframe at night, resulting in lower noise levels at receivers. As a result of fewer vehicles (LDVs, trucks and graders) along the mine access road at night, the noise levels emanating from the road are significantly lower than during the day.

**Table 14: Night-time predicted and background sound levels at receivers during the construction phase of the proposed Yzermyn Underground Coal Mine**

| Receiver | ID | Predicted Sound Level (dBA) | Background Night-time Sound Level (dBA) | Cumulative Sound Level (dBA) | Night-time Guideline (dBA) | Compliant |
|---|---|---|---|---|---|---|
| **Farm House 01** | FH 01 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 02** | FH 02 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 03** | FH 03 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 04** | FH 04 | 54.0 | 25.7 | 54.0 | 35 | No |
| **Farm House 05** | FH 05 | 49.5 | 25.7 | 49.5 | 35 | No |
| **Farm House 06** | FH 06 | 44.5 | 25.7 | 44.6 | 35 | No |
| **Farm House 07** | FH 07 | 20.7 | 25.7 | 26.9 | 35 | Yes |
| **Farm House 08** | FH 08 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 09** | FH 09 | 27.1 | 25.7 | 29.5 | 35 | Yes |
| **Farm House 10** | FH 10 | 13.8 | 25.7 | 26.0 | 35 | Yes |
| **Farm House 11** | FH 11 | 8.9 | 25.7 | 25.8 | 35 | Yes |
| **School** | School | 13.7 | 25.7 | 26.0 | 35 | Yes |
| **Dirkiesdorp** | Dirkiesdorp | 17.9 | 25.7 | 26.4 | 40 | Yes |

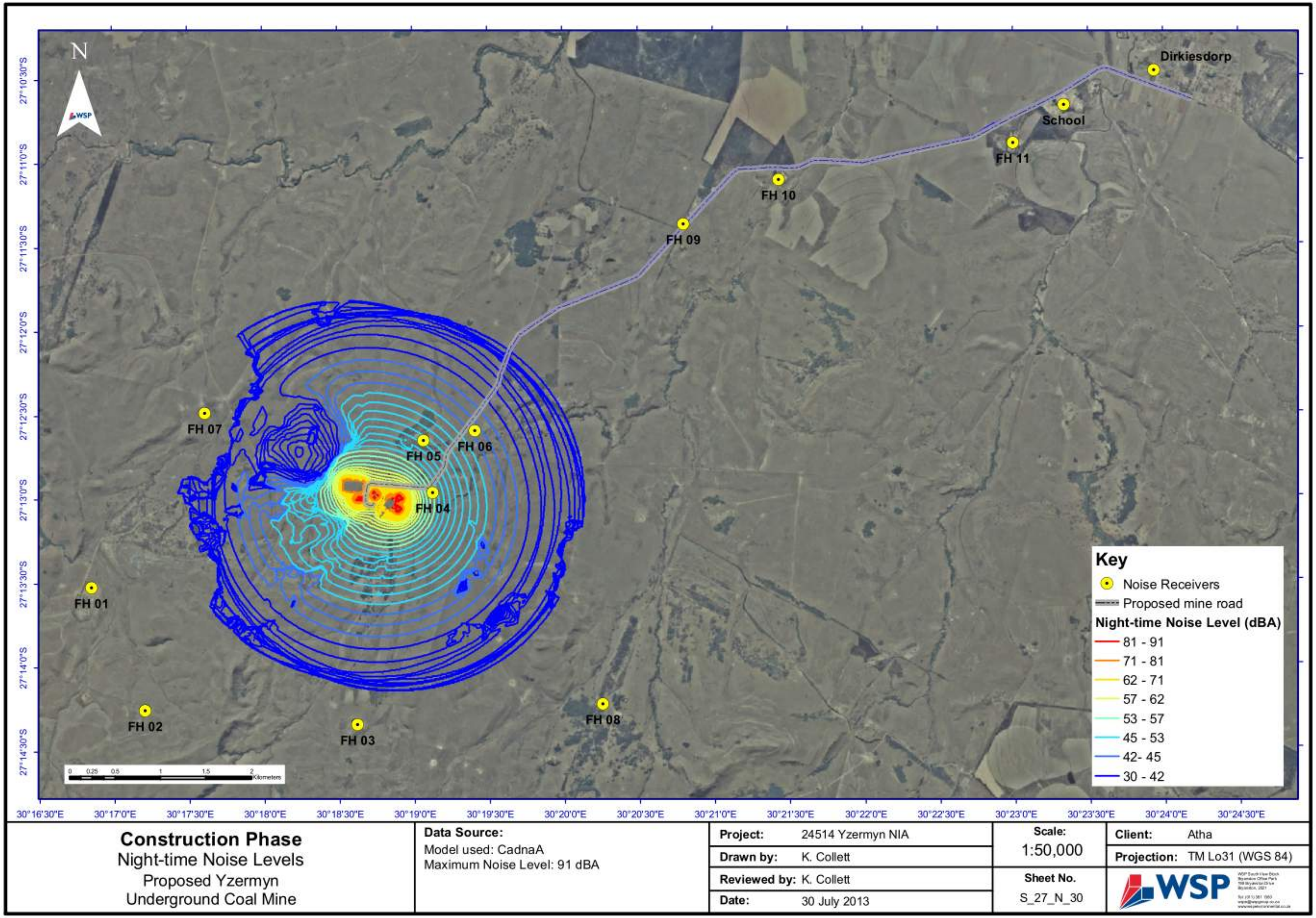


**Figure 17: Predicted night-time noise levels at the proposed Yzermyn Underground Coal Mine during the construction phase**

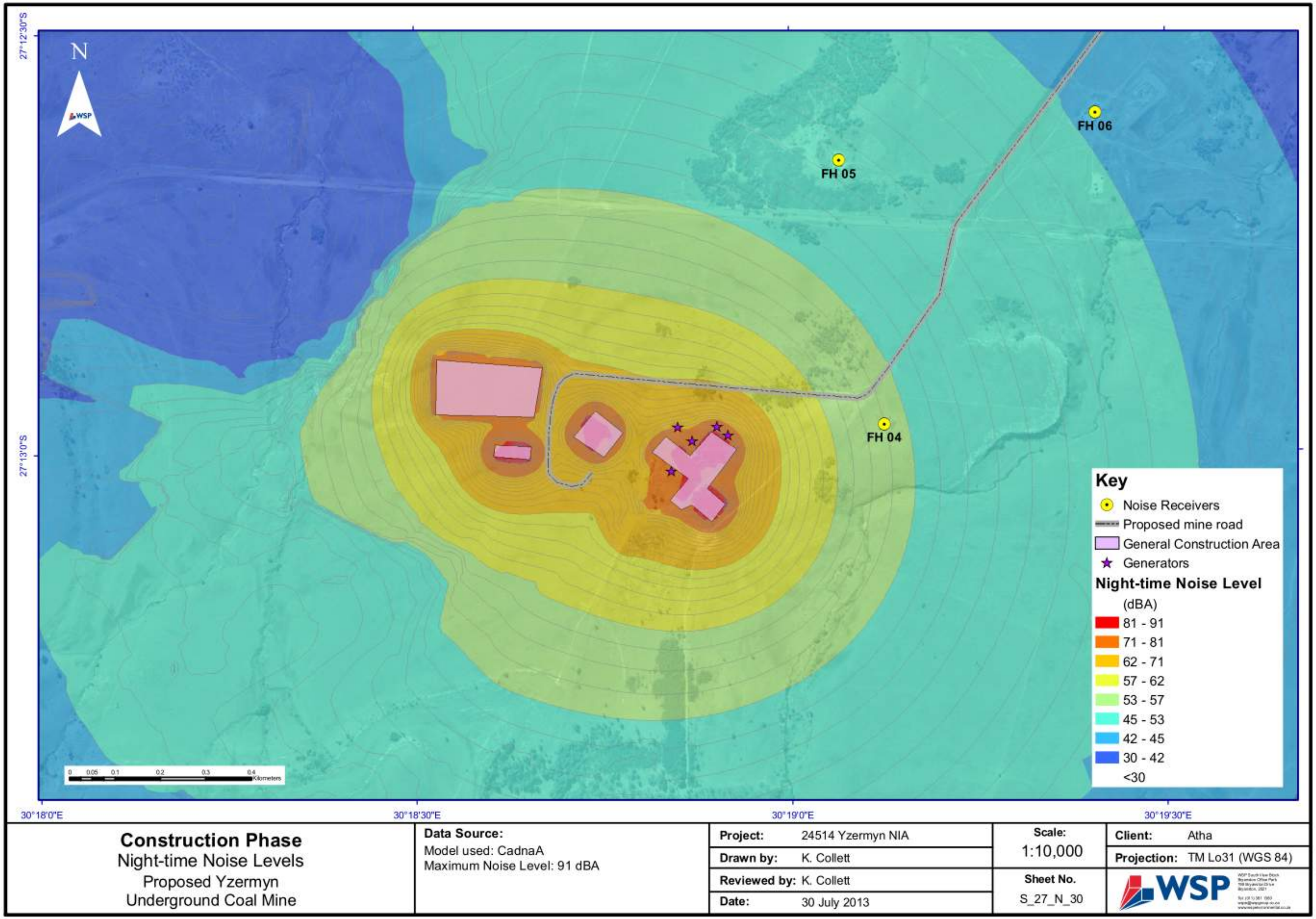


**Figure 18: Predicted night-time noise levels at the proposed Yzermyn Underground Coal Mine during the construction phase (zoomed)**

### 7.2.2 Operational Phase (First 3 years)

Table 15 and Table 16 present the predicted sound levels at each of the specified receiver points during the first three years of the operational phase of the proposed Yzermyn Underground Coal Mine, assessed against the baseline sound levels as well as the SANS rural and suburban guidelines to evaluate compliance.

Predicted noise levels at receivers in close proximity to the mine are slightly elevated, with the highest noise level (66.7 dBA) predicted at FH 04, which is in closest proximity to the mine. Noise levels at most receivers are higher than those noise levels predicted during the construction phase. When the predicted noise levels are added (logarithmically) to the existing baseline daytime noise levels at the receivers, cumulative noise levels are compliant with the respective SANS daytime guidelines except at FH 04, FH 05, FH 06 and FH 09. At night, noise levels are identical, as a result of 24 hour operations at the mine. Due to the stricter SANS night-time guideline, cumulative night-time noise levels exceed the respective guidelines at seven of the ten receivers. These non-compliant receivers are located in close proximity to the mine itself or along the access road from the town of Dirkiesdorp.

Graphical outputs of the modelled results of the operational phase during the first three years are presented in Figure 19 and Figure 20. The highest noise levels are predicted along the conveyor belts; around the export and middlings stockpiles where loading activities will occur; around the pollution control dam water pumps; and around the dewatering pump located outside the adit. Small localised sources include bulldozer and truck unloading activities at the discard dump, although do not impact great distances due to the limited number in operation. Noise from these dominant sources, propagates radially outwards and impacts on FH 04, FH 05 and FH 06.

Noise associated with the mine access road from Dirkiesdorp impacts far more greatly on the adjacent receivers (FH 09, FH 10, FH 11, School and Dirkiesdorp) than noise during the construction phase. This is a result of increased traffic flow on the roads which include 139 coal haul trucks per day and approximately 45 LDVs per day. Since the access road will remain unpaved during the first three years of operation, the noise levels also include grader activity on the road to maintain driveability.

**Table 15: Daytime predicted and background sound levels at receivers during the first three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receiver | ID | Predicted Sound Level (dBA) | Background Daytime Sound Level (dBA) | Cumulative Sound Level (dBA) | Daytime Guideline (dBA) | Compliant |
|---|---|---|---|---|---|---|
| **Farm House 01** | FH 01 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 02** | FH 02 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 03** | FH 03 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 04** | FH 04 | 66.7 | 26.9 | 66.7 | 45 | No |
| **Farm House 05** | FH 05 | 59.5 | 26.9 | 59.5 | 45 | No |
| **Farm House 06** | FH 06 | 54.2 | 26.9 | 54.2 | 45 | No |
| **Farm House 07** | FH 07 | 33.2 | 26.9 | 34.1 | 45 | Yes |
| **Farm House 08** | FH 08 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 09** | FH 09 | 50.2 | 26.9 | 50.2 | 45 | No |
| **Farm House 10** | FH 10 | 36.9 | 26.9 | 37.3 | 45 | Yes |
| **Farm House 11** | FH 11 | 32.0 | 26.9 | 33.2 | 45 | Yes |
| **School** | School | 36.8 | 26.9 | 37.2 | 45 | Yes |
| **Dirkiesdorp** | Dirkiesdorp | 41.0 | 26.9 | 41.2 | 50 | Yes |

**Table 16: Night-time predicted and background sound levels at receivers during the first three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receiver | ID | Predicted Sound Level (dBA) | Background Night-time Sound Level (dBA) | Cumulative Sound Level (dBA) | Night-time Guideline (dBA) | Compliant |
|---|---|---|---|---|---|---|
| **Farm House 01** | FH 01 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 02** | FH 02 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 03** | FH 03 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 04** | FH 04 | 66.7 | 25.7 | 66.7 | 35 | No |
| **Farm House 05** | FH 05 | 59.5 | 25.7 | 59.5 | 35 | No |
| **Farm House 06** | FH 06 | 54.2 | 25.7 | 54.2 | 35 | No |
| **Farm House 07** | FH 07 | 33.2 | 25.7 | 33.9 | 35 | Yes |
| **Farm House 08** | FH 08 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 09** | FH 09 | 50.2 | 25.7 | 50.2 | 35 | No |
| **Farm House 10** | FH 10 | 36.9 | 25.7 | 37.2 | 35 | No |
| **Farm House 11** | FH 11 | 32.0 | 25.7 | 32.9 | 35 | Yes |
| **School** | School | 36.8 | 25.7 | 37.1 | 35 | No |
| **Dirkiesdorp** | Dirkiesdorp | 41.0 | 25.7 | 41.1 | 40 | No |

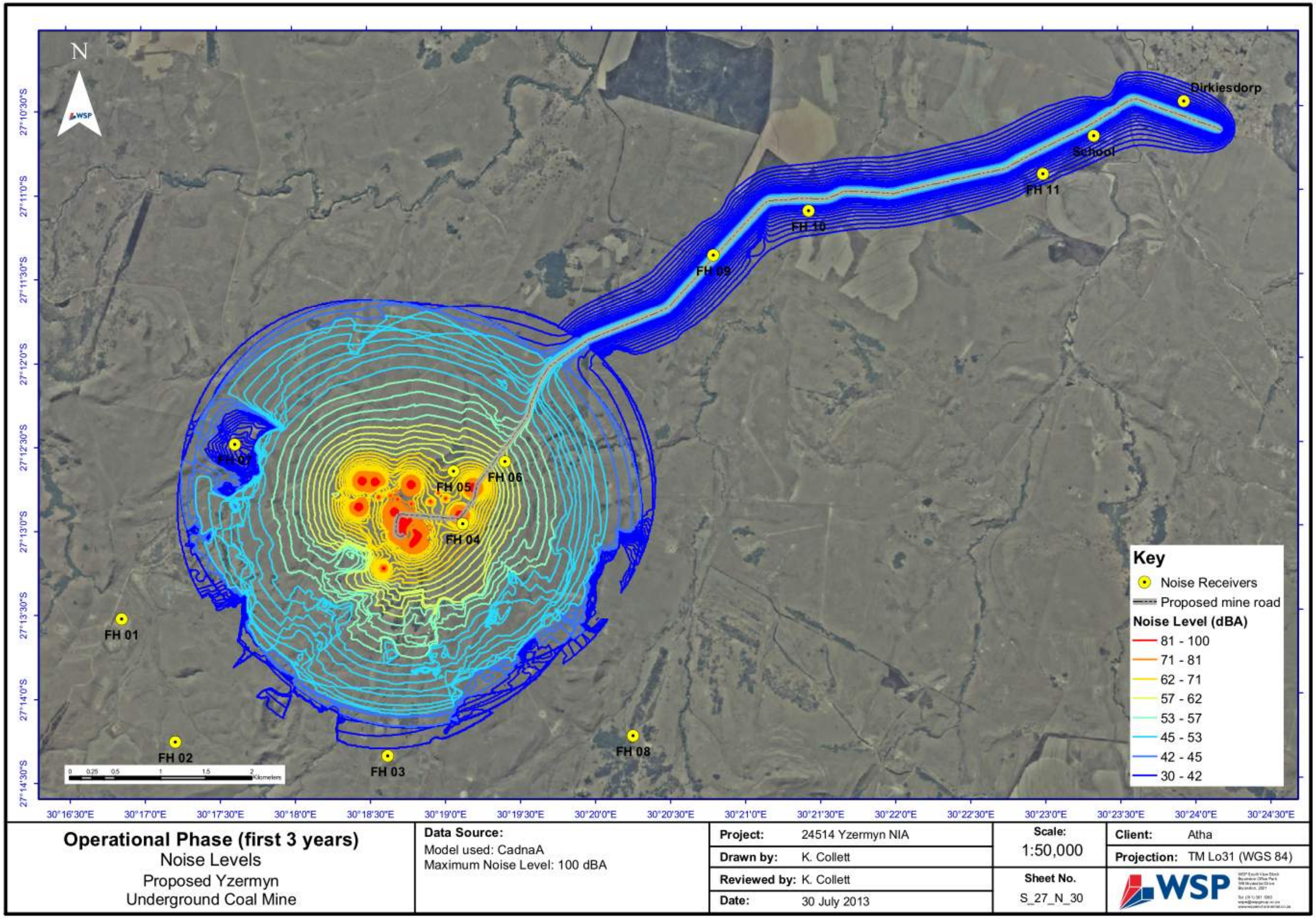


Figure 19: Predicted noise levels at the proposed Yzermyn Underground Coal Mine during the first three years of operation

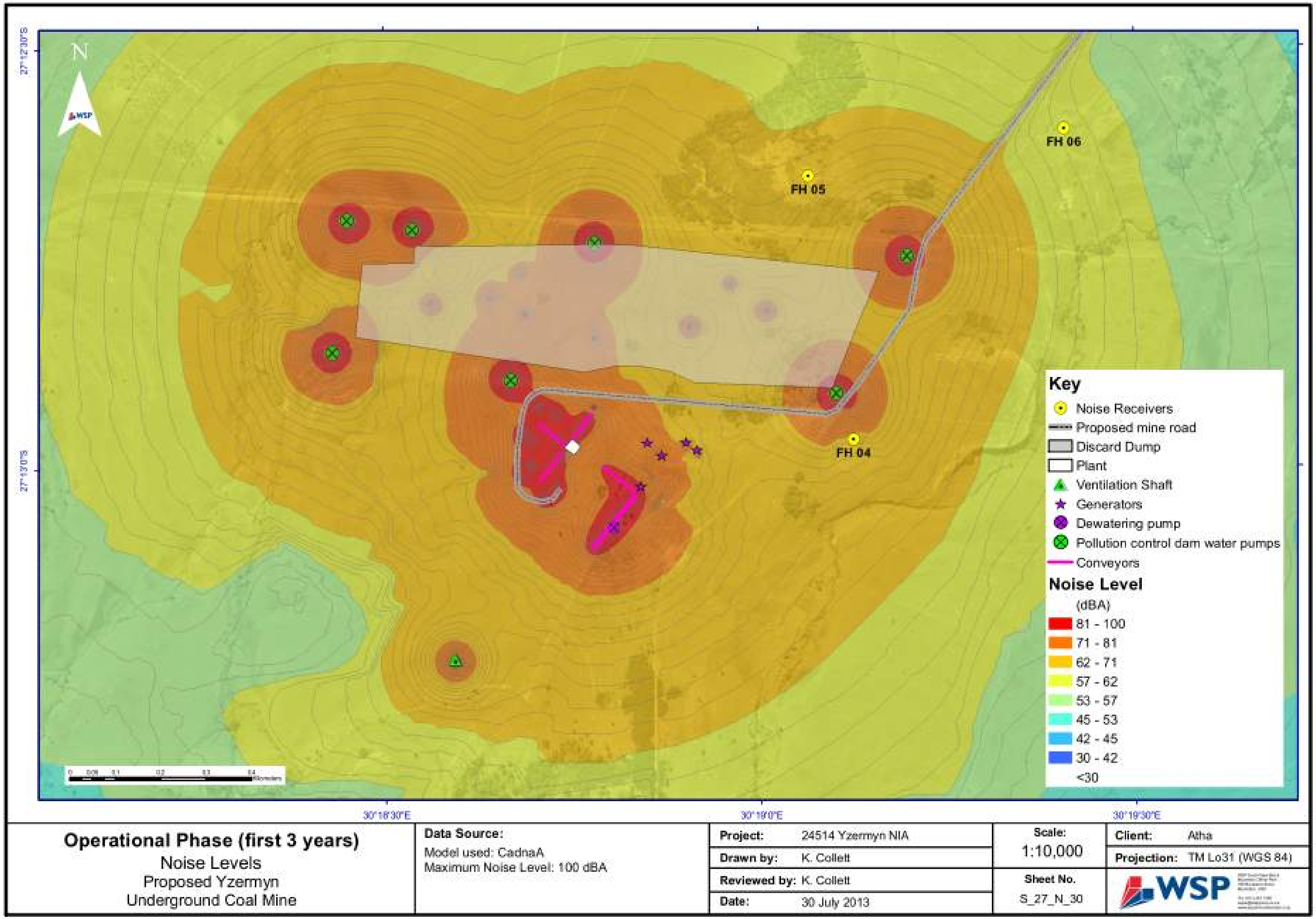


**Figure 20: Predicted noise levels at the proposed Yzermyn Underground Coal Mine during the first three years of operation (zoomed)**

## 7.2.3 Operational Phase (After 3 years)

Table 17 and Table 18 present the predicted sound levels at each of the specified receiver points after the first three years of operation of the proposed Yzermyn Underground Coal Mine, assessed against the baseline sound levels as well as the SANS rural and suburban guidelines to evaluate compliance.

At the receivers in close proximity to the mining operations (FH 04, FH 05, FH 06 and FH 07) predicted noise levels remain similar to those predicted during the first three years of operation, with receiver FH 04, FH 05 and FH 06 still exceeding both the day and night-time guidelines. With the increase in vehicular activity along the mine access road after three years, noise levels at the receivers adjacent to the road are predicted to increase substantially with noise levels exceeding the SANS daytime guideline at FH 09 and the SANS night-time guideline at FH 09, FH 10, FH 11, School and Dirkiesdorp.

Graphical outputs of the modelled results of the operational phase after three years are presented in Figure 21 and Figure 22. The highest noise levels are associated with the same sources as in the first three years of operation as no processes will have changed at the mine. Noise associated with the mine access road from Dirkiesdorp propagates much further from the road and impacts on the adjacent receivers (FH 09, FH 10, FH 11, School and Dirkiesdorp) much more than during the first three years of operation. This is a result of increased traffic flow on the roads as operations progress, with the number of coal haul trucks increasing from 139 trucks per day in the first three years to 240 trucks per day after the first three years.

**Table 17: Daytime predicted and background sound levels at receivers after the first three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receiver | ID | Predicted Sound Level (dBA) | Background Daytime Sound Level (dBA) | Cumulative Sound Level (dBA) | Daytime Guideline (dBA) | Compliant |
|---|---|---|---|---|---|---|
| **Farm House 01** | FH 01 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 02** | FH 02 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 03** | FH 03 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 04** | FH 04 | 66.8 | 26.9 | 66.8 | 45 | No |
| **Farm House 05** | FH 05 | 59.5 | 26.9 | 59.5 | 45 | No |
| **Farm House 06** | FH 06 | 54.7 | 26.9 | 54.7 | 45 | No |
| **Farm House 07** | FH 07 | 33.2 | 26.9 | 34.1 | 45 | Yes |
| **Farm House 08** | FH 08 | 0.0 | 26.9 | 26.9 | 45 | Yes |
| **Farm House 09** | FH 09 | 57.6 | 26.9 | 57.6 | 45 | No |
| **Farm House 10** | FH 10 | 44.3 | 26.9 | 44.4 | 45 | Yes |
| **Farm House 11** | FH 11 | 39.4 | 26.9 | 39.6 | 45 | Yes |
| **School** | School | 44.2 | 26.9 | 44.3 | 45 | Yes |
| **Dirkiesdorp** | Dirkiesdorp | 48.4 | 26.9 | 48.4 | 50 | Yes |

**Table 18: Night-time predicted and background sound levels at receivers after the first three years of operation of the proposed Yzermyn Underground Coal Mine**

| Receiver | ID | Predicted Sound Level (dBA) | Background Night-time Sound Level (dBA) | Cumulative Sound Level (dBA) | Night-time Guideline (dBA) | Compliant |
|---|---|---|---|---|---|---|
| **Farm House 01** | FH 01 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 02** | FH 02 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 03** | FH 03 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 04** | FH 04 | 66.8 | 25.7 | 66.8 | 35 | No |
| **Farm House 05** | FH 05 | 59.5 | 25.7 | 59.5 | 35 | No |
| **Farm House 06** | FH 06 | 54.7 | 25.7 | 54.7 | 35 | No |
| **Farm House 07** | FH 07 | 33.2 | 25.7 | 33.9 | 35 | Yes |
| **Farm House 08** | FH 08 | 0.0 | 25.7 | 25.7 | 35 | Yes |
| **Farm House 09** | FH 09 | 57.6 | 25.7 | 57.6 | 35 | No |
| **Farm House 10** | FH 10 | 44.3 | 25.7 | 44.4 | 35 | No |
| **Farm House 11** | FH 11 | 39.4 | 25.7 | 39.6 | 35 | No |
| **School** | School | 44.2 | 25.7 | 44.3 | 35 | No |
| **Dirkiesdorp** | Dirkiesdorp | 48.4 | 25.7 | 48.4 | 40 | No |

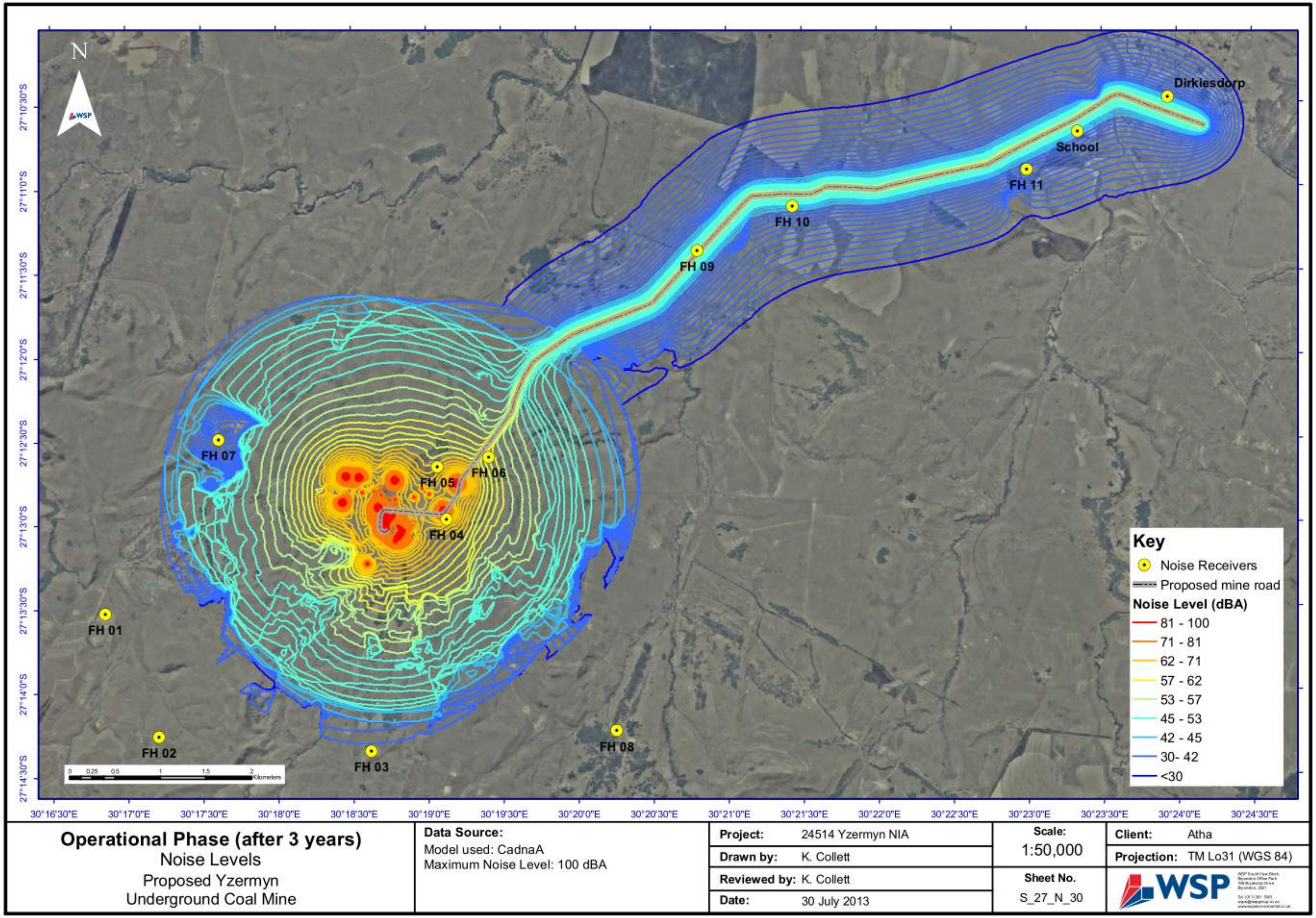


**Figure 21: Predicted noise levels at the proposed Yzermyn Underground Coal Mine after the first three years of operation**

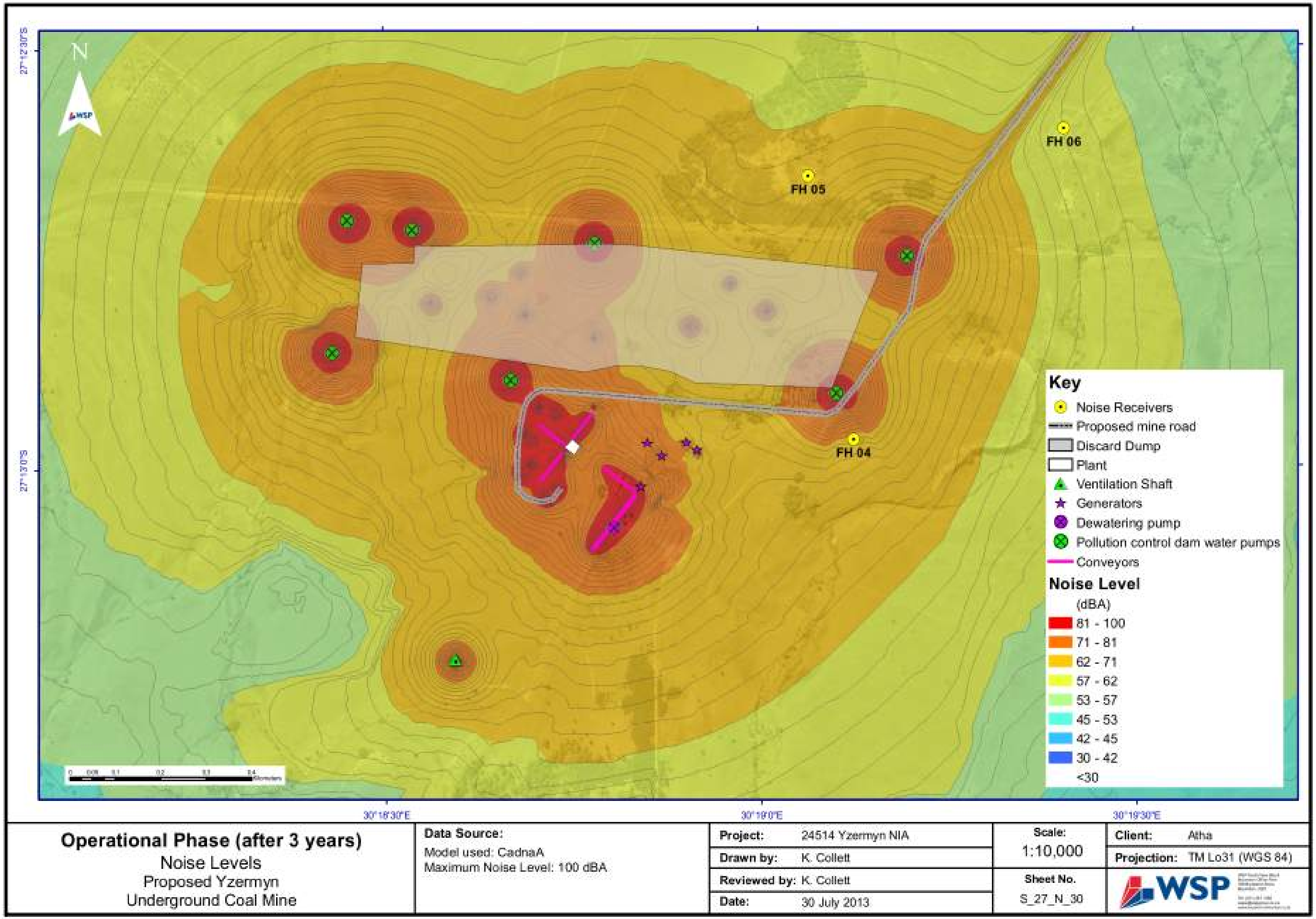


**Figure 22: Predicted noise levels at the proposed Yzermyn Underground Coal Mine after the first three years of operation (zoomed)**

# 8 Assumptions

In this environmental noise impact assessment, various assumptions were made that may impact on the results obtained. These assumptions include:

- The proposed noise source locations as identified in the site layout prepared by Mindset Mining Consultants (Pty) Ltd are assumed to be representative of reality;
- The location of the generators, pollution control dam water pumps and dewatering pump were assumed based on best guess estimates from the mine plan;
- All proposed noise sources for the proposed Yzermyn Underground Coal Mine have been included in this assessment;
- Activities will operate 20 hours a day during construction phase;
- Construction will last for 6 months;
- Roads will be graded twice a month during construction phase;
- Activities will operate 24 hours a day during operational phase;
- Trucks will transport the discard from the discard bin to the discard dump;
- During the first three years of operation, roads will be graded twice a month;
- No underground noise sources were included as this is an environmental noise assessment and not an occupational noise assessment. In addition, with the 107 m depth of the proposed mine together with the logarithmic nature of noise, additional noise from underground sources is assumed to be minimal;
- The number of vehicles operating on the mine access road during the construction phase was assumed;
- The number of vehicles operating on the mine access road during the operational phase, calculated from the personnel numbers depicted in the Mine Works Programme, are assumed to be representative of reality;
- A generic height of 3 m was used for general buildings in the model; and
- A height of 3.5 m for the CHPP was utilised in the model.

A limitation in the study was the lack of site specific metrological data, where only UM model data was obtainable and subsequently utilised in the acoustic model.

# 9 Conclusions and Recommendations

This environmental noise assessment investigated noise associated with the construction and operation of the proposed Yzermyn Underground Coal Mine near Wakkerstroom in the Mpumalanga Province. To assess the existing noise climate of the region baseline noise monitoring was performed during May 2012. From this, it was identified that the region has a characteristic daytime noise level of 26.9 dBA and a night-time noise level of 25.7 dBA, which are both compliant with the SANS rural guidelines. The region is characterised as rural, with the dominant land use being natural bush and grazing land. Existing noise sources at the proposed site include insects, livestock, wind and the odd passing vehicle.

From the acoustic modelling, predicted daytime and night-time noise levels during the construction phase are elevated at receivers in close proximity to the construction activities, whilst receivers that are further away experience much lower noise levels. The highest noise levels are predicted at FH 04, a farmhouse that is in closest proximity to the mine. When the predicted noise levels are added (logarithmically) to the existing baseline daytime or night-time noise levels, cumulative noise levels at all receivers (except FH 04, FH 05 and FH 06) are compliant with the SANS day and night-time guidelines. Owing to the close proximity of these farm houses (FH 04, FH 05 and FH 06) to the main construction activities, such elevated noise levels would be expected. At night, noise levels at receivers in close proximity to construction activities decrease by an average of 3 dBA, whilst those receivers further away decrease by an average of 7.5 dBA. These decreases are a result of fewer construction hours at night; absence of grading and blasting activities at night and fewer vehicles frequenting the site at night.

During the construction phase the highest noise levels are associated with general construction activities, which include land clearing, earthworks, grading, bulldozing and unloading of material. Since blasting events at the boxcut/ high-wall are not continuous and will only occur once per day, impacts from this source are low. Noise levels emanating from the mine access road that runs from Dirkiesdorp to the mine are minimal as all construction vehicles will only use the access road twice during the construction phase (once on entry to the site and once on exit) and grader activity on the road will only occur twice a month. Noise from general traffic on the mine access road will slightly increase the noise levels experienced at FH 09 and the town of Dirkiesdorp, although these levels are still in compliance with the SANS guidelines.

Predicted noise levels at most receivers during the first three years of operation are higher than those noise levels predicted during the construction phase. The highest noise levels are predicted at FH 04. Cumulative noise levels at receivers are compliant with the respective SANS daytime guidelines except at FH 04, FH 05, FH06 and FH09. Night-time noise levels are identical to daytime levels as a result of 24 hour operations at the mine. Due to the stricter SANS night-time guideline, cumulative night-time noise levels exceed the guidelines at seven of the ten receivers. These non-compliant receivers are located in close proximity to the mine itself or along the access road from the town of Dirkiesdorp.

Predicted noise levels after the first three years of operation remain similar in the direct vicinity of the mine as no processes will have changed. With an increase in vehicular activity along the mine access road after three years, noise levels at the receivers adjacent to the road are predicted to increase substantially with noise levels exceeding the SANS daytime guideline at FH 09 and the SANS night-time guideline at FH 09, FH 10, FH 11, School and Dirkiesdorp.

During both operational phases dominant noise sources include conveyor belts; loading activities at the export and middlings stockpiles; the pollution control dam water pumps; and the dewatering pump located outside the adit. Noise associated with the mine access road from Dirkiesdorp impacts far more greatly on the adjacent receivers (FH 09, FH 10, FH 11, School and Dirkiesdorp) than noise during the construction phase. This is a result of increased traffic flow on the roads. Such noise levels increase substantially after the first three years of operation as a result of increased traffic flow.

Since noise associated with the construction phase of the mine is relatively short lived (six months) and will only impact on receivers in close proximity to the mine, noise mitigation is not a key concern at that time. Should complaints arise when construction activities commence, the following mitigation options may be employed:

- Installation of mufflers on exhausts of construction vehicles;
- Limiting the night-time hours in which construction occurs;

- Selecting construction equipment with lower sound power levels; and
- The use of ear protection equipment for personnel working onsite in close proximity to noise sources.

During the operational phase, noise mitigation techniques are more critical as noise generating activities are continuous, operating 24 hours a day. During the operational phase, the following noise mitigation techniques should be employed:

- Installation of suitable mufflers on engine exhausts and compressor components;
- Selecting and installing equipment with lower sound power level specifications;
- Installation of silencers for fans;
- The enclosing of conveyors;
- Enclosing of continuous noise sources (i.e. pumps) within sound absorbing enclosures;
- Installation of acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m² in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective;
- Limiting the hours of operation of "noisy" equipment; and
- Regular maintenance of equipment to reduce the generation of additional unwanted noise.

In accordance with WSP's impact rating methodology, the predicted environmental impacts of the Yzermyn project are expected to be low (L) to medium high (MH) as depicted in Table 19.

**Table 19: Impacts rating table of environmental noise from the proposed Yzermyn Underground Coal Mine**

| | | | | A | B | C | D | E | F | G | (DxG) | (DxG) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ref.** | **Phase** | **Impact Description** | **Mitigation Measure** | **Severity** | **Duration** | **Extent** | **Consequence (A+B+C)/3** | **Frequency** | **Probability** | **Likelihood (E+F)/2** | **Environmental Significance** | **Impact** |
| **Noise** | | | | | | | | | | | | |
| 1 | Construction | Impact on neighbouring farm houses | Without mitigation | 2.0 | 2.0 | 2.0 | 2.0 | 5.0 | 3.0 | 4.0 | **8.0** | **LM** |
| | | | With mitigation | 1.0 | 2.0 | 1.0 | 1.3 | 5.0 | 2.0 | 3.5 | **4.7** | **L** |
| 2 | Construction | Impact on sensitive receivers along the mine access road | Without mitigation | 1.0 | 2.0 | 1.0 | 1.3 | 5.0 | 2.0 | 3.5 | **4.7** | **L** |
| | | | With mitigation | 1.0 | 2.0 | 1.0 | 1.3 | 5.0 | 2.0 | 3.5 | **4.7** | **L** |
| 3 | Operational first three years | Impact on neighbouring farm houses | Without mitigation | 3.0 | 4.0 | 3.0 | 3.3 | 5.0 | 4.0 | 4.5 | **15.0** | **MH** |
| | | | With mitigation | 2.0 | 4.0 | 2.0 | 2.7 | 5.0 | 2.0 | 3.5 | **9.3** | **L** |
| 4 | Operational first three years | Impact on sensitive receivers along the mine access road | Without mitigation | 3.0 | 4.0 | 3.0 | 3.3 | 5.0 | 5.0 | 5.0 | **16.7** | **MH** |
| | | | With mitigation | 2.0 | 4.0 | 3.0 | 3.0 | 5.0 | 3.0 | 4.0 | **12.0** | **M** |
| 5 | Operational after three years | Impact on neighbouring farm houses | Without mitigation | 3.0 | 4.0 | 3.0 | 3.3 | 5.0 | 4.0 | 4.5 | **15.0** | **MH** |
| | | | With mitigation | 2.0 | 4.0 | 2.0 | 2.7 | 5.0 | 2.0 | 3.5 | **9.3** | **L** |
| 6 | Operational after three years | Impact on sensitive receivers along the mine access road | Without mitigation | 3.0 | 4.0 | 3.0 | 3.3 | 5.0 | 5.0 | 5.0 | **16.7** | **MH** |
| | | | With mitigation | 2.0 | 4.0 | 3.0 | 3.0 | 5.0 | 3.0 | 4.0 | **12.0** | **M** |

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**WSP Environmental (Pty) Ltd**
WSP House
Bryanston Place, 199 Bryanston Drive
Bryanston
2191
South Africa
Tel: +27 11 361 1372
Fax: +27 86 556 7189
www.wspenvironmental.co.za

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