Air Quality Impact Assessment:

Mining right application for the Ryst Kuil Project

Beaufort West, Western Cape

prepared for

Lukisa Invest 100 (Pty) Ltd

on behalf of

Aquatox Consulting (Pty) Ltd

Report No: RYS-579

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Lethabo Air Quality Specialists (Pty) Ltd
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Facility details

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Project location	Various farms in the Beaufort West local municipality, Western Cape.

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Nomenclature

Symbols/abbreviations

PM	-	Particulate matter
PM_{10}	-	Particulate matter with an aerodynamic diameter of less than or equal to 10 micrometre
$PM_{2.5}$	-	Particulate matter with an aerodynamic diameter of less than or equal to 2.5 micrometre
TPM	-	Total particulate matter

Units

ha	-	hectare
m	-	Metre
m^3	-	Cubic metre
s	-	Second
tpa	-	Tonne per annum
µg	-	Microgram

1. Introduction

1.1 Background

Luska Invest 100 (Pty) Ltd plans to develop a uranium mine in the Ryst Kuil region. The site is located approximately 40 km towards the south-east of Beaufort West and 22 km north-west of Rietbron in the Western Cape.

Luska Invest 100 (Pty) Ltd appointed Aquatox Consulting (Pty) Ltd (Aquatox) to obtain environmental authorisation for the proposed mining operation. One of the specialist studies required is an air quality impact (AQI) assessment and Aquatox requested Lethabo Air Quality Specialists (Pty) Ltd (LAQS) to assist in this regard.

This report discusses the steps followed by LAQS to comply with this requirement.

1.2 Relevant government regulations

The following government regulations apply to this air quality impact assessment and are referred to in the report where applicable.

- "*National Ambient Air Quality Standards*" as published in Government Notice 1210 of 24 December 2009 (GN1210).
- "*National Ambient Air Quality Standards for Particulate Matter with an Aerodynamic Diameter Less than 2.5 Micron Meters*" as published in Government Notice 486 of 29 June 2012 (GN486).
- "*Regulations Regarding Air Dispersion Modelling*" as published in Government Notice GN R.533 of 11 July 2014 (GN R.533), as amended.

1.3 Proposed activity overview

Both open-cast and underground mining is envisaged as well as the on-site processing of the uranium ore. The following activities are implied:

- Drilling and blasting of overburden.
- Removal and stockpiling of overburden for re-use in land rehabilitation by graders, front-end loaders and heavy haulage trucks.
- Open-cast mining of ore seams using graders, front-end loaders.
- Transporting mined ore to a stockpile on site using heavy haulage trucks.
- Processing of ore on through crushing and screening.
- Acid leeching of the ore.
- Drying and packaging of the refined ore.

2. Site characteristics

2.1 Site location

The proposed operation spans over 60 kilometres. It is located approximately 40 kilometres south-west of Beaufort West and 22 km north-west of Rietbron in the Western Cape Province. The mining rights application is applicable to the shaded area as shown in Figure 1.

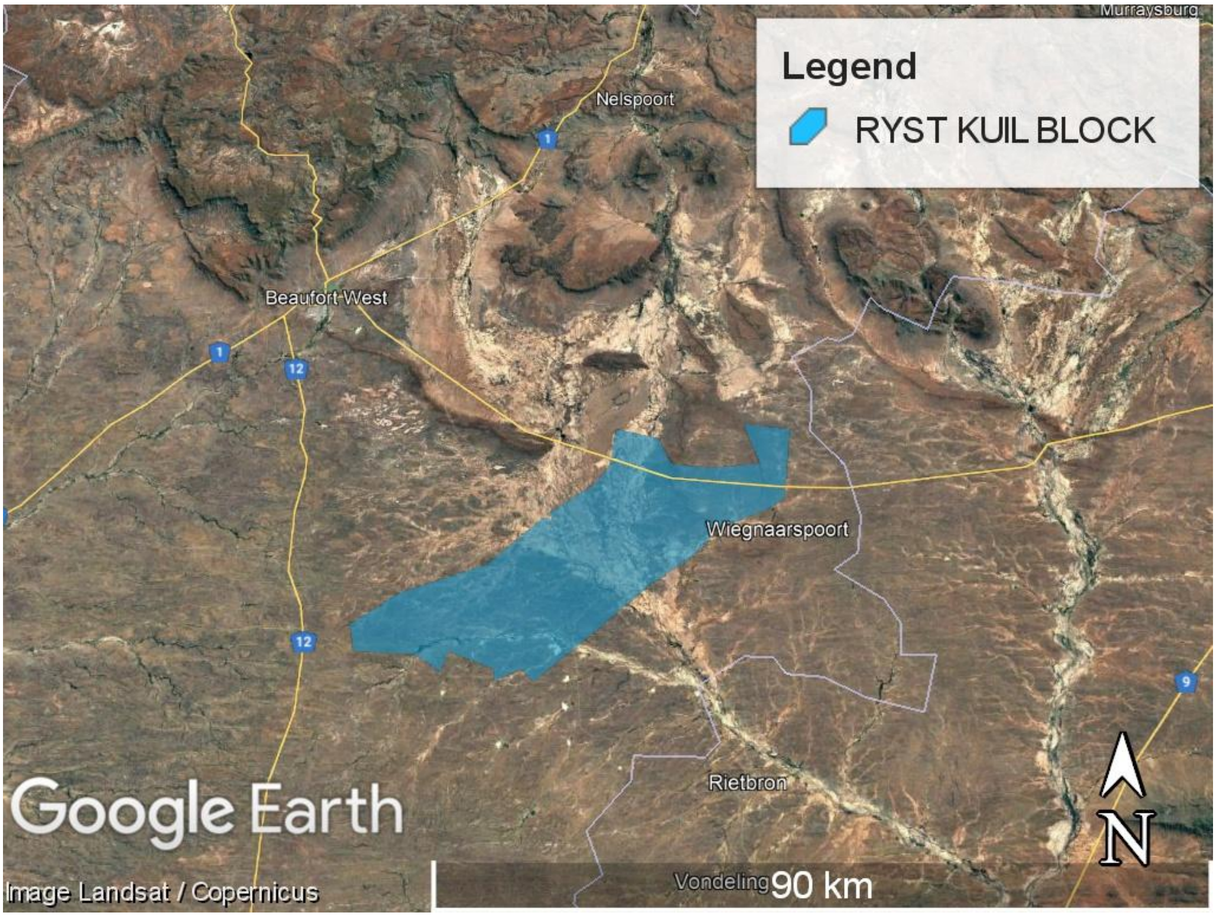

Figure 1: Map of the area of study.

The mining operations will occur in 3 distinct areas within the application area. These areas are detailed in Figure 2 and referred to as:

- Ryst Kuil Main and Abante
- Ryst Kuil Extension
- Haanekuil

Open-cast mining is proposed at all three areas. Underground mining is proposed for the Ryst Kuil Main and Abante area, as well as the Ryst Kuil Extension area.

A central processing plant (CPP) will be located near the Ryst Kuil Main and Abante mining area. The detailed layout of the operation is shown in Figure 2.

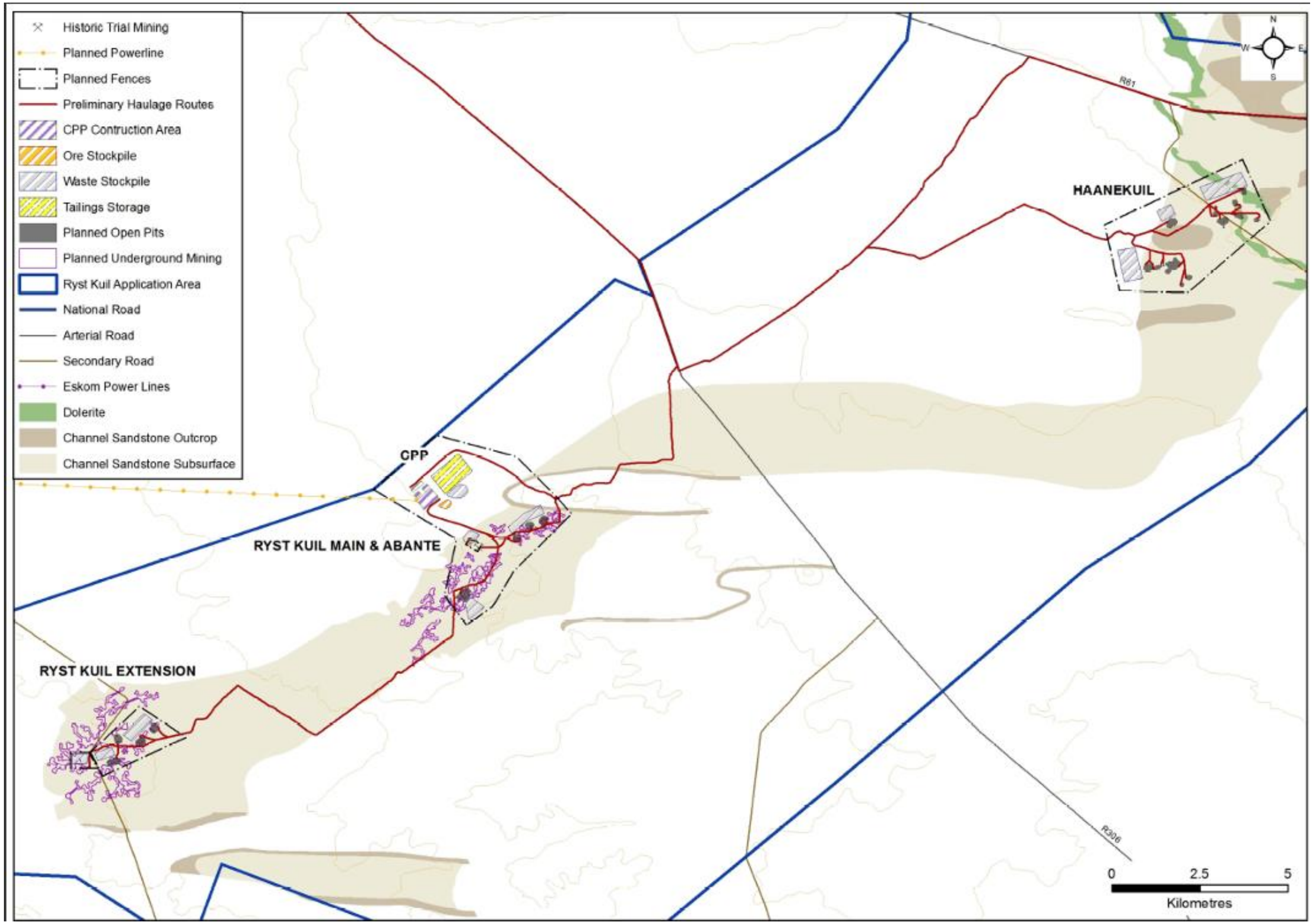

Figure 2: Detailed project layout.

2.2 Air quality

No ambient air quality monitoring data is available for the region of interest so the exact state of air quality is not known. Natural sources that likely affect air quality in the region are wind-blown dust generated by the arid climatic conditions. There are few anthropogenic sources of air pollution in the district. Of interest, especially to the nearby town, Beaufort West, is emissions from vehicles sources, as it is located along the N1 highway. These emissions will include carbon monoxide, oxides of nitrogen, particulate matter and VOC emissions. Other emission sources will include fuel burning for heating and cooking in informal settlements.

2.3 Terrain

The site is located in the Karoo. Altitudes for the area of study shown in Figure 1, range from 613 metres to 1938 metres above mean sea level. The high range elevations are the mountains towards the north of Beaufort West. For the project area itself and the immediate vicinity, elevations range from 775 to 931 metres above sea level.

2.4 Climate

The region is hot and arid and experiences a desert climate according to the Köppen climate classification system. The area receives most of its rainfall in summer. The wind direction in Beaufort West can differ significantly from the site due to the nearby mountain range. A 5-yearly average Windrose shown in Figure 3 below. The data source is detailed in Section 4.2

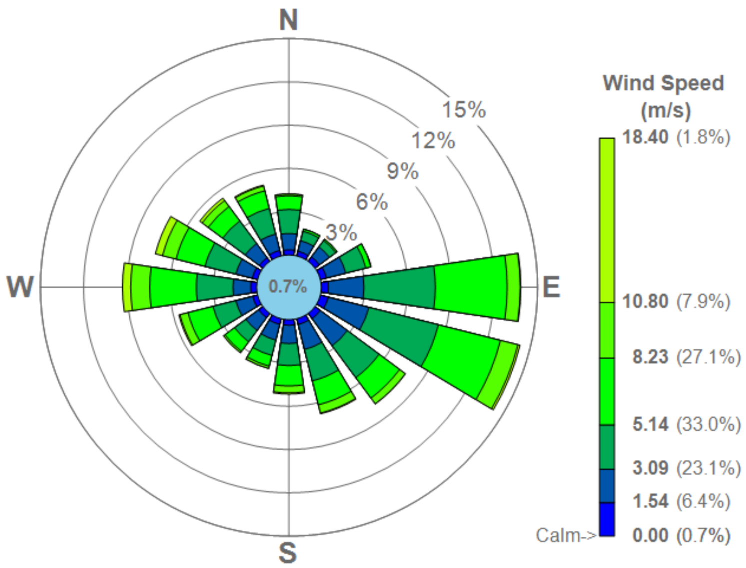

Figure 3: Windrose at 22.88855°E, 32.63386°S.

3. Emissions

The primary source of emissions from the mining activity will be particulates. The CPP may also emit sulphur trioxide from the acid leeching process.

Auxiliary equipment, such as boilers, may also cause emissions of particulate matter, oxides of nitrogen and/or sulphur dioxide. This was however not quantified due to insufficient information.

LAQS calculated the emissions reported in this section based on the process description as contained in the uMoya-NILU (2017): Air Quality Impact Assessment for the EIA for the proposed Karoo Uranium Project, Ryst Kuil, Western Cape Province, Report No uMN132-15, hereafter referred to as the 2017 Screening Report. The assumption was made that mining will occur from all areas simultaneously.

Throughout this chapter, reference is made to the following documents:

Australia' *National Pollutant Inventory Emission Estimation Technique Manuel for Mining, Version 3.1,* hereafter referred to as *NPI mining EET manual.*

United States Environmental Protection Agency Compilation of Pollutant Emissions Factors from Stationary Sources (AP-42), hereafter referred to as *USPEA AP-42.*

3.1 Summary of emissions

A summary of the particulate emissions, as modelled, are shown in Table 1 below. The location of the sources, as modelled, are shown in the Figure 4 below.

Table 1: Summary of particulate emissions

Source Description	**Type**	**Emissions (tonne per annum)**		
		TPM	**PM_{10}**	**$PM_{2.5}$**
Underground mining vent 1	Point source	26.0	26.0	13.0
Underground mining vent 2	Point source	26.0	26.0	13.0
CPP crushing and pulverising	Point source	18.5	6.8	6.8
Drying and packaging	Point source	5.9	5.9	5.9
Pit - Extension	Area source	26.7	15.1	1.7
Pit – Main & Abante	Area source	69.6	39.4	4.5
Pit – Hannekuil	Area source	24.0	13.6	1.3
Waste stockpile – Extension	Area source	97.2	48.4	22.8
Waste stockpile – Main and Abante	Area source	253	125.9	59.2
Waste stockpile – Hannekuil	Area source	87.1	43.3	20.4
Ore stockpile – CPP	Area source	15.9	7.8	2.8
Tailings	Area source	93.1	46.5	23.3
Haul roads – ore stockpiles to CPP	Line source	13 108	2 786	407
Haul roads - pits to waste stockpiles	Line source	1 790	381	55.6

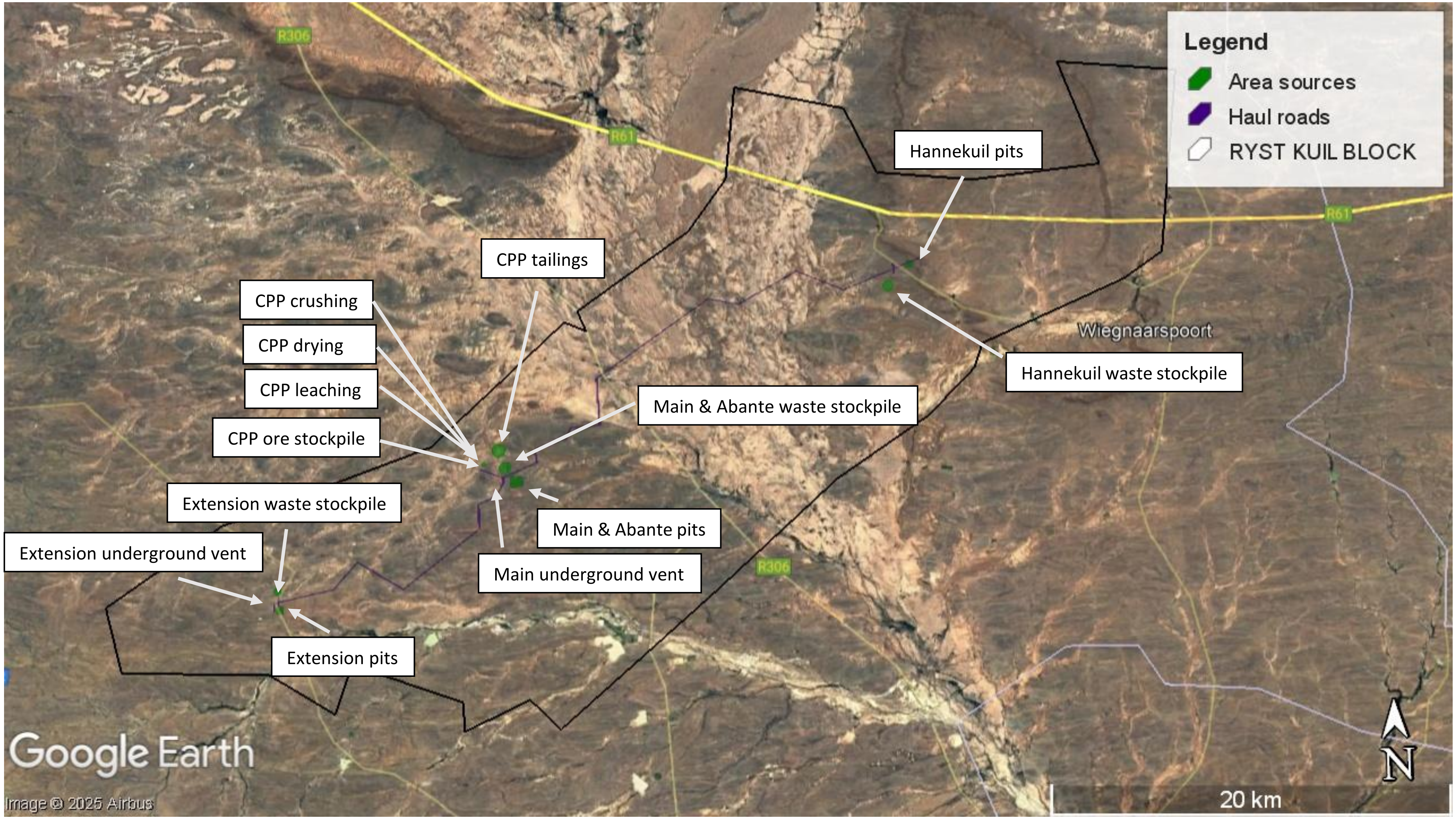

Figure 4: Layout of emission sources as modelled.

3.2 Point sources

3.2.1 Underground mining vents

Two vents will be used to provide circulation for underground mining. The 2017 Screening Report states that each vent will displace 82.5 m^3/s of air. The information provided assumed an exit velocity of 11.7 m/s and a stack height of 1.5 m.

Based on this information, the mass emissions were determined as follows:

- The conservative approach was taken, assuming that all PM are smaller or equal to PM_{10} in size.
- The assumption was made that the PM concentration is equal to the OHSA limit for total inhalable dust of 10 mg/m^3.
- $PM_{2.5}$ was assumed equal to the OHSA respirable dust limit of 5 mg/m^3.
- It was assumed that the vents are operational 24 hours per day, all days of the year.

3.2.2 CPP crushing and screening

The crushing and screening operation consists of 2 stages:

- Primary crushing.
- Screening.

Between these stages, the ore is transported by conveyor systems and pass through transfer points along the way. Emissions were calculated based on a throughput of 1.2 million tonnes per annum. It was assumed that there are 4 transfer points for this operation.

As no stack details were provided, the following was assumed at each transfer point:

- Emissions are emitted through a single stack
- Stack height is 20 m.
- Exit velocity is 10 m/s.
- The total particulates concentration in the stack is 50 mg/m^3.
- The stack is at ambient temperature.

Additional assumption made:

- For transfer points only PM_{10} emission factors are available. Therefore, it was assumed that the emission of TPM and $PM_{2.5}$ are equal to the emission of PM_{10}.
- For crushing and screening no $PM_{2.5}$ data is available. Therefore, it was assumed that the concentration of $PM_{2.5}$ is equal to that of PM_{10}.

3.2.3 Drying and packaging

The emissions reported for packaging are negligible and not included in the study. The emissions for drying were used as provided in the *2017 screening report* uMoya-Nilu due to lack of further details.

The following stack details are assumed:

- Stack height is 10 m.
- Exit velocity is 10 m/s.
- The total particulates concentration in the stack is 50 mg/m^3.

Additional assumption made:

- For drying, only PM_{10} emission factors are available. Therefore, it was assumed that the emission of TPM and $PM_{2.5}$ are equal to the emission of PM_{10}.

3.3 Area sources

The mining pits and stockpiles were modelled as area sources.

3.3.1 Open cast mining pits

A summary of the emissions from the open cast mining pits are shown in Table 2.

Table 2: PM emissions from open pits

Area source	Activity	Annual emissions (tpa)		
		TPM	PM_{10}	$PM_{2.5}$
Extension	Topsoil removal	7.10	5.33	0.75
	Mining (overburden + ore) - Drilling	9.31	4.89	0.28
	Mining (overburden + ore) - Blasting	0.90	0.47	0.03
	Mining (overburden + ore) - Loading	9.42	4.45	0.67
	Combined	***26.73***	***15.14***	***1.73***
Main and Abante	Topsoil removal	18.48	13.86	1.94
	Mining (overburden + ore) - Drilling	24.23	12.73	0.73
	Mining (overburden + ore) - Blasting	2.34	1.22	0.07
	Mining (overburden + ore) - Loading	24.50	11.59	1.75
	Combined	***69.56***	***39.40***	***4.50***
Hannekuil	Topsoil removal	6.36	4.77	0.67
	Mining (overburden + ore) - Drilling	8.34	4.38	
	Mining (overburden + ore) - Blasting	0.81	0.42	0.02
	Mining (overburden + ore) - Loading	8.44	3.99	0.60
	Combined	**23.95**	**13.57**	**1.30**

The pits were modelled as described in Table 3 below.

Table 3: Open-pits modelled source details.

Source	Release height (m)[a]	Area (ha/a)
Open-cast pits – Extension	0	10.3
Open-cast pits – Main and Abante	0	27.0
Open-cast pits – Hannekuil	0	9.2

The emissions were quantified based on the details described below. For the pits, wind erosion was not considered. The combined area of the mining operation was taken as equal to the area of blasting each year. The ratio of mining that occurs at each site was determined relative to the total volume of the pits planned at each site. The

Topsoil removal:

Topsoil removal by grader (30 centimetres). Emission factor is for total particulates.

PM_{10} and $PM_{2.5}$ fractions were determined based on the ratio of PM_{10} and $PM_{2.5}$ emissions generated by bulldozing overburden with a silt content of 6.9% and a moisture content of 7.9%.

Drilling

Drilling emissions were calculated based on an area blasted per yar of 466 643 m^2 through 300 blasts with a total of 71002 holes drilled per year. Emissions factors from the NPI mining EET manual were used to estimate these emissions.

Blasting

Blasting emissions were calculated as per NPI mining EET Manual. The area per blast was calculated to be 1555 m^2.

Loading

Loading emissions were calculated using the emission factors provided in USEPA AP-42 ore mining. The default exposed ground moisture content of 3.4% was used for all material as the region is dry and a mean wind speed of 7 m/ were used.

For modelling purposes, the pits were modelled as single area sources located in each region. It was assumed that, due to the scale of the project, the individual locations of the pits will have negligible impact on the overall impact of the operations on the ground level concentration of particulates.

3.3.2 Stockpiles

A summary of the emissions from the stockpiles is shown in Table 4. The stockpiles consist of waste material stockpile, were unusable material (overburden) that result from blasting are stored and an ore stockpile located at the CPP. The area of each stockpile was calculated based on the total area of the waste stockpiles of 113 ha determined from the information provided in the *2017 screening report*, and divided per site based on the relative mining areas of the sites detailed in Tabel 3.

For modelling purposes, the stockpiles were assumed round with a height of 20 m. The ore stockpile size was calculated based on a volume of 540 000 m^3 (*2017 screening report*).

Table 4: Stockpile emissions.

Area source	Activity	Emission (tpa)		
		TPM	PM_{10}	$PM_{2.5}$
Extension	Loading to stockpile	8.70	4.11	0.62
	Wind erosion	88.51	44.25	22.13
	Combined	**97.20**	**48.37**	**22.75**
Main and Abante	Loading to stockpile	22.63	10.70	1.62
	Wind erosion	230.33	115.16	57.58
	Combined	**252.96**	**125.87**	**59.20**
Hannekuil	Loading to stockpile	7.79	3.69	0.56
	Wind erosion	79.31	39.65	19.83
	Combined	**87.10**	**43.34**	**20.38**
CPP ore stockpile	Loading to stockpile	3.24	1.53	0.23
	Loading from stockpile	3.24	1.53	0.23
	Wind erosion	9.46	4.73	2.37
	Combined	**15.94**	**7.80**	**2.83**

The stockpiles were modelled using the descriptions provided in Table 5.

Table 5: Stockpiles modelled source details.

Source	Release height (m)[a]	Area (ha)
Waste stockpile – Extension	20	25.3
Waste stockpile – Main and Abante	20	65.7
Waste stockpile – Hannekuil	20	22.6
Ore stockpile – CPP	20	2.7

a: above the surface, not mean sea level.

The emissions were quantified based on the details described below.

<u>Loading</u>

Loading emissions were calculated as for the pits in Section **Error! Reference source not found.**.

<u>Wind erosion</u>

Particulate emissions from wind erosion were calculated as per NPI mining EET manual using the default values. The emissions of $PM_{2.5}$ is not explicitly stated in the NPI mining EET manual and was thus determined from the ratio of PM_{10} and $PM_{2.5}$ emissions from wind erosion as provided *in USEPA AP-42* Chapter 13.2.

3.3.3 Tailings

Wind entrainment of particulates from tailings storage facilities is influenced by the physical size of the impoundment and the nature of the exposed surface, i.e. the moisture content, degree of vegetation cover, size of particles on the surfaces, and wind speed. As wet slurry is deposited on the tailings facility, moisture content is high. For this study, the percentage of dry beach area is assumed to be 80% on the upper surface as the slurry dries out. No vegetation cover is assumed due to the arid nature of the project site. The final tailings facility is designed to have a volume of approximately 8 300 000 m^3. A height of 20 metres is assumed giving an area of 2.7 ha. The area was modelled as a square area source. Loading emissions were considered negligible as the tailings are wet when loaded.

Emissions caused by wind erosion was determined as for stockpiles. This is conservative and an overestimate given that the tailings will be covered in time.

Emissions are estimated as follows:

- TPM emissions: 93.07 tpa.
- PM_{10} emissions: 46.53 tpa.
- $PM_{2.5}$ emissions: 23.27 tpa.

The source was modelled with the following details:

- Release height: 20 m above the surface.
- Area: 2.7 ha.

3.4 Line sources

Ore will be hauled from the pits to the CPP. Overburden from the mining operation will also be hauled to the waste stockpiles. Particulate emissions from unpaved roads were determined based on the following equation as per USEPA AP-42 section 13.2.2 as

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

where s is taken at a default 8.4%. W is the mean vehicle mass, taken as 22.5 tonne, determined based on a full mass of 35 tonne per dump truck and an empty mass 10 tonnes. The values a, b and c are empirical constants, and k is a size factor.

Vehicle exhaust emissions were not quantified as they are considered negligible in comparison to the unpaved road emissions with respect to particulates.

3.4.1 Haul roads from pits to CPP

The information provided states that there are 14 haul trucks completing 10 trips per day each. As this is an AQA, a conservative approach was taken. Emissions are calculated based on 10 trips per truck, on the longer hauls (from Haanekuil and Ryst Kuil Extension, to the CPP). An equal split was made between the 14 trucks for the two distant sites.

Resulting emissions are as follows:

- TPM emissions: 13 108 tpa.
- PM_{10} emissions: 2 786 tpa.
- $PM_{2.5}$ emissions: 407 tpa.

The sources were modelled with the following details:

- Road width: 10 m.
- Distance per trip (one way): 27.7 km and 16.5 km.

3.4.2 Haul roads from pits to waste stockpiles

Additional haulage is required to move the overburden/waste rock from the mines to the waste stockpiles. It was assumed that at each site, the distance travelled will be 500 metres. The majority of material will be moved in this manner.
Based a total tonnage of material handled a year of 16.7 million tonnes per year, removing the haulage to the CPP by the 140 trips per day as discussed above, this leaves a balance of 42 000 tonnes of material that needs to be moved per day via short hauls to the stockpiles.

The emissions are as follows:

Line source	Activity	Emission (tpa)		
		TPM	PM_{10}	$PM_{2.5}$
Extension to waste stockpile	Haul roads	398	84.6	12.4
Main and Abante to waste stockpile	Haul roads	1 036	220	32.2
Hanekuil pit to waste stockpile	Haul roads	356	75.8	11.1
Combined	***Haul roads***	***1 790***	***381***	***55.6***

The roads were modelled with the following details:

- Road width: 10 m.
- Distance per trip (one way): 500 m per area, for each of the 3 open-cast mining areas.

4. Modelling methodology

4.1 Model

AERMOD was used to estimate the concentration of PM_{10} and $PM_{2.5}$ for this impact assessment. It is an approved model for impact assessments listed in GN.533.

AERMOD is a steady-state plume dispersion model developed by the U.S. Environmental Protection Agency (EPA) for assessing air pollutant concentrations from stationary industrial sources. It simulates the dispersion of pollutants in the atmosphere, accounting for terrain, meteorology, and building effects, using inputs from preprocessors like AERMAP and AERMET. AERMOD is widely used for regulatory air quality assessments, including permitting and compliance, due to its ability to model complex scenarios with high accuracy over short distances. It is listed as an approved method in GN R.533

4.2 Meteorological inputs

As input for a dispersion model, meteorological data is required. For AERMOD, the data is processed using AERMET. AERMET is a meteorological preprocessor for the U.S. EPA's AERMOD air dispersion model. It processes raw meteorological data, such as surface and upper-air observations, to generate formatted inputs for AERMOD. AERMET calculates key atmospheric parameters like turbulence, wind profiles, and boundary layer characteristics, accounting for local terrain and land use. It ensures accurate meteorological data for modelling pollutant dispersion.

Locally measured weather data is regarded as "reliable" if the monitoring station setup, operating principles and data recovery targets meet the requirements of SANAS Report TR 07-03, "*Supplementary Requirements for the Accreditation of Continuous Ambient Air Quality Monitoring Stations*".

No reliable local measured surface weather data, covering all of the parameters required by AERMOD, is available in the region. GN R.533 allows the use of simulated mesoscale data in the absence of reliable surface data. Mesoscale models use gridded meteorological data and sophisticated physics algorithms to produce meteorological fields at defined horizontal grid resolutions and in multiple vertical levels over a large domain. It, therefore, offers an alternative to localised meteorological measurements as input for Gaussian-plume models and advanced dispersion models.

ERA5 is a state-of-the-art global atmospheric reanalysis model developed by the European Centre for Medium-Range Weather Forecasts (ECMWF). A reanalysis model is a scientific method that combines historical observational data with advanced numerical weather prediction models to produce a consistent, high-resolution dataset. It provides a comprehensive, high-resolution dataset of the Earth's atmosphere, land, and ocean conditions from 1940 to the present, updated regularly. ERA5 combines advanced numerical weather prediction models with vast observational data, offering hourly outputs at a 31 km resolution globally, with 137 vertical levels up to 80 km altitude. It is widely used for climate studies, weather analysis, and environmental research due to its accuracy and extensive variable coverage.

LAQS subsequently used five years' data from the ERA5 database for the years' 2020 to 2024 as the meteorological data source for AERMET. The data set is complete and covers all of the parameters required for reliable dispersion modelling.

4.3 Terrain details

Source elevations were incorporated into the model using AERMAP. AERMAP is a terrain preprocessor for the U.S. Environmental Protection Agency's AERMOD air dispersion modelling system. It processes digital elevation data to generate terrain and receptor elevation inputs, establishing relationships between terrain features and air pollution plume behaviour. AERMAP supports high-resolution 7.5-minute and 1-degree DEM data, producing files for AERMOD to estimate pollutant concentrations from industrial sources while accounting for terrain impacts. It is widely used for regulatory air quality assessments.

Elevation data in the form of SRTM 30 metre resolution DEMs were imported into AERMAP as source of elevation data for the region.

4.4 Model configuration

A summary of the key model configuration used for the project is provided below:

Parameter	Configuration used
AERMOD version	24142
AERMET version	24142
AERMAP version	24142
Modelled period	2020 to 2024
Gridded receptor height	2 m
Gridded receptor resolution	500 by 500 (uniform cartesian); x=1000 m y = 800 m.

5. Results

LAQS modelled the dispersion of PM_{10} and $PM_{2.5}$ particulate matter that may be emitted from the mining operation to show the overall impact for comparison of results against official ambient AQ standards as published by the Department of Environmental Affairs in GN1210.

All simulations were carried out for a receptor height of 2 metres above ground level and a steady-state plume dispersion period of 60 minutes. This simulation period ensured that very low wind speeds, e.g. 1 m/s, would carry pollutants for some distance from the mining area.

The approach was to determine both annual average ground-level concentrations and the mean 4-time high concentrations (the levels below which concentrations will occur for at least 4 days per annum).

The maximum estimated ground-level concentrations were determined, as well as where these would occur.

The dispersion of PM_{10} particulate matter is shown graphically in Figures 5 to 8 below. Figures 5 and 6 respectively show the annual average and 4-time high daily-averaged ground-level concentrations of PM_{10} particulates for all sources. Figure 7 and 8 shows the annual average and 4-time high daily-averaged ground-level concentrations of PM_{10} resulting from the haul roads only.

The dispersion of $PM_{2.5}$ particulate matter is shown graphically in Figures 9 and 10 below.

Figure 5: Annual average PM_{10} concentrations.

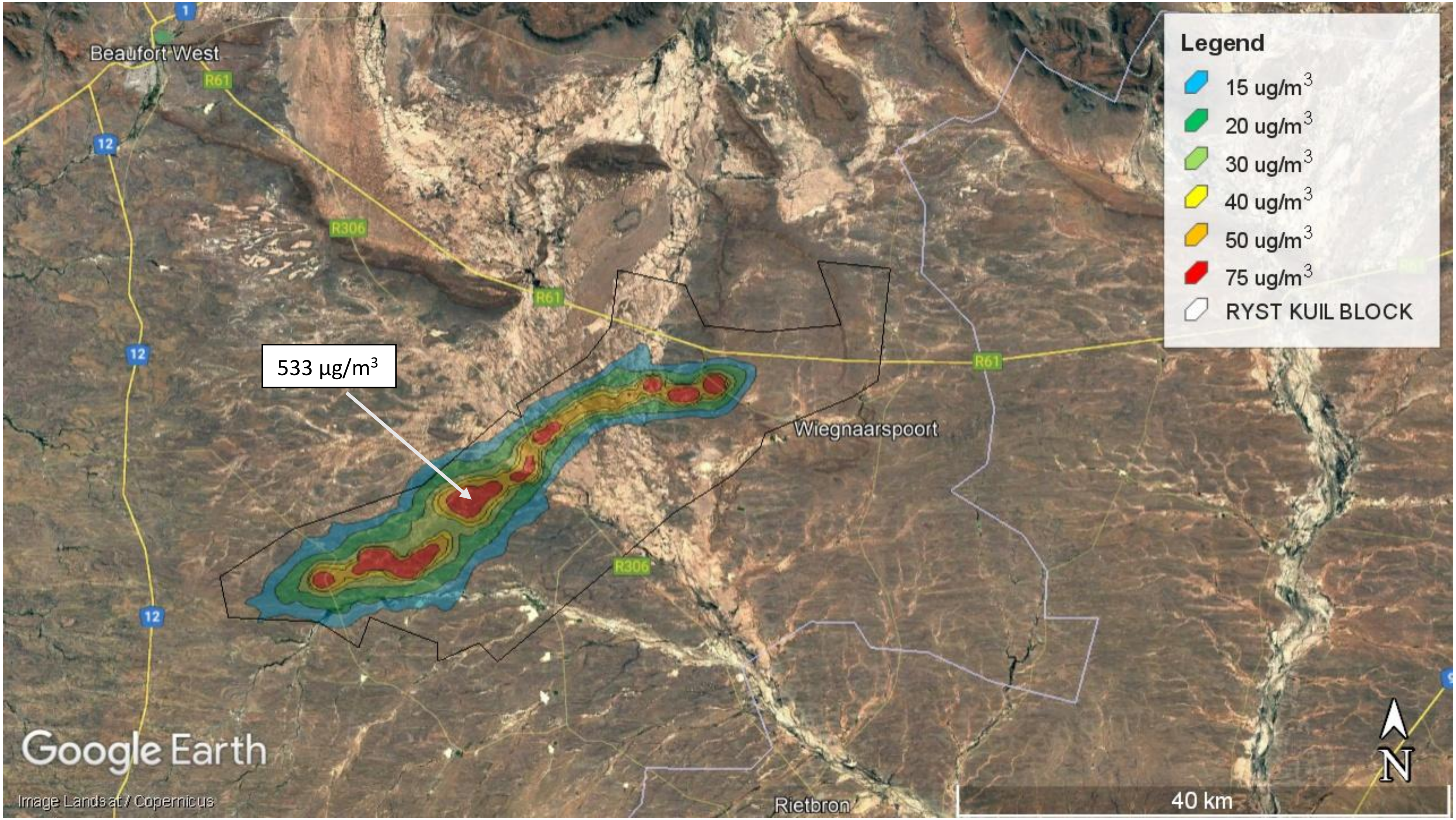

Figure 6: 4-time high daily average PM_{10} concentrations.

Figure 7: Annual average PM_{10} concentrations contribution – haul roads.

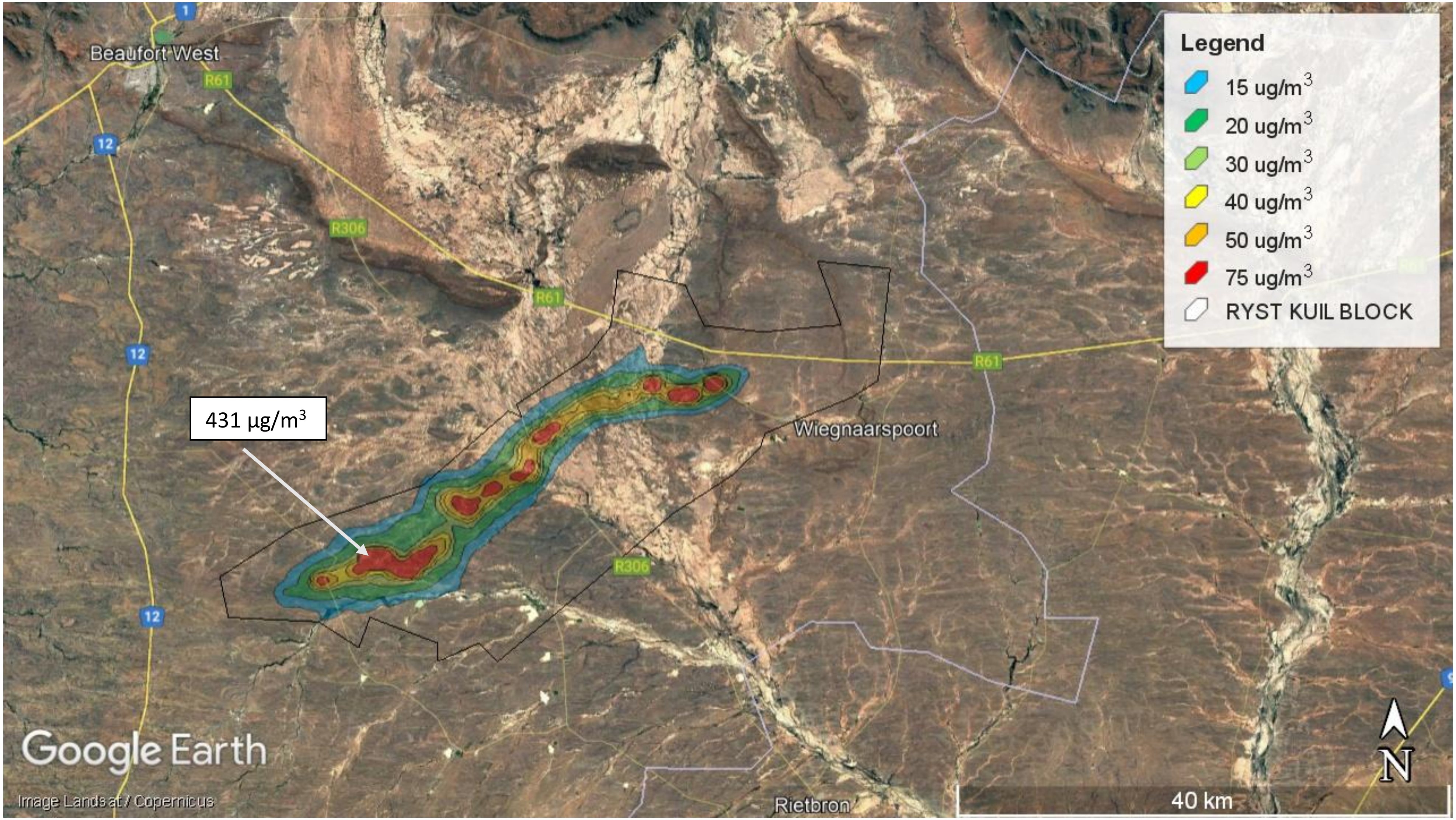

Figure 8: 4-time high daily average PM_{10} concentration contribution – haul roads.

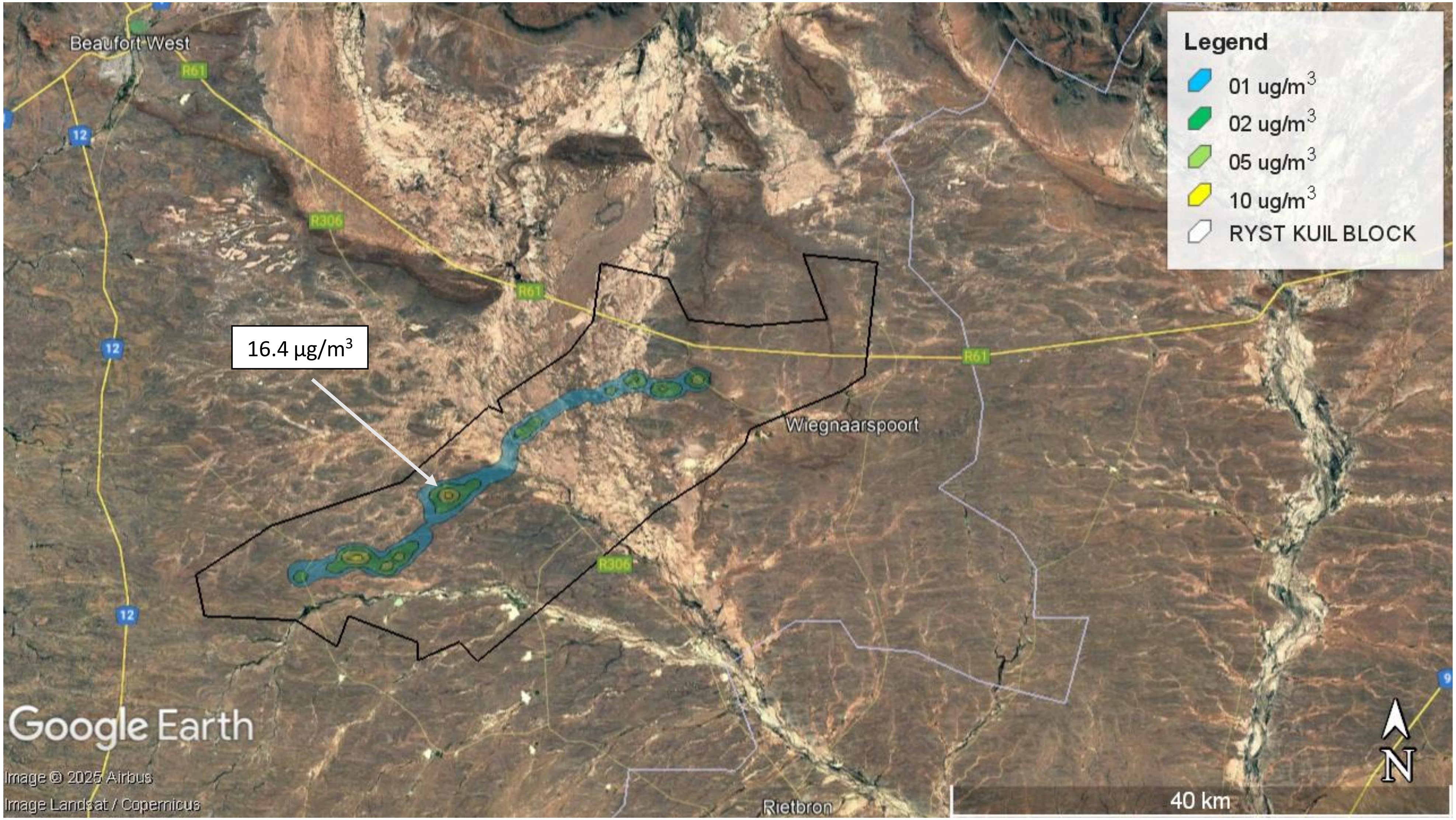

Figure 9: $PM_{2.5}$ annual average concentration.

Figure 10: 4-time high daily average $PM_{2.5}$ concentration (99-percentile).

6. Impact on overall air quality.

Ambient AQ standards for some criteria pollutants were published by the Department of Environmental Affairs (DEA) in Government Notice No. 1210 on 24 March 2009 (GN1210). This included particulates in the form of PM_{10}. In 2012, $PM_{2.5}$ was added to the list of ambient air quality standards through the publication of GN486. These limits applicable to the Ryst Kuil project are shown in Table 6.

Table 6: Ambient air quality standards

Pollutant	Averaging period	Ambient air quality standard (µg/m³)	Exceedances allowed
PM_{10}	Annual	40	0
PM_{10}	Daily	75	4 per annum
$PM_{2.5}$	Annual	20 (15 from 2030)	0
$PM_{2.5}$	Daily	40 (25 from 2030)	4 per annum

There are currently no ambient air quality standards for sulphuric acid and thus its dispersion was not modelled.

6.1 PM_{10} emissions

The highest annual average concentration is estimated to be 113 µg/m^3. This result falls on the Ryst Kuil project area, near the CPP and the Main mining area. This exceeds the ambient air quality standard of 40 µg/m^3. The highest 4-time daily concentration was shown to be 533 µg/m^3 for the same area. This exceeds the maximum daily standard of 75 µg/m^3.

However, no exceedance of either standard is expected outside the project area as can be seen from Figure 5 and Figure 6. The main public road passing through the area, the R61, is not significantly affected by the operation.

The primary contributor to these emissions is the haul roads. To show the significance of the source, the impacts of only the haul roads are shown in Figure 6 and Figure 7.

6.2 $PM_{2.5}$ emissions

Figure 9 and Figure 10 shows the dispersion model results for $PM_{2.5}$ emissions. The highest annual average concentration of $PM_{2.5}$ is estimated to be 16.4 µg/m^3 and is located on the Ryst Kuil project area, near the CPP and the Main mining area. This is below the current ambient air quality standard of 20 µg/m^3, but marginally exceeds the air quality standard for $PM_{2.5}$ that will come into effect in 2030. The highest 4-time daily concentration was shown to be 64.5 µg/m^3 for the same area. This exceeds the maximum daily standard of 40 µg/m^3 and the new standard of 25 µg/m^3 that will come into effect in 2030.

None of the ambient air quality standards are expected to be exceeded off site due to the Ryst Kuil project operations only.

$PM_{2.5}$ are a subset of particulate matter that refers to ultra-fine particulates. These particles are small enough to pass through the lungs and be absorbed into the bloodstream. In comparison to PM_{10}, the $PM_{2.5}$ emissions are generally lower relative to the ambient air quality standards for this operation. This is primarily due to the nature of the most significant emission source, i.e. the emissions from unpaved roads. The size distribution of particulates emitted from unpaved roads show that the majority of particles are relatively large. The fraction of PM_{30} emitted is about 4 times as much as the fraction of PM_{10} emitted, and the fraction of $PM_{2.5}$ is less than a fifth of the PM_{10} emitted.

7. Discussion

7.1 Uncertainty of emissions

The annual mass of emissions of PM_{10} particulates from the various mining operations must be interpreted with care. Emissions were estimated using mining capacities provided in the 2017 Screening Report*,* and a combination of emission factors contained in the NPI mining emissions estimation technique manual as well as the USEPA's AP-42.

As the mine is still in the planning stage, capacities provided must be considered as design data which may differ substantially from capacities reached during full operation. LAQS was provided with limited data for the mining operation and based the emissions of the 2017 screening report.

Furthermore, emission factors all have reliability ratings, ranging from "A" to "U" with the following descriptions:

A - Excellent

B - Above average

C - Average

D - Below average

E - Poor

U - Unrated

The reliability of emission factors for the activities listed in Section 6 are:

Excavators / Shovels / Front-end loaders, on overburden	U
Drilling	C
Blasting	C
Wheel generated dust from unpaved roads	B
Scrapers, removing topsoil	E
Loading stockpiles	U
Loading from stockpiles	U
Miscellaneous transfer points, including conveying	U
Wind erosion	U

The reliability of some of the emission factors used have not yet been rated, while some others vary between "excellent" and "poor". It is likely, therefore, that much uncertainty can be attached to the emission on which this assessment is based, but more reliable information is extremely scarce.

7.2 Cumulative impact of emissions

There is a lack of baseline data in the form of reliable, measured air quality data for the region. Therefor the impact assessment only shows the impact on ambient concentrations resulting from the operation of the Ryst Kuil project.

Although the results show that the impact of the Ryst Kuil project alone will not cause an exceedance of the ambient air quality standards off-site from the project area, it should be borne in mind that air quality is cumulative and other sources in the region may contribute significantly to the ambient air quality in the region.

7.3 Verification of meteorological data

Due to a lack of measured data available in the region, the ERA5 dataset used for the study cannot be validated with on-site measured data. However, the fact that a re-analysis dataset was used means that the dataset was verified and adapted based on multiple measurements at various locations.

8. Conclusions

As stated in Section 4, LAQS investigated the dispersion of air pollutants from the Ryst Kuil project operations based on design capacities and internationally published emission factors. The outcome showed that the impact of PM_{10} and $PM_{2.5}$ emissions will only exceed ambient air quality standards within the project area. The area over which the standards will be exceeded is significantly larger for PM_{10} as the primary contributor to particulate emissions are the haul roads.

The main area of impact is on the Ryst Kuil mining rights area where occupational health standards should apply. The use of personal protective equipment (PPE) will contribute to a reduction of risk for employees active in the mining operations. The main public road passing through the area, the R61 is not significantly affected by the operation. The R306 does however pass through areas where the ambient air quality standards will potentially be exceeded.

There may be a substantial degree of uncertainty in the estimated emissions and concomitant impact on air quality.

However, it must be borne in mind that LAQS did not account for dust suppression measures on the road surfaces, due to the distances involved. To reduce emissions and air quality impact, effective dust suppression measures will be required.

9. Recommendations

An emissions monitoring plan is recommended to monitor the actual impact of particulate emissions on the environment throughout the duration of the project. The remote location of the project allows for dust fallout monitoring as per SANS 1137:2012 to be implemented to monitor the impact of this project on dust fallout in the region. Ideally, such a monitoring programme starts prior to the construction phase of the project to establish a baseline of emissions.