AIR QUALITY IMPACT ASSESSMENT FOR THE PROPOSED TAILINGS STORAGE FACILITY

DWARSRIVIER CHROME MINE (PTY) LTD

19 JANUARY 2022

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REPORT (VERSION 01)

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ABBREVIATIONS

AQIA	Air Quality Impact Assessment
GNR	Government Notice Regulations
g/s	Grams per second
NAAQS	National ambient air quality standards
NEM:AQA	National Environmental Management: Air Quality Act 39 of 2004
PM	Particulate matter
PM_{10}	Particulate matter less than 10 µm in diameter
$PM_{2.5}$	Particulate matter less than 2.5 µm in diameter
SAWS	South African Weather Service
TSF	Tailings Storage Facility
TSP	Total suspended particulates
US EPA	United States Environmental Protection Agency
WSP	WSP Group Africa (Pty) Ltd

EXECUTIVE SUMMARY

Envirogistics (Pty) Ltd (Envirogistics) appointed WSP Group Africa (Pty) Ltd (WSP) to conduct an Air Quality Impact Assessment (AQIA) for the proposed Tailings Storage Facility (TSF) at the existing Dwarsrivier Chrome Mine located near Steelpoort, Limpopo Province. It is anticipated that the existing TSF will reach its full capacity relatively sooner than anticipated due to tonnage ramps up and additional tonnages from other sites. A site selection study was carried out in June 2021, which identified Site B as the best viable option for the proposed TSF, that is anticipated to supersede the current TSF.

The proposed activity requires environmental authorisation in the form of an Environmental Impact Assessment (EIA) which is currently being undertaken by Envirogistics. As part of the authorisation process an AQIA is required to inform the competent authority. Key pollutants associated with onsite activities were identified as PM_{10} (particulate matter with an aerodynamic diameter less than 10 microns), $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 microns) and dust fallout (modelled as TSP)

A baseline assessment was undertaken that included a geographic overview and a review of available meteorological data. On-site surface data was not available; therefore use was made of prognostic MM5 meteorological data representative of the site. To characterise the meteorological conditions of the site, MM5 prognostic meteorological data was obtained for the period January 2018 to December 2020 for input into the air dispersion model.

The impact assessment comprised an emissions inventory and subsequent dispersion modelling simulations. An emissions inventory was developed using site-specific data and emission factors which were sourced from the United States Environmental Protection Agency AP42 (US EPA, 1995) and the Australian Government National Pollutant Inventory (NPI, 2012) databases. This emissions inventory was input into a Level 2 atmospheric dispersion model, AERMOD, together with prognostic MM5 meteorological data, to calculate ambient air concentrations of key pollutants associated with the proposed operations.

Sensitive receptors are identified as areas that may be impacted negatively due to emissions from the proposed TSF. Four receptors (villages and dwellings) were identified in the area surrounding the proposed project area, within a 10 km radius, and were used for this assessment.

Long-term (annual) and short-term (24-hour average) concentrations for the pollutants of concern were compared with the South African National Ambient Air Quality Standards (NAAQS) and dust fallout rates with the National Dust Control Regulations (NDCR) standards.

PM_{10} CONCENTRATIONS

– For Scenario 1 (current mining operations) and Scenario 2 (current with proposed TSF) ambient 24-hour (P99) and annual average PM_{10} concentrations are predicted to be compliant at all sensitive receptors;

– Changes in predicted PM_{10} concentrations between Scenario 1 and Scenario 2 are substantial, with a 66% average increase in the 24-hour (P99) concentrations and a 69% average increase in annual average concentrations across all sensitive receptors. However, despite the increase, predicted concentrations at all receptors remain well below the standards during Scenario 2;

– Highest predicted 24-hour and annual average off-site concentrations are compliant with the respective standards for Scenario 1. Highest concentrations are predicted on the north-western portion of the mine, predominately around the areas of existing haulage roads;

– Highest predicted 24-hour average off-site concentrations during Scenario 2 are non-compliant with the relevant 24-hour standard, due to the close proximity of the new TSF road to the boundary of the mine. However, highest predicted annual average concentrations remain compliant with the standard; and

- However, despite the non-compliance predicted for the 24-hour PM_{10} off-site concentrations (Scenario 2), all concentrations predicted at neighbouring sensitive receptors remain complaint with their relevant standard, as noted previously.

$PM_{2.5}$ CONCENTRATIONS

- For Scenario 1 (current mining operations) and Scenario 2 (current with proposed TSF), ambient 24-hour (P99) and annual average $PM_{2.5}$ concentrations are predicted to be compliant at all sensitive receptors;
- Changes in predicted $PM_{2.5}$ concentrations between Scenario 1 and Scenario 2 are substantial, with a 72% average increase in the 24-hour (P99) concentrations and a 68% average increase in annual average concentrations across all sensitive receptors. However, despite the increase, predicted concentrations at all receptors remain well below the standards during Scenario 2; and
- Highest predicted 24-hour average and annual average off-site concentrations remain compliant with the relevant standards for both scenarios.

DUST FALLOUT

- For both scenarios, no exceedances of the dust fallout residential standard are predicted at any of the neighbouring sensitive receptors;
- Scenario 1 and Scenario 2 highest predicted off-site dust fallout rates remain compliant with the non-residential standard; and
- Overall levels of dust fallout anticipated to occur as a result of the proposed TSF are below the respective National Dust Control Regulations.

MITIGATION MEASURES

- Important Mitigation measures to be implemented during mining operations are:
  - Use of water sprays at crushing and transfer points;
  - Continuous wetting of the access road during vehicle transport;
  - Wetting of exposed stockpiles to limit the dispersion of wind-blown dust and particulate emissions;
  - Avoid dust generating works during the most windy conditions; and
  - Frequent wetting of the access roads.

The proposed TSF will result in minimal air quality impacts on nearby receptors. Given the low impacts on the receiving environment, based on the findings of this AQIA, it is recommended the proposed TSF be authorised.

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1 INTRODUCTION

Envirogistics (Pty) Ltd (Envirogistics) appointed WSP Group Africa (Pty) Ltd (WSP) to conduct an Air Quality Impact Assessment (AQIA) for the proposed Tailings Storage Facility (TSF) at the existing Dwarsrivier Chrome Mine located near Steelpoort, Limpopo Province. It is anticipated that the existing TSF will reach its full capacity relatively sooner than anticipated due to tonnage ramps up and additional tonnages from other sites. A site selection study was carried out in June 2021, which identified Site B as the best viable option for the proposed TSF, that is anticipated to supersede the current TSF.

The proposed activity requires environmental authorisation in the form of an Environmental Impact Assessment (EIA) which is currently being undertaken by Envirogistics. As part of the authorisation process an Air Quality Impact Assessment (AQIA) is required to inform the competent authority on any air quality impacts related to the new TSF. This report presents the findings from the AQIA, using a level two dispersion model (AERMOD) to predict potential impacts associated with the proposed TSF.

1.1 TERMS OF REFERENCE

The scope of work performed by WSP in fulfilment of the requirements of the AQIA is provided below:

Baseline Assessment

- Review of applicable air quality legislation;
- Review of the potential pollutants and associated human health effects;
- Review of available meteorological data for the area;
- Identification of neighbouring sensitive receptors, including adjacent communities and farmers; and
- Identification of any neighbouring sources.

Emissions Inventory and Dispersion Modelling

- Compilation of an emissions inventory for activities undertaken;
- Undertake dispersion modelling simulations (AERMOD) to determine the air quality impacts associated with the proposed TSF; and
- Comparison of predicted model concentrations to air quality standards.

Air Quality Impact Assessment

- Compilation of an Air Quality Impact Assessment.

2 BACKGROUND

2.1 LOCALITY

Dwarsrivier Mine is situated approximately 60 km northwest of Lydenburg, 25 km south of Steelpoort and 63 km northeast of Roossenekal in the Limpopo Province (**Figure 2-1**). The mine currently holds the surface rights for Portion 1 (Remaining Extent) and Portion 0 (Remaining Extent) of the farm Dwarsrivier 372KT, as well as Portion 4 (a portion of Portion 3) of the farm De Grootteboom 373KT. The operation is located in the Fetakgomo-Greater Tubatse Local Municipality, within the boundaries of the Sekhukhune District Municipality.

The R577 roadway that connects to the R555 (Lydenburg-Roossenekal road), is situated to the north of the plant and mine offices. The overall area is characterised by intensive mining development. Various servitudes traversing the site are present, which include gravel roads, telephone lines and electricity lines.

Several neighbouring farms, namely Tweefontein 380JT, Thorncliffe 374KT, De Grootteboom 373KT and Dwarsrivier 372KT are owned by mining houses with existing and operational chrome and platinum mines. On the remainder of the neighbouring farms, agricultural activities take place, in the form of stock grazing and the growing of vegetables, lucerne and cotton.

2.2 TOPOGRAPHY

Topography of an area plays a role in the dispersion of air pollutants. On hilltops and exposed areas, moderate winds will typically cause pollutants to be dispersed, however, in low-lying areas such as valleys, it is difficult for air flow to penetrate, resulting in pollutants being trapped and increasing levels of pollution. Pollutant dispersion processes over complex terrain are more complicated than over flat areas as they are affected by atmospheric interactions with the orography at different spatial scales.

The Farm Dwarsrivier on which the mine is located is traversed by the Dwars River and the Klein Dwars River. The eastern portion of the mine has a slope from westerly to south westerly towards the Dwars River. The slopes in the region are gentle, with a maximum slope gradient reaching 40°. Elevation on site varies between 940 – 975 m above mean sea level **Figure 2-2.**

2.3 SENSITIVE RECEPTORS

Sensitive receptors, as defined by the USEPA (USEPA, 1995) include, but are not limited to, hospitals, schools, day-care facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to toxic chemicals, pesticides and other pollutants. Extra care must be considered when dealing with pollutants in proximity to areas recognised as sensitive receptors. Based on this definition the residential, educational and recreational land uses in the surrounding area are considered sensitive receptors.

For this study, the position of residential communities/dwellings was taken off 1:6300 DRG maps and verified using Google Earth Pro. Residential communities within a 10 km radius of the site were identified as shown in **Table 2-1** and **Figure 2-3**. Such receptors were then utilised in the dispersion model to assess impacts.

Table 2-1: Sensitive receptors

ID	Receptor Name	Distance from proposed TSF (km)	Longitude (ºS)	Latitude (ºE)
1	SR1 (Lodge)	6.37	30.132015	24.975202
2	SR2 (Villages)	5.06	30.119396	24.869117
3	SR3 (Dwelling)	9.19	30.198841	24.948461
4	SR4 (Dwelling)	9.70	30.203276	24.949763

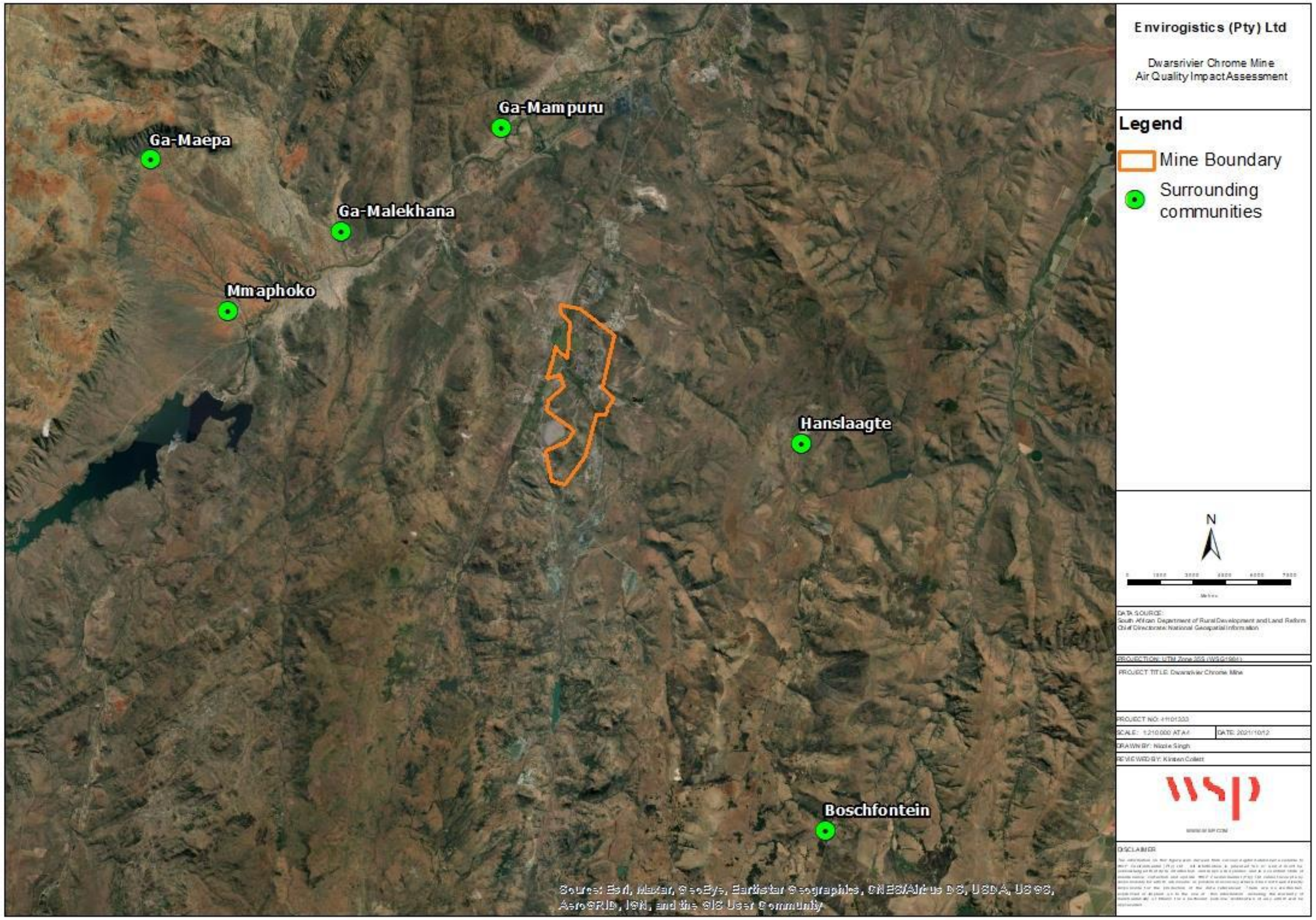

Figure 2-1: Location of Dwarsrivier Chrome Mine

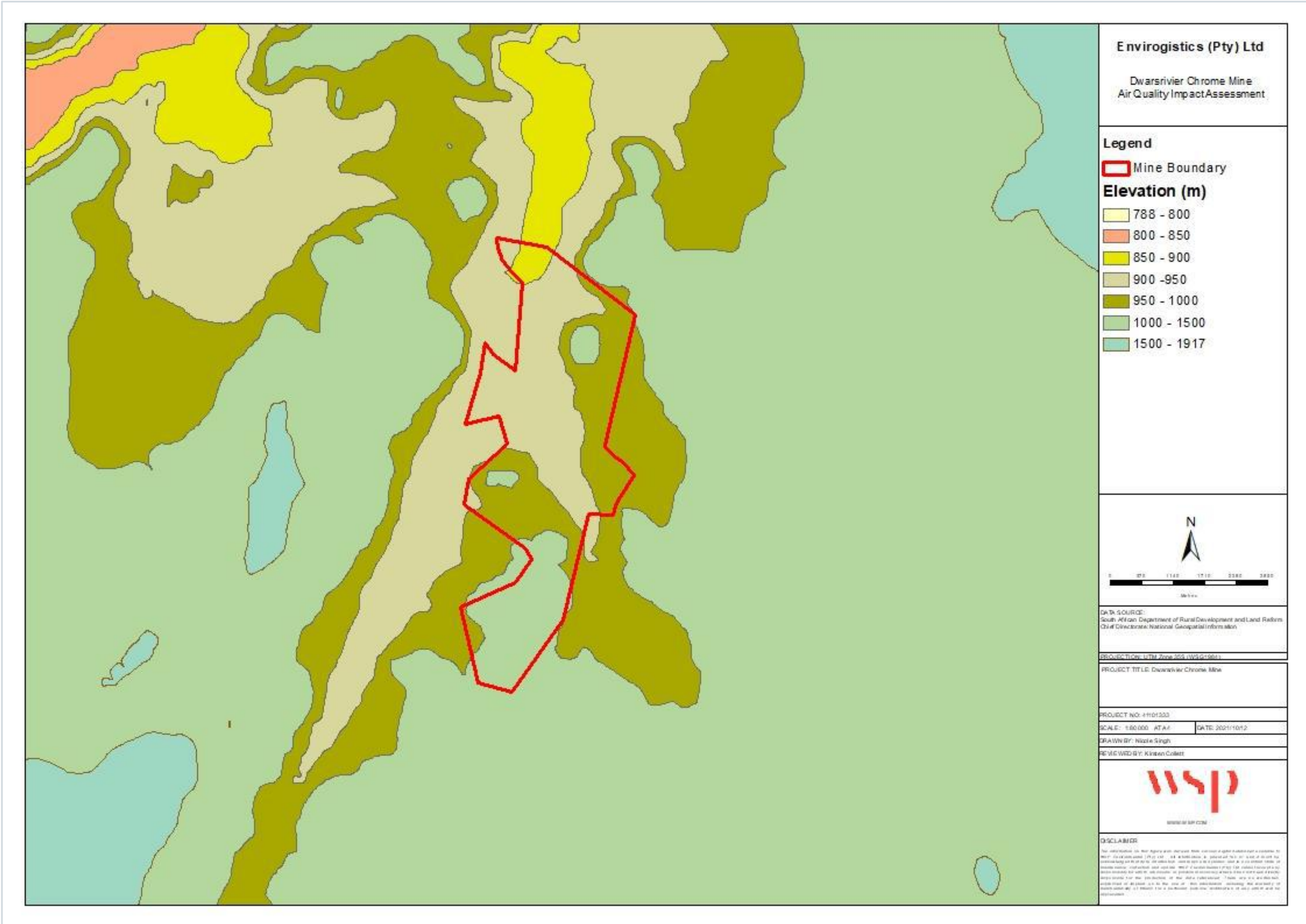

Figure 2-2: Terrain map

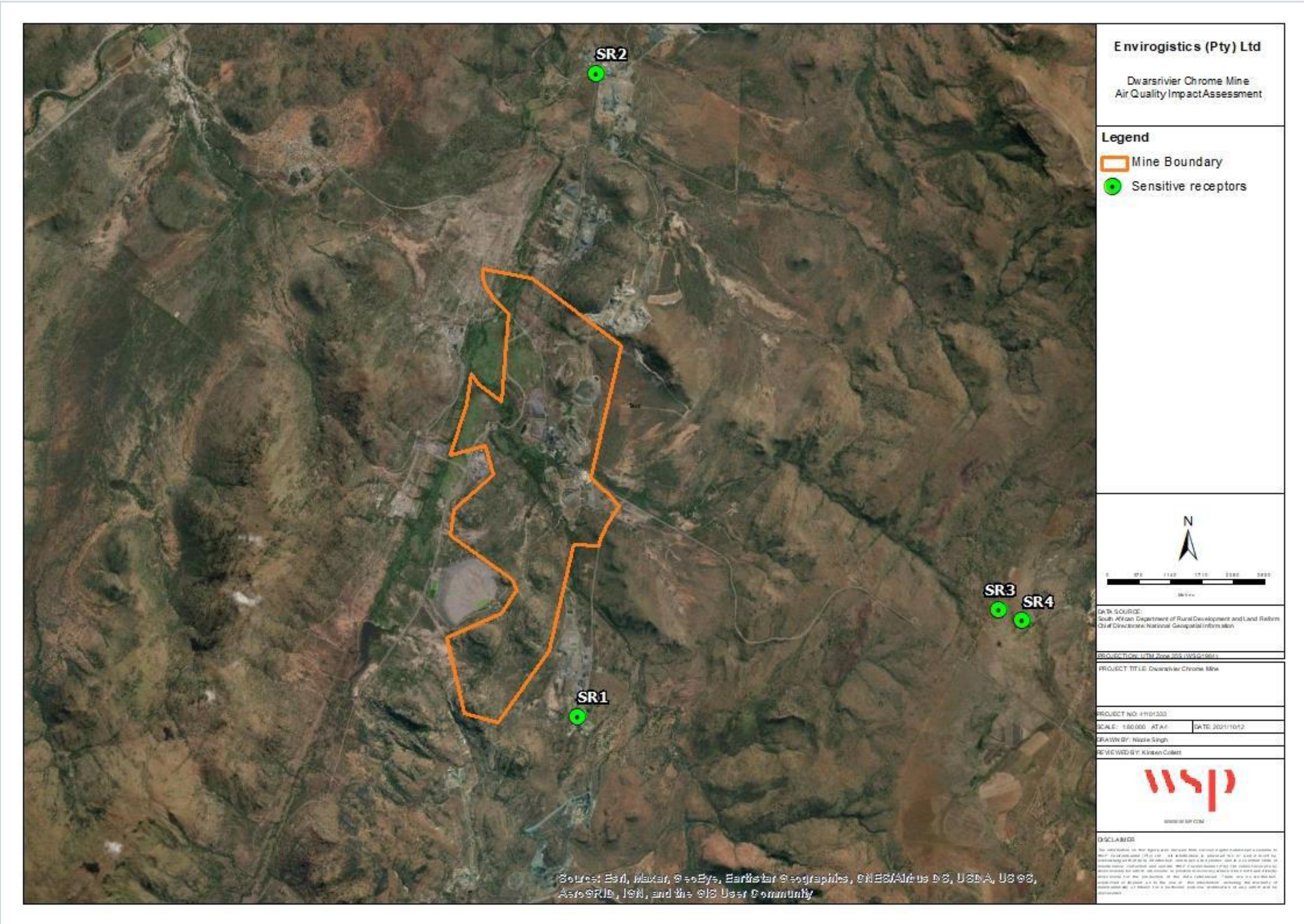

Figure 2-3: Location of sensitive receptors surrounding the Dwarsrivier Chrome Mine

2.4 PROJECT DESCRIPTION

Dwarsrivier Chrome Mine has been mining chromite ore from the Steelpoort Chromite Seam (SCS) since 1999. Between 1999 and 2005, ore was mined using opencast methods. The existing North TSF was designed to contain production tonnages for 23 years, with 29,000 tonnes received for the first two years of operation and allowing for a deposition rate of 17,280 tonnes per month for the remaining 21 years. The deposited tonnage rate was later revised to allow for deposition of 33,500 tonnes per month for the first two years, which is higher than what was originally designed and is anticipated to reduce the expected life of the NTSF of 23 years. It is anticipated that the existing North TSF will reach its full capacity within the next three to five years. For this reason, additional storage capacity on site is required. The mine therefore proposes the development of a new TSF, to be referred to as the Khulu TSF / Site B, in order to accommodate tailings material once the full capacity of the North TSF is reached. In consideration of the above, the overall aim of the proposed activities is to ensure that a well-designed tailings disposal system is operated on site to allow for the production requirements on site. Findings from a multitude of site selection studies, resulted in Site B as being the preferred option for the proposed TSF.

It is the intention of the Dwarsrivier Chrome Mine to carry out the construction of the following infrastructure and activities on site in order to accommodate tonnage ramp up and additional tonnages from other sites. These will include:

- Proposed TSF – Site B;
- Diesel and Emulsion batching;
- Main parking extension;
- Widening of the access road between the south shaft/ main offices and Plant; and
- Access crossing between plant and North Mine.

The infrastructure and activities that will form part of the proposed project will include the following:

- Construction phase
  - Demarcation and identification of protected species;
  - Land and footprint clearing;
  - Topsoil stripping and stockpiling;
  - Establishment of surface infrastructure; and
  - Waste management.
- Operational Phase
  - Operation of proposed Site B TSF and associated rock waste dumps;
  - Operation of roads and parking infrastructure;
  - Operation and use of Diesel and Emulsion storage and supply;
  - Water management;
  - Dust suppression; and
  - Waste management.

Figure 2-4 illustrates the layout of existing sources, including Site B that will assessed in this AQIA.

Figure 2-4: Existing and proposed sources to be assessed

3 REGULATORY FRAMEWORK

Until 2004, South Africa's approach to air pollution control was driven by the Atmospheric Pollution Prevention Act 45 of 1965 (APPA) which was repealed with the promulgation of National Environmental Management: Air Quality Act 39 of 2004 (NEM:AQA)[1]. NEM:AQA represents a shift in South Africa's approach to air quality management, from source-based control to integrated effects-based management. The objectives of NEM:AQA are to:

- Protect the environment by providing reasonable measures for:
  - The protection and enhancement of air quality;
  - The prevention of air pollution and ecological degradation;
  - Securing ecologically sustainable development while promoting justifiable economic and social development; and
  - Give effect to everyone's right "*to an environment that is not harmful to their health and well-being*"[2].

Significant functions detailed in NEM:AQA include:

- The National Framework for Air Quality Management[3];
- Institutional planning matters, including:
  - The establishment of a National Air Quality Advisory Committee;
  - The appointment of Air Quality Officers (AQOs) at each level of government; and
  - The development, implementation and reporting of Air Quality Management Plans (AQMP) at National, Provincial and Municipal levels.
- Air quality management measures including:
  - The declaration of Priority Areas where ambient air quality standards are being, or may be, exceeded;
  - The listing of activities that result in atmospheric emissions and which have the potential to impact negatively on the environment and the licensing thereof through an Atmospheric Emissions Licence;
  - The declaration of Controlled Emitters;
  - The declaration of Controlled Fuels;
  - Procedures to enforce Pollution Prevention Plans or Atmospheric Impact Reporting for the control and inventory of atmospheric pollutants of concern; and
  - Requirements for addressing dust and offensive odours.

1 South Africa (2005): *National Environmental Management: Air Quality Act* (No. R. 39 of 2004) Government Gazette, 24 February 2005 (No. 27318)
2 South Africa (1996): *Constitution of the Republic of South Africa (No. 108 of 1996)*
3 Department of Environmental Affairs (2018*): The 2017 National Framework for Air Quality Management in the Republic of South Africa* (No.R.1144 of 2018) Government Gazette, 26 October 2018 (No. 41996)

3.1 NATIONAL AMBIENT AIR QUALITY STANDARDS

The National Ambient Air Quality Standard (NAAQS) presented in **Table 3-1** below became applicable for air quality management from their promulgation in 2009[4] and 2012[5]. The NAAQS generally have specific averaging periods, compliance timeframes, permissible frequencies of exceedance and measurement reference methods. The NAAQS pollutants of concern, and applicable to this AQIA are Particulate Matter (PM_{10} and $PM_{2.5}$).

Table 3-1: National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration (µg/m^3)	Frequency of Exceedance
Particulate Matter (PM_{10})	24-hour	120	4
		75	4
	1 year	50	0
		40	0
Particulate Matter ($PM_{2.5}$)	24-hour	65	4
		40	4
		25	4
	1 year	25	0
		20	0
		15	0
Sulphur Dioxide (SO_2)	10-minute	500	526
	1-hour	350	88
	24-hour	125	4
	1 year	50	0
Nitrogen Dioxide (NO_2)	1-hour	200	88
	1 year	40	0
Carbon Monoxide (CO)	1-hour	30,000	88
	8-hour	10,000	11
Benzene (C_6H_6)	1 year	10	0
		5	0

3.2 NATIONAL DUST FALLOUT STANDARDS

The NEM:AQA National Dust Control Regulations, were published in Government Notice (GN) 827 of November 2013 (Government Gazette 36974). However, Draft National Dust Control Regulations were published in GN 517 of May 2018 (Government Gazette 41650), bringing about certain changes in the permitted dust fallout monitoring methodology. Notably, since GN 517 of May 2018 are not yet promulgated, GN 827 of November 2013 remain in force and applicable to this AQIA.

The dust fallout rates, applied in this study to assess compliance, are presented in **Table 3-2.**

[4] Department of Environmental Affairs (2009): National Ambient Air Quality Standards. Government Gazette (No. R 1210 of 2009), 24 December 2009 (No. 32816)

[5] Department of Environmental Affairs (2012): National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Micro Metres ($PM_{2.5}$). Government Gazette (No. R 486 of 2012), 29 June 2012 (No. 35463)

Table 3-2: National Dust Fallout Standards

Restriction Areas	Dust fallout rate (mg/m²/day, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential Area	600	Two within a 12-month rolling period, not sequential months
Non-residential Area	1,200	Two within a 12-month rolling period, not sequential months
This table provides the information as contained in the National Dust Control Regulations. Two aspects to note: 1) The dust fallout rate is referred to only in mg/m²/day and not normalised to the 30-day average. The rate can only be presented to either and not both. The 30-day average will require an adjustment to the accepted rates. 2) The accepted dust fallout rate at Non-Residential areas is below 1,200 mg/m²/day.		

In 2018, amendments to these Dust Control Regulations were issued in the form of the *Draft National Dust Control Regulations* (GN 517 of May 2018) (Government Gazette 41650), bringing about certain changes in the permitted dust fallout monitoring methodology. Where GNR 827 of November 2013 allowed the use of ASTM D1739:1970 or equivalent methodology, GN 517 of May 2018 specifically states that the *latest* version of the ASTM D1739 method must be utilised. Currently the latest version is the ASTM D1739:1998 (Reapproved in 2017) methodology. It is important to note that GN 517 has not yet been promulgated, therefore GNR 827 remains in force.

UPDATES TO THE NATIONAL DUST CONTROL REGULATIONS

Key changes, although not limited to these, in the Draft Dust Control Regulations include:

– Permission to exclude exceedances caused by non-anthropogenic sources;
– The reference method is now the latest version of ASTM (D1739:1998), no longer ASTM D1739:1970;
– The latest ASTM requires samplers be installed with a windshield, which has been proven to increase the accuracy of capturing dust fallout;
– All mining operations must implement a DFO program;
– Analysis of both the soluble and insoluble content of samples. As such the dust fallout levels presented in this report are cumulative (representing the sum of the soluble and insoluble fractions) which are assessed cumulatively against the respective standard;
– Submission of dust fallout monitoring reports on a monthly basis to the relevant Air Quality Officer;
– Current fallout levels compared to historic results for at least the previous four years (where available);
– All mining operations must implement a dust management plan; and
– Provide proof of the implementation of the dust management plan in the monthly monitoring reports.

The Draft National Dust Control Regulations (GN 517 of May 2018) stipulate that these changes are effective as of 1 November 2019. These Regulations have, however, not yet been promulgated and formally published.

3.3 POLLUTANTS OF CONCERN

The main pollutants of concern at the Dwarsrivier chrome mine is particulate matter and dust fallout. Particulate matter and dust fallout originate from a variety of sources on-site including loading and unloading, crushing, vehicle entrainment on unpaved roads and wind erosion.

PARTICULATE MATTER

PM refers to solid particles suspended in the air. PM varies in size from particles that are only visible under an electron microscope to soot or smoke particles that are visible to the human eye. PM contributes greatly to deteriorations in visibility, as well as posing major health risks, as small particles (PM_{10}) can penetrate deep into lungs, while even smaller particle sizes ($PM_{2.5}$) can enter the bloodstream via capillaries in the lungs, with the potential to be laid down as plaques in the cardiovascular system or brain. Health effects include respiratory problems, lung tissue damage, cardiovascular problems, cancer and premature death. Acidic particles may damage buildings, vegetation and acidify water sources[6].

DUST FALLOUT

Dust fallout also known as settable particulate matter is defined as any material composed of particles small enough to pass through a 1 mm screen and large enough to settle by virtue of weight into a sampling container from ambient air[7]. Impacts on the environment as a result of dust fallout are often limited to nuisance effects.

Nuisance effect refers to environmental impacts of dust that are not health related. Nuisance dust effects often results in the soiling and discolouration of personal property and can result in physical irritation in plants and animals[8].

[6] United States Environmental Protection Agency (2011): Health Effects of Pollution, available at http://www.epa.gov/region07/air/quality/health.htm.

[7] Department of Environmental Affairs (2013): National Environmental Management: Air Quality Act: National Dust Control Regulations (No. R 39 of 2004), 01 November 2013 (No. 36974)

[8] Michigan Department of Environmental Quality. Managing fugitive dust: A guide for compliance with the air regulatory requirements for particulate matter generation. March 2016.

4 BASELINE ASSESSMENT

4.1 METEOROLOGICAL OVERVIEW

Since meteorological conditions affect how pollutants emitted into the air are directed, diluted and dispersed within the atmosphere, the incorporation of reliable data into an air quality impact assessment is of the utmost importance. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the atmospheric mixing layer control the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as the plume 'stretches'. Mechanical turbulence is influence by wind speed in combination with surface roughness.

Parameters that need to be considered in the characterisation of dispersion potential include wind speed, wind direction, extent of atmospheric turbulence, ambient air temperature and mixing depth. Modelled MM5 (Penn State/NCAR Mesoscale Model) meteorological data representative of the site was obtained for the period January 2018 to December 2020 to provide an understanding of surface and upper air dispersion characteristics. The data coverage stretches over the surrounding site in Steelpoort with a grid cell dimension of 12 km x 12 km over a 50 km x 50 km domain. Data recovery for the meteorological data set is provided in Table 4-1.

No surface data was used in this assessment as the nearest South African Weather Service (SAWS) meteorological station is located over 50 km away and thus not considered site representative for inclusion in the study.

Table 4-1: Meteorological data recovery

Parameter	Data Recovery MM5
Temperature	100%
Humidity	100%
Rainfall	100%
Wind Speed	100%
Wind Direction	100%

4.1.1 WIND FIELD

Winds affect the horizontal and vertical dispersion of air pollutants away from their source[9]. Wind roses are useful for illustrating the prevailing meteorological conditions of an area, indicating wind speeds and directional frequency distributions. In the following wind roses, the colour of the bar indicates the wind speed whilst the length of the bar represents the frequency of winds blowing from a certain direction (as a percentage). In this assessment, meteorological data spanning three calendar years (January 2018 – December 2020) as required by the *Regulations Regarding Air Dispersion Modelling*[10], hereafter referred to as " the *Modelling Regulations*", is discussed in the sections below.

Figure 4-1 presents the local wind conditions from modelled MM5 data representative of the project site for the period January 2018 – December 2020. Typical wind fields have been analysed using Lakes Environmental

[9] Tyson, P.D. & Preston-Whyte, R.A. (2004). *The Weather and Climate of Southern Africa*, 2nd Ed, Oxford University Press Southern Africa, Cape Town.

[10] Department of Environmental Affairs (2014): Regulations Regarding Air Dispersion Modelling (No. R. 533), Government Gazette, 11 July 2014, (No. 37804).

WRPlot Freeware (Version 7.0.0) for the full period (January 2018 – December 2020); diurnally for day (06h00 – 18h00), and night (18h00 – 06h00); and seasonally for summer (December, January and February), autumn (March, April and May), winter (June, July and August) and spring (September, October and November). The following is highlighted:

- Calm conditions occurred 4.76% of the time;
- Moderate winds from the east-southeast prevailed in the region with notable south-easterly, easterly and north-north-easterly components;
- Wind speeds were predominately light to moderate during the period, with a few winds exceeding 8 m/s at times, particularly from the southeast;
- North-north-easterly trajectories prevailed during the day while east-south-easterly trajectories prevailed at night;
- Diurnal wind speeds were predominately light to gentle during morning hours with an average wind speed of 3.8 m/s observed;
- Minimal seasonal variability in seen in the wind profile with east-south-easterly and east-north-easterly winds dominating during the summer and spring months, while south-easterly winds prevailed in winter and autumn; and
- Average seasonal wind speeds for the region were highest during the spring and summer months with an average wind speed of 3.7 m/s and 3.5 m/s observed respectively.

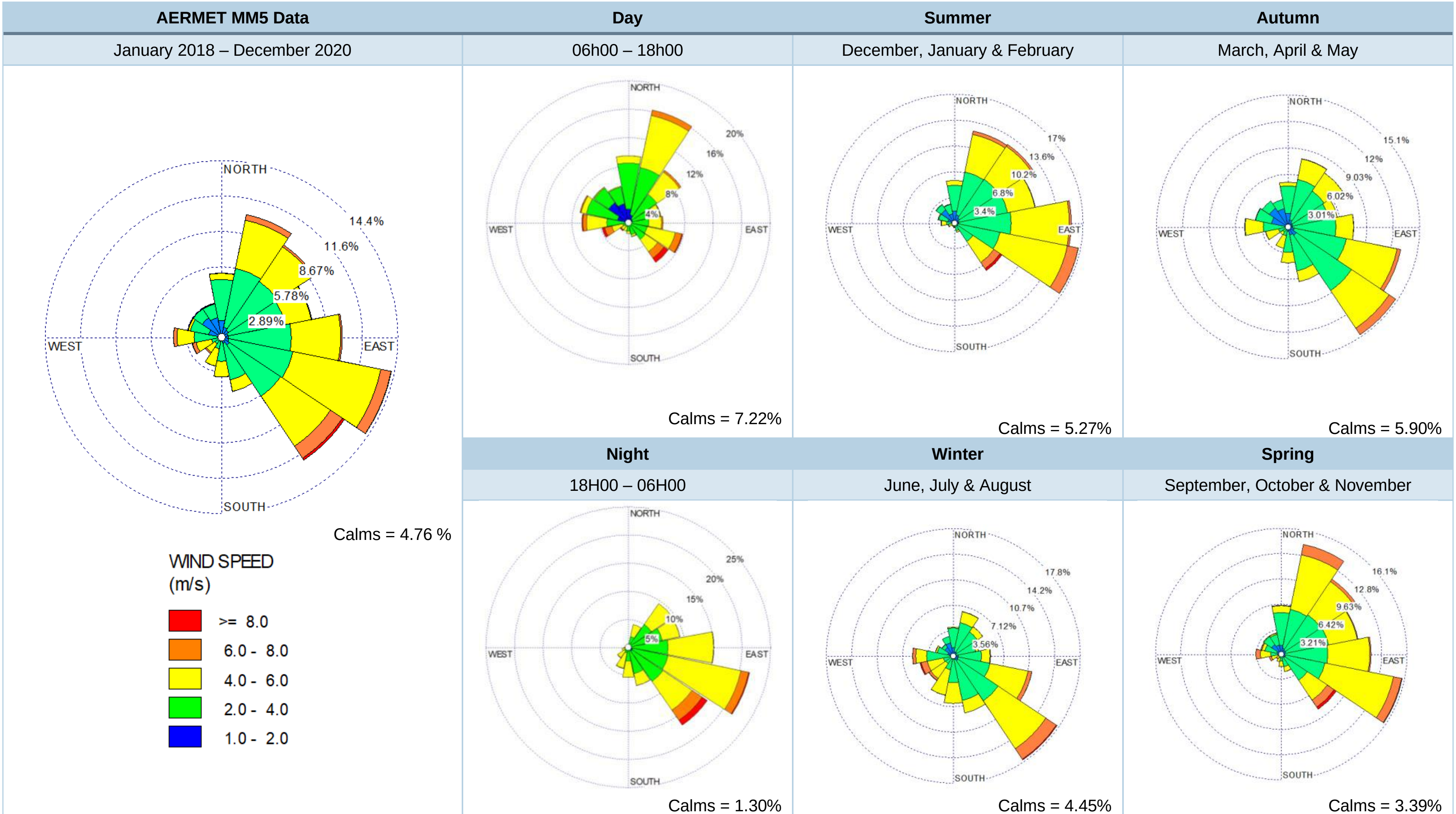

Figure 4-1: Wind conditions using modelled MM5 data for the period January 2018 – December 2020

4.1.2 TEMPERATURE AND RAINFALL

Ambient air temperature influences plume buoyancy as the higher the plume temperature is above the ambient air temperature, the higher the plume will rise. Further, the rate of change of atmospheric temperature with height influences vertical stability (i.e. mixing or inversion layers). Rainfall is an effective removal mechanism of atmospheric pollutants. **Figure 4-2** illustrates the average MM5 monthly temperature, temperature range (maximum and minimum) and total rainfall. Highest levels of rainfall occurred during the warmer, summer months (January and February) with the lowest rainfall experienced during Autumn (April and May) and winter month (June).

Summer temperatures for the region averaged 21.9°C while winter temperatures averaged 13.37°C. Dwarsrivier received, on average, 1,158 mm of rainfall during the period under review, with approximately 47% of that received during the summer months and 10% during the winter months.

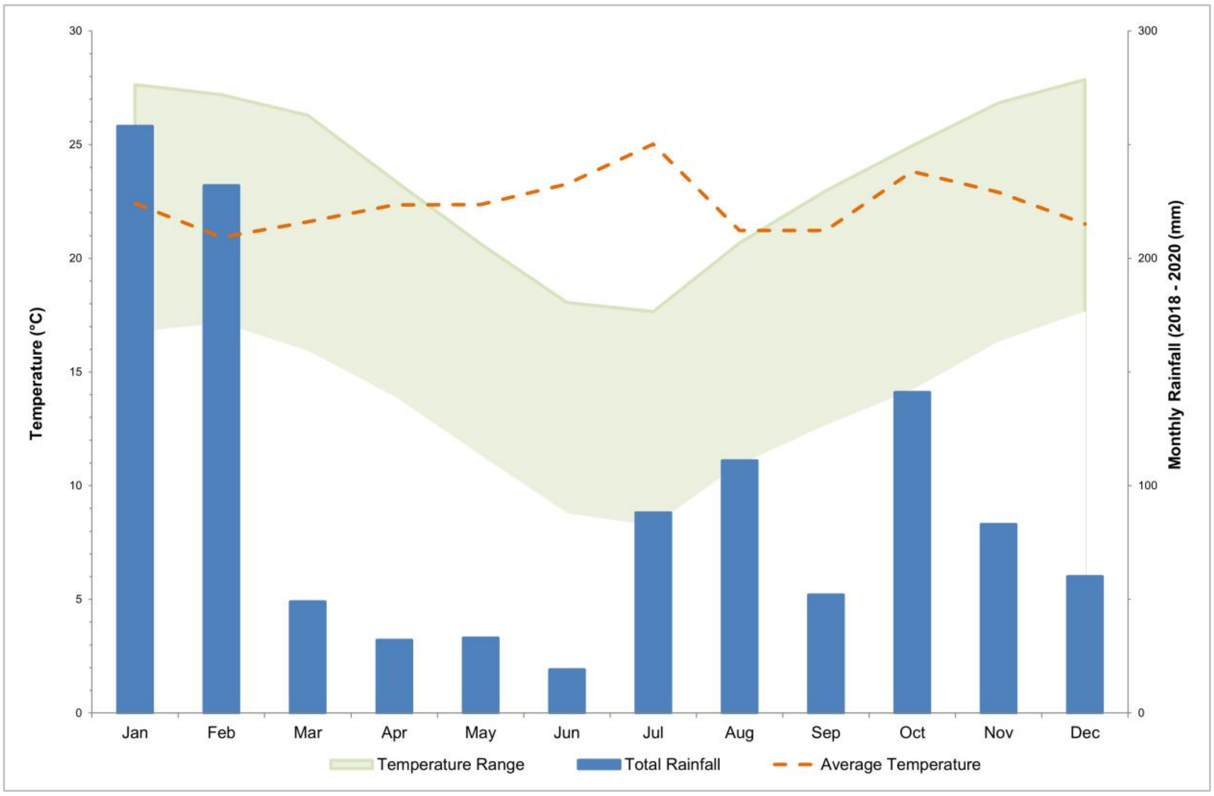

Figure 4-2: MM5 Total monthly rainfall, temperature range and average monthly temperature (2018 – 2020)

4.2 AMBIENT AIR QUALITY

PM_{10} and $PM_{2.5}$ data for the project site was not available for assessment. It was confirmed by Envirogistics upon WSP's request for ambient data that dust fallout (DFO) is the only parameter available for assessment. DFO data for the January 2019 to December 2021 period is assessed in the section below.

4.2.1 LOCAL DUST FALLOUT MONITORING

Dust fallout monitoring at Dwarsrivier Chrome Mine has historically been undertaken at five monitoring locations through the use of multi-directional dust fallout buckets. The dust watch directional gauge system can be defined as a measurement of dust deposition in addition to providing the dust source direction, however, the monitoring methodology are not in line with the Dust fallout regulations and should not be used to assess compliance against relevant guidelines and standards. The monitoring results in the graphs below are presented as the sum of the multidirectional dust buckets for each site and assessed against the respective standards solely for statistical/comparative purposes. **Table 4-2** lists the coordinates and classifications for each monitoring location.

Table 4-2: Dwarsrivier Chrome Mine dust fallout monitoring locations

Locality	Description	Latitude (°S)	Longitude (°E)	Classification
DW001	School monitoring station	24.89157	30.06744	Residential
DW002	Far North Point	24.91622	30.12237	Non-residential
DW003	Parking Lot South Shaft	24.93611	30.12501	Non-residential
DW004	Discard Dump South Shaft	24.93806	30.12517	Non-residential
DW005	North Shaft	24.93193	30.12503	Non-residential

Dust fallout results for the 2019 to 2021 monitoring period are presented below. For comparative purposes only; the dust fallout rates are compared to the National Dust Control Regulations standards. **Figure 4-3** shows dust fallout rates during the 2019 monitoring period. No data was available during September – November 2019.

DW001 exceeded the residential standard four times during 2019 (February, March, April and December), resulting in non-compliance with the Dust Control Regulations. Such regulations allow for two non-sequential exceedances over a rolling twelve-month period. Exceedances of the non-residential standard were recorded at DW003 (January and April) and DW004 (April). These monitoring locations, however, remained compliant with the Dust Control Regulations.

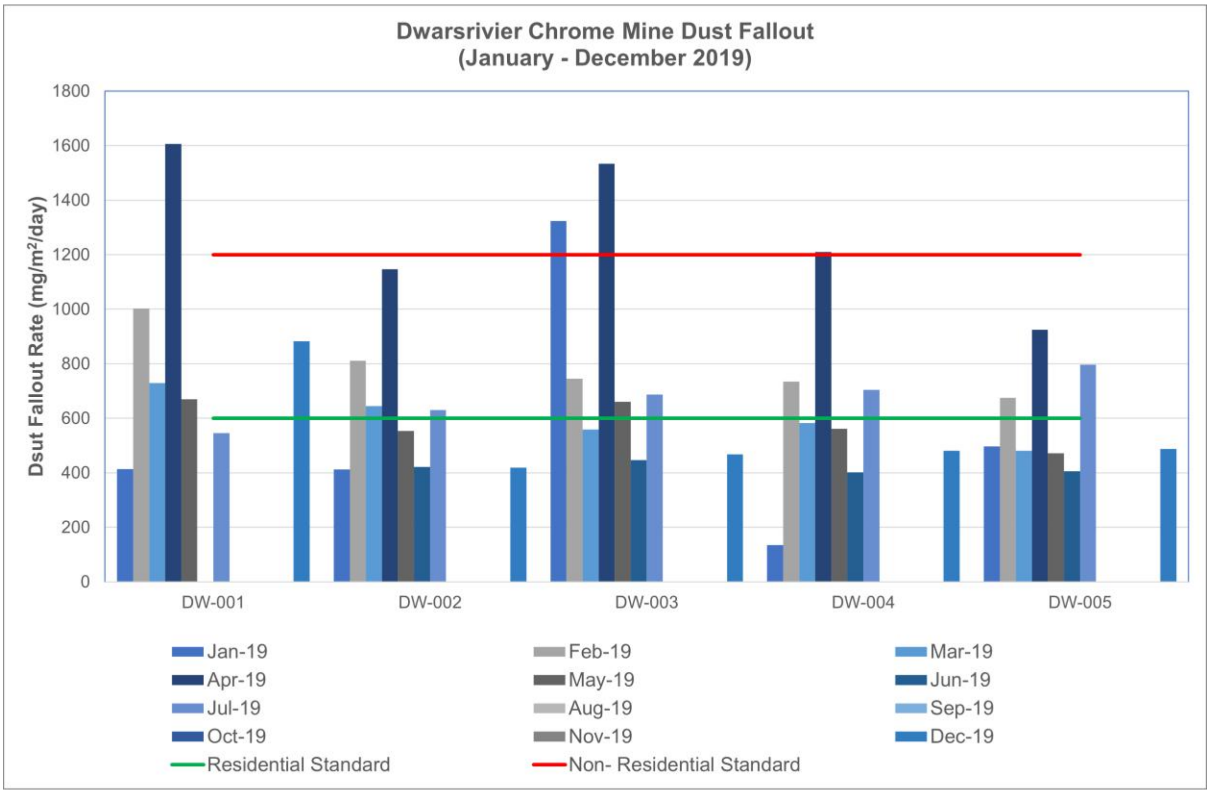

Figure 4-3: Onsite dust fallout results for 2019

Figure 4-4 illustrates the dust fallout monitoring results for 2020. There are no monitoring results for the months of March and April 2020, due to COVID-19 lockdown restrictions. As such, the May results represent exposure over the March to May period. Six exceedances of the residential standard were recorded at DW001 in 2020 (July, August, September, October, November and December), resulting in non-compliance with the Dust Control Regulations. The non-residential standard was exceeded once at DW004 during January, however, remaining complaint with the National Dust Control Regulations.

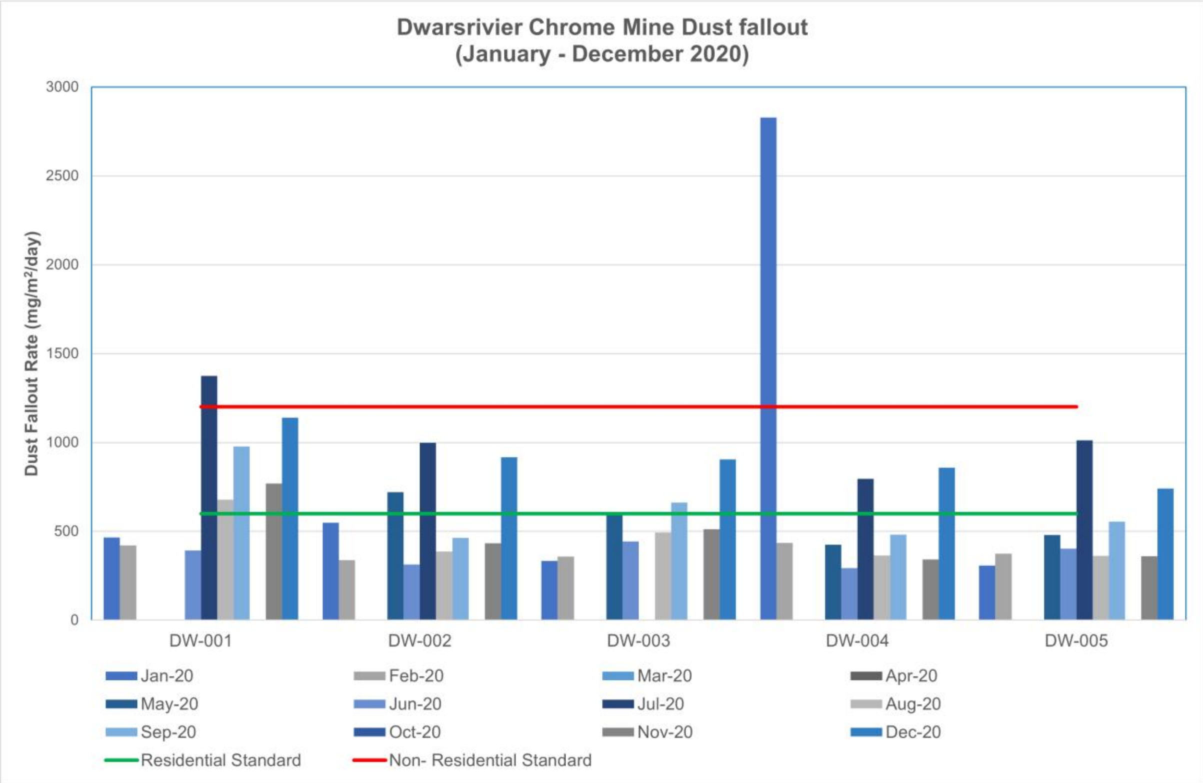

Figure 4-4: Onsite dust fallout rates for 2020

Figure 4-5 illustrates the monitoring results for January to April 2021. In comparison to the National Dust Control Regulation residential standard, DW001 was non-compliant as it recorded three exceedances (January, March and April). All other monitoring sites were compliant.

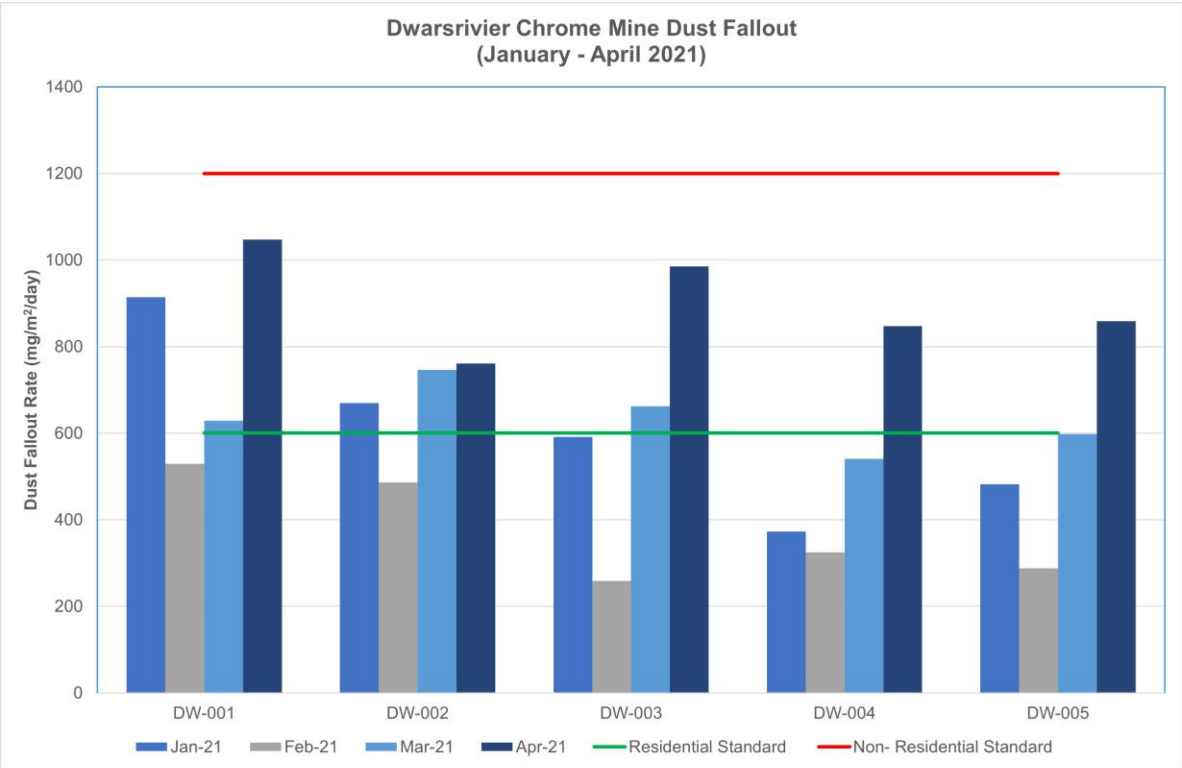

Figure 4-5: Onsite dust fallout rates for 2021

4.2.2 EXISTING SOURCES OF POLLUTION

A qualitative discussion of identified emission sources in the vicinity of the study site is provided below. Key emission sources in the region are mining and agricultural emissions. These emission sources contribute towards the air quality status quo within the region, with PM and DFO being of particular concern in this regard.

MINING

Mining is the predominant land use within the surrounding area, with existing and operational chrome and platinum mines in the surrounding area. Expected fugitive emissions from mining activities include, but are not limited to[11]:

- Vehicle entrainment on paved and unpaved roads;
- Crushing and screening activities;
- Drilling and blasting;
- Wind erosion of exposed stockpiles, waste dumps and TSFs;
- Stripping of overburden; and
- Materials handling operations[11].

Fugitive emissions are noted to be highest during the loading of fresh ore onto stockpiles as fine particulates are easily broken down and dispersed to the atmosphere.

AGRICULTURAL ACTIVITIES

Agriculture is also one of the dominant lands uses within the surrounding area, comprising mostly in the form of stock grazing and the production of vegetables, lucerne and cotton.

Emissions from agricultural activities are difficult to control due to the seasonality of emissions and the large surface area producing emissions (USEPA, 1995). Expected emissions resulting from agricultural activities include particulates associated with wind erosion, ploughing and burning of crop residue, chemicals associated with crop spraying and odiferous emissions resulting from manure, fertilizer and crop residue.

Dust associated with agricultural practices may contain seeds, pollen and plant tissue, as well as agrochemicals, such as pesticides. The application of pesticides during temperature inversions increases the drift of the spray and the area of impact. Dust entrainment from vehicles travelling on gravel roads may also cause increased particulates in an area. Dust from traffic on gravel roads increases with higher vehicle speeds, more vehicles and lower moisture conditions.

These are the most likely contributors of fugitive emissions from agricultural activities. However, it is noted that fugitive emissions from agricultural activities generally have confined impacts near to the source, limiting the regional impacts.

[11] USEPA (1995): Compilation of Air Pollutant Emission Factors (AP-42) US Environmental Protection Agency

5 STUDY METHODOLOGY

5.1 EMISSION ESTIMATION

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

Emission estimates were based on the AP42 sections: Chapter 13.2.4 Aggregate Handling and Storage Piles and Chapter 13.2.2: Unpaved Roads as well as the National Pollutant Inventory Emission Estimation Technique Manual for Mining (NP1). Calculations were applied to individual processes to obtain an emission to air estimate, based on operational information provided by Envirogistics. The specific processes and emission calculations are discussed in detail below.

Emissions of dust fallout (modelled as TSP), PM_{10} and $PM_{2.5}$ were calculated for all proposed TSF activities. Where emission factors for PM_{10} were not available, a factor of 50% was applied to the calculated TSP emission rates according to best international practice and as specified in the US EPA's AP42 documentation (US EPA, 1998[12]). Where emission factors for $PM_{2.5}$ were not available the generalised particle size distributions in the AP42 Appendix B.2 were utilised.

Emission factors are always expressed as a function of the weight, volume, distance or duration of the activity emitting the pollutant. The general equation used for the estimation of emissions is:

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

Where:

E = emission rate

A = activity rate

EF = emission factor

ER = overall emission reduction efficiency (%)

All information regarding diesel storage tanks and emulsion batching have been assessed prior to conducting the impact assessment. Based on the small storage capacity and negligible emissions, fugitive Volatile organic compound (VOCs) emissions will not be assessed in this assessment.

5.1.1 CRUSHING

As specified by the Client, crushing takes place via a primary crusher and is wetted via water sprays. The emission factor for TSP and $PM_{10,}$ associated with crushing, has been applied in accordance with the National Pollutant Inventory Emission Estimation Technique Manual for Mining (NP1). The emission factor and rates are shown in **Table 5-1** and **Table 5-2.**

[12] USEPA (1995): Compilation of Air Pollutant Emission Factors (AP-42) US Environmental Protection Agency

Table 5-1: Emission factors for primary crushing

Source	Unit	Emission Factor	
		TSP	PM_{10}
Primary Crushing	kg/t	0.01	0.004

Table 5-2: Calculated emission rates for primary crushing

Source	Emission Rate (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Primary Crushing	0.116	0.046	0.017

For emission calculations, the following are noted:

- Normal operating conditions of 24 hours, 7 days per week were applied to the calculations;
- 200,000 tons per month of material is processed, 30% of which is passed through the primary crusher;
- Final product was indicated to have a moisture content of 5%;
- $PM_{2.5}$ emission factor ratios were applied based on the US EPA AP-42 Appendix B.2: Generalised particle size distribution ($PM_{2.5}$ is 30 % of TSP); and
- Dust suppression in the form of water sprays is installed at the crushers and transfer points. Therefore a 50% control efficiency was applied as per NPI recommendations utilising water sprays during crushing activity.

5.1.2 MATERIALS HANDLING

The dust emissions from the current and proposed activities have been quantified using the equation below outlined by the USEPA AP42 (USEPA, 1995).

$$E = k(0.0016)\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (kg/megagram [Mg])}$$

Where: k is the particle size multiplier as detailed in **Table 5-3**, together with the mean wind speed (U) and the material moisture content (M). Water will be used to suppress dust for the material handling events, as specified by the Client. Control efficiency of 70% for water sprays and miscellaneous transfer points were applied to the various material handling activities (NPI, 2012). Control efficiencies were not applied to the Proposed TSF, due to the filter press technology employed. Emissions rates for material handling activities are presented in **Table 5-4**.

Table 5-3: Emission parameters for material handling activities

Constant	Symbol	Unit	Emission Factor		
			TSP	PM_{10}	$PM_{2.5}$
Particle Size Multiplier	k	-	0.74	0.35	0.053
Mean Wind Speed	U	m/s	3.41	3.41	3.41
Material Moisture Content	M	%	12	12	12

Table 5-4: Calculated emission rates for material handling activities

Source	Emission Rate (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Transfer from overland conveyor to crusher	0.02	0.009	0.001
Loading from crusher via FEL to road truck	0.20	0.095	0.014
Offloading via FEL onto road truck for offsite use	0.06	0.028	0.004
Loading via FEL to waste dump	0.03	0.016	0.002
Offloading to waste dump	0.01	0.005	0.001
Loading of material from filter press to dump trucks	0.0022	5.03E-08	1.70E-13
Offloading at Site B TSF	0.0022	5.03E-08	1.70E-13

For emission calculations, the following are noted:

- Normal operating conditions of 24 hours, 7 days per week were applied to the calculations;
- Capacity of waste rock and existing tailings is 35,000 tons/month; and
- Deposits at the Proposed Site B TSF occurs via trucks from the filter press.

5.1.3 VEHICLE ENTRAINMENT ON UNPAVED ROADS

Vehicle-entrained dust emissions from unpaved roads represent a significant source of fugitive dust. When a vehicle travels on an unpaved road, the force of the wheels on the road surface causes the pulverisation of surface material[13]. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed[13].

The unpaved road size-specific emission factor equations from the USEPA are given below. The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. In addition to the volume of traffic, emissions also depend on source parameters which characterise the condition of a particular road and the associated vehicle traffic. These parameters include vehicle speeds, mean vehicle weight, average number of wheels per vehicle and road surface moisture[13].

Particulate emission estimates from vehicle entrainment on unpaved roads are presented below. The equation used to determine particulate emissions from vehicles travelling on unpaved roads at industrial sites is presented below:

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

[13] USEPA (1995): Compilation of Air Pollutant Emission Factors (AP-42) US Environmental Protection Agency, Chapter 13.2.2, Unpaved roads.

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

These emission factors relate the amount of particulate emissions (in grams) to the number of kilometres travelled by vehicles on site (VKT). **Table 5-5** presents the empirical constants used in the equation for different particle sizes and **Table 5-6** presents the calculated emissions rates presented in $g/s/m^2$.

Table 5-5: Empirical constants

Constant	TSP	PM_{10}	$PM_{2.5}$
a	0.7	0.9	0.9
b	0.45	0.45	0.45
k	4.9	1.5	0.15

Table 5-6: Emission rates for wheel entrainment on unpaved roads

Source	Emission Rate ($g/s/m^2$)		
	TSP	PM_{10}	$PM_{2.5}$
Existing-Haulage road one	2.56E-04	7.58E-05	7.58E-06
Existing - Haulage road two	4.41E-04	1.31E-04	1.31E-05
New TSF road	5.82E-04	1.72E-04	1.72E-05

The emission calculations, the following are noted:

- Normal operating conditions of 24 hours, 7 days per week was assumed;
- Surface silt content of 10.2% was used;
- Average truck capacity of 20 tons were used in emission estimation;
- Assumed 35,000 tons per month of waste rock transported via trucks with 58 trucks traveling per day on Haulage road one;
- Assumed 60,000 tons of product transported via trucks with 100 trucks per day travelling on haulage road two;
- 4 trucks per day travelling from the filter press to Site B; and
- Dust suppression in the form of water sprays is utilised on all unpaved roads. Therefore a 75% control efficiency was applied as per NPI recommendations.

5.1.4 WIND EROSION

In the absence of available data regarding the fine material and moisture content of the stockpiles, the default emission factor for TSP and PM_{10} have been applied in accordance with the Australian Government NPI (NPI, 2012). In order to determine the $PM_{2.5}$ emission rate, a factor of 15% was applied to the PM_{10} equation (USEPA, 1995). It is understood that the waste rock dumps, discard dumps and existing TSF will be wetted, as provided by the Client. A control efficiency of 50% for watering was thus applied to the stockpile (NPI, 2012). The emission factor and emission rates for wind erosion are presented in **Table 5-7** and **Table 5-8**.

Table 5-7: Emission factor for stockpiles

Source	Unit	Emission Factor	
		TSP	PM_{10}
Wind Erosion	kg/ha/hr	0.40	0.20

Table 5-8: Wind erosion over exposed areas

Source	Emission Rate (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Waste rock dump - South	1.30	0.65	0.10
Waste rock dump - North	0.22	0.11	0.02
Existing TSF	0.92	0.46	0.07
South Pit Backfill	0.14	0.07	0.01
North Pit Backfill	0.31	0.16	0.02
Discard Dump	0.72	0.36	0.05
Site B – Proposed TSF	2.67	1.33	0.20

For emission calculations, the following are noted:

- PM_{10} and $PM_{2.5}$ emission factor ratios were calculated based on the US EPA AP-42 Chapter 13.2.5: Industrial Wind erosion (PM_{10} is 50% of TSP, while $PM_{2.5}$ is 7.5% of TSP); and
- Dust suppression in the form of water sprays will be applied during wind erosion over exposed areas. With the exception of Site B, a 50% control efficiency was applied as per NPI recommendations utilising water sprays over waste rock dumps, discard dumps, pit backfills and existing TSF.

5.2 SOURCE APPORTIONMENT

Figure 5-1- Figure 5-3 illustrates the contribution of individual sources to the overall PM_{10}, $PM_{2.5}$ and TSP concentrations anticipated to occur as a result of the proposed TSF. The largest source of PM_{10} is attributed to unpaved roads (59%), followed by wind erosion (37%) (**Figure 5-1**).

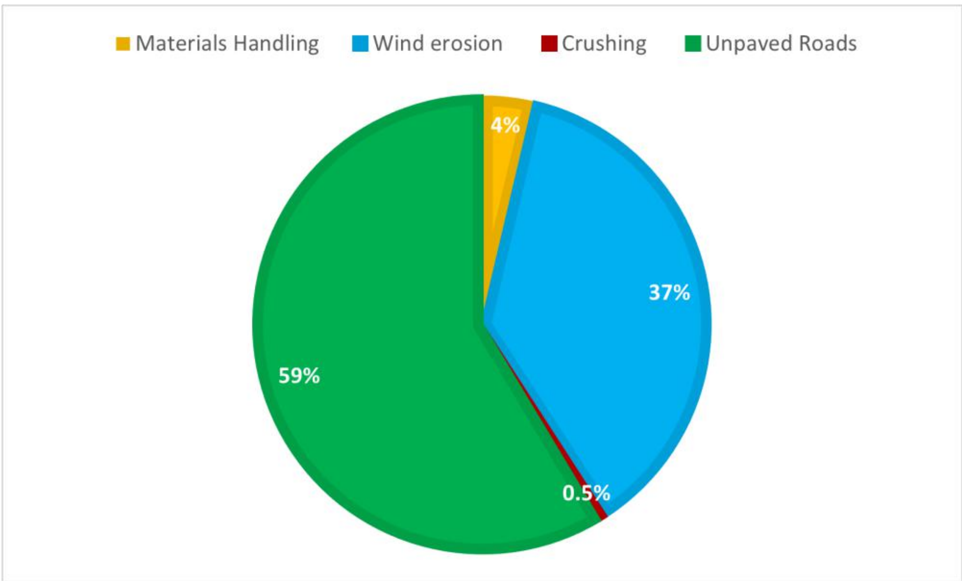

Figure 5-1: PM_{10} source apportionment

Figure 5-2 illustrates the source apportionment of $PM_{2.5}$, with the largest source attributed to unpaved roads (48%), followed by wind erosion (45%).

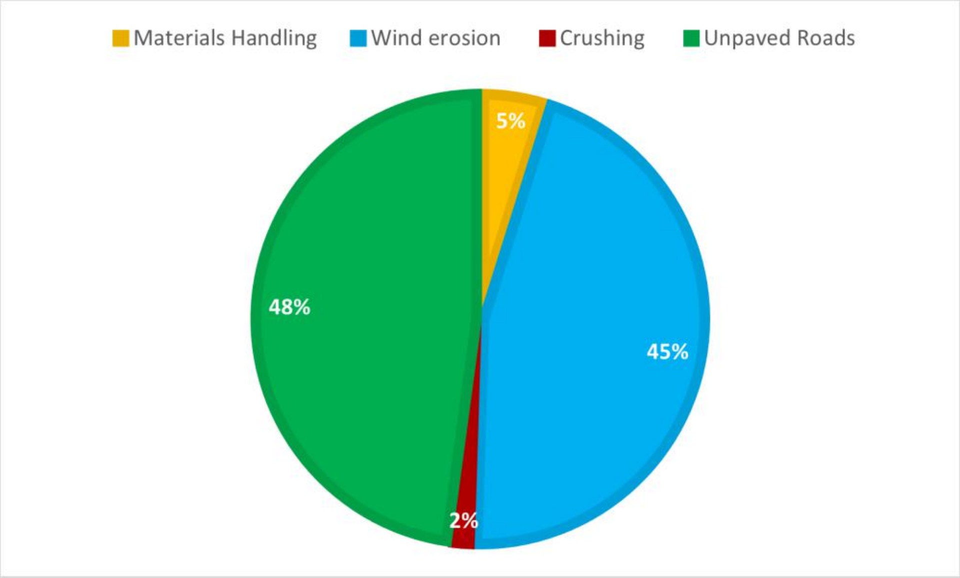

Figure 5-2: $PM_{2.5}$ source apportionment

The largest source of TSP is attributed to wind erosion (56%), followed by unpaved roads (37%) and materials handling and crushing constituting 6% and 1% respectively **(Figure 5-3).**

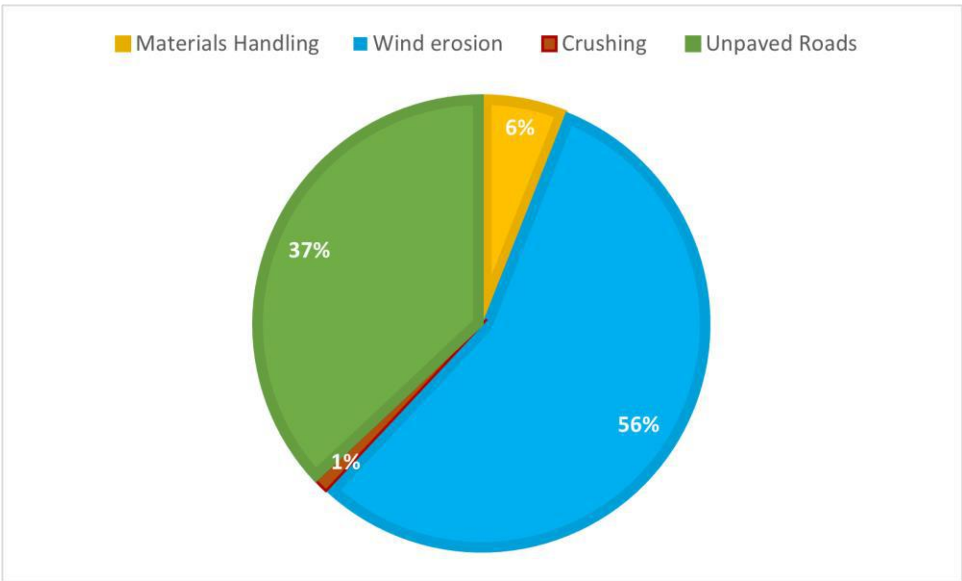

Figure 5-3: TSP source apportionment

5.3 DISPERSION MODELLING

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

AERMOD, a Level Two dispersion modelling platform, is recommended in the Modelling Regulations and was utilised to predict ground-level downwind concentrations of pollutants emitted from the Dwarsrivier Chrome mine.

AERMOD is a new generation air dispersion model designed for short-range dispersion of airborne pollutants in steady state plumes that uses hourly sequential meteorological files with pre-processors to generate flow and stability regimes for each hour, that produces output maps of plume spread with key isopleths for visual interpretation and enables, through its statistical output, direct comparisons with the latest National and International ambient air quality standards for compliance testing.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources;
- A meteorological data pre-processor (AERMET) that accepts surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux; and
- A terrain pre-processor (AERMAP) whose main purpose is to provide a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

5.3.1 MODELLING SCENARIOS

For the purposes of this study, two dispersion modelling simulations was undertaken (Current operations and current operations with the proposed TSF) for the Dwarsrivier Chrome Mine.

The following sources were included in each modelling scenario:

- Scenario 1 – Current Operations
  - Primary crushing activities;
  - Wind erosion from waste rock dump (north and south), pit backfill (north and south), discard dump and existing TSF;
  - Existing roads – haulage road one and haulage road two; and
  - Loading and offloading activities.
- Scenario 2 – Current Operations with Proposed TSF
  - All current sources including wind erosion from Site B; and
  - Proposed TSF road.

Construction phase impacts were not assessed in this study, this includes construction of new roads, parking lots, diesel storage tanks and emulsion batching areas. Construction activities are a source of dust emissions; however, these impacts can be mitigated with the application of appropriate dust control plans. It is highlighted that construction related emissions are transient and will cease once construction is complete.

Diesel storage tanks and emulsion batching were qualitatively assessed prior to conducting the impact assessment. Based on its small storage capacity and negligible emissions, fugitive Volatile organic compound (VOCs) emissions will not be assessed in this assessment.

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

– *Long-term scenario*

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

– *Short-term scenario*

  The short-term scenario refers to the 99^{th} percentile concentrations which are recommended for short-term assessment with the available ambient air quality standards since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. This might cause exceptionally high concentrations that the facility may never actually exceed in its lifetime. The 99^{th} percentile results (1-hour or 24-hours) are graphically presented as concentration isopleths, indicating the short-term concentrations at each grid point.

As defined in the Modelling Regulations, ambient air quality objectives are applied to areas outside the facility fence line (i.e. beyond the facility boundary). Within the facility boundary, environmental conditions are prescribed by occupational health and safety criteria. The facility boundary is defined based on these criteria:

– The facility fence line or the perimeter where public access is restricted;
– If the facility is located within another larger facility boundary, the facility boundary is the boundary of the encompassing facility; and
– If a public access road passes through the facility, the facility boundary is the perimeter along the road allowance.

5.3.2 METEOROLOGICAL INPUT

Data input into the model includes modelled MM5 surface and upper air meteorological data with wind speed, wind direction, temperature, pressure, precipitation, cloud cover and ceiling height for January 2018 – December 2020 (**Figure 5-4**).

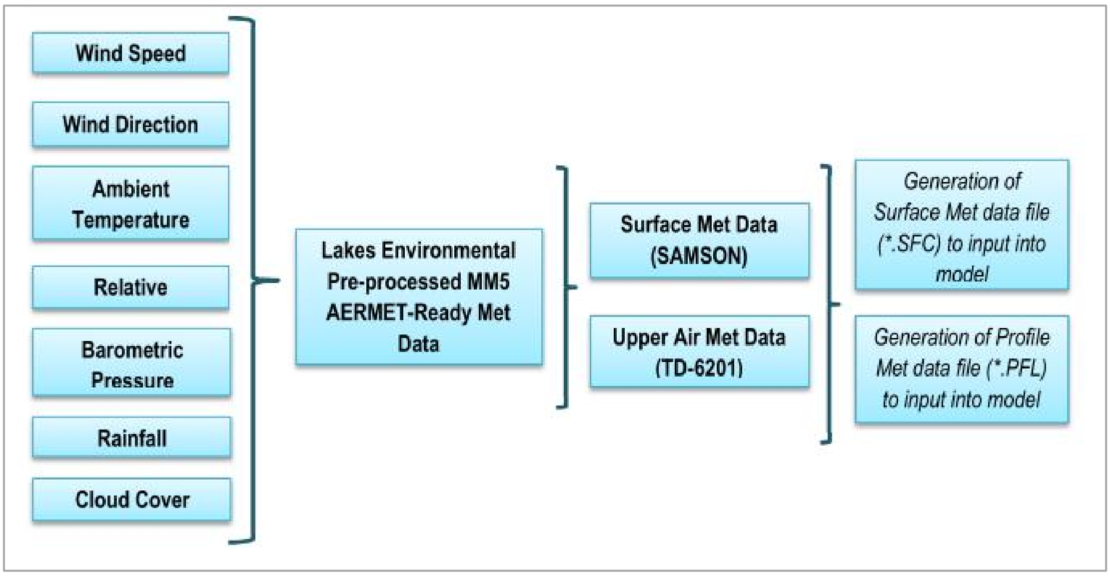

Figure 5-4: Meteorological data path

The model was run in accordance with guidance issued by the Modelling Regulations. The meteorological data used by the model to simulate the dispersion and dilution effects generated by the atmosphere were obtained from Lakes Environmental for the years 2018 to 2020, for the Dwarsrivier project. Data describing the topography of the local area was obtained from the Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global elevation data that offers worldwide coverage of void filled data at a resolution of 1 arc-second (30 meters).

5.3.3 MODEL INPUT PARAMETERS

Table 5-9 presents the model input parameters utilised in this assessment.

Table 5-9: Dispersion model input parameters

Parameter	Model Input
Model	
Assessment Level	Level 2
Dispersion Model	AERMOD
Supporting Models	AERMET and AERMAP
Emissions	
Pollutants modelled	TSP (in the form of dust fallout), PM_{10} and $PM_{2.5}$
Scenario	Current and proposed operations
Chemical transformation	N/A
Exponential decay	N/A
Settings	
Terrain setting	Simple elevated to accommodate for area and volume sources
Terrain data	SRTM30
Terrain data resolution (m)	30
Land characteristics	Rural
Bowen ratio	0.93
Surface albedo	0.29
Surface roughness	0.04
Grid Receptors	
Modelling domain (km)	30 x 30
Property line resolution (m)	50
Fine grid resolution (m)	50 m resolution, 1,000 m from domain centre
Medium grid resolution (m)	100 m resolution, 2,500 m from domain centre
Course grid resolution (m)	250 m resolution, 15,000 m from domain centre

5.3.4 MODELLING DOMAIN

A modelling domain of 30 km × 30 km was used (**Table 5-10**) with multi-tier cartesian grid receptor spacing of 50 m, 100 m and 250 m. The grid spacing selected for the receptor grid is in accordance with those specified in the Modelling Regulations.

Table 5-10: Modelling domain coordinates

Domain Point	**UTM Coordinates mE**	**UTM Coordinates mS**
North-Western Point	193569.4	7254691.97
North-Eastern Point	223578.1	7254702.03
South-Western Point	193578.1	7224702.03
South-Eastern Point	193590.3	7224713.57

6 RESULTS AND DISCUSSION

6.1 CONSTRUCTION PHASE

Dwarsrivier Chrome mine intends to erect two respective diesel and emulsion batching areas, to supply diesel and emulsion to the underground mining operations. Additionally, the mine will also carry out construction of additional parking areas. Construction is a source of dust emissions that can have a substantial temporary impact on the local air quality situation. Emissions during construction are associated with land clearing, drilling and blasting, ground excavation and cut and fill operations. Dust emissions often vary substantially on a daily basis, depending on the level of activity, the specific operations and the prevailing meteorological conditions. A large portion of the emissions results from equipment traffic over temporary roads at the construction site (USEPA, 1995).

The quantity of dust emissions from construction operations is proportional to the area of land being worked and to the level of construction activity. During the construction phase, it is expected that fugitive dust emissions will result from the construction of new infrastructure associated with the expansion. Vehicle activities associated with the transport of equipment to and from the site, and on-site construction equipment traffic may also contribute to elevated fugitive dust levels.

Because construction is of a temporary nature, it is recommended that mitigation control measures be put in place to limit the impacts on the local air quality. Wet suppression and wind speed reduction are common methods used to control open dust sources at construction sites. These mitigation recommendations are further detailed in **Section 6.5.**

6.2 OPERATIONAL PHASE

This section presents the results of the atmospheric dispersion modelling conducted for Dwarsrivier Chrome Mine. Concentration results at specified receptors are presented in tabular format, while concentration isopleths are presented graphically to indicate the dispersion of pollutants. Modelling simulations assessed two scenarios; scenario 1 assessing the current mining activities and scenario 2 assessing proposed activities (current with proposed TSF).

6.2.1 SCENARIO 1

PM_{10} CONCENTRATIONS

Ambient 24-hour (P99) and annual average PM_{10} concentrations are predicted to be compliant at all sensitive receptors (**Table 6-1**). No exceedances were predicted at sensitive receptors with predicted concentrations remaining well below the standard.

Figure 6-1 and **Figure 6-2** present graphical outputs of the 24-hour average and annual average modelled results respectively. Highest predicted 24-hour and annual average off-site concentrations are compliant with the respective 24-hour and annual average PM_{10} standard **(Table 6-2)**. Highest concentrations are predicted on the north-western portion of the mine, predominately around the areas of existing haulage roads.

Table 6-1: Predicted PM_{10} concentrations at neighbouring sensitive receptors for Scenario 1

ID	Sensitive Receptor	24-Hour Average PM_{10} Standard (µg/m^3)	Predicted 24-Hour Average Concentration (µg/m^3)	Annual Average PM_{10} Standard (µg/m^3)	Predicted Annual Average Concentration (µg/m^3)
SR01	Lodge	**75**	0.99	**40**	0.08
SR02	Village	**75**	2.26	**40**	0.19
SR03	Dwelling	**75**	0.19	**40**	0.02
SR04	Dwelling	**75**	0.18	**40**	0.01

Table 6-2: Maximum predicted offsite PM_{10} concentrations for Scenario 1

X (m) (UTM 35S)	Y (m) (UTM 35S)	Predicted concentration (µg/m^3)	Elevation (m)	Grid resolution (m)	Averaging period	Date	Hour
207849.79	7240364.74	26.50	920.79	100	24-hr (P99)	2020/05/07	24:00
207849.79	7240364.74	6.78	920.79	100	Annual	N/A	N/A

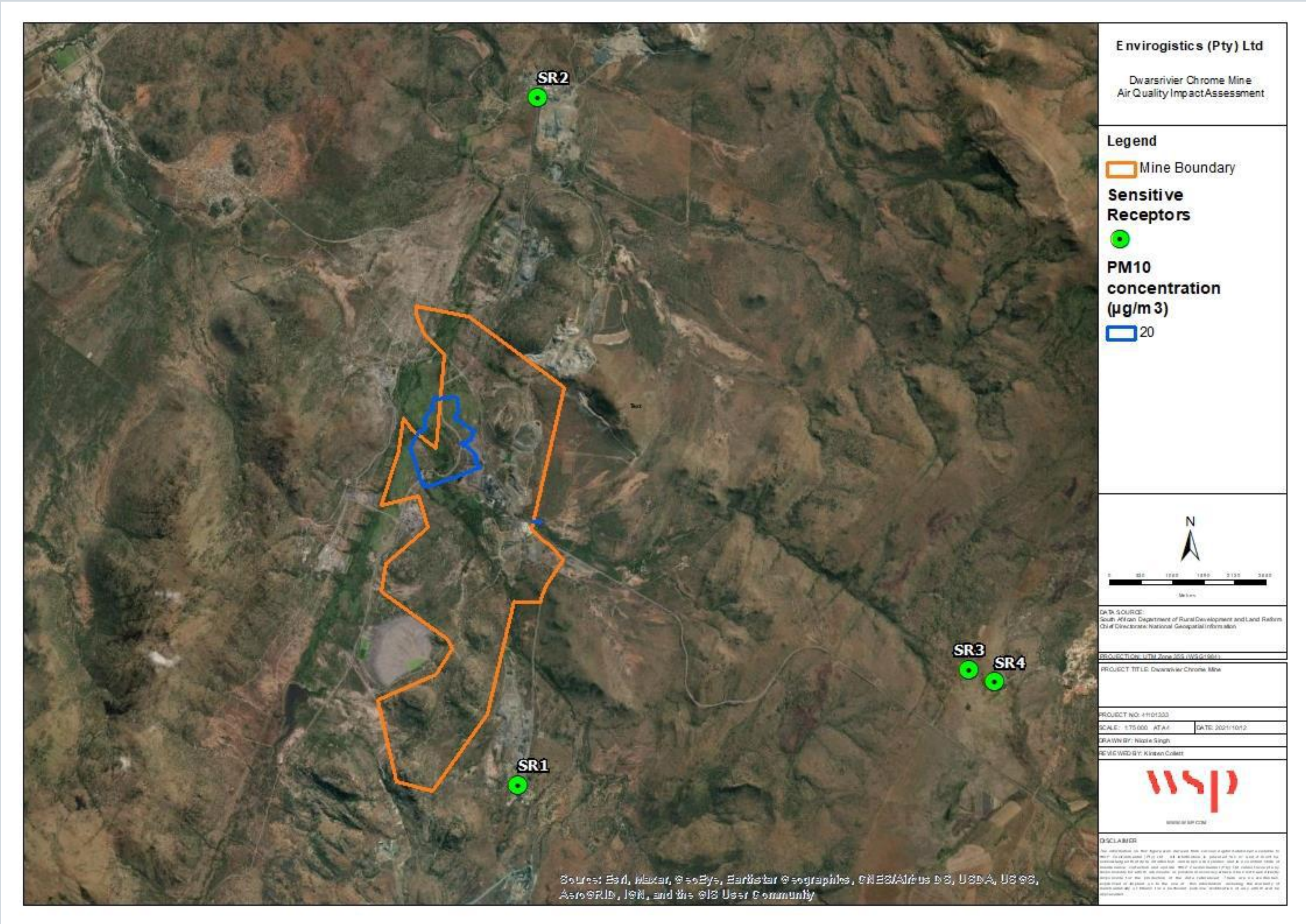

Figure 6-1: P99 24-hour average PM_{10} concentrations (µg/m^3) for Scenario 1

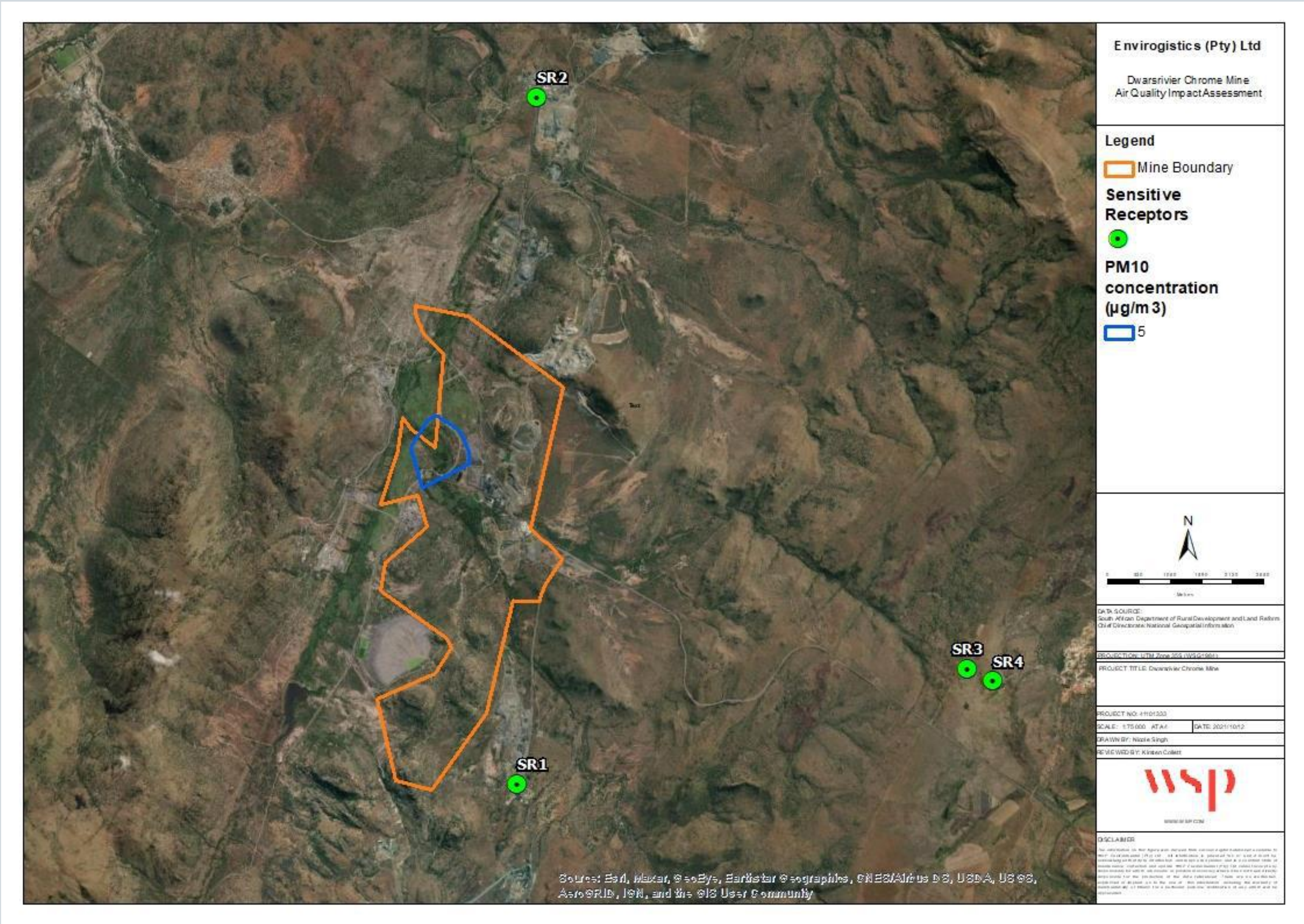

Figure 6-2: Annual average PM_{10} concentrations (µg/m³) for Scenario 1

$PM_{2.5}$ CONCENTRATIONS

Ambient 24-hour (P99) and annual average $PM_{2.5}$ concentrations are predicted to be compliant at all sensitive receptors (**Table 6-3**). No exceedances were predicted at sensitive receptors with concentrations remaining well below the respective standards. **Figure 6-3** and **Figure 6-4** present graphical outputs of the 24-hour average and annual average modelled results respectively. Highest predicted 24-hour and annual average offsite concentrations are compliant with the respective 24-hour and annual average $PM_{2.5}$ standard across the boundary (**Table 6-4**). Highest concentration is predicted on the north-western portion of the mine, predominately around the areas of existing haulage roads.

Table 6-3: Predicted $PM_{2.5}$ concentrations at neighbouring sensitive receptors for Scenario 1

ID	Sensitive Receptor	24-Hour Average $PM_{2.5}$ Standard (µg/m^3)	Predicted 24-Hour Average Concentration (µg/m^3)	Annual Average $PM_{2.5}$ Standard (µg/m^3)	Predicted Annual Average Concentration (µg/m^3)
SR01	Lodge	**40**	0.12	**20**	0.01
SR02	Village	**40**	0.26	**20**	0.02
SR03	Dwelling	**40**	0.02	**20**	2.00E-03
SR04	Dwelling	**40**	0.02	**20**	2.30E-03

Table 6-4: Maximum predicted offsite $PM_{2.5}$ concentrations for Scenario 1

X (m) (UTM 35S)	Y (m) (UTM 35S)	Predicted concentration (µg/m^3)	Elevation (m)	Grid resolution (m)	Averaging period	Date	Hour
207849.79	7240364.74	3.06	920.79	100	24-hr (P99)	2020/05/07	24:00
207849.79	7240364.74	0.82	920.79	100	Annual	N/A	N/A

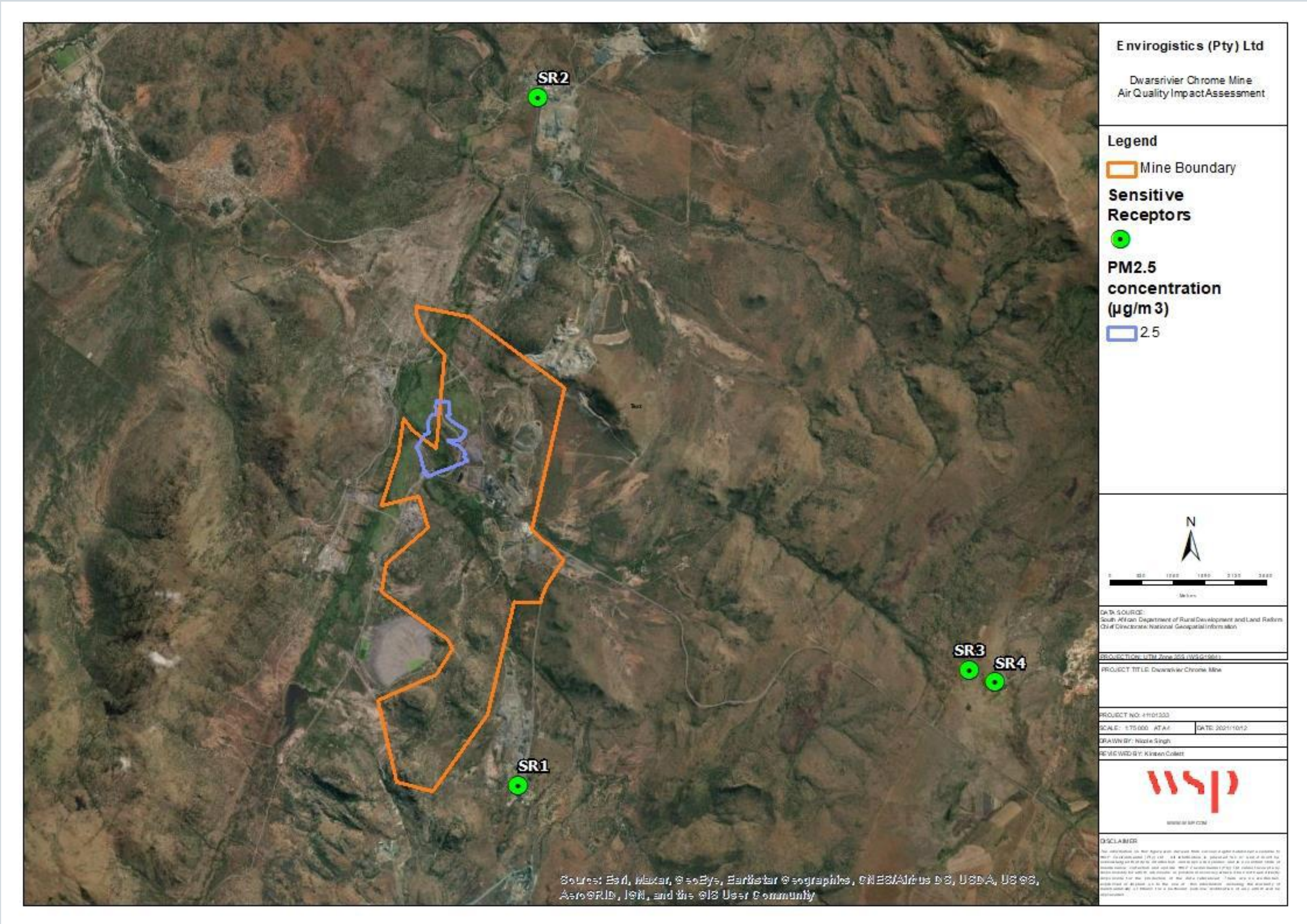

Figure 6-3: P99 24-hour average $PM_{2.5}$ concentrations (µg/m^3) for Scenario 1

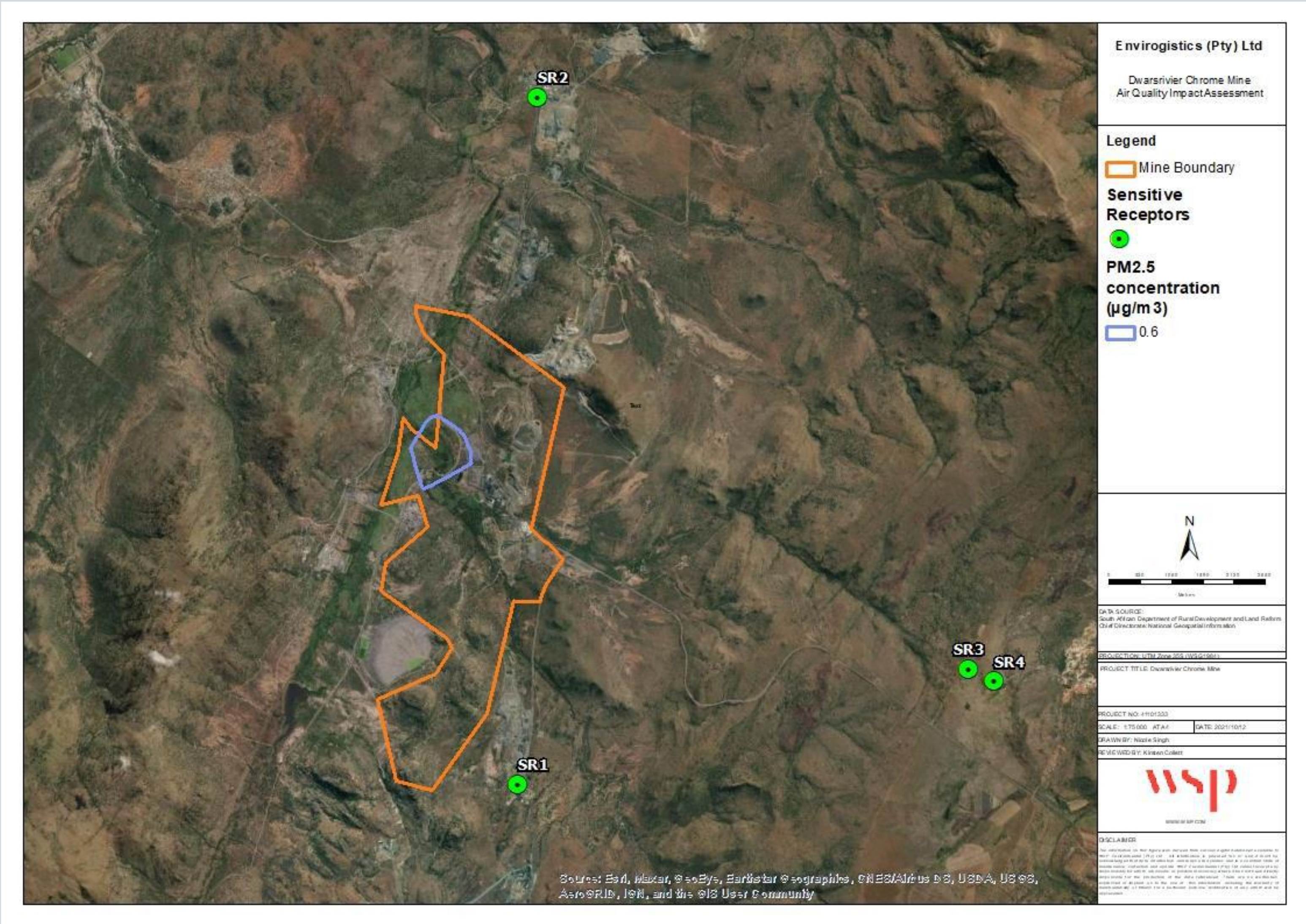

Figure 6-4: Annual average PM2.5 concentrations (µg/m³) for Scenario 1

DUST FALLOUT

Maximum daily dust deposition rates as a result of current mining activities were within the NDCR residential and non-residential standards at all sensitive receptors (**Table 6-5)**. There were no predicted exceedances of the residential standard. **Figure 6-5** present graphical outputs of the daily average modelled dust fallout rates.

Highest predicted daily average off-site dust fallout rates are compliant with the respective non-residential standard across the boundary.

Table 6-5: Predicted dust fallout rates at neighbouring sensitive receptors for Scenario 1

ID	Sensitive Receptor	Residential standard ($mg/m^2/day$)	Predicted 24-hour dust fallout rates ($mg/m^2/day$)
SR01	Lodge	**600**	4.13
SR02	Village	**600**	4.38
SR03	Dwelling	**600**	1.94
SR04	Dwelling	**600**	1.84
Maximum offsite Concentration		**1,200**	121.60

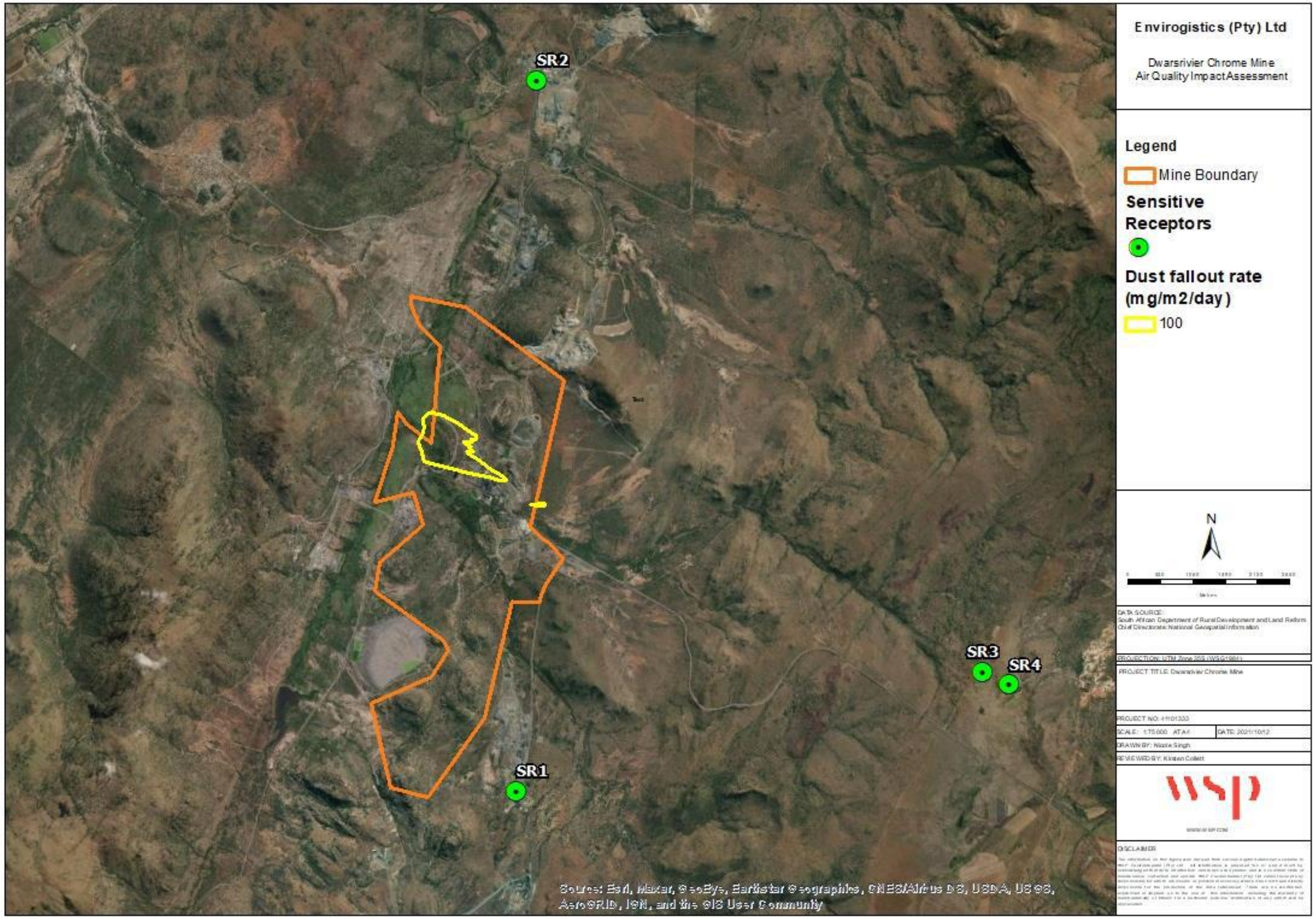

Figure 6-5: Dust fallout rates (mg/m²/day) for Scenario 1

6.2.2 SCENARIO 2

PM_{10} CONCENTRATIONS

Ambient 24-hour (P99) and annual average PM_{10} concentrations are predicted to be compliant at all sensitive receptors (**Table 6-6**). No exceedances were predicted at sensitive receptors with predicted concentrations well below the standard.

Figure 6-6 and **Figure 6-7** present graphical outputs of the 24-hour average and annual average modelled results respectively. Maximum predicted 24-hour off-site concentrations are non-compliant with the relevant standard due to the close proximity of the new TSF road to the boundary of the mine. Maximum predicted annual average off-site concentrations remain compliant with the annual standard. However, despite the non-compliance predicted for the 24-hour off-site concentrations, all concentrations predicted at neighbouring sensitive receptors remain complaint with their relevant standard, as noted previously.

Table 6-6: Predicted PM_{10} concentrations at neighbouring sensitive receptors for Scenario 2

ID	Sensitive Receptor	24-Hour Average PM_{10} Standard (µg/m^3)	Predicted 24-Hour Average Concentration (µg/m^3)	Annual Average PM_{10} Standard (µg/m^3)	Predicted Annual Average Concentration (µg/m^3)
SR01	Lodge	**75**	1.53	**40**	0.14
SR02	Village	**75**	5.54	**40**	0.51
SR03	Dwelling	**75**	0.37	**40**	0.04
SR04	Dwelling	**75**	0.36	**40**	0.04

Table 6-7: Maximum predicted offsite PM_{10} concentrations for Scenario 2

X (m) (UTM 35S)	Y (m) (UTM 35S)	Predicted concentration (µg/m^3)	Elevation (m)	Grid resolution (m)	Averaging period	Date	Hour
207849.79	7240364.74	113.60	910.97	100	24-hr (P99)	2018/03/01	24:00
207849.79	7240364.74	36.80	910.97	100	Annual	N/A	N/A

* Concentrations highlighted in red indicate non-compliance

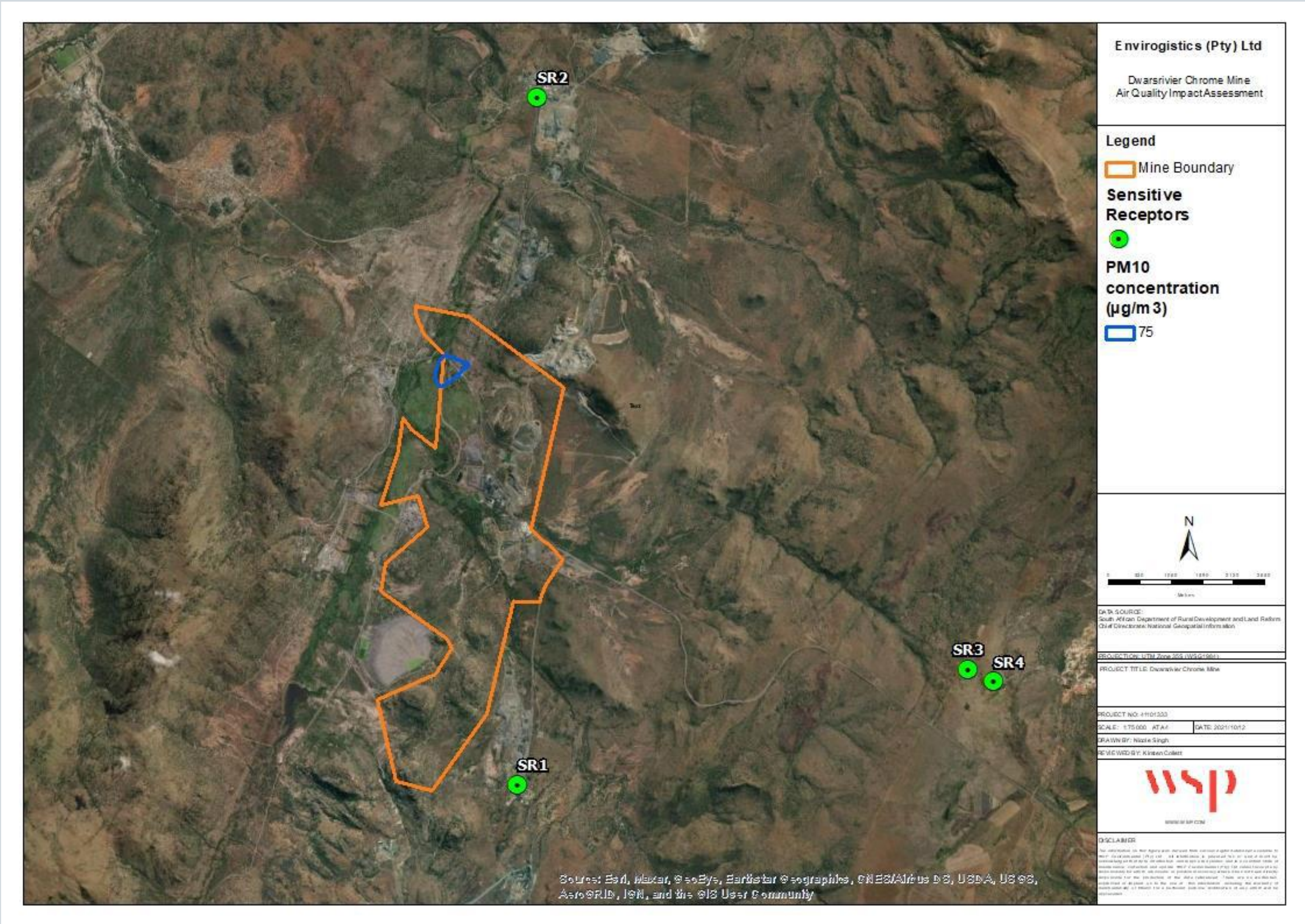

Figure 6-6: P99 24-hour average PM_{10} concentrations ($\mu g/m^3$) for Scenario 2

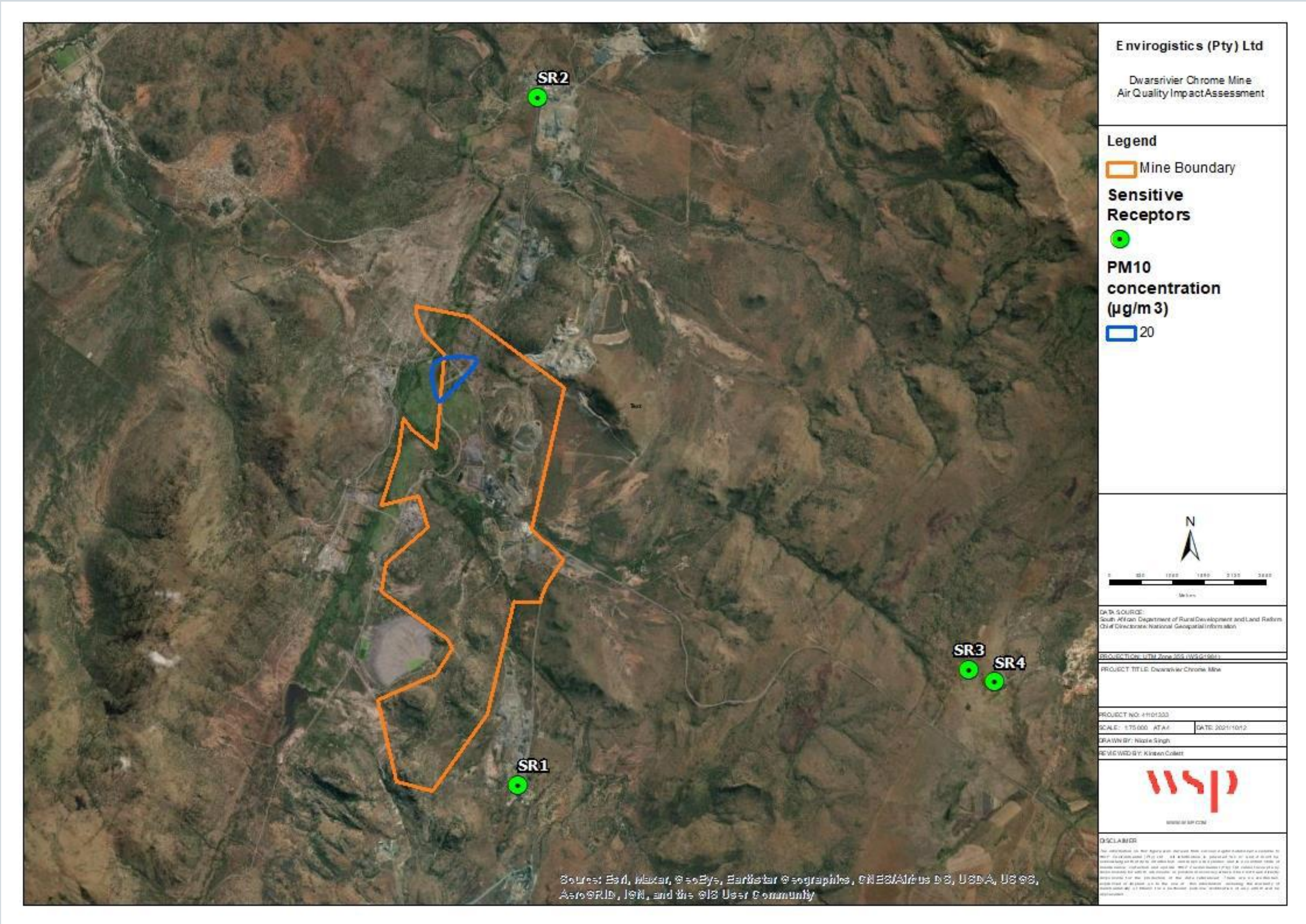

Figure 6-7: Annual average PM_{10} concentrations (µg/m³) for Scenario 2

$PM_{2.5}$ CONCENTRATIONS

Ambient 24-hour (P99) and annual average $PM_{2.5}$ concentrations are predicted to be compliant at all sensitive receptors with the proposed TSF activities (**Table 6-8**). No exceedances were predicted at sensitive receptors, with concentrations remaining below the respective standards. **Figure 6-8** and **Figure 6-9** present graphical outputs of the 24-hour average and annual average modelled results respectively.

Highest predicted 24-hour and annual average off-site concentrations are compliant with the 24-hour and annual average standard respectively. Highest concentrations are predicted on the north-western portion of the mine, predominately around the areas of the new TSF and TSF road.

Table 6-8: Predicted $PM_{2.5}$ concentrations at neighbouring sensitive receptors for Scenario 2

ID	Sensitive Receptor	24-Hour Average $PM_{2.5}$ Standard (µg/m³)	Predicted 24-Hour Average Concentration (µg/m³)	Annual Average $PM_{2.5}$ Standard (µg/m³)	Predicted Annual Average Concentration (µg/m³)
SR01	Lodge	**40**	0.17	**20**	0.01
SR02	Village	**40**	0.65	**20**	0.06
SR03	Dwelling	**40**	0.18	**20**	0.01
SR04	Dwelling	**40**	0.04	**20**	0.01

Table 6-9: Maximum predicted offsite $PM_{2.5}$ concentrations for Scenario 2

X (m) (UTM 35S)	Y (m) (UTM 35S)	Predicted concentration (µg/m³)	Elevation (m)	Grid resolution (m)	Averaging period	Date	Hour
207849.79	7240364.74	11.50	910.97	100	24-hr (P99)	2018/03/01	24:00
207849.79	7240364.74	3.77	910.97	100	Annual	N/A	N/A

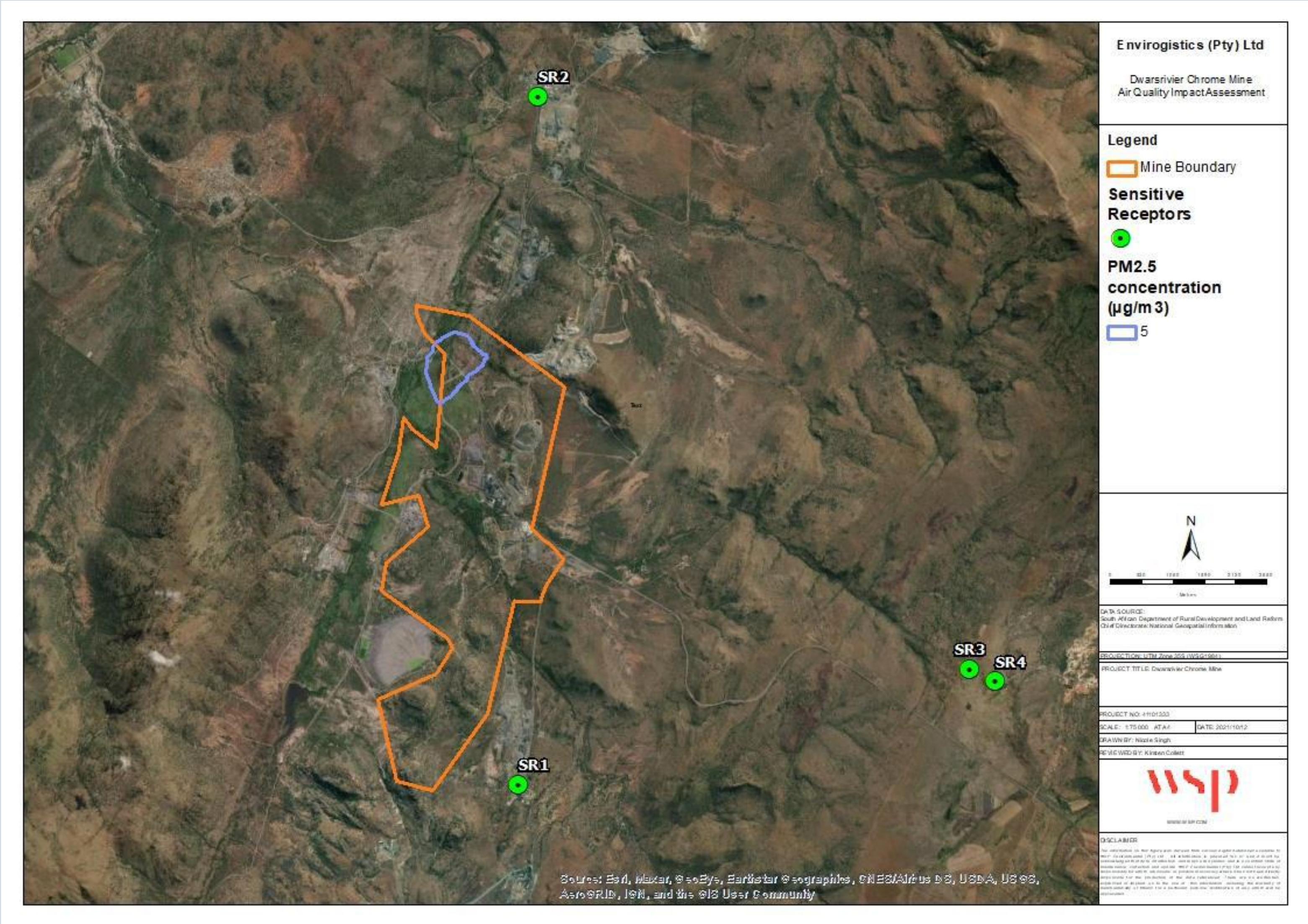

Figure 6-8: P99 24-hour average $PM_{2.5}$ concentrations (µg/m³) for Scenario 2

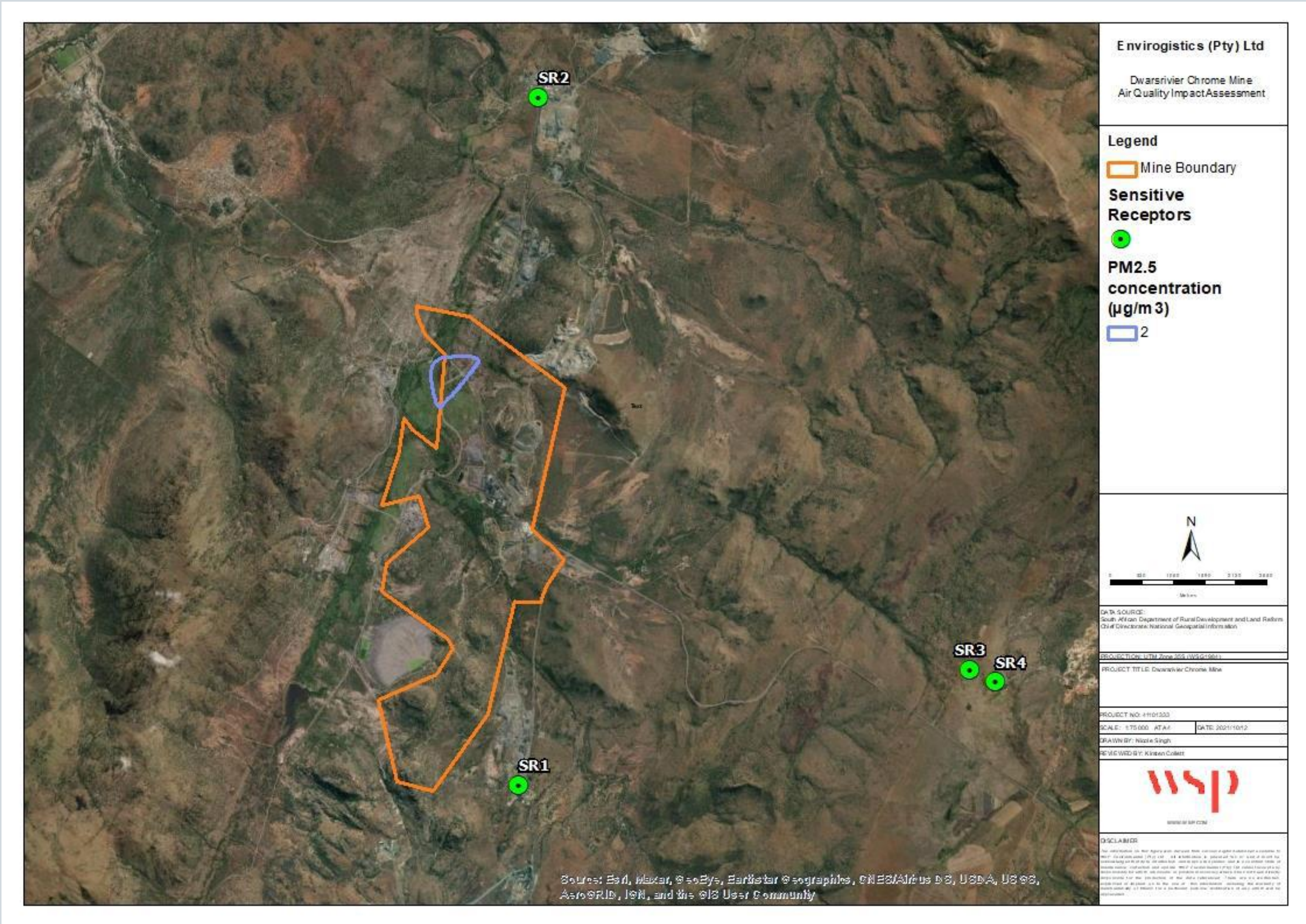

Figure 6-9: Annual average $PM_{2.5}$ concentrations (µg/m³) for Scenario 2

DUST FALLOUT

Maximum daily dust deposition rates as a result of mining and TSF activities were well within the NDCR residential and non-residential standards at all sensitive receptors (**Table 6-10)**. **Figure 6-10** present graphical outputs of the daily average modelled dust fallout rates. Highest predicted daily average off-site dust fallout rates remain compliant with the non-residential standard. Highest predicted dust fallout rates are along the new TSF road close to the boundary of the mine.

Table 6-10: Predicted dust fallout rates at neighbouring sensitive receptors for Scenario 2

ID	Sensitive Receptor	Residential standard ($mg/m^2/day$)	Predicted 24-hour dust fallout rates ($mg/m^2/day$)
SR01	Lodge	**600**	6.95
SR02	Village	**600**	12.92
SR03	Dwelling	**600**	3.61
SR04	Dwelling	**600**	3.40
Maximum off-site Concentration		**1,200**	631.93

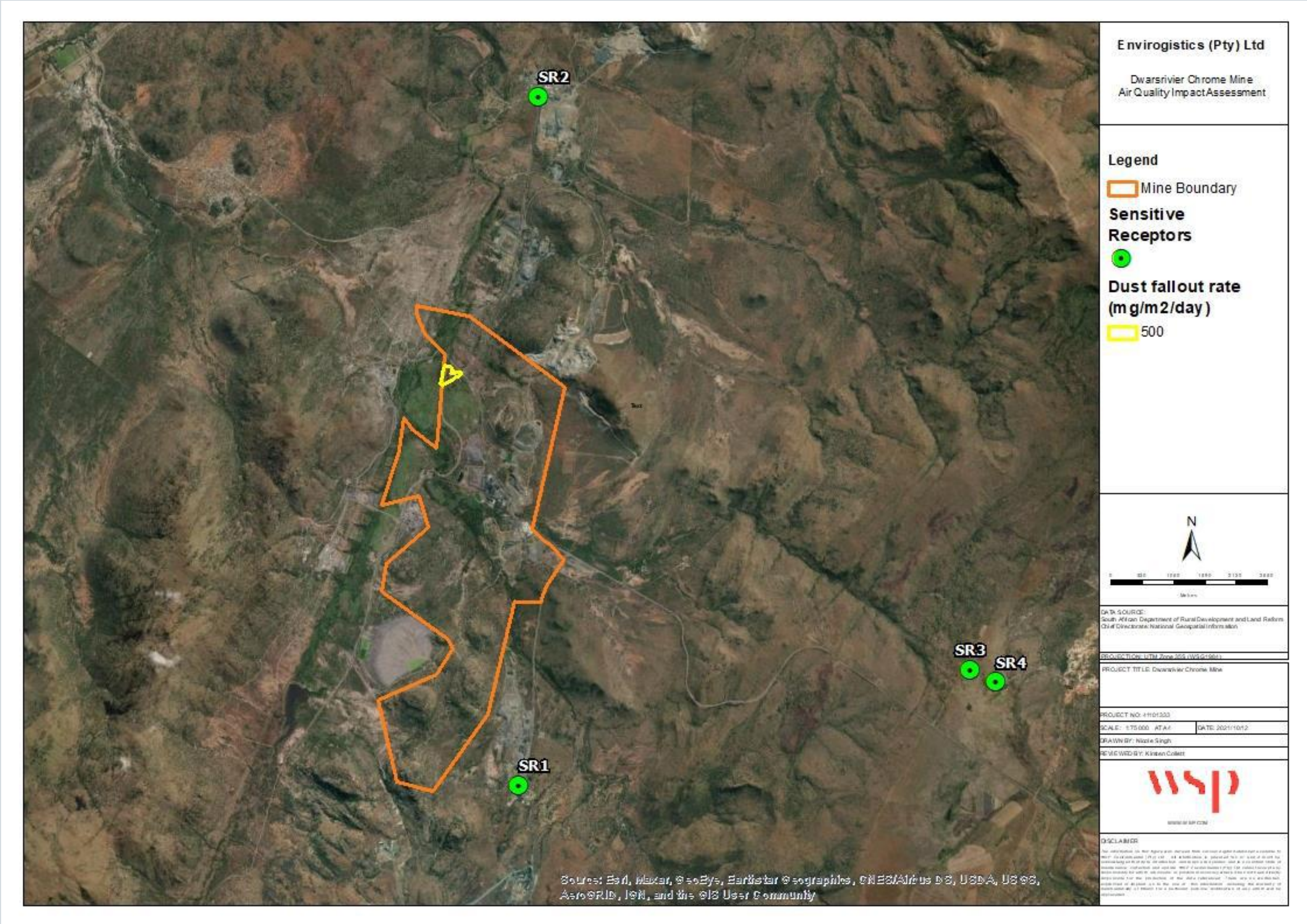

Figure 6-10: Dust fallout rates (mg/m^2/day) for Scenario 2

6.2.3 CUMULATIVE ASSESSMENT

The National Framework for Air Quality Management in South Africa calls for air quality assessment in terms of cumulative impacts rather than the contributions from an individual facility. Compliance with the NAAQS is to be determined by considering all local and regional contributions to background concentrations. For each averaging time, the sum of the model predicted concentration (C_P) and the background concentration (C_B) must be compared with the NAAQS. The background concentrations C_B must be the sum of contributions from non-modelled local sources and regional background air quality. If the sum of background and predicted concentrations (C_B + C_P) is more than the NAAQS, the design of the facility must be reviewed (including pollution control equipment) to ensure compliance with NAAQS. Compliance assessments must provide room for future permits to new emissions sources, while maintaining overall compliance with NAAQS. For the different facility locations and averaging times, the comparisons with NAAQS must be based on recommendations in **Table 6-11.**

Monitoring data from continuous ambient monitoring stations for the project area was not available. As such, cumulative dust fallout impacts associated with the Dwarsrivier proposed TSF could not be assessed.

Table 6-11: Summary of recommended procedures for assessing compliance with NAAQS[14]

Facility Location	Annual NAAQS	Short-term NAAQS (24 hours or less)
Isolated facility not influenced by other sources; C_B insignificant*.	Highest C_P must be less than the NAAQS, no exceedances allowed.	99th percentile concentrations must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.
Facilities influenced by background sources e.g. in urban areas and priority areas.	Sum of the highest C_P and background concentrations must be less that the NAAQS, no exceedances allowed.	Sum of the 99th percentile concentrations and background C_B must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.
*For an isolated facility influenced by regional background pollution C_B must be considered.		

To determine the cumulative impact of the proposed Site B TSF on current operations, predicted annual average and maximum 24-hour concentrations from Scenario 1 have been added to Scenario 2. Daily maximum and annual average results are presented in **Table 6-12** and **Table 6-13** respectively. The following is noted:

- During both scenarios, the cumulative concentrations are below the respective 24-hour and annual average standard for PM_{10} and $PM_{2.5}$;
- Changes in predicted PM_{10} concentrations between Scenario 1 and Scenario 2 are substantial, with a 24-hour average increase of 66% and annual average increase of 69% across all sensitive receptors; and
- Changes in predicted $PM_{2.5}$ concentrations between Scenario 1 and Scenario 2 are substantial, with a 24-hour average increase of 72% and annual average increase of 68% across all sensitive receptors.

[14] DEAT. 2004. *Cumulative effects assessment, integrated environmental management, information series 7. Department of environmental affairs and tourism (DEAT), Pretoria.*

Table 6-12: 24-Hour predicted cumulative assessment for Dwarsrivier

Receptor	24-Hour Ambient Standard (µg/m³)	Predicted Scenario 1 24-Hour Average (µg/m³)	Predicted Scenario 2 24-Hour Average (µg/m³)	Cumulative Concentrations (µg/m³)	Percentage Contribution of Predicted Concentrations to Cumulative Concentrations (%)
PM_{10}					
SR1	**75**	0.99	1.53	2.52	60
SR2		2.26	5.54	7.80	71
SR3		0.19	0.37	0.56	66
SR4		0.18	0.36	0.56	66
$PM_{2.5}$					
SR1	**40**	0.12	0.17	0.29	59
SR2		0.26	0.65	0.91	71
SR3		0.02	0.18	0.20	90
SR4		0.02	0.04	0.06	67

Table 6-13: Annual predicted cumulative assessment for Dwarsrivier

Receptor	Annual Ambient Standard (µg/m³)	Predicted Scenario 1 Annual Average (µg/m³)	Predicted Scenario 2 Annual Average (µg/m³)	Cumulative Concentrations (µg/m³)	Percentage Contribution of Predicted Concentrations to Cumulative Concentrations (%)
PM_{10}					
SR1	**40**	0.08	0.14	0.2247	63
SR2		0.19	0.51	0.717	72
SR3		0.02	0.04	0.064	70
SR4		0.01	0.04	0.061	70
$PM_{2.5}$					
SR1	**20**	0.01	0.01	0.027	62
SR2		0.02	0.06	0.085	70
SR3		2.00E-03	0.01	0.007	71
SR4		2.30E-03	0.01	0.0073	68

6.3 ASSUMPTIONS AND LIMITATIONS

The following assumptions have been made for the assessment:

- Data input for the emissions inventory and dispersion model is based on the information provided by the Client. It is assumed that this information provided is accurate and complete at the time of modelling;
- Site specific meteorological data was not available therefore use was made of MM5 data, which is representative of the site;
- Normal operating conditions of 24 hours, 7 days per week;
- In the absence of data regarding fine material and moisture content of disturbed areas, use was made of the US EPA AP 42 Industrial Wind Erosion emission factor for wind erosion over exposed areas;
- Particulate matter emission factor ratios were applied based on the US EPA AP-42 Appendix B.2: Generalised particle size distribution for the following activities;
  - PM_{10} is 50% of TSP, while $PM_{2.5}$ is 7.5% of TSP for wind erosion; and

  - $PM_{2.5}$ is 30 % of TSP for crushing;
- 200,000 tons of material per month is processed, 30% of which is passed through the primary crusher;
- Final product was indicated to have a moisture content of 5%;
- Surface silt content of 10.2% was used;
- Average truck capacity of 20 tons were used in emission estimation;
- Assumed 35,000 tons per month of waste rock transported via trucks; and
- Assumed 60,000 tons of product transported via trucks;
- As per NPI recommendations the following control efficiencies were applied
  - 75% control efficiency utilising water sprays over unpaved roads;
  - 50% control efficiency utilising water sprays over exposed areas; and
- A cumulative assessment for PM_{10} and $PM_{2.5}$ could not be undertaken due to lack of good quality data representative of the site.

EXCLUSIONS

Following the submission of this AQIA in October 2021, the design of the proposed TSF and associated infrastructure was finalised. The following modifications/changes are noted:

- Increase in TSF height from 37 m to 42m;
- Demarcation of a topsoil area between the proposed TSF and discard dump; and
- Changes in existing haul road route.

These design changes were not assessed in this AQIA, however, WSP is of the opinion that an updated AQIA is not required as:

- The change in TSF height is marginal. The location of the proposed TSF in relation to sensitive receptors, with the closest receptor (SR2) being approximately 5.0 km north of the TSF, will likely have no additional impact on surrounding receptors;
- The addition of a topsoil area between the proposed TSF and discard dump is assumed to have no additional impact on surrounding receptors, given the location of receptors in relation to the site. However, it is advised that control measures be implemented on exposed stockpiles in order to mitigate potential impacts. Please refer to **Section 6.5** for proposed mitigation options; and
- The updated haul road follows the same path as the existing modelled haul road, with the updated road being slightly shorter. Modelling of the existing road hence results in a worst-case scenario assessment of emissions. WSP therefore does not anticipate any additional impact arising from changes to the haul road..

Based on the above findings (not quantified), WSP is of the opinion that an update on the existing AQIA is not required. Given the marginal changes of the Proposed TSF height, additional stockpile and haul route adjustment, this AQIA remains representative of emissions and associated impacts from this project.

6.4 ASSESSMENT OF IMPACTS

The purpose of this air quality impact assessment is to identify the potential impacts and associated risks posed by the proposed TSF on the existing ambient air quality in the area. The outcomes of the impact assessment will provide a basis to identify the key risk drivers and make informed decisions on the way forward to ensure that these risks do not result in unacceptable social or environmental risk.

All impacts of the proposed project were evaluated using a risk matrix, which is a semi-quantitative risk assessment methodology. This system derives an environmental impact level based on the extent, duration, potential intensity and probability of potentially significant impacts. The overall risk level is determined using professional judgement based on a clear understanding of the nature of the impact, potential mitigatory measures that can be implemented and changes in risk profile as a result of implementation of these mitigatory measures. A full description of the risk rating methodology is presented in **Appendix A**. Key localised air quality impacts associated with the proposed project include:

– Future operational phase impacts of air emissions on residential receptors.

Outcomes of the impact assessment are contained within **Table 6-14** outlining the impact of each parameter and the resulting risk level. The resultant air quality risks for residential receptors were ranked "low" during the operational phase.

Table 6-14: Impact assessment of risks associated with the operation of the proposed facility

	Scenario 1						Scenario 2					
Description	Extent	Duration	Potential Intensity	Probability	Significance	**Risk Level**	Extent	Duration	Potential Intensity	Probability	Significance	**Risk Level**
Future operational phase impacts of air emissions on residential receptors	1	3	2	0.1	0.6	**Low**	2	4	2	0.2	0.8	**Low**

6.5 MITIGATION RECOMMENDATIONS

CONSTRUCTION PHASE

The following mitigation measures would serve to reduce air quality impacts to the receiving environment and sensitive receptors:

- Mitigation measures to be implemented during construction are:
  - Use of water sprays during construction activities, thereby limiting the dispersion of particulate emissions;
  - Continuous wetting of the access road during vehicle transport; and
  - Wetting of exposed stockpiles to limit the dispersion of wind-blown dust emissions.
- Information regarding construction activities should be provided to all local communities. Such information includes:
  - Contact details of a responsible person on site should complaints arise to reduce emissions in a timely manner; and
  - Complaints register must be kept recording all events.
- General housekeeping should be implemented on site to keep PM and dust emissions to a minimum;
- All incoming and outgoing truck loads must be covered;
- Avoid dust generating works during extreme windy conditions;
- Use of chemical stabilisation on access road must be considered as its usually cost effective for relatively long term or semi-permanent unpaved roads; and
- Wet suppression and wind speed reduction are common methods used to control open dust sources at construction sites as a source of water and material for wind barriers tend to be readily available. General control methods for open dust sources, as recommended by the USEPA[15], are given in **Table 6-15.**

Table 6-15: Mitigation measures for general construction

Emission Source	Recommended Control Method
Debris handling	Wind speed reduction
	Wet suppression(1)
Truck transport(2)	Wet suppression
	Paving
	Chemical stabilisation(3)
Bulldozers	Wet suppression(4)
Pan scrapers	Wet suppression
Cut/fill material handling	Wind speed reduction
	Wet suppression
Cut/fill haulage	Wet suppression
	Paving
	Chemical stabilisation
General construction	Wind speed reduction

[15] United States Environmental Protection Agency AP 42 (1995): Emission Factors, Chapter 13

	Wet suppression
	Early paving of permanent roads

Notes:

(1) Dust control plans should contain precautions against watering programs that confound trackout problems.

(2) Loads could be covered to avoid loss of material in transport, especially if material is transported offsite.

(3) Chemical stabilisation usually cost-effective for relatively long-term or semi-permanent unpaved roads

(4) Excavated materials may already be moist and may not require additional wetting.

OPERATIONAL PHASE

The Australian NPI recommends a number of ways in which emissions from materials handling and storage activities can be controlled. General control measures and efficiencies are given in **Table 6-16**.

Table 6-16: Emission reduction factors for materials handling and storage (NPI, 2008)

Control Method	Emission Reduction (%)
Wind breaks	30
Water sprays	50
Chemical suppression	80
Enclosure (2 or 3 walls)	90
Covered stockpiles	100

The following additional mitigation measures would serve to reduce air quality impacts to the receiving environment and sensitive receptors:

- Dust emissions from crushing and transfer points can be minimised by water sprays and further, by creating a protective berm at the crushing area to serve as a barrier;
- Continuous wetting of the access road during vehicle transport;
- Wetting of exposed stockpiles to limit the dispersion of wind-blown dust and particulate emissions;
- Avoid dust generating works during the most windy conditions; and
- Dust emissions from dumps, TSFs and stockpiles can occur during loading and offloading, when wind disturbs the surface, and during reclamation. Smaller dumps can be covered using hessian sheets or alternatively protected by a shade cloth windbreak (porous wall)[16]. Both of these techniques aim to reduce wind speed at the surface, in turn reducing the potential for dust scour and entrainment. An important characteristic about wind erosion is that each time a surface is disturbed, its erosion potential is restored.

– [16] United States Environmental Protection Agency AP 42 (2006): Emission Factors, Chapter 13.2.5 Industrial Wind erosion.

7 CONCLUSION

Envirogistics (Pty) Ltd (Envirogistics) appointed WSP Group Africa (Pty) Ltd (WSP) to conduct an Air Quality Impact Assessment (AQIA) for the proposed TSF at the existing Dwarsrivier Chrome Mine located near Steelpoort, Limpopo Province. It is anticipated that the existing TSF will reach its full capacity relatively sooner than anticipated due to tonnage ramps up and additional tonnages from other sites. A site selection study was carried out in June 2021, which identified Site B as the best viable option for the proposed TSF, that is anticipated to supersede the current TSF.

A baseline assessment was undertaken that included a geographic overview and a review of available meteorological data. On-site surface data was not available; therefore use was made of MM5 meteorological data representative of the site. To characterise the meteorological conditions of the site, MM5 prognostic meteorological data was obtained for the period January 2018 to December 2020 for input into the air dispersion model.

The impact assessment comprised an emissions inventory and subsequent dispersion modelling simulations. An emissions inventory was developed using site-specific data and emission factors which were sourced from the United States Environmental Protection Agency AP42 (US EPA, 1995) and the Australian Government National Pollutant Inventory (NPI, 2012) databases. This emissions inventory was input into a Level 2 atmospheric dispersion model, AERMOD, together with prognostic MM5 meteorological data, to calculate ambient air concentrations of key pollutants associated with the proposed operations.

Sensitive receptors are identified as areas that may be impacted negatively due to emissions from the proposed TSF. Four receptors (villages and dwellings) were identified in the area surrounding the proposed project area, within a 10 km radius, and were used for this assessment.

Long-term (annual) and short-term (24-hour average) concentrations for the pollutants of concern were compared with the South African NAAQS and dust fallout levels with the NDCR standards.

PM_{10} CONCENTRATIONS

– For Scenario 1 (current mining operations) and Scenario 2 (current with proposed TSF) ambient 24-hour (P99) and annual average PM_{10} concentrations are predicted to be compliant at all sensitive receptors;
– Changes in predicted PM_{10} concentrations between Scenario 1 and Scenario 2 are substantial, with a 66% average increase in the 24-hour (P99) concentrations and a 69% average increase in annual average concentrations across all sensitive receptors. However, despite the increase, predicted concentrations at all receptors remain well below the standards during Scenario 2;
– Highest predicted 24-hour and annual average off-site concentrations are compliant with the respective standards for Scenario 1. Highest concentrations are predicted on the north-western portion of the mine, predominately around the areas of existing haulage roads;
– Highest predicted 24-hour average off-site concentrations during Scenario 2 are non-compliant with the relevant 24-hour standard, due to the close proximity of the new TSF road to the boundary of the mine. However, highest predicted annual average concentrations remain compliant with the standard; and
– However, despite the non-compliance predicted for the 24-hour PM_{10} off-site concentrations (Scenario 2), all concentrations predicted at neighbouring sensitive receptors remain complaint with their relevant standard, as noted previously.

$PM_{2.5}$ CONCENTRATIONS

– For Scenario 1 (current mining operations) and Scenario 2 (current with proposed TSF), ambient 24-hour (P99) and annual average $PM_{2.5}$ concentrations are predicted to be compliant at all sensitive receptors;

- Changes in predicted $PM_{2.5}$ concentrations between Scenario 1 and Scenario 2 are substantial, with a 72% average increase in the 24-hour (P99) concentrations and a 68% average increase in annual average concentrations across all sensitive receptors. However, despite the increase, predicted concentrations at all receptors remain well below the standards during Scenario 2; and
- Highest predicted 24-hour average and annual average off-site concentrations remain compliant with the relevant standards for both scenarios.

DUST FALLOUT

- For both scenarios, no exceedances of the dust fallout residential standard are predicted at any of the neighbouring sensitive receptors;
- Scenario 1 and Scenario 2 highest predicted off-site dust fallout rates remain compliant with the non-residential standard; and
- Overall levels of dust fallout anticipated to occur as a result of the proposed TSF are below the respective National Dust Control Regulations.

MITIGATION MEASURES

- Important Mitigation measures to be implemented during mining operations are:
  - Use of water sprays at crushing and transfer points;
  - Continuous wetting of the access road during vehicle transport;
  - Wetting of exposed stockpiles to limit the dispersion of wind-blown dust and particulate emissions;
  - Avoid dust generating works during the most windy conditions; and
  - Frequent wetting of the access roads.

The proposed TSF will result in minimal air quality impacts on nearby receptors. Given the low impacts on the receiving environment, based on the findings of this AQIA, it is recommended the proposed TSF be authorised.

APPENDIX

A

IMPACT ASSESSMENT METHODOLOGY

APPENDIX

The impacts were assessed using the risk matrix defined in tables that follow.

Impact Assessment Parameters – Extent

Extent Descriptors	Definitions	Rating
Site	The impact footprint remains within the cadastral boundary of the site.	1
Local	The impact footprint extends beyond the cadastral boundary of the site, to include the immediately adjacent and surrounding areas.	2
Regional	The impact footprint includes the greater surrounding area within which the site is located.	3
National	The scale / extent of the impact is applicable to Botswana.	4
Global	The extent / scale of the impact is global.	5

Impact Assessment Parameters – Duration

Duration Descriptors	Definitions	Rating
Construction Period Only	The impact endures for only as long as the Construction period of the proposed activity. This implies the impact is fully reversible.	1
Short Term	The impact continues to manifest for a period of between 3 – 10 years. The impact is reversible.	2
Medium Term	The impact continues to manifest for a period of 10 – 30 years. The impact is reversible with relevant and applicable mitigation and management actions.	3
Long Term	The impact continues for a period in excess of 30 years. However, the impact is still reversible with relevant and applicable mitigation and management actions.	4
Permanent	The impact will continue indefinitely and is irreversible.	5

Impact Assessment Parameters – Potential Intensity

Descriptors: Potential Negative Consequence	Rating	Score
Human health – morbidity / mortality. Loss of species.	High	16
Reduced faunal populations, loss of livelihoods, individual economic loss.	Moderate-high	8
Reduction in environmental quality – air, soil, water. Loss of habitat, loss of heritage, amenity.	Moderate	4
Nuisance.	Moderate-low	2
Negative change – with no other consequences.	Low	1

APPENDIX

Impact Assessment Parameters – Probability

Likelihood / Probability Descriptors	Definitions	Rating
Improbable	The possibility of the impact occurring is negligible and only under exceptional circumstances.	0.1
Unlikely	The possibility of the impact occurring is low with less than 10% chance of occurring. The impact has not occurred before.	0.2
Probable	The impact has a 10 – 40% chance of occurring. Only likely to happen once every three or more years.	0.5
Highly Probable	It is most likely that the impact will occur. A 41 – 75% chance of occurring.	0.75
Definite	More than 75% chance of occurring. The impact occurs regularly.	1

From the tables above, the significance of the impacts is then calculated using the following equation:

(Extent + Duration + Potential Intensity) x Probability = Significance

The significance level of the risks, as weighted by the above equation, identifies the risk rating that each impact triggers and the associated authorisation implications as outlined in the table below:

Impact Assessment Parameters – Significance

Descriptors	Definitions	Rating
Low	The project can be authorised with a low risk of environmental degradation.	**< 5**
Medium	The project can be authorised but with conditions and routine inspections.	**5 – 8**
High	The project can be authorised but with strict conditions and high levels of compliance and enforcement in respect of the impact in question.	**9 – 15**
Fatally Flawed	The project cannot be authorised.	**> 15**

APPENDIX