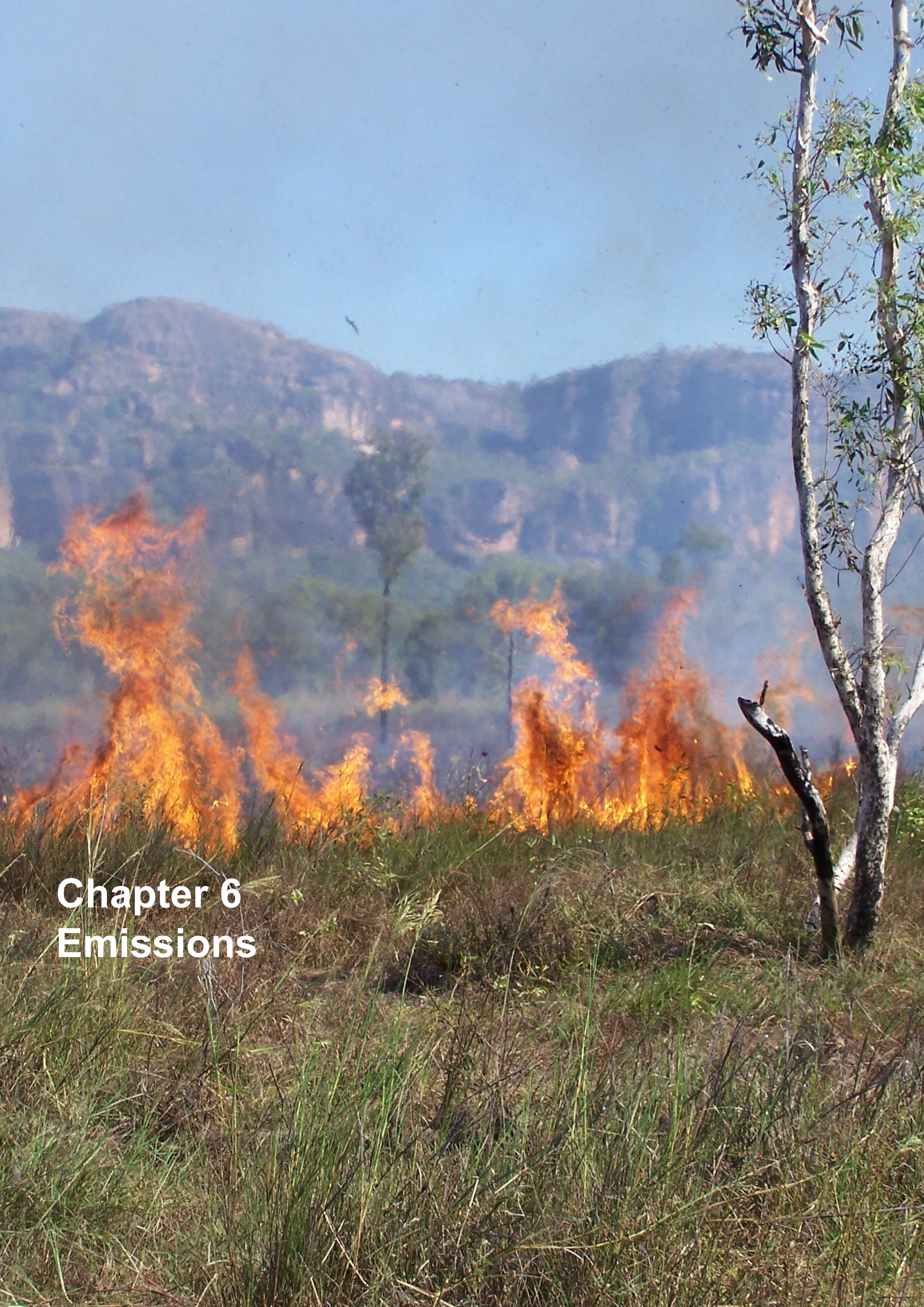
Chapter 6
Emissions



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6 EMISSIONS

6.1 INTRODUCTION

This chapter is based on the findings of the air quality assessment undertaken by Pacific Environment Ltd (**Appendix 6**) and the noise and vibration assessment undertaken by SLR Pty Ltd (**Appendix 7**). In addition, using forecast energy requirements in combination with national greenhouse and energy measurement technical guidelines, greenhouse gas emissions over the proposed Project period have been calculated.

This chapter discusses the risks presented by the Project with respect to air quality, greenhouse gas and energy along with noise and vibration. These risks are of relevance to risks associated with cultural heritage, flora and fauna, community, health and safety. To mitigate potential impacts on these values, existing controls and additional treatments (Project design and management) that ERA will implement are discussed.

The methods used to assess risks to air quality, greenhouse gas and energy, noise and vibration were selected in consideration of the EIS Guidelines. These are discussed in the following chapter sections:

- air quality assessment (**Section 6.4**);
- greenhouse gas and energy assessment (**Section 6.5**);
- noise assessment (**Section 6.6**); and
- vibration assessment (**Section 6.7**).

Assessment of potential impacts resulting from the Project is undertaken with particular reference to **Chapter 5** in combination with modelled outcomes and established criteria.

6.2 RECEPTORS

A number of receptors[1] have been considered in the assessment of ambient air quality; noise and vibration (refer to **Figure 6-1** and **Table 6-1**). Public receptors (residential and commercial) include the township of Jabiru, Jabiru Airport (and other businesses at that location), Ranger mine village contractor camp, Mudginberri Aboriginal community and a transient Aboriginal camp known as 009 Camp.

A number of cultural receptors consisting of Aboriginal heritage sites have been identified. Cultural sites include the Mt Brockman escarpment, R34 and Tree Snake Dreaming.[2] The characteristics of these receptors are as follows:

- Mount Brockman escarpment: located approximately 4.5 km south of the nearest Project operations, this dreaming site contains a number of rock shelters and rock art galleries;

[1] Receptors are locations which have characteristics that may make them sensitive to environmental impact.

[2] At the request of Traditional Owners this site has not been identified on Figure 6-1 and in Table 6-1.

- R34: this occupancy site contains stone artefacts and evidence of occupancy such as grinding grooves. The site is located directly above the existing exploration decline[3] and is the closest cultural heritage site to the Project; and
- Tree Snake Dreaming: this dreaming site is located to the north west of the nearest Project infrastructure.[4]

For further information on these sites refer to **Chapter 10**.

Representative ecological receptors included Retention Pond 1 (RP1), Georgetown Billabong and Magela Creek. A flora and fauna survey conducted in the vicinity of the Project by Eco Logical Australia (2014) has established habitat characteristics and the presence of flora and fauna, including threatened and migratory species. For further information on these receptors refer to **Section 9.2.2**.

Figure 6-1: Public, cultural and ecological receptors

[3] At its closest point, R34 is around 130 m above the Ranger 3 Deeps exploration decline. The Projects underground development depth is more than twice this distance. The closest surface construction activity (ventilation raise) to R34 is approximately 100 m.

[4] This receptor is has been considered, however at the request of the Traditional Owners, is not disclosed in Figure 6-1.

Table 6-1: Receptor identification number, name and type

Id	Receptor name	Receptor type
1	Mudginberri	Residential
2	009 Camp	Residential
3	Jabiru	Residential
4	Jabiru Airport (and businesses)	Commercial
5	Ranger mine village (contractor camp)	Residential
6	Mount Brockman	Cultural
7	Tree Snake Dreaming	Cultural
8	R34 cultural heritage site	Cultural
9	Retention Pond 1	Ecological
10	Magela Creek	Ecological
11	Georgetown Billabong	Ecological

6.3 ASSESSMENT CRITERIA

6.3.1 Air Quality Criteria

6.3.1.1 Substances of Interest

The air quality assessment considered emissions associated with material movement, fuel combustion and ore processing for the Project and the existing Ranger mine. Based on operations where similar activities are undertaken, predominant substances that are typically derived from these activities were identified and evaluated. The evaluation considered the following aspects:

- Whether the substance is emitted from Project and Ranger mine activities, and if so, in what quantities;
- The existing environmental values of the area surrounding the Ranger mine; and
- The availability of relevant guidelines for the substance.

The substances considered in the evaluation and their relevance is identified in **Table 6-2**.

Table 6-2: Substances and their relevance to the air quality assessment

Substance	Relevance
Particulate Matter (PM),Total Suspended Particulate Matter (TSP), PM_{10}, $PM_{2.5}$ Dust deposition	Mining activities (ore processing, wheel generated dust from unpaved roads) and power generation are known to generate PM emissions. The activities that typically lead to dust deposition include earthmoving, mobile equipment movement along unpaved roads or exposed areas, preparation of sites for construction activities, and typical material movement. Particulate matter emissions were therefore included in the air quality assessment.
Metals and Metalloids	Uranium and its decay series elements have been assessed as part of the radiation assessment using other modelled parameters, i.e. radon and TSP. Based on previous analysis undertaken by ERA on the particulate constituents within TSP generated by Ranger mine operations, there are no known metals or metalloids of concern, i.e. there are no metals/metalloids that have significant concentrations within the mine that are potentially toxic to humans. As such, metal emissions have not been considered relevant and therefore were not included in the air quality assessment.
Sulfur dioxide (SO_2)	Sulfur dioxide emissions associated with the Project and existing Ranger mine operations are derived from the combustion of fuels in vehicles and for power generation. SO_2 in high concentration can impact human health or change rock art. As such, SO_2 emissions have been included in the air quality assessment.
Nitrogen dioxide (NO_2)	Nitrogen dioxide emissions associated with the Project and existing Ranger mine operations are derived from the combustion of fuels in vehicles and for power generation. As such, NO_2 emissions have been included in the air quality assessment.
Carbon monoxide (CO)	Carbon monoxide is produced from incomplete combustion of fuels. CO has the potential to impact human health and is relevant to underground ventilation and equipment choice. As such, CO emissions have not been included in the air quality assessment.
Radon	Radon emissions will be produced from mineralised rock faces. Radon emissions associated with the Project have been included in the air quality assessment. Existing radon concentrations are based on monitoring data. All radon results (Project and cumulative) are discussed in **Chapter 7**.

In summary, the following substances were considered in the ambient air quality assessment:

- Particulate matter with an aerodynamic equivalent diameter less than 10 µm (PM10);
- Particulate matter with an aerodynamic equivalent diameter less than 2.5 µm (PM2.5);
- Total suspended particulate (TSP); [5]
- Sulfur dioxide (SO_2);
- Nitrogen dioxide (NO_2); and
- Radon.[6]

These substances are associated with impacts to human health, the environment or the amenity of cultural heritage sites. Specifically, particulates such as PM_{10} and $PM_{2.5}$ are small enough to affect the human respiratory system. Similarly, both SO_2 and NO_2 are gases that are known to impact human health once inhaled. Radon dispersion is relevant to both the assessment of public and environmental risks associated with radiation.

6.3.1.2 Relevant Criteria

There are currently no Northern Territory (NT) specific air quality guidelines. Therefore, the guidelines associated with the National Environment Protection Measure for ambient air quality (Air NEPM) (NEPC 2003), along with those outlined by the New South Wales Department of Environment and Conservation, have been used to assess Project impacts (DEC (NSW) 2005).

These guidelines are applicable to the characteristics of the particular receptor. For example, Air NEPM guidelines are intended for publically occupied areas and relate to the protection of human health (**Table 6-3**). Dust deposition criteria relate to ecological receptors and aesthetic impacts on cultural heritage sites while TSP has the potential to have impacts to visual amenity in addition to human health and the environment when used for radiation assessment.

Note that while SO_2 is associated with human health, it does have the potential to impact rock art at high concentrations. While there is no rock art on the Ranger Project Area, SO_2 emissions and potential impacts to rock art have been considered at the nearest rock art site (Nourlangie - Mount Brockman massif).

There are no specific criteria for SO_2 emissions and impacts to Aboriginal rock art. However, investigations into the effect of SO_2 on rock art in the Burrup Peninsula Western Australia have been undertaken, and are of relevance to the Nourlangie - Mount Brockman massif. Burrup rock samples were exposed in the laboratory to SO_2 concentrations ranging[7] from

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5 In addition to potential impacts to visual amenity, TSP has been modelled for the purposes of conducting a comprehensive radiation assessment and is also discussed in **Chapter 7**.

6 The radon results will be discussed in **Chapter 7**.

7 Existing and future sources of SO_2 are predicted to be 1.6 parts per billion (4.2 µg/m^3). Laboratory tests involved exposing rock samples to concentrations that were five to ten times greater than the predicted existing and future SO_2 concentration.

around 21 µg/m^3 to 42 µg/m^3. According to the Burrup Rock Art Monitoring Management Committee, changes to rock surface colour were not evident at around 29 µg/m^3 (BRAMMC 2009).

Substances have been assessed at relevant receptors within the surrounding environment. During Project operations, emissions within the operational area will be managed in accordance with established occupational health and hygiene requirements (refer **Chapter 15**).

Table 6-3: Air quality criteria

Substance	Averaging period	µg/m^3	Allowable exceedances	Criteria source
[1]Nitrogen dioxide (NO_2)	1 hour	250 µg/m^3	1 day a year	Air NEPM (NEPC 2003)
	1 year	62 µg/m^3	n/a	
[1]Sulfur dioxide (SO_2)	1 hour	570 µg/m^3	1 day a year	
	1 day	230 µg/m^3	1 day a year	
	1 year	57 µg/m^3	None	
[1]Particles as PM_{10}	1 day	50 µg/m^3	5 days a year	
[1]Particles as $PM_{2.5}$	1 day	25 µg/m^3	n/a	
	1 year	8 µg/m^3	n/a	
[1]TSP	1 year	90 µg/m^3	n/a	(DEC (NSW) 2005)
[2]Deposited dusts	1 year	4 g/m^2/month	n/a	

[1] Public receptors associated with these substances and their criteria include: Jabiru, Jabiru Airport (and businesses), Ranger mine village (contractor camp), Mudginberri and 009 Camp, Note that this assessment has considered the Ranger mine village to be a publically occupied receptor as it is a residential site.

[2] Cultural heritage and ecological receptors associated with this substance and their criteria include: Mount Brockman, Tree Snake Dreaming, R34, Retention Pond 1, Magela Creek and Georgetown Billabong.

6.3.2 Noise Criteria

In the absence of NT specific noise regulations, the Industrial Noise Policy (EPA 2000) was adopted for the assessment of incremental and cumulative noise impacts at defined receptors. The policy considers the control of intrusive noise impact in addition to maintaining amenity for particular land uses.

6.3.2.1 Project Construction Noise Criteria

For Project construction, the *Interim Construction Noise Guideline* (Department of Environment & Climate Change 2009) describes relevant noise management levels for residential and other sensitive receptors, and how they are to be applied.

The Ranger project area lies within a remote location and therefore, the minimum noise level prescribed in the *Industrial Noise Policy* of 30 dBA is an appropriate background noise level (EPA 2000). Using this as a baseline, relevant noise criteria for day, evening and night has been established. As outlined in the *Interim Construction Noise Guideline*, where a construction activity occurs from Monday to Friday between the hours of 7 am to 6 pm, or on a Saturday from 8 am to 1 pm, 10 dBA is added to the background noise. Outside these hours, 5 dBA is added to background levels (Dept of Environment & Climate Change 2009). The Project specific residential and public noise criteria for construction, is presented in **Table 6-4**.

Table 6-4: Project specific construction noise criteria

Location	Period	Noise affected[1] LAeq(15 min)(dBA)[2]	Highly noise affected[1] LAeq(15 min)(dBA)
All residential and public locations	Day	40	75
	Evening	35	N/A
	Night	35	N/A

1 These terms and how they have been applied is outlined in **Appendix 7**, Section 8.3

2 LAeq(15 min) is the equivalent noise level over a 15 minute period

6.3.2.2 Project Operational Noise Criteria

The *Industrial Noise Policy* defines both amenity and intrusiveness criteria. Amenity criteria are based on noise criteria specific to land use and associated activities relating to industrial noise sources. To limit continuing increases in industrial noise levels, the maximum ambient noise levels from industrial noise sources in an area should not normally exceed the acceptable noise levels.

The intrusiveness criterion states that the equivalent continuous noise level (LAeq) of the source should not be more than five decibels above the background noise level. As discussed previously, given the remoteness of the Ranger mine, 30 dBA is an appropriate background noise level and therefore 35 dBA is the applicable intrusiveness criteria.

These *Industrial Noise Policy* criteria have been established to protect at least 90% of the population living in the vicinity of industrial noise sources from the adverse effects of noise for at least 90% of the time. Provided the criteria are achieved, it is unlikely that most people would consider the resultant noise levels excessive.

In assessing noise impact, the *Industrial Noise Policy* requires consideration of intrusiveness and amenity. The more stringent of the two criteria, i.e. intrusiveness, was utilised for assessing Project noise emissions **Table 6-5**. For further detail on noise criteria refer to **Appendix 7**.

Table 6-5: Operational Project specific noise criteria

Location	Period	Intrusiveness criteria LAeq(15 min) (dBA)	Amenity criteria LAeq(15 min)(dBA)	Project specific noise criteria LAeq(15 min)
Nearest noise sensitive receptors	Day	35	50	35
	Evening	35	45	35
	Night	35	40	35

6.3.2.3 Fauna Noise Criteria

Research on the effects of noise on terrestrial fauna has been reported in the scientific literature and elsewhere, although the effects of noise on most fauna species are poorly understood (Brown 2001, Larkin*, et al.* 1996). There are no clear or well defined thresholds for species tolerance, even for individual species. Similarly, there are no current government policies or other widely accepted guidelines regarding noise levels or thresholds of relevance to terrestrial fauna.

Notwithstanding the absence of established noise guidelines for terrestrial fauna, the criteria range presented in **Table 6-6** combines information from a number of sources and is considered relevant to all terrestrial fauna present in the vicinity of the Project area. For further information on development of the criteria and its applicability to the noise assessment, refer **Appendix 7**. The behavioural responses to the disturbance criteria presented in **Table 6-6** are outlined in **Table 6-7**.

Table 6-6: Terrestrial fauna disturbance criteria (Project construction and operation)

Disturbance	Steady or continuous noise source LAeq(15 min)(dBA)	Episodic[1] (single event or short term) noise source (LAmax; dBA)
Occasional (alert) – minor impacts on habitat use for most species	50 to 65	45 to 60
Frequent (alarm or flight) – moderate impacts on habitat use	65 to 85	60 to 80
Avoidance of area – by most of the population of some species	>85	>80

[1] Episodic noise can elicit a 'disturbance' response at a lower threshold than continuous noise when contrasted against a relatively quiet background

Table 6-7: Behavioural response of birds and amphibians to disturbance

Disturbance	Response - birds	Response - amphibians
• Alert	• Looks briefly at source • Turns head	• Briefly ceases calling
• Alarm	• Looks intently at source • Changes position • Shows intent to flee	• Ceases calling for long periods
• Flight	• Moves a short distance from source • Ceases feeding of young/and or foraging	• Temporarily moves away from source
• Avoidance	• Permanently vacates area or abandons nests	• Permanently vacates area

6.3.3 Vibration Criteria

6.3.3.1 Residential Criteria

The Australian Standard 2187.2-2006 *"Explosives – Storage, Transport and Use Part 2"* gives criteria for the maximum levels of ground vibration for human comfort and for control of damage to structures (Standards Australia 2006). These criteria are identified in **Table 6-8**.

Table 6-8: Ground vibration limits for human comfort and control of damage to structures

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site[1]	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95% of blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply.
	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply.
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect equipment operation.

[1] A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people.

As previously identified in **Section 6.2**, the nearest residential receptor (sensitive site) in proximity to the Project is the Ranger mine village contractor camp.

6.3.3.2 Cultural Heritage Criteria

There are currently no government policies or widely accepted guidelines on vibration criteria specific to cultural heritage sites. However, a number of previous environmental assessments and approvals not related to this Project have identified and adopted ground vibration criteria for different cultural heritage sites (DECC 2009, Hunter Expressway Alliance 2011).

These criteria, along with the cultural receptors identified previously in **Section 6.2**, are outlined in **Table 6-9**. Note that as the Tree Snake Dreaming cultural heritage site does not exhibit the cultural heritage characteristics identified for either R34 or Mount Brockman, no criteria have been set.

Table 6-9: Cultural heritage site vibration criteria

Type	Vibration criteria (mm/s)	Applicable location
Stone arrangements	3[(1)]	N/A
Grinding groove	80[(2)]	R34
Rock shelter	40[(1)]	Mount Brockman

[1] Source: Hunter Valley Expressway Alliance – Stage 2 Construction Noise Sub Plan – Seahampton to Kurri Kurri Section dated 2011
[2] Source: Moolarben Coal Mines Pty Ltd – Project Approval 05-0117 dated 2007

6.4 AIR QUALITY ASSESSMENT

6.4.1 Context

Ranger mine air emissions have historically been associated with material movement activities, along with emissions from diesel combustion and the generation of electricity for both Ranger mine operations and the township of Jabiru. Recently, commissioning of the brine concentrator water treatment plant has increased site power requirements and associated emissions.

A significant contribution to ambient air is dust generated through activities such as loading and haulage of ore and waste rock. The contribution from such activities has changed with the cessation of open pit mining to the current situation where ore is being processed from stockpiles. Dust emissions associated with material movement through the processing plant remain unaltered.

Project emissions are anticipated to be principally derived from material movement, additional power demand and exhaust air from the mine ventilation system.

ERA sought external expertise from Pacific Environment Ltd to undertake the Project air quality assessment. This report (**Appendix 6**) includes the detailed method and results which have been summarised within this chapter.

The assessment consisted of the following key activities:

- An estimation of emissions from the Project;
- Analysis of meteorological parameters over a number of years to establish a representative year on which to base the predictive modelling;
- A sensitivity or screening assessment to determine the effect of altering the ventilation shaft location, exhaust temperature, exhaust stack height and exit velocity on ground level concentrations of substances of interest; and
- Modelling to predict existing, incremental (the Project) and cumulative air quality impacts at defined receptors, compared to established air quality guidelines.

This section discusses the modelling methods and the outcomes of the air quality assessment.

6.4.2 Assessment Approach

6.4.2.1 Modelling Methods

Predictive modelling was undertaken for the ambient air quality assessment has using the well-established modelling packages TAPM, CALMET and CALPUFF.

TAPM is a three dimensional meteorological and air pollution model produced by the Commonwealth Scientific and Industrial Research Organisation division of atmospheric research. Simply, the TAPM meteorological model reproduces hourly three dimensional weather conditions using archived global weather data and generates the upper air data for input into the CALMET diagnostic model.

As a direct meteorological input to the CALPUFF dispersion model, CALMET generates wind field components, air temperature, relative humidity, mixing heights and other smaller scale meteorological variables for each hour of the modelling period. The CALPUFF dispersion model is capable of accommodating variable meteorological conditions such as wind direction and strength in combination with surrounding terrain features to produce predictive, plume dispersion.

For further information on these models refer to **Appendix 6**.

Meteorological conditions and dispersion characteristics were developed using the representative year of 2012 (refer to **Section 6.4.2.2**).

6.4.2.2 Meteorological Assessment

Meteorology is a dominant determinant of plume dispersion and therefore ambient air quality. Consequently, the meteorological data used in the modelling should be representative of average conditions.

Weather data recorded at the Jabiru Airport over the period 2008 – 2012 was analysed for the ambient air quality assessment. This analysis considered daily maximum and minimum temperatures, and wind speed at 9 am and 3 pm. These times represent differing diurnal variability and therefore are appropriate to compare and contrast from one year to the next.

While the monthly statistical analysis over the assessment period and the parameters considered were within a 95% confidence level, the 2012 rainfall pattern was better correlated with the long term mean. Consequently, the year 2012 formed the basis of the predictive modelling.

6.4.2.3 Screening Assessment

The air quality assessment included a sensitivity analysis of the relationship between potential design features such as stack configuration, and release parameters, and the resultant ground level concentrations. The outcomes were used to ensure that subsequent modelling was representative of the stack design.

This analysis investigated the effects of varying stack height, exit temperature and exit velocity. Specifically, the following parameters were compared and contrasted:

- Stack heights of 5 m and 10 m;
- Exit temperatures[8] of 23˚C, 28˚C and 33˚C; and
- Exit velocities of 12.5 m/s, 18.7 m/s and 21 m/s.

Of the modelling parameters assessed, exit velocity was predicted to exert more of an influence on ground level concentration. Of the velocities considered, 18.7 m/s was preferable to 12.5 m/s and 21 m/s as the former achieved both dispersion performance and energy efficiency. Therefore, 18.7 m/s was adopted as a modelling input. Conversely, the model output was relatively insensitive to exhaust temperature and so a mid-range value of 28^{o}C, representing 'neutral' buoyancy was selected for subsequent modelling. While limited in extent, the modelling predicted that a 10 m stack height improved dispersion characteristics. Consequently, a 10 m stack height design was adopted as a modelling input.

6.4.2.4 Model Input Parameters

In addition to parameters defined during the screening assessment, input parameters for the model were derived from a combination of emission estimation methods, manufacturer specifications and calculated discharge rates. To provide a conservative and therefore maximum predicted ground level concentration or deposition, it has been assumed that emission sources are running at their maximum design capacity. For example, electricity generation has been modelled on the basis that all available generator units are operating simultaneously. In a normal operational mode, these generator units would be supplying electricity in response to operational demand. For example, in the dry season months, ambient air temperature and relative humidity do not necessitate the same need for refrigeration as would be required in the wet season months when these same parameters are markedly different. For further information on input parameters refer to **Appendix 6**.

6.4.3 Air Emission Sources

The source parameters modelled in the CALPUFF dispersion model consist of both fugitive[9] and point source[10] contributors associated with both the Project and existing operations. As discussed in **Section 6.4.2.4**, the modelling has been conducted in a conservative manner in that all emission sources are assumed to be operating at full capacity. Key sources of existing gaseous and particulate emissions are identified in **Table 6-10**.

Fugitive emissions for both existing Ranger mine operations and the Project will be associated with haulage and material movement activities.

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8 The average ambient temperature is around 28^{o}C representing ‘neutral buoyancy’ while temperatures of 23^{o}C and 33^{o}C represent negative and positively buoyant discharge air respectively.

9 Fugitive emissions, such as dust generated by vehicle movements are emissions that are not released from a discreet source.

10 Point source emissions are emissions from a point of direct discharge such as a stack.

Table 6-10: Existing and Project emission sources

Existing sources		Project sources	
Facility	**Description**	**Facility**	**Description**
Brine concentrator water treatment plant	This facility requires four 2 MW diesel fuelled generators, with each generator exhaust emissions through two waste heat boilers.	Power plant	Consisting of five 2 MW diesel fuelled generators.
Primary, coarse ore and fine crusher scrubbers.[1]	Components of the crushing circuit consisting of primary crushing, primary screening, secondary crushing and tertiary crushing.	Exhaust ventilation stacks	A series of ventilation exhaust stacks will be established with underground emissions exhausted to the surface to maintain suitable underground air quality.
Crushing and screening unit	This equipment crushes material down to an appropriate size for further crushing and grinding.	Crushing and screening unit	Utilising this existing equipment for crushing and screening waste rock, aggregate material (≤ 20 mm) will be produced and placed in the feed hopper as a component of the backfill plant.
Ranger operations power station.	Consisting of five 5.2 MW diesel fuelled generators, this facility supplies electricity for both Ranger mine operations and the township of Jabiru.	Backfill plant	Aggregate and washed mill tailings are transferred from feed hoppers into a mixer to produce backfill material to be piped underground.
Exploration decline exhaust ventilation stack.	The exploration decline ventilation stack will become part of the overall Project ventilation infrastructure and management strategy.		

[1] Scrubber units are designed to remove a portion of particulate that would otherwise be exhausted to atmosphere

The location of both existing and Project emission sources is illustrated in **Figure 6-2**. Note that there is anticipated to be a total of six ventilation exhaust stacks with one of these a component of existing infrastructure. Central ventilation exhaust locations 2 and 3 each consist of two "twinned" ventilation exhausts, approximately 20 m apart. Point sources that are located close to one another can be modelled as a single point source. Consequently, ventilation exhaust locations 2 and 3 in combination with exhaust locations 1 and 4 were each modelled as a single point source location. This arrangement is representative of the six ventilation exhausts described in **Section 3.5.2**.

ID	Label
1	Exhaust 1
2	Exhaust 2
3	Exhaust 3
4	Backfill plant
5	Exhaust 4
6	Waste rock stockpile
7	Power plant
8	Power station
9	Secondary crusher
10	Fine crushing
11	Brine concentrator
12	Primary crusher
13	Ore sorter
14	Crushing & screening plant
15	Waste rock stockpile (A)
16	Ore stockpile (B)
17	Waste rock stockpile (C)

Figure 6-2: Existing and Project emission sources

6.4.4 Assessment of Risk

The environmental risk assessment identified a total of 80 risks. The initial identification of risks was aided by applying a prompt list derived from the major identified risks in the EIS guidelines and augmented by previous and current operational risk registers. Potential impacts on sensitive receptors (e.g. world heritage values of Kakadu National Park, Mount Brockman) were considered when evaluating and rating each risk scenario. Where multiple potential impacts are associated with a risk scenario, the impact with the highest risk rating defines the risk management class. Risk ratings reflect the implementation of appropriate mitigation measures (existing controls and new treatments).

Of the 80 risks referred to above, four of these are associated with ambient air quality. Of these four risks, risk TA5-02 has a current and residual risk ranking of Class III (high). Risk TA3-04 has a current and residual Class II (moderate) risk ranking. Risk TA4-01 has a current and residual Class II risk ranking. TB4-01 has a current and residual Class I (low) risk ranking. The impacts associated with these risks are discussed in **Section 6.4.5**. The significance of risks TA3-04 and TA5-02 to cultural heritage is discussed in **Section 10.4.2.2**.

Therefore, current and residual risks to ambient air quality assessed in this section relate primarily to:

- TA3-04, e.g. ventilation emissions may adversely affect the surrounding environment;
- TA4-01, e.g. the exhaust plume and resultant off-site ground level concentrations associated with power generation may be greater than anticipated;
- TA5-02, e.g. the backfill plant may generate greater levels of dust than is expected; and
- TB4-01, e.g. dust associated with surface material movement (haulage, loading and dumping) may have an adverse environmental impact.

A description of the risk assessment method is provided in **Chapter 5**. Additional discussion of the risks associated with the Project is provided in **Appendix 5**.

6.4.5 Potential Impact

The modelled ground level concentrations have been assessed at 11 locations representing a combination of residential (public), commercial (public), cultural and ecological receptors. These receptors and their proximity to Ranger mine were identified previously in **Figure 6-1**.

Predicted ground level concentrations or deposition rate for each of the substances identified in **Section 6.3.1.1** is presented in **Appendix 6**. These relate to risks TA3-04, TA4-01, TA5-02 and TB4-01 associated with particulates and gases from Project activities such as haulage, ventilation, backfill plant, power generation and underground blasting. The potential for these activities to result in impacts to either the public, surrounding ecology and cultural heritage have been assessed using the criteria and guidance discussed in **Section 6.3.1.2**.

Predicted existing concentrations and deposition rates have been provided for comparison to Project emission rates along with combined emission rates. The Project itself does not exceed relevant air quality guidelines associated with either health or visual amenity criteria.

Emission estimation has been applied conservatively to both existing and Project sources. Consequently, the resultant ground level concentrations are also highly conservative, i.e. they overestimate the likely concentrations. In addition, the methods used in the air quality assessment have a strong tendency to over predict concentrations, particularly within 1 - 5 km from the emission source with the Ranger mine village contractor camp falling within this range (refer **Appendix 6**).

6.4.5.1 Existing Impact

For existing operations, the model has identified that on four separate one hour intervals of the modelled year (2012), the 1 hour NO_2 concentration exceeds the relevant Air NEPM guideline at the nearest residential receptor (Ranger mine village contractor camp). The maximum predicted 1 hour NO_2 concentrations over 2012 at defined residential receptors are identified in **Table 6-11**.

Table 6-11: Maximum 1 hour NO_2 concentration

ID	Receptor	Existing ($\mu g/m^3$)	Project ($\mu g/m^3$)	Cumulative[1] ($\mu g/m^3$)
1	Mudginberri	29	15	29
2	009 Camp	86	61	110
3	Jabiru	84	28	72
4	Jabiru Airport (and businesses)	200	74	190*
5	Ranger mine village (contractor camp)	310	120	330

1 The cumulative result is not always the sum of the maximum predicted concentrations for existing and incremental (i.e. the maximum result for the existing model may be on a different day or hour to the maximum result for the incremental model).

* This concentration is after applying the 75% conversion from nitric oxide to nitrogen dioxide. For further clarification see **Appendix 6**.

Note: The guideline for maximum 1 hour NO_2 concentration is 250 $\mu g/m^3$.

Of the 10 highest existing 1 hour NO_2 concentrations predicted at the Ranger mine village contractor camp, the highest eight were predicted to occur between 7 am and 8 am in the months of July and August. In the months of September and November, the remaining highest concentrations were also predicted to occur in the morning.

Higher 1 hour NO_2 concentrations are associated with the interaction of emissions and meteorological conditions which are prevalent at certain times of the year. During these conditions, the plume from the power station is trapped within the vertically limited mixing layer (mixing height),[11] turbulent convective eddies bring the plume to ground. In combination with dominant wind direction, NO_2 emissions are concentrated during these events. The particular meteorological conditions necessary for these events to potentially occur are infrequent.

6.4.5.2 Cumulative Impact

All other substances under consideration (SO_2 and particulate matter), both with and without the Project, are below the relevant air quality guideline. [12] Therefore, for the majority of substances considered, there are no significant potential impacts associated with risks TA3-04, TA4-01, TA5-02 and TB4-01.

For the highest predicted maximum 1 hour NO_2 concentration (cumulative) at the Ranger mine village, the Project contributes around 20 µg/m^3 or 6%. The Project itself does not exceed the maximum 1 hour NO_2 concentration.

The maximum cumulative annual SO_2 concentration predicted to occur at the closest rock art site to the Project[13] is 0.0019 µg/m^3 compared to approximately 29 µg/m^3 that the Burrup rock art monitoring management committee found not to result in rock surface colour change (BRAMMC 2009), refer to **Section 6.3.1.2**.

6.4.6 Mitigation

The predicted emission concentrations presented in **Appendix 6** have assumed that additional Project treatment controls will be integrated into the design and management of the Project and their relevance to the following risks are discussed.

The following mitigation measures address risk TA4-01; where emissions produced by power generation may result in a greater than expected offsite impact:

- Particulate emissions associated with the Project power generation will be limited through the installation of catalytic converters on each of the generators, (refer to **Section 3.5.3.2**);
- To enhance plume dispersion characteristics, each of the Project's generators will have exhaust routed to, and emitted from, a single stack, (refer to **Section 3.5.3.1**);
- The Project power plant will be integrated with the brine concentrator power plant. This will reduce the number of power generators that need to be installed for the Project by sharing the back-up power generators with the brine concentrator power plant, (refer to **Section 3.5.3.3**); and

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11 The mixing height is the zone between the ground and an upper air layer where turbulent mixing occurs. This mixing height defines the potential volume of air the plume can be diluted into.

12 Note that to determine cumulative results, the output from the existing and incremental models are combined for each time period. As such, the cumulative result is not always the sum of the maximum predicted concentrations for existing and incremental.

13 The Nourlangie-Mount Brockman massif is the closest rock art site.

- Pollutant monitoring will be undertaken at the nearest residential receptor, the Ranger mine village contractor camp taking guidance from the air dispersion modelling.

The following mitigation measures address risk TB4-01 where particulates associated with both wheel generated dust and material loading activities may result in an adverse effect on the surrounding environment:

- As necessary, the management of dust associated with material movement will be mitigated through dust suppression on both underground haulage routes and material loading. This will be achieved through conventional water spray practices.

The mitigation measures that address risks TA3-04, where ventilation emissions may have an adverse effect on the surrounding environment, and TA5-02, were particulate emissions from the backfill plant may be greater than anticipated, are discussed in **Chapter 10**.

6.4.7 Summary

The assessment of risks to ambient air quality values assumes that all the mitigation measures, e.g. controls and treatments, are demonstrably feasible and implemented successfully. The main mitigation measures include:

- Dust suppression, e.g. minimisation of wheel generated dust using water sprays;
- Emission reduction technology applied to equipment, such as diesel power generators;
- Ventilation system design, e.g. improved plume dispersion characteristics obtained through exhaust parameters such as air flow (exit velocity) and stack height;
- Power generation stack design, e.g. exhaust emissions from each diesel power generator will be routed through a single stack which enhances dispersion characteristics; and
- Power generation operational regime, e.g. the Project power generating infrastructure will be integrated with existing power generation which will optimise diesel consumption and therefore reduce emissions.

Residential, cultural and ecological receptors were considered in the air quality impact assessment. Using appropriate air quality criteria, the air modelling has taken a conservative approach to predicting contaminant dispersion and potential impact at defined receptors. Modelling is therefore likely to overestimate ground level concentrations and deposition at defined receptors.

Current and residual risks to ambient air quality assessed in this section relate primarily to:

- TA3-04, e.g. ventilation emissions may adversely affect the surrounding environment;
- TA4-01, e.g. the exhaust plume and resultant off-site ground level concentrations associated with power generation may be greater than anticipated;
- TA5-02, e.g. the backfill plant may generate greater levels of dust than is expected; and

- TB4-01, e.g. dust associated with surface material movement (haulage, loading and dumping) may have an adverse environmental impact.

For each of the risks identified, the modelling predicts that for all substances considered, the Project alone does not exceed relevant health and visual amenity ambient air quality criteria.

In reference to risk TA4-01, while Project power generation contributes to NO_2 emissions, the existing emissions assessment has identified that at certain times of the year when specific meteorological conditions are prevalent, the maximum 1 hour NO_2 Air NEPM criteria may be exceeded infrequently at the Ranger mine village contractor camp. This criterion is not exceeded at any other residential receiver. The main source of NO_2 emissions is existing power generation. Nitrogen dioxide monitoring will be undertaken at the Ranger mine village to determine whether additional controls are required.

The combined (existing operations and the Project) concentrations of all other substances are below relevant criteria.

6.5 GREENHOUSE GAS AND ENERGY ASSESSMENT

6.5.1 Context

Ranger mine relies on diesel as its primary source of energy, with power generation and the heavy vehicle fleet being the predominant consumers. A significant quantity of diesel is consumed to generate electricity which is utilised by the township of Jabiru.

ERA has a thorough understanding of the greenhouse gas emission and energy consumption profile associated with the Ranger mine. Compliance with both the *Energy Efficiency Opportunities Act* 2006 (Commonwealth)[14] and the *National Greenhouse and Energy Reporting Act* 2007 (Commonwealth), in addition to internal Rio Tinto requirements, have resulted in an established greenhouse gas and energy management framework.

This section discusses historical and projected greenhouse gas emissions and energy in the absence of the Project. Using this information as a baseline, the incremental contribution of the Project to total greenhouse gas emissions and energy is then discussed.

6.5.2 ERA's Greenhouse Gas and Energy Policy

ERA's environment policy commits to developing and implementing plans to improve energy efficiency and minimise greenhouse gas emissions. Consistent with this objective, ERA has adopted a range of greenhouse and energy performance indicators:

- Greenhouse gas intensity: greenhouse emissions per tonne of product (tCO_{2-e} /t uranium oxide);
- Energy use intensity: total energy consumed per tonne of product (GJ/t uranium oxide);

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14 The Energy Efficiency Opportunities (Repeal) Bill 2014 is currently before the Senate. The bill provides that the repeal of the Act will occur retrospectively on 29 June 2014.

- Milling energy efficiency: milling electricity consumption per tonne of ore milled (GJ/t); and
- Power station efficiency: energy consumed to generate electricity (GJ/MWh).

6.5.3 Reporting

Since 2003, ERA has reported energy consumption, production and greenhouse gas emissions through a social and environment survey prepared by Rio Tinto. Greenhouse gas and energy reporting is undertaken on a six monthly basis through this survey.

The health, safety and environment management system complies with the requirements for certification under the ISO 14001 standard. The management system is audited by both internal and external auditors. As a component of this management system, ERA has a greenhouse gas and energy management plan outlining how emission estimates for the existing Ranger operations are documented and reported to the Australian government by Rio Tinto on behalf of ERA.

6.5.4 Emissions Estimations

The methods used to calculate greenhouse gas emissions and energy for existing operations are specified within the national greenhouse and energy reporting measurement technical guidelines (Department Climate Change & Energy Efficiency 2011). These guidelines have also been used for Project specific greenhouse gas calculations.

6.5.5 Existing Greenhouse Gas and Energy Emission Sources

The main sources of existing greenhouse gas emissions are associated with diesel combustion for onsite electricity generation, mobile heavy mining equipment[15] and the acid digestion of carbonates[16] contained within the ore. Greenhouse gas emission sources[17] and their percentage contribution are presented below in **Figure 6-3**.

The onsite power station provides the power requirements of both the Ranger mine operations and the township of Jabiru, and consists of 5 × 5.2 MW and 1 × 1.9 MW, generators relying exclusively on diesel as an energy source. In addition, the existing power station for the brine concentrator process water treatment plant consists of 4 × 2 MW generators. This power generation arrangement will not change under the Project scenario.

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15 The relative contribution of the heavy mining fleet is based on the 2011 – 2012 greenhouse gas reporting year. At the time the Project is anticipated to commence, this relative contribution will be less by comparison.

16 Carbonate constituents are calcite (limestone), magnesite and dolomite, a portion of which react with sulfuric acid to generate CO_2.

17 Excludes Jabiru township.

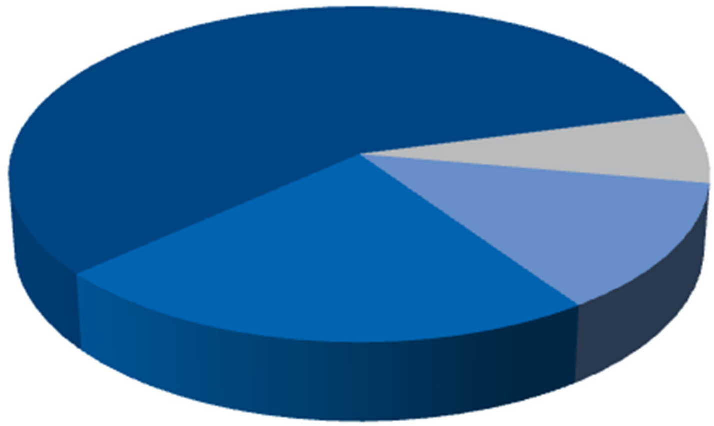

Figure 6-3: Predominant existing greenhouse gas emission sources

The electricity demand for both existing accommodation requirements at the Ranger mine village (contractor camp) and Jabiru Airport represent 1% and 3% respectively of the overall power station supply.[18] The Project will utilise existing accommodation and the Jabiru Airport with no significant change to energy demand or associated greenhouse gas emission anticipated.

6.5.6 Historical and Forecast Greenhouse Gas Emissions and Energy

Ranger mine energy consumption and greenhouse gas emissions fluctuate from year to year in response to mining and milling rates as well as processing and power station efficiency. This variability is evident over the 7 year historical period presented in **Figure 6-4** and **Figure 6-5**.

Over the period 2007 – 2013, Ranger mine emissions and annual energy demand averaged 114 kt CO_{2-e} of greenhouse gas and 1.5 PJ of energy respectively. In late 2013, the brine concentrator process water treatment plant was commissioned and will continue to operate over the proposed Project years (2016 – 2020) regardless of whether the Project proceeds. This infrastructure requires additional energy, and therefore additional diesel consumption to that previously required. Consequently, the existing annual average greenhouse gas emissions and energy demand are forecast to increase to 126 kt CO_{2-e} and 1.7 PJ respectively.

[18] Excludes Jabiru township.

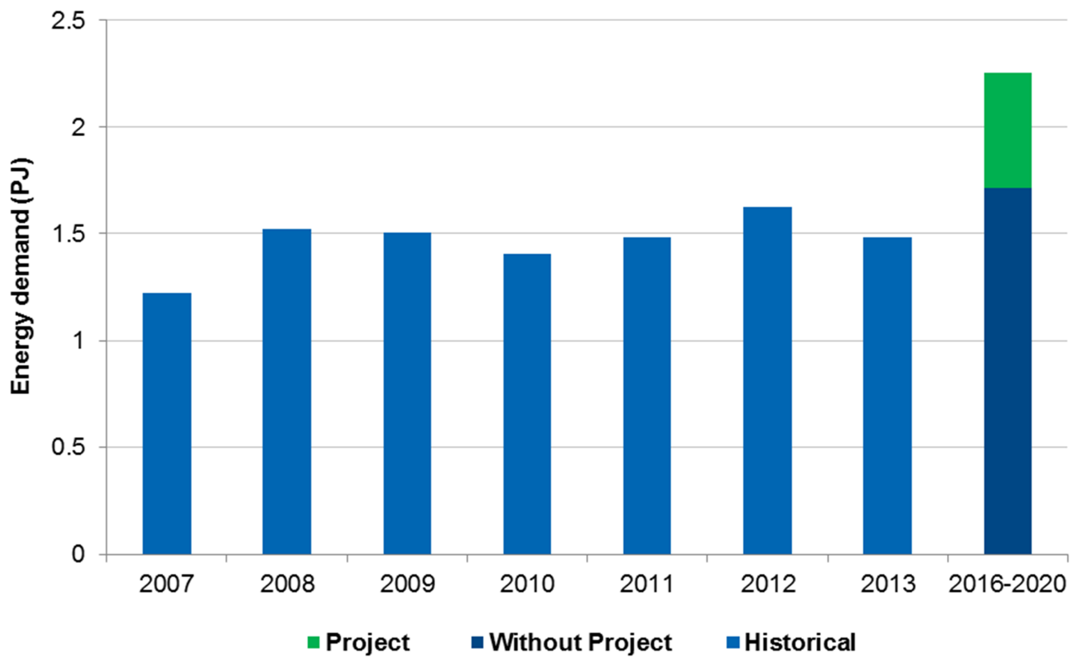

Figure 6-4: Historical and projected average (with and without Project) energy demand

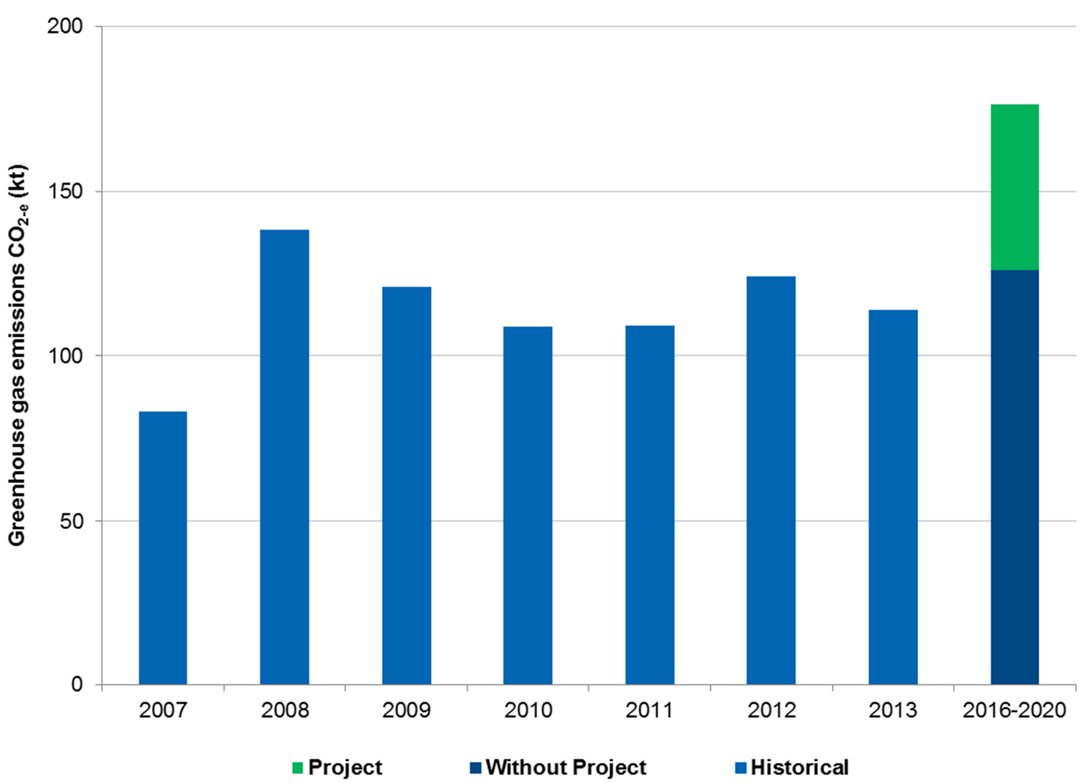

Figure 6-5: Historical and projected average (with and without Project) greenhouse gas emissions

6.5.7 Assessment of Risk

Of the 80 risks identified in the environmental risk assessment there were no current (inherent) or residual Class II (moderate), Class III (high) or Class IV (critical) risks identified for greenhouse gas emissions.

There are two greenhouse gas risks (TC1-01 and TD7-01) which are both Class I (low) rated risks for current and residual risk ratings. Each of these risks outlined below is discussed further in **Section 6.5.8**.

- TC1-01, e.g. increases in carbonate digestion within the processing circuit result in additional greenhouse gas emissions; and
- TD7-01, e.g. greenhouse gas emissions and their contribution to existing greenhouse gases contained within the Earth's atmosphere.

A description of the risk assessment method is provided in **Chapter 5**. Additional discussion of the risks associated with the Project is provided in **Appendix 5**.

6.5.8 Potential Impact

This section relates to risk's TC1-01 and TD7-01 in which there will be increased greenhouse gas emissions from additional carbonate digestion and diesel consumption respectively.

The Project will result in an average annual increase in energy demand of around 0.5 PJ with an average annual increase to greenhouse gas emissions of approximately 50 kt $CO_{2\text{-e}}$. The increase in energy demand and greenhouse gas emissions is predominantly associated with power generation during operations, mobile equipment and ancillary mining equipment. Greenhouse emissions associated with processing are a consequence of the acid digestion of carbonates and not energy consumption.

All other energy and greenhouse gas emission sources relate to Ranger mine operations that will continue to operate regardless of whether the Project proceeds.

6.5.8.1 Construction Phase

Negligible greenhouse gas emissions will result from the construction phase of the Project. The most significant construction activities are associated with ventilation shaft development and are of limited duration. Underground mine development is an operational phase and therefore greenhouse gas emissions associated with this phase are discussed in **Section 6.5.8.2**. For further discussion on Project construction refer to **Section 3.5**.

6.5.8.2 Operational Phase

Additional power generation for the Project will supply electricity to energise the ventilation fan assemblies, backfill plant, refrigeration systems and other ancillary equipment. This equipment and associated power requirements are detailed in **Table 6-12**. An average of 30 kt $CO_{2\text{-e}}$ will be produced in providing electricity to power this infrastructure. Residual greenhouse gas emissions are associated with mobile equipment diesel combustion (7 kt $CO_{2\text{-e}}$) and carbonate digestion in the processing circuit (13 kt $CO_{2\text{-e}}$).

Further detail on this equipment is provided in **Section 3.5**.

Table 6-12: Infrastructure and ancillary equipment power consumption

Equipment	Average annual energy consumption (MWh) rounded
Primary fans	11,800
Refrigeration	3,400
Secondary fans	5,700
Main pumps	4,600
Face pumps	50
Compressor	600
Jumbo	700
Cable bolter	80
Production drill	800
Tailings dewatering plant	4,400
Backfill plant	4,400

The power requirement for the Project will increase incrementally over time with the commissioning of infrastructure such as ventilation fans and refrigeration units. As a consequence, the final power requirement will range from approximately 4 MW to 8 MW.[19] The annual average electrical load for both underground and surface infrastructure will be approximately 5.0 MW (refer **Table 6-13**).

In addition, the need for refrigeration is dependent on the influence of seasonal fluctuations in temperature and humidity. Consequently, annual power demand will vary in response to the need for refrigeration.

Table 6-13: Annual average power demand and diesel consumption for the Project

Project year	2016	2017	2018	2019	2020	Average
Annual average power demand (MW)	4.9	5.1	5.1	5	4.8	5.0
Diesel (ML/year) (rounded)	11	11	11	11	11	11

[19] The power requirement for the underground mine will increase as the mine is extended and additional ventilation fans and refrigeration plants are commissioned. This wide band is due to both the mining operations being intermittent and limited refrigeration requirements over the cooler months during the dry season (May – October).

The Project will be developed with mining equipment such as loaders and trucks and a range of ancillary equipment. The equipment inventory, fuel consumption and associated greenhouse emissions are presented in **Table 6-14**. For further information on the equipment associated with mine development refer to **Section 3.3.4**.

Table 6-14: Ancillary mine equipment, fuel consumption and greenhouse gas emission

Equipment	Annual average diesel fuel consumption (kL/unit) rounded	Total Project diesel fuel consumption (kL) rounded	Annual $CO_{2\text{-}e}$ (kt) (per unit)	Total $CO_{2\text{-}e}$ (kt)
Haul truck	1,500	7,700	4.1	21
Loader	930	4,700	2.5	13
Jumbo	30	150	0.1	0.4
Production drill	10	60	0.03	0.2
Cable bolter	10	50	0.03	0.1
Shotcreter	20	110	0.1	0.3
Agitator	240	1,200	0.6	3
Charge up	40	200	0.1	1
IT vehicle	160	800	0.4	2
Grader	90	430	0.2	1
Light vehicle	20	110	0.1	0.3
Water truck	100	510	0.3	1
Total (rounded)	–	**16,000**	**-**	**42**

All other sources of energy demand are similar to those that are currently utilised and will continue to be required without the Project. These include the ore sorter and crushing, grinding and milling circuit as well as the brine concentrator water treatment plant. This equipment is described in greater detail in **Section 2.6**.

The incremental Project specific sources of energy demand and greenhouse gas emissions are presented in **Figure 6-6** and **Figure 6-7** respectively.

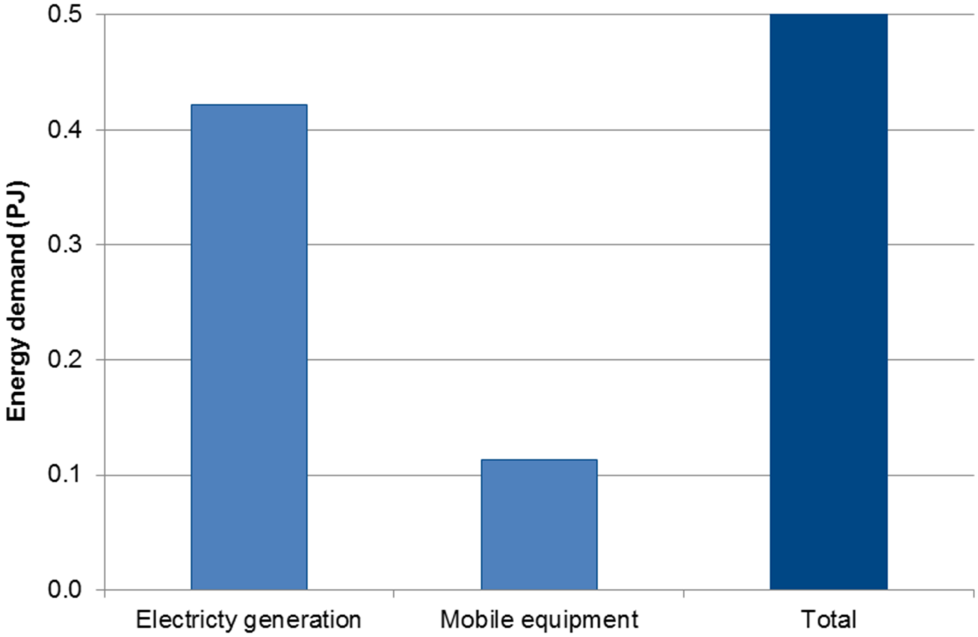

Figure 6-6: Energy sources and average Project energy demand

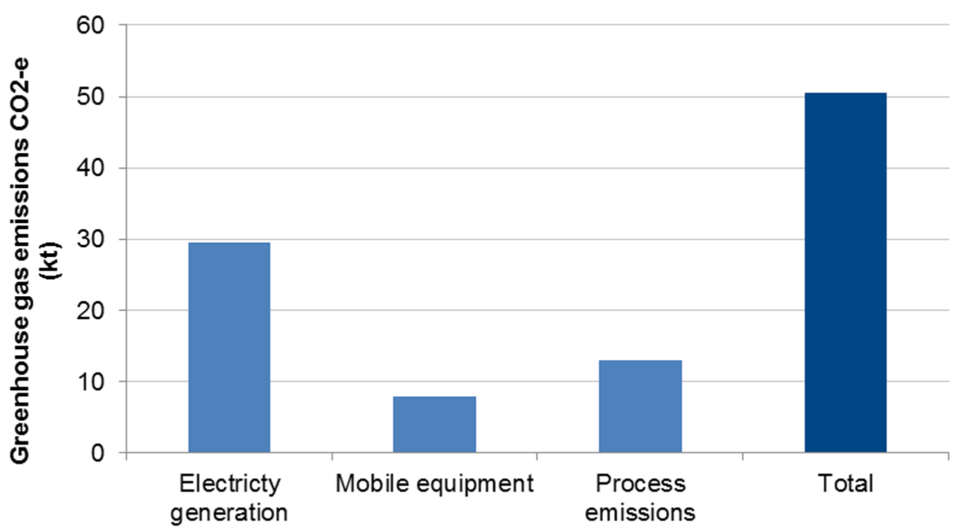

Figure 6-7: Greenhouse gas emission sources and average Project greenhouse gas emissions

6.5.8.3 Cumulative Impact

The forecast annual cumulative energy demand and greenhouse gas emissions for existing operations and with the Project is identified in **Figure 6-8** and **Figure 6-9** respectively. The average annual cumulative energy demand and greenhouse gas emissions are 2.3 PJ and 176 kt CO_{2-e} respectively. A significant source of future energy demand without the Project is associated with operating the brine concentrator water treatment plant.

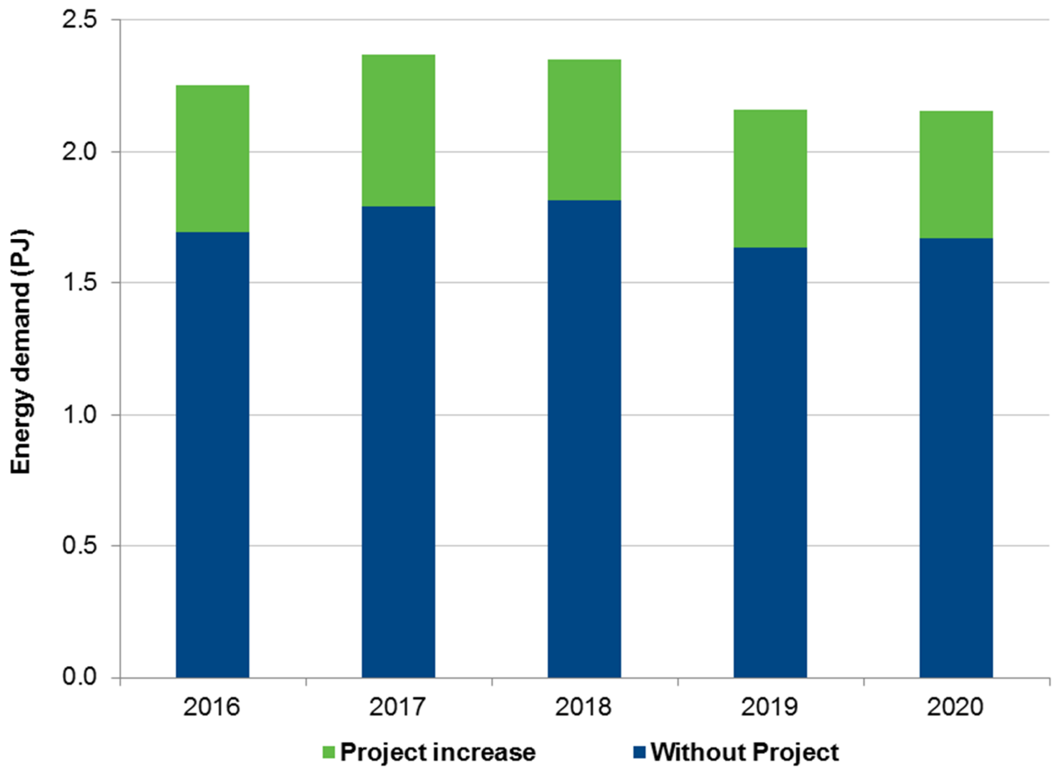

Figure 6-8: Annual cumulative energy demand

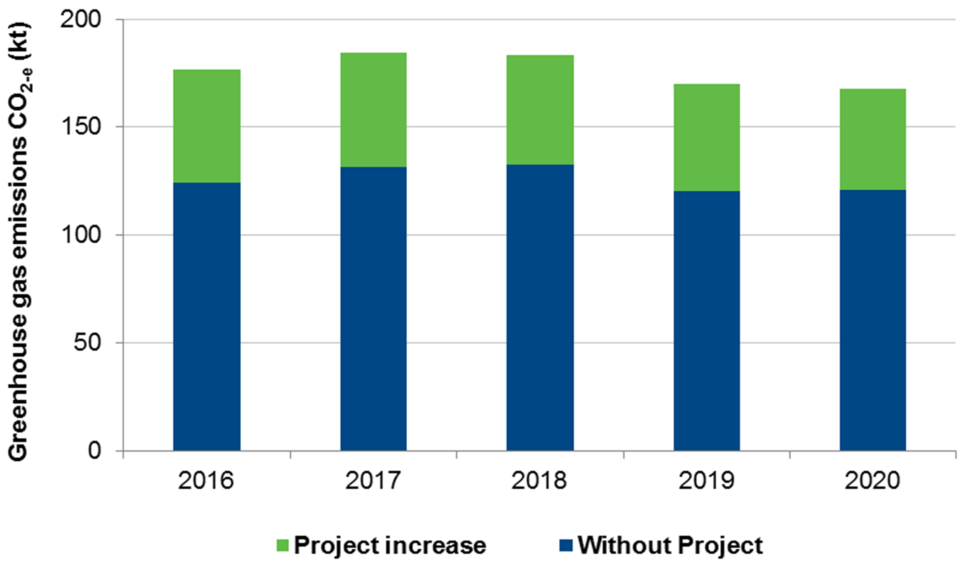

Figure 6-9: Annual cumulative greenhouse gas emissions

6.5.9 Mitigation

The following mitigation measures address risks TC1-01 and TD5-01; where increases in carbonate digestion within the processing circuit result in additional greenhouse gas emissions, and the risk that greenhouse gas emissions may impact the Earth's atmosphere, respectively:

- Additional greenhouse gas emissions will be associated with the Project. To limit these emissions, the existing ore sorter will reduce the contribution of carbonated material into the processing circuit. This will mitigate the potential for increased carbonate digestion and subsequent generation of greenhouse emissions (refer to **Section 3.4.1**); and
- The Project power plant will be integrated with the power plant supplying electricity to the brine concentrator water treatment plant. This will reduce the number of power generators that need to be installed for the Project and optimise energy usage overall, (refer to **Section 3.5.3.3**).

6.5.10 Lifecycle Greenhouse Gas Emissions

The Project will produce uranium oxide as a raw material to fuel nuclear power stations in the generation of base load electricity.

Each method of electricity generation[20] produces greenhouse gas emissions in varying quantities through construction, operation and decommissioning. Accounting for emissions

[20] These electricity generating methods include nuclear, coal, natural gas, oil, solar photovoltaic, biomass, hydroelectric, and wind.

from all phases of the Project (construction, operation, and decommissioning) is referred to as the 'lifecycle approach'.

To enable a fair comparison of lifecycle greenhouse gas emissions, alternative electrical generation is compared on a per gigawatt hour basis with the lower the value, the less greenhouse gas emissions emitted. Using this comparative measure, greenhouse gas emissions of nuclear power plants are among the lowest of any electricity generation method. On a lifecycle basis, nuclear power plants are comparable to wind, hydro-electricity and biomass (WNA 2011).

6.5.11 Summary

The assessment of risks to greenhouse gas assumes that all the mitigation measures, e.g. controls and treatments, are demonstrably feasible and implemented successfully. The main mitigation measures include:

- Use of the ore sorter to effectively limit the introduction of carbonate material into the processing circuit and consequently limit greenhouse gas production and emission; and
- Power generation operational regime, where the Project power generating infrastructure will be integrated with existing power generation which will optimise diesel consumption and therefore reduce greenhouse emissions.

No inherent or residual Class II, III or IV risks were identified for greenhouse gas emissions. Two Class I risks (inherent and residual) were associated with greenhouse gas emissions (TC1-01 and TD7-01):

- TC1-01, e.g. increases in carbonate digestion within the processing circuit result in additional greenhouse gas emissions; and
- TD7-01, e.g. greenhouse gas emissions and their contribution to existing greenhouse gases contained within the Earth's atmosphere.

Forecast greenhouse gas emissions associated with diesel consumption and carbonate digestion have been calculated using national greenhouse gas and energy measurement methods. Relevant sources of energy consumption and greenhouse gas emissions have been considered in this assessment.

The Project will require energy which is derived almost exclusively from diesel combustion which generates greenhouse gas. The incremental Project increase in energy demand and greenhouse gas emissions is associated with electricity generation, mobile mining equipment and processing.

Regardless of whether the Project proceeds or not, all other sources of Ranger mine energy demand and resultant greenhouse gas emissions will continue to operate over the intended timeframe of the Project.

6.6 NOISE ASSESSMENT

6.6.1 Context

Noise at the Ranger mine has historically been associated with open cut mining and the processing of ore extracted from these deposits. Predominant noise sources associated with these activities consisted of blasting, heavy vehicle movements and the operation of processing and power generation infrastructure.

This section outlines existing and Project noise sources, and associated noise and vibration emissions. Using this data, predicted cumulative emissions and their relevance to established criteria at defined receptor locations are discussed.

ERA sought external expertise from SLR Pty Ltd to undertake the Project noise and vibration assessment. This report is appended to the draft EIS as **Appendix 7** and includes detailed methods and results which have been summarised within this chapter.

The noise and vibration assessment consisted of the following key activities:

- Update the 2010 Ranger mine noise model incorporating additional existing infrastructure;
- Run the updated noise model to establish the current baseline noise profile;
- Run existing and Project model
- Assess potential impact to relevant public noise sensitive receptors using established noise criteria;
- Assess potential impact to native fauna at nearby ecologically sensitive receptors using nominated noise criteria; and
- Assess potential impacts of vibration at culturally sensitive receptors.

6.6.2 Noise Emission Sources

6.6.2.1 Current Operation

With the cessation of open cut mining in November 2012, heavy mining vehicles have been engaged in transferring waste rock back into Pit 3 and stockpiled ore to the existing processing plant.

At the time the Project is anticipated to commence, the noise and vibration profile will differ to that of previous Ranger mine operations. While heavy vehicle operation will continue in support of both surface and underground material movement, there will be a hiatus with regard to Pit 3 rock backfill.[21] In addition, there is no longer a need for blast activities on the Ranger mine surface. Current noise emissions are identified in **Section 6.6.5.1**.

The full inventory of significant plant and equipment associated with the current Ranger mine is presented in **Appendix 7**.

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[21] During this period tailings will be transferred to Pit 3.

6.6.2.2 Project Construction

Sources of noise associated with the Project construction phase include the installation of ventilation shafts[22] and associated surface infrastructure. This will involve the preparation of the site, drilling of the shaft and the installation of stack and fan assembly. The installation of other surface infrastructure such as the backfill plant, refrigeration units, and power plant are not significant noise sources as much of this infrastructure will arrive at site pre-assembled, and are located within the operational area and thus further from receptor locations. Underground development is associated with the operational phase. Further information on the construction program is provided in **Section 3.5**.

6.6.2.3 Project Operation

During the Projects operational phase, the main noise sources will include ventilation fans, refrigeration units, backfill plant, crushing and screening plant, power generation and material movement. Noise impacts associated with underground equipment will not be discernible at the surface.

The complete list of acoustically significant plant and equipment is provided in **Appendix 7**. Additional information concerning this equipment and the relative location is given in **Section 3.5**.

6.6.3 Assessment Approach

All acoustically significant infrastructure and mobile equipment were considered in both construction and operational phases to determine and assess predicted noise levels associated with the Project.

Establishing both the current Ranger mine noise profile and that of the Project is an integral component of the cumulative noise assessment. Noise modelling of the Project was conducted using the Conservation of Clean Air and Water Europe prediction method (Manning 1981). This method uses algorithms that are incorporated in the 'SoundPlan' noise modelling software. This prediction method is specially designed for large industrial facilities and incorporates the influence of distance, topography, ground and air absorption, and atmospheric conditions on noise propagation in the environment.

The modelling process has utilised the 2010 Ranger mine noise model developed by SLR Pty Ltd. This has been updated to reflect current operational infrastructure and activities at the Ranger mine. To calibrate the updated noise model, a noise survey was undertaken in December 2013 and January 2014 within the operational area and at defined receptor locations. This noise model has been modified to include the plant and equipment associated with the construction and operation of the Project.

The Ranger mine noise model uses three dimensional digital terrain maps of all relevant topographic information, together with noise source data, ground type, shielding such as barriers and/or adjacent buildings and atmospheric information to predict noise levels in the vicinity of Ranger mine.

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[22] To provide a conservative assessment of noise associated with this activity, it has been assumed that this construction is occurring concurrently.

In addition to the effect of terrain, the model considers acoustically relevant meteorological conditions such as atmospheric stability, wind speed and direction. In particular, wind has the potential to increase noise at a receiver when it is light and stable and blows from the direction of the noise source. As the wind strengthens, it increases ambient noise levels by rustling surrounding vegetation and creates turbulence when passing around and over structures. As such, at higher wind speeds, the noise produced will obscure noise from industrial sources. To provide a conservative approach, noise modelling has been conducted under acoustically adverse meteorological conditions, assuming a light and stable wind is blowing from the source to the receiver at 3 m/s.

6.6.4 Assessment of Risk

Of the 80 risks identified in the environmental risk assessment there were no current (inherent) or residual Class IV (critical) risk ratings for noise. A comparison of the current and residual risk profile shows that there is one noise risk (TA3-02) which has been reduced from a current Class III (high) risk to a Class II (moderate) risk. The impact associated with risk TA3-02 is discussed in **Section 6.6.5**. The significance of this risk to cultural heritage is discussed in **Section 10.4.2**.**1**.

A description of the risk assessment method is provided in **Chapter 5**. Additional discussion of the risks associated with the Project is provided in **Appendix 5**.

6.6.5 Potential Impact

This section relates to risk TA3-02 and the potential for Project infrastructure to generate noise levels that are incompatible with traditional lifestyle, public amenity, and fauna.

Receptors of relevance to the assessment of potential noise impacts were identified in **Section 6.2**

6.6.5.1 Existing Impact

The predicted maximum operating noise contours for current operations are presented in **Appendix 7**. These predictions are correlated closely with measured values at the nearest residential receptors (Ranger mine village) and ecological receptors (Georgetown Billabong and RP1) as identified in **Table 6-15**.

Table 6-15: Predicted and measured existing operational noise levels

Receptor location	**Predicted noise level LAeq (15minute) (dBA)**		**Measured noise level[2] (LAeq (15minute) (dBA))**
	Calm	Worst case[1]	Calm
Ranger mine village	<30	35	<34
Georgetown Billabong	41	45	40
RP1	42	46	44

1 Where wind speed is 3 m/s and moving in the direction of the receiver
2 At the time measurements were taken conditions were calm

6.6.5.2 Construction Impact (Residential)

The main construction activities consist of installing ventilation shafts and associated surface infrastructure. These activities are described in greater detail in **Section 3.5.2.4**. Underground development is not relevant to the noise assessment, as the depth at which these activities occur will not produce discernible noise emissions at the surface.

Construction noise modelling has assumed that the construction of the ventilation shafts will occur concurrently to provide a conservative assessment approach. Therefore, as this construction activity is anticipated to occur in different time periods, actual noise levels will be lower than predicted.

Predicted noise levels are well below the Project construction noise criteria at all residential and public receptor locations, and during all times of the day (**Table 6-16**).

Table 6-16: Predicted construction noise levels at public receptors (residential and commercial)

Location	**Period**	**Predicted noise level LAeq(15minute)(dBA)**		**Construction noise criteria (dBA)**	
		Calm winds	**Worst case[1] source to receiver winds**	**Noise affected (daytime, evening and night time)**	**Highly noise affected (day only)**
Residential and public receptors	All periods (daytime, evening and night time)	<30	<30	40/35/35	75
		<30	<30		

1 Where wind speed is 3 m/s and moving in the direction of the receiver

6.6.5.3 Construction Impact (Fauna)

The predicted noise levels at ecological receptors associated with construction activities[23] are provided in **Table 6-17**. This is presented graphically in **Figure 6-10** relative to defined disturbance criteria[24] for steady or continuous noise sources presented previously in **Table 6-6** and **Table 6-7** (refer **Section 6.3.2**).

Table 6-17: Predicted construction noise levels at ecological receptors

Receptor	Period	Predicted noise level LAeq(15minute) (dBA)	Disturbance effect criteria[2] LAeq(15 min) (dBA) Steady or continuous noise sources	
		Worst case (source to receiver winds[1])	Occasional	Frequent
Georgetown Billabong	All periods (daytime, evening and night)	49	50-65	65-85
RP1		32		
Magela Creek (closest point)		58		

1 Where wind speed is 3 metres per second and moving in the direction of the receiver
2 Steady or continuous noise sources

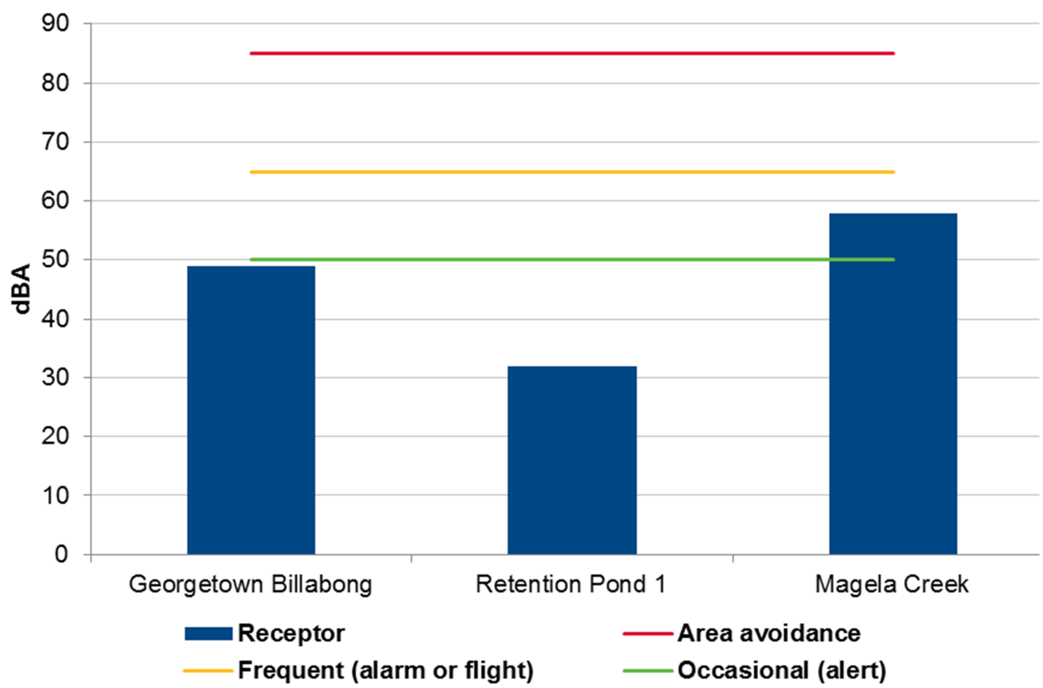

Figure 6-10: Predicted construction noise levels at ecological receptors

23 This does not include existing noise sources.

24 The criteria have been presented at the lower, more conservative end of the range presented in **Table 6-6.**

Construction of the ventilation shafts may result in the modified behaviour of some fauna that inhabit defined ecological receptors. During the initial stages of construction involving earthworks and drilling, general impacts may include the following:

- likely changes in species composition near the construction work areas but limited in extent. Less noise tolerant species may choose to temporarily relocate;
- selection for more noise tolerant individuals within the populations of species in close proximity to the work areas; and
- habituation of some species and individuals to noise impacts as currently displayed by some species.

Generally, terrestrial fauna will avoid areas associated with noise levels capable of resulting in physical impact.[25] However, even in close proximity, the construction and operation of the Project does not involve equipment or activities that generate these noise levels, and therefore risk of physical injury is negligible.

6.6.5.4 Cumulative Operational Impact (Residential)

The predicted existing and cumulative noise levels at public receptors (residential and commercial) is presented in **Table 6-18**. The incremental increase in noise level at the nearest public noise sensitive receptors is negligible (less than 1 dBA). The operational noise contours for all receptor types are provided in **Figure 6-11**.

Table 6-18: Predicted operational noise levels at public receptors (residential and commercial)

Receptor	Period	Predicted noise level LAeq(15minute) (dBA)				Project noise criteria LAeq(15minute) (dBA)
		Existing		Cumulative (existing and Project)		
		Calm winds	Worst case[1] source to receiver winds	Calm winds	Worst case[1] source to receiver winds	
Ranger mine village contractor camp	All periods (daytime, evening and night time)	<30	<30	<30	35	35
Public receptors		<30	<30	<30	<30	

[1] Where wind speed is 3 m/s and moving in the direction of the receiver

[25] It is anticipated that noise levels in excess of 100 dBA over extensive periods are required to result in injury or damage.

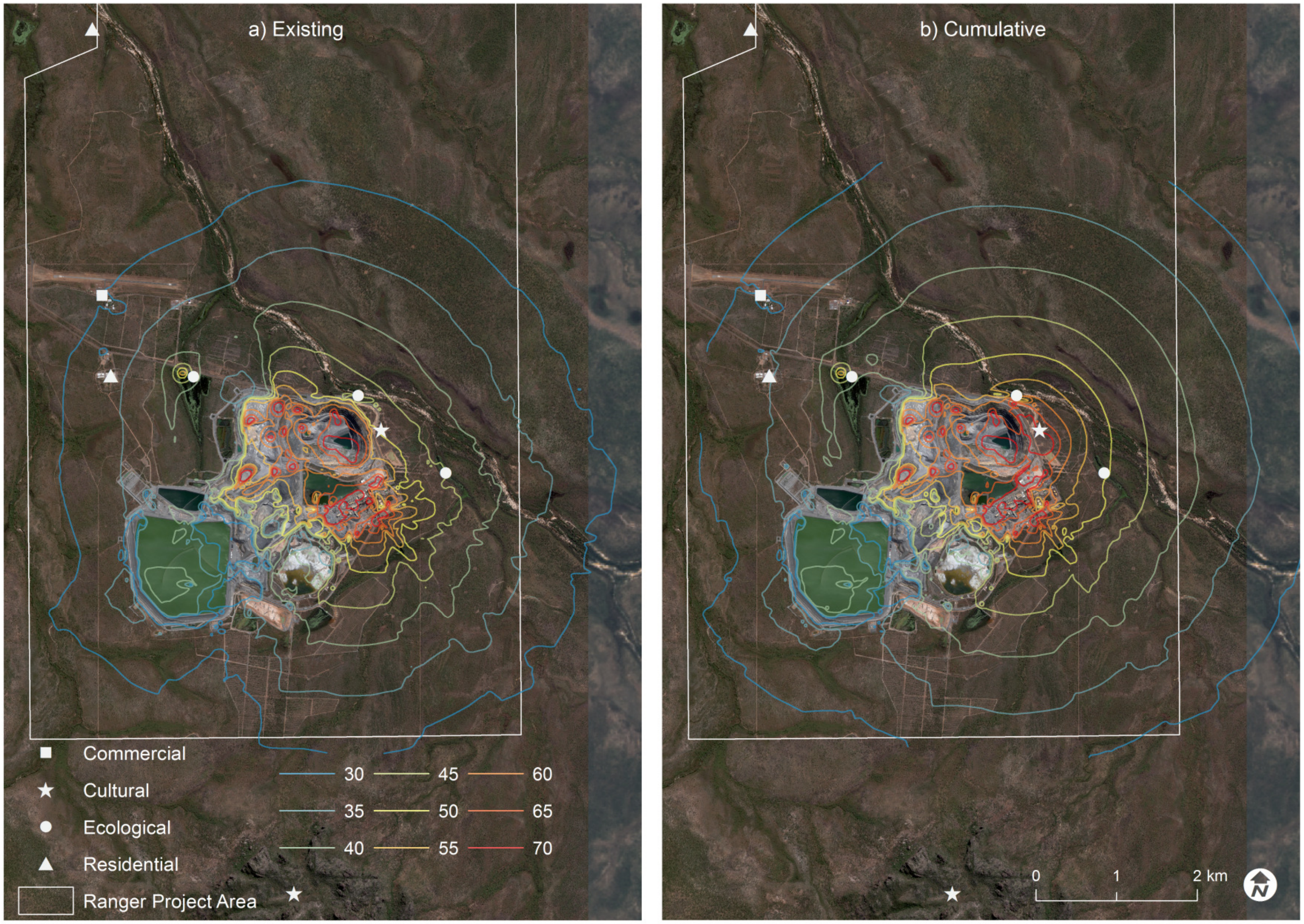

Figure 6-11: Operational noise contours (dBA)

6.6.5.5 Cumulative Operational Impact (Fauna)

The potential effects of noise on terrestrial fauna include physical damage to hearing organs, increased energy expenditure or physical injury while responding to noise, interference with normal activities, and impaired communication. The ongoing impacts of these effects may include habitat loss through avoidance, reduced reproductive success and increased mortality (Goosem*, et al.* 2007, Manci*, et al.* 1988).

Following the construction phase of the Project, the main noise source adjacent to defined ecological receptors are the ventilation fans. These are generally steady state or continuous noise sources. Episodic noise sources are unlikely to change from those associated with existing Ranger operations.

There are a number of considerations with respect to noise disturbances which would result from Project operation, including:

- The types of noise emitted – continuous noise (for example, ventilation fans and generators) and episodic or short duration and/or intermittent noise (for example, mobile plant during construction works);
- The types of fauna response elicited – ranging from the masking of calls, to a scale of responses from alert to avoidance (or abandonment) of habitats;
- Variations in the responses of different species, and even of individuals within a single species, to different noise disturbances; and
- The relationship between noise disturbances and bird activities.

The predicted operational noise levels at ecological receptors are provided in **Table 6-19.**

These same data is presented graphically in **Figure 6-12** relative to defined noise disturbance criteria[26] for steady or continuous noise sources presented previously in **Table 6-6** and **Table 6-7** (refer **Section 6.3.2**).

The areas of occasional alert and frequent alarm or flight disturbance associated with existing operations and combined with the Project are illustrated in **Figure 6-13**. The Project is predicted to increase the area exposed to noise levels above the occasional and frequent disturbance criteria to the north east of the Ranger mine site. The area experiencing noise levels above the occasional noise disturbance criteria and the frequent noise disturbance criteria is predicted to increase by approximately 182 ha and 39 ha respectively. It is likely that noise sensitive species will relocate, from the (latter) immediate zone to lower noise areas.

[26] The criteria have been presented at the lower, more conservative end of the range provided in **Table 6-6**.

Table 6-19: Predicted operational noise levels at ecological receptors

Receptor	Period	Predicted noise level LAeq(15minute) (dBA)			Disturbance effect criteria LAeq(15 min) (dBA) Steady or continuous noise sources	
		Existing	Cumulative	Incremental Project increase	Occasional	Frequent
Georgetown Billabong	All periods (daytime, evening and night)	45	51	6	50 – 65	65 - 85
Retention Pond 1		43	43	0		
Magela Creek (closest point)		45	58	13		

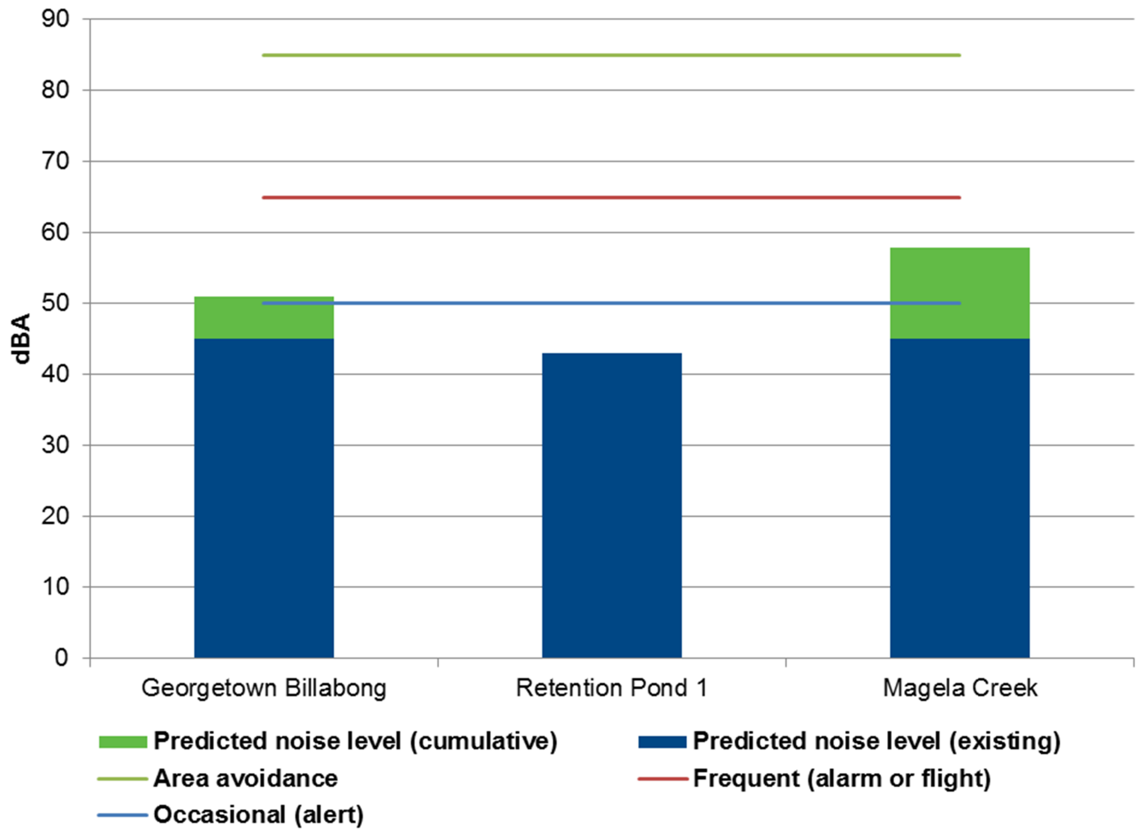

Figure 6-12: Predicted operational noise levels at ecological receptors

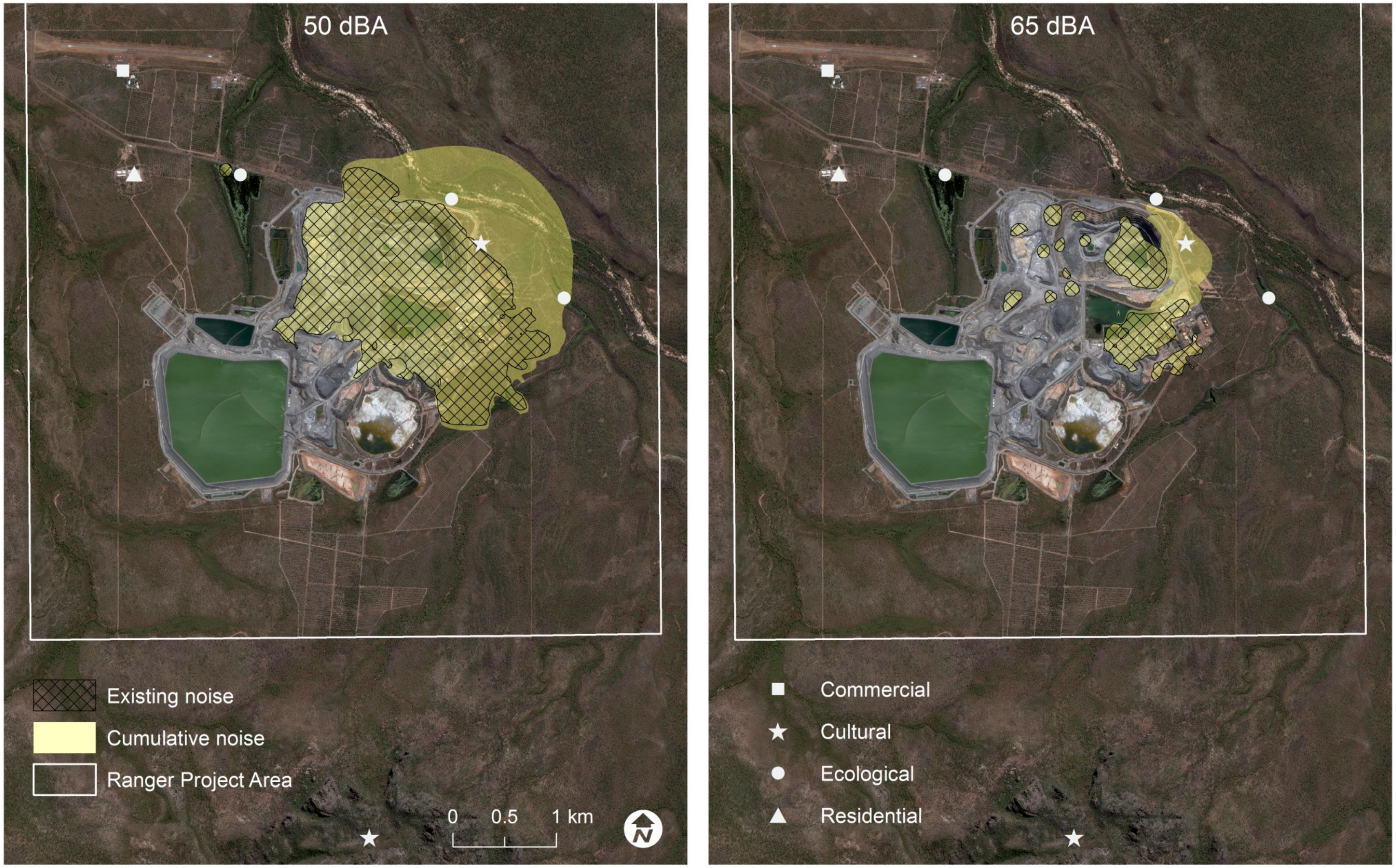

Figure 6-13: Occasional alert zone (50 dBA) and frequent alarm or flight zone (65 dBA)

6.6.6 Mitigation

Additional treatments identified include the installation of noise attenuation in selected exhaust fans in addition to purchasing equipment such as refrigeration plants and compressors with pre-installed noise suppression technology. These controls have reduced the TA3-02 from a Class III to a Class II risk ranking.

Mitigation measures to address risk TA3-02; where project infrastructure may generate noise levels that are incompatible with traditional lifestyle, public amenity, and/or fauna are discussed in **Chapter 10**.

6.6.7 Summary

The assessment of noise risks assumes that all the mitigation measures, e.g. controls and treatments, are demonstrably feasible and implemented successfully.

Relevant residential, cultural and ecological receptors were considered in the noise impact assessment. Using appropriate noise criteria, noise modelling has taken a conservative approach to predicting noise emissions and potential impact at defined receptors.

The predicted noise level increase at the nearest affected residential and public receptors associated with the construction and operation of the Project is insignificant (<1 dBA) and therefore any potential noise impacts are considered negligible.

The predicted cumulative noise levels associated with existing operations along with Project specific infrastructure are at or below the operational Project specific noise criteria at all public receptor locations.

An incremental increase in noise levels is predicted at both Georgetown Billabong and Magela Creek ecological receptors. In combination with existing noise levels, the occasional fauna disturbance noise criteria of 50 dBA will be exceeded, but noise levels will remain below the frequent fauna noise disturbance criteria of 65 dBA. Therefore, within the immediate vicinity of the Project, there will be a minor to moderate impact on habitat use for most species.

Based on the outcomes of the noise impact assessment, significant sources of noise associated with the Project will have noise attenuation integrated into their design. This reduces the inherent risk ranking from Class III to Class II, for risks to amenity and traditional lifestyle, and Class I, for risks to flora and fauna.

6.7 VIBRATION ASSESSMENT

6.7.1 Context

The main activities that have the potential to cause surface vibration are associated with construction of the ventilation shafts and underground blast activities. This section outlines the vibration modelling approach and the outcomes of the vibration assessment.

6.7.2 Vibration Sources

6.7.2.1 Project Construction

Activities that may produce vibration during construction are associated with the operation of mobile equipment and drilling the ventilation raises. No blast related activity is required for establishing the ventilation raises. For further information on the construction of the ventilation raises refer to **Section 3.5.2.4**.

6.7.2.2 Project Operation

Relevant sources of vibration during the operational phase are associated with both light and heavy vehicle movement. As with potential noise arising from underground development, blast activity will not produce surface vibration that is discernible above background levels. Notwithstanding this, underground blast activity has been modelled and assessed.

6.7.3 Assessment Approach

In 2009, a ground vibration prediction method was established at Ranger mine. This method established the relationship between the maximum instantaneous explosive charge at the blast source, and resultant vibration received over distance known as a 'site law' (Heggies 2010).

Site law formulas provide specific relationships between the level of blast emissions and scaled distance. The assessment of blast emissions involves the statistical analysis of large amounts of recorded blast events in order to develop a site specific relationship between scaled distance and instantaneous explosive charge mass. As the site law was prepared for open pit operations involving larger instantaneous explosive charge mass, applying the 2009 site law to predicted vibration from underground blast activity is a conservative approach.

6.7.4 Assessment of Risk

Of the 80 risks identified in the environmental risk assessment there are no current (inherent) or residual Class IV (critical) risks for vibration. A comparison of the current and residual risk profile shows that there is one vibration risk (TB2-03) which has been reduced from a current Class III (high) risk to a Class II (moderate) risk. Potential impact associated with TB2-03 is discussed in **Section 6.7.5**. The significance of this risk to cultural heritage is discussed in **Section 10.4.2.3**.

A description of the risk assessment method is provided in **Chapter 5**. Additional discussion of the risks associated with the Project is provided in **Appendix 5**.

6.7.5 Potential Impact

A vibration monitoring program has been established to provide empirical data on existing operations. The location of each monitoring site is provided in **Figure 6-14**.[27] Measurements

27 At the request of Traditional Owners, the location of one vibration monitor is not identified in this image.

at these sites have recorded vibrations from both surface (Pit 3 open pit mine) and underground blast activity associated with the existing exploration decline.

Due to the depth associated with advancing the decline development,[28] measured surface vibration has not been discernible above existing background vibration. Consequently, using the Ranger mine ground vibration site method to predict vibration from underground blasting provides a conservative method, i.e. an over-estimate.

Figure 6-14: Vibration monitoring sites

28 The minimum vertical distance between the existing exploration decline development and the R34 cultural heritage receptor was 130 m.

6.7.5.1 Construction

Vibration associated with construction equipment diminishes with distance from the source. The minimum separation distance between surface construction operations associated with the establishment of Exhaust 3 (refer **Figure 6-2**) and the nearest cultural receptor (R34) is around 100 m. Using the fore mentioned site vibration method, it is predicted that vibration levels at this location will not be detectable. Therefore, a similar outcome is predicted at more distant receptors.

6.7.5.2 Operation

At the depth[29] and location at which mining will occur, blast induced vibration during operations will be small. The level of vibration predicted as a result of both stope and mine access and ore-body stope development[30] at the closest cultural and residential receptors is provided in **Table 6-20**. Ground level vibration is well below the relevant site specific vibration criteria at each of these locations. Therefore, blast vibration at surface is considered negligible. Furthermore, this vibration is derived from upper mine working levels closest to surface.

Table 6-20: Predicted receptor vibration

Receptor	Approximate distance to closest blast source (m)	Vibration criteria (mm/s)	Predicted vibration (mm/s)	
			Mine development	Stope
R34	340	80	0.9	4.5
Mount Brockman	4,500	40	0	0.1
Tree Snake Dreaming	1,500	N/A	0.1	0.4
Ranger mine village (contractor camp)	3,500	5	0	0.1

6.7.6 Mitigation

A risk has been identified where underground blasting and general underground mining activities produce vibration with the potential to destabilise the Pit 3 walls causing damage to R34 (TB2-02). ERA continues to monitor the pit wall stability during the backfill of the lower section of the pit with 30 million tonnes of waste rock. The backfill is effectively buttressing the Pit 3 wall. While the likelihood of TB2-02 eventuating has been assessed as rare, additional treatments have been identified. These consist of blast design and adopting a safety margin between Pit 3 and the stoping areas. These treatments in combination with the fore mentioned buttressing will significantly reduce the risk of impact to nearby cultural heritage sites from vibration associated with underground mining.

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29 The closest underground stope development to the R34 cultural heritage receptor is around 345 m.

30 Explosives characteristics are larger with ore body stope development than is required to generally develop mine access tunnels.

The following mitigations address risk TB2-03 where vibration from underground mining may impact on cultural sites of significance. Risk mitigation measures associated with TB2-03 is discussed in **Chapter 10**.

6.7.7 Summary

The assessment of risks associated with vibration assumes that all the mitigation measures, e.g. controls and treatments, are demonstrably feasible and implemented successfully.

Residential and cultural receptors were considered in the vibration impact assessment. Using appropriate vibration criteria, surface vibration associated with ventilation raise construction and underground blast operations are predicted to be minor at all receptor locations.

These predictions will be validated by undertaking a surface vibration monitoring program at relevant locations over the early phase of mine development, beyond which vibration will become increasingly undetectable by surface instruments.

The risk that vibration from underground mining may impact cultural heritage sites of significance had an inherent Class III risk ranking. However, surface vibration became undetectable once the exploration decline reached a depth of approximately 90 m (and the Ranger 3 Deeps mine will be developed at greater depths). Therefore, the original risk is no longer credible, resulting in a residual risk ranking of Class II.

6.8 REFERENCES

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