West Musgrave Copper and Nickel Project

December 2020

EPA Section 38 Referral Supporting Document Appendix H Air Quality

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APPENDIX H. AIR QUALITY

Appendix H1. Air Quality Characterisation and Effects Assessment

West Musgrave Project

Air Quality Impact Assessment

March 2020

DOCUMENT CONTROL

Version	Description	Author	Date
1	Initial Draft	D Winterburn	January 2020
2	Incorporation of OZ Minerals and MBS Environmental feedback	D Winterburn	March 2020

ES 1 EXECUTIVE SUMMARY

OZ Minerals Exploration Pty Ltd (OZL) has entered into a Joint Venture (JV) with Cassini Resources Limited (CZI) to develop the West Musgrave Project (WMP or 'the Project'). The Project will involve the mining and processing of the Nebo-Babel Ni-Cu-PGE sulfide deposits. The Project area is located approximately 1,300 km northeast of Perth near the border with South Australia and Northern Territory, 29 km south of Jameson and 110 km southeast of Warburton.

A desktop assessment of the potential for air pollutants from the proposed Project to result in adverse impacts to human health, amenity and non-human biota (flora) was undertaken in accordance with the relevant WA EPA Environmental Factor Guidelines.

Baseline air quality for the Project area was established using air quality monitoring undertaken at Wingellina as part of baseline environmental studies for the proposed Wingellina Nickel Project, which included:

- Eight depositional dust gauges (August 2008 to April 2011)
- Particulate monitoring using Tapered Elemental Oscillating Microbalance (TEOM) monitoring equipment (October 2010 to November 2011)

This monitoring demonstrated that existing air quality in the region is like, if generally better, than air quality at other, similar, arid environments in central Australia.

The distance between the Project and the nearest human sensitive receptors (at least 29 km) was demonstrated to be sufficient to result in no change in air quality at the nearest receptors, and therefore human health and amenity is not predicted to be significantly affected as a result of implementation of the Project. With respect to flora, some impacts to some individual plants within approximately 3 km of Project-related dust generating activities may occur, however these will not result in a change in biological diversity and ecological integrity within the region due to the extensive distribution of the flora species.

Based on the outcomes of the air quality impact assessment, air quality is not considered a Key Environmental Factor for the purposes of the EPA Referral under Part IV of the *Environment Protection Act 1986* (WA).

1 INTRODUCTION

OZ Minerals Exploration Pty Ltd (OZL) has entered into a Joint Venture (JV) with Cassini Resources Limited (CZI) to develop the West Musgrave Project (WMP or 'the Project'). The Project will involve the mining and processing of the Nebo-Babel Ni-Cu-PGE sulfide deposits.

1.1 Project Location

The Project area is located approximately 1,300 km northeast of Perth near the border with South Australia and Northern Territory, 29 km south of Jameson and 110 km southeast of Warburton (Figure 1).

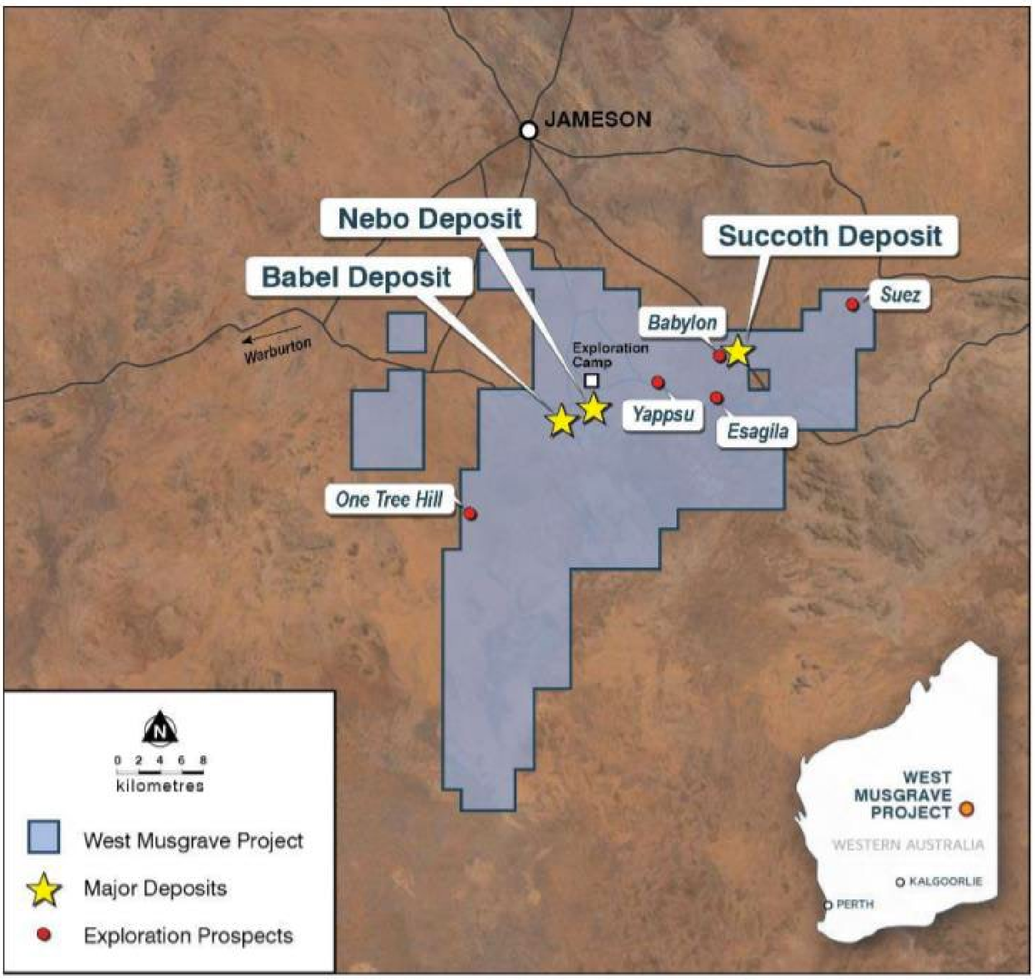

Figure 1: Location of the West Musgrave Project

A summary of the key Project information is presented in Table 1.

Table 1: West Musgrave Project Key Project Characteristics

Activity	Aspect	Description
Mining	Resource	342 Mt at 0.33% Ni and 0.36% Cu
	Pits	Nebo and Babel
	Ore Reserve	229 Mt at 0.33% Ni and 0.36% Cu
	Mining Rate	10 Mtpa Ore, Average 32 Mtpa Waste
	Life of Mine	26 Years
	Operations	Conventional open pit mining from two pits (Nebo and Babel) (drill and blast, load and haul)
Processing	Flowsheet	Crushing, Vertical Roller Mill, Flotation producing separate Nickel and Copper concentrates
	Recoveries	69% Ni and 78% Cu LOM
	Concentrate Grades	10-11% Ni in Ni Con, 25-26% Cu in Cu Con.
	Nickel Production	~26,000 tpa (Y1-5) ~22,000 tpa (Y6-LOM)
	Copper Production	~33,000 tpa (Y1-5) ~27,000 tpa (Y6-LOM)
Infrastructure	Roads	Upgrade of existing 30 km road to Jameson 80 km north to the Great Central Road (via Jameson), 700 km along Great Central Road to Leonora.
	TSF	Two cells with water recycle back to process. Upstream raises with downstream buttressing with mine waste rock
	Village and Airstrip	400 person operations village and airstrip located at site
	Water	7 GL/yr Northern borefield from local paleochannels (approx. 150m deep aquifer) 15 km from site
	Power	55 MW Power Purchase Agreement, Hybrid Renewables (Wind, Solar, Battery and Diesel)
	Logistics	Containerised Quads to Leonora, Rail to Esperance for bulk shipping to customers
	Customers	Nickel and copper smelters in Australia, Asia and Europe
Workforce	Workforce	Potentially 1,000 people construction, 400 during operations.

2 REGULATORY ENVIRONMENT

The Western Australia Environmental Protection Authority (EPA) produce guidance related to the assessment of air quality via the *Environmental Factor Guideline – Air Quality* (December 2016). The EPA's objective for air quality is to:

Maintain air quality and minimise emissions so that environmental values are protected. T

In the context of this factor and objective, the EPA's primary focus is maintaining air quality and minimising emissions for human health and amenity.

Where air quality has been identified as an environmental factor to be addressed in an Environmental Review Document required to be prepared under Part IV of the *Environmental Protection Act*, the EPA may require the proponent to provide information or studies within the following broad topics:

For air emissions that may affect human health or amenity:

- *characterisation of the feedstock and the pollutants and contaminants that are likely to be emitted*
- *characterisation of and proximity to sensitive receptors*
- *background ambient air modelling and the impact of emissions on sensitive receptors, including likely impacts during, worst, best and most likely case scenarios*
- *assessment against published standards and criteria*
- *identification of emission reduction equipment and proposed technologies and, where relevant, demonstration of the use of proven technologies*
- *description of proposed management and monitoring arrangements.*

For greenhouse gas emissions:

- *characterisation of greenhouse gas emission sources from the proposal and estimation of expected Scope 1 (direct) and Scope 2 (energy indirect) greenhouse gas emissions in accordance with the National Greenhouse and Energy Reporting Act 2007 (NGER Act)2*
- *analysis of greenhouse gas intensity (i.e. quantity of CO2-e generated per tonne of product produced) and comparison with published benchmarked practice for equivalent plant, equipment and operations.*

A referral to the EPA for the WMP has not been submitted and no determination has been made by the EPA as to whether Air Quality will be a designated factor for future impact assessment under Part IV of the EP Act.

The following sections address the above EPA Guideline requirements.

3 PROJECT CONTEXT

3.1 Receiving Environment

The WMP is situated in a remote location of Western Australia within the Shire of Ngaanyatjarraku. The nearest town is Warburton (approximate population of 580 people) located approximately 110 km south east. Two remote Aboriginal settlements, Jameson (Mantamaru, approximate population 160 people) and Blackstone (Papulankutja, approximate population 153 people) are located approximately 26 km north and 46 km east of the project area respectively.

The WMP is situated within the 98,000 km^2 Ngaanyatjarra Indigenous Protected Area (IPA Reserve No. 17614), which forms part of the National Reserve System under the Commonwealth Department of Prime Minister and Cabinet. The Reserve is categorised under International Union for Conservation of Nature (IUCN) Category VI (Managed Resource: Protected area managed mainly for the sustainable use of natural ecosystems).

The pattern of existing land use within the Ngaanyatjarra Lands is complex and varied, though traditional practices continue to predominate. There has never been a pastoral industry in the Shire, although the United Aborigines Mission at Warburton managed sheep, cattle, goats and horses until the mid-1980s. The only export industries have been sandalwood harvest, collection of dingo scalps, and prospecting.

The WMP area has an arid, desert climate with distinct summer and winter rainfall patterns. The Project area experiences a broad temperature regime. Average daily maximum temperatures exceed 34°C between November and March. Average daily minimum temperatures range from 23.1°C to 5.7°C (BoM 2018). Rainfall is of variable nature with the average annual rainfall being approximately 181 mm/yr. Evaporation rates are estimated to be greater than 20 times the mean annual rainfall. Analysis of wind speed and direction data for the Warburton and Giles Bureau of Meteorology Stations (BoM 2019) indicate that prevailing winds are predominantly from the east (north east to south east) in the morning, becoming more evenly spread throughout the day, although maintaining a bias from the east to south-east. Measurements from the on-site wind monitoring station confirms these trends, with the dominant wind direction being from 135 degrees (i.e. from the south east). Average wind speeds at 10 m are consistent with those of other areas of arid Australia at around 4.1 m/s.

The area has a natural background dust (particulate) concentration that is contributed to by sources such as bush fires or wind erosion.

3.2 Sensitive Receptors

3.2.1 Human

Sensitive receptors are defined as living things that can be adversely impacted by exposure to pollution or contamination. In relation to air quality and the EPA factor, these are typically those humans who are at heightened risk of negative health impacts due to exposure to air pollution e.g. children, elderly, asthmatics. Sensitive receptors locations are where these people congregate e.g. schools, hospitals, elderly housing areas.

The nearest non project area potential sensitive receptor locations are those in Jameson. This may include the non-residential clinic facility and the combined pre-school and primary school facility (approximately 24 students). The only project area sensitive receptor is the Project accommodation village that will house the FIFO workforce.

3.2.2 Non-Human Biota

The Project area has been subject to significant survey effort associated with flora. When the results of the 2014, 2015 and 2018 / 2019 surveys are combined, 390 native flora taxa from 166 genera and 50 families are recognised within the Survey Area. *Fabaceae*, *Poaceae*, *Malvaceae*, *Asteraceae*, *Chenopodiaceae*, *Goodeniaceae* and *Amaranthaceae* represent the most prevalent families and *Acacia*, *Eragrostis*, *Eremophila*, *Sida*, *Ptilotus* and *Senna* represent the most prevalent genera. The majority of species recorded are widespread and well represented in the Central Ranges and Great Victoria Desert Interim Biogeographic Regionalisation for Australia (IBRA) regions.

No Threatened Ecological Communities (TEC) or Priority Ecological Communities (PECs) are located within a 100 km radius of the Survey Area during the desktop search. No vegetation associations described across the Greater Survey Area were considered to warrant a TEC or PEC listing due to being regionally limited or restricted in distribution.

No Threatened Flora formerly listed under the superseded *Wildlife Conservation Act 1950* (WA) (prior to January 2016) or the *Biodiversity Conservation Act 2016* (WA), or *Environment Protection and Biodiversity Conservation Act 1999* (Cth) were recorded within the Greater Survey Area.

During the surveys, 11 Priority Flora species were identified. This included two Priority 1 species and nine Priority 3 species. Of these, one Priority 1 and three Priority 3 species occur within the immediate Project Area, noting that records for these species indicate that these also occur at distance from the Project Area.

3.3 Ambient Air Quality

Project-specific air quality monitoring has not been undertaken due to the remoteness of the Project site and the lack of anthropogenic emission sources. No other sources of air quality data are available for the project area or its immediate surrounds.

The closest location where air quality monitoring has been undertaken is at Wingelina which is also located in the Ngaanyatjarra lands, approximately 120 km east of the project area. The Wingellina site is considered highly analogous to the West Musgrave project area as it is in a climatic and geologically similar are within the West Musgrave Province and has the same land use (traditional land management by Traditional Owners).

Air quality monitoring was undertaken at Wingellina as part of baseline environmental studies for the proposed Wingellina Nickel Project. Monitoring included:

- *Eight depositional dust gauges (August 2008 to April 2011)*
- *Particulate monitoring using Tapered Elemental Oscillating Microbalance (TEOM) monitoring equipment (October 2010 to November 2011)*

There are limited sources of anthropogenic sources of pollutants in the area, and as such contributions from the WMP are unlikely to be of any significance given the lack of development in the area. Estimated baseline air quality for the Project Area is presented in Table 2.

Table 2: Estimated Baseline Air Quality at West Musgrave

Parameter	Value and Unit
Maximum 24-hour average PM_{10}	19.7 µg/m^3
Maximum 24-hour average $PM_{2.5}$	8.7 µg/m^3
Annual average PM_{10}	11.3 µg/m^3
*Annual average $PM_{2.5}$	7.7 µg/m^3
Background average dust deposition rate (all seasons)	0.9 g/m^2/month

* Estimated, not measured

To provide context to the estimated baseline air quality, the results of monitoring at other similar (arid and semi-arid) sites within Western Australia and South Australia is presented in Table 3. This indicates that the assumed baseline air quality at the Project site is broadly equivalent, although slightly better, to that measured at other arid and semi-arid locations within central Australia. This likely reflects the lack of anthropogenic emission sources associated with the lack of pastoral operations.

Table 3: Air Quality in Arid and Semi-Arid areas of Australia

Project Site	Distance from Project (km)	PM_{10} (µg/m^3)		$PM_{2.5}$ (µg/m^3)		Dust Deposition (g/m^2/month)
		24-hr	Annual	24-hr	Annual	
Carrapateena (OZ Minerals)	1,110	3.0–23.0	13.0	1.0–7.7	3.9	1.6
Olympic Dam (BHP)	1,010	N/A	N/A	N/A	N/A	1.9
Tarcoola Gold (WPG Resources)	840	25	15	12.5	2.5	2
Kalgoorlie (DWER 2018 NEPM monitoring)	810	29.7	12.8	15.9	5.1	N/A
Kintyre (Cameco)	700	N/A	N/A	N/A	N/A	2.0
Mulga Rock (Vimy Resources)	590	N/A	13.5	N/A	N/A	0.6
Wiluna Uranium Project (Toro Energy)	760	N/A	16	N/A	N/A	N/A

4 ASSESSMENT OF EFFECT AND IMPACT

4.1 Pollutant-Generating Activities

The three most significant air pollutants expected to be emitted by the proposed operations are:

- Particulates (dust) generated by mining and ore and waste rock materials handling operations,
- Combustion product emissions associated with the use of diesel electricity generation and the use of diesel-powered mining and earth moving vehicles. This includes particulates and greenhouse gases, and
- Emissions from road transport on unpaved roads to and from the Project site

4.1.1 On-site Activities

Fine particles produced at mine sites from vehicle exhausts and mobile equipment generally only account for about 5 per cent of the particles emitted during the mining process (NSW Health 2019). On the basis that this constitutes a minor particulate source in comparison to other operational sources, these are not considered further in this assessment. Greenhouse gas emissions arising from combustion emissions are assessed separately in the greenhouse gas sections of the EPA Referral.

Particulate emissions may occur from several sources associated with mining and processing, including:

- Blast hole drilling
- Blasting
- Bulldozer and grader operations
- Shovels and/or excavators loading haul trucks
- Haul trucks operating on unpaved roads
- Unloading of rock from haul trucks to stockpiles and/or crushers
- Primary crushing
- Grinding in the vertical roller mill (VRM)
- Transfer, conveying and stacking of crushed material
- Wind erosion of stockpiles and cleared areas (e.g. laydown areas, tailings facilities etc.)

Processing operations beyond the VRM are generally undertaken after the addition of water to form slurries, and thus have limited potential to emit dusts, and final concentrates are generally around 10% moisture, sufficient to resist dusting during loading and unloading.

4.1.2 Product and Reagent Transport on Unpaved Roads (Off Site)

Between 10-20 heavy vehicle (nominally quad road train) one-way trips would occur per day to the Project site (i.e. 20-40 individual movements per day). These would originate from regional centres and/or Perth and would travel from the Great Central Road to site via the proposed Jameson bypass, which is unpaved. The closest receptor to the bypass is approximately 1.5 km distant from the road.

4.2 Pollutant Characterisation

In terms of mineralisation, the major materials moved are unmineralised waste rock (overburden) and mineralised ore of various grades, categorised by nickel concentrations. The results of mineralogical analyses are detailed in Martinick Bosch Sell (2019) and are summarised below:

- All rock samples comprised substantial proportions of calcium and sodium plagioclase (19 – 52%) minor proportions of biotite (1 – 4%), ilmenite (1 – 5%), potassium feldspar (≤3%) and quartz (1 – 5%). All samples contained amphibole (2 – 31%), although unweathered barren and mineralised gabbronorite contained more substantial proportions (28 – 31%) compared with the other samples, along with apatite (5 – 7%). These are common rock forming minerals and are consistent with the deposit geology.
- All samples contained moderate proportions (9 – 22%) of amorphous phases, which comprise substances lacking well-defined mineral lattice structures (e.g. ferrihydrite, solid solution phases or unknown mineral phases).
- Trace to minor proportions of alunite (≤1%), chlorite (1 - 6%) and talc (<1 – 3%) were detected in most samples, together with moderate proportions (3 – 32%) of clinopyroxene and orthopyroxene. The presence of these minerals is consistent with the volcanic-metamorphic provenance of the deposit. Whilst alunite may form as the result of sulfide (pyrrhotite) oxidation under neutral or basic conditions, this mineral is also known to occur in undisturbed rocks affected by volcanism.
- Pyrite content was generally low, whereby traces (<1 – 1%) were detected in mineralised gabbronorite, variably textured gabbronorite and mineralised breccia, and none was detected in the other samples. Traces of chalcopyrite (≤1%) were also detected in all samples analysed, except mineralised gabbronorite.
- Low proportions of pyrrhotite (1 – 2%) were detected in variably textured gabbronorite, oxide-apatite gabbronorite and orthogneiss, whereas mineralised breccia contained 15% pyrrhotite and the mineralised and barren gabbronorite contained no detectable pyrrhotite. The presence of pyrrhotite and prevalence over pyrite is consistent with the geological understanding of mineralisation at the Nebo-Babel deposits.

- Although no violarite was detected in the samples (i.e. collected from the pyrite-violarite weathering zone), it was noted that the QXRD technique cannot distinguish violarite from feldspars. The oxide-apatite gabbronorite sample did not contain detectable apatite.
- Minor proportions (1 – 2%) of carbonate minerals, dolomite and calcite, were found in all samples except mineralised gabbronorite (not detected).
- Jarosite, a mineral generally associated with sulfide oxidation, was detected (2%) in the mineralised gabbronorite collected from the fresh rock zone. The absence of detectable sulfides (pyrite, chalcopyrite or pyrrhotite) or carbonate minerals in this sample suggests that the material may have undergone weathering prior to analysis, although this weathering most likely occurred in situ and not as a result of the sample preparation process.

Mined rock can be expected to contain elevated concentrations of copper and nickel. Test work has identified it will not contain, radioactive materials, asbestiform or other specifically toxicological contaminants. On this basis, impacts on human health are considered likely to be associated with the physical particulate sizes rather than any chemical constituents.

4.3 Assessment of Effects

4.3.1 On-Site Activities

The WA EPA (2005) provides advice on the use of generic separation distances (buffers) between industrial and sensitive land uses to avoid conflicts between incompatible land uses. The distances outlined in the guideline are not intended to be absolute separation distances, rather they are a default distance for the purposes of identifying the need for specific separation distance or buffer definition studies and providing general guidance on separation distances in the absence of site specific technical studies. The specified minimum separation distance between large open cut mining operations and residences is 1,500 – 3,000 m. This range is more conservative than similar guidelines in other states (e.g. Queensland 1,000 m (Queensland Government 2016), ACT 500 m (ACT Government 2018), Northern Territory 600 m (NT EPA 2017), Victoria 1,000 m (EPA Victoria 2013)).

Benchmarking of air quality modelling and monitoring data at the OZ Minerals Prominent Hill operation, being of similar scale (12 Mtpa ore movement) and in a similar arid location, demonstrate that concentrations of PM_{10} dusts generated from the operations is indistinguishable from background within less than 20 km of the mining operations, with the *National Environment Protection (Ambient Air Quality) Measure* criterion for PM_{10} met approximately 4 km from the operations, reasonably consistent with the WA EPA (2005) separation distance guideline value.

Due to the remoteness of the site, the lack of cumulative emissions sources and the lack of nearby sensitive receptors, air quality (dispersion) modelling was considered not to be necessary, and the Project is considered unlikely to result in any change in the air quality at the nearest sensitive (human) receptor locations.

4.3.2 Off-Site Activities

Wheel-generated dust is expected to be generated by heavy vehicles travelling on the unpaved site access road and Jameson bypass. Maintenance of the road surface, and the reduced speed of the heavy vehicles due to the nature of the approaches to and from the staggered intersection of the bypass road and the Blackstone-Warburton Road, will effectively reduce the generation of dust from the road surface. The distance between the road and the nearest receptor (1.5 km) is significant in the context of wheel-generated dust emissions, which are typically limited to an extent of tens to hundreds of metres (e.g. Bluett et al 2017, Cuscino et al 2006, SA EPA 2016).

4.4 Assessment of Impacts

This section presents an assessment of the potential for impacts to occur to receptors based on the change in air quality (effect) as a result of the proposed pollutant-generating activities.

4.4.1 Human Health

Human health impacts as a result of air quality effects are generally measured against the criteria nominated in the *National Environment Protection (Ambient Air Quality) Measure*. Monitoring and modelling undertaken at the similar Prominent Hill operation demonstrates that the criteria is likely to be met within approximately 4 km of the dust generating activities, reasonably consistent with the WA EPA (2005) separation distance guideline value of 3 km. Further, this benchmarking indicates that air concentrations of dusts generated from the Project will be indistinguishable from background within approximately 20 km.

The nearest sensitive receptors are located at Jameson, 29 km from the Project area. As a result, there are predicted to be no changes to baseline air quality at Jameson and as such, the distance between the receptors and the Project ensures that human health is not significantly affected as a result of implementation of the Project.

Dust from the transport of materials on the off-site unpaved roads near Jameson are unlikely to result in a change in air quality as a result of the distance between the road and the nearest residence (1.5 km).

4.4.2 Amenity

The extent of changes to baseline air quality is predicted to be approximately 20 km based on the monitoring and modelling undertaken at the similar OZ Minerals Prominent Hill operation. The nearest residences are located at Jameson, 29 km from the Project area. As a result, there are predicted to be no changes to baseline air quality at Jameson, and therefore no direct amenity impacts.

The generation of particulates from on-site and off-site activities may, however, result in a change in the clarity of the air when viewed from a distance, with the potential for some days where the horizon (when looking toward the operation) appears more "hazy" than is currently the case. Due to the distances involved, this deterioration of visual amenity is expected to be relatively minor in nature. Determining the actual impact of changes in amenity on individuals is difficult to predict with certainty. Research into the amenity impacts of dust arising from mining operations has been undertaken for communities in the Hunter Valley region of New South Wales exposed to varying concentrations of dust. A 1986 survey of three communities (Dean *et al*. 1987) suggested that there was no specific dust deposition threshold that represented a precise point where people generally perceive a decline in their level of amenity commencing. This study subsequently concluded that the most important factor in determining a community's response to dust was likely to be the existing air quality and its rate of change. A similar study undertaken in 1999 (ACARP 1999), also for the Hunter Valley, concluded that community perceptions to air quality do not correlate well with exposure to long-term average dust concentrations, nor do community perceptions appear to correlate well with even quite extreme exposures to dust measured at a particular location. This is likely because community perceptions of air quality are based on visual cues (such as general haze and dust fallout onto roofs and cars) rather than specific dust concentrations. Together these studies indicate that the perception of dust is more closely related to the receivers' previous exposure to dusty environments, the nature of their relationship to the generator of the dust, and the rate of increase or decrease in dust concentrations over time, with dust more noticeable the more its concentration varied in intensity.

4.4.3 Non-Human Biota

A review of available literature related to the potential effects of increasing dust deposition on vegetation was undertaken in order to develop a reasonable vegetation impact criterion against which to assess Project-related dust deposition. This is summarised in the following sections.

Effects of Dust on Vegetation

At a high level, it has been shown that increases in deposited dust concentrations cause a reduction in the growth, yield, flowering and reproduction of vegetation (Saunders and Godzik 1986, cited in Prajapati 2012). The three principal mechanisms by which this occurs are:

- Changes in energy exchange (i.e. the absorption and conversion of radiation);
- Reductions in light absorption (i.e. effects on vegetation photosynthesis) ; and
- Inhibition of water vapour exchange (gas diffusion between leaves and air) (Doley 2006).

Reductions in photosynthesis and inhibition of water vapour exchange, combined with an increase in leaf temperature as a result of changes in the energy exchange mechanism is likely to make vegetation more susceptible to drought (Farmer 1991). Dust may lodge in the stomata of vegetation, inhibiting water vapour exchange, however the nature of the stomata has a significant influence over this process, and it is known that some desert plants have glandular hairs covering the stomata which may result in an increased tolerance to dust deposition (Doley 2006). In desert conditions, unpaved road dust loads of 40 g/m^2 were shown to increase leaf temperatures by 2 to 3° (Sharifi *et al*, cited in Doley 2006), however the effects vary with particle size and colour (Doley 2006).

Chemical effects associated with the deposition of reactive materials (sulphates, nitrates and high/low pH materials) can also occur, although mineral dusts are generally less soluble and less reactive than anthropogenic acid-forming sulphate and nitrate particles, and dusts from hard rock quarries have been shown to be relatively inert in their chemical effects (Farmer 1991). Dusts with a high pH (greater than 9) may cause direct injury to vegetation on which the dusts are deposited or indirectly through accumulation in soils (Doley 2006).

Levels at Which Dust Deposition Impacts Vegetation

The deposition rates and concentrations at which vegetation is impacted are dependent on many variables including the vegetation type, the nature and concentration of the deposition, and the meteorological environment. Critical dust loads that result in significant alterations in the most sensitive plant functions have been found to vary with the particle size distribution and the colour of the dust, from around 1 g/m^2 for ultra-fine carbon black particles to about 8 g/m^2 for more coarse road or limestone particles with a median diameter of greater than 50 µm (Doley 2006). Farmer (1993) showed that direct physical effects of mineral dusts on vegetation become apparent only at relatively high surface loads (greater than 7 g/m^2), as compared to the chemical effects of reactive materials (sulphates and nitrates) which may become evident at levels of around 2 g/m^2.

Analysis of roadside dust deposition has found that vegetation near unpaved roads can be subjected to up to 10 g/m^2/day of dust deposition (Everett 1980, cited in Farmer 1991). Thomson *et al* (1984) found that around 5 g/m^2/day was required to cause a reduction in photosynthesis of roadside vegetation, and a dust load of 10 g/m^2 reduced photosynthesis by between 18% and 30%. His experiments established that dust may affect photosynthesis by shading and obstructing diffusion and that dust was found to have an appreciable effect at concentrations between 5 and 10 g/m^2.

A controlled study undertaken in the Mojave Desert subjected a desert plant species (*Astragalus Jaegerianus*) to varying levels of dust deposition to assess decreases in vigour, via measurements of leaf-level net photosynthesis, mid-day water potentials and plant shoot growth (Upekala *et al* 2009). At dust concentrations of between 20 and 40 g/m^2, neither shoot growth nor leaf production differed between dusted plants and control plants. In field experiments the same effects were observed with deposited dust concentrations in the control vegetation of around 1.1 – 2.8 g/m^2 and in the dusted plants at around 4 – 9 g/m^2.

Non-Human Biota Impact Assessment

A review of the available literature supports the notion that impacts to vegetation as a result of dry deposition and dust accumulation begin to occur at deposited concentrations of around 5 – 10 g/m^2. The nature of desert and arid area vegetation, in particular the characteristics of their stomata, suggest that they are, in general, more tolerant of higher dust concentrations than vegetation in other, more temperate climates. This is supported by the few studies that have investigated dust deposition effects on desert vegetation. The nominated criterion for this assessment has been conservatively assumed to be approximately in the middle of the indicated range, at 7 g/m^2.

AQEG (2012) observed that there appears to be few direct effects of dry particles on vegetation except where a leaf surface is covered by dust. The potential maximum dust deposited on vegetation surrounding the Project is therefore important in quantifying the potential for vegetation impacts. Dust deposition rate does not, however, necessarily describe the net rate of dust accumulation on leaf surfaces and the consequent effects. Leaf orientation, size and shape, age, roughness and wettability of the leaf surface all influence dust interception and retention (Doley 2006, Prajapati 2012). Dust loss as a result of wind and rain actions is difficult to predict and there is a general lack of data to draw any firm conclusions. This means that coarse approximations between dust concentration or deposition rate and dust load on vegetation remain the most appropriate assumption (Doley 2006). Keller and Lamprecht (1995, cited in Prajapati 2012) reported that dust levels near an unpaved highway in Alaska were relatively invariable over much of the summer growing season and that up to 85% of the dust falling on vegetation surfaces may be removed. It is therefore assumed, in practice, that the movement of vegetation from interaction with the wind and other leaves is likely to mean that a proportion of the dust would be "shaken" free. For the purpose of this assessment, it is conservatively assumed that dust accumulation on vegetation is proportional to the deposition rate.

Conservatively applying the WA EPA separation distance value (3,000 m) as the distance at which the dust deposition criterion of 4 g/m^2/month (total deposition) is achieved, and assuming that no rainfall occurs for two consecutive months, and that no dust is shaken off the leaves due to wind (very conservative), the nominated criterion of 7 g/m^2 has the potential to be exceeded for an area of 3 km around dust generating activities and therefore there may be some potential impacts to individual plants within this area, noting that species in arid Australia are generally already adapted to fluctuating dust levels and prolonged periods of drought where the build-up of particles on leaves occurs.

Surveys of vegetation in the Project area have found no Threatened flora, as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act, Cth) nor the *Biodiversity Conservation Act* 2016 (WA), and therefore no impacts to Threatened flora are predicted. Eleven DBCA priority taxa, comprising two Priority 1 and nine Priority 3 species were recorded, of which one Priority 1 and three Priority 3 species occur within 3 km of dust-generating activities. Surveys have shown that there are numerous records of all four species also occurring outside of the potential impact area.

It is considered unlikely that there will be a significant impact on flora as a result of dust deposition, and the Project activities will not adversely affect biological diversity and ecological integrity of flora in the region.

5 MITIGATION, MANAGEMENT AND MONITORING

5.1 Mitigation

The proposed mining and processing operations are relatively conventional in nature, meaning that standard mitigation measures, proven to be effective at other operations, are available to be implemented as required to minimise the potential for air quality impacts. Some of the most common mitigation measures and their relative effectiveness are detailed in the National Pollutant Inventory Emission Estimation Technical Manual for Mining (Version 3.1, 2012), specifically:

Table 4: Potential Mitigation Measures and Emissions Reduction Potential

Dust-Generating Operation	Control Method	Effectiveness (% Emission Reduction)
Scrapers on topsoil	Moistening of soil	50%
Drilling	Fabric filters	99%
	Water sprays	70%
Blasting	Blast hole stemming optimisation	Unknown
Loading haul trucks	Water spray/misting systems	Up to 50%
Vehicles on unpaved roads	Level 1 watering (up to 2 L/m2/hour)	50%
	Level 2 watering (>2 L/m2/hour)	75%
	Sealed or salt-encrusted roads	100%
Loading stockpiles	Water sprays	50%
	Variable height stackers	25%
	Telescopic chutes with water sprays	75%
	Total enclosure	99%
Unloading from stockpiles	Water sprays	50%
	Underground reclaim	100%
Wind erosion from stockpiles	Water sprays	50%
	Wind breaks	30%
	Total enclosure	99%
	Reshaping and/or profiling	30%
	Rock armouring	30%
Loading to transport vehicles	Enclosure	70%
	Enclosure and use of fabric filters	99%
Miscellaneous transfer and conveying	Water sprays	90%
	Enclosure	70%
	Enclosure and fabric filters	99%
Wind erosion of cleared areas	Primary rehabilitation	30%
	Initial vegetation reestablishment	40%
	Secondary rehabilitation	60%

Dust-Generating Operation	Control Method	Effectiveness (% Emission Reduction)
	Revegetation	83%
	Full rehabilitation	100%
Dusts generated in the open pits	In-pit retention of TSP	50%
	In-pit retention of PM_{10}	5%

The mitigation measures to be applied will be determined during detailed design and during initial operations, as required.

For the roads, road maintenance costs will be contributed to by OZ Minerals for the parts of the road managed by the Jameson Shire, and OZ Minerals will be wholly responsible for maintenance of the section of the road south of Jameson to the operation to ensure that the road remains fit-for-purpose. Other mitigation measures may include the use of dust suppressants (e.g. water or chemical additives) on sections of the road nearest to Jameson as and if required.

5.2 Management

Management of air quality to comply with occupational exposure requirements for onsite personnel will likely address the majority of localised dust emission issues. Management of regional air quality would be largely based on a reactive complaints management system and an operational response plan for situations where air pollutant concentrations and/or deposition rates were demonstrated to exceed the relevant criterion. This may include actions as detailed in Section 5.1.

5.3 Monitoring

Due to the remoteness of the Project from public human health and amenity receptors, no specific human health or amenity-related air quality monitoring is proposed. Occupational dust monitoring may be undertaken as necessary to comply with relevant OHS requirements.

Similarly, due to the lack of potential for significant impacts to flora, no specific vegetation condition or dust deposition monitoring is proposed. Reactive monitoring may be undertaken where ad hoc observations of a change in vegetation condition are noted

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