Project done on Behalf of

Aurecon South Africa (Pty) Ltd and SLR Consulting (Africa) (Pty) Ltd

Noise Impact Assessment for the Proposed Mining of the Rössing Uranium Ltd Z20 Uranium Deposit

Scoping and Infrastructure Corridor Assessment Report

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Prepared by: N Krause

Airshed Planning Professionals (Pty) Ltd

P O Box 5260
Halfway House
1685

Tel : +27 (0)11 805 1940
Fax : +27 (0)11 805 7010
e-mail : mail@airshed.co.za

Report Details

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Prepared by	Nicolette Krause, BEng Hons (Mech) (University of Pretoria)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
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Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
Aurecon	Aurecon South Africa (Pty) Ltd
dB	Decibels
EHS	Environmental, Health and Safety
SEIA	Social and Environmental Impact Assessment
Hz	Hertz
IFC	International Finance Organisation
ISO	International Organisation for Standards
L_p	The sound pressure level in dB
L_W	Sound power level in dB
kW	kilo Watt
p	The actual sound pressure in Pa
p_{ref}	The reference sound pressure (p_{ref} in air is 20 µPa)
RUL	Rössing Uranium Ltd
SANS	South African National Standards
SLR	SLR Consulting (Africa) (Pty) Ltd
WBG	World Bank Group
WHO	World Health Organisation
Δ	The increase in noise level

Note: All acoustic terminology are discussed in detail in Section 2.1

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Aurecon South Africa (Pty) Ltd (Aurecon) and SLR Consulting (Africa) (Pty) Ltd (SLR) to undertake a Noise Impact Assessment as part of the Social and Environmental Impact Assessment (SEIA) for the Rössing Uranium Ltd Z20 Project.

The study included a baseline noise assessment as well as the assessment of noise impacts associated with the proposed infrastructure corridor that will connect the Z20 ore body to existing Rössing mining and processing activities. Construction and operational phase impacts were assessed. Decommissioning noise impacts were not quantified but are considered to be similar to construction phase impacts.

The main findings of the baseline assessment are as follows:

- The closest areas of residence (noise sensitive receptors) are Arandis Airport and the Khan Mine situated approximately 3 km and 4 km from proposed activities respectively. Visitors to the Khan River valley will also be affected.
- Changes in normal behavioural patterns are the most apparent effects of noise on wildlife will be the most noticeable for impact associated with the infrastructure corridor. When noise becomes an objectionable intrusion on wildlife habitats, these changes include alterations in habitat locations and migration patterns, and abnormal behaviour that can cause difficulty in mating and survival. Noise has the greatest effect on wildlife which relies on auditory signals for survival.
- Ground cover in the study area is considered ‘acoustically hard’ and reflective i.e. providing no noise attenuation.
- Even though the topography within the Khan Valley my serve as a natural acoustic barrier, it is possible that noise from the infrastructure within the valley, confined and bundled as it propagates down a valley, is intensified. The reflection of noise generated within the valley, specifically during the construction has been raised as a concern by farmers residing to the west of proposed operations.
- The prevailing wind field indicate that day-time noise impacts will most likely be most significant to north-east and night-time impacts to the south-west.
- An increase of 3 dB in ambient noise level is considered the indicator of noise impacts. This is the level at which individuals with average hearing acuity would be able to detect a change in noise level.
- Baseline day and night-time noise levels at noise sensitive receptors located on the plains of 45 dBA and 35 dBA respectively were calculated from available baseline noise data.
- A baseline day and night-time noise level of 30 dBA within the Khan River valley was reported.

The main findings of the impact assessment are as follows:

- A conservative approach was followed in the estimation of predicted noise impacts. Impacts were predicted for the day- and night-time hour during which noise impacts would be most significant.
- Construction and decommissioning phase noise impacts are likely to be similar.
- Within the Khan River valley, construction activities will be audible over long distances down the valley and may result in strong reaction from visitors to the valley, especially during helicopter operational times.
- The increase in noise level over reported baseline noise levels were:
  - For the construction phase, between 1.9 and 5 km during the day (day-time only).
  - For the operational phase:
    - Between 500 m and 2.5 km during the day; and
    - Between 1.4 km and 1.7 km during the night.
- The potential for cumulative noise impacts within the Khan River valley as a result of the Rössing Z20 Infrastructure Corridor and the Husab Linear Infrastructure exists and is qualitatively discussed. The Husab Linear Infrastructure crosses the Khan River approximately 3 km downstream of the Rössing Infrastructure Corridor. The Husab Linear Infrastructure noise assessment concluded that under the most unfavourable meteorological conditions, noise impacts may be expected up to 2.5 km from the road. Impact areas may therefor overlap and result in more significant impacts between the Husab Linear Infrastructure crossing and the Rössing Infrastructure Corridor crossing.
- The significance of cumulative noise impacts at noise sensitive receptors located on the plains to the north of the Khan River is “Very Low (-)”.
- The significance of cumulative noise impacts on visitors to Khan River valley close to the infrastructure corridor crossing is “Medium (-)” to “High (-)” due to very quiet surroundings.
- Overall, with noise mitigation and management measures in place, impacts may be reduced to range between “Very Low (-)” and “Medium (-)”.

Although impacts are considered very low, the following management and mitigations measures are recommended to minimise the potential for noise impacts from the project.

- Good Engineering Practice
  - All diesel powered equipment must be regularly maintained and kept at a high level of maintenance. This must particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment must serve as trigger for withdrawing it for maintenance.
  - To minimise noise generation, vendors can be required to guarantee optimised equipment design noise levels.

- During the planning and design stages of the project, possibly related noise aspects should always be kept in mind. The enclosure of major sources of noise, must be included in the design process, since they represent basic good engineering practice.
- Vibrating equipment is known to be noisy and good design philosophies should be followed for equipment of this nature. The mentioned equipment must be installed on vibration isolating mountings.
- By enclosing the tipper discharge and lowering conveyor drop height, noise emissions may be reduced. Mechanical and electrical design also influences the amount of noise from stacking and reclaiming operations.
- Re-locate noise sources to less sensitive areas to take advantage of distance and shielding.
- Site permanent facilities away from community areas if possible.
- Develop a mechanism to record and respond to complaints.

- It is recommended that, as far is as practicable, noise generating activities such as maintenance and construction, be limited to day-time hours (considered to be between 07:00 and 22:00) since noise impacts are often most significant during the night.
- Blasting related noise impacts can be mitigated by adhering to blast schedules that have been communicated to the affected parties as well as having evacuation procedures in place in the event of blasting. It is recommended that blasting be assessed in more detail as an addendum to this report once blast design detail becomes available.
- It is recommended that a noise management zone of be considered around the operations. This area should corresponds to the area over which noise levels may result in annoyance i.e. complaints and occasional community action. Complaints and noise levels in this area should be recorded and monitored and results communicated to interested and affected parties.
- It is likely that as activities within the Khan River valley increase, the number of visitors to the area where the infrastructure corridor crosses the valley will reduce. Tourism offsets should be considered to encourage overnight visitors to visit other, less impacted parts of the Khan River.
- Ambient noise measurements should be conducted during the construction and operational phases to assess and confirm the project's noise impact area. Specific attention should be paid to noise levels at Arandis, the Arandis airport, the Khan Mine and at noise sensitive receptors within the Khan River valley. Periodical noise measurements can also serve to assess the efficiency of implemented management and mitigation measures aimed at reducing noise impacts. Day and night-time sound pressure levels as well as 3rd octave band frequency spectra should be recorded. Blasting noise should also be monitored within the Khan River valley.

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1 Introduction

Rössing Uranium Limited (RUL) has operated an open pit uranium mine, north of the Khan River, in the Erongo Region of Namibia since 1976. Mining operations include the Rössing open pit, waste rock disposal, ore processing, tailings disposal and ancillary activities (Aurecon & SLR, 2012).

RUL is considering mining the Z20 ore body located south of the Khan River. It is envisaged that the project would include the mining of the Z20 ore body including disposal of waste rock; the production of sulfuric acid at Rössing; modifications to the processing plant; changes to the present Tailings Storage Facility; and the establishment of a new High Density Tailings Storage Facility on the Rössing Dome. In order to access the Z20 ore body, an infrastructure corridor across the Khan River is required to link the Z20 site to the existing Rössing Uranium Mine. This infrastructure corridor would facilitate the transport of crushed ore generated at the Z20 site to the existing Rössing Uranium facilities (Aurecon & SLR, 2012).

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Aurecon South Africa (Pty) Ltd (Aurecon) and SLR Consulting (Africa) (Pty) Ltd (SLR) to undertake the noise impact assessment for proposed operations. The study will form part of the Social and Environmental Impact Assessment in which a phased approach was adopted.

The first phase includes project scoping and the assessment of impacts associated with the construction and operation of the infrastructure corridor. The second phase will address social and environmental impacts associated with all other proposed operations i.e. mining of Z20, ore processing and waste disposal.

The focus of this report is project scoping and assessment of impacts associated with the construction and operation of the infrastructure corridor from an environmental noise perspective.

2 Approach to the Study

2.1 Noise Defined

As background to a noise impact study, the reader should take note of some definitions and conventions used in the measurement, calculation and assessment of environmental noise.

Noise is generally defined as unwanted sound transmitted through a compressible medium such as air. Sound in turn, is defined as any pressure variation that the ear can detect. Human response to noise is complex and highly variable as it is subjective rather than objective.

Noise is reported in decibels (dB). “dB” is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure. The relationship between sound pressure and sound pressure level is illustrated in Equation 1:

$$L_p = 20 \cdot \log_{10}\left(\frac{p}{p_{ref}}\right)$$

Equation 1

Where:

$\boldsymbol{L_p}$ *is the sound pressure level in dB;*

$\boldsymbol{p}$ *is the actual sound pressure in Pa; and*

$\boldsymbol{p_{ref}}$ *is the reference sound pressure (p_{ref} in air is 20 µPa)*

2.1.1 Perception of Sound

Sound has already been defined as any pressure variation that can be detected by the human ear. The number of pressure variations per second is referred to as the frequency of sound and is measured in hertz (Hz). The hearing of a young, healthy person ranges between 20 Hz and 20 000 Hz (20 kHz).

In terms of sound pressure level, audible sound ranges from the threshold of hearing at 0 dB to the pain threshold of 130 dB and above. Even though an increase in sound pressure level of 6 dB represents a doubling in sound pressure, an increase of 8 to 10 dB is required before the sound subjectively appears to be significantly louder. Similarly, the smallest perceptible change is about 1 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

2.1.2 Frequency Weighting

As human hearing is not equally sensitive to all frequencies, a 'filter' has been developed to simulate human hearing. The 'A-weighting' filter simulates the human hearing characteristic, which is less sensitive to sounds at low frequencies than at high frequencies. "dBA" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities, that have the same units (in this case sound pressure) that has been A-weighted.

2.1.3 Adding Sound Pressure Levels

Since sound pressure levels are logarithmic values, the sound pressure levels as a result of two or more sources cannot just simply be added together. To obtain the combined sound pressure level of a combination of sources such as those at an industrial plant, individual sound pressure levels must be converted to their linear values and added using Equation 2.

$$L_{p\_combined} = 10 \cdot \log\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + 10^{\frac{L_{p3}}{10}} + \cdots 10^{\frac{L_{pi}}{10}}\right)$$

Equation 2

This implies that if the difference between the sound pressure levels of two sources is nil the combined sound pressure level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound pressure levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

2.1.4 Environmental Noise Propagation

Many factors affect the propagation of noise from source to receiver. The most important of these are:

- The type of source and its sound power;
- The distance between the source and the receiver;
- The extent of atmospheric absorption (attenuation);
- Wind speed and direction;
- Temperature and temperature gradient;
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption;
- Reflections;
- Humidity; and

- Precipitation

To arrive at a representative result from either measurement or calculation, all these factors must be taken into account (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

2.1.5 Environmental Noise Indices

In assessing environmental noise either by measurement or calculation, reference is generally made to the following indices:

- **L_{PA}** – The A-weighted instantaneous sound pressure level.
- **L_{Aeq} (T)** – The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). The International Finance Corporation (IFC) provides guidance with respect to L_{Aeq} (1 hour), the A-weighted equivalent sound pressure level, averaged over 1 hour.
- **L_{AIeq} (T)** – The A-weighted impulse corrected equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).
- **L_{AZeq} (T)** – The un-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).
- **L_{A90}** – The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels.
- **L_{A10}** – The A-weighted 10% statistical noise level, i.e. the noise level that is exceeded during 10% of the measurement period.
- **L_{Amax}** – The maximum level generated from a single noise event.

2.2 Methodology

The project has the potential to cause environmental noise impacts. The main objective of the noise assessment is to provide an estimate of potential impacts from the proposed project on the surrounding environment. Based on the overall objective the following were included in the study:

- A review of local and international legislation and (or) guidelines pertaining to environmental noise impacts.
- The assessment of existing environmental noise levels vicinity of the project and proposed transport corridor as well as nearby residences and tourist destinations.
- A review of all available project documentation and information as well as other impact assessments conducted in the area.

- The identification and quantification of sources of environmental noise associated with the construction and operation of the transport corridor.
- The preparation of meteorological data and site specific acoustic parameters for use in the calculation of noise propagation.
- The calculation of noise propagation from the construction and operation of the transport corridor to noise sensitive receptors as well as zones of influence (buffer and management zones) through the application of a suitable noise propagation model.
- The evaluation of estimated noise impacts based on legislation and (or) guidelines.
- A review of mitigation measures pertaining to environmental noise management.
- The compilation of a noise scoping and transport corridor impact assessment report.

The assessment included a study of the legal requirements pertaining to noise impacts, a study of the physical environment of the area surrounding the project and the analyses of existing noise levels in the area. The impact assessment focused on the estimation of sound power levels (noise 'emissions') and sound pressure levels (noise impacts) associated with the construction and operation of the infrastructure corridor. The findings of the assessment components informed recommendations of management measures, including mitigation and monitoring. Individual aspects of the noise impact assessment methodology followed in the study are discussed in more detail below.

Extensive noise measurements and noise propagation modelling were conducted by DDA Environmental Engineers in association with J.H. Consulting for RUL in 2010. Additional baseline noise monitoring was not considered necessary for the proposed project. In determining the existing noise climate, extensive reference was made to the findings presented in the 2010 study. Noise studies conducted for Swakop Uranium's Husab Mine just south of the Khan River valley and associated linear infrastructure (Stobart, 2011) was also referred to.

Sound power levels (noise "emissions") from activities associated with the infrastructure corridor were estimated based on source data provided by Aurecon and SLR, sound power level predictions for industrial machinery as published in the 'Handbook of Acoustics' (Crocker, 1998) and SANS 10210, 'Calculating and predicting road traffic noise' (SANS 10210, 2004). Reference was also made to general sound power data obtained from Francois Malherbe Acoustic Consulting cc and air transport related noise levels published by Nelson (1987).

The propagation of noise from proposed operations was calculated according to 'The calculation of sound propagation by the Concawe method' (SANS 10357, 2004). The Concawe method makes use of the International Organisation for Standardization's (ISO) air absorption parameters and equations for noise attenuation as well as the factors for barriers and ground effects. In addition to the ISO method, the Concawe method facilitates the calculation of sound propagation under a variety of meteorological conditions. Average meteorological parameters obtained from modelled on-site data were applied in calculations.

Due to varying baseline noise levels, impacts at receptors/visitors on the plains north of the Khan River were assessed separately from receptors/visitors within the Khan River valley.

Predicted noise impacts were calculated both in terms of total ambient noise levels as a result of proposed operations as well as the effective increase in ambient noise levels. Impacts were assessed according to International Finance Corporation (IFC) ambient noise guidelines for residential areas. These guidelines refer to guidelines provided by the World Health Organisation (WHO) in their ‘Guidelines for Community Noise’.

3 Assumptions and Limitations

The following limitations and assumptions to the study should be noted:

- The assessment of blasting noise (air over pressure) needs a significant amount of blast design information. In the absence of this, blasting noise could not be quantified. It is however qualitatively described. Recommendations with regards to the quantification and mitigation of blast noise are however provided.
- No information regarding the construction of road was provided. Typical diesel mobile equipment used for road construction along with blasting and the use of impact breakers was assumed. Take note of blasting noise limitations.
- A conservative approach was followed in all aspects of the noise impact assessment. Results presented represent the worst case day and night-time hour of the day.
- No information was available to quantify decommissioning phase noise impacts. Noise generated during the decommissioning phase is however expected to be similar to that of the construction phase.
- RopeCon/RailCon and helicopter noise levels were back calculated from reported reference noise assuming cylindrical and spherical divergence.
- The frequency content of noise generated by the RopeCon/RailCon system was unknown.

4 Legislative Context

Prior to assessing the impact proposed operations on the surrounding area, reference needs to be made to the environmental regulations governing the impact of such operations i.e. ambient noise level guidelines.

Namibia has published regulations addressing hearing conservation at the work place. There are however no regulations concerning environmental noise and the nuisance that it may cause. The World Bank Group (WBG) IFC provides guidance on the assessment of noise impacts beyond the property boundaries of industrial facilities in its General Environmental, Health and Safety (EHS) Guidelines. In the absence of national ambient noise regulations, reference is made to the noise level guidelines published by the IFC. These guidelines are in line with those published by the WHO.

The IFC states that noise impacts should not exceed the levels presented in Table 4-1, or result in a maximum increase in background levels of 3 dBA at the nearest receptor location off-site (IFC, 2007).

Table 4-1: Noise level guidelines

Noise Level Guidelines (IFC, 2007)		
Area	**One Hour L_{Aeq} (dBA)** **07:00 to 22:00**	**One Hour L_{Aeq} (dBA)** **22:00 to 07:00**
Residential; institutional and educational receptors	55	45

In addition to the noise level guidelines specified by the IFC, reference is also made to noise assessment criteria employed in South Africa. The South African Bureau of Standards (SABS) provides a guideline for estimating community response to an increase in the general ambient noise level caused by intruding noise (SANS 10103, 2008). If Δ is the increase in noise level, the following community response can be expected:

- $\Delta \leq 0$ dBA: There will be no community reaction.
- 0 dBA $<\Delta\leq$ 10 dBA: There will be 'little' reaction with 'sporadic complaints'. For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. $\Delta = 3$ dBA is, therefore, a useful significance indicator for a noise impact.
- 5 dBA $<\Delta\leq$ 15 dBA: There will be a 'medium' reaction with 'widespread complaints'. $\Delta = 10$ dBA is subjectively perceived as a doubling in the loudness of the noise.

- 10 dBA $< \Delta \leq$ 20 dBA: There will be a ‘strong’ reaction with ‘threats of community action’.
- 15 dBA $> \Delta$: There will be a ‘very strong’ reaction with ‘vigorous community action’.

The categories of community response overlap because the response of a community does not occur as a stepwise function, but rather as a gradual change.

It should be noted that environmental noise impacts are focussed on the annoyance caused from a human perspective. A short description of the effects of noise on animals is provided in Appendix C.

5 The Effected Noise Environment

5.1 Locality and Distance to Communities

The Rössing Mine lies approximately 70 km inland from the coastal town of Swakopmund in Erongo Region of Namibia. The mine licence area (MLA) and accessory works area is bordered by the town of Arandis, approximately 12 km to the north west, and by the Khan River valley, approximately 4.5 km to the south-east.

The location of the Rössing Mine MLA in relation to towns, communities and farm residences are presented in Figure 5-1. Locations in and around the MLA at which impacts will be assessed are also indicated. Locations most likely to be affected by noise from proposed operations include the Khan Mine, E-camp, Arandis Airport, Arandis Town and visitors to the Khan River valley.

Figure 5-2 shows the location of infrastructure proposed as part of the Z20 project in relation to existing Rössing Mine operations and approved expansion projects.

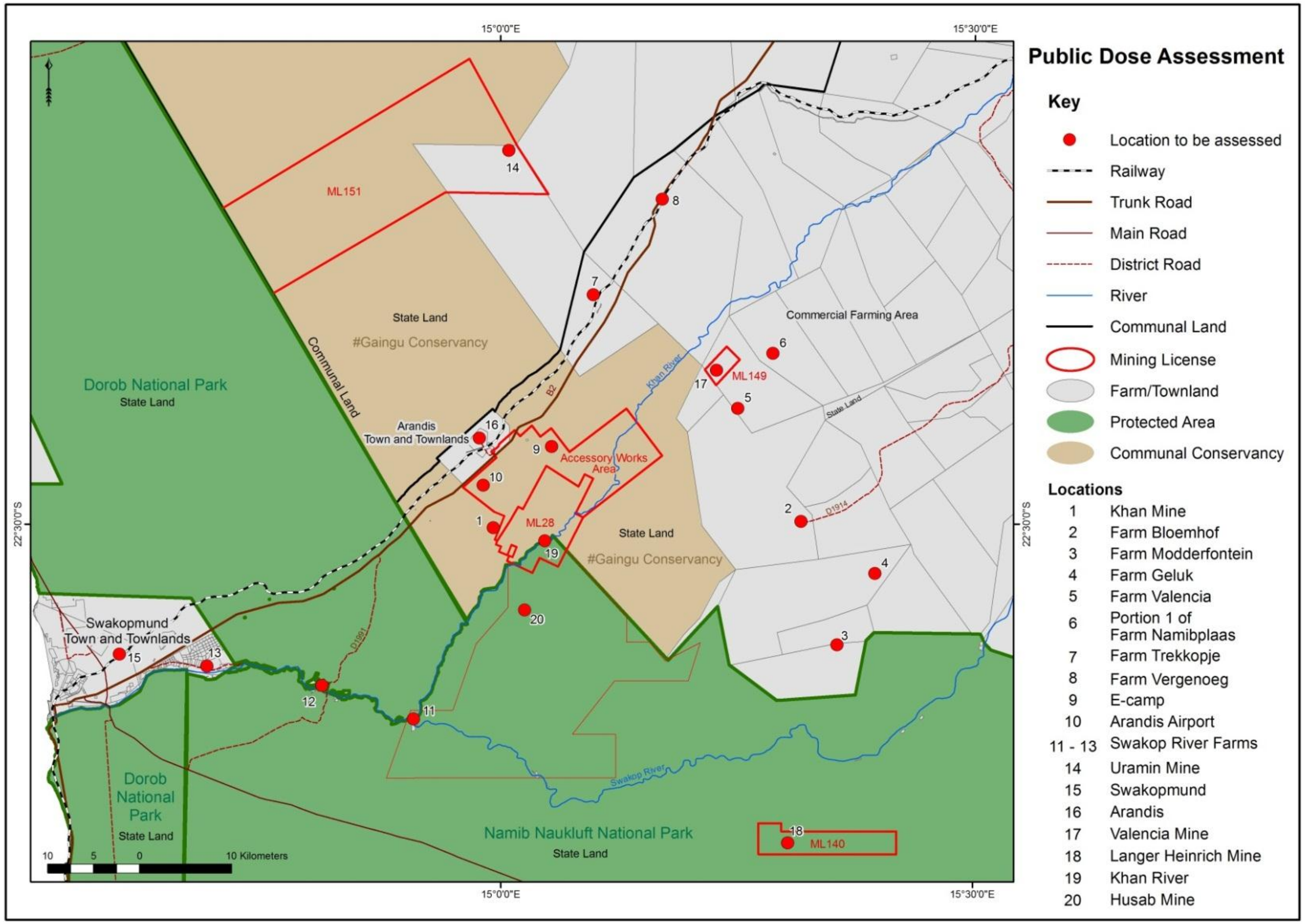

Figure 5-1: Rössing Mine locality, communities and residences (provided by Aurecon and SLR, 2012)

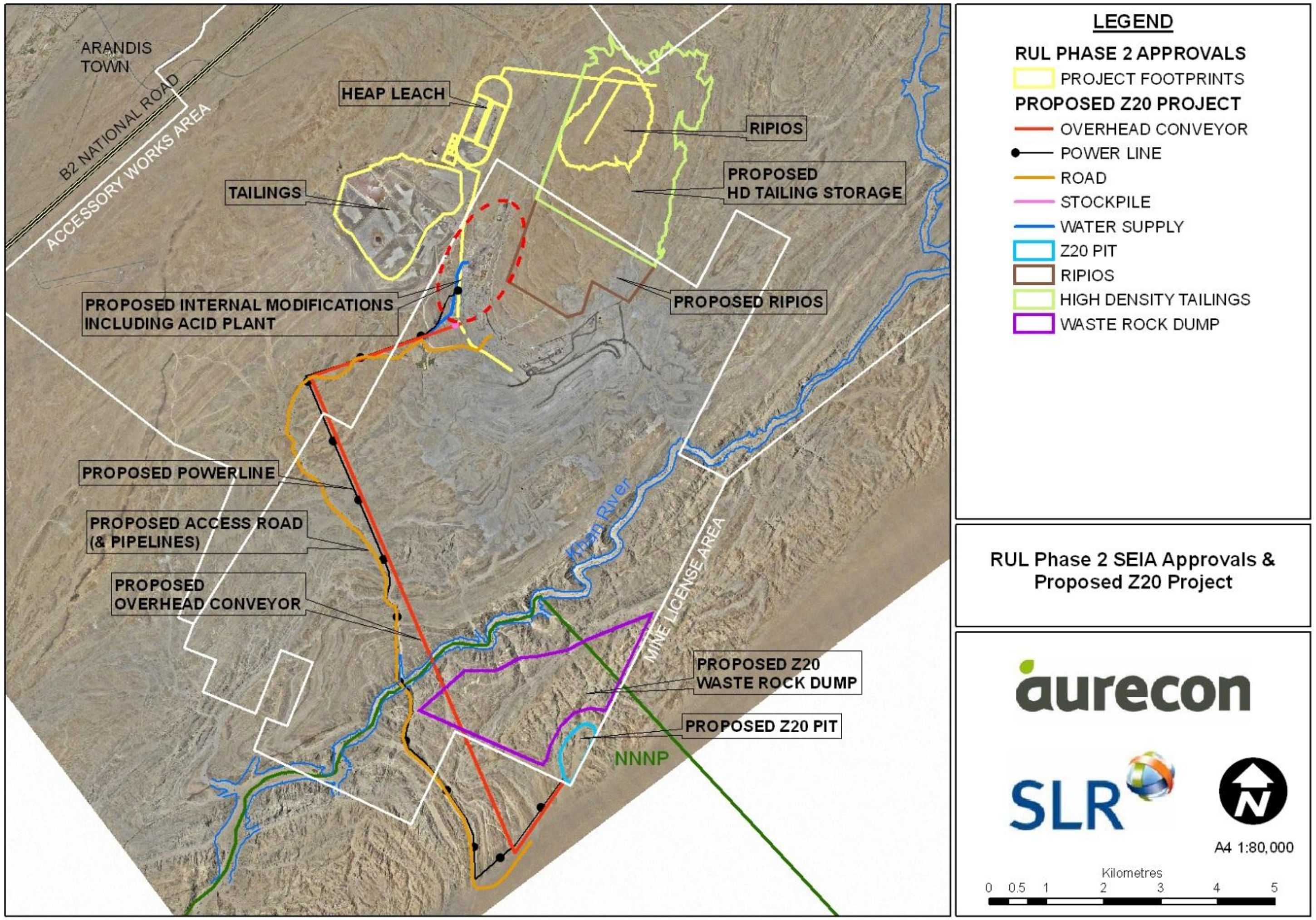

Figure 5-2: Rössing Mine and the proposed Z20 project (provided by Aurecon and SLR, 2012)

5.2 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to its role in the propagation on noise from source to receiver (Section 2.1.4). Meteorological parameters affecting the propagation of noise, when calculated using the Concawe method, include wind speed, wind direction, temperature, relative humidity, air pressure, solar radiation and cloud cover.

Average wind speed, wind direction, temperature, relative humidity, pressure and solar radiation as calculated from data collected at the Rössing on-site meteorological station for the period January 2001 to December 2004 are provided in Table 5-1.

It is well known that wind speed increases with altitude. This results in the 'bending' of the path of sound to 'focus' it on the downwind side and creating a 'shadow' on the upwind side of the source. Depending on the wind speed, the downwind level may increase by a few dB but the upwind level can drop by more than 20 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

Wind roses indicating prevailing wind directions in the area during the day and night are provided in Figure 5-3. Wind roses represent wind frequencies for the 16 cardinal wind directions. Frequencies are indicated by the length of the shaft when compared to the circles drawn to represent a frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies with high and low winds occurring for each wind vector. The frequencies of calms, defined as periods for which wind speeds are below 1 m/s, are also indicated.

The average day-time wind field is characterised by frequent moderate winds (3 to 5 m/s) from the south-west to the west and frequent strong winds (more than 5 m/s) from the north-northeast and north-east. During nigh-time the wind field is dominated by strong winds from the north-northeast and northeast and weak winds from the north-west. It should be noted that at wind speeds of more than 5 m/s ambient noise levels are mostly dominated wind generated noise.

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On a clear night, temperatures may increase with altitude thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more significant during the night.

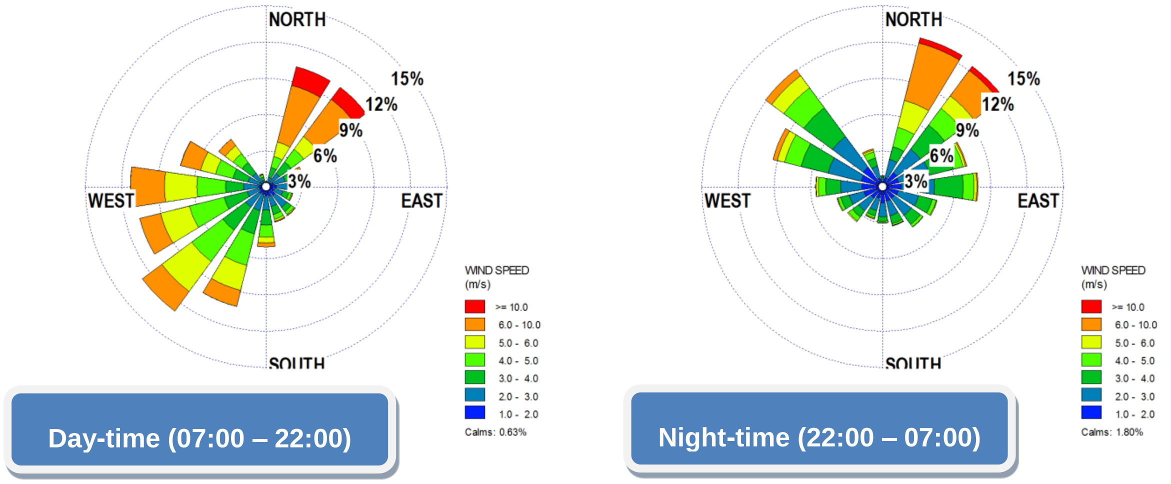

Figure 5-3: Day and night-time wind roses generated from on-site Rössing data (2001 to 2004)

Table 5-1: Average meteorological data obtained from on-site Rössing data (2001 to 2004)

Average meteorological data obtained from on-site Rössing data (2001 to 2004)		
Meteorological Parameter	**Day-time (07:00 – 22:00)**	**Night-time (22:00 – 07:00)**
Average wind speed (m/s)[(a)]	4.6	3.4
Average temperature (°C)[(a)]	23.4	18.6
Average relative humidity (%)[(a)]	40.3	55.7
Air pressure (kPa) [(b)]	94	94
Solar radiation (W/m^2)[(b)]	700	Not applicable
Cloud cover (8^{ths}) [(b)]	3	3

Notes:

(a) Rössing Data

(b) Assumption, no data available

5.3 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (natural terrain or installed acoustic barrier) feature depends on two factors namely the path difference of the sound wave as it travels over the barrier compared with direct transmission to the receiver and the frequency content of the noise. Low frequency noise is difficult to reduce with barriers (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

The Rössing Mine, at 575 meters above mean sea level, is located on the generally south-east-facing, rough and undulating slopes near the Western edge of the Central Namib Dessert. Terrain in the southern parts of the MLA is characterised by the several steep gullies and gorges that drain into the Khan River resulting in a rugged and hilly landscape. As one moves north from the Khan River, toward the town of Arandis the storm-wash gullies become less pronounced and are interspersed with resilient rock ridges resembling a more typical Namibian desert plain (Aurecon & SLR, 2012). The Khan River valley may serve as a natural noise barrier between the activities within the valley and communities on the gravel plains i.e. Arandis.

Sound reflected by the ground interferes with the directly propagated sound. The effect of the ground is different for acoustically hard (e.g., concrete or water), soft (e.g., grass, trees or vegetation) and mixed surfaces. Ground attenuation is often calculated in frequency bands to take into account the frequency content of the noise source and the type of ground between the source and the receiver barriers (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Ground cover consists of gravel plains with sparse vegetation and is considered acoustically hard i.e. not conducive to noise attenuation.

Even though the topography within the Khan Valley my serve as a natural acoustic barrier, it is possible that noise from infrastructure within the valley, confined and bundled as it propagates down a valley, is intensified. The reflection of noise generated within the valley, specifically during the construction has been raised as a concern by farmers residing to the west of proposed operations and complaints have been reported at noise sensitive receptors up to 25 km down the Khan River valley from Rössing operations.

5.4 Baseline Noise Levels

It is important to note that the increase in ambient noise level as a result of the introduction of an industrial noise source into the environment depends largely on existing noise levels in the project area. Higher ambient noise levels will result in the less noticeable noise impacts. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels. In order to quantify existing noise levels in the vicinity the project, reference is made to the results of ambient noise measurements and noise propagation modelling results reported by DDA Environmental Engineers in association with J.H. Consulting in 2010.

Noise measurements were conducted at nine background positions near the Rössing Mine boundary and three at affected community sites (Figure 5-4). Measurement results reported included the impulse weighted equivalent continuous A-weighted sound pressure level (L_{AIeq})[1] and L_{90}, the A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels. Measured L_{AIeq} and L_{90} levels are summarised in Table 5-2. It should be noted that the

[1] Calculated in accordance with South African National Standards (SANS) 10103 (2008)

2010 report compiled by Dracoulides does not specify the time of day measurements represent. It is therefore unclear whether the measurements refer to day-time, night-time or 24 hour average levels.

Measured background noise levels ranged between 25 dBA and 45 dBA. Measurements were found to correlate well with typical noise levels in reported for rural districts, i.e. 45 dBA during the day and 35 dBA during the night (SANS 10103, 2008). Levels at Arandis were found to be similar to levels typically found in suburban districts i.e. 50 dBA during the day and 40 dBA during the night (SANS 10103, 2008). Levels in remote wilderness areas, specifically the Khan River valley, were reported to be in the 30 dBA range during the day and night. The quiet nature of these wilderness areas were confirmed by noise studies conducted for Swakop Uranium's Husab Mine just south of the Khan River valley and associated linear infrastructure (Stobart, 2011).

In addition to baseline noise measurements, environmental noise levels as a result of existing Rössing mining operations were calculated. Predicted baseline day and night-time noise levels are presented in Figure 5-5 and Figure 5-6 respectively. It should be noted that since raw results data was not made available, reference is made to graphics extracted from the report compiled by Dracoulides in 2010.Existing noise levels along the proposed infrastructure corridor varies between 35 dBA and 65 dBA during the day and night.

For use in the assessment of cumulative noise impacts and the increase in environmental noise levels as a result of the infrastructure corridor, the following baseline noise levels (as derived from available data discussed above) were used in the assessment:

- At noise sensitive receptors located on the plains (i.e. those located on the plains and in close proximity to the B2 and existing Rössing mining operations):
    - Day-time noise level – 45 dBA to 50 dBA
    - Night-time noise level – 35 dBA to 40 dBA
- Remote wilderness areas i.e. the Khan River valley:
    - Day-time noise level – 30 dBA
    - Night-time noise level – 30 dBA

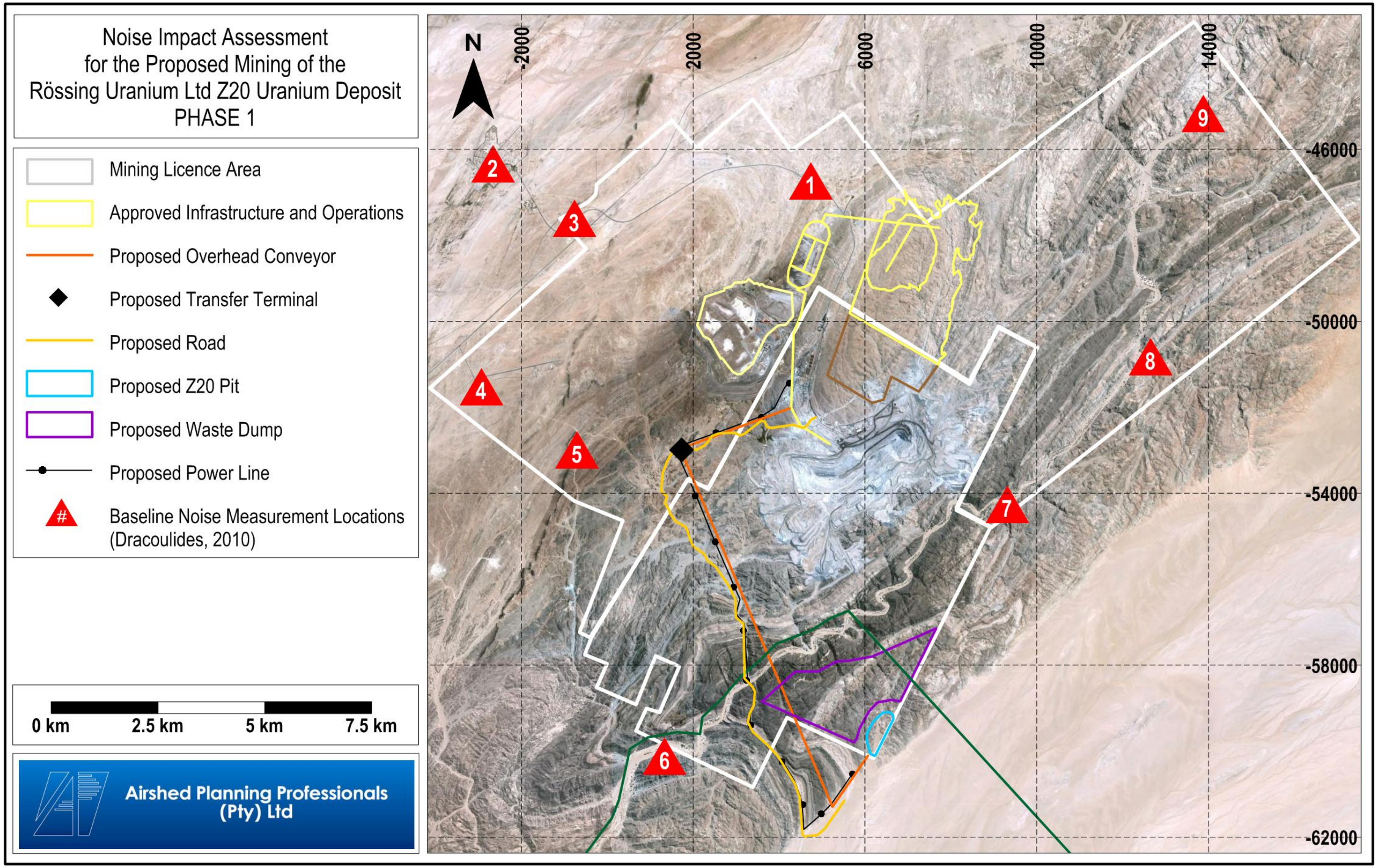

Figure 5-4: Baseline noise measurement locations (Dracoulides, 2010)

Table 5-2: Baseline noise measurement results

Location	Description	L_{Aleq} (dBA)	L_{90} (dBA)
1	Along the main access road, 45 m from road centreline	45	29
2	Arandis	53	45
3	Next to Arandis road intersection	50	37
4	On Arandis airport road	41	34
5	Along dirt road towards the Khan Mine	38	29
6	In the Khan River valley	40	28
7	Along the Khan River valley (close to open pit)	43	28
8	Along Khan River valley	41	25
9	Along Khan River valley at a remote site	45	34

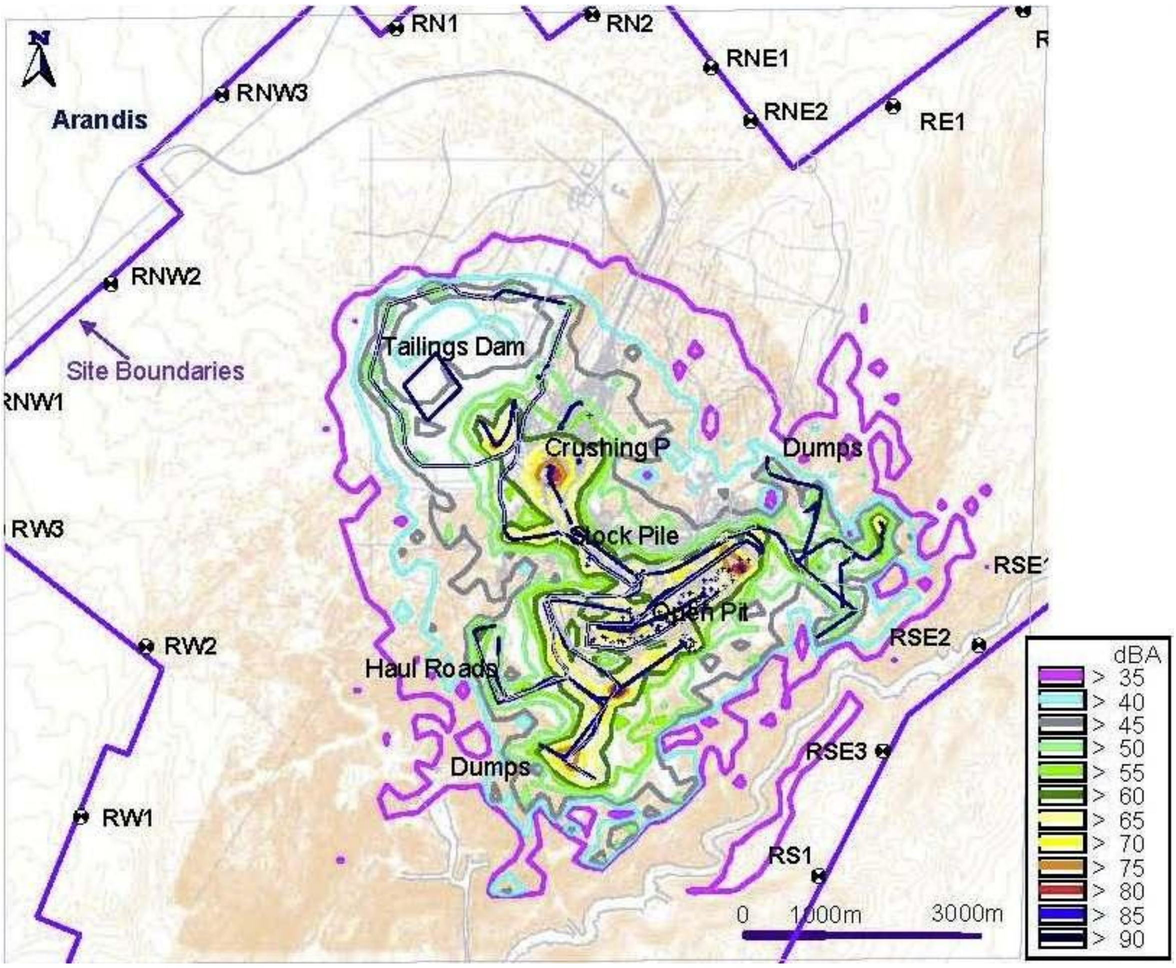

Figure 5-5: Predicted baseline day-time noise levels (Dracoulides, 2010)

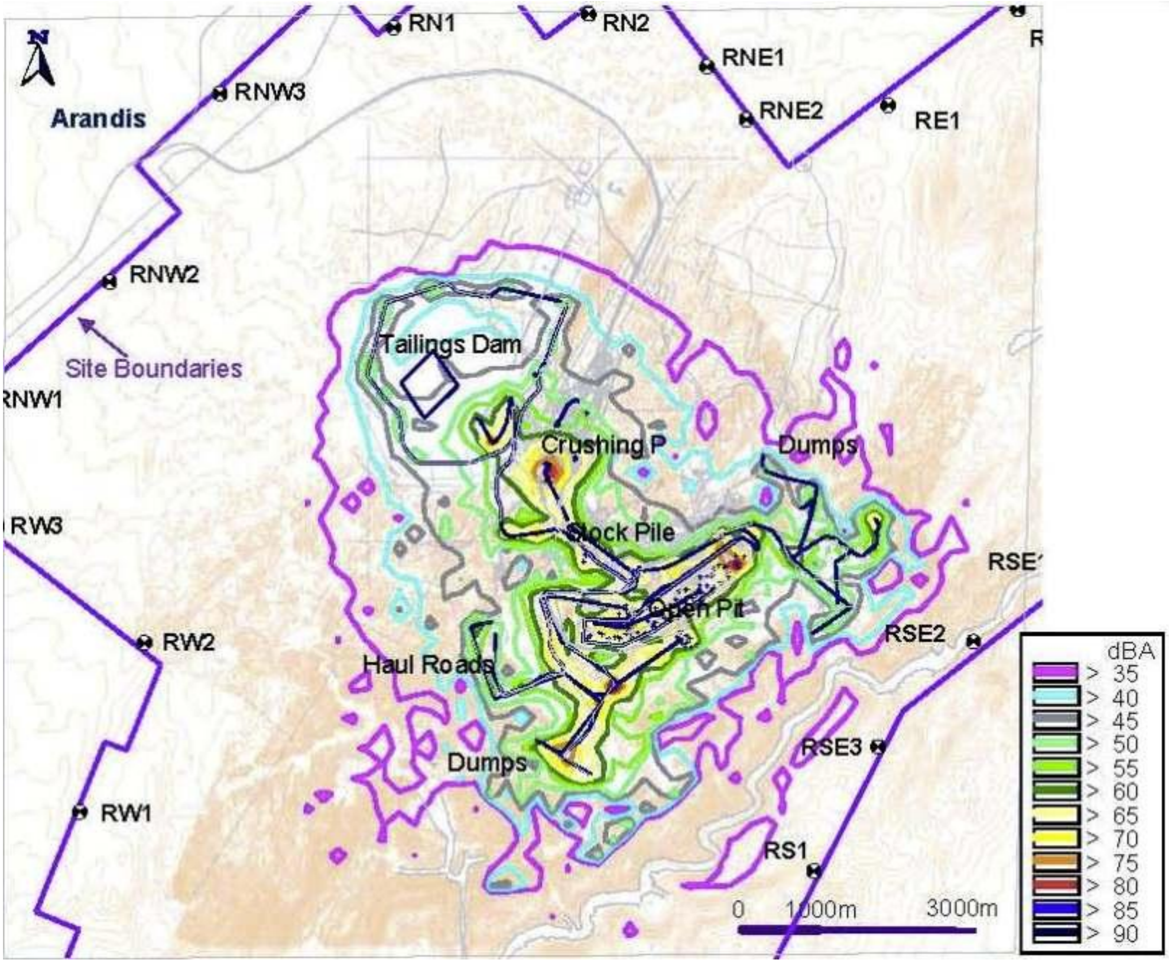

Figure 5-6: Predicted baseline night-time noise levels (Dracoulides, 2010)

5.5 The Effects of Noise on Animals

Generally, noise impacts on wildlife are determined by the extent to which noise disrupts a functioning ecosystem. Different types of animals are affected differently and react differently to noise. Potential noise effects on wildlife include auditory damage, physiological changes and behavioural changes (Air and Noise Compliance, 2012).

Auditory effects are associated with very high noise levels (often in excess of 90 dBA) which are unlikely in natural habitats, even with the instruction of an industrial noise source. These effects would involve hearing loss or threshold shifts which are a reduced sensitivity to sound similar to a partial hearing loss. Threshold shifts have the potential interfere with communication and reduce an animal's functioning ability (Air and Noise Compliance, 2012).

Physiological effects, such as metabolic and hormonal changes, are often associated with stress. For wildlife stress reactions are part of survival and a routine occurrence, i.e. the "fight or flight" response. When this reaction is inappropriate, such as fleeing from a non-threaten noise, impacts begin to occur. Inappropriate reactions unnecessarily deplete an animal's energy resources which can increase susceptibility to predators, disease, and starvation (Air and Noise Compliance, 2012).

Changes in normal behavioural patterns are the most apparent effects of noise on wildlife will be the most noticeable for impact associated with the infrastructure corridor. When noise becomes an objectionable intrusion on wildlife habitats, these changes include alterations in habitat locations and migration patterns, and abnormal behaviour that can cause difficulty in mating and survival. Noise has the greatest effect on wildlife which relies on auditory signals for survival (Air and Noise Compliance, 2012).

6 Impact Assessment

6.1 Predicted Impacts

Noise will be generated during the construction, operation and decommissioning of the infrastructure corridor. The noise source inventory, noise propagation modelling and results for these phases are discussed Section 6.1.1, Section 6.1.2 and Section 6.1.3 respectively.

6.1.1 Construction Phase

6.1.1.1 Noise Sources and Sound Power Levels

Based on process descriptions provided, noise will be generated by the following activities associated with the construction of the infrastructure corridor:

- Blasting;
- Land clearing and bulk earthworks by diesel mobile equipment for the road and RopeCon; and
- Helicopter noise (a helicopter will be used in the transport of heavy equipment and erection of RopeCon towers)

The extent and character of construction noise from the infrastructure corridor will be highly variable as different activities with different equipment will take place at different times, over different periods, in different combinations, in different sequences and on different parts of the construction site. As a conservative measure, noise levels as a result of all construction operations were assumed to occur at one location simultaneously. It is understood that construction activities will be limited to day-time hours.

6.1.1.1.1 Blasting

Predicting the noise caused by the air overpressure generated during a blasting event is a highly complex process. The air overpressure consists of air transmitted sound pressure waves that move outwards from and exploding charge. A well confined explosives charge creates pressure waves with frequencies that are mostly less than 20 Hz with relatively small amounts of energy in the frequency bands above 20 Hz. As discussed in Section 2.1.1, the human ear responds to frequencies above 20 Hz and filters out frequencies below 20 Hz

Air overpressure from blasting is therefore measured at frequencies between 2 and 250 Hz on a linear decibel scale (dBL) as opposed to measuring community noise on an A-weighted decibel scale that filters out frequencies below 20 Hz. As a comparison between the two scales, if a sound level meter set to measure air overpressure from a well confined blast measured is measured at 120 dBL, a sound level meter set to measure community noise on the dBA scale would measure approximately 95 dBA.

Factors that influence airblast levels include:

- Charge mass and distance from the blast;
- Face height and orientation;
- Topographic shielding;
- Stemming height and type;
- Blast hole diameter to burden ratio;
- Burden , spacing and sequential initiation timing; and
- Meteorological parameters.

In the absence of project specific blast information blasting noise could not be quantified. Management measures to reduce the impact of blasting noise on the receiving environment are however recommended in Section 7.1.3.

6.1.1.1.2 Earthworks and Diesel Mobile Equipment

Sound power levels of diesel mobile equipment to be used in the construction of the infrastructure corridor, were calculated using the sound power level predictive equations for industrial machinery (Crocker, 1998). A list of equipment to be used during the construction phase of the RopeCon/RailCon system (as provided by Aurecon and SLR), and associated calculated sound power levels are presented in Table 6-1. No information regarding the construction of the road was provided. Typical diesel mobile equipment used for road construction was assumed. These are also listed in Table 6-1.

Table 6-1: Summary of construction phase sound power levels

Summary of Construction Phase Sound Power Levels		
RopeCon/RailCon Construction:	**Qty.**	**Sound Power Level, L_W (dBA)**
Tele-handler (5 tonne and 12 tonnes)	5	109
Man Lift (20 m and 35 m)	2	108
Truck (20 tonnes)	5	114
Mobile Crane (50 tonnes)	1	115

Summary of Construction Phase Sound Power Levels		
Mobile Crane (90 tonnes)	1	116
Mobile Crane (150 tonnes)	1	116
Mobile Crane (250 tonnes)	1	117
Mobile Crane (350 tonnes)	1	117
General Construction Noise	-	109
Materials Transfer and Handling	-	106
Road Construction	**Qty.**	**Sound Power Level, L_W (dBA)**
Articulated Truck	2	114
Asphalt Paver	1	110
Backhoe Loader	1	109
Compact Multi-terrain Loader	1	108
Motor Grader	1	114
Wheeled Dozer	1	113
Vibratory Asphalt Compactor	1	110
Materials Transfer and Handling	-	106

6.1.1.1.3 Helicopter Noise

A helicopter will be used for civil works and RopeCon erection during construction. It is estimated that the construction helicopter will perform 1 400 cycles of 3 to 4 minutes in duration each during the construction phase.

Engineering and operational factors influencing helicopter noise include the engine/transmission, the propeller/rotor, aerodynamic design, flight path and helicopter performance (Nelson, 1987). No information regarding noise generated by the helicopters considered for use are publically available. Reference is therefore made to reference noise levels published by Nelson for various helicopters types. Maximum A-weighted sound pressure levels (L_{Amax}) at 152 m (500 ft) range between 75 dBA (small single turbine helicopter i.e. Bell 206/Jet ranger) and 89 dBA (large twin rotor helicopter i.e. Chinook) (Nelson, 1987).

In this assessment an average L_{Amax} level of 81 dBA at 152 m was used in the estimation of helicopter noise impacts. As a conservative measure, it was assumed that the helicopter will be operational for the entire day-time hour over which impacts are assessed.

6.1.1.2 Noise Propagation Modelling and Predicted Noise Levels

The propagation of noise from the construction of the infrastructure corridor was calculated in accordance with *'The calculation of sound propagation by the Concawe method'* (SANS 10357, 2004) and SANS 10210. Meteorological and site specific acoustic parameters as discussed in Section 5 along with source data discussed in Section 6.1.1.1, were applied in the model. The propagation of noise was calculated over a downwind distance of 5 km at a resolution of 100 m.

To facilitate comparison with IFC guidelines the following were calculated for the construction phase:

- Total day and night-time noise levels (L_{Aeq}(1 hour)); and
- The increase in environmental day and night-time noise levels when compared to existing baseline noise levels over the plains and within the Khan River valley.

Calculated maximum cumulative day-time noise levels during the construction phase are presented in Figure 6-1. The expected increase in day-time noise levels over the 45 dBA baseline level over the plains and 30 dBA within the Khan River valley is provided in Figure 6-2.

Cumulatively noise levels as a result of all construction activities in close proximity to each other may exceed the IFC guideline of 55 dBA up to 1.1 km and will result in a 3 dBA increase over the baseline day-time level of 45 dBA up to 1.9 km from construction areas over the plains.

Within the Khan River valley, cumulative noise levels as a result of all construction activities in close proximity to each other may exceed the IFC guideline of 55 dBA up to 900 m and will result in a 3 dBA increase over the baseline day-time level of 30 dBA over 5 km.

The extent of construction noise impacts are mostly as a result of the use of the helicopter for the transport of materials and erection of the RopeCon/Railcon system. When the helicopter is not in use the area of exceedance of the IFC day-time 55 dBA will range between 500 and 600 m. The 3 dBA increase will be between 1.1 and 3.2 km.

Most of the noise sensitive receptors included in the SEIA are located at distances of more than 3 km away from construction areas. Day-time noise impacts at these receptors are considered improbable and community reaction unlikely.

Within the Khan River valley, construction activities will be audible over long distances down the valley and may result in strong reaction from visitors to the valley, especially during helicopter operational times.

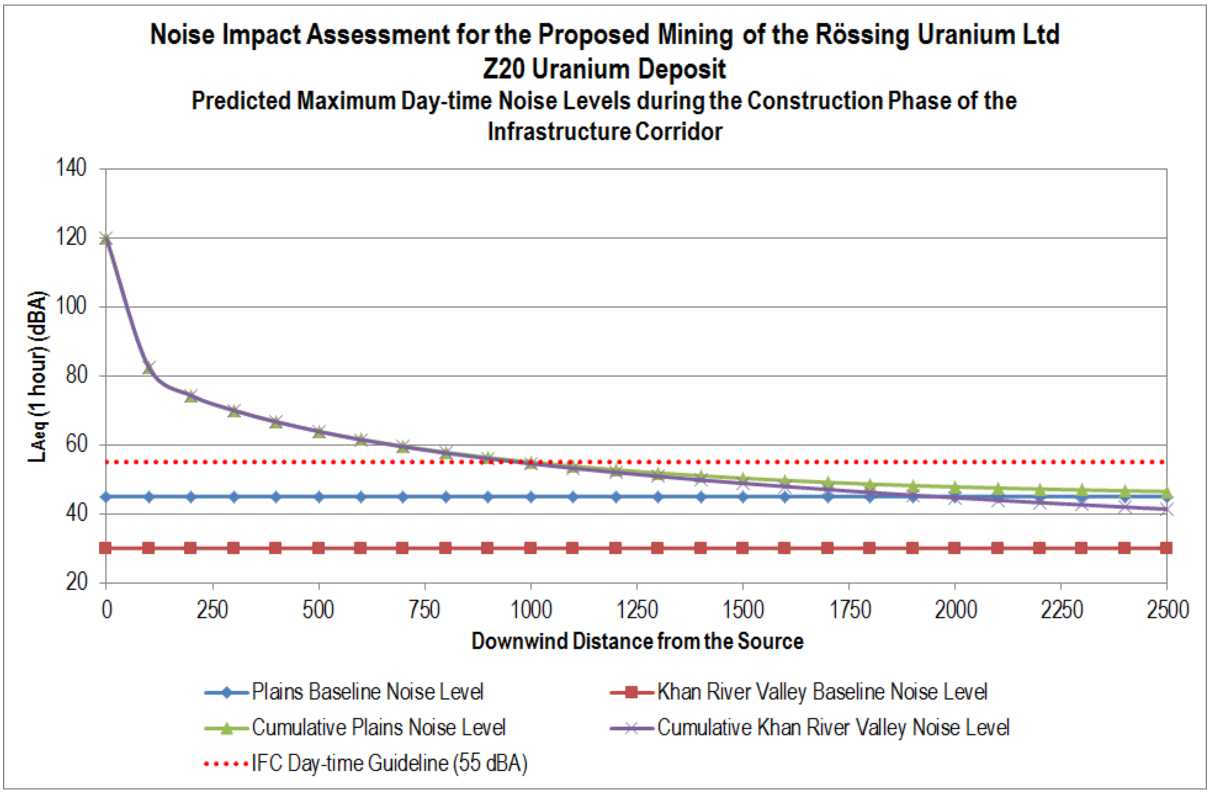

Figure 6-1: Construction phase - Predicted maximum day-time noise levels

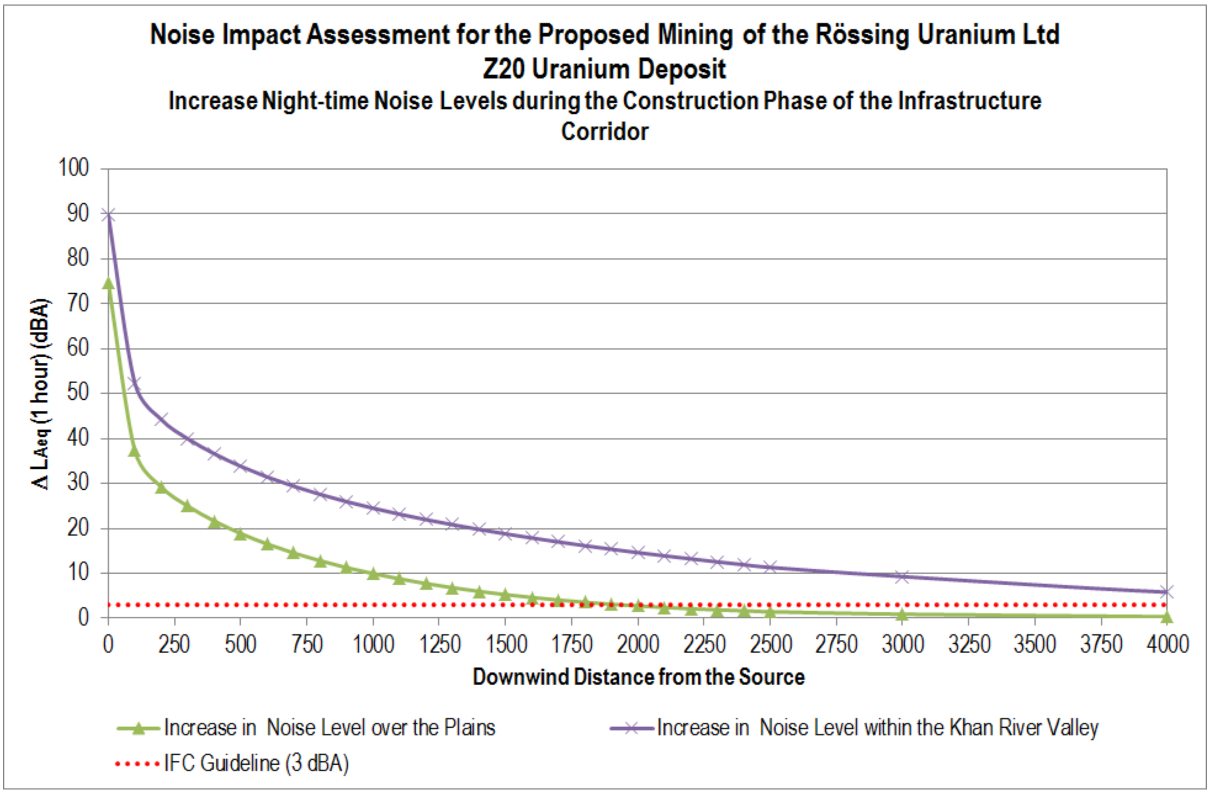

Figure 6-2: Construction phase - Predicted increase in day-time noise levels

6.1.2 Operational Phase

6.1.2.1 Noise Sources and Sound Power Levels

Sources of noise were identified from process descriptions and information provided by Aurecon and SLR, RUL and Doppelmayr. The following sources of noise were included in the study:

- Traffic along the proposed road;
- The continuous operation of the RopeCon and RailCon system including the drive units and the transfer station.

6.1.2.1.1 Road Traffic Noise

Road traffic noise was calculated in accordance with SANS 10210 (2004). Traffic data provided by RUL is summarised in Table 6-2. It will be an asphalt road with a design traffic speed of 60 km/h. The hour during which day-time traffic will be a maximum is 16:00 to 17:00. Night–time traffic will peak at midnight. These hours were used to calculate worst-case day-time and night-time L_{Aeq} (1 hour) as a function of distance from the road centreline. SANS 10210 defines a heavy vehicle as any vehicle of unladen mass that exceeds 1.5 tonnes.

Table 6-2: Project operational phase road traffic

Projected Operational Phase Road Traffic (provided by RUL, 2012)		
Hour of the Day	**Vehicles per Hour**	**% Heavy Vehicles**
00:00 – 01:00	3	100%
07:00 – 08:00	8	38%
08:00 – 09:00	5	100%
09:00 – 10:00	1	100%
15:00 – 16:00	4	100%
16:00 – 17:00	10	50%
23:00 – 00:00	3	100%

6.1.2.1.2 RopeCon/RailCon Noise

The conveyor system consist of two sections 12 550 m in length and is designed to transport up to 2 250 tonnes of ore per hour at speeds of up to 4.65 m/s. The conveyor consists of cross-reinforced steel cord belt with corrugated sidewalls and is covered by a roof. Cross members with flanged wheels on each side will suspend and guide the belt on the track ropes or rails. The wheels, located at intervals of approximately 6 m will on 6 full-locked coil track ropes for the RopeCon and on steel rails for the RailCon.

The drives for RailCon/RopeCon (Section 1) as well as the RopeCon (Section 2) and RopeWay will be located at the transfer terminal. The electric drive system achieves constant acceleration during start-up under all loading conditions. The electrical drive system of Section 1 will provide 1 300 kW continuous power and 2 150 kW during startup. Section 2 requires 750 kW continuous power and 1 150 kW during startup. The aerial RopeWay (used for maintenance and inspection) will require 500 kW continuous power and 780 kW during startup.

The following elements of the RopeCon/RailCon will produce noise:

- Wheel and rope or rail contact noise;
- Drive unit noise at the transfer terminal; and
- Materials transfer at the terminal.

Research conducted by Doppelmayr on noise generated by their RopeCon system indicated that a person, at a distance of 1 m from the RopeCon system would be exposed to a sound pressure level of between 55 and 60 dBA (Kessler, et al., 2002). The report did not distinguish between noise along RopeCon and RailCon and the 55 to 60 dBA range was assumed to be applicable to both systems. The report also did not provide any information regarding the frequency content of the noise produced by the system and that level of detail could therefore not be included in the noise propagation calculations. As a conservative measure, the sound power level of the system was back calculated from the 60 dBA sound pressure level reported at a distance of 1 m from the system and by assuming cylindrical divergence.

Noise from electrical drives was calculated for continuous operations (not start up) through the application of predictive sound power levels and equations for electrical motors as published by Crocker (1998).

In the absence of project specific sound power levels for materials transfer, noise generated by the transfer or ore at the transfer terminal was obtained from the database of Francois Malherbe Acoustic Consulting cc.

A summary of sound power levels applied in calculations for the operational phase is provided in Table 6-3.

Table 6-3: Summary of operational phase sound power levels

Operational Phase Sound Power Levels	
Source Description:	**Sound Power Level, L_W (dBA)**
RopeCon/RailCon	65
Section 1 continuous electric drive unit – 1 300 kW	104
Section 1 continuous electric drive unit – 750 kW	104
RopeWay continuous electric drive unit – 500 kW	82
Coarse Materials Transfer	106

6.1.2.2 Noise Propagation Modelling and Predicted Noise Levels

The propagation of noise from the operational phase was calculated in accordance with SANS 10103 and SANS 10210. Meteorological and site specific acoustic parameters as discussed in Section 5 along with source data discussed in Section 6.1.2.1, were applied in the model.

The propagation of noise was calculated downwind of operations at 100 m intervals.

To facilitate comparison with IFC guidelines the following were calculated for the operational phase:

- Total day and night-time noise levels (L_{Aeq}(1 hour)); and
- The increase in environmental day and night-time noise levels when compared to existing baseline noise levels.

6.1.2.2.1 Predicted Day-time Noise Levels

Calculated total day-time noise levels during the operational period are presented in Figure 6-3. The expected increase in day-time noise levels over the 45 dBA baseline level over the plains and 30 dBA within the Khan River valley is provided in Figure 6-4.

Cumulatively noise levels as a result of the operational phase (transfer terminal, road and RailCon/RopeCon) may exceed the IFC guideline of 55 dBA up to 200 m and will result in a 3 dBA increase over the baseline day-time level of 45 dBA up to 500 m from the transfer terminal over the plains.

Within the Khan River valley, cumulative noise levels as a result of the road and RailCon exceed the IFC guideline of 55 dBA up to 50 m and will result in a 3 dBA increase over the baseline day-time level of 30 dBA up to 2.5 km down the valley.

Most of the noise sensitive receptors included in the SEIA are located at distances of more than 3 km away from operational areas. Day-time noise impacts at these receptors are considered improbable and community reaction unlikely.

Within the Khan River valley, activities will be audible over distances up to 2.5 km down the valley and may result in strong reaction from visitors to the valley. Road traffic will be responsible for most of the noise impacts within the valley during the day. It should be noted that, according to traffic projections provided by Aurecon and SLR, traffic noise impacts will only occur for a total 5 hours of the day. The increase in night-time noise as a result of the RopeCon will be less than 3 dBA within 1 km. Within the valley, where the conveyor runs approximately 100 m above ground the increase will be less than 10 dBA directly underneath the RopeCon system.

6.1.2.2.2 Predicted Night-time Noise Levels

Calculated total night-time noise levels during the operational phase are presented in Figure 6-5. The expected increase in night-time noise levels over the 35 dBA baseline level over the plains and 30 dBA within the Khan River valley is provided in Figure 6-6.

Cumulatively noise levels as a result of the operational phase (transfer terminal, road and RailCon/RopeCon) may exceed the IFC guideline of 45 dBA up to 550 m and will result in a 3 dBA increase over the baseline night-time level of 35 dBA up to 1.4 km from the transfer terminal over the plains.

Within the Khan River valley, cumulative noise levels as a result of the road and RailCon exceed the IFC guideline of 45 dBA up to 100 m and will result in a 3 dBA increase over the baseline night-time level of 30 dBA up to 1.7 km down the valley.

Most of the noise sensitive receptors included in the SEIA are located at distances of more than 3 km away from operational areas. Night-time noise impacts at these receptors are considered improbable and community reaction unlikely. Within the Khan River valley, activities will be audible over distances of up to 1.7 km down the valley and may result in strong reaction from visitors to the valley.

The cumulative night-time time noise impact area is less than the day-time impact area because of reduced traffic volumes. According to traffic projections provided by Aurecon and SLR, traffic noise impacts will only occur for a total 2 hours of the night. The increase in night-time noise as a result of the RopeCon only will be less than 3 dBA within 1 km. Within the valley, where the conveyor runs approximately 100 m above ground the increase will be less than 10 dBA directly underneath the RopeCon system. According to SANS 10103 (2008) a 10 dBA increase in noise level may result in medium community reaction and complaints. An increase of 10 dBA is subjectively perceived as a doubling in the loudness of the noise.

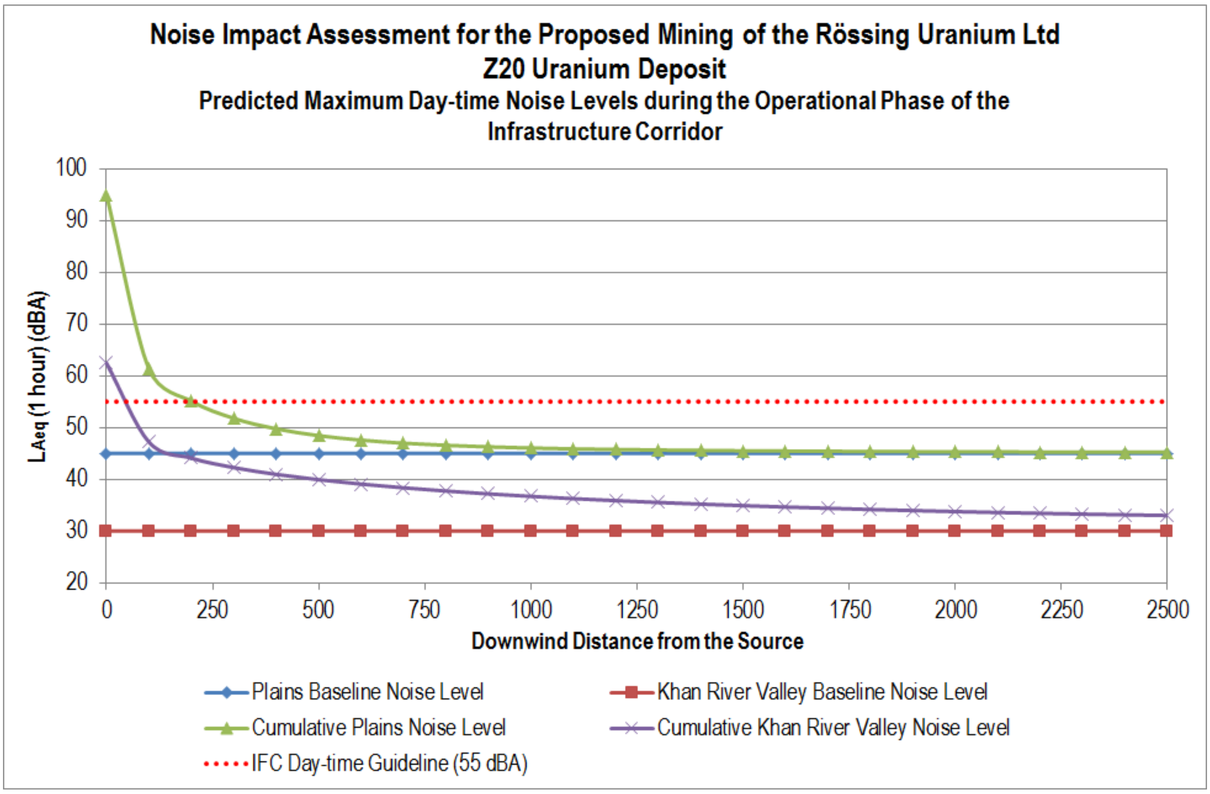

Figure 6-3: Operational phase - Predicted maximum day-time noise levels

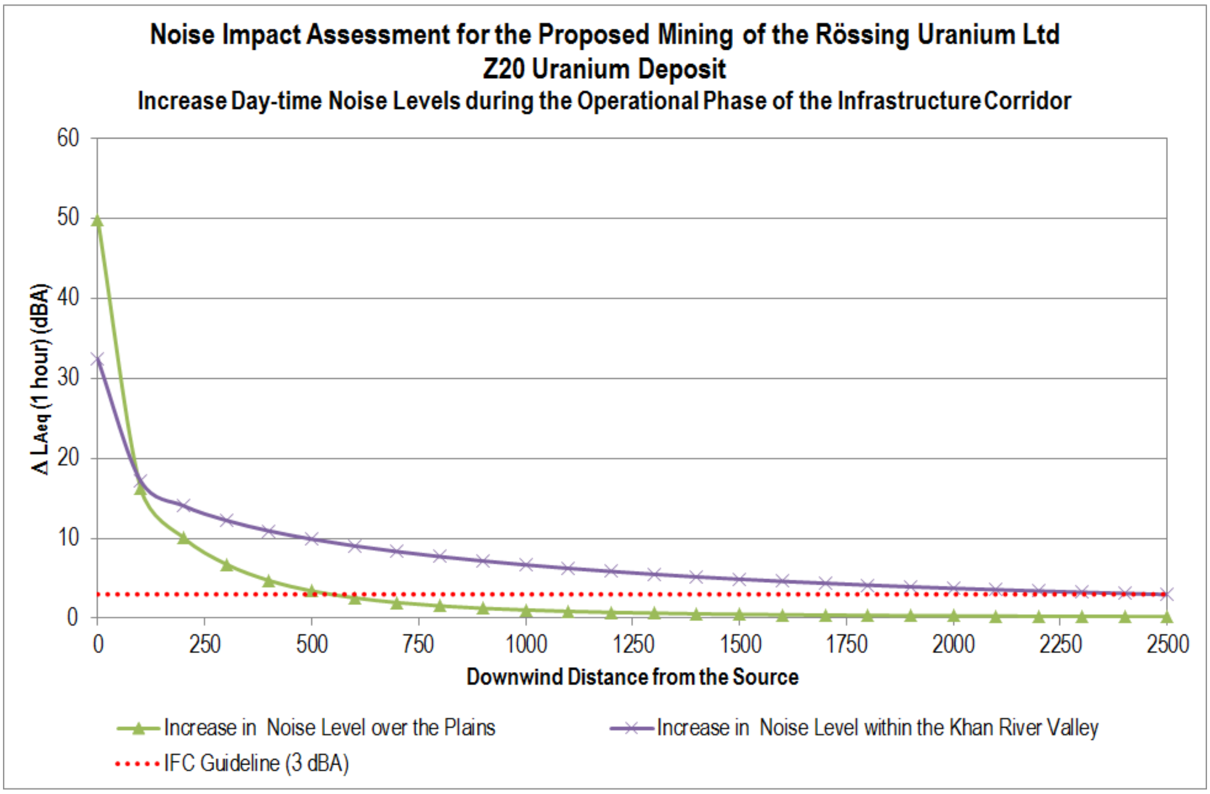

Figure 6-4: Operational phase - Predicted increase in day-time noise levels

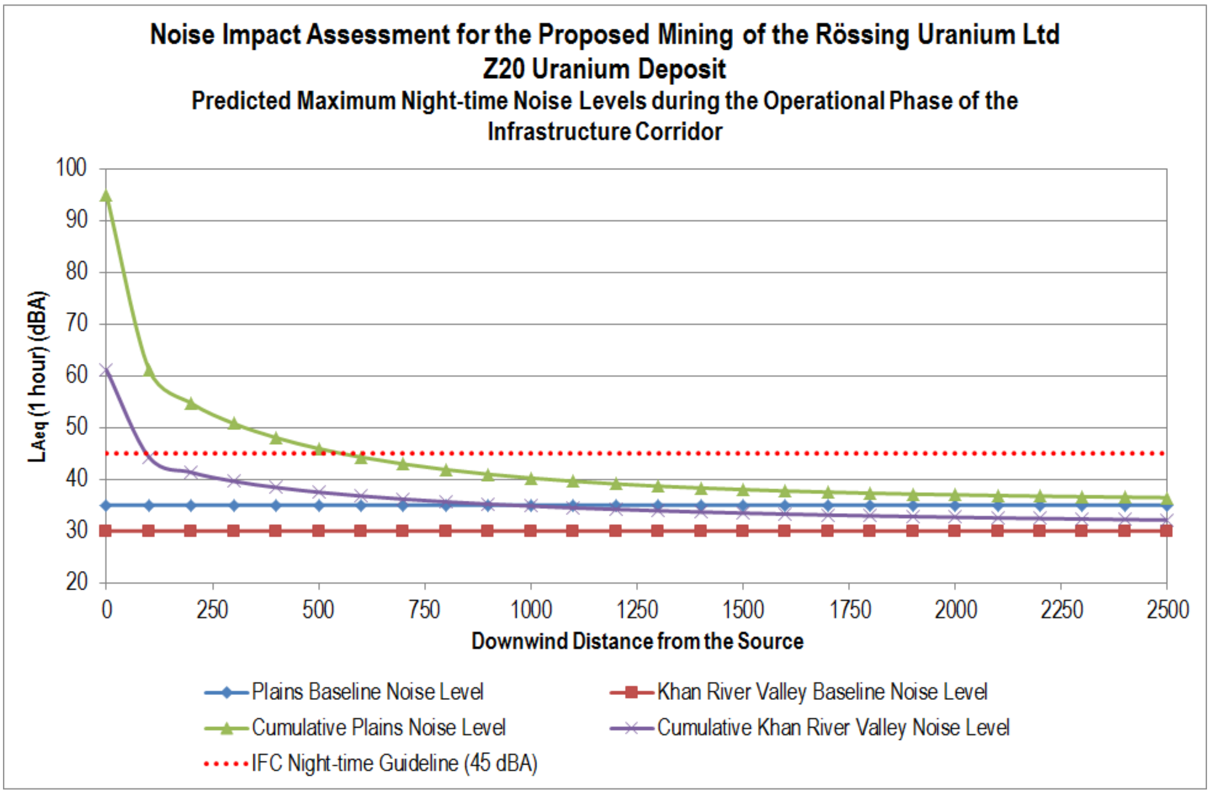

Figure 6-5: Operational phase - Predicted maximum night-time noise levels

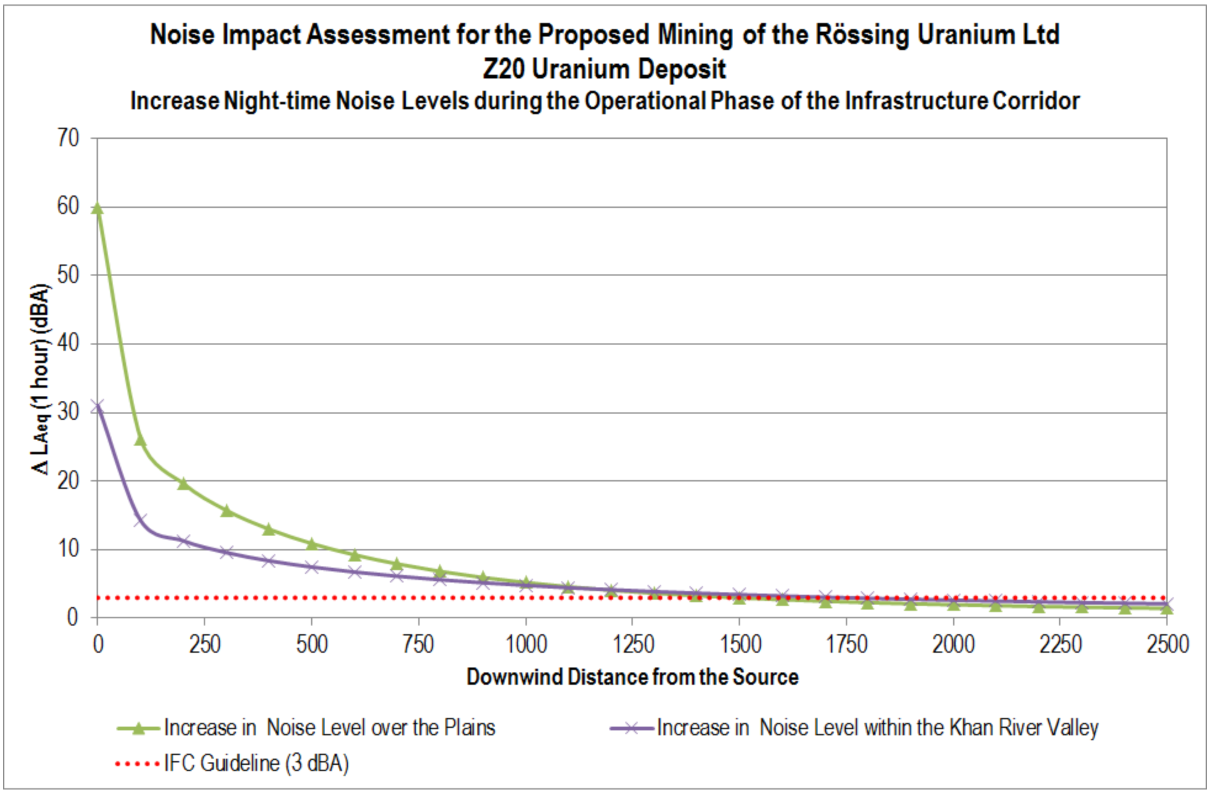

Figure 6-6: Operational phase - Predicted increase in night-time noise levels

6.1.3 Decommissioning Phase

No information regarding potential noise sources for the decommissioning phase was available at the time of the study and could therefore not be quantified. Noise impacts will depend on the extent of rehabilitation and demolition activities. It is however expected that noise impacts during the decommissioning phase would be comparable to that of the construction phase.

6.2 The Potential for Cumulative Noise Impacts

The potential for cumulative noise impacts within the Khan River valley as a result of the Rössing Z20 Infrastructure Corridor and the Husab Linear Infrastructure exists and is qualitatively discussed. The Husab Linear Infrastructure crosses the Khan River approximately 3 km downstream of the Rössing Infrastructure Corridor. The Husab Linear Infrastructure noise assessment concluded noise impacts up to 2.5 km (van Zyl, 2011) from the road. Impact areas may therefor overlap and result in more significant impacts between the Husab Linear Infrastructure crossing and the Rössing infrastructure Corridor crossing.

6.3 Impact Significance

The significance of predicted noise impacts were assessed in accordance with the procedure outlined by Aurecon and SLR. The impact significance criteria and its interpretation from an environmental noise perspective is summarised in Appendix A.

It should be noted that the noise impact assessment methodology provides for the assessment of cumulative impacts. As a conservative measure, the significance of noise impacts is assessed based on the predicted increase in noise level above the reported baseline noise level. The IFC guideline of a 3 dBA increase is used as the impact indicator since it presents the level at which a person with average hearing acuity will not detect a change in ambient noise levels.

It is also important to note than environmental noise is assessed from an *annoyance perspective* and not a *health impact perspective* since levels and exposure times are generally not enough to cause hearing loss or health effects.

Noise impacts were assessed separately for impacts over the plains and within the Khan River valley where baseline noise levels are very low.

Table 6-4: Impact significance at noise sensitive receptors located on the plains as a result of the infrastructure corridor (Pre-mitigation)

Cumulative Noise Impact Significance at Noise Sensitive Receptors Located the Plains as a Result of the Infrastructure Corridor (Pre-mitigation)										
Aspect	**Phase**	**Impact Description**	**Type**	**Extent**	**Magnitude**	**Duration**	**Probability**	**Confidence**	**Reversibility**	**Significance**
Day-time noise impacts	Construction Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Very Low	Short Term	Probable	Unsure	Reversible	Very Low (-)
Day-time noise impacts	Operational Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Very Low	Long Term	Probable	Sure	Reversible	Very Low (-)
Night-time noise impacts	Operational Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Very Low	Long Term	Probable	Sure	Reversible	Very Low (-)
Day-time noise impacts	De-comm. Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Very Low	Short Term	Probable	Unsure	Reversible	Very Low (-)

Table 6-5: Impact significance at noise sensitive receptors located on the plains as a result of the infrastructure corridor (Post-mitigation)

Cumulative Noise Impact Significance at Noise Sensitive Receptors Located the Plains as a Result of the Infrastructure Corridor (Post-mitigation)										
Aspect	**Phase**	**Impact Description**	**Type**	**Extent**	**Magnitude**	**Duration**	**Probability**	**Confidence**	**Reversibility**	**Significance**
Day-time noise impacts	Construction Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Very Low	Short Term	Probable	Unsure	Reversible	Very Low (-)
Day-time noise impacts	Operational Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Very Low	Long Term	Probable	Sure	Reversible	Very Low (-)
Night-time noise impacts	Operational Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Very Low	Long Term	Probable	Sure	Reversible	Very Low (-)
Day-time noise impacts	De-comm. Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Very Low	Short Term	Probable	Unsure	Reversible	Very Low (-)

Table 6-6: Impact significance within the Khan River valley as a result of the infrastructure corridor (Pre-mitigation)

Cumulative Noise Impact Significance within the Khan River valley as a Result of the Infrastructure Corridor (Pre-mitigation)										
Aspect	**Phase**	**Impact Description**	**Type**	**Extent**	**Magnitude**	**Duration**	**Probability**	**Confidence**	**Reversibility**	**Significance**
Day-time noise impacts	Construction Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	High	Short Term	Probable	Unsure	Reversible	Medium (-)
Day-time noise impacts	Operational Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	High	Long Term	Probable	Sure	Reversible	High (-)
Night-time noise impacts	Operational Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	High	Long Term	Probable	Sure	Reversible	High (-)
Day-time noise impacts	De-comm. Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	High	Short Term	Probable	Unsure	Reversible	Medium (-)

Table 6-7: Impact significance within the Khan River valley as a result of the infrastructure corridor (Post-mitigation)

Cumulative Noise Impact Significance within the Khan River valley as a Result of the Infrastructure Corridor (Post-mitigation)										
Aspect	Phase	Impact Description	Type	Extent	Magnitude	Duration	Probability	Confidence	Reversibility	Significance
Day-time noise impacts	Construction Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Medium	Short Term	Probable	Unsure	Reversible	Medium (-)
Day-time noise impacts	Operational Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Medium	Long Term	Probable	Sure	Reversible	Medium (-)
Night-time noise impacts	Operational Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Medium	Long Term	Probable	Sure	Reversible	Medium (-)
Day-time noise impacts	De-comm. Phase	A detectable increase in predicted noise levels above the reported baseline noise levels at the nearest noise sensitive receptor	Negative	Local	Medium	Short Term	Probable	Unsure	Reversible	Medium (-)

7 Management, Mitigation and Recommendations

7.1 Mitigation

Although noise impacts at the nearest permanent noise sensitive receptors are not likely, impacts on visitors to the Khan River valley is of concern. The management and mitigations measures referred to in this Section should be considered to minimise potential noise impacts from the various project phases.

7.1.1 Good Engineering Practice

For general construction, operational and decommissioning activities the following good engineering practice should be applied:

- All diesel powered equipment must be regularly maintained and kept at a high level of maintenance. This must particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment must serve as trigger for withdrawing it for maintenance.
- To minimise noise generation, vendors can be required to guarantee optimised equipment design noise levels for example the RopeCon/RailCon electrical drive motors.
- During the planning and design stages of the project, possibly related noise aspects should always be kept in mind. The enclosure of major sources of noise, such as compressor or pump systems, must be included in the design process, since they represent basic good engineering practice.
- Vibrating screens structures are known to be noisy and good design philosophies should be followed for equipment of this nature. The mentioned equipment must be installed on vibration isolating mountings.
- By enclosing the tipper discharge and lowering the conveyor drop height, noise emissions may be reduced. Mechanical and electrical design also influences the amount of noise from stacking and reclaiming operations.
- Re-locate noise sources to less sensitive areas to take advantage of distance and shielding.
- Site permanent facilities away from community areas if possible.
- Develop a mechanism to monitor noise levels, record and respond to complaints and mitigate impacts.

7.1.2 Operational Hours

It is recommended that, as far is as practicable, noise generating activities such as maintenance and construction, be limited to day-time hours (considered to be between 07:00 and 22:00) since noise impacts are often most significant during the night.

7.1.3 Blasting

Predicting the noise caused by blasting events is a highly complex and unreliable process that depends on various factors. Blasting at the surface will be audible over long distances and may cause a startling reaction at receptors in close proximity.

This can be mitigated by adhering to blast schedules that have been communicated to the affected parties. The best approach to the control of blasting noise is proper blast design. The air overpressure can be controlled trough proper, charge mass, stemming height and type, burden to blast hole ratios and the combined effect of burden, spacing and blast timing control.

Very little information was available with respect to blasting and noise impacts could not be quantified. It is recommended that blasting be assessed in more detail as an addendum to this report once blast design detail becomes available.

7.1.4 Noise Management Zone

It is recommended that a noise management zone of be considered around the operations. This area should corresponds to the area over which noise levels may result in annoyance i.e. complaints and occasional community action. Complaints and noise levels in this area should be recorded and monitored and results communicated to interested and affected parties.

7.1.5 Tourism within the Khan River valley

It is likely that as activities within the Khan River valley increase, the number of overnight to the area where the infrastructure corridor crosses the valley will reduce. Tourism offsets should be considered to encourage overnight visitors to visit other, less impacted parts of the Khan River valley.

7.2 Noise Monitoring

It is recommended that, should the project continue, ambient noise measurements be conducted during the construction, operational and decommissioning phases to assess and confirm the impact area. Specific attention should be paid to noise levels at Arandis, the Arandis airport, the Khan Mine and at noise sensitive receptors within the Khan River valley.

The frequency of noise monitoring as well as the parameters that should be determined are summarised in Table 7-1. Locations, identified by Dracoulides (Dracoulides, 2010) at which monitoring should be conducted are shown in Figure 5-4.

In addition to the measurement of sound pressure levels, the 3rd octave band frequency spectra should also be recorded. Frequency spectrum data can provide useful insight into the nature of recorded sound pressure levels and assist with distinguishing between potential sources of noise that contribute to noise levels at a certain location. Source noise measurements could be conducted to confirm equipment manufacturer sound power data and assumed sound power data used in the current study.

Table 7-1: Proposed monitoring plan

Proposed Monitoring Plan	
Parameters to be Measured	**Frequency**
L_{Aeq}(1 hour) between 07:00 and 22:00	One campaign during the construction of the transfer terminal One campaign during the construction of infrastructure within the Khan River valley One campaign per year of operation
L_{Aeq}(1 hour) between 22:00 and 07:00	One campaign per year of operation
L_{Zeq} (T) during a blast event	During as many blast events as possible but at least 2 campaigns
3rd Octave band frequency spectrum	During every campaign

8 Conclusions

Airshed was appointed by Aurecon and SLR to undertake a Noise Impact Assessment for the infrastructure corridor component of the Rössing Uranium Ltd Z20 Project.

The main findings of the baseline assessment are as follows:

- The closest areas of residence (noise sensitive receptors) are Arandis Airport and the Khan Mine situated approximately 3 km and 4 km from proposed activities respectively. Visitors to the Khan River valley will also be affected.
- Ground cover in the study area is considered 'acoustically hard' and reflective i.e. providing no noise attenuation.
- The prevailing wind field indicate that day-time noise impacts will most likely be most significant to north-east and night-time impacts to the south-west.
- An increase of 3 dB in ambient noise level is considered the indicator of noise impacts. This is the level at which individuals with average hearing acuity would be able to detect a change in noise level.
- Baseline day and night-time noise levels at noise sensitive receptors located on the plains of 45 dBA and 35 dBA respectively were calculated from available baseline noise data.
- A baseline day and night-time noise level of 30 dBA within the Khan River valley was reported.

The main findings of the impact assessment are as follows:

- A conservative approach was followed in the estimation of predicted noise impacts. Impacts were predicted for the day- and night-time hour during which noise impacts would be most significant.
- Construction and decommissioning phase noise impacts are likely to be similar.
- The increase in noise level over reported baseline noise levels were:
  - For the construction phase (day-time only), between 1.9 and 5 km during the day.
  - For the operational phase:
    - Between 500 m and 2.5 km during the day; and
    - Between 1.4 km and 1.7 km during the night.
- The significance of cumulative noise impacts at noise sensitive receptors located on the plains to the north of the Khan River is "Very Low (-)".
- The significance of cumulative noise impacts on visitors to Khan River valley close to the infrastructure corridor crossing is "Medium (-)" to "High (-)" due to very quiet surroundings.
- Overall, with noise mitigation and management measures in place, impacts may be reduced to range between "Very Low (-)" and "Medium (-)".

9 References

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10 Appendix A – Impact Significance Methodology

A standardised and internationally recognised methodology[2] has been applied to assess the significance of the potential environmental impacts of Rössing Uranium's project

For each impact, the EXTENT (spatial scale), MAGNITUDE (size or degree scale) and DURATION (time scale) is be described. These criteria are used to ascertain the SIGNIFICANCE of the impact, firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place. Namibia's Environmental Assessment Policy requires that, "as far as is practicable", cumulative environmental impacts should be taken into account in all environmental assessment processes. The impact significance criteria and its interpretation from an **environmental noise perspective** is summarised in Appendix A.

Table 10-1: Extent or spatial influence of impact

Extent or Spatial Influence of Impact		
Category	**Description**	**Interpretation from an Environmental Noise Perspective**
National	Within Namibia	Not applicable
Regional	Within the Erongo Region	Not applicable
Local	On-site or within 100 m of the Impact Site	On- or near site, not at any noise sensitive receptors

Table 10-2: Magnitude of impact at the indicated special scale

Magnitude of Impact at the Indicated Special Scale		
Category	**Description**	**Interpretation from an Environmental Noise Perspective**
High	Social and/or natural functions and/ or processes are severely altered	More than 15 dBA increase in environmental noise level at the nearest noise sensitive receptor i.e. serious complains and reaction expected

[2] As described, *inter alia*, in the South African Department of Environmental Affairs and Tourism's Integrated Environmental Management Information Series (Government of SA, 2004).

Magnitude of Impact at the Indicated Special Scale		
Medium	Social and/or natural functions and/ or processes are notably altered	5 to 15 dBA increase in environmental noise level at the nearest noise sensitive receptor
Low	Social and/or natural functions and/ or processes are slightly altered	3 to 5 dBA increase in environmental noise level at the nearest noise sensitive receptor
Very Low	Social and/or natural functions and/ or processes are negligibly altered	Less than 3 dBA increase in environmental noise level at the nearest noise sensitive receptor
Zero	Social and/or natural functions and/ or processes remain unaltered	Not applicable

Table 10-3: Duration of impact

Duration of Impact		
Category	**Description**	**Interpretation from an Environmental Noise Perspective**
Short Term	Up to 3 years	Construction Phase
Medium Term	4 to 10 years after construction	Not applicable
Long Term	More than 10 years after construction	Operational Phase

The SIGNIFICANCE of an impact is derived by taking into account the temporal and spatial scales as well as magnitude. The means of arriving at the different significance ratings is explained in the following table, developed by Ninham Shand in 1995 as a means of minimising subjectivity in such evaluations, i.e. to allow for standardisation in the determination of significance.

Table 10-4: Significance rating

Significance Rating	
Category	**Description**
High	High magnitude with a regional extent and long term duration High magnitude with either a regional extent and medium term duration or a

Significance Rating	
	local extent and long term duration Medium magnitude with a regional extent and long term duration
Medium	High magnitude with a local extent and medium term duration High magnitude with a regional extent and construction period or a site specific extent and long term duration High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term Low magnitude with a regional extent and long term duration
Low	High magnitude with a site specific extent and construction period duration Medium magnitude with a site specific extent and construction period duration Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term Very low magnitude with a regional extent and long term duration
Very Low	Low magnitude with a site specific extent and construction period duration Very low magnitude with any combination of extent and duration except regional and long term
Medium	Zero magnitude with any combination of extent and duration

Once the significance of an impact has been determined, the PROBABILITY of this impact occurring as well as the CONFIDENCE in the assessment of the impact is determined using the rating systems outlined in the following two tables. It is important to note that the significance of an impact should always be considered in concert with the probability of that impact occurring.

Table 10-5: Probability rating

Probability of Impact		
Category	**Description**	**Interpretation from an Environmental Noise Perspective**
Definite	Estimated greater than 95% chance of the	Not applicable

Probability of Impact		
	impact occurring	
Probable	Estimated 5 to 95% chance of the impact occurring	Considered the appropriate probability rating for predicted noise impacts
Unlikely	Estimated less than 5% chance of the impact occurring	Not applicable

Table 10-6: Confidence rating

Confidence Rating		
Category	**Description**	**Interpretation from an Environmental Noise Perspective**
Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact.	Not applicable
Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.	Considered the appropriate confidence rating for predicted operational phase noise impacts
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact.	Considered the appropriate confidence rating for predicted construction phase noise impacts

Lastly, the REVERSIBILITY of the impact is estimated using the rating system outlined in the following table.

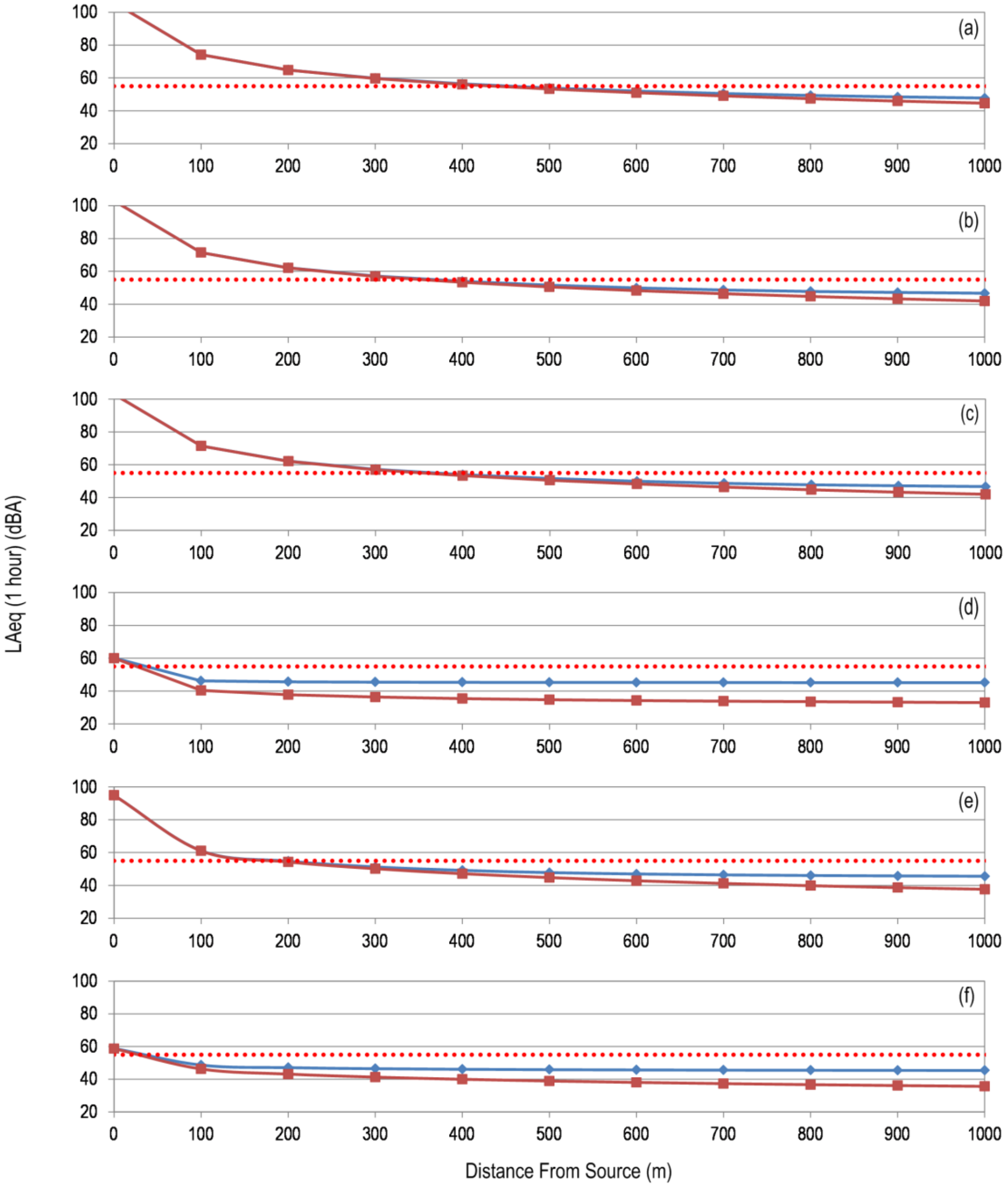
Table 10-7: Reversibility rating

Reversibility Rating		
Category	**Description**	**Interpretation from an Environmental Noise Perspective**
Irreversible	The activity will lead to an impact that is permanent	Not applicable

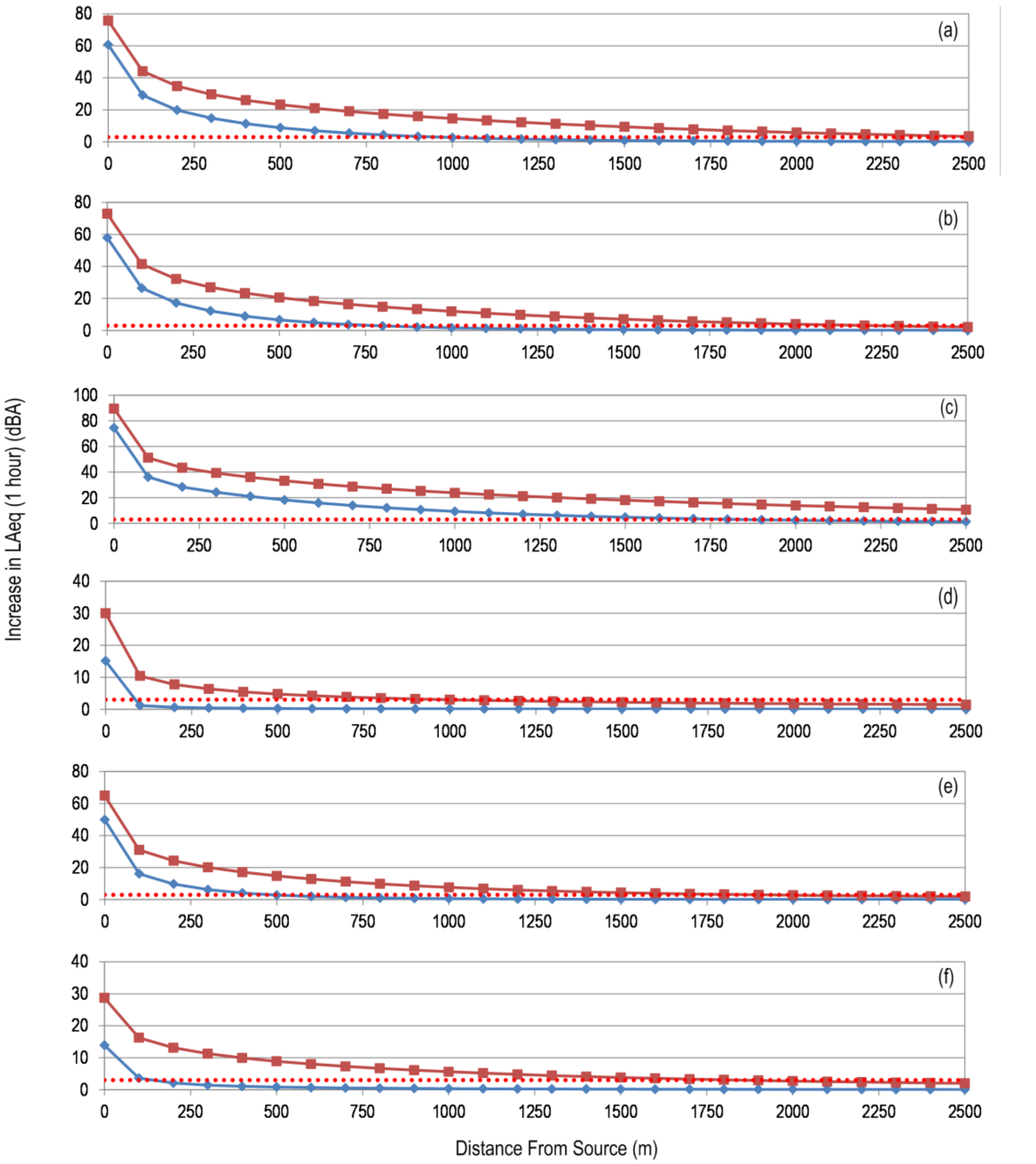
Reversibility Rating		
Reversible	The impact is reversible, within a period of 10 years	The impact is reversible, within a period of 10 years

11 Appendix B – Source Group Contributions to Predicted Cumulative Noise Levels

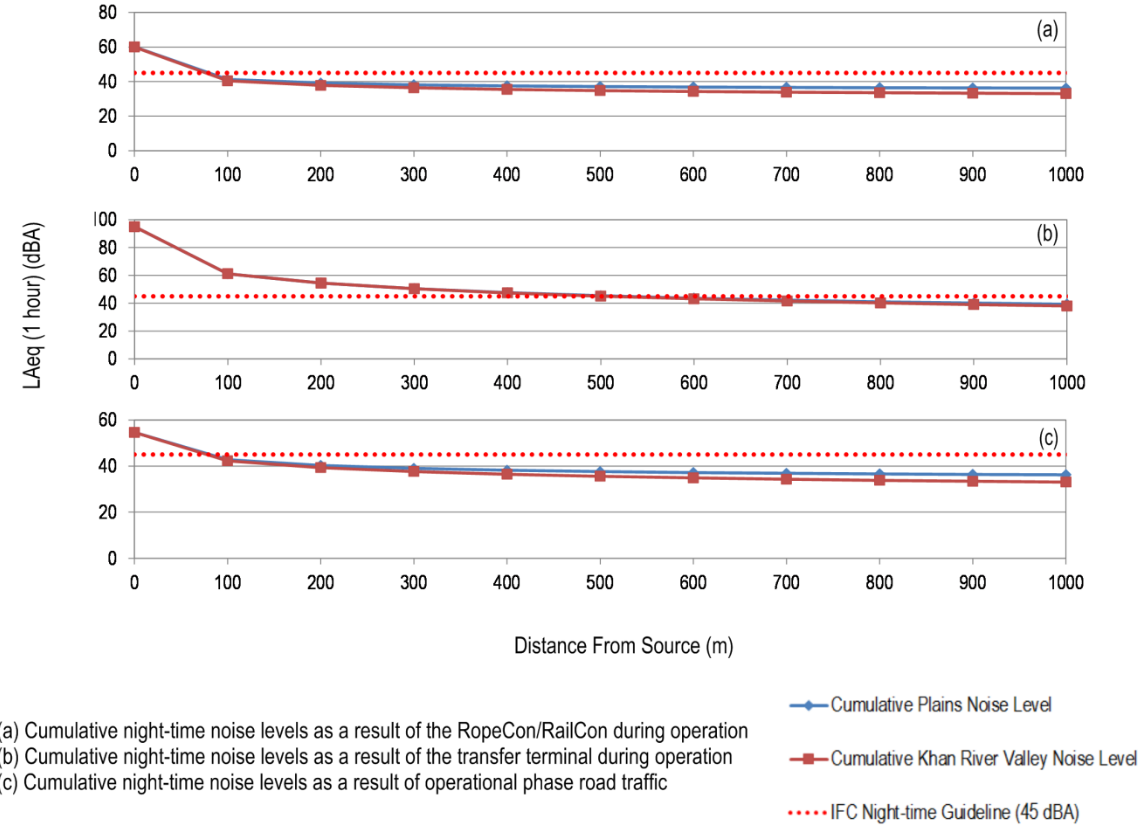
Source group contributions to cumulative noise levels are graphically presented in this appendix.



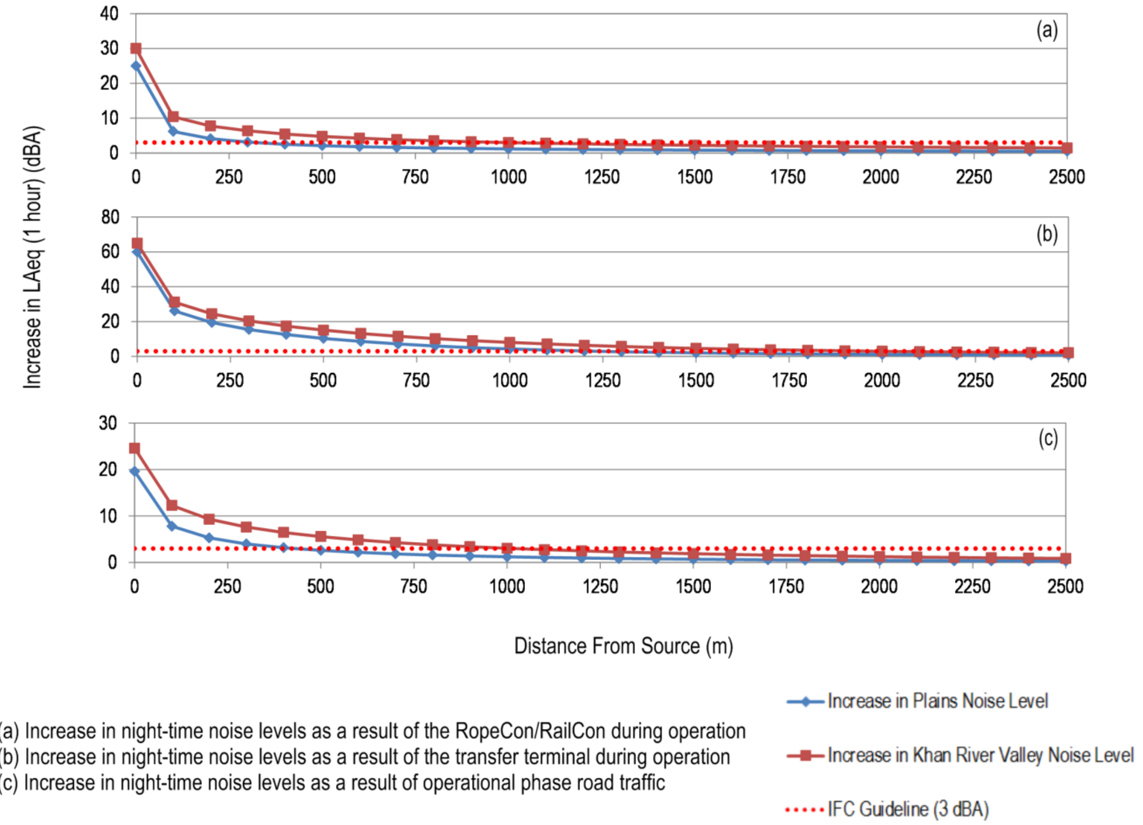
(a) Cumulative day-time noise levels as a result of road construction
(b) Cumulative day-time noise levels as a result of RopeCon/RailCon construction
(c) Cumulative day-time noise levels as a result of helicopter use
(d) Cumulative day-time noise levels as a result of the RopeCon/RailCon during operation
(e) Cumulative day-time noise levels as a result of the transfer terminal during operation
(f) Cumulative day-time noise levels as a result of operational phase road traffic



(a) Increase in day-time noise levels as a result of road construction
(b) Increase in day-time noise levels as a result of RopeCon/RailCon construction
(c) Increase in day-time noise levels as a result of helicopter use
(d) Increase in day-time noise levels as a result of the RopeCon/RailCon during operation
(e) Increase in day-time noise levels as a result of the transfer terminal during operation
(f) Increase in day-time noise levels as a result of operational phase road traffic



(a) Cumulative night-time noise levels as a result of the RopeCon/RailCon during operation
(b) Cumulative night-time noise levels as a result of the transfer terminal during operation
(c) Cumulative night-time noise levels as a result of operational phase road traffic



(a) Increase in night-time noise levels as a result of the RopeCon/RailCon during operation
(b) Increase in night-time noise levels as a result of the transfer terminal during operation
(c) Increase in night-time noise levels as a result of operational phase road traffic