Environmental Noise Impact Assessment for the Proposed Osino Gold Mine Near Karibib in Namibia

Project done for **Environmental Compliance Consultancy**

Report compiled by:
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Report Details

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Revision Record

Version	Date	Comments
Rev 0	August 2021	For client review
Rev 0.1	August 2021	Update of site layout

Glossary and Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
dB	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure.
dBA	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 to simulate human hearing.
ECC	Environmental Compliance Consultancy
Hz	Frequency in Hertz
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Standards Organisation
K1	Noise propagation correction for geometrical divergence
K2	Noise propagation correction for atmospheric absorption
K3	Noise propagation correction for the effect of ground surface;
K4	Noise propagation correction for reflection from surfaces
K5	Noise propagation correction for screening by obstacles
kW	Power in kilowatt
L_{Aeq} (T)	The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
L_{AIeq} (T)	The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
$L_{Req,d}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.
$L_{Req,n}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.
$L_{R,dn}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10 dB in order to account for the additional disturbance caused by noise during the night.
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_{A90}) (in dBA)
L_{AFmax}	The A-weighted maximum sound pressure level recorded during the measurement period
L_{AFmin}	The A-weighted minimum sound pressure level recorded during the measurement period
L_P	Sound pressure level (in dB)
Ltd	Limited
L_W	Sound Power Level (in dB)
masl	Meters above sea level
NACA	National Association for Clean Air
NEMAQA	National Environmental Management Air Quality Act
NSR	Noise sensitive receptor

p	Pressure in Pa
Pa	Pressure in Pascal
μPa	Pressure in micro-pascal
p_{ref}	Reference pressure, 20 μPa
Pty	Proprietary
ROM	Run of Mine
SABS	South African Bureau of Standards
SACNASP	South African Council for Natural Scientific Professions
SANS	South African National Standards
SLM	Sound Level Meter
STRM	Shuttle Radar Topography Mission
tpa	Tonnes per annum
USGS	United States Geological Survey
WHO	World Health Organisation
%	Percentage

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Compliance Consultancy (ECC) to undertake a specialist environmental noise impact study for the proposed Osino Gold Mine near Karibib in Namibia (hereafter referred to as the project).

The main objective of the noise specialist study was to determine the potential impact on the acoustic environment and noise sensitive receptors (NSRs) as a result of the proposed project and to recommend suitable management and mitigation measures.

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps and field observations.
    b. A study of environmental noise attenuation potential by referring to land use and topography data sources.
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from the survey conducted on the 7th to 8th of April 2021.
4. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Noise propagation simulations to determine environmental noise levels as a result of the project activities.
    c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist noise impact assessment report.

In the assessment of simulated noise levels, reference was made to the IFC noise level guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night) which is also in line with the SANS 10103 rating for urban districts.

The baseline acoustic environment was described in terms of the location of NSRs, the ability of the environment to attenuate noise over long distances, as well as existing background and baseline noise levels. The baseline noise levels were measured at seven sites and were co-located with potential NSRs.

Noise emissions from mobile and non-mobile equipment were estimated using L_W predictions for industrial machinery (Bruce & Moritz, 1998), where L_W estimates are a function of the power rating of the equipment engine. Numerous noise source L_W's for operations at the Osino Mine plant was obtained from a database for similar operations. Values from the database are based on source measurements carried out in accordance with the procedures specified in SANS 10103.

The source inventory, local meteorological conditions and information on local land use were used to populate the noise propagation model (CadnaA, ISO 9613).

Based on the findings of the assessment, IFC guidelines may be exceeded at NSRs closest to the project operations (i.e. NSR 1 to the south of the Twin Hills pit and NSR 4 to the north of the Osino plant). The overall increase in noise levels due to the project operations, is expected to result in 'strong' reaction from NSR 1 and NSR2. It is the specialist's opinion that the project may be authorised provided that noise management measures are implemented to ensure that IFC noise guidelines for residential areas are met at NSR 1 and NSR 4. If it is not possible to meet IFC noise guidelines for residential areas at these receptors with noise attenuation measures in place, consideration needs to be made to purchase these farms. A complaints register must be kept throughout the life of the operations, including during the construction of the project.

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1 Introduction

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Compliance Consultancy (ECC) to undertake a specialist environmental noise impact study for the proposed Osino Gold Mine near Karibib in Namibia (hereafter referred to as the project).

1.1 Study Objective

The main objective of the noise specialist study was to determine the potential impact on the acoustic environment and noise sensitive receptors (NSRs) as a result of the operations at the project site and to recommend suitable management and mitigation measures.

1.2 Scope of Work

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

7. A review of available technical project information.
8. A review of the legal requirements and applicable environmental noise guidelines.
9. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps and field observations.
    b. A study of environmental noise attenuation potential by referring to land use and topography data sources.
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from the survey conducted on the 7th to 8th of April 2021.
10. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Noise propagation simulations to determine environmental noise levels as a result of the project activities.
    c. The screening of simulated noise levels against environmental noise criteria.
11. The identification and recommendation of suitable mitigation measures and monitoring requirements.
12. The preparation of a comprehensive specialist noise impact assessment report.

1.3 Specialist Details

1.3.1 Specialist Details

Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

1.3.2 Competency Profile of Specialist

Reneé von Gruenewaldt is a Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP) and a member of the National Association for Clean Air (NACA).

Following the completion of her bachelor's degree in atmospheric sciences in 2000 and honours degree (with distinction) with specialisation in Environmental Analysis and Management in 2001 at the University of Pretoria, her experience in air pollution started when she joined Environmental Management Services (now Airshed Planning Professionals) in 2002. Reneé von Gruenewaldt later completed her master's degree (with distinction) in Meteorology at the University of Pretoria in 2009.

Reneé von Gruenewaldt became a partner of Airshed Planning Professionals in September 2006. Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering, and strategic impact assessments and management services and policy support to assist clients in addressing a wide variety of air pollution and environmental noise related assessments.

She has experience on the various components of environmental noise assessments from 2015 to present. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to noise impacts.

A comprehensive curriculum vitae of Reneé von Gruenewaldt is provided in Appendix A.

1.4 Description of Activities from a Noise Perspective

As is typical of opencast mining and ore processing facilities, sources of noise at the project site will include the following:

- Drilling
- Blasting;
- Ore and waste handling (loading, unloading, dozing) in open pits, on waste dumps, crusher/plant area;
- Crushing and screening of ore;
- Haul truck traffic;
- Diesel mobile equipment use (including reverse warnings); and,
- Ore processing activities such as crushing, screening and milling.

Whereas ore processing activities generate noise fairly constantly; drilling, blasting, ore and waste handling, transport activities and operating diesel mobile equipment generate noise that is intermittent and highly variable spatially.

The biggest determinant of noise impacts from operations will be the spatial distribution of noise sources and to a lesser extent mining rates and fleet size due to the non-linear cumulative nature of sound pressure levels (see

Section 1.5.3). Taking into consideration the above in addition to the location of potential NSRs in relation to operational areas, two operational scenarios were considered.

Although not assessed as part of this study, the character of noise generated by blasting is mentioned. Blasting can cause noise and vibration, which can have an impact upon neighbouring noise receptors. Blasting usually results in both ground and airborne vibration. The latter includes both audible noise and vibration known as airblast, which can cause objects to rattle and make noise. Annoyance and discomfort from blasting can occur when noise startles individuals or when airblast or ground vibration causes vibration of building elements such as windows. The degree of annoyance is influenced by the level of airblast and vibration as well as factors such as the time of day, the frequency of occurrence and the sensitivity of individuals. The generation and transmission of airblast and ground vibration is affected by a number of factors including blast design, meteorology (particularly wind speed and direction and temperature inversions), topography, geology and soil water content **Invalid source specified.**. Whereas the audible part of the airblast (acoustic) is characterized by frequencies ranging from 20 to 20 000 Hz the non-audible part, consist of sound energy below 20 Hz and is referred to as an 'over pressure' when the air blast pressure exceeds atmospheric pressure. Airblast over pressure exerts a force on structures and may in turn cause secondary and audible rattles within structures such as windows **Invalid source specified.**.

1.5 Background to Environmental Noise and the Assessment Thereof

Before more details regarding the approach and methodology adopted in the assessment is given, the reader is provided with some background, 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.

A direct application of linear scales (in pascal (Pa)) to the measurement and calculation of sound pressure leads to large and unwieldy numbers. As the ear responds logarithmically rather than linearly to stimuli, it is more practical to express acoustic parameters as a logarithmic ratio of the measured value to a reference value. This logarithmic ratio is called a decibel or dB. The advantage of using dB can be clearly seen in Figure 1. Here, the linear scale with its large numbers is converted into a manageable scale from 0 dB at the threshold of hearing (20 micro-pascals (µPa)) to 130 dB at the threshold of pain (~100 Pa) (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

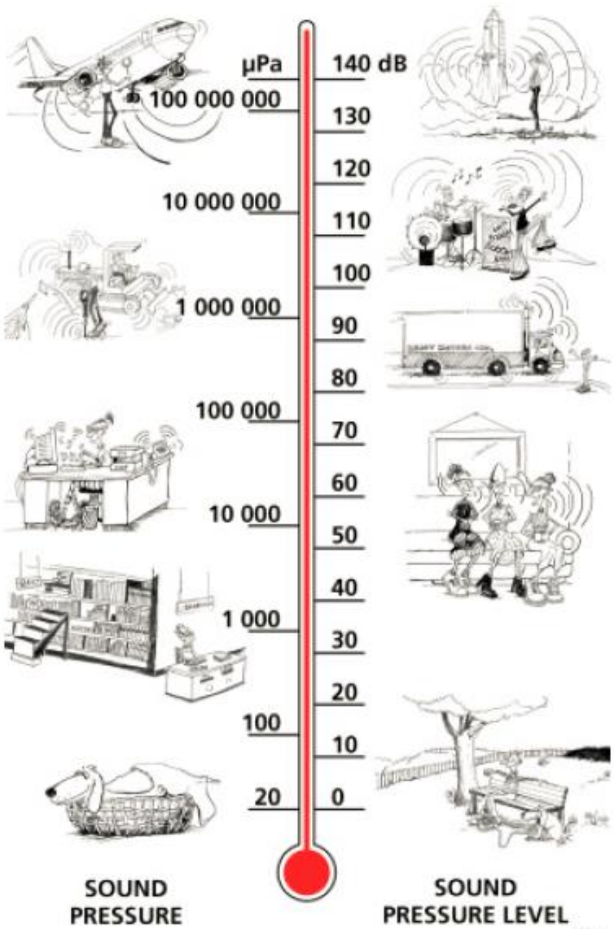


Figure 1: The decibel scale and typical noise levels (Brüel & Kjær Sound & Vibration Measurement A/S, 2000)

As explained, noise is reported in 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 this equation.

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

Where:

L_p *is the sound pressure level in dB;*

p *is the actual sound pressure in Pa; and*

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

1.5.1 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 frequency of a young, healthy person ranges between 20 Hz and 20 000 Hz.

In terms of L_P, audible sound ranges from the threshold of hearing at 0 dB to the pain threshold of 130 dB and above. Even though an increase 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).

1.5.2 Frequency Weighting

Since 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 (Figure 2). "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) and have been A-weighted.

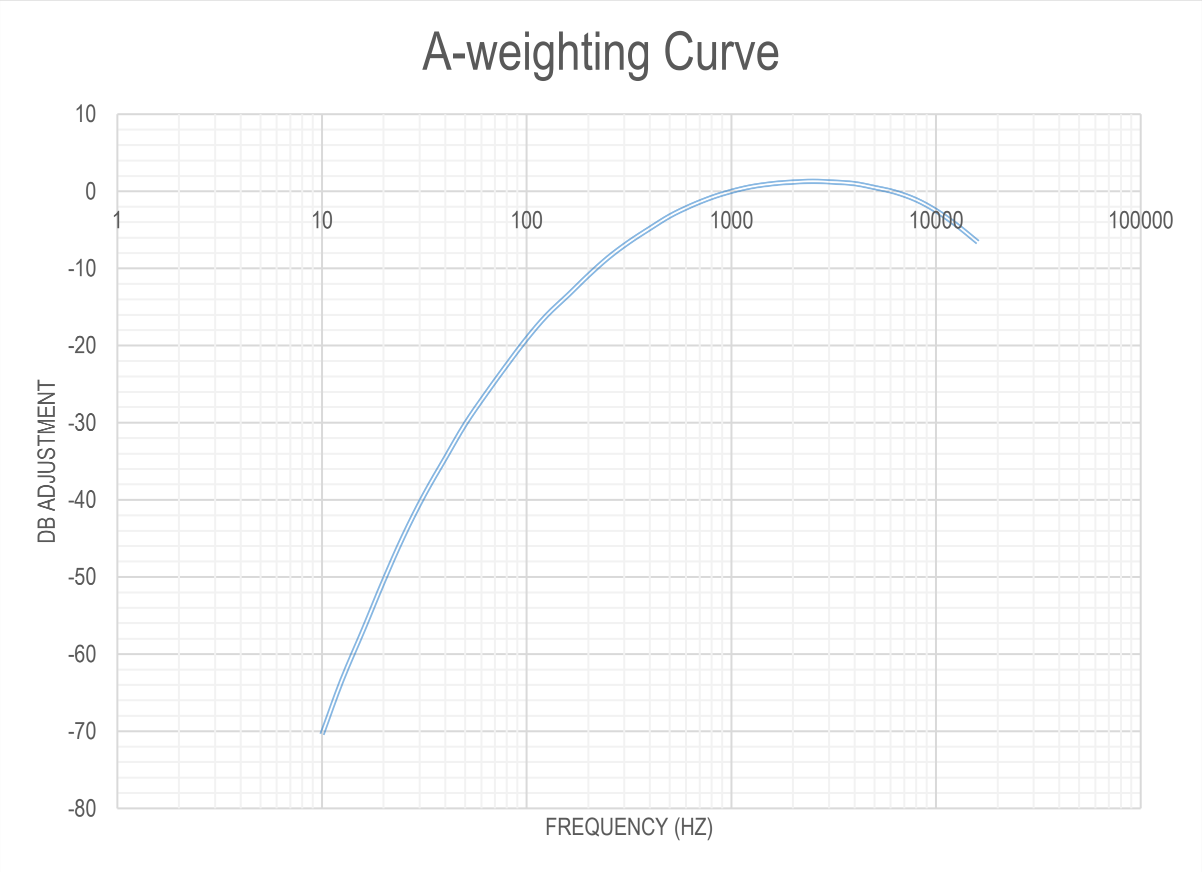


Figure 2: A-weighting curve

1.5.3 Adding Sound Pressure Levels

Since sound pressure levels are logarithmic values, the sound pressure levels as a result of two or more sources cannot 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:

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

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).

1.5.4 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 (L_W);
- The distance between the source and the receiver;
- Atmospheric conditions (wind speed and direction, temperature and temperature gradient, humidity etc.);
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption; and
- Reflections.

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).

1.5.5 Environmental Noise Indices

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

- **L_{Aeq} (T)** – The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).
- **L_{AIeq} (T)** – The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). In the South African Bureau of Standards' (SABS) South African National Standard (SANS) 10103 of 2008 for *'The measurement and rating of environmental noise with respect to annoyance and to speech communication'* prescribes the sampling of L_{AIeq} (T).
- **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_{AFmax}** – The maximum A-weighted noise level measured with the fast time weighting. It's the highest level of noise that occurred during a sampling period.
- **L_{AFmin}** – The minimum A-weighted noise level measured with the fast time weighting. It's the lowest level of noise that occurred during a sampling period.

1.6 Approach and Methodology

The assessment included a study of the legal requirements pertaining to environmental 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 (L_W's) (noise 'emissions') and sound pressure levels (L_P's) (noise impacts) associated with the operational phase. The findings of the assessment components informed recommendations of management measures, including mitigation and monitoring. Individual aspects of the noise impact assessment methodology are discussed in more detail below.

1.6.1 Information Review

An information requirements list was sent to ECC at the onset of the project. In response to the request, the following information was supplied:

- Georeferenced project layout;
- Process description;
- Mining schedule; and,
- Project equipment details.

1.6.2 Review of Assessment Criteria

In the absence of local guidelines and standards, this study refers to noise level guidelines published by the International Finance Corporation (IFC) in their '*General Environmental, Health, and Safety (EHS) Guidelines'* (IFC, 2007), as well as South African National Standard (SANS) 10103 (2008) '*The measurement and rating of environmental noise with respect to annoyance and to speech communication'*. The latter has been widely applied in neighbouring South Africa and is frequently used by local authorities when investigating noise complaints.

1.6.3 Study of the Receiving Environment

NSRs generally include private residences, community buildings such as schools, hospitals and any publicly accessible areas.

The ability of the environment to attenuate noise as it travels through the air was studied by considering land use and terrain.

Readily available terrain data was obtained from the United States Geological Survey (USGS) web site (https://earthexplorer.usgs.gov/) accessed in August 2021. A study was made of Shuttle Radar Topography Mission (STRM) 1 arc-sec data.

1.6.4 Noise Survey

The extent of noise impacts as a result of an intruding noise depends largely on existing noise levels in an area. Higher ambient noise levels will result in less noticeable noise impacts and a smaller impact area. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels. The data from a baseline noise survey conducted on the 7th and 8th of April 2021 was studied to determine current noise levels within the area.

The survey methodology, which closely followed guidance provided by the IFC (2007) and SANS 10103 (2008), is summarised below:

- The survey was conducted by ECC under the guidance of a trained specialist.
- Sampling was carried out using a Type 1 sound level meter (SLM) that meet all appropriate International Electrotechnical Commission (IEC) standards and is subject to calibration by an accredited laboratory (Appendix C). Equipment details are included in Table 1.
- The acoustic sensitivity of the SLM was tested with a portable acoustic calibrator before and after each sampling session.
- Samples representative and sufficient for statistical analysis were taken with the use of the portable SLM capable of logging data continuously over the sampling time period.
- L_{Aleq} (T), L_{Aeq} (T); L_{AFmax}; L_{AFmin}; L_{90} and octave frequency spectra were recorded.
- The SLM was located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- SANS 10103 states that one must ensure (as far as possible) that the measurements are not affected by the residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer.
- A detailed log and record were kept. Records included site details, weather conditions during sampling and observations made regarding the acoustic environment of each site.

Table 1: Sound level meter details

Equipment	Serial Number	Purpose	Last Calibration Date
Svantek 977 sound level meter	S/N 36183	Noise sampling.	1,2 March 2021
Svantek 7052E ½" microphone	S/N 78692		
Svantek SV 12L ½" pre-amplifier	S/N 40659		
SVANTEK SV33 Class 1 Acoustic Calibrator	S/N 43170	Testing of the acoustic sensitivity before and after each daily sampling session.	2 March 2021
Kestrel 4000 Pocket Weather Tracker	S/N 559432	Determining wind speed, temperature and humidity during sampling.	Not Applicable

1.6.5 Source Inventory

To determine the change in noise impacts associated with the project, a source inventory had to be developed. A list of mobile and stationary equipment was made available for the study. L_W's for these were calculated using predictive equations for industrial machinery as per the Handbook of Acoustics, Chapter 69, by Bruce and Moritz (1998).

Numerous noise source L_W's for operations at the Osino Mine plant was obtained from a database for similar operations. Values from the database are based on source measurements carried out in accordance with the procedures specified in SANS 10103.

Estimates of road traffic were made given mining rates and assumed vehicle speeds and road conditions.

1.6.6 Noise Propagation Simulations

The propagation of noise from proposed activities was simulated with the DataKustic CadnaA software. Use was made of:

(a) The International Organisation for Standardization's (ISO) 9613 module for outdoor noise propagation from industrial noise sources; and
(b) The German "Richtlinien für den Lamschutz an Straben" or RLS90 traffic noise module (for the access road).

1.6.6.1 ISO 9613

The propagation of noise from proposed activities was simulated with the DataKustic CadnaA software. Use was made of the International Organisation for Standardization's (ISO) 9613 module for outdoor noise propagation from industrial noise sources.

ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favourable to propagation from sources of known sound emission. These conditions are for downwind propagation or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

The method also predicts an average A-weighted sound pressure level. The average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions. The method specified in ISO 9613 consists specifically of octave-band algorithms (with nominal mid-band frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects: geometrical divergence, atmospheric absorption, ground surface effects, reflection and obstacles. A basic representation of the model is given in the equation below:

$$L_P = L_W - \sum[K_1, K_2, K_3, K_4, K_5, K_6]$$

Where;

> ***L_P*** *is the sound pressure level at the receiver;*
> ***L_W*** *is the sound power level of the source;*
> ***K_1*** *is the correction for geometrical divergence;*
> ***K_2*** *is the correction for atmospheric absorption;*
> ***K_3*** *is the correction for the effect of ground surface;*
> ***K_4*** *is the correction for reflection from surfaces; and*
> ***K_5*** *is the correction for screening by obstacles.*

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources.

To apply the method of ISO 9613, several parameters need to be known with respect to the geometry of the source and of the environment, the ground surface characteristics, and the source strength in terms of octave-band sound power levels for directions relevant to the propagation.

1.6.6.2 RLS90

The RLS90 road traffic noise module included in CadnaA requires average hourly traffic flow, separated into heavy and light vehicles, the average speed for each group, the dimension, geometry and type of the road and of any natural and artificial obstacles. As with ISO 9613, the module also takes also into account the main features which influence the propagation of noise namely obstacles, vegetation, air absorption, reflections and diffraction.

1.6.6.3 Simulation Domain

If the dimensions of a noise source are small compared with the distance to the listener, it is called a point source. All sources were quantified as point sources or areas/lines represented by point sources. The sound energy from a point source spreads out spherically, so that the sound pressure level is the same for all points at the same distance from the source and decreases by 6 dB per doubling of distance. This holds true until ground and air attenuation noticeably affect the level. The impact of an intruding industrial noise on the environment will therefore rarely extend over more than 5 km from the source and is therefore always considered “local” in extent.

The propagation of noise was calculated over an area of 25 km east-west by 25 km north-south and encompasses the Osino Mine. The area was divided into a grid matrix with a 50 m resolution. NSRs and survey locations were included as discrete receptors. The model was set to calculate L_P’s at each grid and discrete receptor point at a height of 1.5 m above ground level.

1.6.7 Presentation of Results

Results are presented in tabular and isopleth form. An isopleth is a line on a map connecting points at which a given variable (in this case sound pressure, L_P) has a specified constant value. This is analogous to contour lines on a map showing terrain elevation. In the assessment of environmental noise, isopleths present lines of constant noise level as a function of distance.

Simulated noise levels were assessed according to guidelines published by the IFC. To assess annoyance at nearby places of residence, the increase in noise levels above the baseline at NSRs were calculated and compared to guidelines published in SANS 10103.

1.6.8 Recommendations of Management and Mitigation

The findings of the noise specialist study informed the recommendation of suitable noise management and mitigation measures.

1.7 Management of Uncertainties

The following limitations and assumptions should be noted:

- Estimates of road traffic were made with the provided material throughputs and haul truck capacities. The vehicle speeds and road conditions were assumed. Trucks were assumed to travel at 40 km/h on site.
- The mitigating effect of pit walls, buildings, and infrastructure acting as acoustic barriers were not taken into account providing a conservative assessment of the noise impacts off-site.
- The quantification of sources of noise was limited to the operational phase of the Osino Mine. Construction and closure phase activities are expected to be similar or less significant. Noise impacts will cease post-closure.
- All activities were assumed to be 24 hours per day, 7 days per week.
- Although other existing sources of noise within the area were identified, such sources were not quantified but were taken into account during the survey.
- Blast vibration and noise did not form part of the scope of work of this assessment.
- The environmental noise assessment focuses on the evaluation of impacts for humans.

2 Legal Requirements and Noise Level Guidelines

The IFC best practice guidelines were adopted in the absence of Namibian legislation.

2.1 International Finance Corporation Guidelines on Environmental Noise

The IFC General Environmental Health and Safety Guidelines on noise address impacts of noise beyond the property boundary of the facility under consideration and provides noise level guidelines.

The IFC states that noise impacts **should not exceed the levels presented in Table 2**, or result in a maximum **increase above background levels of 3 dBA** at the nearest receptor location off-site (IFC, 2007). For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. Δ = 3 dBA is, therefore, a useful significance indicator for a noise impact.

It is further important to note that the IFC noise level guidelines for residential, institutional and educational receptors correspond with the SANS 10103 guidelines for urban districts.

Table 2: IFC noise level guidelines

Area	One Hour L_{Aeq} (dBA) 07:00 to 22:00	One Hour L_{Aeq} (dBA) 22:00 to 07:00
Industrial receptors	70	70
Residential, institutional and educational receptors	55	45

2.2 South African National Standards

In South Africa, provision is made for the regulation of noise under the National Environmental Management Air Quality Act (NEMAQA) (Act. 39 of 2004) but legally enforceable environmental noise limits have yet to be set. It is believed that when published, national criteria will make extensive reference to the South African Bureau of Standards (SABS) standard SANS 10103 (2008) *'The measurement and rating of environmental noise with respect to annoyance and to speech communication'.* This standard has been widely applied in South Africa and is frequently used by local authorities when investigating noise complaints. The standard is also fully aligned with the WHO guidelines for Community Noise (WHO, 1999). It should be noted that the values given in Table 3 are typical rating levels that it is recommended should not be exceeded outdoors in the different districts specified. Outdoor ambient noise exceeding these levels will be annoying to the community.

Table 3: Typical rating levels for outdoor noise

Type of district	Equivalent Continuous Rating Level ($L_{Req,T}$) for Outdoor Noise		
	Day/night $L_{R,dn}$[(c)] (dBA)	Day-time $L_{Req,d}$[(a)] (dBA)	Night-time $L_{Req,n}$[(b)] (dBA)
Rural districts	45	45	35
Suburban districts with little road traffic	50	50	40
Urban districts	55	55	45
Urban districts with one or more of the following: business premises; and main roads.	60	60	50
Central business districts	65	65	55
Industrial districts	70	70	60

Notes

(a) $L_{Req,d}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.

(b) $L_{Req,n}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.

(c) $L_{R,dn}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.

SANS 10103 also provides a useful guideline for estimating community response to an increase in the general ambient noise level caused by intruding noise. If Δ is the increase in noise level, the following criteria are of relevance:

- "$\Delta \leq 0$ dB: There will be no community reaction;
- 0 dB < $\Delta \leq$ 10 dB: There will be 'little' reaction with 'sporadic' complaints;
- 5 dB < $\Delta \leq$ 15 dB: There will be a 'medium' reaction with 'widespread complaints'. Δ = 10 dB is subjectively perceived as a doubling in the loudness of the noise;
- 10 dB < $\Delta \leq$ 20 dB: There will be a 'strong' reaction with 'threats of community action'; and
- 15 dB < Δ: 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.

3 Description of the Receiving Environment

This chapter provides details of the receiving acoustic environment which is described in terms of:

- Local NSRs;
- The local environmental noise propagation and attenuation potential; and
- Current noise levels and the existing acoustic climate.

3.1 Noise Sensitive Receptors

Noise sensitive receptors generally include places of residence and areas where members of the public may be affected by noise generated by mining, processing and transport activities.

Potential noise sensitive receptors within the study area (Figure 3), include individual homesteads, industrial areas and residential areas (i.e. Usab and Karibib).

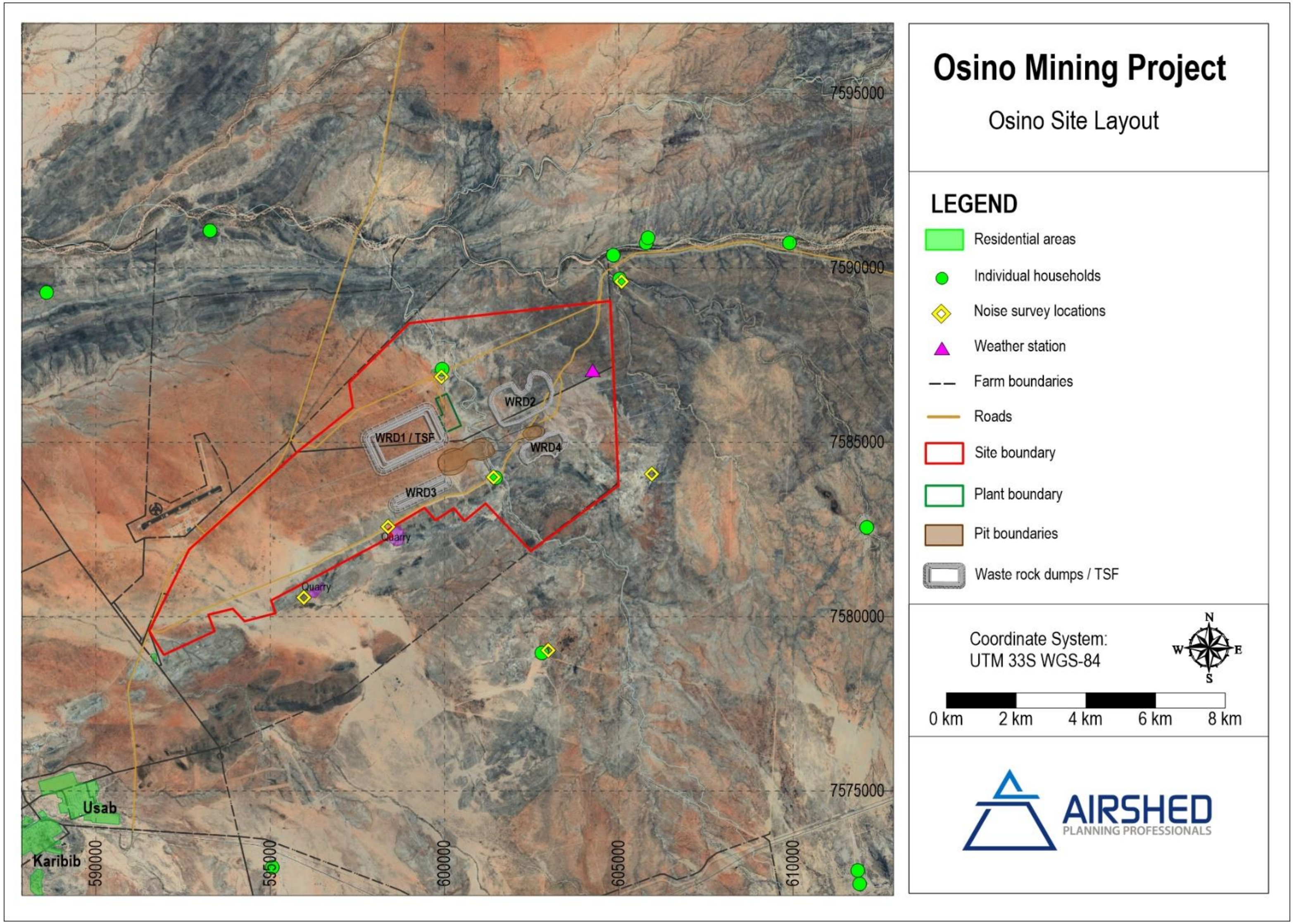


Figure 3: Osino site layout and sensitive receptors within the study area

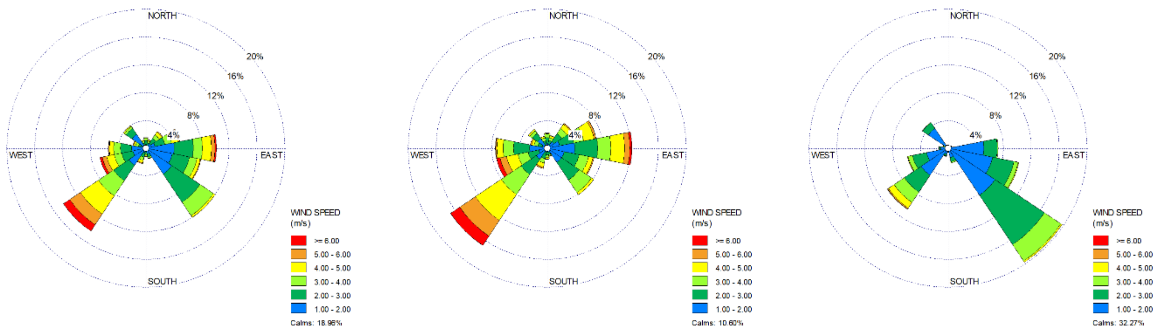
3.2 Environmental Noise Propagation and Attenuation potential

3.2.1 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to their role in the propagation on noise from a source to receiver (Section 1.5.4). The main meteorological parameters affecting the propagation of noise include wind speed, wind direction and temperature. These along with other parameters such as relative humidity, air pressure, solar radiation and cloud cover affect the stability of the atmosphere and the ability of the atmosphere to absorb sound energy.

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). It should be noted that at wind speeds of more than 5 m/s, ambient noise levels are mostly dominated by wind generated noise.

Meteorological data from an on-site station, for the period 23 July 2020 to 22 July 2021, was used for the assessment. The measured data set indicates wind flow primarily from the southwest (Figure 4 (a)). At night, the predominant wind direction shifts to the southeast. On average, noise impacts are expected to be more notable to the northwest and northeast of the project activities.



(a) Period average wind rose | (b) Day-time wind rose (07:00 – 22:00) | (d) Night-time wind rose (22:00 – 07:00)

Figure 4: Wind rose for on-site station for the period 23 July 2020 to 23 July 2021

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 notable during the night (Figure 5).

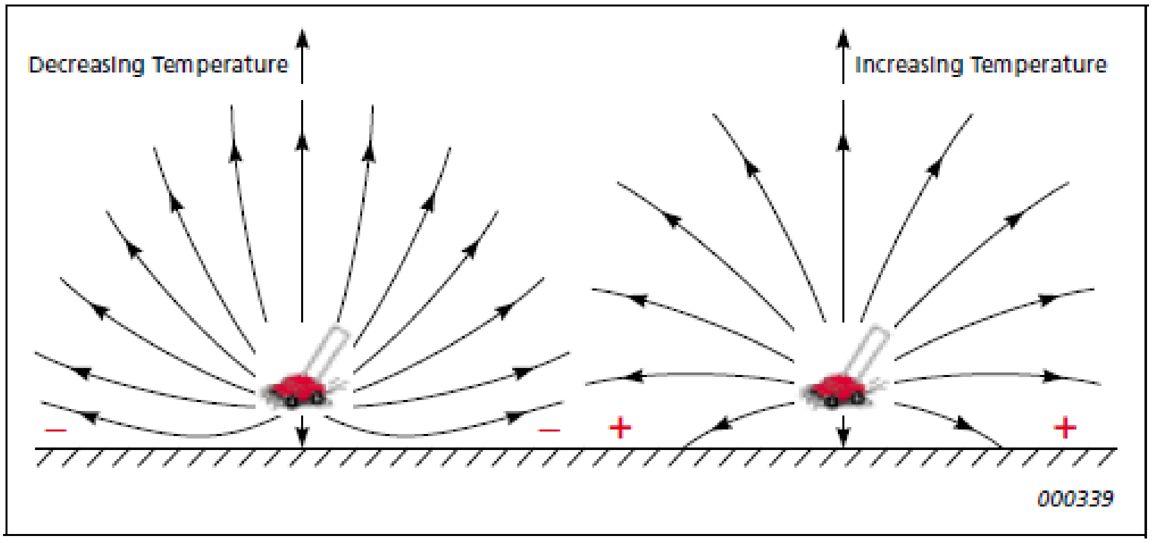


Figure 5: Bending the path of sound during typical day time conditions (image provided on the left) and night-time conditions (image provided on the right)

3.2.2 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (i.e. natural terrain, installed acoustic barrier, building) feature depends on two factors namely: the path difference of a sound wave as it travels over the barrier compared with direct transmission to the receiver and the frequency content of the noise (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Readily available terrain data was obtained from the United States Geological Survey (USGS) web site (https://earthexplorer.usgs.gov/) accessed in July 2021. A study was made of Shuttle Radar Topography Mission (STRM) 1 arc-sec data.

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 (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Based on observations, ground cover was found to be acoustically hard.

3.3 Survey Results

Survey sites were selected after careful consideration of future activities, accessibility, potential noise sensitive receptors, and safety restrictions. A total of seven survey sites were selected. The location of the noise survey sites is provided in Figure 6. Photographs of the sites are included in Appendix E.

Survey results for the campaign undertaken on the 7th and 8th of April 2021 are summarised in Table 4 and for comparison purposes, visually presented in Figure 7 (day-time results) and Figure 8 (night-time results).

For detailed time-series, frequency spectra and statistical results, the reader is referred to Appendix D.

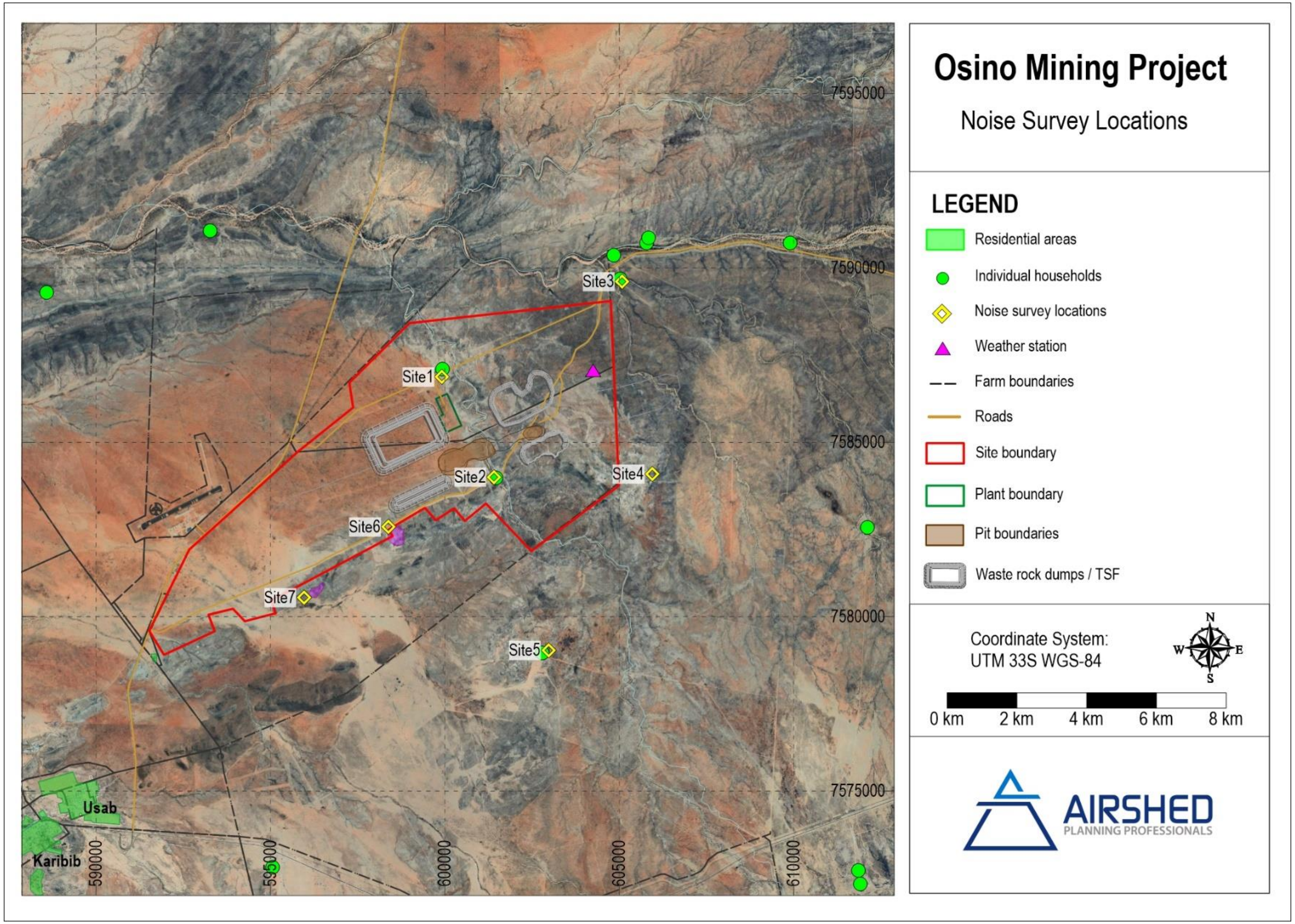


Figure 6: Locations of environmental baseline noise survey sites

Table 4: Project baseline environmental noise survey results summary

Sampling point	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7	
Description	In a grassland, close to farmhouse.		Near a cattle post.		Located close to farmhouse.		Next to small hills/ridges.		Close to a farmhouse.		Next to a marble quarry.		Close to quarry.	
Coordinates	21.81920°S; 15.96673°E		21.84507°S; 15.98131°E		21.7942202°S; 16.0165406°E		21.84400°S; 16.02519°E		21.88982°S; 15.99677°E		21.85814°S; 15.95217°E		21.87656°S; 15.92878°E	
Time of day	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Start date and time	07/04/2021 15:38	08/04/2021 00:57	07/04/2021 11:48	08/04/2021 01:36	07/04/2021 10:30	08/04/2021 00:05	07/04/2021 16:58	07/04/2021 23:20	08/04/2021 09:00	07/04/2021 22:34	07/04/2021 13:10	08/04/2021 02:04	07/04/2021 14:25	08/04/2021 02:39
Duration	00:30:14	00:15:27	00:46:05	00:15:31	00:42:12	00:15:29	00:30:38	00:15:48	00:35:11	00:15:06	00:31:58	00:15:45	00:33:08	00:17:21
Visual and acoustic observations	Very quiet surroundings, not much movement. People speaking in the distance during the day and insects at night, contribute to the acoustic sources.		Farm community activities, livestock, dogs, birds and vehicles contribute to the acoustic sources.		Farmhouse activities, insects and birds contribute to the acoustic sources.		Very quiet surroundings, not much movement. Insects contribute to the night-time acoustic sources.		Farmhouse activities, sheep, goats, dogs, birds and tractor contribute to the acoustic sources during the day. Barking dogs were audible during the night.		Quarry activities and heavy and light vehicles contribute to the acoustic sources during the day with insects and a train contributing to the acoustic sources during the night.		Quarry activities contribute to the acoustic sources during the day with dogs and insects contributing to the acoustic sources during the night.	
General weather conditions	Wind speeds of 1.8 m/s from the north east 36°C 50% cloud cover	Wind speeds of 0.4 m/s from the north west 26°C No clouds	Wind speeds of 0.6 m/s from the north west 32°C No clouds	Wind speeds of 1.8 m/s from the south 22°C No clouds	Wind speeds of 0.6 m/s from the south east 17°C No clouds	Wind speeds of 0.6 m/s from the north east 26°C No clouds	Wind speeds of 0.7 m/s from the east 34°C 60% cloud cover	No wind 24°C No clouds	Wind speeds of 2.4 m/s from the south east 22°C No clouds	No wind 24°C No clouds	Wind speeds of 0.8 m/s from the south 34°C 40% cloud cover	Wind speeds of 0.5 m/s from the north east 26°C No clouds	Wind speeds of1.5 m/s from the north east 34°C 40% cloud cover	Wind speeds of 1.1 m/s from the south east 21°C No clouds
LAIeq (dBA)	50.6	51.4	47.8	47.8	51.2	48.9	50	68.6	57.4	67.1	56	49.5	55.9	50.6
LAFmin (dBA)	19.6	34.1	21.7	21.9	20.3	25.9	18.9	30.7	25	26.8	22.7	22.2	19.9	20.5
LAFmax (dBA)	56	53.1	66.3	57.7	58.2	58.3	58.2	73	63.9	65.4	84.9	55.4	55.5	54.5
LA90 (dBA)	21.2	36.3	24.6	26	22.9	32.4	20.3	34.3	30.5	33.2	25.1	26.2	20.8	23
LAeq	28.7	38.6	39.7	34.1	33.1	38.4	28.6	43.1	41.1	50.2	54.8	39.5	30.6	29.4

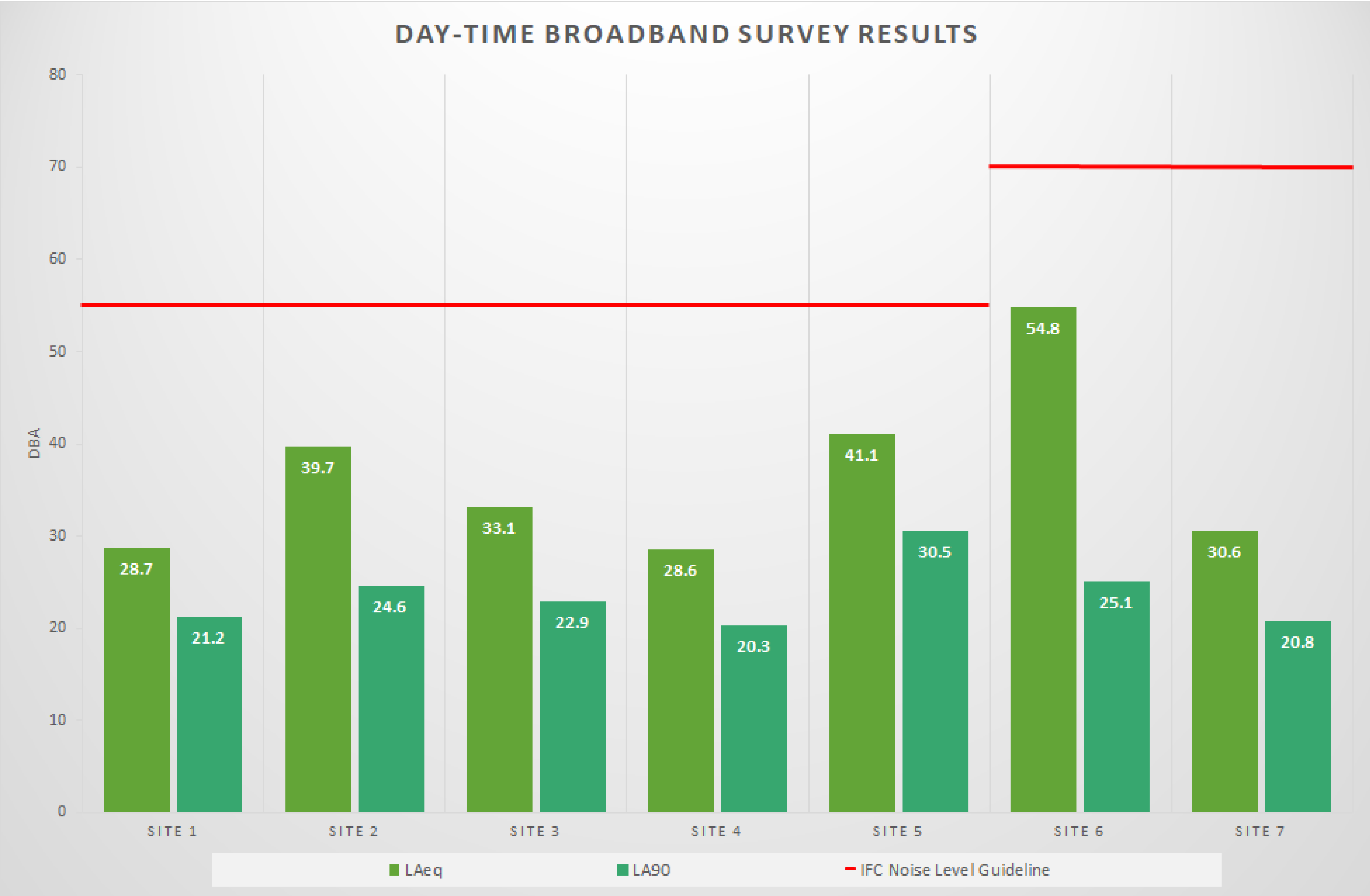


Figure 7: Day-time broadband survey results

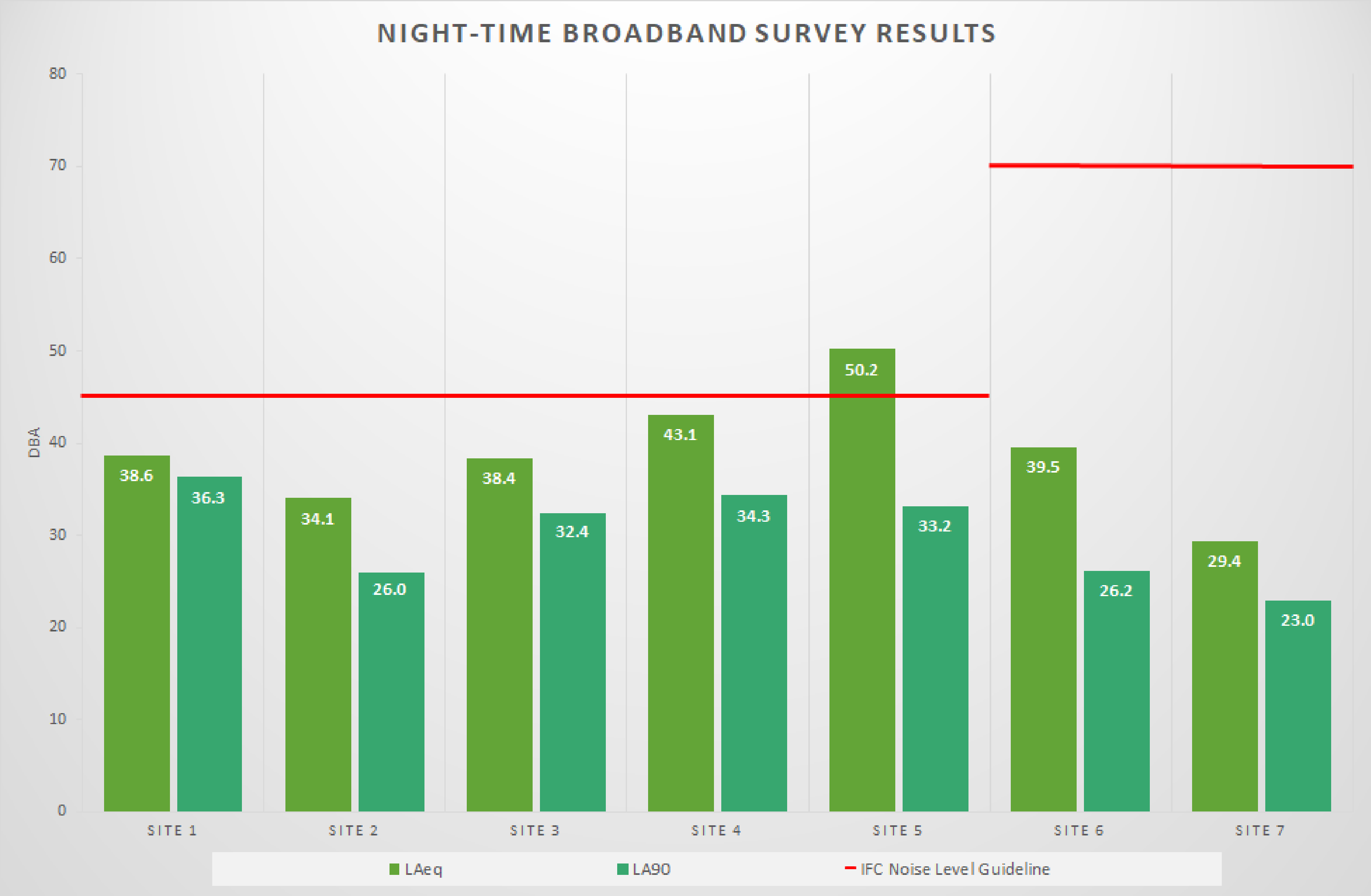


Figure 8: Night-time broadband survey results

4 Impact Assessment

The noise source inventory, noise propagation modelling and results are discussed in Section 4.1 and Section 4.2 respectively.

Two operational years were selected to reflect the maximum noise impacts:

- Operational Year 7 – maximum noise impacts to the eastern section of Osino Mine
- Operational Year 10 – maximum noise impacts to the western section of Osino Mine

4.1 Noise Sources and Sound Power Levels

The complete noise source inventory for the Osino Mining equipment is included in Table 5. The distribution of mining equipment between the pits and waste rock dumps was determined based on mining throughputs for the two operational years selected (viz. Year 7 and Year 10). Haul truck traffic noise as well as access road traffic were included. Traffic parameters as determined from mining rates and truck capacities are summarised in Table 6 along with assumptions.

Octave band frequency spectra L_W's for the plant and the mine are included in Table 7 and Table 8 respectively. The frequency spectra were determined for the source term (total dBA) based on measured databases for similar equipment or from calculations.

The reader is reminded of the non-linearity in the addition of L_W's. If the difference between the sound power levels of two sources is nil the combined sound power level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound power 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). Therefore, although some sources of noise could not be quantified (e.g. light vehicle movements, etc.), the incremental contributions of such sources are expected to be minimal given that the majority of sources are considered in the source inventory.

Table 5: Noise source quantities for the Osino Mine

Equipment		Quantity (Year 7)	Quantity (Year 10)
Primary	Drill rigs	14	14
	Large shovel	5	4
	Small shovel	1	2
	Trucks	22	25
Secondary	FEL - ore in pit	1	1
	FEL - ore ROM pad & LG stockpiles	2	2
	Track Dozer - dumps & loading area	7	7
	Wheel Dozer - loading area & ramp cleaning	3	3
	Diesel Tanker	2	2

Equipment		Quantity (Year 7)	Quantity (Year 10)
	Water Tanker	2	2
	Grader	2	2
Support Equipment	Mobile Lube truck	2	2
	Mobile Service truck	2	2
	Tyre Handler	1	1
	Roller / Compactor	1	1
	Rock Breaker	2	2
	Lightning Plant	8	8
	Crane	1	1
	Skid Steer Loader	1	1
	Hi Lift Crane / Access Platform	1	1
	Forklift	1	1
	Light Delivery Vehicle	30	30
	Busses	3	3
	Lowbed and truck	1	1
	TLB	1	1
	Pit dewatering pump	1	1

Table 6: Traffic noise sources

Activity/Road	Vehicles per hour Year 7	Vehicles per hour Year 10	% Heavy Vehicles
Twin Hills ore haul	0.4	5.3	100
Twin Hills waste rock haul	4.3	25.9	100
Cloud ore haul	2.3	-	100
Cloud waste rock haul	24.2	-	100
Access road (a)	200.0	200.0	15

(a) Assumed

Table 7: Octave band frequency spectra L_W's for the plant equipment

Plant Section	Equipment	Lw octave band frequency spectra (dB)								Lw (dB)	LwA (dBA)	Source
		63	125	250	500	1000	2000	4000	8000			
263: Sub Stations	Ball Mill	107	108	109	107	106	101	97		114.9	110.0	Lw Database
120: Primary Crushing	Maintenance Hoist	64.0	64.0	65.0	65.0	63.0	61.0	59.0	52.0	71.9	68.3	Lw Database
	Primary crusher	123	123	121	111	106	105	100		127.4	115.8	Lw Database
	Conveyor drive unit	97	102	110	107	107	97	91		113.7	110.0	Lw Database
	Dust collection fan	121	120	123	118	110	108	105		127.0	119.0	Lw Database
122: Secondary Crushing	Primary crushing sump pump	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	Lw Predictions (Bruce & Moritz, 1998)
	Secondary crusher	113	115	119	124	123	118	110		128.1	126.1	Lw Database
	Conveyor drive unit	97	102	110	107	107	97	91		113.7	110.0	Lw Database
	Secondary crushing sump pump	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	Lw Predictions (Bruce & Moritz, 1998)
	Tertiary crusher feed screen	124	120	113	111	110	108	107		125.8	115.6	Lw Database
	Tertiary crusher #1	109	114	116	116	118	118	113		123.9	122.6	Lw Database
	Tertiary crusher #2	115	114	114	116	116	115	112		123.2	121.2	Lw Database
	Conveyor drive unit	97	102	110	107	107	97	91		113.7	110.0	Lw Database
	Conveyor transfer	107	106	106	108	106	102	97		113.9	109.8	Lw Database
	Conveyor drive unit	97	102	110	107	107	97	91		113.7	110.0	Lw Database
	Dust collection fan #1: secondary crusher	121	120	123	118	110	108	105		127.0	119.0	Lw Database
	Dust collection fan #2: tertiary crusher	121	120	123	118	110	108	105		127.0	119.0	Lw Database
	Dust collection fan #3: tertiary crusher	121	120	123	118	110	108	105		127.0	119.0	Lw Database
125: Stockpiling	Conveyor drive unit	97	102	110	107	107	97	91		113.7	110.0	Lw Database
	Tertiary crushing sump pump	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	Lw Predictions (Bruce & Moritz, 1998)
130: Milling	Dust collection fan	121	120	123	118	110	108	105		127.0	119.0	Lw Database
	Stockpile sump pump	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	Lw Predictions (Bruce & Moritz, 1998)
	Cyclone feed pump	99.0	100.0	102.0	102.0	105.0	102.0	98.0	92.0	110.2	108.5	Lw Predictions (Bruce & Moritz, 1998)
	Sump pump	87.5	88.5	90.5	90.5	93.5	90.5	86.5	80.5	98.8	97.1	Lw Predictions (Bruce & Moritz, 1998)

Plant Section	Equipment	L_W octave band frequency spectra (dB)								L_W (dB)	L_{WA} (dBA)	Source
		63	125	250	500	1000	2000	4000	8000			
	Cyclone Maintenance Hoist	64.0	64.0	65.0	65.0	63.0	61.0	59.0	52.0	71.9	68.3	L_W Database
	Gravity Scalping Screen	113.3	109.0	108.4	108.4	108.2	105.8	102.4		117.4	112.6	L_W Database
140: Trash removal and thickening	Trash screening	113.3	109.0	108.4	108.4	108.2	105.8	102.4		117.4	112.6	L_W Database
	Pre-Leach Thickener Underflow Pump 1	90.2	91.2	93.2	93.2	96.2	93.2	89.2	83.2	101.4	99.7	L_W Predictions (Bruce & Moritz, 1998)
	Pre-Leach Thickener Underflow Pump 2	90.2	91.2	93.2	93.2	96.2	93.2	89.2	83.2	101.4	99.7	L_W Predictions (Bruce & Moritz, 1998)
	Ball Mill Water Pump 1	86.2	87.2	89.2	89.2	92.2	89.2	85.2	79.2	97.4	95.8	L_W Predictions (Bruce & Moritz, 1998)
	Pre-Leach Area Sump Pump	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	L_W Predictions (Bruce & Moritz, 1998)
160: Leaching	C.I.L. Tank 1 Pump	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	C.I.L. Tank 2 Pump	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	C.I.L. Tank 3 Pump	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	C.I.L. Area Sump Pump	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	L_W Predictions (Bruce & Moritz, 1998)
	C.I.L. Tank 4 Pump	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	C.I.L. Tank 5 Pump	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	C.I.L. Tank 6 Pump	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	Sump Pump #1	87.5	88.5	90.5	90.5	93.5	90.5	86.5	80.5	98.8	97.1	L_W Predictions (Bruce & Moritz, 1998)
	Sump Pump #2	87.5	88.5	90.5	90.5	93.5	90.5	86.5	80.5	98.8	97.1	L_W Predictions (Bruce & Moritz, 1998)
	CIL Gantry Crane	81.0	77.0	66.0	62.0	59.0	57.0	51.0	46.0	82.6	66.5	L_W Database
170: Elution and gold room	Loaded Carbon Recovery Screen	113.3	109.0	108.4	108.4	108.2	105.8	102.4		117.4	112.6	L_W Database
	Carbon Sizing Screen	113.3	109.0	108.4	108.4	108.2	105.8	102.4		117.4	112.6	L_W Database
	Elution Sump Pump	83.2	84.2	86.2	86.2	89.2	86.2	82.2	76.2	94.4	92.7	L_W Predictions (Bruce & Moritz, 1998)
	Carbon De-Watering Screen	111.4	102.7	100.5	102.0	95.6	90.8	86.1		112.8	101.9	L_W Database
	Carbon Regeneration Kiln	112.1	112.8	113.9	110.1	107.9	104.6	98.6		119.0	112.9	L_W Database
	In-line Leach Reactor Product Pump	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	Pregnant Solution Pump	77.5	78.5	80.5	80.5	83.5	80.5	76.5	70.5	88.8	87.1	L_W Predictions (Bruce & Moritz, 1998)
	Intensive Cyanidation Sump Pump #1	87.5	88.5	90.5	90.5	93.5	90.5	86.5	80.5	98.8	97.1	L_W Predictions (Bruce & Moritz, 1998)
	Electrowinning Extraction Fan	121	120	123	118	110	108	105		127.0	119.0	L_W Database
	High Pressure Cathode Washer	111.4	102.7	100.5	102.0	95.6	90.8	86.1		112.8	101.9	L_W Database

Plant Section	Equipment	L_W octave band frequency spectra (dB)								L_W (dB)	L_{WA} (dBA)	Source
		63	125	250	500	1000	2000	4000	8000			
	Fumehood Extraction Fan	121	120	123	118	110	108	105		127.0	119.0	L_W Database
	Goldroom Hoist	64.0	64.0	65.0	65.0	63.0	61.0	59.0	52.0	71.9	68.3	L_W Database
	Goldroom Extraction Fan 1	121	120	123	118	110	108	105		127.0	119.0	L_W Database
	Goldroom Extraction Fan 2	121	120	123	118	110	108	105		127.0	119.0	L_W Database
	Goldroom Sump Pump #1	87.5	88.5	90.5	90.5	93.5	90.5	86.5	80.5	98.8	97.1	L_W Predictions (Bruce & Moritz, 1998)
180: Tailings handling	Tailings Thickener Underflow Pump 1	90.2	91.2	93.2	93.2	96.2	93.2	89.2	83.2	101.4	99.7	L_W Predictions (Bruce & Moritz, 1998)
	Tailings Thickener Underflow Pump 2 - Standby	90.2	91.2	93.2	93.2	96.2	93.2	89.2	83.2	101.4	99.7	L_W Predictions (Bruce & Moritz, 1998)
	Tailings Thickener Feed Pump 1	88.5	89.5	91.5	91.5	94.5	91.5	87.5	81.5	99.7	98.0	L_W Predictions (Bruce & Moritz, 1998)
	Tailings Thickener Feed Pump 2 - Standby	88.5	89.5	91.5	91.5	94.5	91.5	87.5	81.5	99.7	98.0	L_W Predictions (Bruce & Moritz, 1998)
	Tailings Sump Pump	87.5	88.5	90.5	90.5	93.5	90.5	86.5	80.5	98.8	97.1	L_W Predictions (Bruce & Moritz, 1998)
	Filtrate Water Pump 1	88.5	89.5	91.5	91.5	94.5	91.5	87.5	81.5	99.7	98.0	L_W Predictions (Bruce & Moritz, 1998)
	Filtrate Water Pump 2	88.5	89.5	91.5	91.5	94.5	91.5	87.5	81.5	99.7	98.0	L_W Predictions (Bruce & Moritz, 1998)
	Wash Water Pump 1	87.5	88.5	90.5	90.5	93.5	90.5	86.5	80.5	98.8	97.1	L_W Predictions (Bruce & Moritz, 1998)
	Wash Water Pump 2	87.5	88.5	90.5	90.5	93.5	90.5	86.5	80.5	98.8	97.1	L_W Predictions (Bruce & Moritz, 1998)
	Conveyor transfer	107	106	106	108	106	102	97		113.9	109.8	L_W Database
220: Water services	Raw Water Pump 1	91.5	92.5	94.5	94.5	97.5	94.5	90.5	84.5	102.7	101.1	L_W Predictions (Bruce & Moritz, 1998)
	Raw Water Pump 2	91.5	92.5	94.5	94.5	97.5	94.5	90.5	84.5	102.7	101.1	L_W Predictions (Bruce & Moritz, 1998)
	Gland Water Pump 1	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	Gland Water Pump 2	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	Diesel Fire Water Pump	90.8	91.8	93.8	93.8	96.8	93.8	89.8	83.8	102.0	100.3	L_W Predictions (Bruce & Moritz, 1998)
	Fire Water Jockey Pump	74.5	75.5	77.5	77.5	80.5	77.5	73.5	67.5	85.7	84.1	L_W Predictions (Bruce & Moritz, 1998)
	Fire Water Pump	88.5	89.5	91.5	91.5	94.5	91.5	87.5	81.5	99.7	98.0	L_W Predictions (Bruce & Moritz, 1998)
	Process Water Pump 1	98.0	99.0	101.0	101.0	104.0	101.0	97.0	91.0	109.2	107.5	L_W Predictions (Bruce & Moritz, 1998)
	Process Water Pump 2	98.0	99.0	101.0	101.0	104.0	101.0	97.0	91.0	109.2	107.5	L_W Predictions (Bruce & Moritz, 1998)
	Fluidising Water Pump	85.4	86.4	88.4	88.4	91.4	88.4	84.4	78.4	96.7	95.0	L_W Predictions (Bruce & Moritz, 1998)
	Potable Water Pump 1	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	L_W Predictions (Bruce & Moritz, 1998)

Plant Section	Equipment	L_W octave band frequency spectra (dB)								L_W (dB)	L_{WA} (dBA)	Source
		63	125	250	500	1000	2000	4000	8000			
	Potable Water Pump 2	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
240: Air services	Plant/Instrument High Pressure Air Compressor 1	82.4	87.4	86.4	84.4	87.4	92.4	89.4	82.4	96.8	96.3	L_W Predictions (Bruce & Moritz, 1998)
	Plant/Instrument High Pressure Air Compressor 2	82.4	87.4	86.4	84.4	87.4	92.4	89.4	82.4	96.8	96.3	L_W Predictions (Bruce & Moritz, 1998)
	Cyanide Destruction and CIL Air Blower 1	106	114	110	109	110	113	110		119.6	117.5	L_W Database
	Cyanide Destruction and CIL Air Blower 2	106	114	110	109	110	113	110		119.6	117.5	L_W Database
	Cyanide Destruction and CIL Air Blower 3	106	114	110	109	110	113	110		119.6	117.5	L_W Database
	Pre- Oxidation Air Blower 1	110	111	105	105	108	110	108		117.1	114.6	L_W Database
	Pre- Oxidation Air Blower 2	110	111	105	105	108	110	108		117.1	114.6	L_W Database
250: Fuels	Site Diesel Storage and Pumping Plant	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	L_W Predictions (Bruce & Moritz, 1998)
	Plant Diesel Storage and Pumping Plant	84.5	85.5	87.5	87.5	90.5	87.5	83.5	77.5	95.7	94.1	L_W Predictions (Bruce & Moritz, 1998)
450: Mining facility	Mine/Instrument High Pressure Air Compressor 1	82.4	87.4	86.4	84.4	87.4	92.4	89.4	82.4	96.8	96.3	L_W Predictions (Bruce & Moritz, 1998)

Table 8: Octave band frequency spectra L_W's for the mine equipment

Equipment		L_W octave band frequency spectra (dB)								L_W (dB)	L_{WA} (dBA)	Source
		63	125	250	500	1000	2000	4000	8000			
Primary	Drill rigs	114.1	119.1	122.1	117.1	115.1	112.1	106.1	100.1	125.7	120.3	L_W Predictions (Bruce & Moritz, 1998)
	Large shovel	116.6	121.6	124.6	119.6	117.6	114.6	108.6	102.6	128.3	122.9	L_W Predictions (Bruce & Moritz, 1998)
	Small shovel	114.9	119.9	122.9	117.9	115.9	112.9	106.9	100.9	126.5	121.1	L_W Predictions (Bruce & Moritz, 1998)
	Trucks	117.5	122.5	125.5	120.5	118.5	115.5	109.5	103.5	129.1	123.8	L_W Predictions (Bruce & Moritz, 1998)
Secondary	FEL - ore in pit	114.0	119.0	122.0	117.0	115.0	112.0	106.0	100.0	125.6	120.2	L_W Predictions (Bruce & Moritz, 1998)
	FEL - ore ROM pad & LG stockpiles	114.2	119.2	122.2	117.2	115.2	112.2	106.2	100.2	125.8	120.4	L_W Predictions (Bruce & Moritz, 1998)
	Track Dozer - dumps & loading area	113.3	118.3	121.3	116.3	114.3	111.3	105.3	99.3	124.9	119.5	L_W Predictions (Bruce & Moritz, 1998)
	Wheel Dozer - loading area & ramp cleaning	114.0	119.0	122.0	117.0	115.0	112.0	106.0	100.0	125.6	120.2	L_W Predictions (Bruce & Moritz, 1998)

Equipment		L_W octave band frequency spectra (dB)								L_W (dB)	L_{WA} (dBA)	Source
		63	125	250	500	1000	2000	4000	8000			
	Diesel Tanker	111.9	116.9	119.9	114.9	112.9	109.9	103.9	97.9	123.5	118.2	L_W Predictions (Bruce & Moritz, 1998)
	Water Tanker	115.4	120.4	123.4	118.4	116.4	113.4	107.4	101.4	127.0	121.7	L_W Predictions (Bruce & Moritz, 1998)
	Grader	108.9	113.9	116.9	111.9	109.9	106.9	100.9	94.9	120.5	115.2	L_W Predictions (Bruce & Moritz, 1998)
	Mobile Lube truck	113.3	118.3	121.3	116.3	114.3	111.3	105.3	99.3	124.9	119.5	L_W Predictions (Bruce & Moritz, 1998)
	Mobile Service truck	111.9	116.9	119.9	114.9	112.9	109.9	103.9	97.9	123.5	118.2	L_W Predictions (Bruce & Moritz, 1998)
	Tyre Handler	108.8	113.8	116.8	111.8	109.8	106.8	100.8	94.8	120.4	115.0	L_W Predictions (Bruce & Moritz, 1998)
	Roller / Compactor	110.4	115.4	118.4	113.4	111.4	108.4	102.4	96.4	122.0	116.7	L_W Predictions (Bruce & Moritz, 1998)
	Rock Breaker	91.0	89.0	85.0	89.0	87.0	87.0	84.0	80.0	96.5	93.0	L_W Database
	Lightning Plant	119.2	109.1	108.9	109.2	106.0	100.8	94.0		120.5	110.5	L_W Database
	Crane	81.0	77.0	66.0	62.0	59.0	57.0	51.0	46.0	82.6	66.5	L_W Database
Support Equipment	Skid Steer Loader	106.0	111.0	114.0	109.0	107.0	104.0	98.0	92.0	117.6	112.2	L_W Predictions (Bruce & Moritz, 1998)
	Hi Lift Crane / Access Platform	80.0	79.0	73.0	74.0	73.0	73.0	64.0	55.0	84.3	78.2	L_W Database
	Forklift	109.1	114.1	117.1	112.1	110.1	107.1	101.1	95.1	120.7	115.3	L_W Predictions (Bruce & Moritz, 1998)
	Light Delivery Vehicle	121.7	126.7	129.7	124.7	122.7	119.7	113.7	107.7	133.3	128.0	L_W Predictions (Bruce & Moritz, 1998)
	Busses	111.5	116.5	119.5	114.5	112.5	109.5	103.5	97.5	123.1	117.7	L_W Predictions (Bruce & Moritz, 1998)
	Lowbed and truck	114.3	119.3	122.3	117.3	115.3	112.3	106.3	100.3	125.9	120.5	L_W Predictions (Bruce & Moritz, 1998)
	TLB	106.1	107.1	109.1	109.1	112.1	109.1	105.1	99.1	117.4	115.7	L_W Predictions (Bruce & Moritz, 1998)
	Pit dewatering pump	95.8	96.8	98.8	98.8	101.8	98.8	94.8	88.8	107.0	105.3	L_W Predictions (Bruce & Moritz, 1998)

4.2 Noise Propagation and Simulated Noise Levels

The propagation of noise generated during the operational phase was calculated with CadnaA in accordance with ISO 9613. Meteorological and site-specific acoustic parameters as discussed in Section 3.2 along with source data discussed in 4.1, were applied in the model.

Table 9 provides a summary of simulated noise levels for the operational Year 7 and Year 10 at NSRs. Results for the Osino Mine operational Year 7 and Year 10 are presented in isopleth form (Figure 9 to Figure 12).

Table 9: Summary of simulated noise levels (provided as dBA) for proposed operations (Year 7 and Year 10) at NSR within the study area[(a)]

NSR	Year 7		Year 10		Baseline [(b)]		Increase above baseline[(c)] for operational Year 7		Increase above baseline[(c)] for operational Year 10	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1: farmhouses (residential)	**61.9**	**62.0**	**69.6**	**69.6**	39.7	34.1	22.2	27.9	29.9	35.5
2: marble quarry (industrial)	39.3	39.5	47.5	47.8	54.8	39.5	0.1	3.0	0.7	8.9
3: marble quarry (industrial)	-	-	-	-	30.6	29.4	0.0	0.0	0.0	0.0
4: farmhouse (residential)	51.6	**52.1**	51.6	**52.2**	28.7	38.6	22.9	13.7	22.9	13.8
5: farmhouse (residential)	-	-	-	-	41.1	50.2	0.0	0.0	0.0	0.0
6: farmhouse (residential)	-	-	-	-	33.1	38.4	0.0	0.0	0.0	0.0
7: farmhouse (residential)	-	-	-	-	33.1	38.4	0.0	0.0	0.0	0.0
8: farmhouse (residential)	-	-	-	-	33.1	38.4	0.0	0.0	0.0	0.0

Notes:

(a) Exceedance of day- and night-time IFC guideline is provided in bold (guideline for residential areas is 55 dBA for day-time and 45 dBA for night-time; guideline for industrial areas is 70 dBA for day- and night-time).

(b) Baseline noise levels taken from the closest survey sites

(c) Likely community response:

- 0 to 1 dBA – No reaction, increase not detectable
- 1 to 3 dBA – Increase just detectable to persons with average hearing acuity, annoyance unlikely.
- 3 to 5 dBA – There will be 'little' reaction with 'sporadic complaints'.
- 5 to 10 dBA – There will be 'little' to 'medium' reaction with 'sporadic' to 'widespread' complaints.
- 10 to 20 dBA - There will be a 'strong' reaction with 'threats of community action'

Noise levels due to Osino Mine operations are predicted to exceed the day- and night-time IFC noise guidelines for residential areas at the NSR 1 (south of the Twin Hills pit) and the night-time IFC noise guidelines for residential areas at the NSR 4 (north of the Osino plant).

For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. The increase in noise levels above the baseline for proposed operations (Year 7 and Year 10) is more than 3 dBA at the NSR 1 and NSR 4. According to SANS 10103 (2008); the predicted increase in noise levels due to proposed project operations is expected to result in 'strong' community reaction at NSR 1 and NSR 4. The increase in night-time noise levels above the baseline for proposed operations for Year 10 is more than 3 dBA at the NSR 2. This is an industrial NSR (i.e. a Marble Quarry). The Quarry activities do not contribute to the night-time noise levels at this site (as observed during the baseline noise survey). This indicates that the quarries are not operational during the night. If this is the case, night-time noise level increases would not affect NSRs at this site.

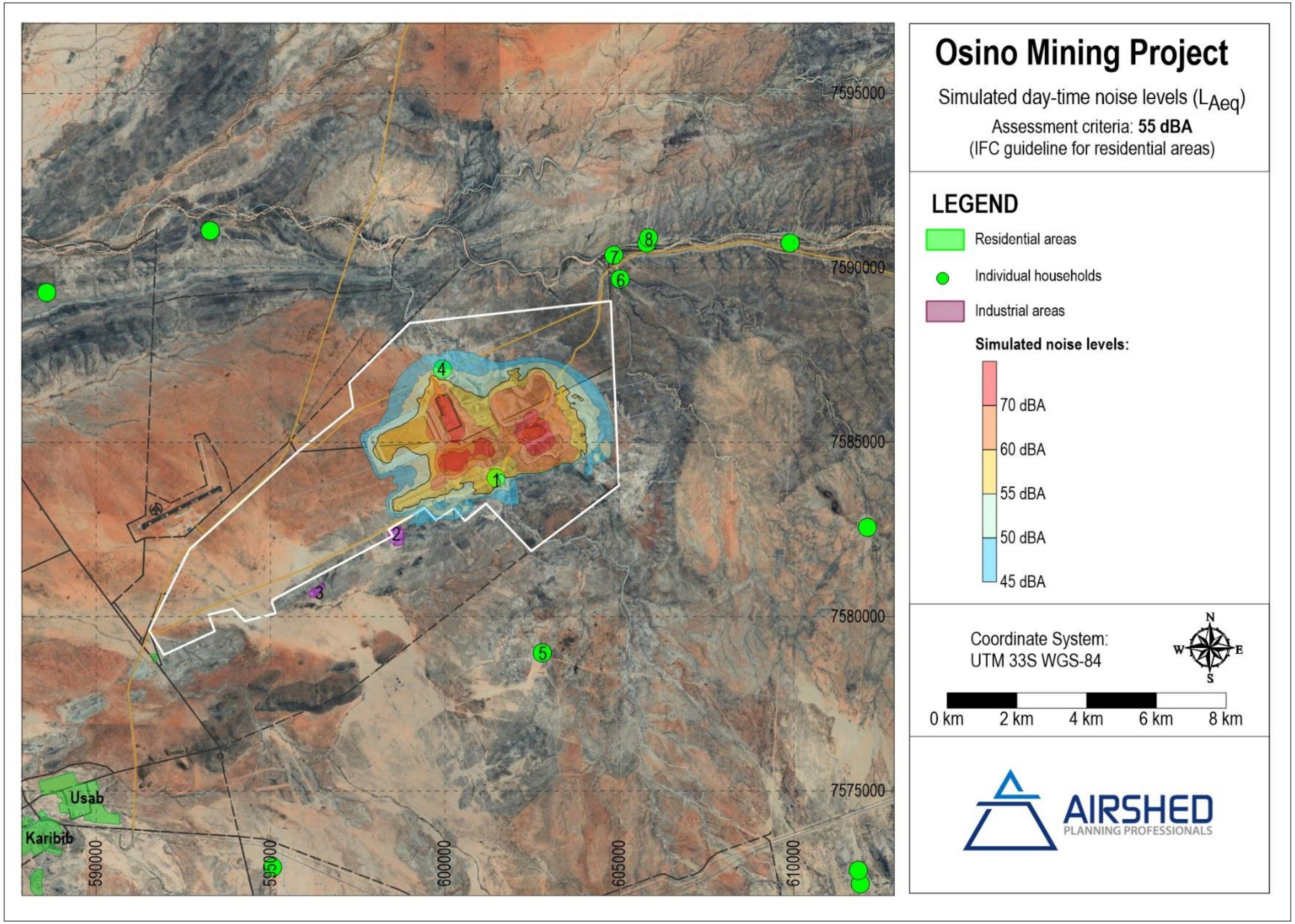


Figure 9: Simulated day-time noise levels for the Osino Mine activities (operational Year 7)

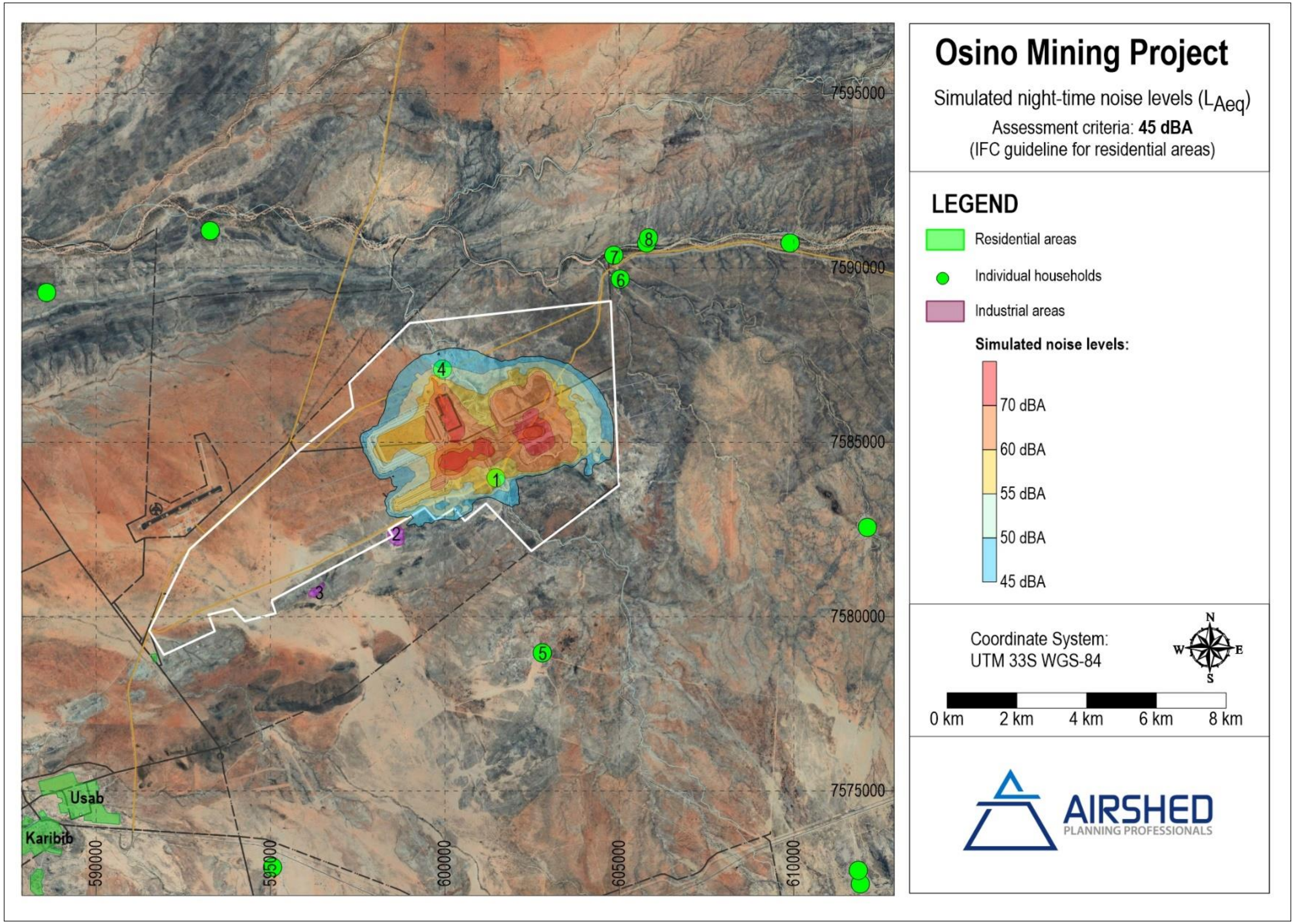


Figure 10: Simulated night-time noise levels for the Osino Mine activities (operational Year 7)

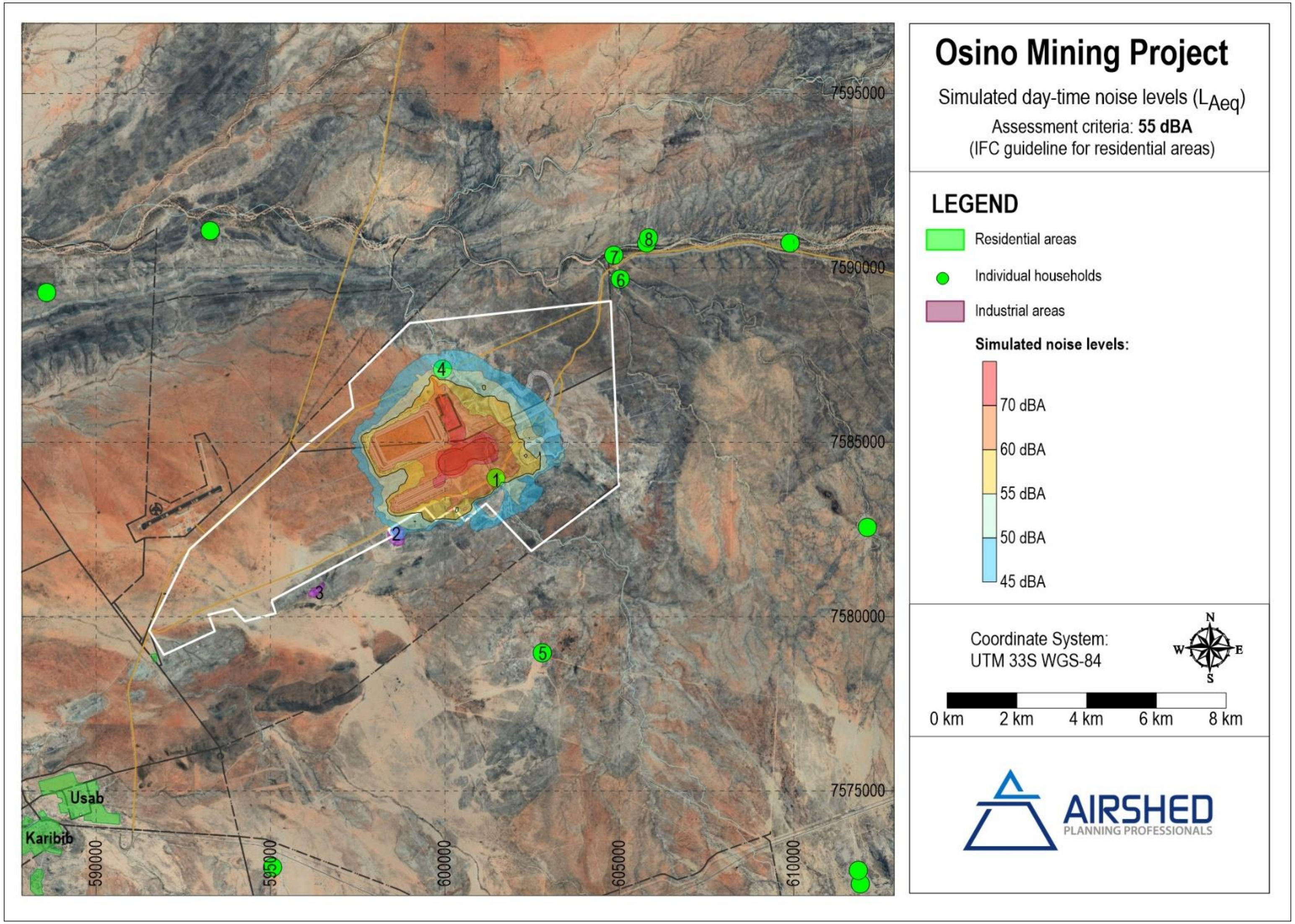


Figure 11: Simulated day-time noise levels for the Osino Mine activities (operational Year 10)

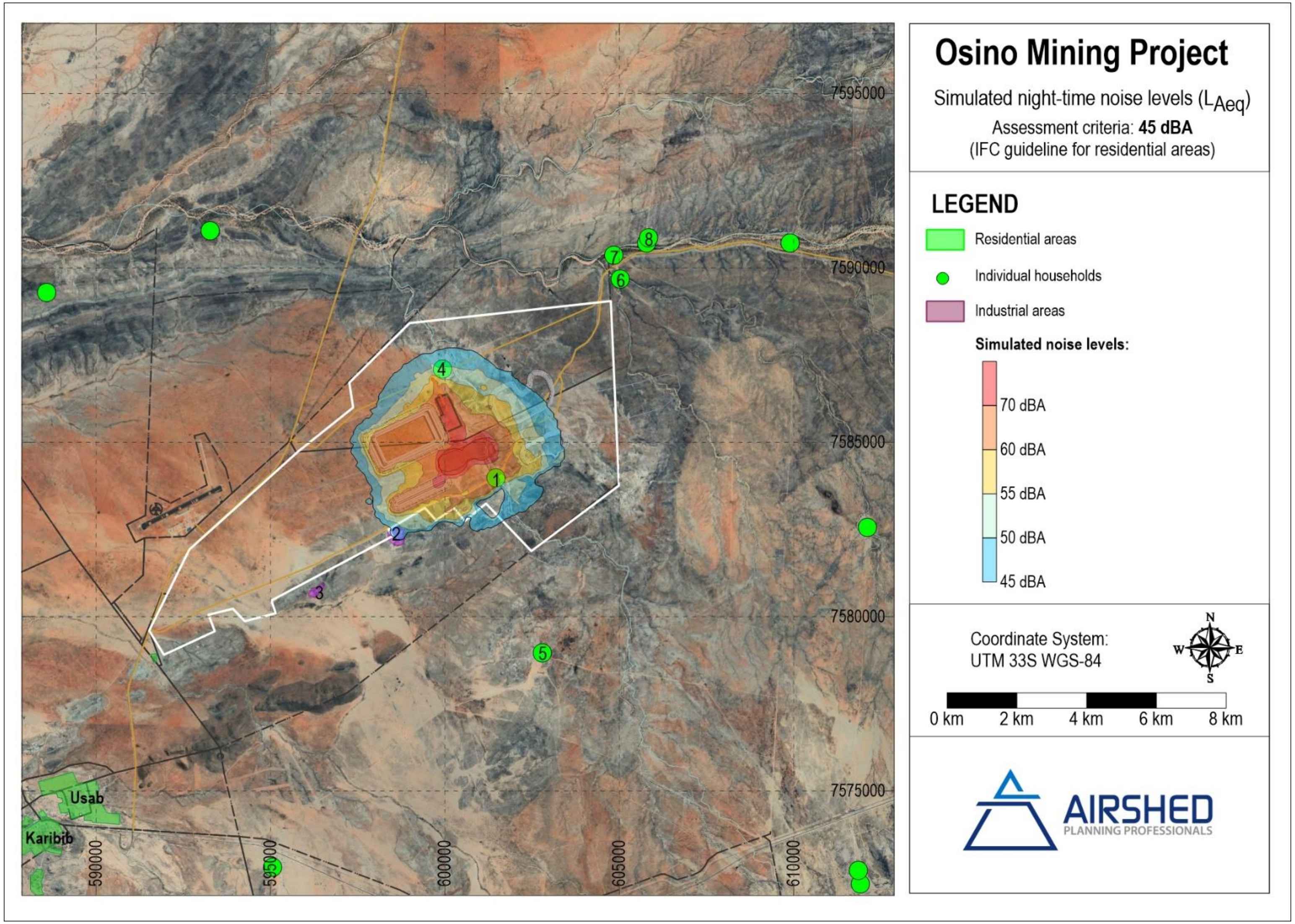


Figure 12: Simulated night-time noise levels for the Osino Mine activities (operational Year 10)

5 Management Measures

In the quantification of noise emissions and simulation of noise levels as a result of the project, it was found that environmental noise evaluation criteria for residential, educational, and institutional receptors is potentially exceeded at NSR 1 and NSR 4 due to proposed Osino Mine operations. The noise levels at all NSRs should be within the IFC noise guidelines. This can be achieved through effective noise mitigation and management measures.

The measures discussed in this section are measures typically applicable to industrial sites and are considered good practice by the IFC (2007) and British Standard BSI (2014).

It should be noted that not all mitigation measures are to be implemented, but should the need arise the mitigation measures as discussed in this section can be considered.

5.1 Controlling Noise at the Source

5.1.1 General Good Practice Measures

Good engineering and operational practices will reduce levels of annoyance. For general activities, the following good engineering practice **should** be applied to **all project phases**:

- All diesel-powered equipment and plant vehicles should be kept at a **high level of maintenance**. This should particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment should serve as trigger for withdrawing it for maintenance.
- In managing noise specifically related to vehicle traffic, efforts **should** be directed at:
    - Minimising individual vehicle engine, transmission, and body noise/vibration. This is achieved through the implementation of an equipment maintenance program.
    - Maintain road surfaces regularly to repair potholes etc.
    - Keep all roads well maintained and avoid steep inclines or declines to reduce acceleration/brake noise.
    - Avoid unnecessary equipment idling at all times.
    - Minimising the need for trucks/equipment to reverse. This will reduce the frequency at which disturbing but necessary reverse warnings will occur. Alternatives to the traditional reverse 'beeper' alarm such as a 'self-adjusting' or 'smart' alarm could be considered. These alarms include a mechanism to detect the local noise level and automatically adjust the output of the alarm is so that it is 5 to 10 dB above the noise level near the moving equipment. The promotional material for some smart alarms does state that the ability to adjust the level of the alarm is of advantage to those sites 'with low ambient noise level' **Invalid source specified.**. Also, when reversing, vehicles should travel in a direction away from NSR's if possible.
- Where possible, other non-routine noisy activities such as construction, decommissioning, start-up and maintenance, should be limited to day-time hours.

- A noise complaints register must be kept.
- Provision of general notices to the community in the form of notice boards indicating blast times and dates.

5.1.2 Specifications and Equipment Design

As the site or activity is in close proximity to NSRs, equipment and methods to be employed should be reviewed to ensure the quietest available technology is used. Equipment with lower sound power levels must be selected in such instances and vendors/contractors should be required to guarantee optimised equipment design noise levels.

5.1.3 Enclosures

As far as is practically possible, source of significant noise should be enclosed. The extent of enclosure will depend on the nature of the machine and their ventilation requirements. Pumps are examples of such equipment.

It should be noted that the effectiveness of partial enclosures and screens can be reduced if used incorrectly, e.g. noise should be directed into a partial enclosure and not out of it, there should not be any reflecting surfaces such as parked vehicles opposite the open end of a noise enclosure.

5.1.4 Use and Siting of Equipment and Noise Sources

Equipment should be sited as far away from NSRs as possible. Also:

a) Machines used intermittently should be shut down between work periods or throttled down to a minimum and not left running unnecessarily. This will reduce noise and conserve energy.
b) Plants or equipment from which noise generated is known to be particularly directional, should be orientated so that the noise is directed away from NSRs.
c) Acoustic covers of engines should be kept closed when in use or idling.
d) Doors to pump houses should be kept closed at all times.
e) Construction materials such as beams should be lowered and not dropped.

5.1.5 Maintenance

Regular and effective maintenance of equipment and plants are essential to noise control. Increases in equipment noise are often indicative of eminent mechanical failure. Also, sound reducing equipment/materials can lose effectiveness before failure and can be identified by visual inspection.

Noise generated by vibrating machinery and equipment with vibrating parts can be reduced through the use of vibration isolation mountings or proper balancing. Noise generated by friction in conveyor rollers, trolley etc. can be reduced by sufficient lubrication.

5.1 Controlling the Spread of Noise

Naturally, if noise activities can be minimised or avoided, the amount of noise reaching NSRs will be reduced. Alternatively, the distance between source and receiver must be increased, or noise reduction screens, barriers, or berms must be installed.

5.1.1 Distance

To increase the distance between source and receiver is often the most effective method of controlling noise since, for a typical point source at ground level, a 6-dB decrease can be achieved with every doubling in distance. It is however conceded that it might not always be possible.

5.1.2 Screening

If noise control at the source and the use of distance between source and receiver is not possible, screening methods may be considered. The effectiveness of a noise barrier is dependent on its length, effective height, and position relative to the source and receiver as well as material of construction. To optimize the effect of screening, screens should be located close to either the source of the noise, or the receiver.

The careful placement of barriers such as screens or berms can significantly reduce noise impacts but may result in additional visual impacts. Although vegetation such as shrubs or trees may improve the visual impact of construction sites, it will not significantly reduce noise impacts and should not be considered as a control measure.

Earth berms can be built to provide screening for large scale earth moving operations and can be landscaped to become permanent features once construction is completed. Care should be taken when constructing earth berms since it may become a significant source of dust.

5.2 Monitoring

Noise monitoring at sites where noise is an issue or may become an issue is essential. Annual noise sampling over a period of 10 to 30 minutes for day- and night-time at NSRs surrounding the Osino Mine (detailed in Section 3.3) should be incorporated in an annual environmental noise monitoring programme.

Also, in the event that noise related complaints are received short term ambient noise measurements should be conducted as part of investigating the complaints. The results of the measurements should be used to inform any follow up interventions. The investigation of complaints should include an investigation into equipment or machinery that likely result or resulted in noise levels annoying to the community. This could be achieved with source noise measurements.

The following procedure should be adopted for all noise surveys:

- Any surveys should be designed and conducted by a **trained specialist**.

- Sampling should be carried out using a **Type 1** SLM that meets all appropriate IEC standards and is subject to **annual calibration** by an accredited laboratory.
- The **acoustic sensitivity of the SLM should be tested** with a portable acoustic calibrator before and after each sampling session.
- Samples sufficient for statistical analysis should be taken with the use of portable SLM's capable of logging data continuously over the time period. Samples representative of the day- and night-time acoustic environment should be taken.
- The following acoustic indices should be recoded and reported: L_{Aeq} (T), statistical noise level $L_{A90,}$ L_{AFmin} and $L_{AFmax,}$ octave band or 3rd octave band frequency spectra.
- The SLM should be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- Efforts should be made to ensure that measurements are not affected by the residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer. It is good practice to avoid conducting measurements when the wind speed is more than 5 m/s, while it is raining or when the ground is wet.
- A detailed log and record should be kept. Records should include site details, weather conditions during sampling and observations made regarding the acoustic environment of each site.

6 Conclusion

Based on the findings of the assessment, IFC guidelines may be exceeded at NSRs closest to the project operations (i.e. NSR 1 to the south of the Twin Hills pit and NSR 4 to the north of the Osino plant). The overall increase in noise levels due to the project operations, is expected to result in ‘strong’ reaction from NSR 1 and NSR2. It is the specialist’s opinion that the project may be authorised provided that noise management measures are implemented to ensure that IFC noise guidelines for residential areas are met at NSR 1 and NSR 4. If it is not possible to meet IFC noise guidelines for residential areas at these receptors with noise attenuation measures in place, consideration needs to be made to purchase these farms. A complaints register must be kept throughout the life of the operations, including during the construction of the project.

7 References

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Appendix A – Specialist Curriculum Vitae

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Reneé von Gruenewaldt (*nee* Thomas)
Profession	Air Quality and Environmental Noise Scientist
Date of Birth	13 May 1978
Years with Firm	19 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

Reneé von Gruenewaldt (Air Quality Scientist): Reneé joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over nineteen (19) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and eight (8) years of experience in the field of environmental noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various air quality modelling packages including the AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff-based model (CALPUFF and CALMET), puff-based HAWK model and line-based models. Her experience with air emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of wastewater treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise and CadnaA for propagation of industrial, road and rail noise sources.

Having worked on projects throughout Africa (i.e., South Africa, Mozambique, Malawi, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar and Egypt for Air Quality Impact Assessments and Mozambique, Namibia, Botswana, Kenya, Ghana, Suriname and Afghanistan for Environmental Noise Impact Assessments) Reneé has developed a broad experience base. She has a good understanding of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

RELEVANT EXPERIENCE (AIR QUALITY)

Mining and Ore Handling

Reneé has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite, manganese and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for numerous mines over Mpumalanga (viz. Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein, Hartogshoop, Belfast, New Largo, Geluk, etc.), Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Flourspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi), Kusile Rail (SA) and WCL Rail (Liberia).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC), and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infrachem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol (at Elrode) and Island View (in Durban) tanks quantification, Petro SA and Chevron (including the postponement/exemption application).

Pulp and Paper Industry

Air quality studies have been undertaken or the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the ash expansion projects at Kusile, Kendal, Hendrina, Kriel and Arnot; Fabric Filter Plants at Komati, Grootvlei, Tutuka, Lethabo and Kriel Power Stations; the proposed Kusile, Medupi (including the impact assessment for the Flue Gas Desulphurization) and Vaal South Power Stations. Reneé was also involved and the cumulative assessment of the existing and return to service Eskom power stations assessment and the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of Pebble Bed Modular Reactor and nuclear plants at Duynefontein, Bantamsklip and Thyspunt.

Apart from Eskom projects, power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Paratus Power Plant).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill, Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill), Cape Winelands District Municipality Landfill and the Tsoeneng Landfill (Lesotho). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town), the Ergo Rubber Incinerator and the Ecorevert Pyrolysis Plant.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

Reneé undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

Reneé has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

RELEVANT EXPERIENCE (NOISE)

Mining

Reneé has undertaken numerous environmental noise assessments for mining operations. These include environmental noise impact assessments including baseline noise surveys for Balama (Mozambique), Masama Coal (Botswana), Lodestone (Namibia), Prieska (SA), Kolomela (SA) Heuningkranz (SA), Syferfontein (SA), South 32 (SA), Mamatwan and Marula Platinum Mine (SA).

Power Generation

Environmental noise assessments have been completed for numerous Eskom coal fired power station studies in SA including the Kriel Fabric Filter Plant, Kendal ash facility, Medupi ash facility. Apart from Eskom projects, power plant assessments have also been completed in Botswana (Morupule), Kenya (Or Power geothermal power plants), Suriname (EBS power plant) and SA (Richards Bay combined cycle power plant).

Process Operations

Environmental noise assessments have been undertaken for various process operations including waste disposal facilities (Bon Accord in Gauteng), bottling and drink facilities (Imali and Isanti Project in Gauteng) and Smelter (Gamsberg in Northern Cape).

Transport

An environmental noise assessment was completed for the Obetsebi road expansion and flyover project in Ghana.

Gas Pipelines

An environmental noise assessment is currently being undertaken for the Sheberghan gas pipeline in Afghanistan.

Baseline Noise Surveys

Baseline noise surveys have been undertaken for numerous mining and process operation activities (including Raumix quarries and Sibanye Stillwater Platinum Mines (SA)) in support of onsite Environmental Management Programmes.

OTHER EXPERIENCE (2001)

Research for B.Sc Honours degree was part of the "Highveld Boundary Layer Wind" research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: *An Air Quality Baseline Assessment for the Vaal Airshed in South Africa*
B.Sc Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)
ARCINFO	GIMS, Course: Introduction to ARCINFO 7 (2001)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Botswana, Ghana, Suriname, Afghanistan, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Lesotho, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Understanding the Synoptic Systems that lead to Strong Easterly Wind Conditions and High Particulate Matter Concentrations on The West Coast of Namibia, H Liebenberg-Enslin, R von Gruenewaldt, H Rauntenbach and L Burger. National Association for Clean Air (NACA) conference, October 2017.
- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High-Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas. Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Fair	Fair

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and my experience.

______________________	24/05/2021
Signature of staff member	Date (Day / Month / Year)

Full name of staff member: Reneé Georgeinna von Gruenewaldt

Appendix B – Declaration of Independence

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: René von Gruenewaldt
Name of Registration Body: South African Council for Natural Scientific Professions
Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, René von Gruenewaldt, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer. The additional information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at Pretoria on this 18th of August 2021

SIGNATURE
Principal Noise Scientist
CAPACITY OF SIGNATORY

Appendix C – Sound Level Meter Calibration Certificates

sanas Calibration Laboratory
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1302

M AND N ACOUSTIC SERVICES (Pty) Ltd
Co. Reg. No: 2012/123238/07 VAT NO: 4300255876 BEE Status: Level 4
P.O. Box 61713, Pierre van Ryneveld, 0045
No. 15, Mustang Avenue
Pierre van Ryneveld, 0045
Tel: 012 689-2007 (076 920 3070) • Fax: 086 211 4690
E-mail: admin@mnacoustics.co.za
Website: www.mnacoustics.co.za

CERTIFICATE OF CONFORMANCE

CERTIFICATE NUMBER	2021-AS-0246
ORGANISATION	AIRSHED PLANNING PROFESSIONALS (PTY) LTD
ORGANISATION ADDRESS	P.O. BOX 5260, HALFWAY HOUSE, 1685
CALIBRATION OF	ACOUSTIC CALIBRATOR
MANUFACTURER	SVANTEK
MODEL NUMBER	SV 33
SERIAL NUMBER	43170
DATE OF CALIBRATION	02 MARCH 2021
RECOMMENDED DUE DATE	--------------------
PAGE NUMBER	PAGE 1 OF 3

This certificate is issued in accordance with the conditions of approval granted by the South African National Accreditation System (SANAS). This Certificate may not be reproduced without the written approval of SANAS and M and N Acoustic Services.

Calibrations performed by this laboratory are in terms of standards, the accuracies of which are traceable to national measuring standards as maintained by NMISA.

The measurement results recorded in this certificate were correct at the time of calibration. The subsequent accuracy will depend on factors such as care, handling, frequency of use and the amount of different users. It is recommended that re-calibration should be performed at an interval, which will ensure that the instrument remains within the desired limits and/or manufacturer's specifications.

The South African National Accreditation System (SANAS) is member of the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA). This arrangement allows for mutual recognition of technical test and calibration data by member accreditation bodies worldwide. For more information on the arrangement please consult www.ilac.org

Calibrated by:	Authorized/Checked by:	Date of Issue:
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDÉ (SANAS TECHNICAL SIGNATORY)	02 MARCH 2021

Director: Marianka Naudé

Conditions under Which M and N Acoustic Services (Pty) Ltd Will Perform Work

In this document, reference to a service of services will include: calibration, measurement analysis or conformance work performed by M and N Acoustics on behalf of the Applicant.

1. Services are carried out at the discretion of M and N Acoustic Services, which reserves the right to decline any application for performance or services when deemed to be outside the scope of services of this Company.

2. Through acceptance of the original quotation, the Applicant agrees to the quoted fee and the conditions state herein. In cases where M and N Acoustic Services has not published the amount of the fee, M and N Acoustic Services will in good faith give estimates of the time and cost of the service based upon its previous experience.

3. Payment is strictly COD, or 30 days from the date of invoice, or as mutually agreed in writing between the Applicant and M and N Acoustic Services before the service is commenced. M and N Acoustic Services retains the right to ask for a deposit for services.

4. All instruments, items of equipment, etc. sent by the Applicant for performance of service shall be delivered and collected at the Applicant's own cost and risk.

5. M and N Acoustic Services cannot guarantee to complete the work within the estimated time and cost but will consult the Applicant of it becomes apparent that either estimate will be exceeded.

6. If a service is not completed because of defects or deficiencies in the item submitted by the applicant, an appropriate reduction in the fee may be allowed depending on the amount of work already performed. The normal practice will be to charge the fee in full.

7. The Applicant hereby consents that the legal liability of M and N Acoustic Services with regard to any damage whatsoever or a mistake made by M and N Acoustic Services in services performed for the Applicant will be limited to the original quoted fee.

8. Regarding certificates and reports:

    - A certificate or report will be furnished to the Applicant on completion of the service.
    - Additional certified copies of certificates, or re-issued certificates will be subjected to an additional fee, as determined on a case by case basis.
    - The values in the issued certificates are correct at the time of calibration. Subsequently the accuracy will depend on such factors as the care exercised in handling and use of the instrument and the frequency of use.
    - Re-calibration should be performed after a period which has been chosen to ensure that the instrument's accuracy remains within the desired limits.

1. PROCEDURE

The UUT was calibrated according to the procedures 1002/P/001 and also to the IEC 60942 specifications for Sound Level Calibrators as well as the manufacturer's specifications.

2. MEASURING EQUIPMENT

Keysight	34461A	Digital Multimeter	MY 53223905
Greysinger	80 CL	Environmental Logger	02304030/1/2
G.R.A.S	42 AP	Piston Phone	256092
G.R.A.S	26 AJ	½" Pre-Amplifier	188476
B&K	2363	Measuring Amplifier	1232647
G.R.A.S	40 AG	½" Microphone	19721
Leader	LDM-170	Distortion Meter	0100240
Svantek	SV 35	Acoustic Calibrator	58106
LG	FC-7015	Universal Counter	00022701
Agilent	34461A	Digital Multimeter	MY 53205694
G.R.A.S	42 AG	Multi-Frequency Calibrator	279025

3. RESULTS

3.1 The following parameters of the Calibrator were calibrated:

Output Level	IEC 60942: Section 5.2.3
Output Frequency	IEC 60942: Section 5.3.3
Selective Distortion	IEC 60942: Section A.4.9

The Calibrator output level was found to be 114,1 dB at 1 000 Hz.
No adjustment was made.

These results were corrected to the ambient condition of 1 013,25 Pa.

Conclusion: The Calibrator complied with the above-specified clauses of the IEC 60942 specification and requirements according to ARP 0109:2014. **Class 1.**

Calibrated by:	*Authorized/Checked by:*
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	*M. NAUDÉ (SANAS TECHNICAL SIGNATORY)*

Director: Marianka Naudé

4. REMARKS

4.1 The reported expanded uncertainties of measurements are based on a standard uncertainty multiplied by a coverage factor of $k=2$, providing a level of confidence of approximately 95,45 %, the uncertainties of measurements have been estimated in accordance with the principles defined in the GUM (Guide to Uncertainty of Measurement) ISO, Geneva, 1993.

4.2 The environmental conditions were:

Temperature:	(23 ± 2) °C
Relative Humidity:	(50 ± 15) %RH

4.3 Calibration labels bearing cal date, due date (if requested), certificate number and serial number have been affixed to the instrument.

4.4 The above statement of conformance is based on the measurement values obtained, extended by the estimated uncertainty of measurement, being within the appropriate specification limits

4.5 The uncertainty of measurements was estimated as follows:

Acoustic Calibrator:	± 0,19 dB

4.6 The results on this Certificate relates only to the items and parameters calibrated.

-----------SECTION 4.5 THE END OF CERTIFICATE----------

Calibrated by:	*Authorized/Checked by:*
W.S. SIBANYONI *(CALIBRATION TECHNICIAN)*	*M. NAUDÉ* *(SANAS TECHNICAL SIGNATORY)*

Director: Marianka Naudé

M AND N ACOUSTIC SERVICES (Pty) Ltd
Co. Reg. No: 2012/123238/07 VAT NO: 4300255876 BEE Status: Level 4
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No. 15, Mustang Avenue
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Tel: 012 689-2007 (076 920 3070) • Fax: 086 211 4690
E-mail: admin@mnacoustics.co.za
Website: www.mnacoustics.co.za

sanas Calibration Laboratory
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1302

CERTIFICATE OF CALIBRATION

CERTIFICATE NUMBER	2021-AS-0250
ORGANISATION	AIRSHED PLANNING PROFESSIONALS (PTY) LTD
ORGANISATION ADRESS	P.O. BOX 5260, HALFWAY HOUSE, 1685
CALIBRATION OF	SOUND & VIBRATION ANALYZER complete with built-in ⅓-OCTAVE/OCTAVE FILTER, ½" PRE-AMPLIFIER and ½" MICROPHONE
MANUFACTURERS	SVANTEK and ACO
MODEL NUMBERS	SVAN 977, SV 12L and 7052E
SERIAL NUMBERS	36183, 40659 and 78692
DATE OF CALIBRATION	01-02 MARCH 2021
RECOMMENDED DUE DATE	-------------------------
PAGE NUMBER	PAGE 1 OF 6

This certificate is issued in accordance with the conditions of approval granted by the South African National Accreditation System (SANAS). This Certificate may not be reproduced without the written approval of SANAS and M and N Acoustic Services.

The measurement results recorded in this certificate were correct at the time of calibration. The subsequent accuracy will depend on factors such as care, handling, frequency of use and the number of different users. It is recommended that re-calibration should be performed at an interval, which will ensure that the instrument remains within the desired limits and/or manufacturer's specifications.

The South African National Accreditation System (SANAS) is member of the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA). This arrangement allows for mutual recognition of technical test and calibration data by member accreditation bodies worldwide. For more information on the arrangement please consult www.ilac.org

Calibrated by:	Authorized/~~Checked by~~:	Date of Issue:
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDÉ (SANAS TECHNICAL SIGNATORY)	03 MARCH 2021

Director: Marianka Naudé

Conditions under Which M and N Acoustic Services (Pty) Ltd Will Perform Work

In this document, reference to a service of services will include: calibration, measurement analysis or conformance work performed by M and N Acoustics on behalf of the Applicant.

1. Services are carried out at the discretion of M and N Acoustic Services, which reserves the right to decline any application for performance or services when deemed to be outside the scope of services of this Company.
2. Through acceptance of the original quotation, the Applicant agrees to the quoted fee and the conditions state herein. In cases where M and N Acoustic Services has not published the amount of the fee, M and N Acoustic Services will in good faith give estimates of the time and cost of the service based upon its previous experience.
3. Payment is strictly COD, or 30 days from the date of invoice, or as mutually agreed in writing between the Applicant and M and N Acoustic Services before the service is commenced. M and N Acoustic Services retains the right to ask for a deposit for services.
4. All instruments, items of equipment, etc. sent by the Applicant for performance of service shall be delivered and collected at the Applicant's own cost and risk.
5. M and N Acoustic Services cannot guarantee to complete the work within the estimated time and cost but will consult the Applicant of it becomes apparent that either estimate will be exceeded.
6. If a service is not completed because of defects or deficiencies in the item submitted by the applicant, an appropriate reduction in the fee may be allowed depending on the amount of work already performed. The normal practice will be to charge the fee in full.
7. The Applicant hereby consents that the legal liability of M and N Acoustic Services with regard to any damage whatsoever or a mistake made by M and N Acoustic Services in services performed for the Applicant will be limited to the original quoted fee.
8. Regarding certificates and reports:
    - A certificate or report will be furnished to the Applicant on completion of the service.
    - Additional certified copies of certificates, or re-issued certificates will be subjected to an additional fee, as determined on a case by case basis.
    - The values in the issued certificates are correct at the time of calibration. Subsequently the accuracy will depend on such factors as the care exercised in handling and use of the instrument and the frequency of use.
    - Re-calibration should be performed after a period which has been chosen to ensure that the instrument's accuracy remains within the desired limits.

1. PROCEDURE

The Integrating Sound Level Meter was calibrated according to procedure 1002/P/013 and to the IEC 61672-3:2006 specifications as well as the manufacturer's specifications.

The ½" Microphone was calibrated according to procedure 1002/P/002 and 1002/P/011 as well as the manufacturer's specifications.

The ⅓-Octave/Octave Filter was calibrated according to procedure 1002/P/008 and to the IEC 61260 specification as well as the manufacturer's specifications.

2. MEASURING EQUIPMENT

JFW	50BR-022	50 Ohm Step Attenuator	4610290708
Agilent	33522A	Function Generator	MY 50005443
Agilent	34461A	Digital Multimeter	MY 53224004
Onset	UX100-011	Environmental Logger	2047747
Majortech	MT669	Environmental Logger	150828469
Svantek	SV 35	Acoustical Calibrator	58106
Keysight	34461A	Digital Multimeter	MY 53223905
G.R.A.S	42 AP	Piston Phone	256092
G.R.A.S	26 AJ	½" Pre-Amplifier	188476
G.R.A.S	40 AG	½" Microphone	19721
B&K	4226	Multi-Functional Calibrator	3081642
Greysinger	80 CL	Data Logger	02304030/1/2
Gems	3500B0001A01B000	Pressure Sensor	1606-0204475
B&K	2829	4-Ch Microphone Power Supply	2329283

Calibrations performed by this laboratory are in terms of standards, the accuracies of which are traceable to national measuring standards as maintained by NMISA.

Calibrated by:	*Authorized/Checked by:*
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	*M. NAUDÉ (SANAS TECHNICAL SIGNATORY)*

Director: Marianka Naudé

3. RESULTS - ACCORDING TO THE IEC 61672-3: 2006:

3.1 The following parameters of the Integrating Sound Level Meter were calibrated:

Parameter	Specification	Uncertainty of Measurement in dB
Calibration Check Frequency at 114,0 dB at 1 000 Hz at Nominal Range: High	IEC 61672-3: Clause 9	± 0,3
Self-Generated Noise: A-Weighted with Microphone 37,7 dB A-Weighted Electrical 1,1 dB C-Weighted Electrical 0,0 dB Z-Weighted Electrical 3,7 dB B-Weighted Electrical - 0,2 dB	IEC 61672-3: Clause 10	-------
Level Linearity at 8 000 Hz Nominal Range: High Reference Level at 114,0 dB: (59,3 dB to 148,9 dB)	IEC 61672-3: Clause: 14	± 0,3
Level Range Control at 1 000 Hz Reference Level at 114,0 dB Nominal Range: High Low Range	IEC 61672-3: Clause: 15	± 0,3
Frequency and Time Weightings at 1 000 Hz at 114,0 dB	IEC 61672-3: Clause 13	± 0,3
Tone Burst Response (Max. Fast, Max. Slow, LA_{eq} and SEL)	IEC 61672-3: Clause 16	± 0,3

Calibrated by:	Authorized/Checked by:
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDÉ (SANAS TECHNICAL SIGNATORY)

Director: Marianka Naudé

Parameter	Specification	Uncertainty of Measurement in dB
A-Weighting Network (31,5 to 20 000) Hz	IEC 61672-3: Clause 12	± 0,3
C-Weighting Network (31,5 to 20 000) Hz	IEC 61672-3: Clause 12	± 0,3
Z- Weighting Network (31,5 to 20 000) Hz	IEC 61672-3: Clause 12	± 0,3
B- Weighting Network (31,5 to 20 000) Hz	IEC 61672-3: Clause 12	± 0,3
Peak, C Low Peak Range	IEC 61672-3: Clause 17	± 0,3

Conclusion: The Integrating Sound Level Meter complied with the above-specified clauses of the IEC 61672-3:2006 specifications and requirements according to ARP 0109:2014. **Class 1.**

3.2 The following parameters of the built-in ⅓-Octave/Octave Filter were calibrated:

Octave Frequency Response (31,5 to 16 000) Hz	IEC 61260: Sections 4.7 & 5.6
⅓-Octave Frequency response (25 to 20 000) Hz	IEC 61260: Sections 4.7 & 5.6

The uncertainty of measurement was estimated as follows: ± 0,3 dB

Conclusion: The built-in Octave Filter complied with the above-specified clauses of the IEC 61260 specification, **Class 1.**

Calibrated by:	*Authorized/Checked by:*
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	*M. NAUDE (SANAS TECHNICAL SIGNATORY)*

Director: Marianka Naudé

3.3 The following parameters of the ½" Microphone were calibrated and the results were corrected to the ambient condition of 1 013,25 mBar:

Output Sensitivity at 250 Hz at 94,0 dB
Frequency Response (31,5 to 16 000) Hz

The uncertainty of measurements was estimated as follows: ± 0,3 dB

Conclusion: The parameters measured for the ½" Microphone, complied with the manufacturer's specification.

3.4 The ½" Microphone was calibrated Electroacoustic according to Clause 12 of IEC 61672-3: 2006 complete with Integrating Sound Level Meter and Svantek SV 12L ½" Pre-amplifier Serial No: 25686, free-field corrections were taken into consideration and the results were corrected to the ambient condition of 1 013,25 mBar:

FREQUENCY (Hz)	CALCULATED EXPECTED VALUE (dB)	MEASURED VALUE (dB)	DEVIATION (dB)	UoM (dB)
1 000 (Ref)	114,1	114,1	0,0	± 0,3
31,5	111,3	111,2	- 0,1	± 0,3
63	113,4	113,3	- 0,1	± 0,3
125	113,9	113,9	0,0	± 0,3
250	114,1	114,0	- 0,1	± 0,3
500	114,0	114,0	0,0	± 0,3
1 000	114,1	114,1	0,0	± 0,3
2 000	113,9	113,9	0,0	± 0,3
4 000	113,4	113,5	+ 0,1	± 0,3
8 000	109,4	109,2	- 0,2	± 0,3
12 500	106,5	106,9	+ 0,4	± 0,3
16 000	103,3	104,0	+ 0,7	± 0,3

Calibrated by:	*Authorized/Checked by:*
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	*M. NAUDE (SANAS TECHNICAL SIGNATORY)*

Director: Marianka Naudé

4. REMARKS

4.1 The reported expanded uncertainties of measurements are based on a standard uncertainty multiplied by a coverage factor of $k=2$, providing a level of confidence of approximately 95,45 %, the uncertainties of measurements have been estimated in accordance with the principles defined in the GUM (Guide to Uncertainty of Measurement) ISO, Geneva, 1993

4.2 The environmental conditions during calibration of items in section 3 were:
Temperature: (23 ± 2) °C
Relative Humidity: (50 ± 15) %RH

4.3 Calibration labels bearing cal date, due date (if requested), certificate number and serial number have been affixed to the instrument.

4.4 The above statement of conformance is based on the measurement values obtained, extended by the estimated uncertainty of measurement, being within the appropriate specification limits

4.5 The microphone's frequency range determines the useful frequency range of the sound level meter and vice versa.

4.6 The results on this Certificate relates only to the items and parameters calibrated.

4.7 Abbreviation:
UoM = Uncertainty of Measurement

------------SECTION 4.7 THE END OF CERTIFICATE-----------

Calibrated by:	*Authorized/Checked by:*
W.S. SIBANYONI *(CALIBRATION TECHNICIAN)*	*M. NAUDÉ* *(SANAS TECHNICAL SIGNATORY)*

Director: Marianka Naudé

Appendix D – Time-series, Statistical, and Frequency Spectrum Results

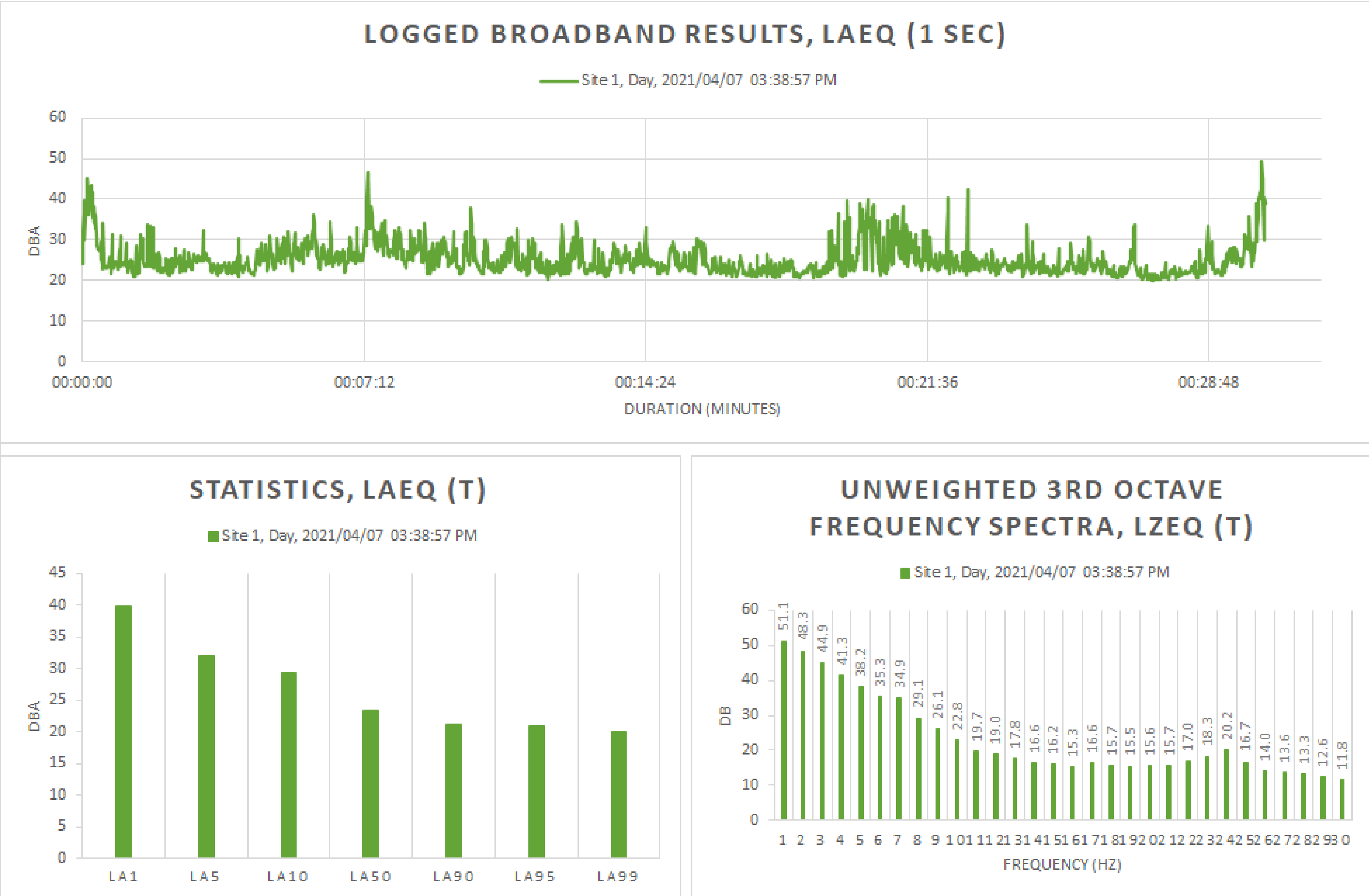

Figure 13: Detailed day-time survey results for Site 1

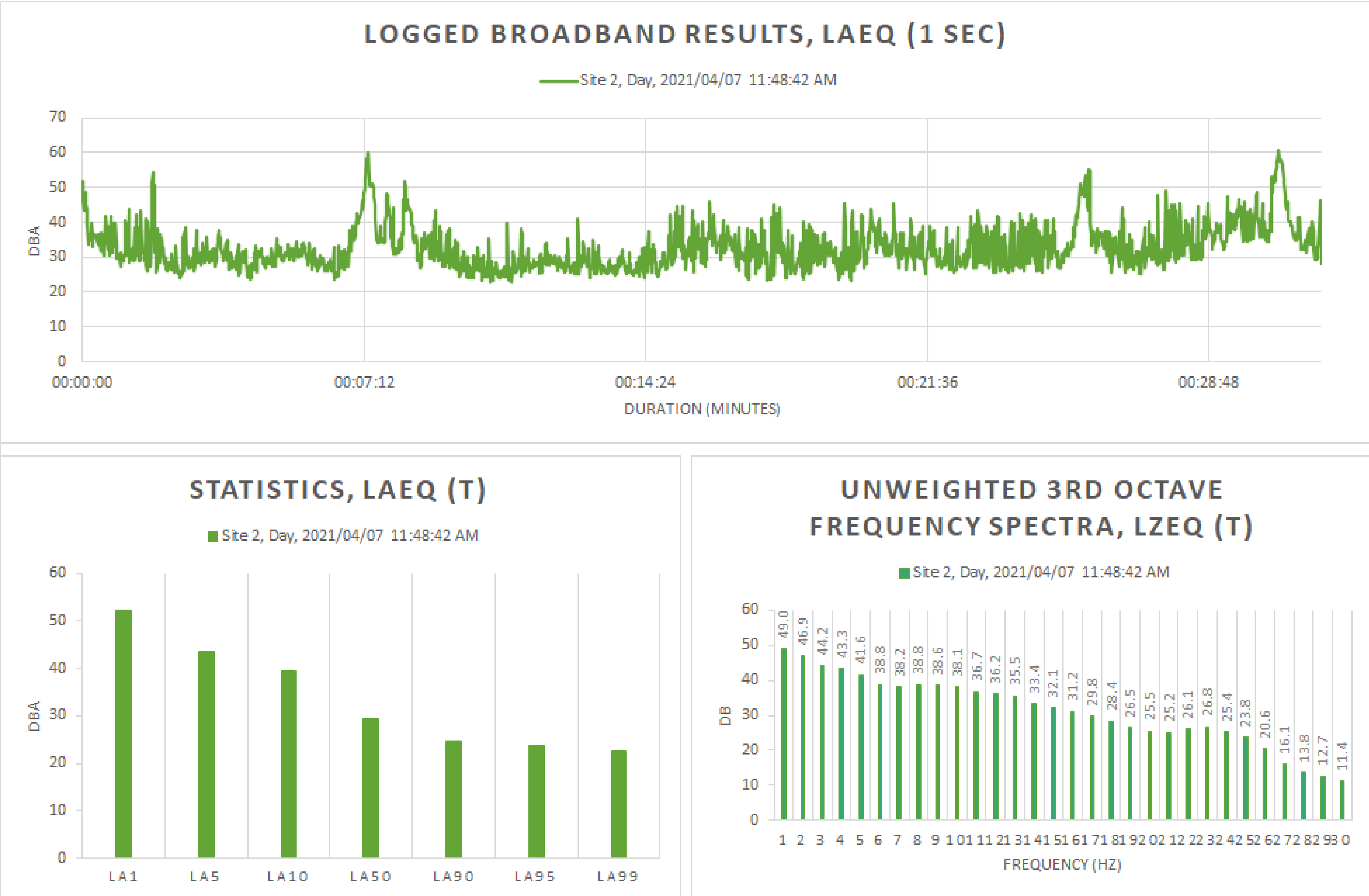

Figure 14: Detailed day-time survey results for Site 2

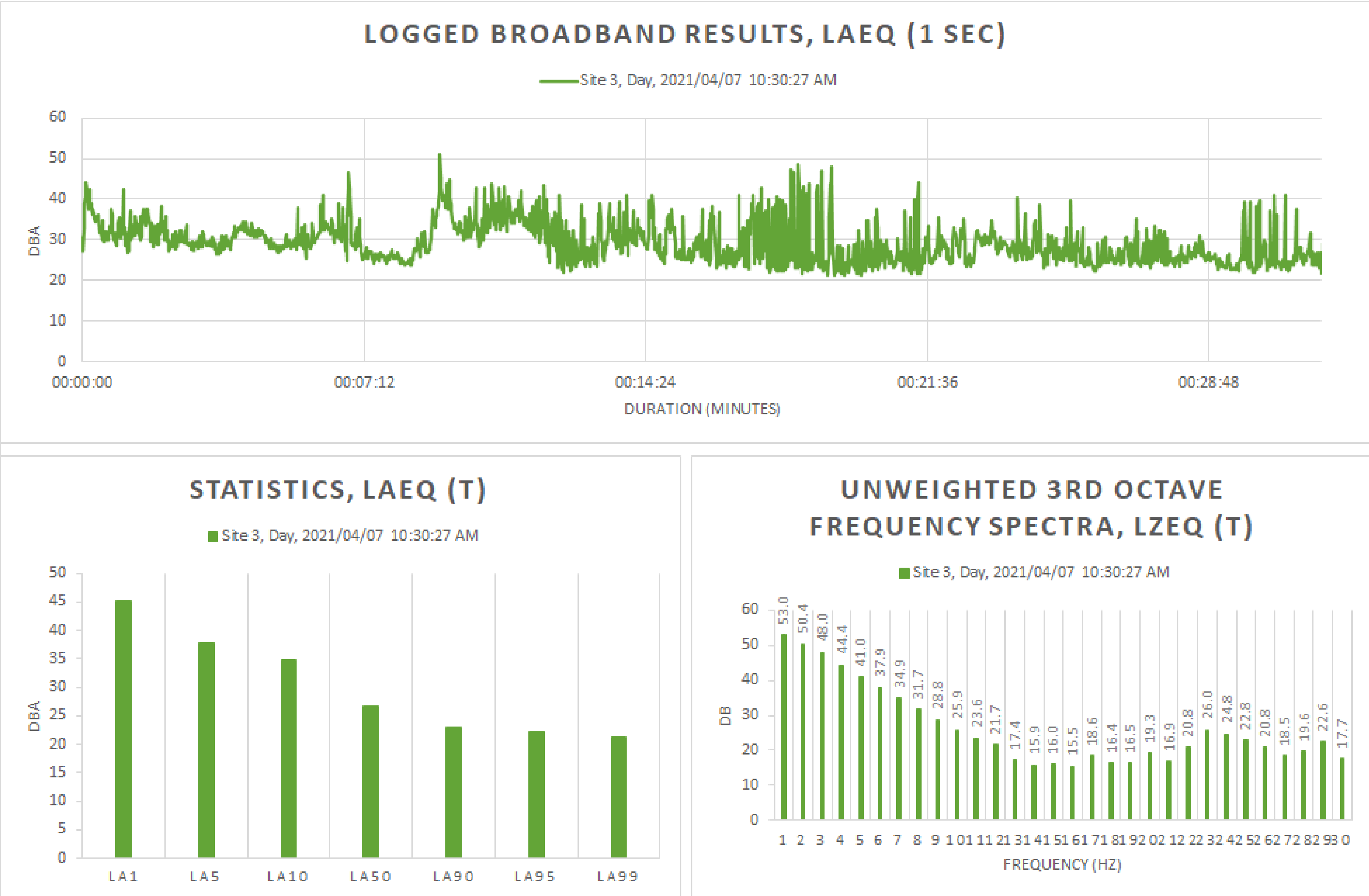

Figure 15: Detailed day-time survey results for Site 3

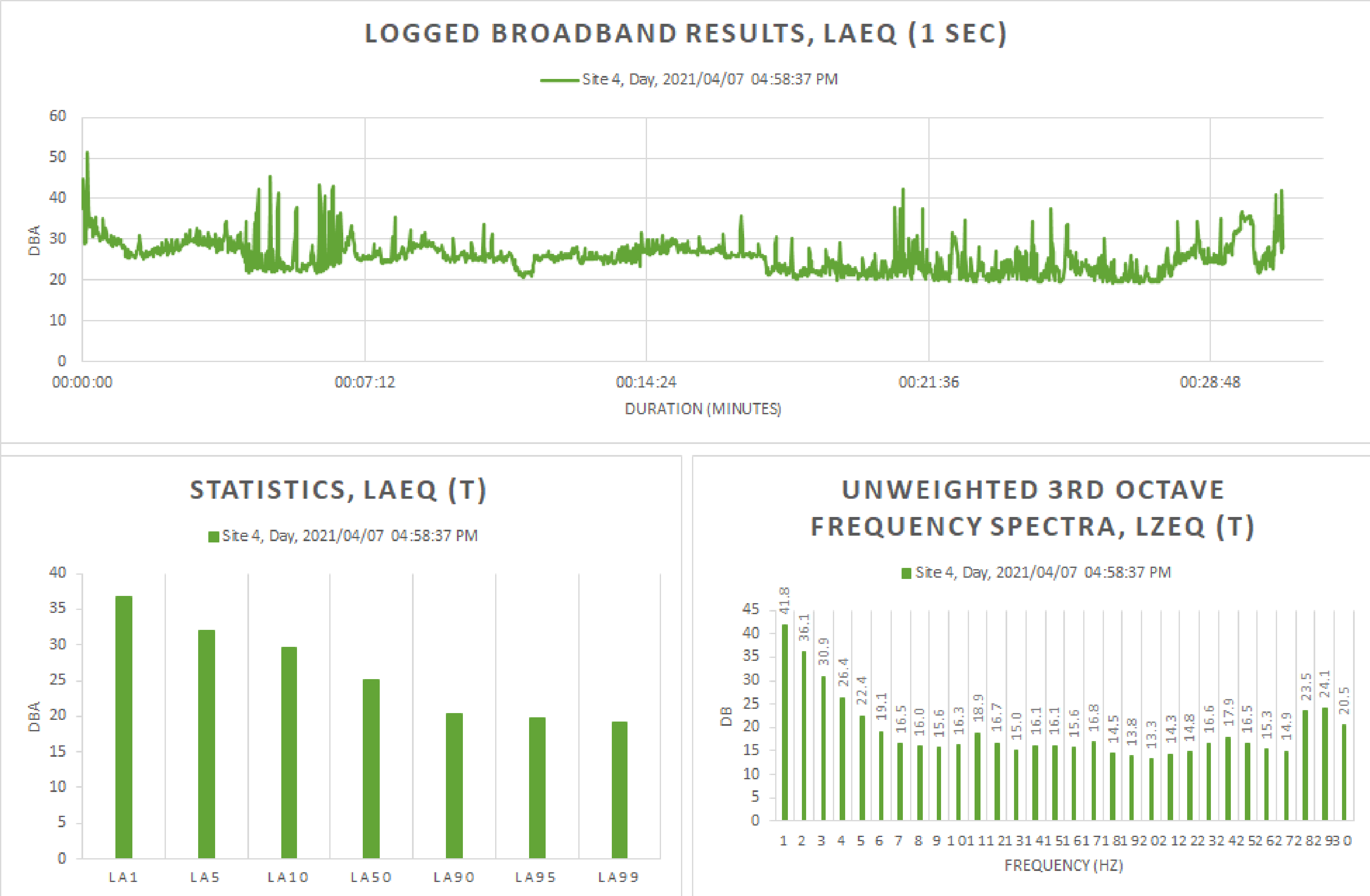

Figure 16: Detailed day-time survey results for Site 4

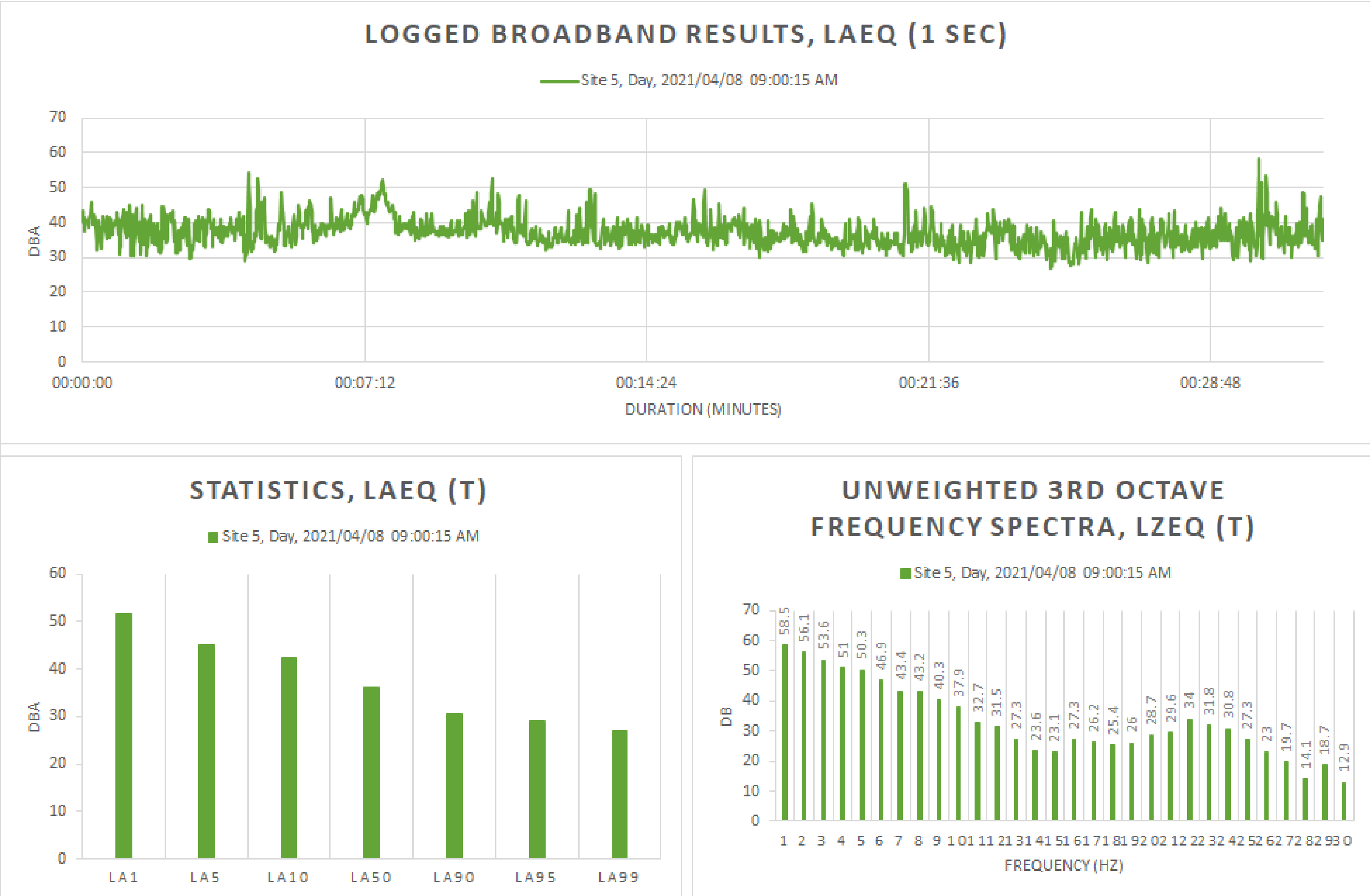

Figure 17: Detailed day-time survey results for Site 5

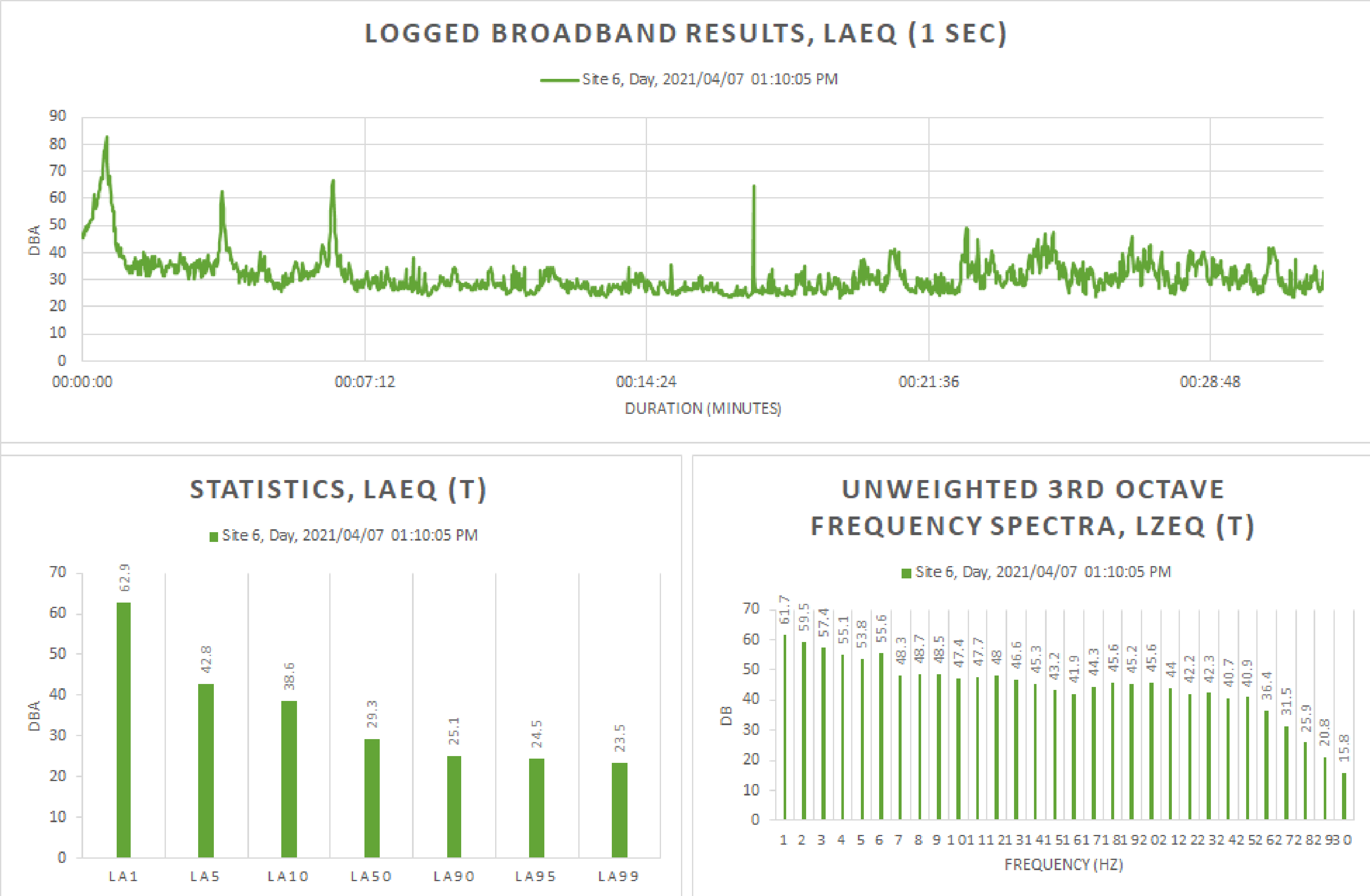

Figure 18: Detailed day-time survey results for Site 6

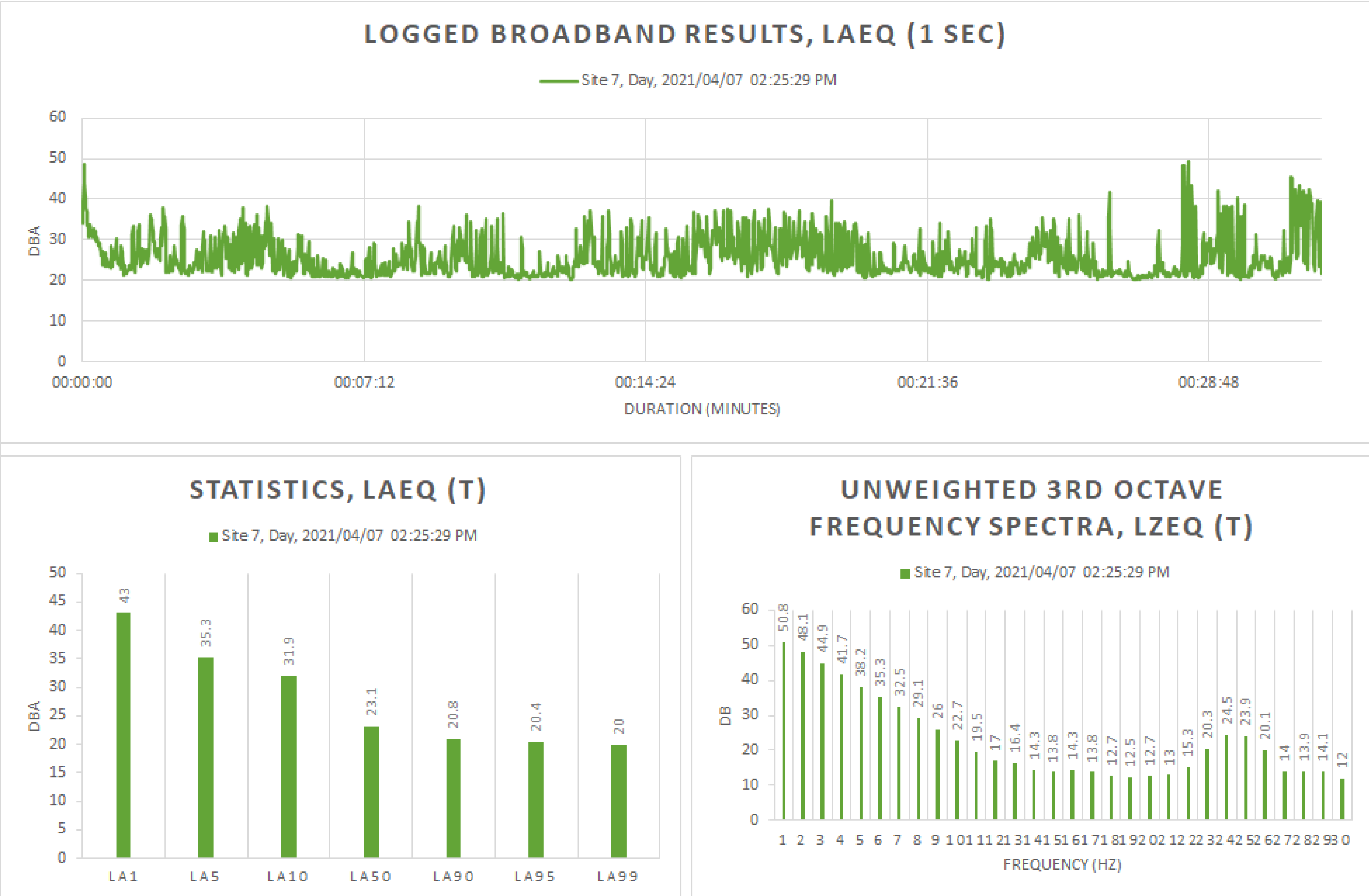

Figure 19: Detailed day-time survey results for Site 7

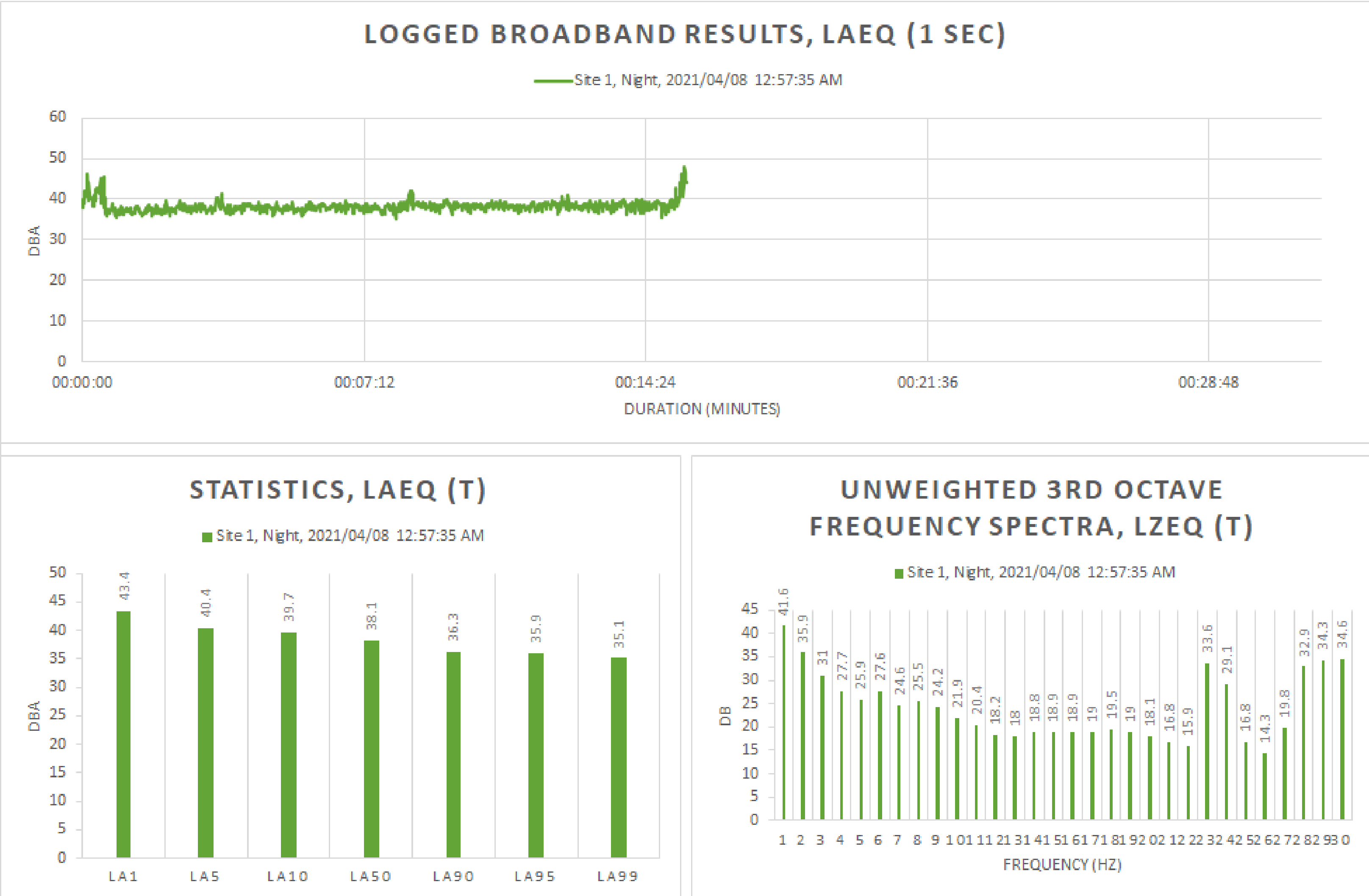

Figure 20: Detailed night-time survey results for Site 1

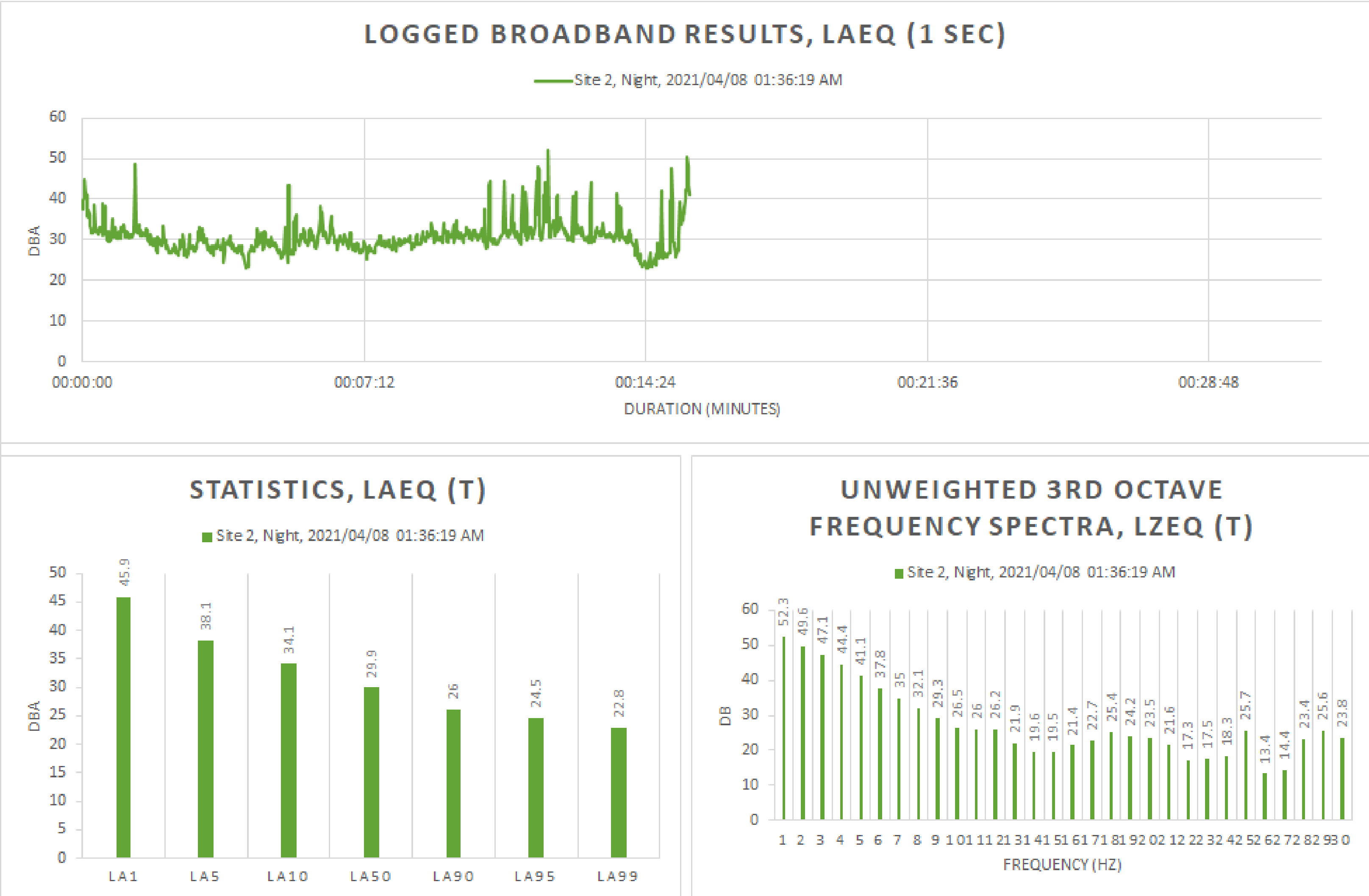

Figure 21: Detailed night -time survey results for Site 2

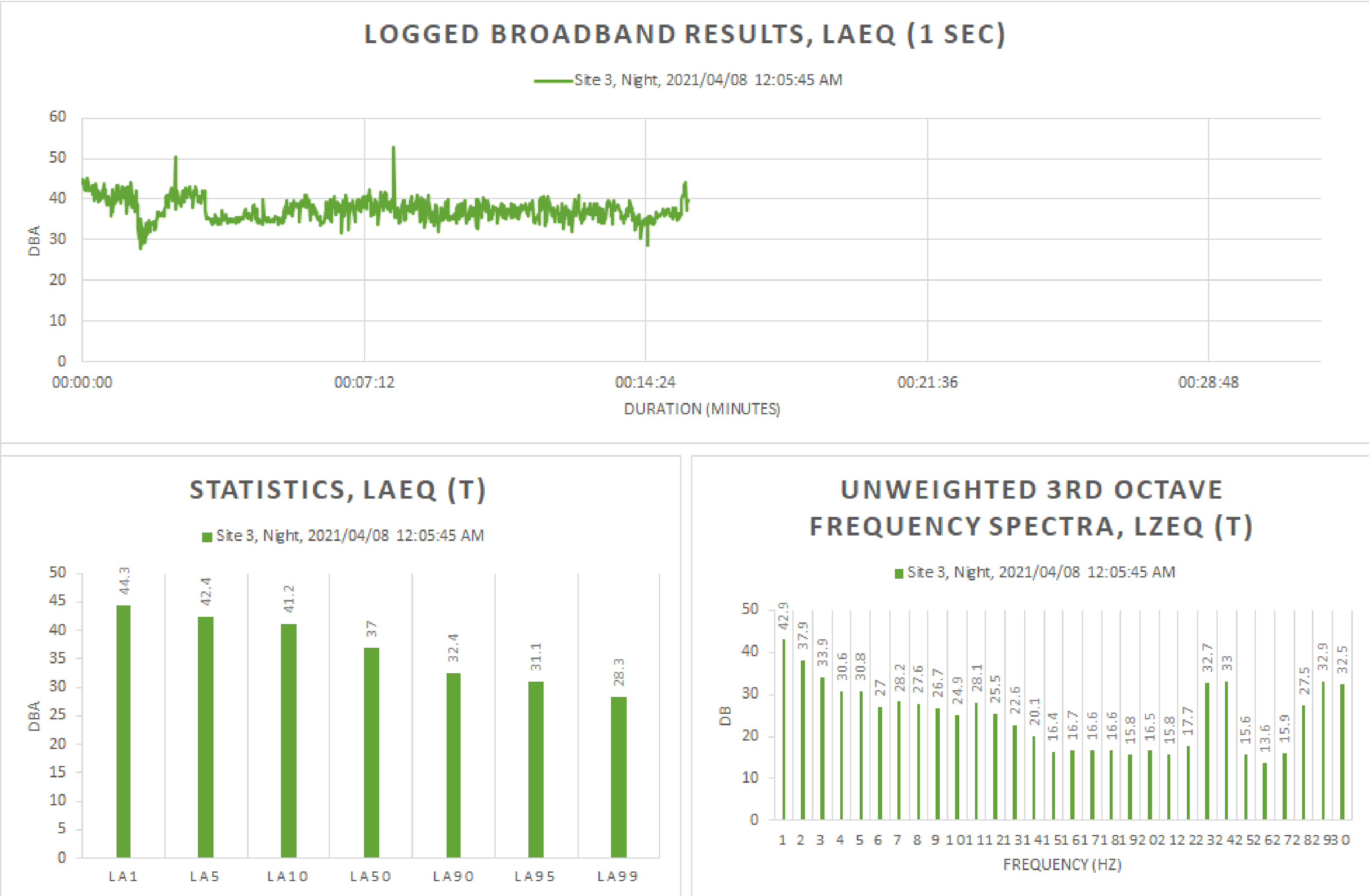

Figure 22: Detailed night -time survey results for Site 3

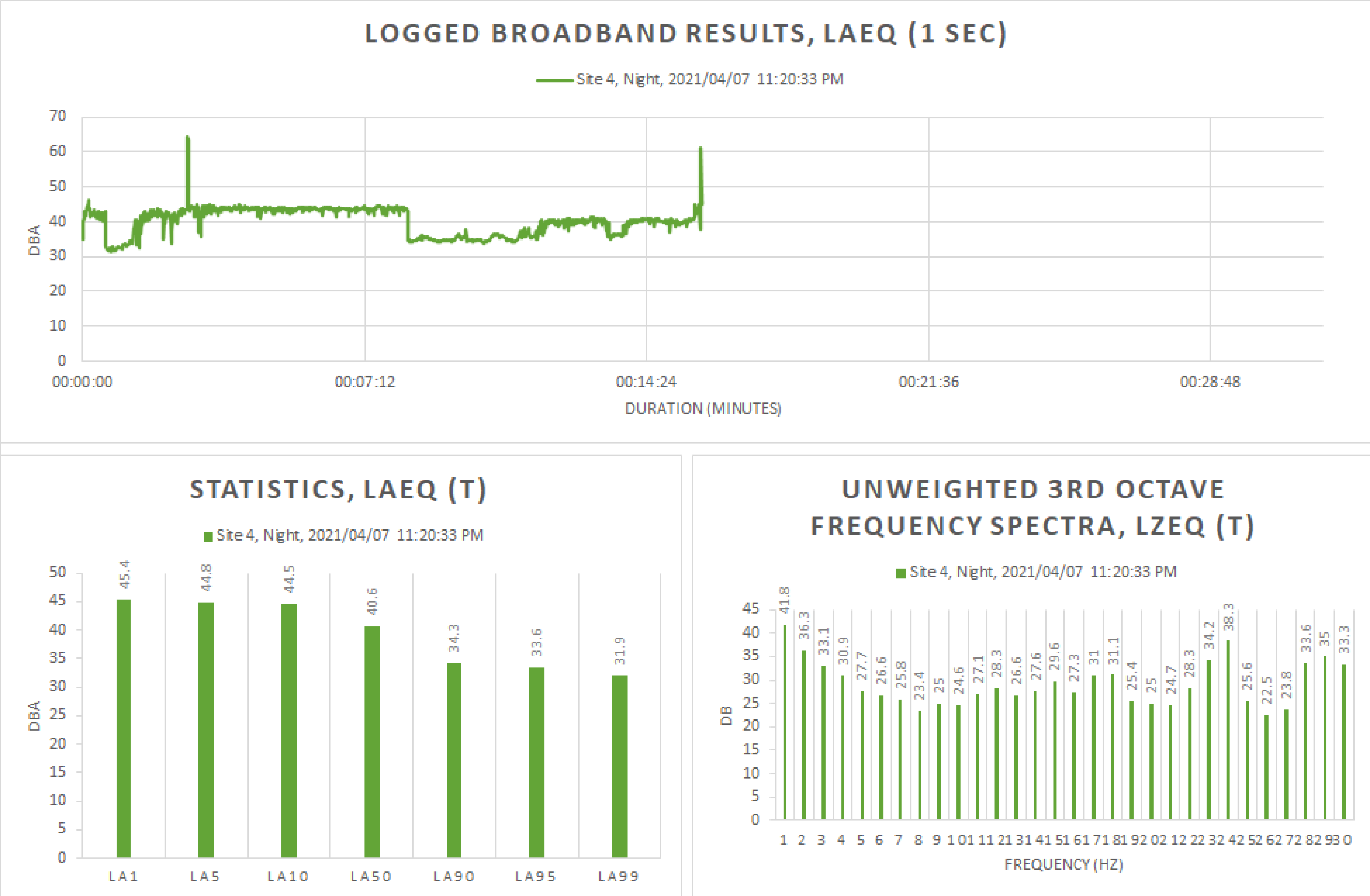

Figure 23: Detailed night -time survey results for Site 4

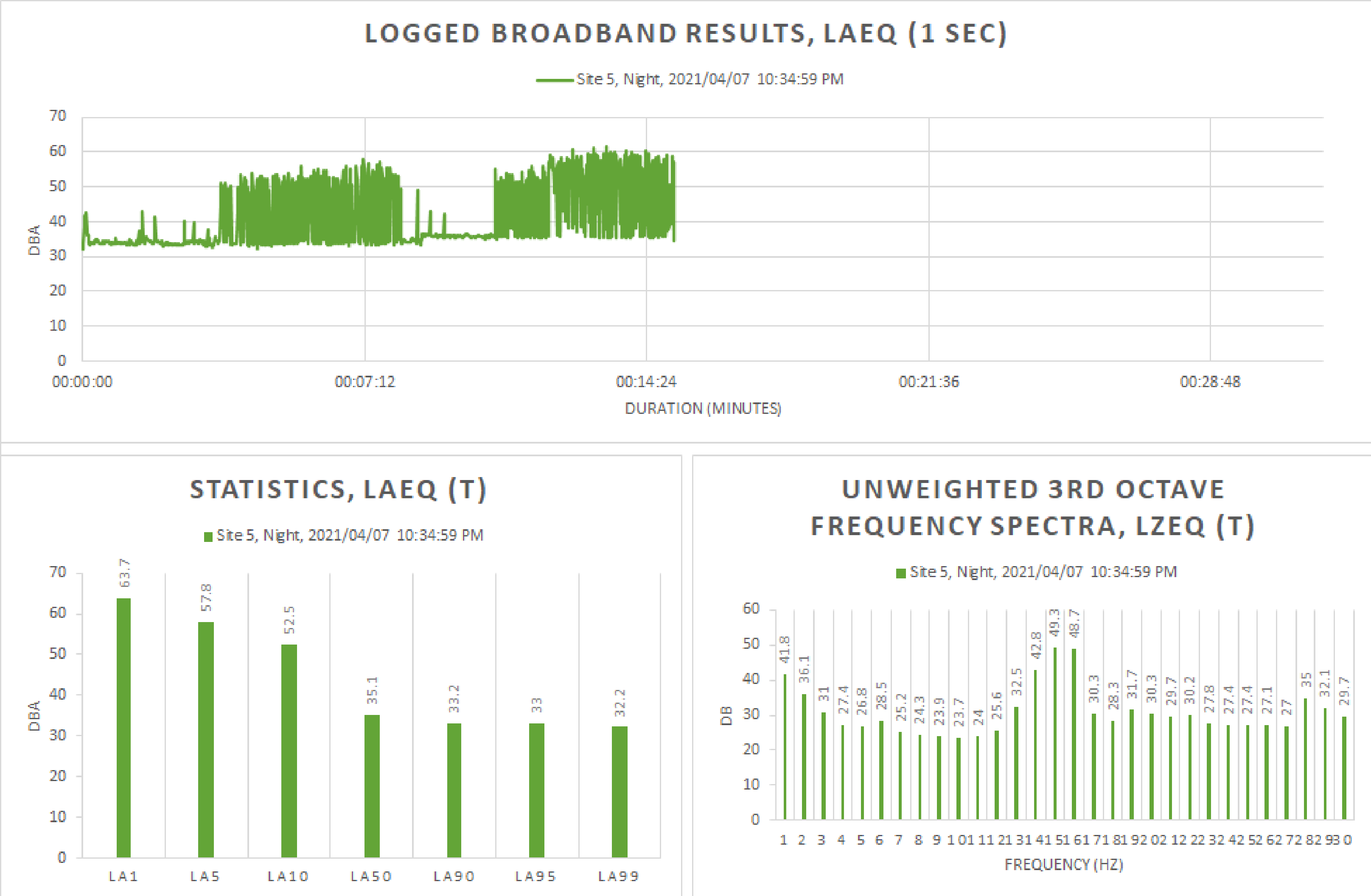

Figure 24: Detailed night -time survey results for Site 5

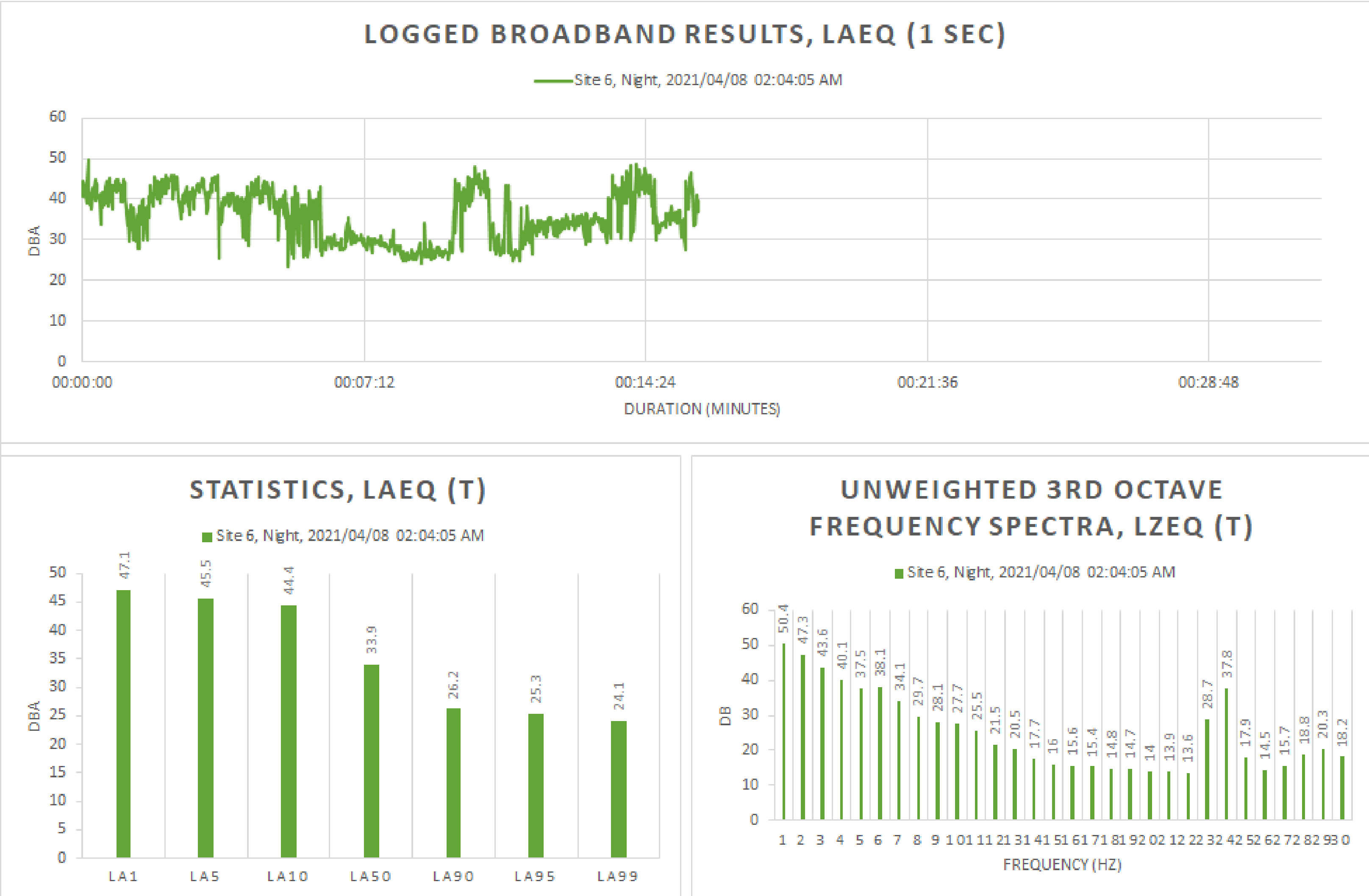

Figure 25: Detailed night -time survey results for Site 6

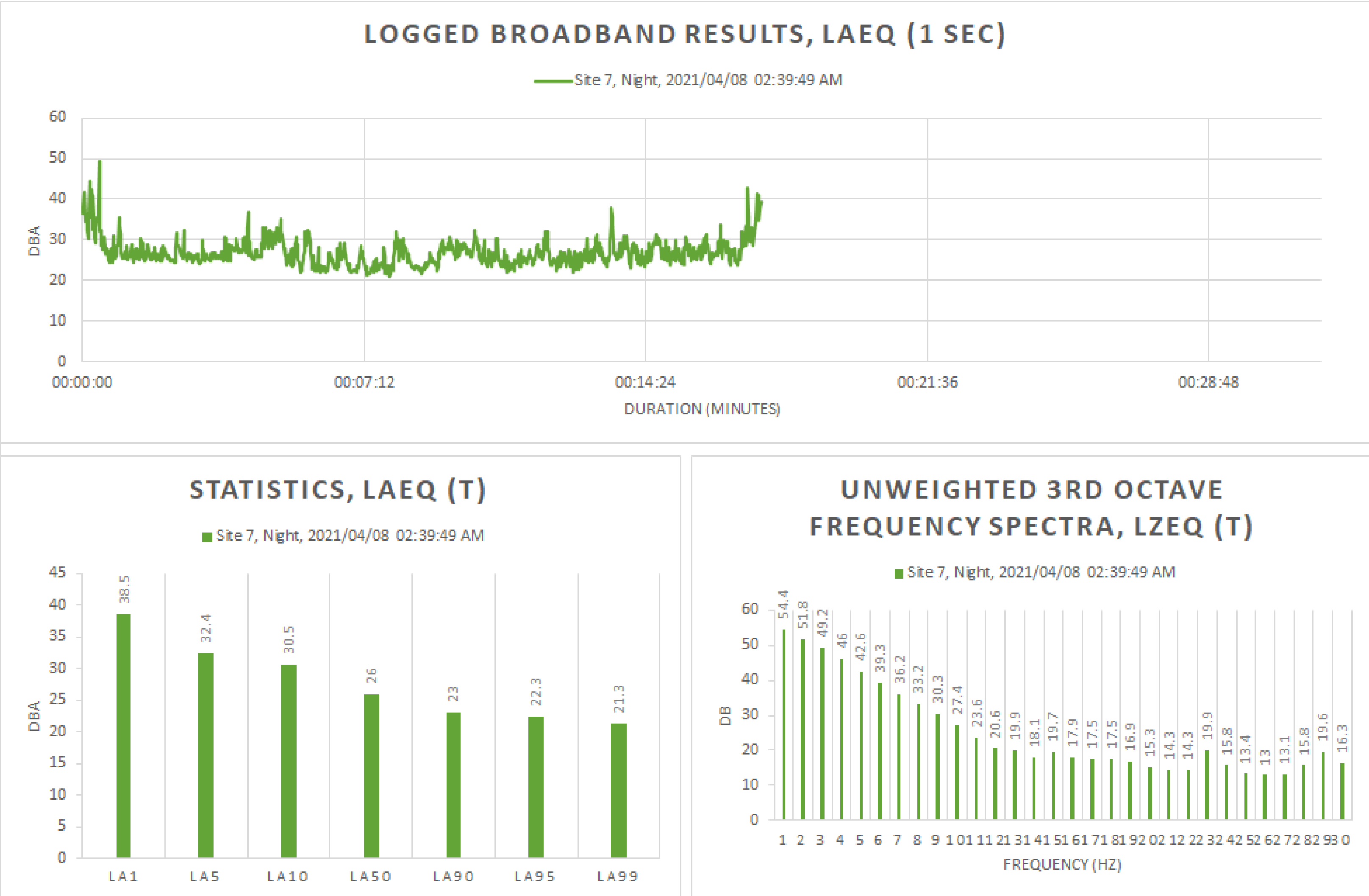

Figure 26: Detailed night -time survey results for Site 7

Appendix E – Site Photographs

Facing north

Facing east

Facing south

Facing west

Figure 27: Photographs of environmental noise survey Site 1

Facing north

Facing east

Facing south

Facing west

Figure 28: Photographs of environmental noise survey Site 2

Facing north

Facing east

Facing south

Facing west

Figure 29: Photographs of environmental noise survey Site 3

Facing north

Facing east

Facing south

Facing west

Figure 30: Photographs of environmental noise survey Site 4

Facing north

Facing east

Facing south

Facing west

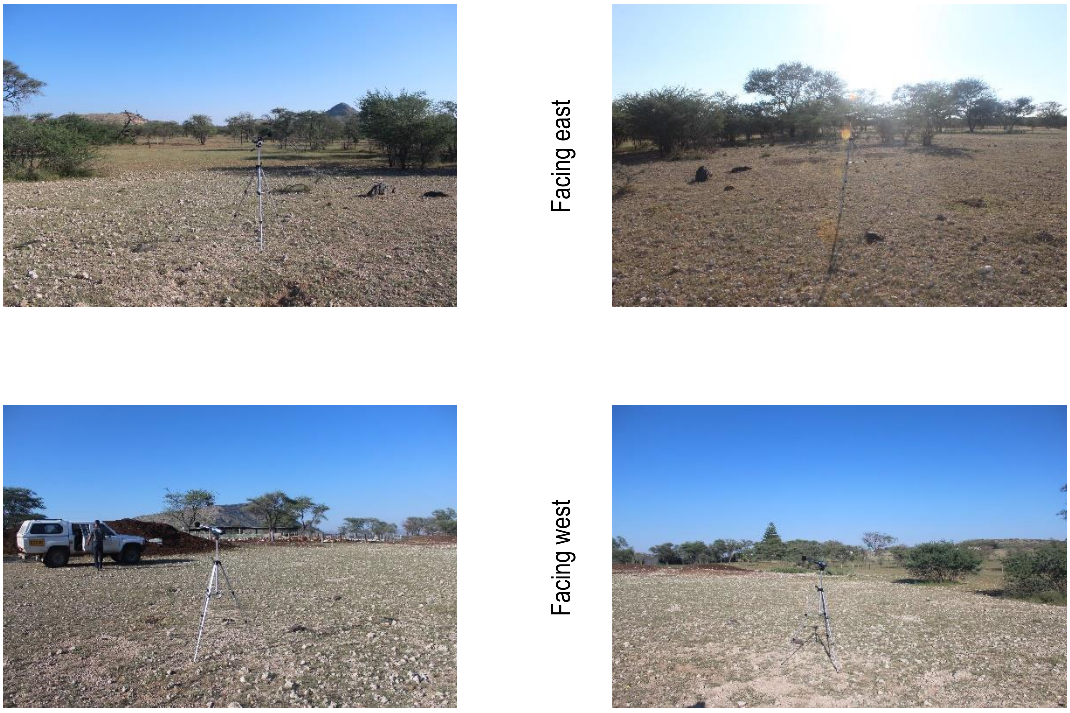

Figure 31: Photographs of environmental noise survey Site 5

Facing north

Facing east

Facing south

Facing west

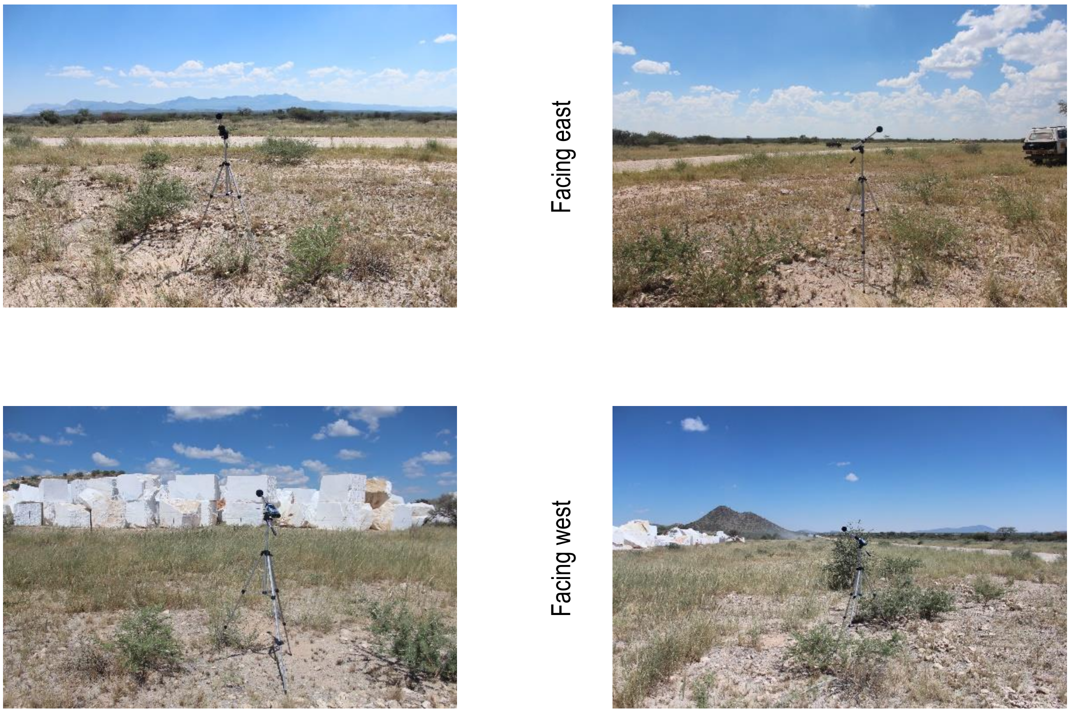

Figure 32: Photographs of environmental noise survey Site 6

Facing north

Facing east

Facing south

Facing west

Figure 33: Photographs of environmental noise survey Site 7