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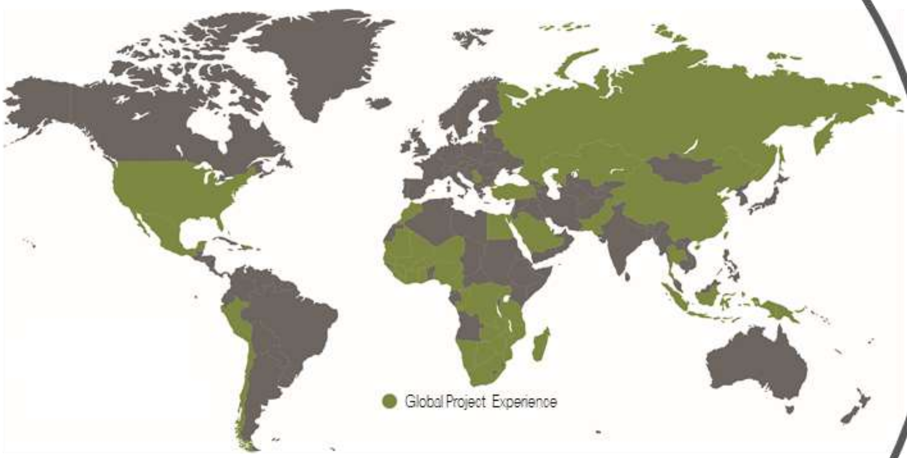

Providing innovative and sustainable solutions throughout the resources sector

Environmental Impact Assessment for the Dorstfontein East Mine Amendment, Mpumalanga Province

Air Quality Impact Assessment

Prepared for:
Exxaro Coal Central (Pty) Ltd

Project Number:
EXX5725

May 2021

Digby Wells and Associates (South Africa) (Pty) Ltd
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Name	**Responsibility**	**Signature**	**Date**
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Stephen Burton	Reviewer		May 2021

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Brief Background of Specialist

Matthew has broad knowledge in the "*Atmospheric Sciences*" field, with more than 15 years of experience in academia and industry combined. He has garnered practical field experiences in setting up, monitoring, and decommissioning ambient air quality units and stations, encompassing real-time particulate monitor – AQ-Mesh®, Grimm Aerosol monitor®, Met-One E-Sampler®, radiello® passive/diffusive samplers for environmental monitoring, indoor and outdoor air monitoring, industrial air quality (IAQ), personal sampling and breathing zone assessment.

He is currently registered as a Professional Natural Scientist with the South African Council for Natural Scientific Professions (Reg. No. 116980/18) and is a member of the National Association for Clean Air. He has authored and co-authored research articles and conference papers in peer-reviewed journals both locally and internationally.

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I, Matthew Ojelede, declare that: –

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

May 2021

Signature of the Specialist *Date*

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Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or make reference to this report. Whenever such recommendations, statements or conclusions form part of a main report relating to the current investigation, this report must be included in its entirety.

EXECUTIVE SUMMARY

Exxaro Central Coal (Pty) Ltd (hereafter ECC) holds an approved Mining Right with reference number **MP 30/5/1/2/3/2/1 (51) MR** for opencast and underground mining at the Dorstfontein East Coal Mine (DECM) situated in the Mpumalanga Province. The current proposal aims to extend the existing underground mining area (approved under the ownership of Total Coal South Africa (Pty) Ltd, hereafter "Total") and introduce infrastructure in support of the extension. Exxaro Central Coal aims to extend the underground mining area of the 2 Seam and 4 Seam associated with the Mining Right.

The proposed additional infrastructure triggers activities listed in the Environmental Impact Assessment (EIA) Regulations, 2014 (GN R 982 of 4 December 2014 as amended by GN R 326 of 7 April 2017) promulgated under the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). To this end, Digby Wells Environmental (hereinafter Digby Wells) was appointed as the independent Environmental Assessment Practitioner (EAP) to complete the EIA in support of the Environmental Authorisation (EA) application.

This Air Quality Impact Assessment (AQIA) forms part of the suite of specialist studies required. The planned life-of-mine (LoM) is one year for the construction phase, followed by a 14 year operational phase.

This Air Quality Impact Assessment (AQIA) was set out to establish the future perturbation on ambient air quality and associated cumulative impacts from the proposed Project's operational phase. For this AQIA, a holistic approach was adopted by considering all air emissions sources associated with the expansion, with the focus on the worst-case scenario (i.e. without mitigation measures in place). The latter may have resulted in the model over-predicting future potential impacts.

Findings from the baseline assessment have confirmed that the prevailing winds are from the east northeast (10.5%) and northwest (9.6%) respectively. Secondary contributions are from the north northwest (8.8%) and east (8.1%). The average wind speed at the project site is 3.2 m/s and calm conditions (<0.5 m/s) occurred for some 4.7% of the time. Wind speed capable of causing wind erosion i.e. ≥5.4 m/s occurred for about 7.9% of the time (Figure 6-6).

Historical dustfall records from 20 months (January 2018 – August 2019) of monitoring at 19 sites were used to evaluate the background air quality. Measured dustfall rates were below the respective limit values for more than the 95th percentile of the time, with sequential exceedances measured at DDES-2, DDES-6 and M-DDED-2 for the period.

Potential emissions from the operational phase of the Project were assessed. Model simulations of Ground Level Concentration (GLC) of criteria pollutants were generated, for different averaging periods as recommended by the regulatory authorities and compared with the South African standards to ascertain compliance.

A summary of the predicted GLC is given below:

- The areas where the predicted GLC of $PM_{2.5}$ will exceed the 24-hour standard (40 µg/m³) are within the MR boundary. The predicted GLC at the sensitive receptors (DDES-6, DDES-12, DDES-13, and DDES14) will be lower than the standard. The predicted annual GLC of $PM_{2.5}$ will not exceed the regulatory standard at the selected receptors.
- The predicted GLC of PM_{10} over a 24-hour averaging period returned simulation isopleths for PM_{10} daily and PM_{10} annual. The area where the 24-hour standard of 75 µg/m³ will be exceeded will be confined within the MR boundary. The GLC at the selected sensitive receptors (DDES-6, DDES-12, DDES-13, and DDES14) were lower than the standard. The predicted annual isopleth showed that areas, where exceedance will occur, are confined to within the MR boundary during operation, with no exceedance predicted for the sensitive receptors.
- The predicted dustfall simulation was conducted with mitigation and without mitigation. The predicted dustfall rates without mitigation confirmed that both the residential and the non-residential limit of 1,200 mg/m^2/d will be exceeded within the MR boundary, with less implications for the sensitive receptors. With mitigation in place, the predicted dustfall rates at the selected receptors were lowered significantly.

The impacts of the proposed Project were evaluated using a risk matrix that considers the nature, significance, extent, duration, and probability of impacts occurring. Based on this rating system, impacts on the surrounding receptors from the operational phase are deemed “major negative” without mitigation. However, with mitigation, the impacts were reduced to “negligible negative”. Since anticipated emissions from the operational phase activities are likely to influence receptors outside the Project boundary, mitigation and management intervention measures are crucial.

Some of the possible mitigation measures and management intervention measures recommended include:

- Application of dust suppressants/binders on haul roads and exposed areas, setting maximum speed limits on haul roads and to have these limits enforced, and application of mitigation technology at the dryer exhaust at the Discard Plant; and
- Operation of ambient air quality monitoring network to collect valuable data needed to assess the effectiveness of mitigation measures put in place during operation.

Once the mine implements the recommended mitigation measures outlined in this report, associated emissions can be contained to below standards, ensuring compliance with regulatory requirements.

TABLE OF CONTENTS

1. Introduction 1
1.1. Project Background and Description........ 1
1.2. Mining 1
1.3. Infrastructure 2
2. Scope of Work........ 1
3. Details of the Specialist 2
4. Assumptions, Limitations and Exclusions 2
5. Relevant Legislation, Standards, and Guidelines 2
5.1. Applicable South African Standard 3
6. Methodology........ 5
6.1. Baseline Assessment 5
6.2. Project Area 5
6.3. General Description of Climate in the Project Area 8
6.3.2. Assessment of Existing Air Quality........ 14
6.4. Air Quality Impact Assessment........ 17
6.4.1. Impact Assessment Approach 17
7. Findings and Discussion 22
7.1. Baseline Results........ 22
7.2. Dispersion Model Simulation Results 22
7.3. Isopleth Plots and Evaluation of Results........ 22
7.3.1. Predicted GLC of $PM_{2.5}$ 22
7.3.2. Predicted GLC of PM_{10} 22
7.3.3. Predicted Dustfall Rates 23
8. Discussions 31
8.1. Findings 31
9. Impact Assessment Ranking........ 31
9.1. Construction Phase 31
9.1.1. Impact Description 32

9.2. Operational Phase ... 34
9.2.1. Impact Description ... 34
9.3. Decommissioning Phase ... 36
9.3.1. Impact Description ... 36
9.4. Cumulative Impacts ... 38
9.5. Unplanned and Low Risk Events ... 38
10. Environmental Management Programme ... 38
11. Monitoring Programme ... 40
12. Stakeholder Engagement Comments Received ... 40
13. Recommendations ... 40
14. Reasoned Opinion Whether Project Should Proceed ... 41
15. Conclusion ... 41
16. References ... 43

LIST OF FIGURES

Figure 1-1: Surface Infrastructure Layout ... 1
Figure 1-2: Approved and Proposed Underground Areas (Seam 2) ... 2
Figure 1-3: Approved and Proposed Underground Areas (Seam 4) ... 3
Figure 6-1: Project Boundary Showing Surrounding Receptors and Dust Monitoring Locations ... 7
Figure 6-2: Rainfall ... 10
Figure 6-3: Monthly - Temperature and Humidity ... 11
Figure 6-4: Surface Wind Rose ... 12
Figure 6-5: Seasonal Wind Roses ... 13
Figure 6-6: Wind Class Frequency ... 13
Figure 6-7: Dustfall Results for 2018 ... 15
Figure 6-8: Dustfall Results for 2019 ... 16
Figure 6-9: Air Quality Impact Assessment Methodology ... 17
Figure 7-1: Predicted 4th highest (99th percentile) daily $PM_{2.5}$ Concentrations (µg/m^3**)** ... 25

Figure 7-2: Predicted 1st highest (100th percentile) Annual PM2.5 Annual Concentrations (µg/m^3) 26

Figure 7-3: Predicted 4th highest (99th percentile) daily PM_{10} Concentrations (µg/m^3) 27

Figure 7-4: Predicted 1st highest (100th percentile) Annual PM_{10} Concentrations (µg/m^3) 28

Figure 7-5: Predicted (100th percentile) Monthly TSP Deposition Rates (mg/m^2/day) No Mitigation 29

Figure 7-6: Predicted (100th percentile) Monthly TSP Deposition Rates (mg/m^2/day) With Mitigation 30

LIST OF TABLES

Table 1-1: Project Phases and Associated Activities 1

Table 4-1:Assumptions, Limitations and Exclusions 2

Table 5-1: Applicable Legislation, Regulations, Guidelines, and By-Laws 2

Table 5-2: Dust Fall Standards (NDCR, 2013) 4

Table 5-3: National Ambient Air Quality Standards for Particulate Matter (PM_{10}) (2009) 4

Table 5-4: National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$) (2012) 5

Table 6-1: Climate Statistics 9

Table 6-2: Emission Factor Equations 18

Table 6-3: Parameters adopted for the Ventilation Shafts 20

Table 6-4: MHSA OEL (2006) 20

Table 6-5: Summary of Meteorological and AERMET Parameters 21

Table 7-1: Predicted Concentrations of PM_{10}, $PM_{2.5}$ and Dust Deposition Rates at Selected Sensitive Receptors 24

Table 9-1: Interactions and Impacts of Activity 32

Table 9-2: Significance Ratings for Site Clearing, Construction of Haul Road and Surface Infrastructure 33

Table 9-3: Interactions and Impacts of Activity 34

Table 9-4: Significance Ratings for Operation of the Underground Mine, Ventilation Shaft, in-pit Stockpiling and Operation of the Discard Plant 35

Table 9-5: Interactions and Impacts of Activity 36

Table 9-6: Significance Ratings for Demolition and Removal of Infrastructure and Rehabilitation of the Project area 37

Table 9-7: Comparison of Modelled to Baseline Data.. 38
Table 9-8: Unplanned Events and Associated Mitigation Measures 38
Table 10-1: Environmental Management Programme 39
Table 11-1: Recommended Monitoring Plan 40
Table 16-1: Impact Assessment Parameter Ratings 48
Table 16-2: Probability/Consequence Matrix.. 50
Table 16-3: Significance Rating Description... 51

LIST OF APPENDICES

Appendix A: Impact Assessment Ranking

LIST OF ACRONYMS, ABBREVIATIONS AND DEFINITION

AERMOD	American Meteorological Society/United States Environmental Protection Agency Regulatory Model
AQIA	Air Quality Impact Assessment
DEA	Department of Environmental Affairs
EMPr	Environmental Management Plan Report
EIA	Environmental Impact Assessment
GLC	Ground Level Concentrations
LOM	Life of Mine
MM5	Mesoscale model - Fifth generation
NDCR	National Dust Control Regulations
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NEMAQA	National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004)
PM_{10}	Particulate Matter less than 10 microns in diameter
$PM_{2.5}$	Particulate Matter with Aerodynamic Diameter less than 2.5 Micron
ROM	Run of Mine
SAAELIP	South African Atmospheric Emission Licensing & Inventory Portal
tpa	Tonnes per annum
TSP	Total Suspended Particulates
USEPA	The United States Environmental Protection Agency
WBG	World Bank Group
WHO	World Health Organisation

CONTENT OF THIS REPORT IN ACCORDANCE WITH THE REGULATION GNR982 OF 2014, APPENDIX 6 (AS AMENDED)

Legal Requirement		Section in Report
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of- (i) the specialist who prepared the report; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	iii iv Section 3
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Iii, iv
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 2
cA	And indication of the quality and age of the base data used for the specialist report;	Section 6
cB	A description of existing impacts on site, cumulative impacts of the proposed development and levels of acceptable change;	Section 9.4
(d)	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	N/A
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of the equipment and modelling used;	Section 6
(f)	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternatives;	N/A
(g)	an identification of any areas to be avoided, including buffers;	N/A
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 4

Legal Requirement		Section in Report
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 7
(k)	any mitigation measures for inclusion in the EMPr;	Section 10
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 14
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 11
(n)	a reasoned opinion (Environmental Impact Statement) -	Section 14
	whether the proposed activity, activities or portions thereof should be authorised; and	Section 14
	if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	N/A
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 12
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Section 12
(q)	any other information requested by the competent authority.	N/A

1. Introduction

Exxaro Central Coal (Pty) Ltd (hereafter ECC) holds an approved Mining Right (MR) with reference number **MP 30/5/1/2/3/2/1 (51) MR** for opencast and underground mining at the Dorstfontein East Coal Mine (DECM) situated in the Mpumalanga Province. The current proposal aims to extend the existing underground mining area (approved under the ownership of Total Coal South Africa (Pty) Ltd, hereafter “Total”) and introduce infrastructure in support of the extension. ECC aims to extend the underground mining area of the 2 Seam and 4 Seam associated with the Mining Right.

The additional infrastructure triggers activities listed in the Environmental Impact Assessment (EIA) Regulations, 2014 (GN R 982 of 4 December 2014 as amended by GN R 326 of 7 April 2017) promulgated under the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). To this end, Digby Wells Environmental (hereinafter Digby Wells) was appointed as the independent Environmental Assessment Practitioner (EAP) to complete the EIA in support of the Environmental Authorisation (EA) application.

The EIA process includes a suite of specialist studies including an Air Quality Impact Assessment (AQIA) in support of the EIA process.

1.1. Project Background and Description

The DECM was previously owned by Total and was ceded to ECC on 20 August 2015 which has an approved Environmental Management Plan (EMP), dated October 2017. ECC is now applying to expand the underground mining areas as approved under Total. Subsequently, additional coal reserves have been identified for mining which were not covered under the existing approval. ECC is also approved to undertake underground mining of deeper coal reserves at DECM. The underground mining operations will be accessed from the existing Pit 2 open cast and Dorstfontein West operations. DECM, therefore, intends to further extend the Life-of-Mine (LoM) through the exploitation of these identified additional coal reserves between 2021 until 2034.

In addition, a portion of Pit 3, which is approved for opencast mining, will now be included in the underground mining extension.

1.2. Mining

The planned LoM is one year for the construction phase followed by an approximate 14-year operational (production) phase. A coal discard processing plant has been proposed to treat 100 kilotons per month (ktpm) of re-mined coal discard, with a total of 1,200,000 tonnes per annum (tpa).

1.3. Infrastructure

The required infrastructure/activities proposed for the extension are listed below and depicted in Figure 1-1. The approved and proposed underground area are described in Figure 1-2 and Figure 1-3 below.

- Portal ventilation fan;
- Sewage Treatment Plant;
- Water Treatment Plant;
- Potable Water storage tank;
- Erikson Pond;
- A new 22 kV overhead powerline from the existing substation to a new 22kV substation;
- Run of Mine (RoM) Stockpile conveyor at portal;
- Change house;
- Lamp room;
- Office;
- Clinic;
- Stores;
- Workshop area;
- Stone dust silo; and
- Coal discard processing plant.

An environmental regulatory process comprising of an amendment and consolidation of the Environmental Management Programme (EMPr) and Integrated Water Use License (IWUL) is required for the new proposals.

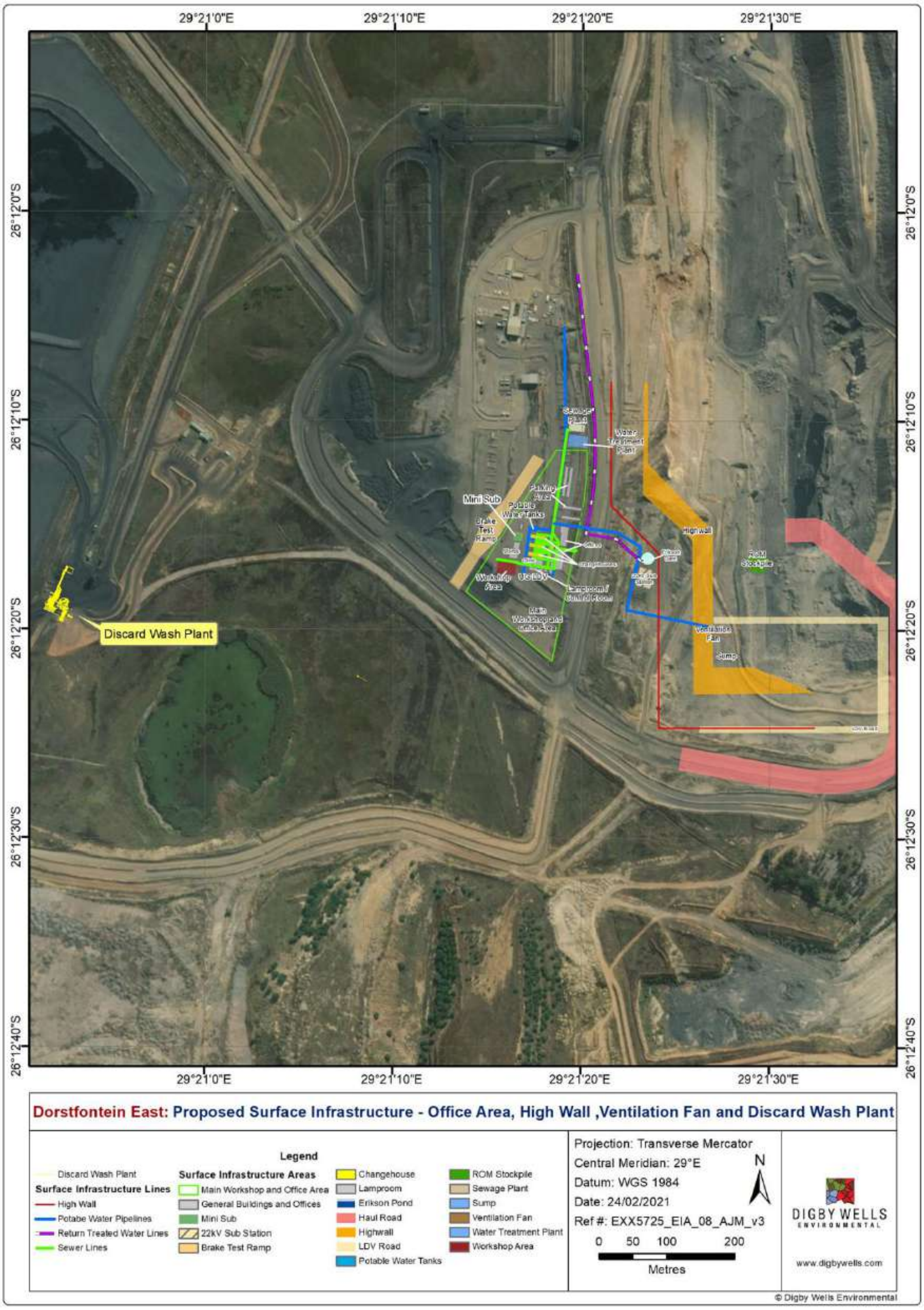


Figure 1-1: Surface Infrastructure Layout

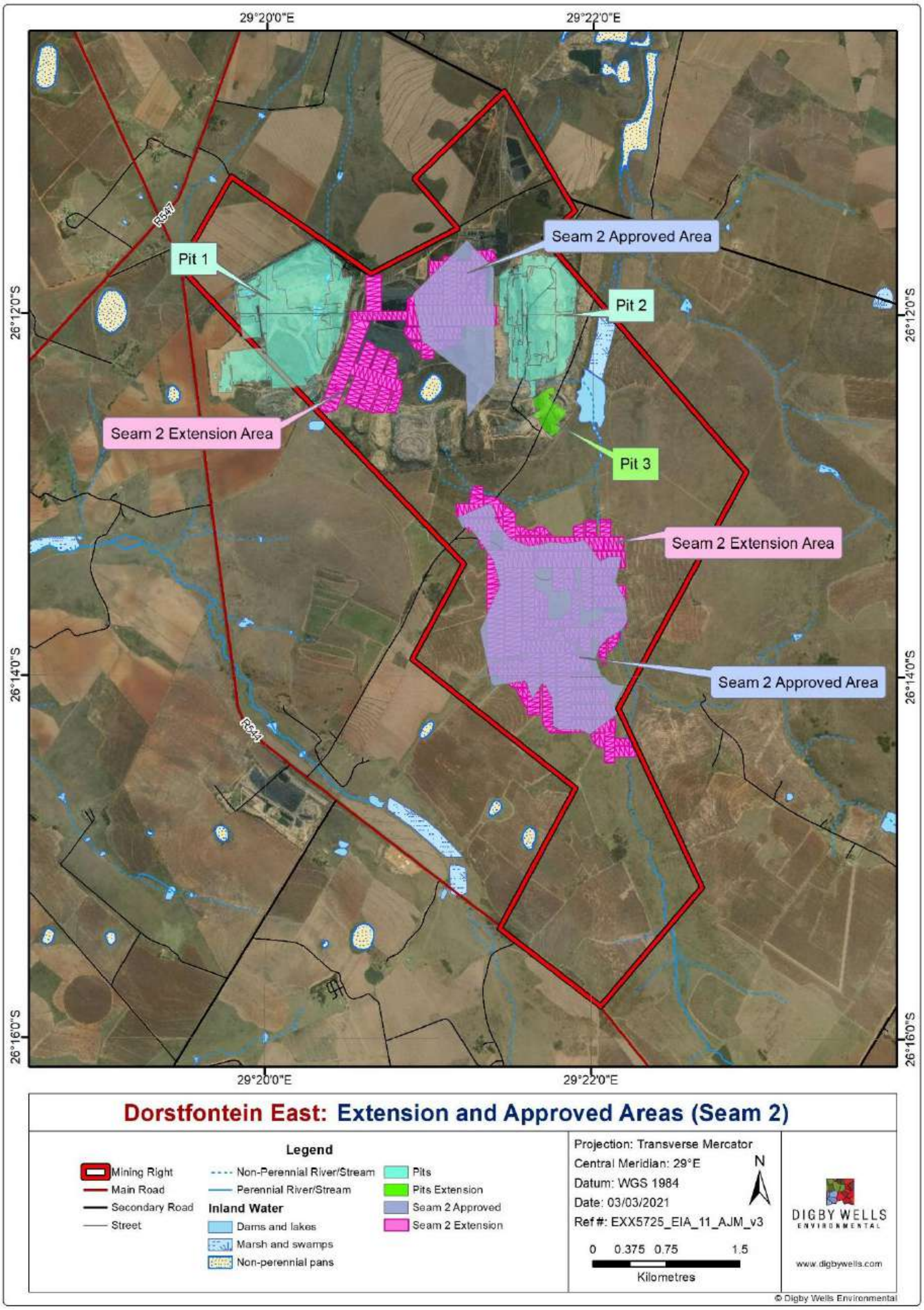


Figure 1-2: Approved and Proposed Underground Areas (Seam 2)

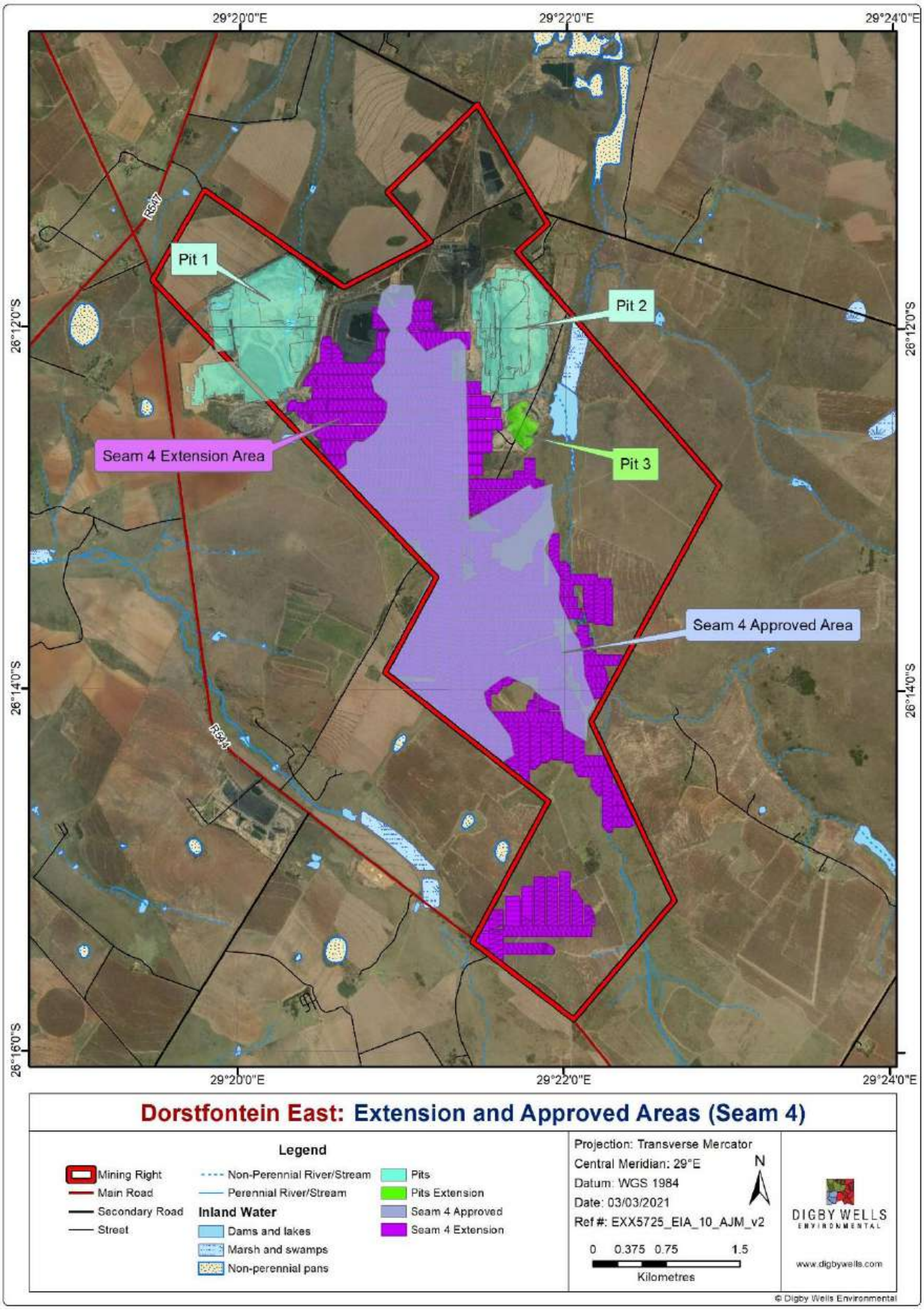


Figure 1-3: Approved and Proposed Underground Areas (Seam 4)

The Project list of activities for the construction, operation, and decommissioning phases are depicted in Table 1-1 below.

Table 1-1: Project Phases and Associated Activities

Project Phase	Project Activity
Construction Phase	Site/vegetation clearance for site establishment (infrastructure including ventilation fans, change houses, offices, ablutions, and workshops).
	In-put RoM Stockpiling.
	Access road construction.
	Power line construction.
	Construction of infrastructure.
Operational Phase	Mining of coal by underground mining.
	Blasting (only when dikes and other geological features are encountered).
	In-pit RoM Stockpiling.
	Diesel storage and explosive magazine.
	Underground Mining Machinery Maintenance.
	Operation of water and sewer reticulation.
	Use of existing haul roads.
Decommissioning Phase	Demolition and removal of infrastructure – once mining activities have been concluded infrastructure will be demolished in preparation for the final land rehabilitation.
	Rehabilitation – rehabilitation mainly consists of spreading and landscaping of the preserved subsoil and topsoil, profiling of the land, and re-vegetation.
	Post-closure monitoring and rehabilitation.

2. Scope of Work

The AQIA aimed to complete an air dispersion modelling assessment to predict the future implications of mining on the ambient air quality and exposure scenarios for nearby sensitive receptors as a result of the amendment.

Based on the above mentioned, the air quality Scope of Work (SoW) encompasses the following:

- Establishment of the site meteorology and existing background air quality;
- Assessment of the future air quality impacts of the proposed Project on ambient air quality based on the additional infrastructure and comparison of results against the regulatory standards for compliance; and

- Recommendation of management measures, including mitigation and monitoring requirements.

3. Details of the Specialist

Dr Matthew Ojelede is an air quality specialist at Digby Wells & Associates (Pty) Ltd and the Manager at the Department of Atmospheric Sciences and Noise. He holds a BSc in Geology (Hons), an MSc in Environmental Science, and a Ph.D. in Environmental Management. He is a member of the South African Council for Natural Scientific Professions (SACNASP), and the National Association for Clean Air (NACA). Matthew has authored and co-authored research articles and conference papers in both local and international peer-reviewed journals.

He has attended specialised courses in atmospheric dispersion modeling (AERMOD and CALPUFF).

4. Assumptions, Limitations and Exclusions

Assumptions, limitations, and exclusions pertaining to this Project are discussed in Table 4-1.

Table 4-1:Assumptions, Limitations and Exclusions

Assumption, Limitation, or Exclusion	Consequence
The uncertainty associated with dispersion models	Since mining activities were selected to demonstrate the worst-case scenario, the predicted model may have resulted in an overestimation

5. Relevant Legislation, Standards, and Guidelines

The legislation, regulation, and guidelines considered in this air quality report are tabulated and discussed briefly in Table 5-1. The applicable standards in terms of compliance are discussed in Section 5.1 below.

Table 5-1: Applicable Legislation, Regulations, Guidelines, and By-Laws

Legislation, Regulation, Guideline, or By-Law	Applicability
National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) The NEMA is the statutory framework to enforce Section 24 of the Constitution of the Republic of South Africa …(Section 24: ***the right to a healthy environment and the right to have the environment protected).*** The NEMA is intended to promote co-operative governance and ensure that the rights of people are upheld, but also recognising the necessity of economic development.	Principles from NEMA are relevant to air pollution, Section 24(4) b(i) … “the investigation and assessment of the potential impacts of activities that require authorisation or permission.”, and Section 24(7).

Legislation, Regulation, Guideline, or By-Law	Applicability
National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) The prevailing legislation in the Republic of South Africa with regards to the Air Quality field is the National Environment Management: Air Quality Act, 2004 (Act No. 39 of 2004) (NEM: AQA). According to the Act, the Department of Environmental Affairs (DEA), the provincial environmental departments and local authorities (district and local municipalities) are separately and jointly responsible for the implementation and enforcement of various aspects of NEM: AQA. A fundamental aspect of the new approach to air quality regulation, as reflected in the NEM: AQA is the establishment of National Ambient Air Quality Standards (NAAQS). These standards provide the goals for air quality management plans and also provide the benchmark by which the effectiveness of these management plans is measured. The NEM: AQA provides for the identification of priority pollutants and the setting of ambient standards with respect to these pollutants.	NEM:AQA puts in place various measures for the prevention of pollution and national norms and standards for the regulation of air quality in South Africa.
NEM:AQA National Dust Control Regulation 2013 (GN No. 827 of 2013) The Minister of Water and Environmental Affairs, released on 01 November 2013 the National Dust Control Regulation, in terms of Section 53, read with Section 32 of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004)(NEM:AQA). In the published National Dust Control Regulations, terms like target, action, and alert thresholds were omitted. Another notable observation was the reduction of the permissible frequency of exceedance from three to two incidences within a year. The standard adopted a more stringent approach than previously and would require dedicated mitigation plans now that it is in force.	The purpose of these Regulations is to prescribe general measures for the control of dust in all areas.
Mine Health and Safety Act, 1996 (Act No. 29 of 1996) as amended GN R 989 of 5 October 2006 The limit states the occupational exposure values for airborne pollutants with respect to occupational hygiene.	The purpose of these Regulations is to prescribe general measures for the control of airborne pollutants in workplace environment.

5.1. Applicable South African Standard

According to the World Health Organization (WHO, 2000), guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating or reducing to minimum ambient levels of pollutants that are known or likely to be hazardous to human health and wellbeing. Once the guidelines are adopted as standards, they become legally enforceable. These standards prescribe the allowable ambient concentrations of pollutants which are not to be exceeded during a specified period in a defined area. If the air quality guidelines/standards are exceeded, the ambient air quality is poor and the potential for health effects is greatest.

The NEMA provides a legislative framework for environmental management in South Africa. The principles of NEMA are relevant to air pollution, Section 24(4) b(i) … "*the investigation and* assessment of the potential impacts of activities that require authorisation or permission.", and Section 24(7).

The NEM:AQA is the prevailing legislation in the Republic of South Africa with regards to Air Quality, and forms one of the many pieces of legislation that falls under the ambit of the NEMA.

NEM:AQA puts in place various measures for the prevention of pollution and national norms and standards for the regulation of air quality in South Africa. It also authorizes the Minister of Environmental Affairs to enforce its provisions through the issuance of policy documents and regulations. As in Section 24G of NEMA, Section 22A of NEM:AQA has a provision for administrative fines for contraventions. In line with NEM:AQA, the Department of Environmental Affairs (DEA) published National Dust Control Regulations (NDCR), the acceptable dustfall (particulate matter with an aerodynamic diameter less than 45 µm (considered as Total Suspended Particulate (TSP) as described by the World Bank Group (WBG) (WBG, 1998) limits for residential and non-residential areas (GN R 827 of 1 November 2013). The dust fallout standard is given in Table 5-2 below.

Table 5-2: Dust Fall Standards (NDCR, 2013)

Restriction Areas	Dustfall rate (mg/m^2/day, 30-days average)	Permitted Frequency of exceeding dust fall rate
Residential Area	< 600	Two within a year, not sequential months
Non-Residential Area	< 1200	Two within a year, not sequential months

The DEA has established National Ambient Air Quality Standards for particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}) in Table 5-3 and particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) since June 2012 (GN R 486 of 29 June 2012) as in Table 5-4.

Table 5-3: National Ambient Air Quality Standards for Particulate Matter (PM_{10}) (2009)

National Ambient Air Quality Standard for Particulate Matter (PM_{10})			
Averaging Period	**Limit Value (µg/m^3)**	**Frequency of Exceedance**	**Compliance Date**
24 hours	75	4	1 January 2015

National Ambient Air Quality Standard for Particulate Matter (PM_{10})			
Averaging Period	**Limit Value (µg/m^3)**	**Frequency of Exceedance**	**Compliance Date**
1 year	40	0	1 January 2015
The reference method for the determination of the PM_{10} fraction of suspended particulate matter shall be EN 12341.			

Table 5-4: National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$) (2012)

National Ambient Air Quality Standards for Particulate Matter (PM2.5)			
Averaging Period	**Limit Value (µg/m^3)**	**Frequency of Exceedance**	**Compliance Date**
24 hours	40	0	1 January 2016 – 31 December 2029
24 hours	25	0	01 January 2030
1 year	20	0	1 January 2016 – 31 December 2029
1 year	15	0	01 January 2030
The reference method for the determination of $PM_{2.5}$ fraction of suspended particulate matter shall be EN 14907.			

6. Methodology

The methodology adopted in this AQIA study encompasses two components, an environmental baseline assessment and an environmental impact assessment. The baseline component characterises, mainly, the meteorology and ambient air quality of the project area. The second component involves the use of a computational air dispersion model to predict potential emissions associated with the proposed amendments and the degree of impact on the receiving environment.

6.1. Baseline Assessment

The baseline assessment examines the site and immediate surroundings, the sensitive receptors likely to be impacted, and the meteorology and background air quality of the Project area.

6.2. Project Area

The project area is approximately 3,288.53 hectares (ha) in size and located in the Mpumalanga Province, approximately 16 kilometres (km) northeast of the town of Kriel. The project area falls within the Gert Sibande and the Nkangala District Municipalities and crosses over the Emalahleni as well as the Govan Mbeki Local district municipalities.

The area is dominated by mechanised crop farming (i.e. maize), livestock farming and mining activities as the predominant land use types as observed on Google Earth Imagery® (Google Earth Pro V.7.3 (October 3, 2020)).

Figure 6-1 shows the Project boundary and historical dust monitoring locations. These monitoring points were selected as sensitive receptors. According to the United States Environmental Protection Agency (USEPA), 2016, a sensitive receptor encompasses but is not limited to "*hospitals, schools, daycare facilities, elderly housing, and convalescent facilities. The aforementioned are locations where the occupants are more susceptible to airborne pollutants" if exposed*.

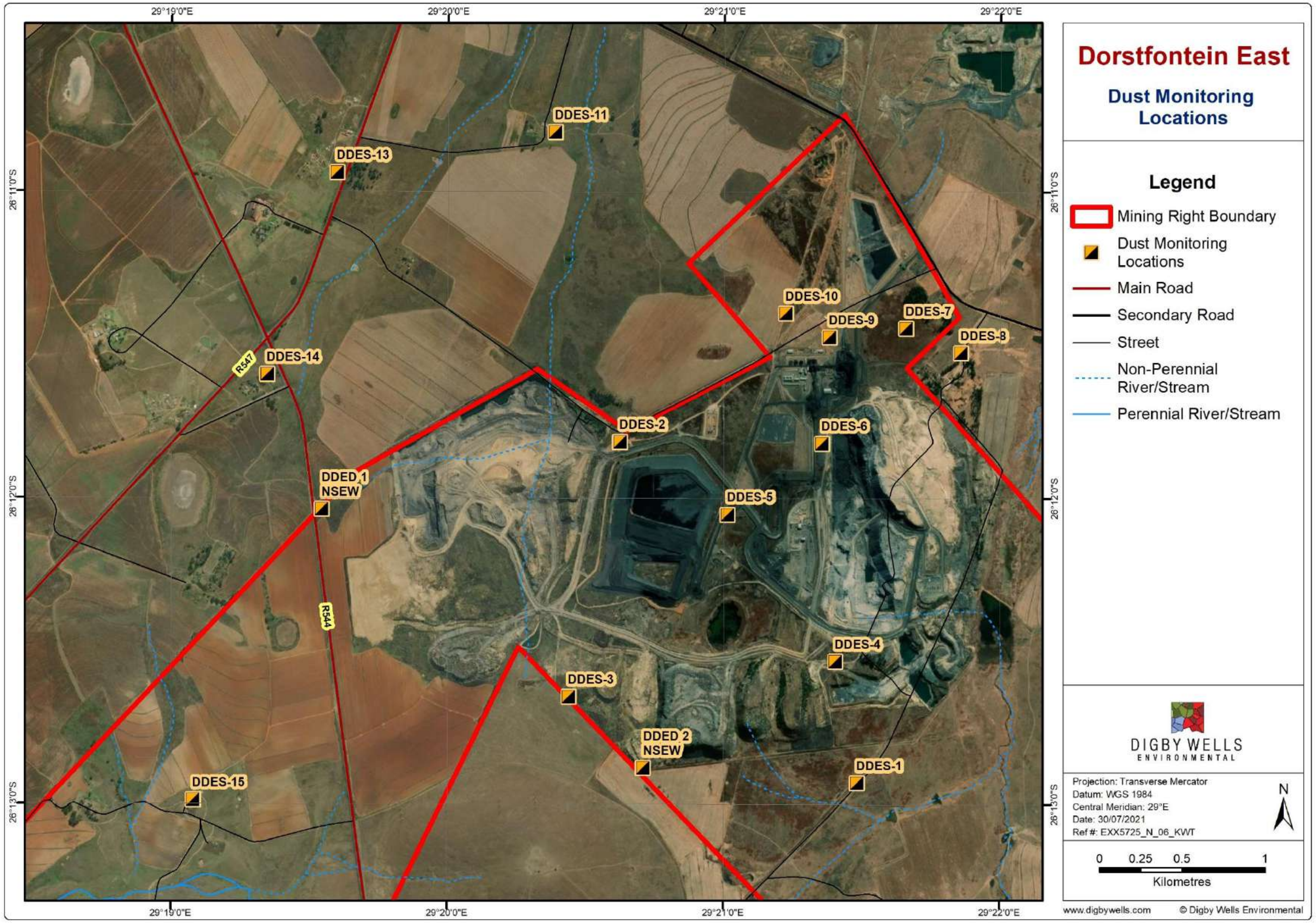


Figure 6-1: Project Boundary Showing Surrounding Receptors and Dust Monitoring Locations

6.3. General Description of Climate in the Project Area

Site-specific MM5 modeled meteorological data set for three years (2017-2019) obtained from Lakes Environmental Software was used to assess the prevailing weather conditions. The Pennsylvania State University / National Centre for Atmospheric Research (PSU/NCAR) mesoscale model (known as MM5) is a limited-area, non-hydrostatic, terrain-following sigma-coordinate model, which was designed to simulate or predict mesoscale atmospheric circulation. Meteorological data for a point in the proposed project area 18 km east southeast of Delmas (26.208678 S, 28.861028 E) was obtained. Data availability was 100%.

Wind roses comprise 16 spokes which represent the directions from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence. The figure given at the bottom of the legend describes the frequency with which calms conditions (wind speed below 0.5 m/s) occur. The meteorological data assessed encompasses temperature, relative humidity, wind speed, and direction, and are discussed (Table 6-1).

6.3.1.1. Temperature

The monthly temperature (3-year average) is presented in Table 6-1 and Figure 6-3. The data indicates that the monthly temperature maximum varied between 18°C - 30°C, and the minimum between 20°C - 9°C. Ambient temperatures were observed to be higher during the summer months.

6.3.1.2. Rainfall

The total monthly rainfall records (3-years average) are provided in Table 6-1 and Figure 6-2. Based on the rainfall data, the summer months (December – February) received much of the rains (i.e. >68%) (Figure 6-2), followed by Spring with 23% and Autumn with 9%. While winter (June – August), with no rainfall in winter (less than 0%).

6.3.1.3. Relative Humidity

The relative humidity records (3-year average) ranged between 73% and 90% (Table 6-1 and Figure 6-3). Ravi et al., (2006)[1], investigated the effect of near-surface air humidity on soil erodibility. Results show that the *threshold friction velocity* required for fine particulate matter to be airborne decreases with increasing values of relative humidity between about 40% and 65%, while above and below this range the threshold friction velocity increases with air humidity i.e. In air-dry soils (RH < 65%), the soils are too dry for the liquid-bridge bond to exist. However, with humidity conditions (RH > 65%) water condenses into liquid and forms bridges between the soil grains and then the liquid-bridge bonding dominates, increasing the *threshold friction velocity*.

[1] Ravi S; Zobeck TM; Over TM; Okin GS; D'Odorico P (2006) On the effect of moisture bonding forces in air-dry soils on threshold frictional velocity of wind erosion. *Sedimentology, 53, 597-609*

Table 6-1: Climate Statistics

Parameters		3-year average												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Temp. (◦C)	Max	30	28	27	26	20	18	18	21	25	28	28	30	25
	Min	20	20	19	16	12	9	9	12	15	17	19	20	16
Total Mon. Rain (mm)		199	132	72	12	2	0	0	9	31	46	92	172	766
Rel. Hum. (%)		90	89	81	95	79	73	83	77	91	82	79	81	83

(Source: Lakes Environmental)

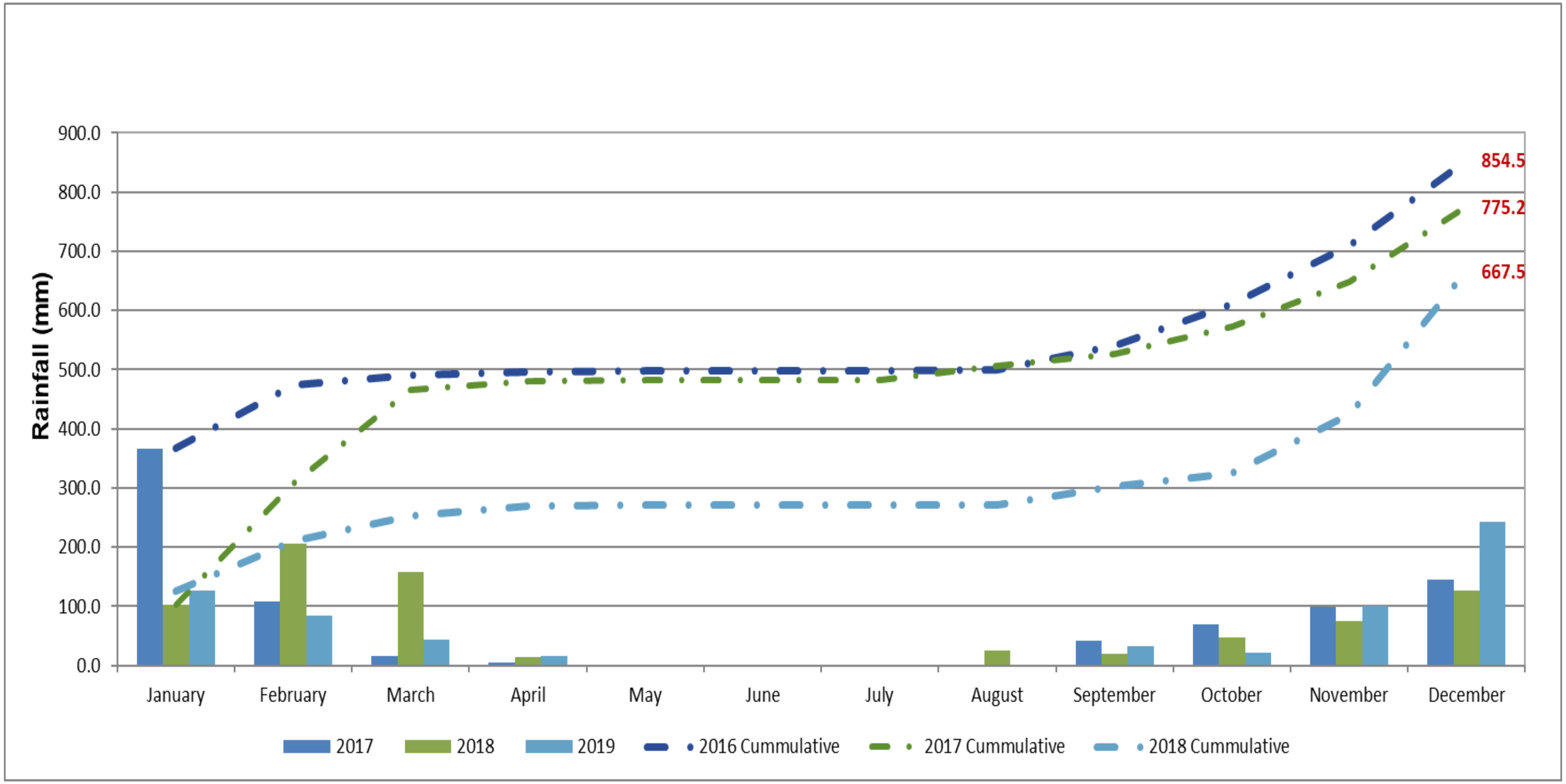


Figure 6-2: Rainfall

(Source: Lakes Environmental)

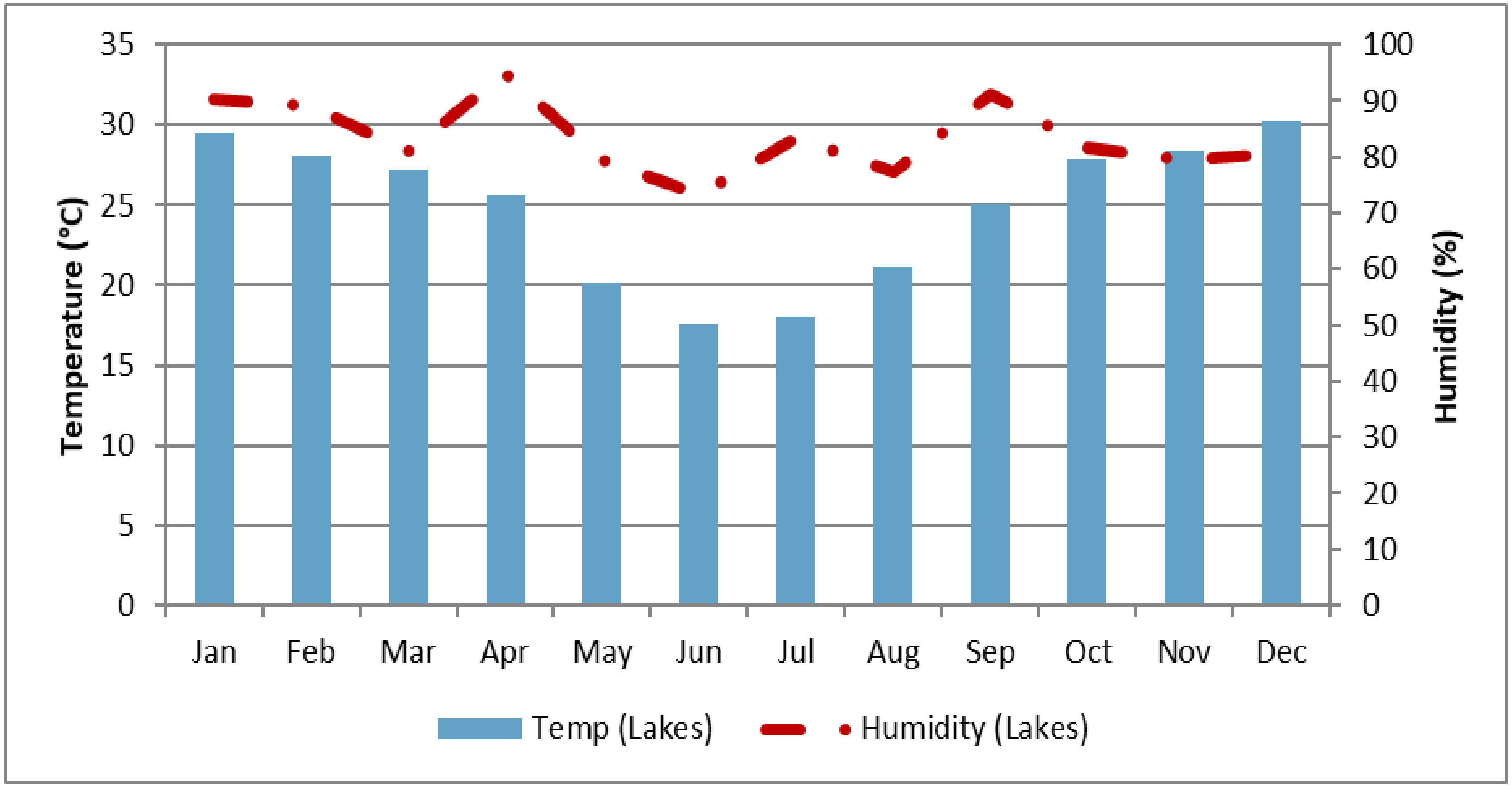


Figure 6-3: Monthly - Temperature and Humidity

(Source: Lakes Environmental)

6.3.1.4. Wind Speed

Hourly meteorological data was analysed and used to understand the prevailing wind patterns at the project area. Data was used to assess the wind speed and wind direction regime on site.

The wind rose for the project area is depicted in (Figure 6-4). The prevailing winds are from the east northeast (10.5%) and northwest (9.6%) respectively. Secondary contributions are from the north northwest (8.8%) and east (8.1%).

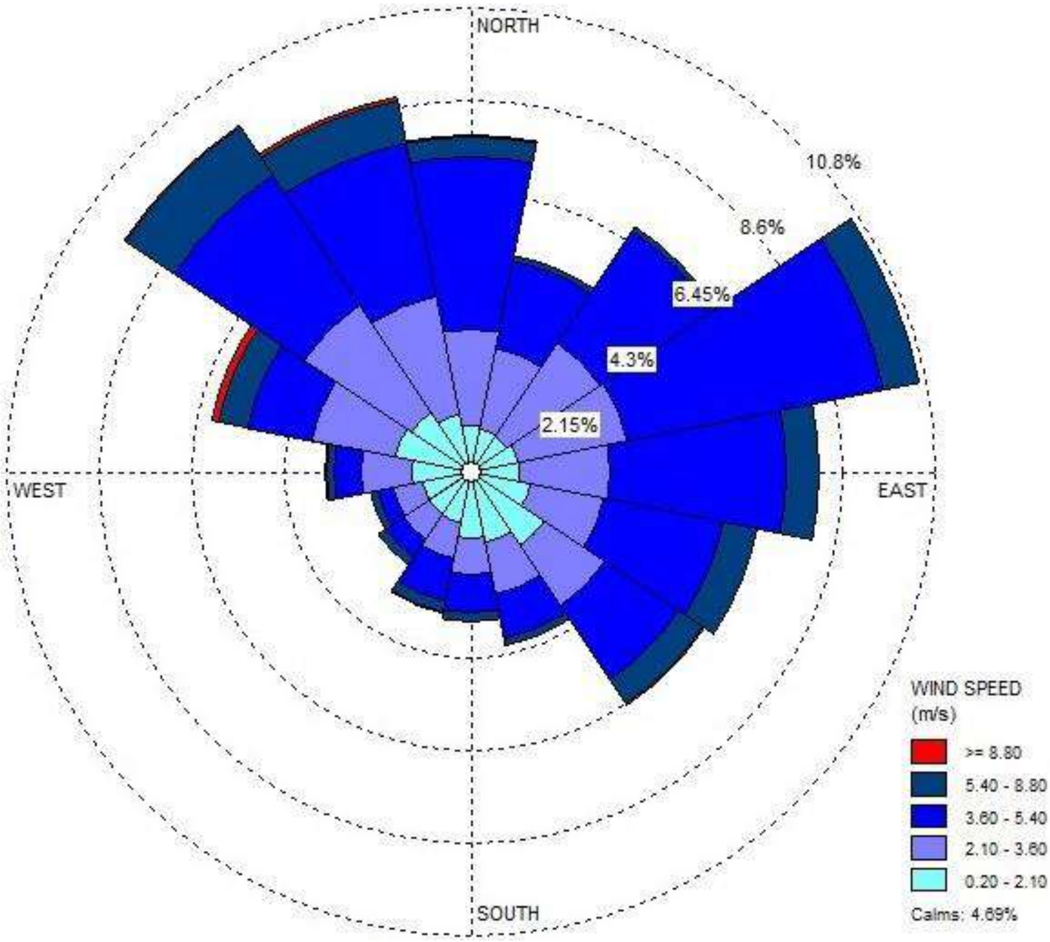


Figure 6-4: Surface Wind Rose

(Source: Lakes Environmental)

The average wind speed at the project site is 3.2 m/s and calm conditions (<0.5 m/s) occurred for some 4.7% of the time. Wind speed capable of causing wind erosion i.e. ≥5.4 m/s occurred for about 7.9% of the time (Figure 6-6). This equates to about 29 days of high wind speed each year. Based on the statistics, 12 days in spring experience wind speed greater than 5.4 m/s, seven days in winter, seven days in summer, and three days in autumn. The frequency of winds from a particular direction and the seasonal variability in wind speed pattern is shown in Figure 6-5.

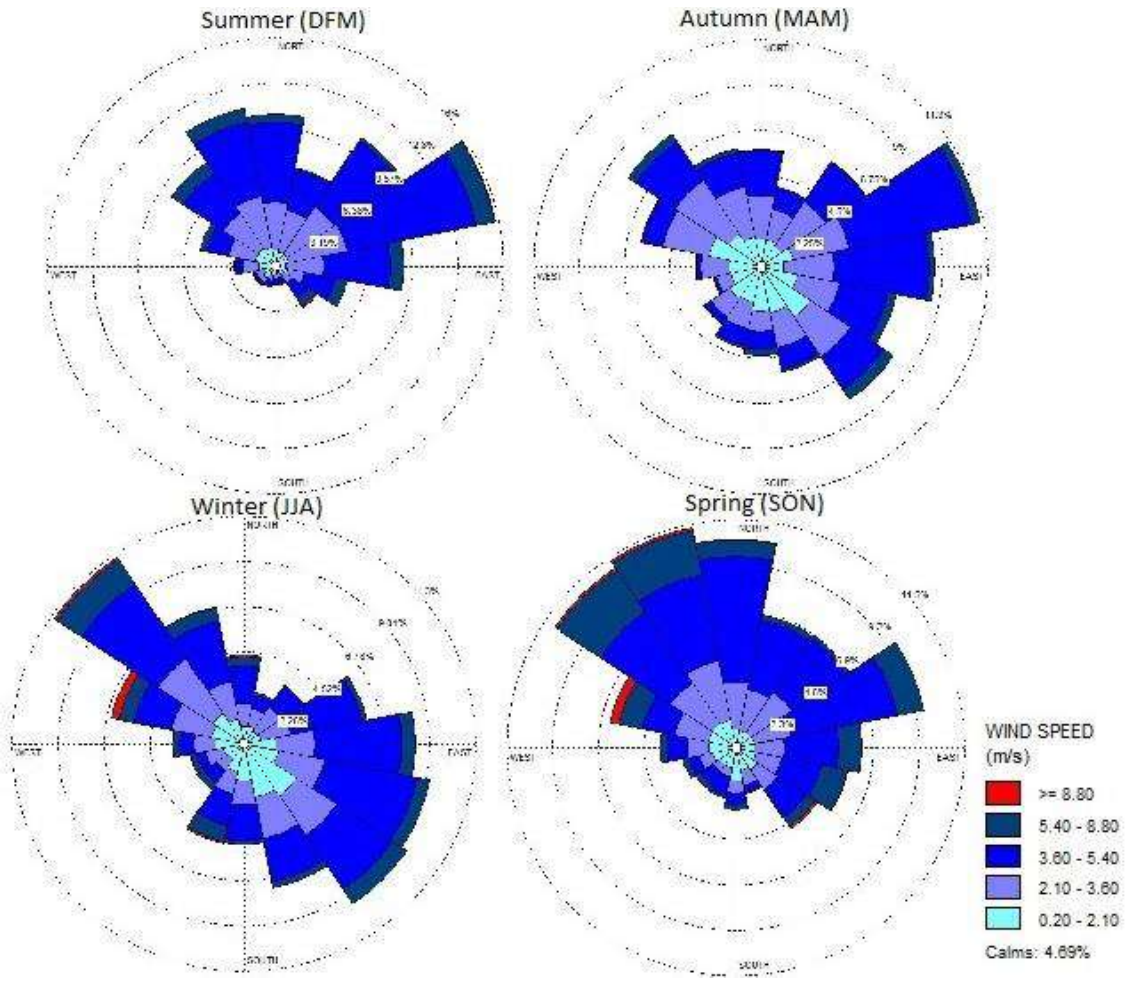


Figure 6-5: Seasonal Wind Roses

(Source: Lakes Environmental)

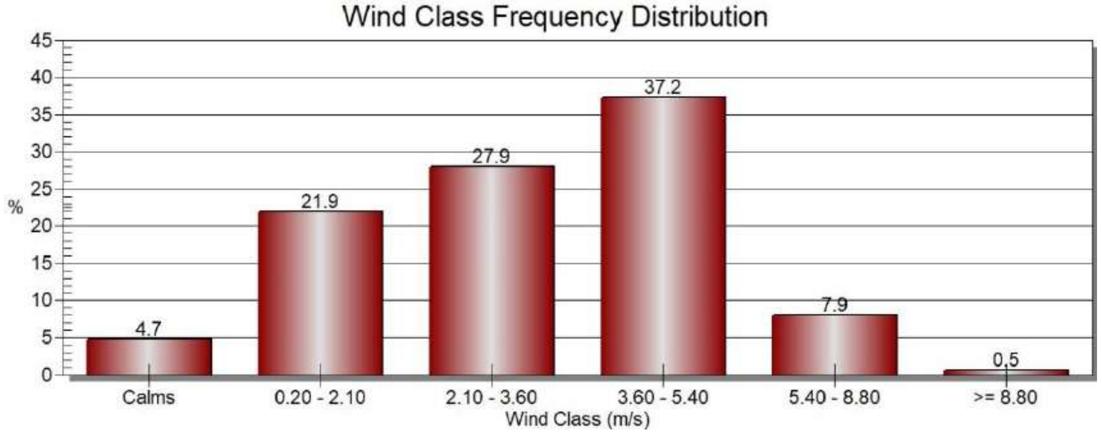


Figure 6-6: Wind Class Frequency

(Source: Lakes Environmental)

6.3.2. Assessment of Existing Air Quality

6.3.2.1. Dustfall

Archived dust deposition data collected using the American Standard Test Method (ASTM D1739) in the project area was used to assess background air quality. Data for 19 months, from January 2018 to July 2019 were obtained from the archive records. The graph showing the results is depicted below (Figure 6-7 and Figure 6-8). Most of the monitoring sites are categorised as a non-residential site with two residential sites (DDES-15 and M-DDED-2). The dustfall rates were compared with the South African *Dust standards* (GN R 827 of 1 November 2013) for compliance.

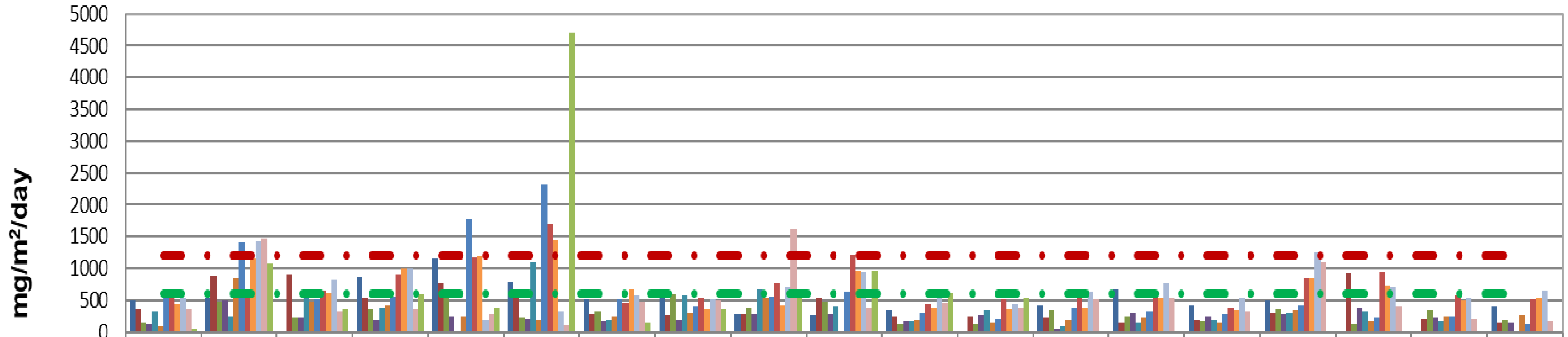
Based on the dustfall results, the sites where exceedances of the residential limits were measured and in sequential months (i.e. non-compliant) are discussed below in sequential order:

- DDES-2 (2018): the dustfall rates measured at this site were in exceedance of the non-residential limit of 1200 $mg/m^2/d$ in October (1432 mg/m^2d) and November (with 1456 mg/m^2d). Therefore, the site is not compliant due to the sequential exceedances measured;
- DDES-6 (2018): the dustfall rates measured at this site were in exceedance of the non-residential limit of 1200 $mg/m^2/d$ in July (with 2309 mg/m^2d), August (with 1695 mg/m^2d) and September (with 1436 mg/m^2d). Therefore this site was not compliant as exceedances occurred in sequential months; and
- M-DDED-2 (2018): the dustfall rates measured at this site were in exceedance of the residential limit of 600 $mg/m^2/d$ in August (with 944 mg/m^2d), September (with 737 mg/m^2d) and October (with 704 mg/m^2d). Therefore this site was not compliant as exceedances occurred in sequential months.

In 2019, although exceedances were measured for some months, not a single sequential exceedance was measured. However, there were a lot of missing data in 2019, with a 44% data recovery.

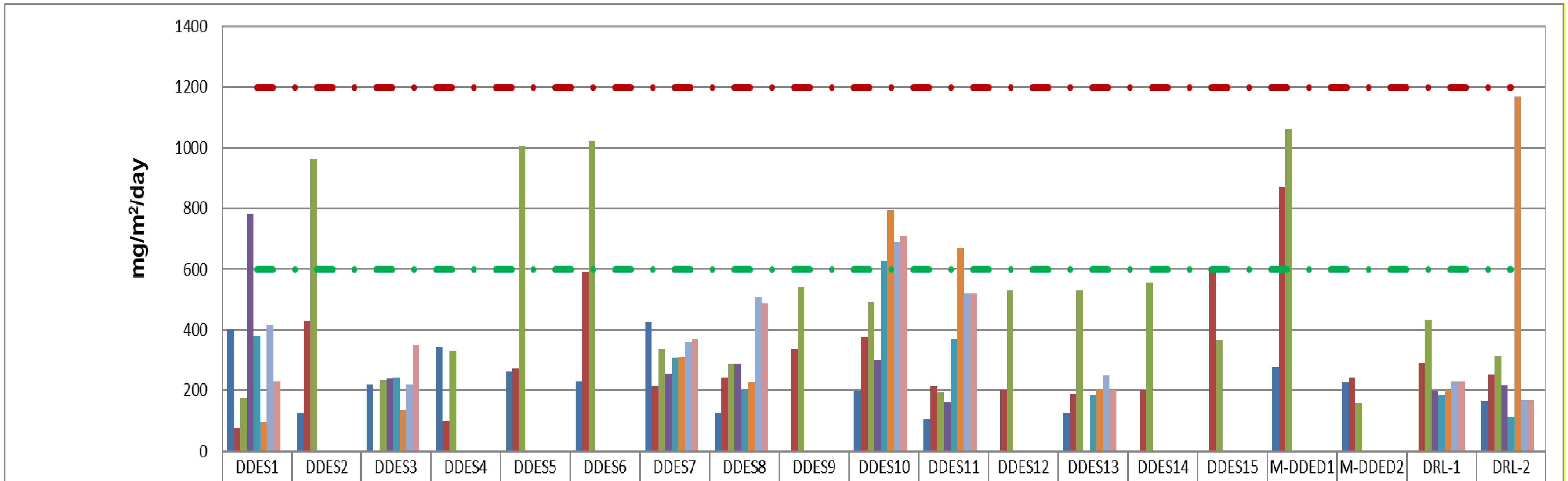
6.3.2.2. Fine Particulate Matter and Gasses

Data for fine particulate matter with an aerodynamic diameter of less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$), and gaseous pollutants such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone (O_3) were not available for assessment.



	DDES1	DDES2	DDES3	DDES4	DDES5	DDES6	DDES7	DDES8	DDES9	DDES10	DDES11	DDES12	DDES13	DDES14	DDES15	M-DDES1	M-DDES2	DRL-1	DRL-2
Jan-18	498	533	0	859	1153	784	509	661	284	261	350	0	417	676	413	494	0	0	395
Feb-18	361	893	903	532	757	547	276	263	285	529	244	247	220	147	181	295	930	205	149
Mar-18	138	472	220	359	552	231	321	599	387	478	135	135	334	245	162	360	133	346	189
Apr-18	129	502	216	190	247	207	167	177	283	291	175	268	58	300	248	292	376	221	155
May-18	316	238	633	386	0	1099	177	568	678	391	166	346	97	155	193	306	325	160	0
Jun-18	96	839	468	427	243	184	235	302	529	0	181	152	193	231	155	340	157	237	257
Jul-18	587	1403	519	555	1774	2309	511	390	560	635	299	196	375	312	290	427	222	235	122
Aug-18	571	530	646	904	1183	1695	463	526	760	1214	437	507	526	595	384	852	944	579	520
Sep-18	429	1158	612	998	1188	1436	661	365	415	952	386	368	376	542	349	843	737	488	530
Oct-18	535	1432	825	1009	186	318	581	511	717	947	601	439	627	763	533	1251	704	533	655
Nov-18	352	1456	320	359	286	113	473	492	1627	388	466	385	519	526	315	1100	394	205	170
Dec-18	53	1072	355	592	388	4698	143	358	668	963	604	543							
Residential standard	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Industrial standard	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200

Figure 6-7: Dustfall Results for 2018



	DDES1	DDES2	DDES3	DDES4	DDES5	DDES6	DDES7	DDES8	DDES9	DDES10	DDES11	DDES12	DDES13	DDES14	DDES15	M-DDED1	M-DDED2	DRL-1	DRL-2
Jan-19	404	125	219	344	262	231	426	125	0	197	107	0	126	0	0	278	227	0	165
Feb-19	78	427	0	99	271	590	214	244	336	376	215	199	186	201	594	872	244	292	252
Mar-19	175	962	232	330	1005	1020	337	287	539	489	193	530	530	554	368	1061	157	431	313
Apr-19	781		239				256	289		301	161							197	216
May-19	379		244				307	204		628	369		183					183	113
Jun-19	95		137				310	226		793	671		204					202	1168
Jul-19	416		221				360	507		689	519		250					229	167
Aug-19	230		350				371	488		710	520		201					230	169
Dec-19																			
Residential standard	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Industrial standard	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200

Figure 6-8: Dustfall Results for 2019

6.4. Air Quality Impact Assessment

The NEM: AQA regulation regarding Air Dispersion Modelling (GN R 533 of 11 July 2014) informed the assessment approach adopted. A Level 3 assessment was used, which required detailed meteorological geophysical and source input data.

6.4.1. Impact Assessment Approach

The approach used to determine the future impacts from the operational phase of the Project and related activities is provided in Figure 6-9.

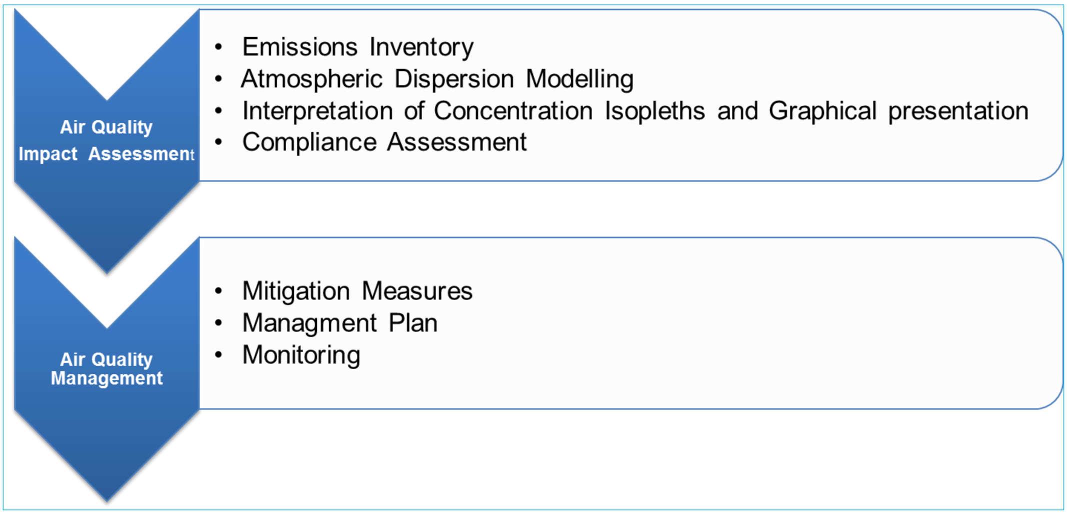


Figure 6-9: Air Quality Impact Assessment Methodology

During the impact assessment, tasks to be completed included the development of an emissions inventory, followed by model simulations to predict Ground Level Concentration (GLC) of criteria pollutants. The model outputs were used to assess compliance with regulatory standards and inform the mitigation and management measures recommended, as well as monitoring requirements to assess the efficiency of the mitigation measures.

6.4.1.1. Emissions Inventory

The development of an emissions inventory forms the basis for any conceptual model. Emission rates are typically obtained using actual sampling equipment at the point of emission or are estimated from mass and energy balances or emission factors that have been established at similar operations. The latter was followed, employing emission factors published by the USEPA in its *AP-42* "Compilation of Air Pollution Emission Factors" (USEPA, 1995; 1998; 2016) and Australian National Pollutant Inventory (*NPi*) "Emission Estimation Technique (EET, 2012)" manuals were employed.

Quoting directly from the USEPA AP-42 (2016), …" *air pollutant emission factors are representative values that attempt to relate the quantity of a pollutant released to the ambient air with an activity associated with the release of that pollutant. These factors are usually* *expressed as the weight of the pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. Such factors facilitate the estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages*".

The equations and parameters used in the calculations of the emissions anticipated from the various sources within the mine during operation are discussed in Table 6-2.

Table 6-2: Emission Factor Equations

Activity	Emission Equation	Source	Information assumed/provided
Materials handling (including conveying)	$EF_{TSP\,(kg/t)} = k_{TSP} \times 0.0016 \times \frac{\left(\frac{U_{(m/s)}}{2.2}\right)^{1.3}}{\left(\frac{M_{(\%)}}{2}\right)^{1.4}}$ Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%) The KTSP:0.74; KPM10:0.35 respectively. An average wind speed of 3.1 m/s was used based on the Lakes Environmental data for the period 2017 – 2019.	US-EPA AP42 Section 13.2.4	The moisture content of the materials are as follows: Ore: 4.5% Hours of operation were given as 24 hrs per day, 7 days per week.
Vehicle entrainment on unpaved surfaces	$EF_{(\frac{KG}{VKT})} = \frac{0.4536}{1.6093} * k * (\frac{s(\%)}{12}) a * (\frac{w(t))}{3}) b$ Where, E = particulate emission factor in grams per vehicle km traveled (g/VKT) k = basic emission factor for particle size range and units of interest s = road surface silt content (%) W = average weight (tonnes) of the vehicles traveling the road = 40 t side truck The particle size multiplier (k) is given as 0.15 for PM2.5 and 1.5 for PM10, and as 4.9 for TSP The empirical constant (a) is given as 0.9 for PM2.5 and PM10, and 4.9 for TSP	US-EPA AP42 Section 13.2.2	Default silt content: Mine Road: 8.6% Hours of operation were assumed as 24 hrs per day, 7 days per week. The layout of the haul roads was assumed to be 20 m wide.

Activity	Emission Equation	Source	Information assumed/provided
	The empirical constant (b) is given as 0.45 for PM2.5, PM10, and TSP		
Wind Erosion	$E_{TSP} = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365-p}{235}\right) \times \left(\frac{f}{15}\right)$	USEPA, 1998	Silt content: 6.9% (Assumed)
Drilling	$0.59 \frac{kg}{hole}$	NPi 1999	
Blasting	$0.000014(A)^{1.5}$	USEPA, 1998	Blasting two times a week (Assumed)
Crusher	Primar High moisture (TSP:0.01; PM10:0.004) Low moisture (TSP:0.2; PM10:0.02) Secondary High moisture (TSP:0.03; PM10:0.012) Low moisture (TSP:0.6; PM10:No data)	NPI EET Manual for Mining (NPI, 2012)	
Tipping	$E_{TSP} = 0.74 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \times \left(\frac{M}{2}\right)^{-1.4}$ $E_{PM10} = 0.35 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \times \left(\frac{M}{2}\right)^{-1.4}$	US-EPA AP42 Section 13.2.4	The silt contents of materials are as follows: Topsoil: 6.9% (Assumed) U = mean wind speed in m/s: 3.17 m/s M = moisture content (4.5 %)
Processing Plant Dryer Exhaust	PM_{10}: mg/Nm^3 $PM_{2.5}$: mg/Nm^3		Parameters applied: Exit temperature:425.4°C Exit Velocity: 2.5 m/s Release height: 10 m Volumetric flow rate: 38,8 m^3/s

Coal mine ventilation systems are usually designed to maintain healthy and safe atmospheric working conditions underground. The aforementioned, help provide fresh air to the miners, to ensure that toxic, noxious, and explosive gases and dusts are diluted by fresh air and are subsequently expelled to the surface via the ventilation system. The parameters adopted for the ventilation shaft are indicated in Table 6-3 and Table 6-4, and emissions from the shaft were considered as a point source.

Table 6-3: Parameters adopted for the Ventilation Shafts

Source	Diameter (m)	Release Height (m) (1)	Volumetric Flow rate (m^3/s)	Exit Velocity (m/s) (2)	Exit temperature (K) (3)
Up cast shaft	3	6	92	13	298

Table 6-4: MHSA OEL (2006)

Pollutant	Occupational Limit	Emissions Rate
	(mg/Nm^3)	(g/s)
CO	35	17.5
NO_2	5	2.5
SO_2	5	2.5
PM_{10}	10	5.0
$PM_{2.5}$	3	1.5

6.4.1.2. Air Quality Dispersion Modelling and Data Requirements

6.4.1.2.1. Meteorological Data Requirements

Dispersion models compute ambient concentrations as a function of source configurations, emission rates, and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in GLCs of pollutants arising from the emissions of various sources.

An AERMOD modeling system incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including both surface and elevated sources, and of simple or complex terrain.

Three years' worth of MM5 modeled meteorological data were obtained from Lakes. This dataset consists of surface and upper air meteorological data required to run the dispersion model.

6.4.1.2.2. Modelling Domain

The AERMAP terrain pre-processor requires the user to define a modeling domain. The modeling domain is defined as the area that contains all the receptors and sources being modeled with a buffer, to accommodate any significant terrain elevations.

The influence of the terrain will vary with the source height and position and the local meteorology. Table 6-5 gives an overview of meteorological parameters and basic setup options for the AERMOD model runs.

AERMOD's three models and required model inputs are described below:

- AERMET: calculates boundary layer parameters for input to AERMOD:
  - Model inputs: wind speed; wind direction; cover; ambient temperature; albedo; surface roughness; and Bowen ratio.
- AERMAP: calculates terrain heights and receptor grids for input to AERMOD:
  - Model inputs: Digital elevation model data [x,y,z]; design of receptor grid; and
  - Model outputs for AERMOD: [x,y,z] and hill height scale for each receptor.
- AERMOD: calculates temporally-averaged air pollution concentrations at receptor locations for comparison to the relevant standard:
  - Model inputs: source parameters (from permit application); boundary layer meteorology (from AERMET); and receptor data (from AERMAP).

Table 6-5: Summary of Meteorological and AERMET Parameters

Number of grids (spacing)	200 m
Number of grids points	121 x 121
Years of analysis	January 2017 to December 2019
Centre of analysis	Kriel (26.218064 S; 29.352994 E)
Meteorological grid domain	20 km (east-west) x 20 km (south-north)
Station Base Elevation	1584 m
MM5-Processed Grid Cell (Grid Cell Centre)	26.218064 S; 29.352994 E
Anemometer Height	14 m
Sectors	The surrounding area land use type was cultivated
Albedo	0,33
Surface Roughness	0,27
Bowen Ratio	4,8
Terrain Option	Flat

6.4.1.3. Impact Assessment Ranking

Based on the predicted GLC of various pollutants and the spread across the mining landscape, the impact assessment ranking methodology in Appendix A was applied in rating impacts of the project on the surrounding air quality.

7. Findings and Discussion

7.1. Baseline Results

The meteorology of the project area was assessed with three years' worth of data. The wind rose for the Project area is depicted in (Figure 6-4). The prevailing winds are from the east northeast (10.5%) and northwest (9.6%) respectively. Secondary contributions are from the north northwest (8.8%) and east (8.1%).

The average wind speed at the project site is 3.2 m/s and calm conditions (<0.5 m/s) occurred for some 4.7% of the time. Wind speed capable of causing wind erosion i.e. ≥5.4 m/s occurred for about 7.9% of the time. This equates to about 29 days of high wind speed each year. Based on the statistics, 12 days in spring, seven days in winter, seven days in summer, and three days in autumn experience wind speed greater than 5.4 m/s.

The dustfall rates measured in the proposed project area were used to understand the air quality scenario. The sites that were non-compliant with the non-residential limit were DDES-2 and DDES-6 (experienced exceedances in sequential months) and M-DDES-2 (experienced exceedances sequential months). In general, more than 95th percentile of the dustfall rates measured were below the limit values.

7.2. Dispersion Model Simulation Results

The model results consist of a graphical presentation of GLC (in a unit of µg/m^3) for the different pollutants, and for dust deposition rates (mg/m^2/d). The daily averages were calculated as the 4th highest value (99th percentile). Annual averages were shown as the 1st highest value (100th percentile).

7.3. Isopleth Plots and Evaluation of Results

7.3.1. Predicted GLC of $PM_{2.5}$

The predicted GLC of $PM_{2.5}$ over a 24-hour averaging period for the operational phase returned simulation isopleths that are shown in Figure 7-1 ($PM_{2.5}$ daily) and Figure 7-2 ($PM_{2.5}$ annual).

The model simulations show the worst-case scenario (assuming no mitigation measures were put in place). The areas where exceedances of the 24-hour standard (40 µg/m^3) are confined within the MR boundary (Figure 7-1). The predicted GLC at the sensitive receptors (DDES-6 (non-residential), DDES-12 (residential), DDES-13 (residential), and DDES14 (residential) will be lower than the daily standard (Table 7-1). The annual GLC of $PM_{2.5}$ predicted will not exceed the regulatory standard at the selected receptors ((Table 7-1).

7.3.2. Predicted GLC of PM_{10}

The predicted GLC of PM_{10} over a 24-hour averaging period returned simulation isopleths shown in Figure 7-3 (PM_{10} daily) and Figure 7-4 (PM_{10} annual).

The area where the 24-hour standard of 75 µg/m³ will be confined within the MR boundary. This can be seen in Figure 7-3 below. The predicted GLC at the nearest sensitive receptors DDES-6, DDES-12, DDES-13, and DDES14 were lower than the daily standard (Table 7-1). The predicted annual isopleth showed that areas, where exceedance will occur, are confined to within the MR boundary during operation (Figure 7-4).

7.3.3. Predicted Dustfall Rates

The predicted dustfall rates are shown in Figure 7-5 (without mitigation and with mitigation). The predicted dustfall rates confirmed that the non-residential limit of 1,200 mg/m^2/d will be exceeded mostly within the MR boundary. With mitigation in place, the predicted dustfall rates at the selected receptors were lowered significantly (Table 7-1).

Table 7-1: Predicted Concentrations of PM_{10}, $PM_{2.5}$ and Dust Deposition Rates at Selected Sensitive Receptors

Pollutants	Averaging Period	South Africa Air Quality Standard (µg/m³)	Predicted Ground Level Concentration (µg/m³)			
			DDES-6	DDES-12	DDES-13	DDES-14
$PM_{2.5}$ (No Mitigation)	Daily	40(1)	7.8	1.7	4.4	5.7
	Annual	20(1)	0.8	0.2	0.4	0.5
PM_{10} (No Mitigation)	Daily	75(1)	47.8	8.4	21.5	29.5
	Annual	40(1)	4.5	0.9	2.1	2.6
Dust Deposition Rates (mg/m²/day)						
Dust (No Mitigation)	Monthly	Residential (600(2)) Non-residential (1200(2))	836	139	357	463
Dust (With Mitigation)			85	13	32	42

1. South African National Ambient Air Quality Standards, 2009;2012
2. South African National Dust Control Regulation, 2013 (NDCR)

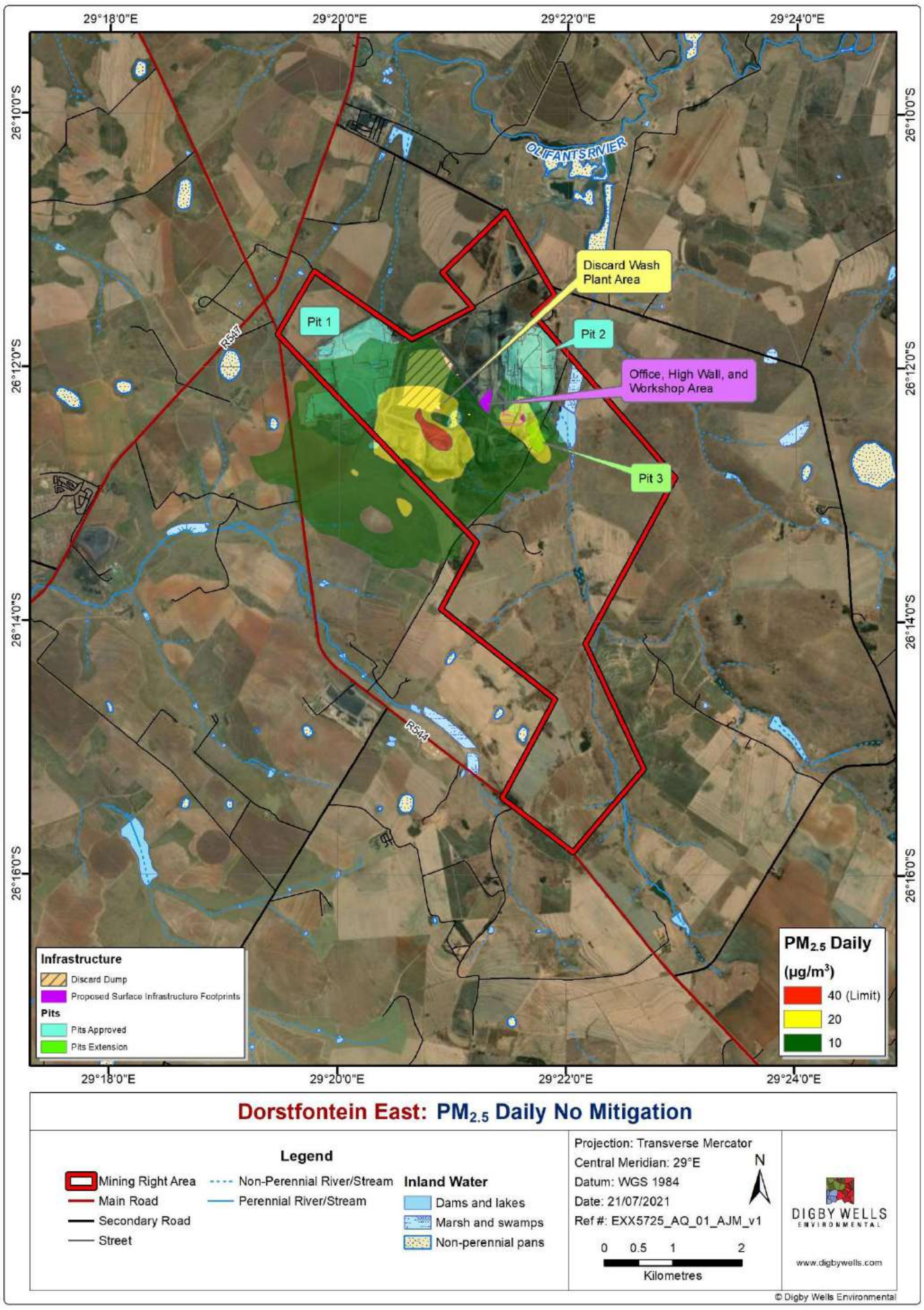


Figure 7-1: Predicted 4th highest (99th percentile) daily $PM_{2.5}$ Concentrations (µg/m³)

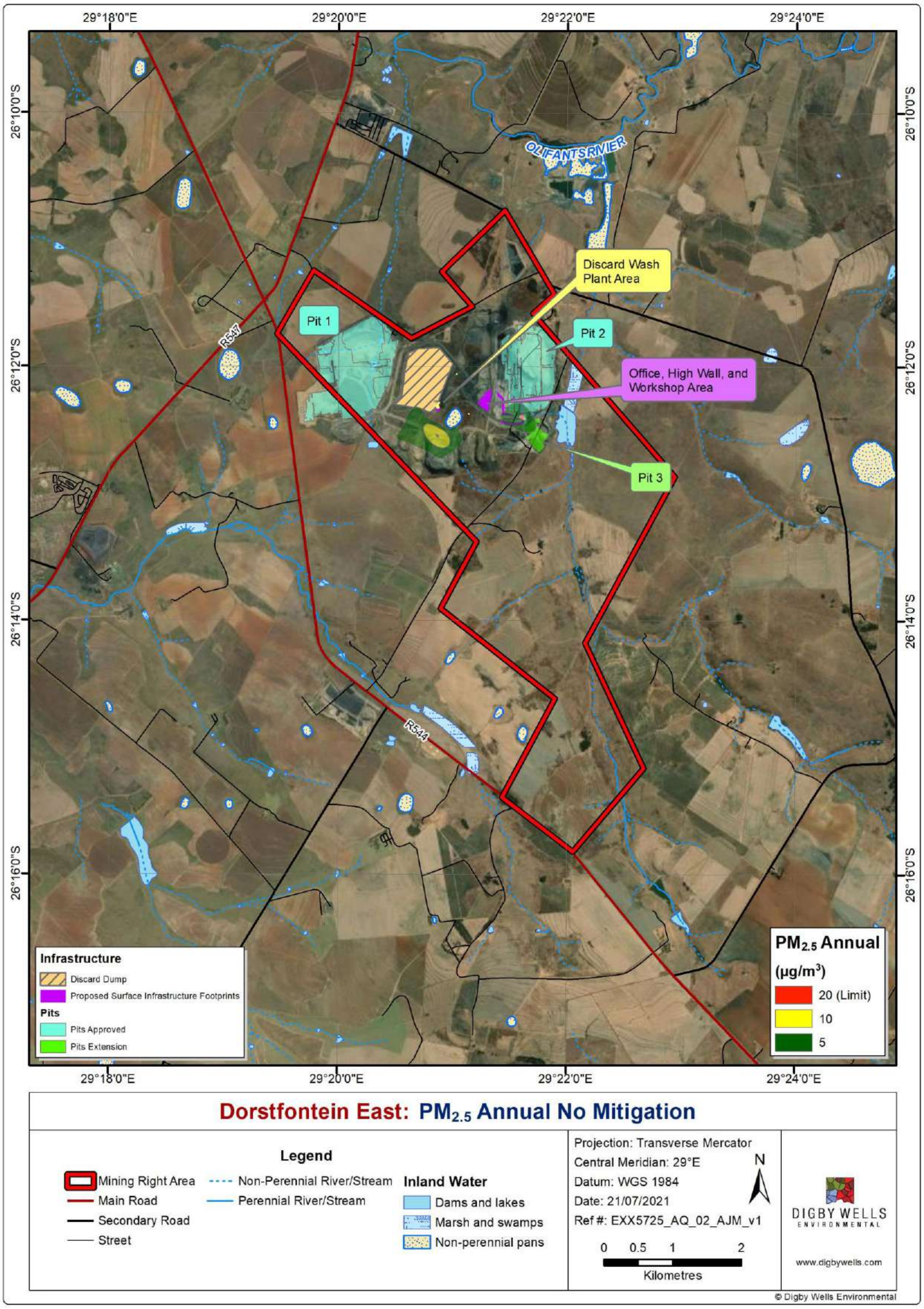


Figure 7-2: Predicted 1st highest (100th percentile) Annual PM2.5 Annual Concentrations (µg/m³)

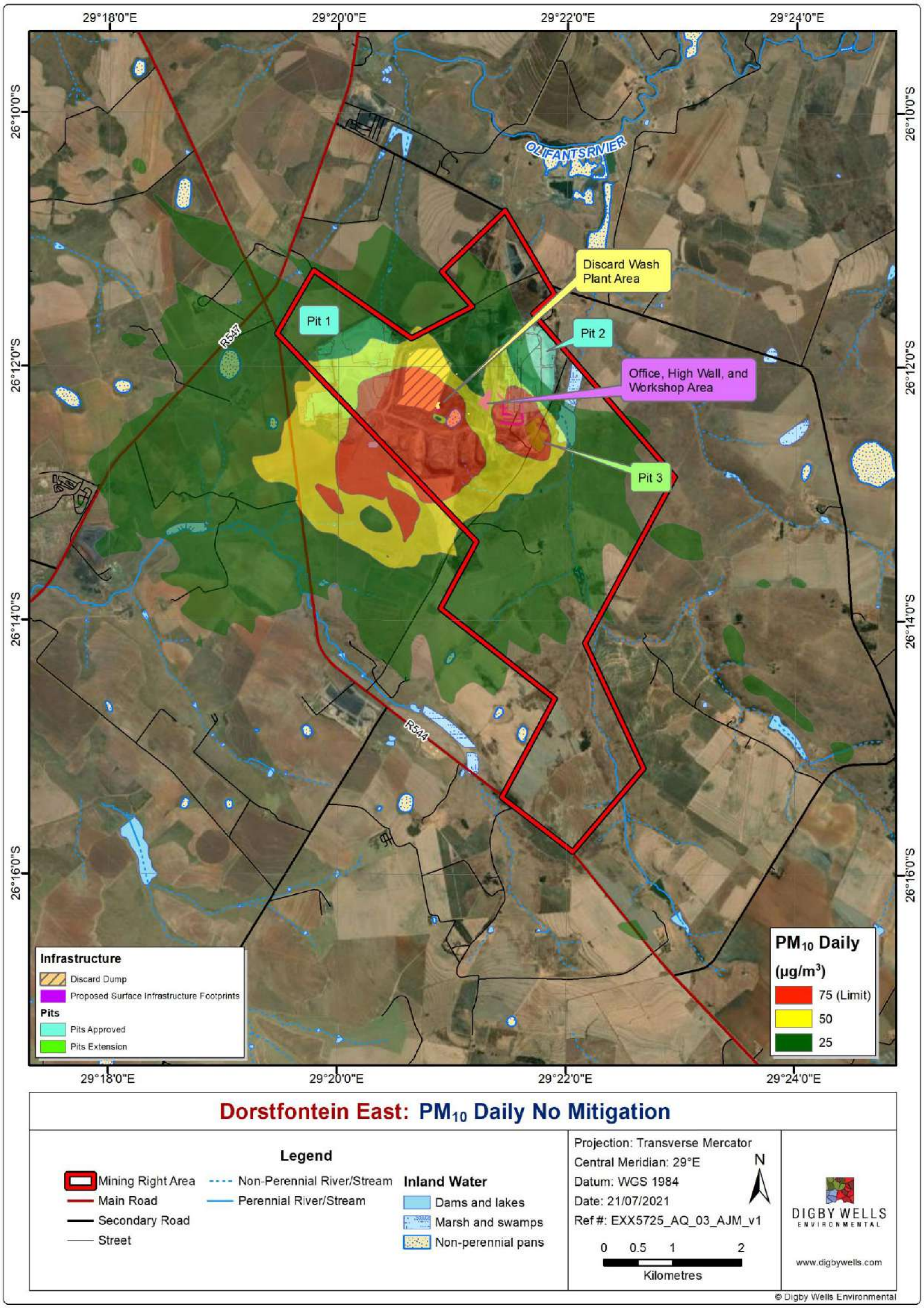


Figure 7-3: Predicted 4th highest (99th percentile) daily PM_{10} Concentrations ($\mu g/m^3$)

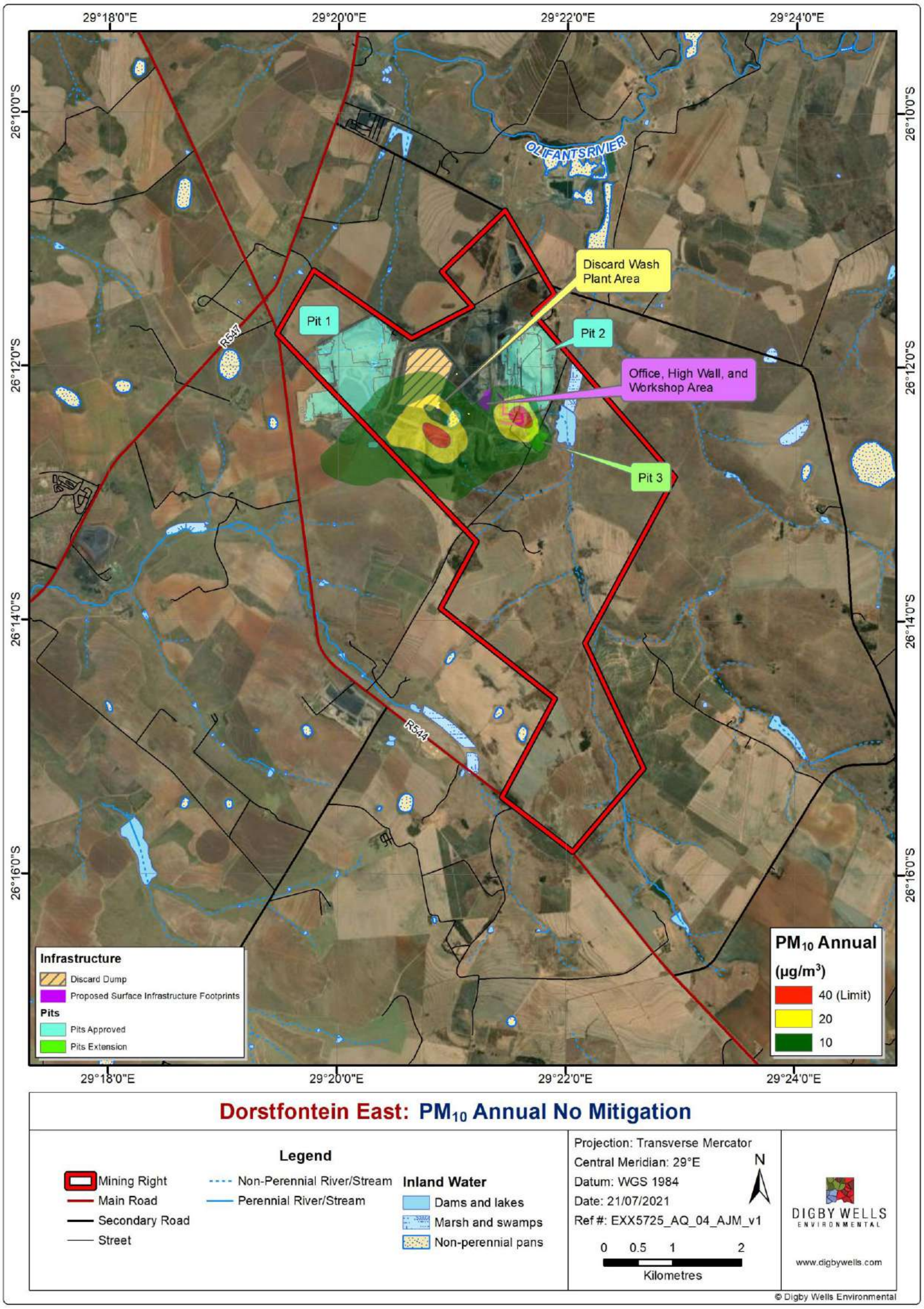


Figure 7-4: Predicted 1st highest (100th percentile) Annual PM_{10} Concentrations ($\mu g/m^3$)

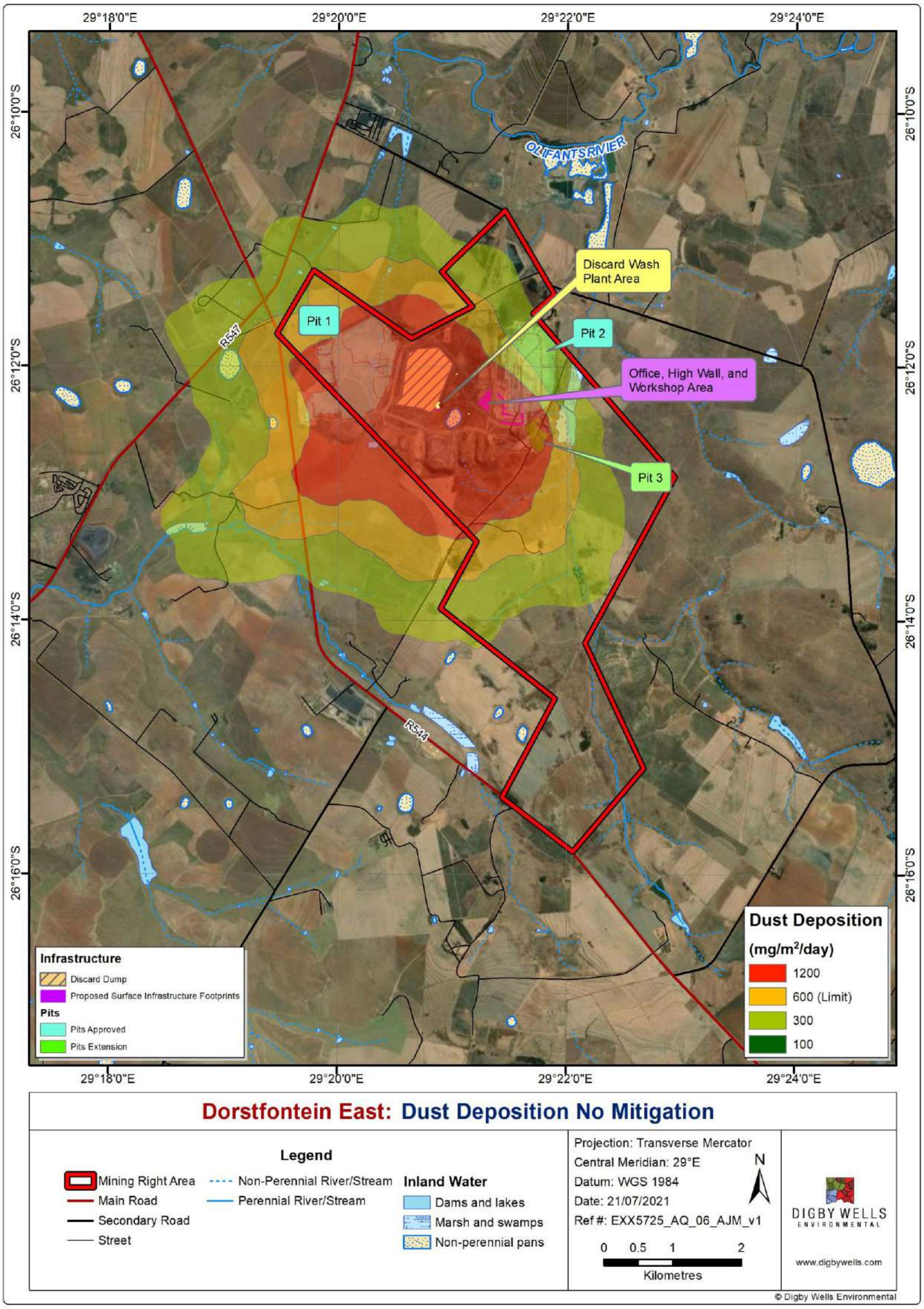


Figure 7-5: Predicted (100th percentile) Monthly TSP Deposition Rates ($mg/m^2/day$) No Mitigation

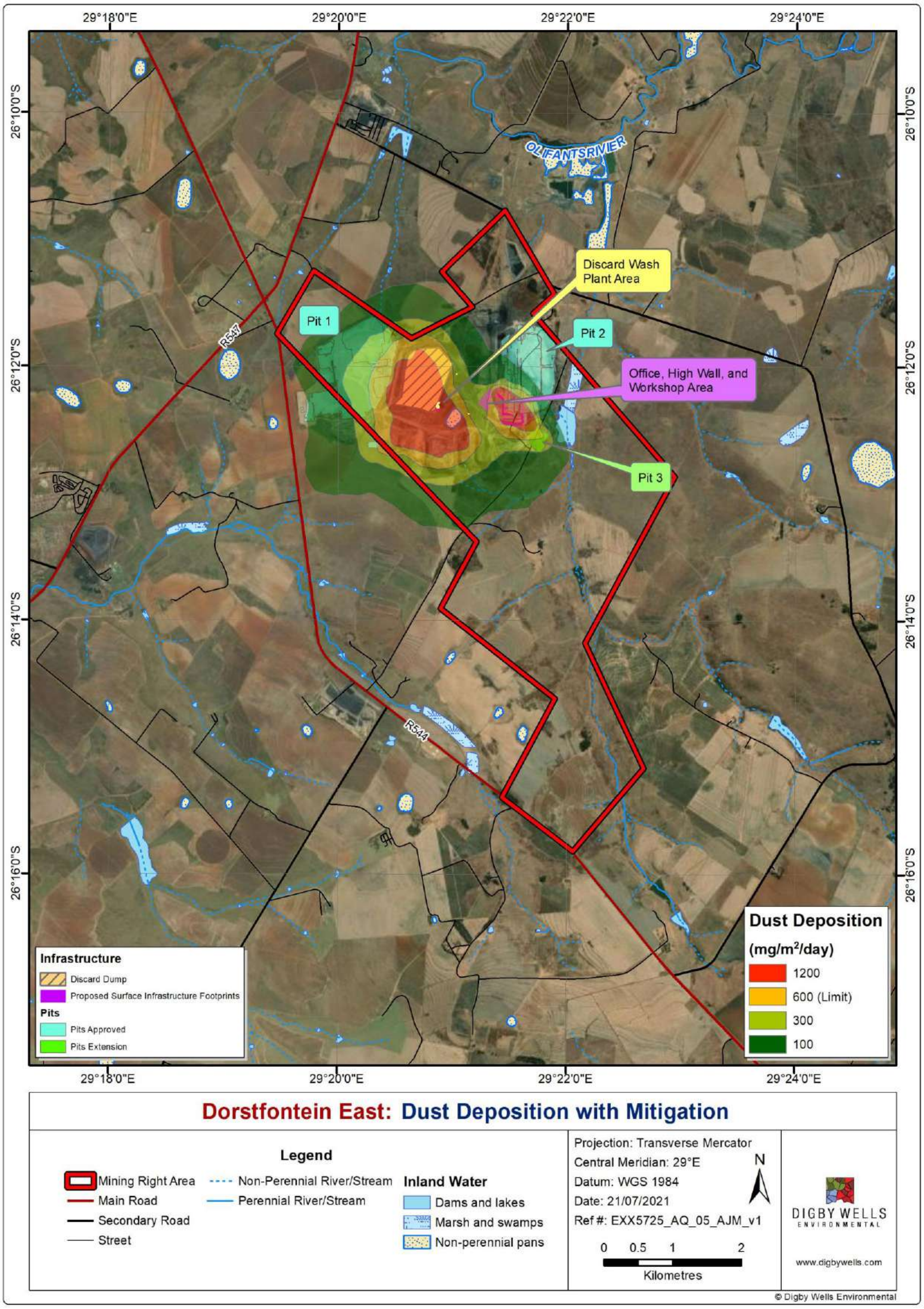


Figure 7-6: Predicted (100th percentile) Monthly TSP Deposition Rates (mg/m²/day) With Mitigation

8. Discussions

The predicted GLC for the operational phase and associated Project risks have been appraised.

8.1. Findings

The findings presented here represent the worst-case scenario, i.e. without mitigation measures factored into the model runs, except for the dustfall rates. The findings of this air quality study are summarised as follows:

- The areas where the predicted GLC of $PM_{2.5}$ will exceed the 24-hour standard (40 µg/m³) are within the MR boundary. The predicted GLC at the sensitive receptors (DDES-6, DDES-12, DDES-13, and DDES14) will be lower than the standard. The predicted annual GLC of $PM_{2.5}$ will not exceed the regulatory standard at the selected receptors.
- The predicted GLC of PM_{10} over a 24-hour averaging period returned simulation isopleths for PM_{10} daily and PM_{10} annual. The area where the 24-hour standard of 75 µg/m³ will be exceeded will be confined within the MR boundary. The GLC at the selected sensitive receptors (DDES-6, DDES-12, DDES-13, and DDES14) were lower than the standard. The predicted annual isopleth showed that areas, where exceedance will occur, are confined to within the MR boundary during operation, with no exceedance predicted for the sensitive receptors.
- The predicted dustfall simulation was conducted with mitigation and without mitigation. The predicted dustfall rates without mitigation confirmed that both the residential and the non-residential limit of 1,200 mg/m²/d will be exceeded within the MR boundary, with less implications for the sensitive receptors. With mitigation in place, the predicted dustfall rates at the selected receptors were lowered significantly.

9. Impact Assessment Ranking

The impact assessment ranking methodology in Appendix A was applied in rating the implications of the different phases of the Project on the ambient air quality of the area.

9.1. Construction Phase

Activities during the Construction Phase that may have potential implications on the ambient air quality in the Project area and surroundings i.e. increasing pollutant levels in the atmosphere are indicated in Table 9-1.

Table 9-1: Interactions and Impacts of Activity

Interaction	Impact
Site/vegetation clearance for site establishment (infrastructure including ventilation fans, change houses, offices, ablutions, and workshops).	Generation of dust Increased particulate matter load in the atmosphere leading to poor air quality Soiling of surfaces due to dustfall
Access and haul road construction	
Infrastructure construction	

9.1.1. Impact Description

Construction of project infrastructure will occur in phases and will be short-term in nature. Therefore, the anticipated impacts will be negligible.

Activities associated with site clearing will result in the generation of fugitive dust comprising of TSP, PM_{10}, and $PM_{2.5}$. Also, use of the haul roads and erosion of bare soil surfaces, construction of infrastructural and topsoil stockpiling will result in entrainment of dust. In addition, excavation, loading, and tipping of construction material will lead to dust generation. These activities will occur in phases, will be short-term and localised in nature, and will have low impacts on the ambient air quality.

9.1.1.1. Management Objectives

The management objective is to ensure that emissions on-site and at off-site locations are not in exceedance of the regulatory limits for the protection of the environment, human health, and wellbeing. Mitigation measures will be implemented to ensure that emissions remain below limit values and in compliance with the relevant standards.

9.1.1.2. Management Actions

- Air quality monitoring at upwind and downwind locations and sensitive receptors; and
- Application of dust suppressants e.g. Dust-A-Side on haul roads and exposed areas to ensure compliance.

9.1.1.3. Impact Ratings

The construction phase activities will require similar mitigation measures to contain emissions to the atmosphere, hence in the impact rating, these activities are grouped for ranking (Table 9-2).

Table 9-2: Significance Ratings for Site Clearing, Construction of Haul Road and Surface Infrastructure

Activity and Interaction: Site Clearing, Construction of Haul Roads and Surface Infrastructure			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in ambient air quality			
Prior to mitigation/ management			
Duration	Short term (1)	Dust will be generated for the duration of each activity in the construction phase	Negligible (negative) – 30
Extent	Limited (2)	Limited to the project area and immediate surroundings.	
Intensity	Minor (2)	Minor implications on the surrounding air quality are anticipated	
Probability	Almost certain (6)	There is a possibility that generated dust will impact ambient air quality.	
Nature	Negative		
Mitigation/ Management actions			
• Application of a dust suppressant on the haul roads and exposed areas; • Limit activity to non-windy days (wind speed less than 5.4 m/s); • Set maximum speed limits on haul roads and have these limits enforced; • The area of disturbance must be kept to a minimum at all times and no unnecessary clearing, digging or scraping must occur, especially on windy days; and • The drop heights when loading onto trucks and at tipping points should be minimised.			
Post- mitigation			
Duration	Short term (1)	Dust will be generated for the duration of each activity in the construction phase	Negligible (negative) – 12
Extent	Very Limited (1)	After mitigation measures are implemented, It is expected that the dust generated will be limited to isolated parts of the site.	
Intensity	Minimal (1)	Generated dust will have negligible impacts on the ambient air quality after mitigation	
Probability	Probable (4)	Probable that the impact on ambient air quality will occur.	
Nature	Negative		

9.2. Operational Phase

Activities that will be conducted during the Operational Phase that may have implications on the ambient air quality of the Project and surroundings i.e. increasing emission to the ambient atmosphere are indicated in Table 9-3.

Table 9-3: Interactions and Impacts of Activity

<table>
<tr><th>Interaction</th><th>Impact</th></tr>
<tr><td>Mining of coal by underground mining and use of ventilation shaft.</td><td rowspan="3">Generation of dust
Increased particulate matter load in the atmosphere leading to poor air quality
Soiling of surfaces due to dustfall
Gaseous and particulate pollutant from the underground via the ventilation shaft</td></tr>
<tr><td>In-pit ROM Stockpiling.</td></tr>
<tr><td>Use of haul roads.</td></tr>
<tr><td>Diesel storage and explosive magazine.</td><td>Release of gaseous pollutants</td></tr>
</table>

9.2.1. Impact Description

The operation of the ventilation shaft, wind erosion from the stockpile, use of haul roads and operation of the discard plant (screening and crusher circuit) will result in the emission of particulate and gaseous pollutants.

9.2.1.1. Management Objectives

The management objective is to ensure that emissions on-site and at off-site locations are not in exceedance of the regulatory limits for the protection of the environment, human health, and wellbeing. Mitigation measures will be implemented to ensure that emissions remain below limit values and in compliance with the relevant standards.

9.2.1.2. Management Actions

- Air quality monitoring to ensure compliance at upwind and downwind locations.
- Application of dust suppressants e.g. Dust-A-Side on haul roads and exposed areas to ensure compliance.
- The enclosure of the screening and crushing unit.
- Use of dust mitigation equipment at the dryer exhaust in the discard processing plant.

9.2.1.3. Impact Ratings

The operational phase activities will require similar mitigation measures to contains emissions from certain sources to the atmosphere, hence the rating of grouped some activities (Table 9-4).

Table 9-4: Significance Ratings for Operation of the Underground Mine, Ventilation Shaft, in-pit Stockpiling and Operation of the Discard Plant

Activity and Interaction: Establishment of Open Underground Mine, Ventilation Shaft, In-pit Stockpiling and Operation of the Discard Plant			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Dust generation and reduction in ambient air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Dust will be generated for the project life	Major (negative) – 78
Extent	Local (3)	Airborne dust will extend across the development site area and beyond.	
Intensity	Very Serious (5)	Very serious impact on ambient air quality	
Probability	Almost certain (6)	It is almost certain that the impact will occur.	
Nature	Negative		
Mitigation/ Management actions			
• Application dust suppressant on the haul roads and exposed areas; • Limit activity to non-windy days (wind speed less than 5.4 m/s); • Set maximum speed limits on haul roads and have these limits enforced; • The drop heights when loading onto trucks and at tipping points should be minimised; • The enclosure of the screening and crushing circuit; and • Dust mitigation equipment for the dryer exhaust.			
Post- mitigation			
Duration	Project life (5)	Dust will be generated for the project life	Negligible (negative) – 36
Extent	Limited (2)	Airborne dust will be limited to the MR boundary and its immediate surrounding after mitigation.	
Intensity	Minor (2)	Minor impacts anticipated after mitigation	
Probability	Probable (4)	Probable that impact will occur after mitigation.	
Nature	Negative		

9.3. Decommissioning Phase

Activities during the Decommissioning Phase that may have potential impacts on the ambient air quality in the Project area and surroundings are indicated in Table 9-5.

Table 9-5: Interactions and Impacts of Activity

Interaction	Impact
Demolition and removal of infrastructure	Generation of dust Increased particulate matter load in the atmosphere leading to poor air quality Soiling of surfaces due to dustfall
Rehabilitation (spreading of the preserved subsoil and topsoil, profiling of the land and re-vegetation)	
Post-closure monitoring and rehabilitation	

9.3.1. Impact Description

The dismantling of mine infrastructure and rehabilitation activities which will include spreading of subsoil and topsoil, profiling, and re-vegetation of the Project area will involve the use of heavy machinery and vehicles similar to those used in the construction phase. This will result in the release of fugitive emissions, such as TSP, $PM_{10,}$ and $PM_{2.5}$.

9.3.1.1. *Management Objectives*

The management objective is to ensure that emissions on-site and at off-site locations are not in exceedance of the regulatory limits for the protection of the environment, human health, and wellbeing. Mitigation measures will be implemented to ensure that emissions remain below limit values and in compliance with the relevant standards.

9.3.1.2. *Management Actions*

- Air quality monitoring at upwind and downwind locations.
- Application of dust suppressants e.g. Dust-A-Side on haul roads and exposed areas to ensure compliance.

9.3.1.3. *Impact Ratings*

The decommissioning phase activities will require similar mitigation measures to those employed during the construction phase. The impact rating for this phase is discussed in Table 9-6.

Table 9-6: Significance Ratings for Demolition and Removal of Infrastructure and Rehabilitation of the Project area

<table>
<tr><th colspan="4">Activity and Interaction: Demolition and Removal of Infrastructure and Rehabilitation</th></tr>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Impact Description: Dust generation and reduction in ambient air quality</td></tr>
<tr><td colspan="4">Prior to mitigation/ management</td></tr>
<tr><td>Duration</td><td>Medium-term (3)</td><td>Dust will be generated in the medium term for the duration of each activity in the decommissioning phase</td><td rowspan="5">Major (negative) – 42</td></tr>
<tr><td>Extent</td><td>Limited (2)</td><td>Limited to the project area and immediate surroundings.</td></tr>
<tr><td>Intensity</td><td>Minor (2)</td><td>Minor effect on surrounding air quality is anticipated</td></tr>
<tr><td>Probability</td><td>Almost certain (6)</td><td>Almost certain that generated dust will impact ambient air quality.</td></tr>
<tr><td>Nature</td><td>Negative</td><td></td></tr>
<tr><td colspan="4">Mitigation/ Management actions</td></tr>
<tr><td colspan="4">Application dust suppressant on the haul roads and exposed areas;
Limit activity to non-windy days (wind speed less than 5.4 m/s);
Set maximum speed limits on haul roads and have these limits enforced;
The area of disturbance must be kept to a minimum at all times and no unnecessary clearing, digging or scraping must occur, especially on windy days;
The drop heights when loading onto trucks and at tipping points should be minimised
Rehabilitation of disturbed land to allow for vegetation growth.</td></tr>
<tr><td colspan="4">Post- mitigation</td></tr>
<tr><td>Duration</td><td>Medium-term (3)</td><td>Dust will be generated in the medium term for the duration of each activity in the decommissioning phase</td><td rowspan="5">Negligible (negative) – 20</td></tr>
<tr><td>Extent</td><td>Very Limited (1)</td><td>After mitigation measures are implemented, It is expected that the dust generated will be limited to isolated parts of the site.</td></tr>
<tr><td>Intensity</td><td>Minimal (1)</td><td>Generated dust will have minimal impacts on the ambient air quality after mitigation</td></tr>
<tr><td>Probability</td><td>Probable (4)</td><td>Probable that an impact on ambient air quality will occur.</td></tr>
<tr><td>Nature</td><td>Negative</td><td></td></tr>
</table>

9.4. Cumulative Impacts

Historical dustfall records for the proposed project area are available for sensitive receptor sites DDES-6 (non-residential), DDES-12 (residential), DDES-13 (residential), and DDES14 (residential) were used to evaluate cumulative impacts. The averages over the twelve months at DDES-6 (1135 mg/m^2/d), DDES-12 (292 mg/m^2/d), DDES-13 (372 mg/m^2/d) and DDES-14 (432 mg/m^2/d) were taken as the background to which the model predicted GLC for the same locations were added (**model prediction + the background**). The final cumulative values were then compared with the standards for compliance. The final cumulative levels were higher than the limit value for the non-residential receptor at DDES-6 (**1971** mg/m^2/d), and in exceedance at the residential sites DDES-13 (**729** mg/m^2/d) and DDES-14 (**899** mg/m^2/d), as depicted in Table 9-7.

Table 9-7: Comparison of Modelled to Baseline Data

Pollutants	Averaging Period	Location	Regulatory Limit	Dust Deposition Rates (mg/m^2/d)		
				Model	Background	Total
Dustfall	Monthly	DDES-6	1200 mg/m^2/d (Res. Limit)	837	1135	**1971**
		DDES-12	600 mg/m^2/d (Res. Limit)	299	139	438
		DDES-13		372	357	**729**
		DDES-14		436	463	**899**

9.5. Unplanned and Low Risk Events

Table 9-8 highlights some likely unplanned events related to this Project. This was based on expert knowledge drawn from the related industry. Data on the type of incidents and frequency will assist in establishing the nature, risk type, geographic spread, and appropriate mitigation measures to curtail impacts in the event of an occurrence.

Table 9-8: Unplanned Events and Associated Mitigation Measures

Unplanned Risk	Mitigation Measures
Extreme wind erosion event	Adequate cover and care for storage facilities which will serve as protection during an unplanned event Exposed areas prone to erosions should be avoided or minimised at all times

10. Environmental Management Programme

Table 10-1 provides a summary of the proposed project activities, environmental aspects, and impacts on the receiving environment. Information on the mitigation measures, mitigation type, timing of implementation of the Environmental Management Programme (EMPr) are specified.

Table 10-1: Environmental Management Programme

Activity	Potential Impacts	Aspects Affected	Phase	Mitigation Measures	Mitigation Type	Time period for implementation
• Site clearing; • Access and haul road construction; • Construction of surface infrastructure.	Poor air quality due to the generation of dust	Air Quality	Construction	• Apply wetting agents, dust suppressants, and binders on exposed areas; • Limit activity to non-windy days (with wind speed ≤ 5.4 m/s); • Keep the area of disturbance to a minimum and avoid any unnecessary clearing, digging, or scraping, especially on windy days; • Minimise the drop heights when loading onto trucks and at tipping points; and • Set maximum speed limits and have these limits enforced.	• Control through the implementation of an air quality management plan; • Dust control measures; and • Ambient air quality monitoring	On commencement of the construction phase and for the duration of the phase
• Operation of the underground mining • In-pit RoM stockpiling • Loading, handling, and stockpiling of ROM ore • Operation of the ventilation shaft • Operation of the screening and crusher circuit.	Poor air quality due to the generation of dust	Air Quality	Operation	• Apply wetting agents, dust suppressants, and binders on exposed areas and haul roads; • Conduct mining activities judiciously on windy days (with wind speed ≥ 5.4 m/s); • Keep the area of disturbance to a minimum and avoid any unnecessary clearing, digging, or scraping, especially on windy days; • Minimise the drop heights when loading onto trucks and at tipping points; • The enclosure of the screening and crushing circuit, fitted with dust mitigation equipment; • Set maximum speed limits and have these limits enforced; and • Application of the mitigation equipment at the Discard Processing Plant dryer exhaust.	• Control through the implementation of an air quality management plan; • Dust control equipment; and • Ambient air quality monitoring.	Measurements must commence before the start of the operation phase and for the life of mine.
• Dismantling and removal of infrastructure • Rehabilitation of the Project area • Post-closure monitoring and rehabilitation	Poor air quality due to the generation of dust	Air Quality	Decommissioning	• Apply wetting agents, dust suppressants, and binders on exposed areas; • Conduct mining activities judiciously on windy days (with wind speed ≥ 5.4 m/s); • Keep the area of disturbance to a minimum and avoid any unnecessary clearing, digging, or scraping, especially on windy days; • Minimise the drop heights when loading onto trucks and at tipping points; • Set maximum speed limits and have these limits enforced; • The dismantling of infrastructure must occur in phases; and • The rehabilitated landscape should be vegetated.	• Control through the implementation of an air quality management plan; • Dust control measure; and • Ambient air quality monitoring	On commencement of the decommissioning phase and for the duration of the phase

11. Monitoring Programme

It is recommended that the historic dustfall monitoring network be revived and maintained to ensure regular collection of baseline data for the LoM. In addition to the aforementioned, it is recommended that a continuous real-time monitoring station with the ability to measure both particulates and gases be commissioned before the commencement of the construction phase activities. The frequency of monitoring will ensure that diurnal, seasonal, annual, and inter-annual records are available to inform management decision making. Table 11-1 shows the criteria pollutants that should be measured and the frequency of monitoring.

Table 11-1: Recommended Monitoring Plan

Method	Frequency	Target	Responsibility
Monitoring in accordance with: • EN14097 for PM2.5; • EN12341 for PM10; and • American Standard Test Method ASTM 1739-98 in SANS1137:2019	• Monthly dustfall monitoring; • Continuous PM_{10}, $PM_{2.5}$ monitoring; • Continuous monitoring of gases: SO_2, NO_2, and CO	Particulate pollutants from the ongoing mining operation must be kept below the South African standards: • GN R 1210 of 24 December 2009 • GN R 486 of June 2012; and • GN R 827 of 1 November 2013	A designated Environmental Officer (EO) onsite to collect ambient air quality data and submit it to an independent consultant for interpretation and reporting.

12. Stakeholder Engagement Comments Received

In terms of comments related to the potential impacts from the Project on air quality, nothing has been received from Interested and Affected Parties (I&AP). If in future concerns are raised, these concerns will be documented in line with the prescribed regulatory requirements and the EA application will be updated.

13. Recommendations

Based on the results presented in this report, the following recommendations should be applied once operation commences:

- Continue with the dustfall monitoring network and maintain the programme for the LoM;
- Set up a continuous real-time air quality monitoring station to measure criteria particulate(PM_{10} and $PM2_{.5}$) and gaseous pollutants (SO_2, NO_2, CO, and O_3) because these are regulated. Also, mines are required in accordance with the National Atmospheric Emissions Reporting Regulation (NAERR) (GN R 283 of 2 April 2015) to submit annualy on site emission via the National Atmospheric Emission Inventory System (NAEIS) website.

- Designate a qualified person to act as the EO to oversee implementation of mitigation measures and assess efficiency on a regular basis;
- Ensure air quality information is incorporated into the environmental management information system and submit annual reports to the South African Atmospheric Emission Licensing & Inventory Portal (SAAELIP), as required by law;
- Establish codes of practice for good housekeeping concerning dust management and mitigation, including regular appropriate restrictions on vehicle movements and speeds;
- The enclosure of the crushing and screening circuit at the Discard Plant;
- Use of mitigation equipment at the dryer exhaust at the Discard Plant; and
- Monitor the air quality management measures and information to ensure that adopted mitigation measures are sufficient to achieve current air quality standards at the Project area and nearby receptors.

14. Reasoned Opinion Whether Project Should Proceed

The historical dustfall rates measured in the proposed Project area was used to understand the baseline air quality scenario. In general, more than 95th percentile of the dustfall rates measured were below the limit values.

Based on the model predictions, areas, where exceedances are likely to occur, are confined within the mine boundary. As depicted with the dust deposition isopleths, the predicted impacts can be minimised with adequate mitigation measures that are factored into the daily operations during mining.

Overall, assuming the dustfall status quo established with historical records has not been altered significantly, the model results show cumulative impacts will result at three of the four selected sensitive receptors. With appropriate mitigation measures and management measures in place, it is anticipated that the mine will operate within compliance. The air quality specialist will recommend that the EA Application be approved, provided the recommended mitigation measures are implemented.

15. Conclusion

The wind rose for the Project area is depicted in (Figure 6-4). The prevailing winds are from the east northeast (10.5%) and northwest (9.6%) respectively. Secondary contributions are from the north northwest (8.8%) and east (8.1%). The average wind speed at the project site is 3.2 m/s and calm conditions (<0.5 m/s) occurred for some 4.7% of the time. Wind speed capable of causing wind erosion i.e. ≥5.4 m/s occurred for about 7.9% of the time (Figure 6-6).

Historical dustfall records from 20 months (January 2018 – August 2019) of monitoring at 19 sites were used to evaluate the background air quality. Measured dustfall rates were below the respective limit values for more than 95th percentile of the time, with sequential exceedances measured at DDES-2, DDES-6 and M-DDED-2 for the period.

Potential emissions from the operational phase of the Project were assessed. Model simulations of GLC of criteria pollutants were generated, for different averaging periods as recommended by the regulatory authorities and compared with the South African standards to ascertain compliance.

A summary of the predicted GLC is given below:

- The areas where the predicted GLC of $PM_{2.5}$ will exceed the 24-hour standard (40 µg/m³) are within the MR boundary. The predicted GLC at the sensitive receptors (DDES-6, DDES-12, DDES-13, and DDES14) will be lower than the standard. The predicted annual GLC of $PM_{2.5}$ will not exceed the regulatory standard at the selected receptors.
- The predicted GLC of PM_{10} over a 24-hour averaging period returned simulation isopleths for PM_{10} daily and PM_{10} annual. The area where the 24-hour standard of 75 µg/m³ will be exceeded will be confined within the MR boundary. The GLC at the selected sensitive receptors (DDES-6, DDES-12, DDES-13, and DDES14) were lower than the standard. The predicted annual isopleth showed that areas, where exceedance will occur, are confined to within the MR boundary during operation, with no exceedance predicted for the sensitive receptors.
- The predicted dustfall simulation was conducted with mitigation and without mitigation. The predicted dustfall rates without mitigation confirmed that both the residential and the non-residential limit of 1,200 mg/m²/d will be exceeded within the MR boundary, with less implications for the sensitive receptors. With mitigation in place, the predicted dustfall rates at the selected receptors were lowered significantly.

The impacts of the proposed Project were evaluated using a risk matrix that considers the nature, significance, extent, duration, and probability of impacts occurring. Based on this rating system, impacts on the surrounding receptors from the operational phase are deemed "major negative" without mitigation. However, with mitigation, the impacts were reduced to "negligible negative". Since anticipated emissions from the operational phase activities are likely to influence receptors outside the Project boundary, mitigation and management intervention measures are crucial.

Some of the possible mitigation measures and management intervention measures recommended include:

- Application of dust suppressants/binders on haul roads and exposed areas, setting maximum speed limits on haul roads and to have these limits enforced, and application of mitigation technology at the dryer exhaust at the Discard Plant; and
- Operation of ambient air quality monitoring network to collect valuable data needed to assess the effectiveness of mitigation measures put in place during operation.

Once the mine implements the recommended mitigation measures outlined in this report, associated emissions can be contained to below standards, ensuring compliance with regulatory requirements.

16. References

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Appendix A: Impact Assessment Ranking

The potential impacts from the proposed Project have been assessed based on the severity predicted on-site and at sensitive receptor(s). This culminates in a significance rating which identifies the most important impacts that require mitigation and/or management.

Based on international guidelines and South African legislation, the following criteria were considered when examining potentially significant impacts:

- Nature of impacts (direct / indirect, positive / negative);
- Duration (short / medium / long-term, permanent (irreversible) / temporary (reversible), frequent / seldom);
- Extent (geographical area, size of affected population / habitat / species);
- Intensity (minimal, severe, replaceable / irreplaceable);
- Probability (high / medium / low probability); and
- Possibility to mitigate, avoid or offset significant adverse impacts.

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact / risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 16-1. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts. Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in the Environmental Management Plan Report (EMPr).

The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 16-2, which is extracted from Table 16-1. The description of the significance ratings is discussed in Table 16-3.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

DIGBY WELLS ENVIRONMENTAL

Table 16-1: Impact Assessment Parameter Ratings

RATING	INTENSITY/REPLACABILITY		EXTENT	DURATION/REVERSIBILITY	PROBABILITY
	Negative impacts	**Positive impacts**			
7	Irreplaceable damage to highly valued items of great natural or social significance or complete breakdown of natural and / or social order.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable damage to highly valued items of natural or social significance or breakdown of natural and / or social order.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.
5	Very serious widespread natural and / or social baseline changes. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.

RATING	INTENSITY/REPLACABILITY		EXTENT	DURATION/REVERSIBILITY	PROBABILITY
	Negative impacts	Positive impacts			
4	On-going serious natural and / or social issues. Significant changes to structures / items of natural or social significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.
3	On-going natural and / or social issues. Discernible changes to natural or social baseline.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor natural and / or social impacts which are mostly replaceable. Very little change to the baseline.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.
1	Minimal natural and / or social impacts, low-level replaceable damage with no change to the baseline.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 16-2: Probability/Consequence Matrix

Significance																																						
Probability 7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Consequence	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Table 16-3: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Substantial (positive)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Major (positive)
36 to 72	An positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Major (negative)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Substantial (negative)