Resonate

Muswellbrook Pump Hydro Upper Reservoir

Geotechnical Investigation Noise and Vibration Assessment

S210514RP2 Revision D

Monday, 5 June 2023

Resonate

Document Information

Project	Muswellbrook Pump Hydro Upper Reservoir
Client	SMEC Australia Pty Ltd
Report title	Geotechnical Investigation Noise and Vibration Assessment
Project Number	S210514

Revision Table

Report revision	Date	Description	Author	Reviewer
0	13 December 2022	Draft – first issue	Marc Schlussel	Raymond Sim
A	13 January 2023	Final	Marc Schlussel	Raymond Sim
B	1 February 2023	Final – update work duration	Marc Schlussel	Raymond Sim
C	20 April 2023	Final – update site description	Marc Schlussel	Raymond Sim
D	5 June 2023	Final – update borehole locations	Marc Schlussel	Raymond Sim

Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Ambient noise	The total noise in a given situation, inclusive of all noise source contributions in the near and far field.
Characteristic	Associated with a noise source, means a tonal, impulsive, low frequency or modulating characteristic of the noise that is determined in accordance with the NSW EPA's *Noise Policy for Industry* to be fundamental to the nature and impact of the noise.
Compliance	The process of checking that source noise levels meet with the noise limits in a statutory context.
Day	Between 7 am and 6 pm as defined in the NPI
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of loudness.
dB(A)	dB(A) denotes a single number sound pressure level that includes a frequency weighting ("A-weighting") to reflect the subjective loudness of the sound level. The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).
Evening	Between 6 pm and 10 pm as defined in the NPI
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second.
ICNG	NSW EPA's *Interim Construction Noise Guideline*.
L_{10}	Noise level exceeded for 10 % of the measurement time. The L_{10} level represents the typical upper noise level and is often used to represent traffic or music noise.
L_{90}	Noise level exceeded for 90 % of the measurement time. The L_{90} level is commonly referred to as the background noise level.
L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
L_{max}	The maximum instantaneous noise level.
Night	Between 10 pm on one day and 7 am on the following day as defined in the NPI
Noise criteria	The general set of non-mandatory noise levels for protecting against intrusive noise (for example, background noise plus 5 dB) and loss of amenity (e.g. noise levels for various land use).
Noise source	Premises or a place at which an activity is undertaken, or a machine or device is operated, resulting in the emission of noise
NPI	NSW EPA's *Noise Policy for Industry*.

Rating Background Level (RBL)	The RBL is the overall single figure background level representing each assessment period (day, evening and night) over the whole monitoring period (as opposed to over each 24-hour period used for the ABL). This is the level used for assessment purposes. It is the median value of: • All the day assessment background levels over the monitoring period for the day; • All the evening assessment background levels over the monitoring period for the evening; or All the night assessment background levels over the monitoring period for the night.
Sound Power Level (SWL)	The sound power level of a noise source is the sound energy emitted by the source. Notated as SWL, sound power levels are typically presented in *dB(A)*.
Sound Pressure Level (SPL)	The level of noise, usually expressed as SPL in *dB(A)*, as measured by a standard sound level meter with a pressure microphone. The sound pressure level in *dB(A)* gives a close indication of the subjective loudness of the noise.

Resonate

Table of Contents

1 Introduction

Resonate Consultants has been engaged by SMEC Australia Pty Ltd to conduct a noise and vibration assessment for geotechnical investigations drilling works to be undertaken in early 2023 at the upper reservoir location of the proposed Muswellbrook Pump Hydro. This geotechnical investigation noise and vibration assessment would be used to support the application to conduct the borehole works.

It is understood the drill boring works are likely to occur 24 hours day and have an expected duration of 12 weeks.

It is also understood that works at the boring sites at the upper reservoir location would be undertaken consecutively and not concurrently.

The objective of this report is to document the potential noise and vibration impacts that may be generated due to the geotechnical site investigation work. A number of noise sensitive receivers located near the boring sites have been identified to be potential impacted by the works and hence an assessment of noise and vibration impacts is required.

2 Existing ambient noise environment

2.1 Site location and noise catchment areas

The borehole sites are to be located on the upper slopes of Bells Mountain. The surrounding land-uses of the site are detailed below:

- North – Distant noise sensitive receivers scattered to the north of the site. Nearest sensitive receiver is at a distance of approximately 1.2 kilometres.
- West – Distant noise sensitive receivers scattered to the west of the site. Nearest sensitive receiver is at a distance of approximately 1.2 kilometres.
- East – Distant noise sensitive receivers scattered to the west of the site. Nearest sensitive receiver is at a distance of approximately 1.2 kilometres.
- South – Vegetation and hills are located to the east of the site with no noise sensitive receivers.

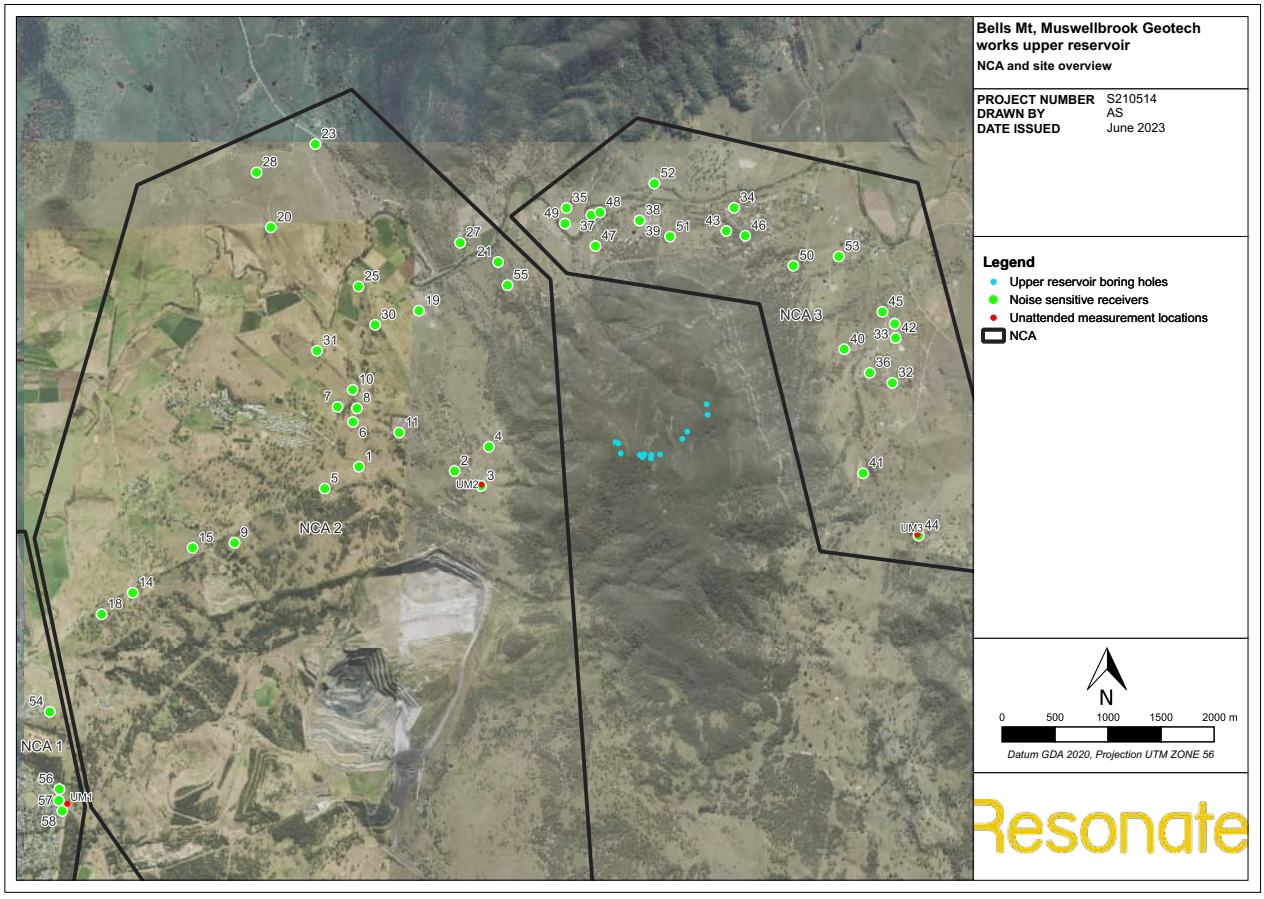


Figure 1: NCA and noise study area overview

2.2 Unattended noise monitoring

Unattended noise monitoring was undertaken between the dates of 11 November 2022 and 23 November 2022 at three locations (UM1, UM2 and UM3 as shown in Figure 1) to characterise the background noise level of the nearest sensitive receiver locations.

2.3 Instrumentation

The instrumentation of the unattended noise monitoring comprised of three Rion NL-42 environmental noise loggers (serial number: 00946983, 00946978, 00946981) fitted with wind shields. Field calibration was conducted at the commencement and at the conclusion of the logging period and no significant calibration drift was observed (drift in calibration did not exceed ±0.5 dB(A)). All instrumentation carried appropriate and current NATA (or manufacturer) calibration certificates.

2.4 Weather conditions

It is a requirement that noise data is captured during periods of favourable weather conditions avoiding adverse impacts of wind and rain on background noise levels. To assess weather conditions for the measurement period, half-hourly weather data was obtained from the Bureau of Meteorology (BOM) weather observation station ID 061363 at Scone Airport AWS.

Noise data has been excluded from the processed results if:

- rain was observed during a measurement period, and/or
- wind speed exceeded 5 m/s (18 km/h) at the measurement height of 1.5 m above ground. Wind data obtained from the BOM is presented as the value at 10 m above ground.

The BOM wind speed data obtained for this report was measured at a height of 10 m above ground level. It is therefore necessary to apply a correction factor in order to estimate the wind speed at the height of the logger (1.5 m).

The methodology to formulate a correction factor has been derived[1]. The correction multiplier for the measured wind speed at 10 m is derived by the following formula:

$$W_{1.5} = W_{10} \times \left(\frac{M_{1.5,cat}}{M_{10,cat}} \right)$$

where:

$W_{1.5}$ = Wind speed at height of 1.5 m
W_{10} = Wind speed at height of 10 m
$M_{1.5,cat}$ = AS 1170 multiplier for receiver height of 1.5 m and terrain category
$W_{10,cat}$ = AS 1170 multiplier for receiver height of 10 m and terrain category

2.5 Unattended noise monitoring results

The noise data obtained from the noise logger has been processed in accordance with the procedures contained in the NSW Noise Policy for Industry (NPI) to establish representative noise levels at the monitoring location.

A summary of background L_{A90} results from the unattended noise survey during proposed operational hours of the playground is presented in Table 1.

The background noise levels were determined by taking the arithmetic mean noise level that was exceeded for 90% of the time during the relevant assessment periods for each day and then taking the median of all the days where monitoring took place for each assessment period as identified in the NPI. This process provides a single figure rating background noise level (RBL) for the day, evening and night periods. These RBLs were used to establish the relevant noise criteria in accordance with the NPI for each assessment period.

[1] Gowen, T., Karantonis, P. & Rofail, T. (2004), *Converting Bureau of Meteorology wind speed data to local wind speeds at 1.5m above ground level*, Proceedings of ACOUSTICS 2004

Detailed graphs presenting measured noise levels versus time overlaid with weather data for the monitoring period are presented in Appendix A.

Table 1: Unattended noise monitoring results summary

Monitoring location	Baseline noise levels – dB(A)					
	Daytime 7:00 am – 6:00 pm		Evening 6:00 pm – 10:00 pm		Night 10:00 pm – 7:00 am	
	RBL	$L_{eq, period}$	RBL	$L_{eq, period}$	RBL	$L_{eq, period}$
UM1	35 (33[1])	44	35	49	33	42
UM2	35 (27[1])	56	31	46	30 (26[1])	37
UM3	35 (27[1])	46	34	53	30 (29[1])	49

(1) Actual RBL is below assumed policy minimums; therefore, NPI minimum RBL has been adopted.

3 Construction noise and vibration criteria

The NSW Department of Environment and Climate Change – *Interim Construction Noise Guideline* (ICNG), presents an accepted method by which construction noise impacts may be assessed for a range of receptor types for works completed in NSW. It provides a set of recommended standard hours of construction, as reproduced below:

- Monday to Friday: 7 am to 6 pm.
- Saturday: 8 am to 1 pm.
- No work on Sundays or public holidays.

The ICNG encourages works to occur within the recommended standard hours of construction unless justification is provided. It focuses on minimising construction noise impacts, rather than only on achieving numeric noise levels, and recognises that some noise from construction sites is inevitable.

The ICNG encourages organisations involved with construction, maintenance or upgrading works (e.g. large scale contractors or Government agencies) to develop their best-practice techniques for managing construction noise and vibration and implementing feasible and reasonable mitigation measures.

In this case, the ICNG is the most suitable guideline document to quantitatively assess potential noise emissions and impacts associated with project construction. The ICNG assessment methodology has been adopted to develop project-specific construction noise management levels (refer Chapter 3), assess potential impacts (refer Chapter 4) and recommend any necessary mitigation, management measures or provisions for monitoring (refer Chapter 5).

Table 2 details the construction noise management levels guidance for residential noise sensitive receptors developed in accordance with the ICNG.

Table 2: Construction airborne noise management levels for residential receivers

Time of Day	Noise Management Level, $L_{Aeq,\ 15\ minute}$ – dB(A)	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or Public Holidays	Noise affected Rating Background Level (RBL) + 10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{eq,\ 15\ minute}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be a strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-

Time of Day	Noise Management Level, $L_{Aeq,\ 15\ minute}$ – dB(A)	How to Apply
		morning or mid-afternoon for works near residences) 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected Rating Background Level (RBL) + 5 dB(A)	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2 of the ICNG.

3.1 Noise Policy for Industry

Responsibility for the control of noise emissions in NSW is typically vested in Local Government and the NSW Environment Protection Authority (EPA). The *Noise Policy for Industry* (NPI) and relevant application notes provide a framework and methodology for deriving limit conditions for project consent and environment protection licence conditions.

The NPI is designed for the assessment of operational noise emissions from large and complex industrial sources and outlines processes designed to strike a feasible and reasonable balance between the operations of industrial activities and the protection of the community from noise levels that are intrusive or unpleasant.

The NPI measurement and evaluation methodology to quantify existing ambient and background noise levels has been adopted for this assessment, with the baseline values utilised to derive construction noise management levels.

3.2 Construction noise and vibration management levels

Construction works for this project would be undertaken in accordance with the ICNG and could potentially occur 24 hours a day, 7 days a week, over a period of 12 weeks.

3.2.1 Airborne noise

The project-specific construction “Noise Management Levels” (NML), for works within and outside the recommended standard hours for construction, are presented in Table 3 below.

Table 3: Noise Management Levels

Receiver Type	Construction Noise Management Levels, $L_{eq,\ 15\ minute}$, dB(A)				High Noise Affected, $L_{eq,\ 15\ minute}$, dB(A)
	Standard Hours	Out-of-Hours			Daytime (Standard Hours)
	Day	Day	Evening	Night	
Residential NCA 1 (UM1)	45	40	40	38	75
Residential NCA 2 (UM2)	45	40	36	35	75
Residential NCA 3 (UM3)	45	40	39	35	75
Commercial	70	70	70	70	-[1]
Industrial	75	75	75	75	-[1]
Classrooms at schools and other educational institutions	45[2]	45[2]	45[2]	45[2]	-[1]
Hospital wards and operating theatres	45[2]	45[2]	45[2]	45[2]	-[1]
Places of worship	45[2]	45[2]	45[2]	45[2]	-[1]
Active recreation areas	65	65	65	65	-
Passive recreation Areas	60	60	60	60	-

(1) Dash "-" indicates that these criteria do not apply to that receiver type.

(2) Internal noise level criteria. An assumed 10 dB façade noise reduction has been implemented for internal properties.

3.2.2 Sleep disturbance criteria

As stated in the NPI the potential for sleep disturbance from maximum noise level events generated by industrial premises during the night-time period needs to be considered. The term "sleep disturbance" is considered to be both awakenings and disturbance to sleep stages.

To evaluate potential sleep disturbance or awakening issues associated with the operation of the proposal the NPI screening method has been adopted as follows. There is limited potential for sleep disturbance or awakening issues to occur, where:

- The predicted project night-time noise level ($L_{eq,\ 15\ minute}$ in dB(A)) at any residential receptor remains below 40 dB(A) (or the prevailing night-time background noise level plus 5 dB(A)), whichever is the greater.
- The predicted project night-time noise level (L_{max} in dB(A)) at any residential receptor remains below 52 dB(A) (or the prevailing night-time background noise level plus 15 dB(A)), whichever is the greater.

These screening method features have been adopted for likely maximum noise level events from the operation of the proposal.

In accordance with the NPI, the sleep disturbance noise criteria for assessing the proposal are presented in Table 4 below.

Table 4: Sleep disturbance noise criteria for all NCAs

Receiver Type	$L_{eq,\ 15minute}$ dB(A)	L_{max} dB(A)
Residential receivers (all NCAs)	40	52

3.2.3 Ground-borne noise

Ground-borne noise will not be a controlling factor with respect to construction noise impacts. No underground works will occur and therefore air-borne noise levels will exceed the ground-borne noise levels and control noise management requirements. As such, a detailed ground-borne noise assessment is not required for the geotechnical investigation works.

3.2.4 Construction vibration criteria

Ground vibration generated by construction can have a range of effects on buildings and building occupants, with the main effects generally classified as:

- Human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- Effects on building structures – vibration that may compromise the condition of the building structure itself.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on building contents and structural damage. Building occupants will normally feel vibration readily at levels well below those that may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3[2]
- NSW Environmental Protection Agency's Human comfort: Assessing Vibration – a technical guideline (the Guideline)

Cosmetic and structural damage

The DIN 4150-3 structural and cosmetic damage assessment criteria for different types of buildings are presented in Table 5. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended in Table 5 would not necessarily result in damage. Rather it recommends these values as maximum levels of short-term construction vibration at which experience has shown that damage that reduces the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as the standard considers a reduction in serviceability of the structure is deemed to have occurred if:

- Cracks form in plastered surfaces of walls.

[2] German Standard DIN 4150-3, 1999, *Structural Vibration – Part 3: Effects of vibration on structures*.

- Existing cracks in the building are enlarged.
- Partitions become detached from loadbearing walls or floors.

Table 5: DIN 4150-3 vibration cosmetic and structural damage criteria

Structure type	Peak Particle Velocity (PPV), mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	<10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

DIN4150 states that exceedances of the guidance values do not necessarily mean that damage will occur, but that more detailed analysis may be required in order to quantify the site specific relationship between vibration levels, strain and the potential for damage. If required, the additional analysis may include more detailed vibration, strain or displacement measurements combined with engineering analysis.

Human comfort

The ICNG recommends that vibration from construction works be assessed under the EPA's *Assessing Vibration – a technical guideline* (the Vibration Guideline). The vibration assessment criteria defined in this Vibration Guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Vibration Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classified according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build-up to a vibration peak followed by a damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as the occasional dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).
- The majority of construction works as part of the proposal would be expected to be intermittent in nature with the potential for some impulsive activities (e.g. demolition works).

Table 6 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted root-mean-square (rms) vibration velocity levels (V_{rms}). The

Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

Table 6: Daytime V_{rms} management levels for continuous and impulsive vibration

Receiver	Continuous vibration V_{rms}, mm/s		Impulsive vibration V_{rms}, mm/s	
	Preferred	Maximum	Preferred	Maximum
Residences – daytime	0.2	0.4	6	12
Residences – night-time	0.14	0.28	2	4
Offices, schools, place of worship	0.4	0.8	13	26
Workshops	0.8	1.6	13	26

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in Table 7.

Table 7: VDV management levels for intermittent vibration

Receiver	VDV – Intermittent vibration, $m/s^{1.75}$	
	Preferred	Maximum
Residences – daytime	0.2	0.4
Residences – night-time	0.13	0.26
Offices, schools, places of worship	0.4	0.8
Workshops	0.8	1.6

4 Construction noise assessment

In order to quantify noise emissions from the proposed construction works, environmental noise modelling software (SoundPLAN v8.2 using the CONCAWE calculation algorithm Category 6) has been utilised to predict the $L_{Aeq(15\text{-}minute)}$ noise levels at nearby receivers. The calculations include: the source noise levels of the anticipated equipment, the location of selection of nearby sensitive receivers, the number of plant items likely to be operating at any given time and the distance between the equipment and the receivers.

Total sound power levels (SWLs) are then provided for required construction stage. The typical noise levels are based on previous measurements conducted by Resonate and RMS's *Construction Noise and Vibration Guideline* (CNVG). The predicted noise level results are presented as a summary of the potential noise impacts when the work is located at the nearest position within the project area to the sensitive receiver in question.

In practice, the noise levels will vary because plant will move around the worksites and will not all be operating concurrently. As such, noise levels are likely to be lower than the worst-case noise levels presented for notable periods of time during the works.

4.1 Plant and equipment

The predicted plan and equipment that will be used at the site are presented in Table 8 with their associated sound power levels. The schedule of plant and equipment to be used would be confirmed with the final construction program. The current staging and plant for the bore hole works have been provided by the client while the assessed sound power level for the piling rig has been supplied and is a RMS approved self-assessment for the rig.

Table 8 Plant and equipment sound power levels

Stage	Plant and equipment	Plant items	Lw, dB(A)
Borehole works	Piling rig (bored)	1	104
	Water cart	1	107
	Light vehicles	3	88
	Daymakers	1	98
		Total Lw	**109**

4.2 Predicted construction noise impacts and discussions

Detailed predicted noise levels (PNLs) from the bore hole works are presented in Appendix B.

Based on our review of the predicted noise levels in Appendix B, it is noted that there are no exceedances of the noise criteria predicted from any borehole locations.

Notwithstanding, noise mitigation measures and application of good practice noise management have been considered. Noise mitigation and management measures are discussed in Chapter 5 of this document.

4.3 Construction vibration

It is understood that the vibration-intensive equipment that may be used during the proposal includes compaction equipment such as a vibratory roller. Relevant recommended safe setback distances to maintain building cosmetic and human comfort criteria for these types of plant are reproduced from the CNVG below in Table 9.

Table 9: Recommended safe setback distances for relevant vibration-generating plant

Plant Item	Rating/Description	Minimum Working Distance – Cosmetic Damage[1] (BS7385)	Minimum Working Distance – Human Response (OH&E Guideline)
Pile Boring	≤ 800 mm	2 m (nominal)	4 m

The nearest residential building has been identified to be approximately 1.2 kilometres from the nearest borehole site. At this distance, the works are assessed to comply with the safe working distance for potential building damage Pile boring as described in Table 9 and are not expected to result in vibration levels above the human comfort criteria.

5 Construction noise management and mitigation measures

This section details pre-construction and construction phase management and mitigation measures designed as best-practice methods to mitigate construction noise and vibration impacts regardless of predicted exceedances.

The management measures have been informed from guidance provided in the ICNG which promotes principles of best management practice and community notification of likely noise and vibration impacts.

It will be important for the contractor to undertake all reasonable and feasible measures to reduce noise impacts and minimise impact potential through programming works to minimise duration and liaise with affected landowners and local communities throughout the construction program.

All Contractors commissioned to undertaken construction works associated with the Project are recommended to adhere to all noise and vibration management and mitigation measures recommended.

5.1 Recommended measures

During the planning and scheduling of construction works, the predicted noise levels should be considered in establishing work site locations, construction techniques and on-site practices.

Construction works should adopt Best Management Practice (BMP) and Best Available Technology Economically Achievable (BATEA) practices as addressed in the ICNG. BMP includes factors discussed within this report and encouragement of a project objective to reduce noise emissions. BATEA practices involve incorporating the most advanced and affordable technology to minimise noise emissions. The following principles and proactive noise management measures are to be considered for implementation:

- Fixed and mobile construction plant and equipment shall be located to maximise separation distance from nearest noise and vibration sensitive and residential receivers.
- Construction plant shall be orientated away from nearest receivers where possible.
- Where practical, simultaneous operation of dominant noise generating plant shall be managed to reduce noise impacts, such as operating at different times or increasing the distance between the plant.
- Where possible and in compliance with occupational safety and health standards, reversing beepers on trucks would be replaced with low pitch non-tonal beepers (quackers). Alternatives to reversing beepers include the use of spotters and designing the site to reduce the need for reversing may assist in minimising the use of reversing beepers.
- Where feasible and practicable, surrounding residences shall be notified of potential construction works at least 2 weeks prior to the commencement of works.
- Construction noise and vibration management practices are to be provided to all staff and contractors and be included during site inductions and daily tool-box talks. The tool-box talks should include as a minimum, the permitted hours of construction work, work site locations, site ingress/egress and the required noise management measures for each construction phase.

5.2 Monitoring of construction noise

This section details the noise monitoring strategy for borehole works:

- In the event of justified adverse community response or complaint to construction noise, monitoring of construction noise is recommended to confirm construction noise levels at the complainant's property.
- All noise monitoring should be undertaken by suitably qualified practitioners with consideration to guidance provided in the ICNG and relevant regulatory and statutory guidelines.

5.3 Non-compliance / complaint response

Non-conformances for noise and vibration during construction works may include:

- Exceedance of adopted receiver specific construction noise management levels; triggering the requirement for noise management measures.
- Exceedance of annoyance and structural vibration objectives.
- Justified community complaints relating to noise and vibration.

The construction works shall be immediately assessed to review operation of noise generating plant, required construction activity and current on and off-site noise mitigation measures in place.

Any non-conformances and subsequent corrective actions shall be resolved with consideration to the project's Community Consultation Strategy. The Environment Manager and Site Supervisor shall determine where corrective action is required and implement necessary mitigation measures.

All adopted noise mitigation measures should be updated in work method statements and identified as part of routine tool-box talks to inform staff of current construction noise and vibration issues and required mitigation measures.

Consistent with the noise mitigation measures presented in this report; examples of corrective actions to be implemented by the Environment Manager include:

- Implementing alternative construction methodologies utilising low noise or low vibration generating plant.
- Replacing excessively noisy equipment.
- Fitting additional acoustic controls to minimise emissions from machinery.
- Increasing separation distance between noise generating plant and nearest sensitive receivers.
- Consider respite periods where construction noise impacts include potential tonal, low frequency or impulsive annoying characteristics at nearest receivers.

6 Conclusion

Resonate Consultants has completed a noise and vibration impact assessment to support the application of the borehole works.

Due to the location of the construction site, several potentially affected noise and vibration sensitive receivers have been identified. Background noise levels have been established with unattended noise measurements and the NPI and have been used to establish the project specific NMLs.

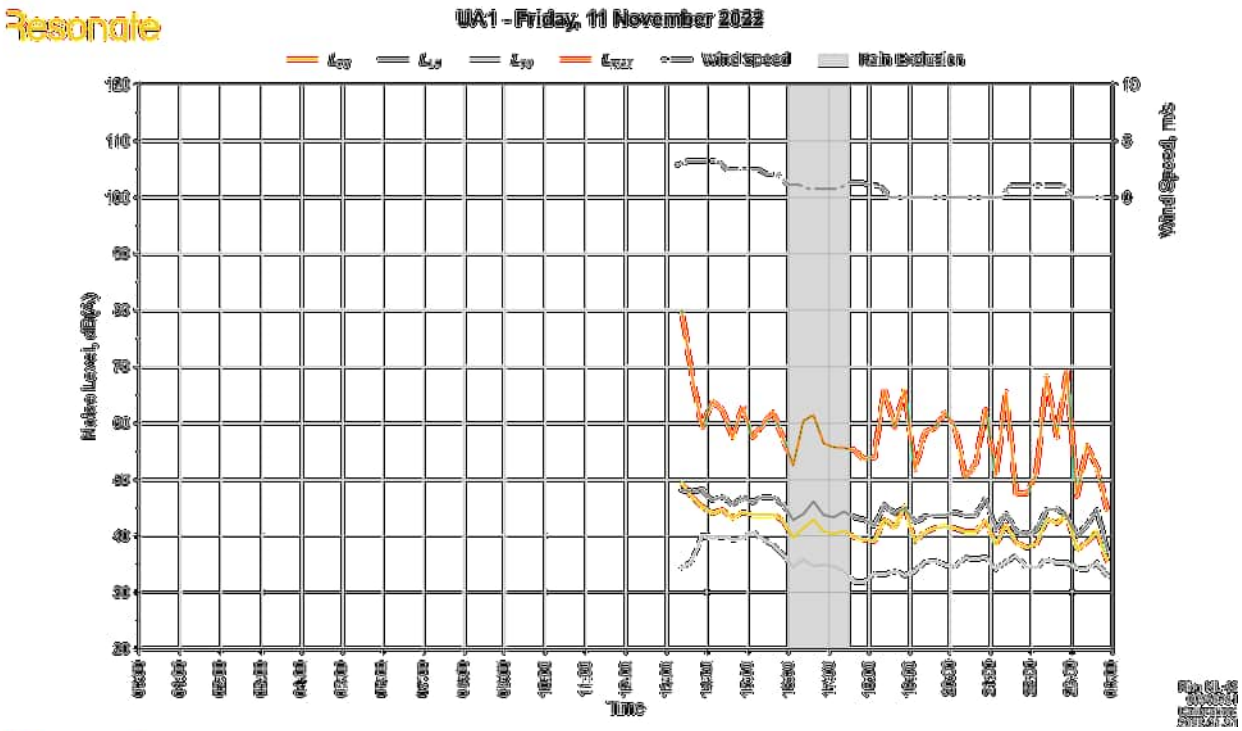
Construction noise impacts have been assessed against the project specific NMLs in accordance with the ICNG. Construction vibration impacts have been assessed against recommended limits specified in the German Standard DIN 4150-3[3] and the *Assessing Vibration – a technical guideline*.

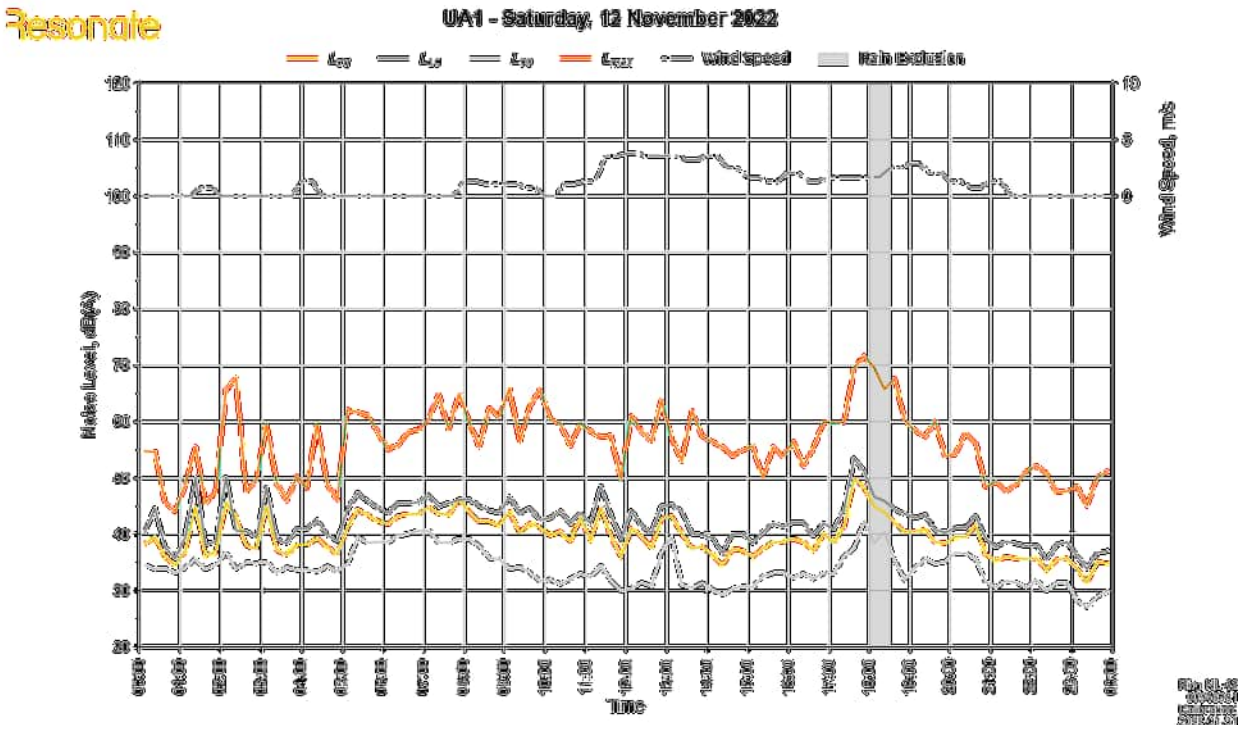
Construction noise levels during the boring works are predicted to be within the NMLs at all receivers. Construction noise levels are predicted to be well below the highly affected NML of 75 dB(A). Based on the predicted noise levels, best-practice standard noise mitigation measures have been recommended for implementation where feasible and reasonable.

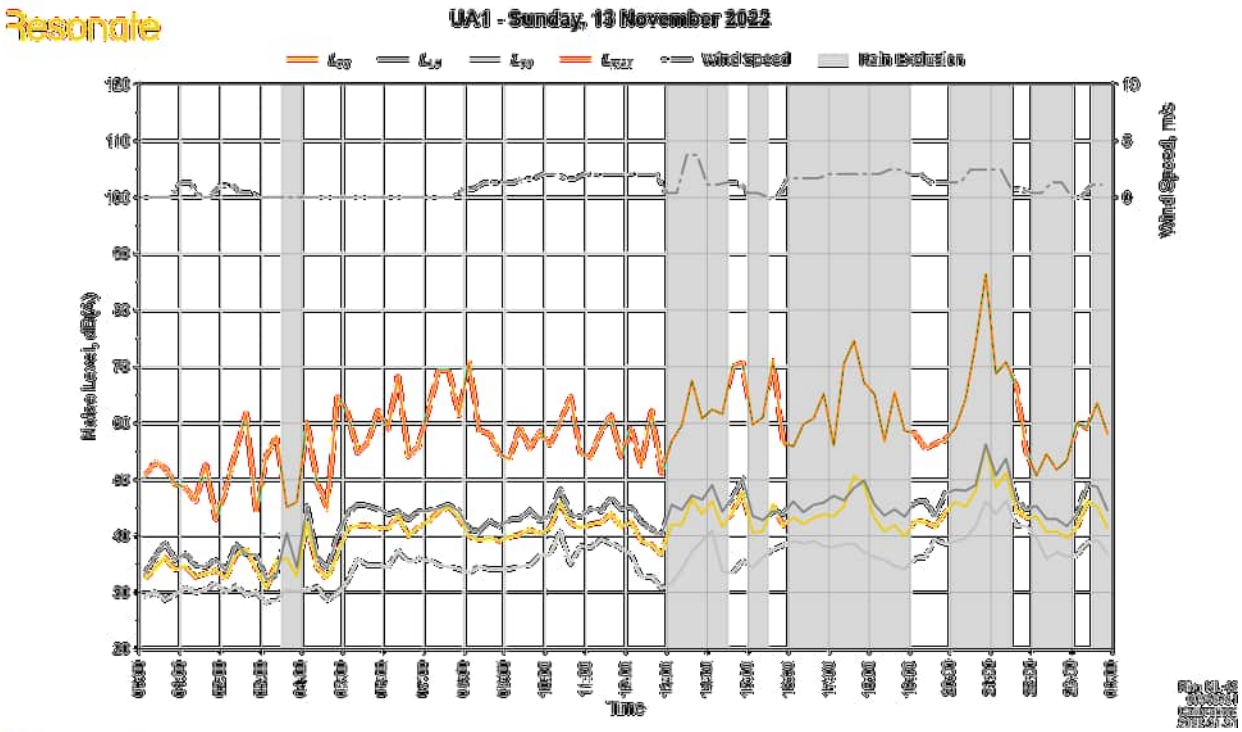
Vibration emissions generated by activities associated with the construction works have been assessed to have very low risk of structural damage to and adverse comments from the closest sensitive receivers. Based on the assessed compliance of the construction vibration, implementation of measures to reduce vibration impacts are not deemed to be necessary.

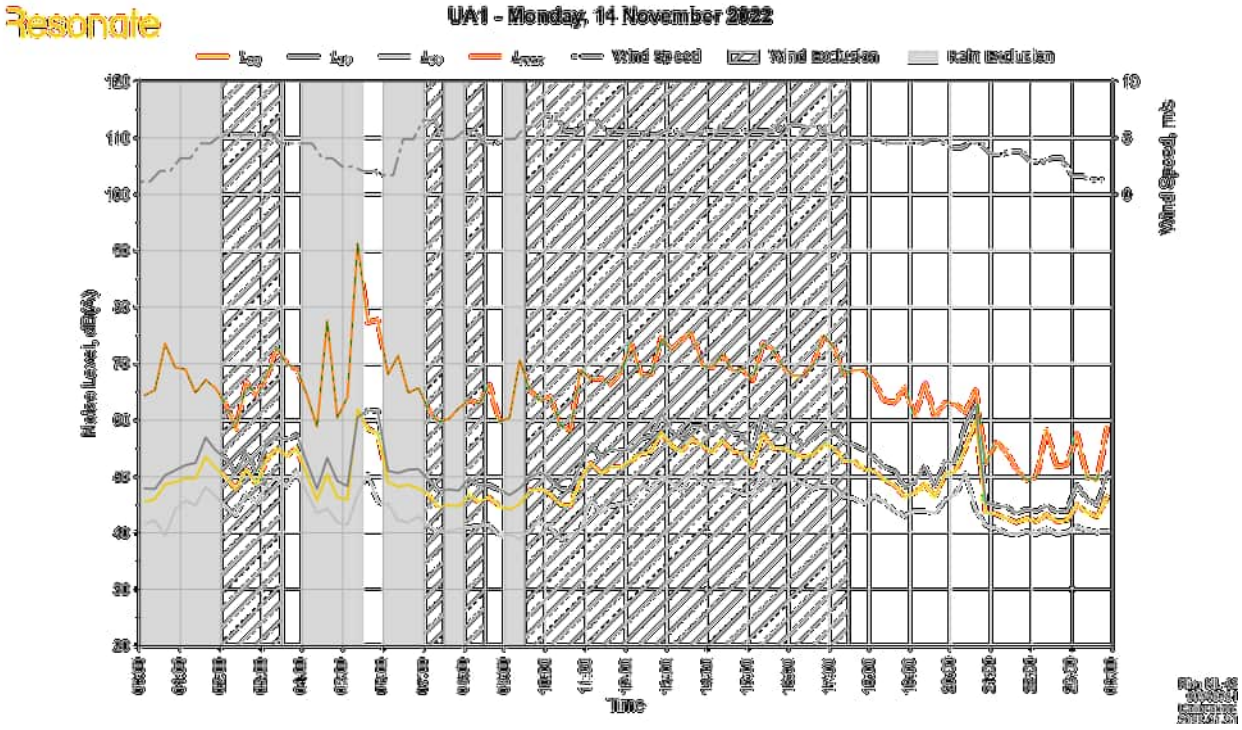
[3] German Standard DIN 4150-3, 1999, *Structural Vibration – Part 3: Effects of vibration on structures*.

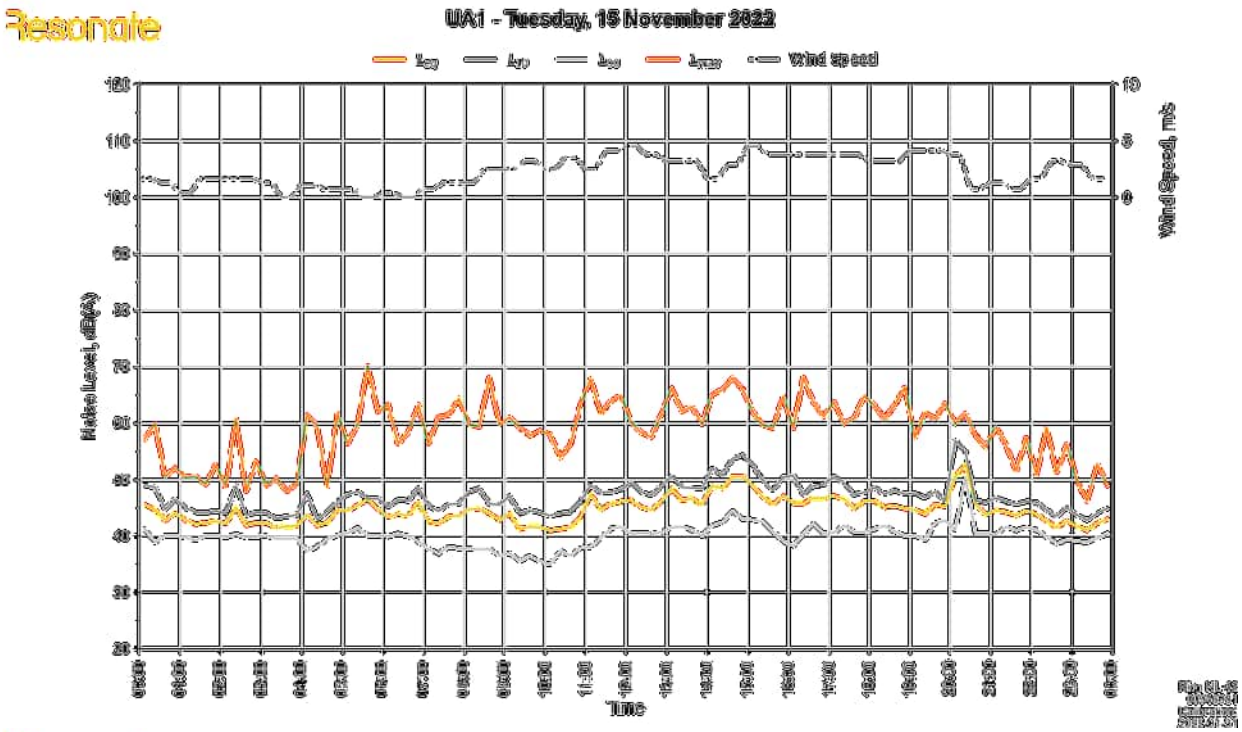
Appendix A – Noise logger graphs

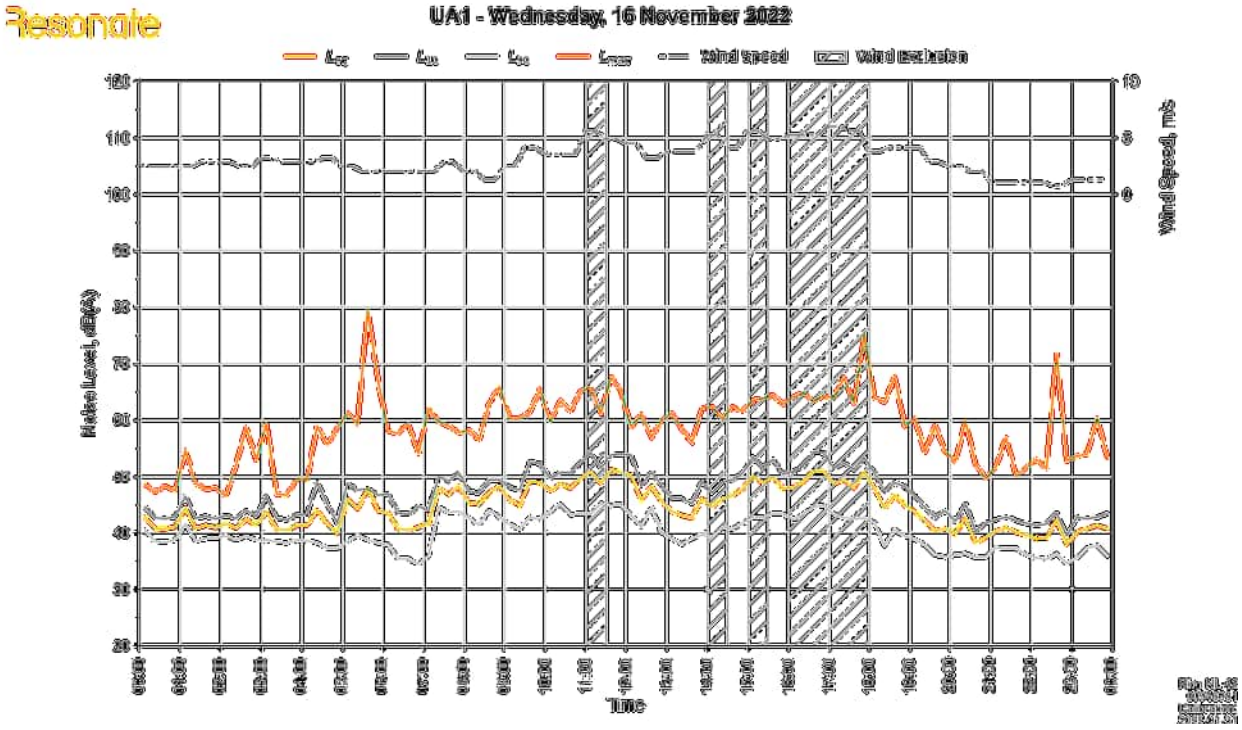


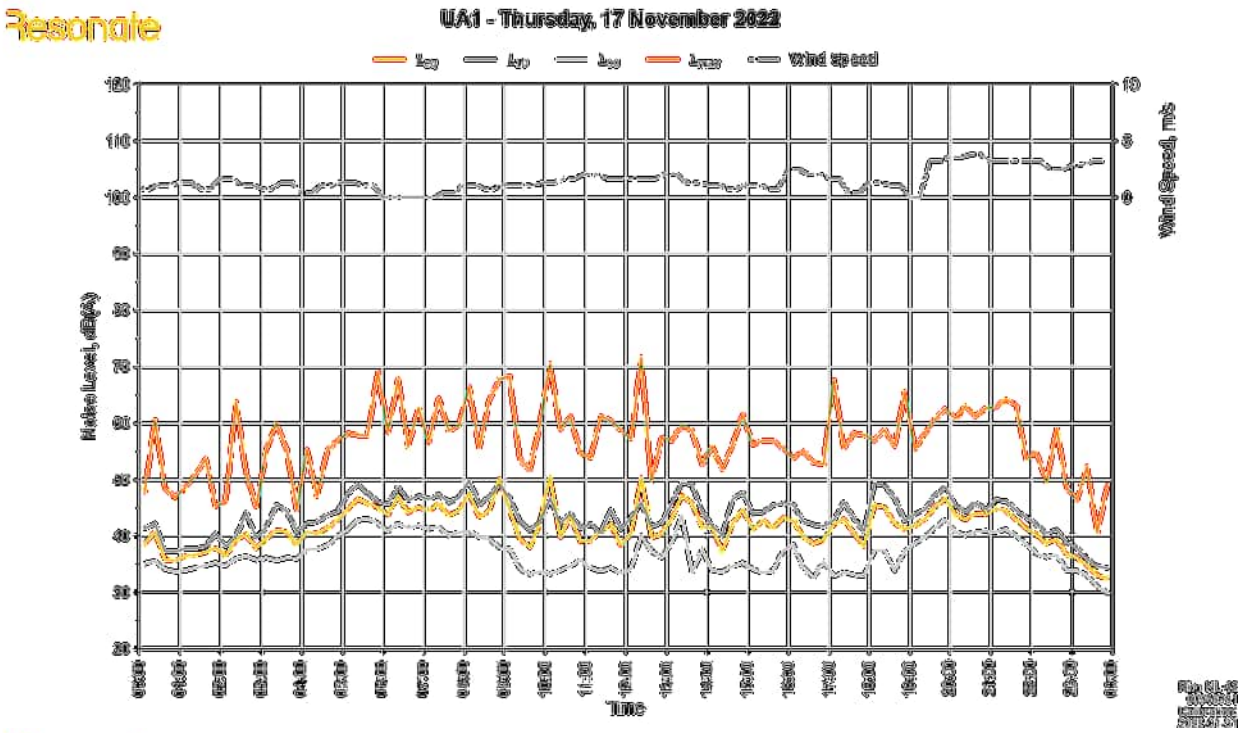


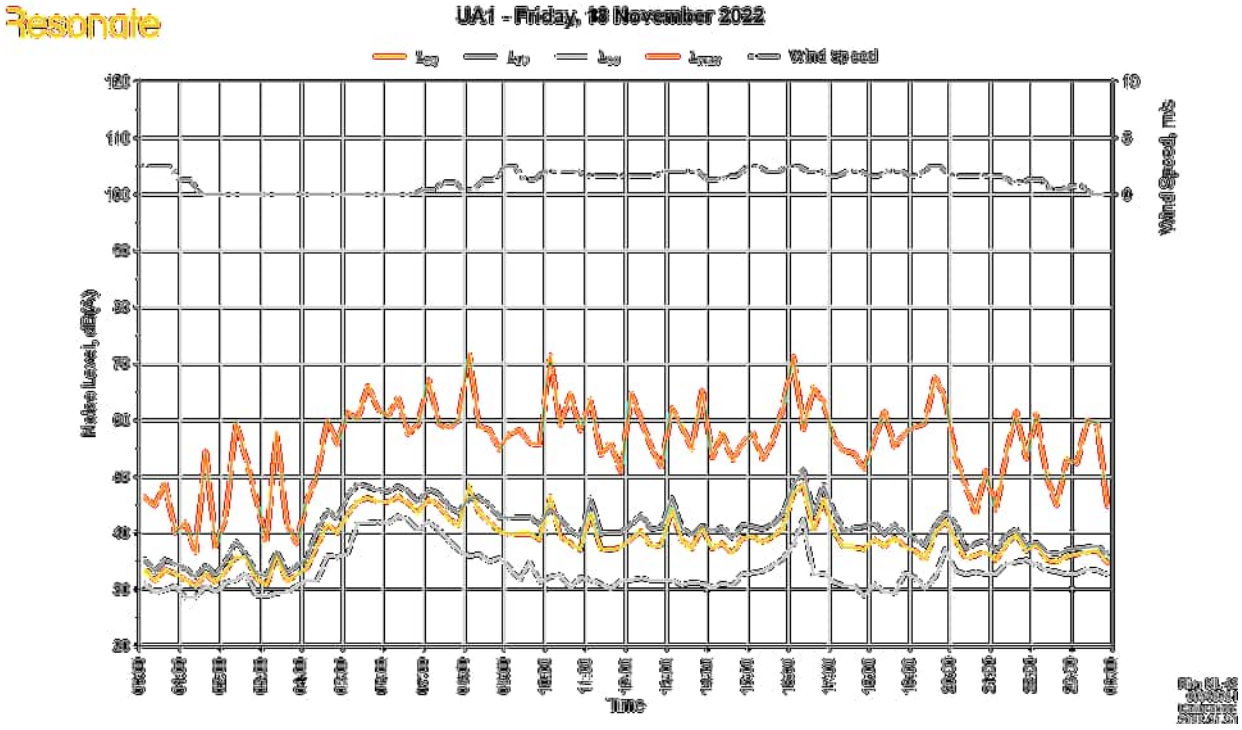

Resonate
UA1 - Sunday, 13 November 2022
Wind speed
Rain exclusion
Wind Speed, m/s
Time

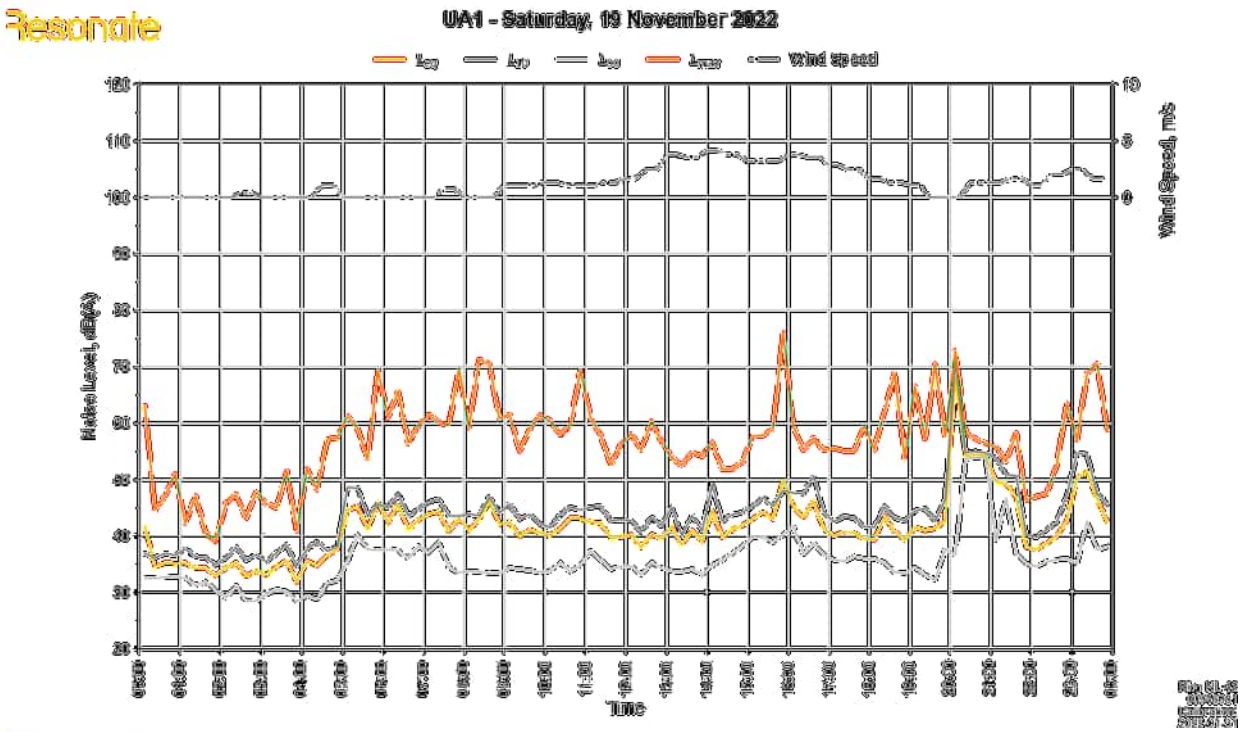

Resonate
UA1 - Monday, 14 November 2022
Wind speed
Wind exclusion
Rain exclusion
Wind Speed, m/s
Time

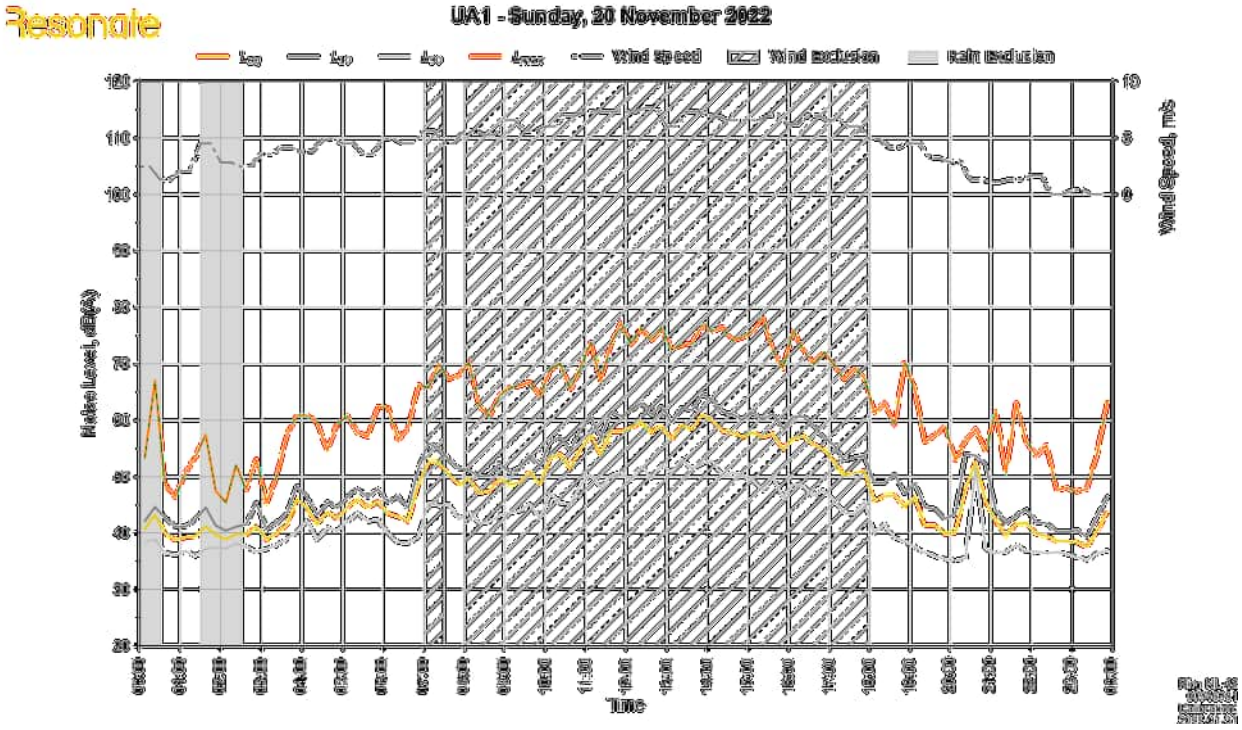

UA1 - Tuesday, 15 November 2022
Wind speed
Wind Speed, m/s
Time

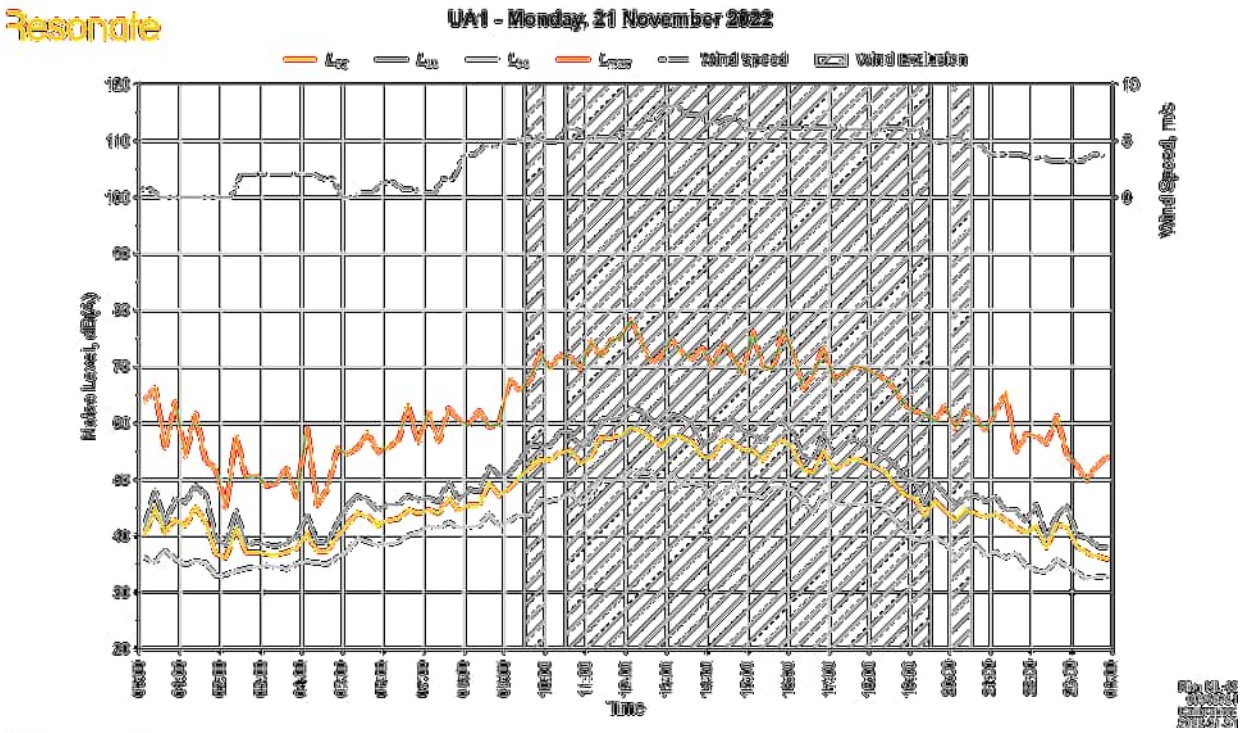

UA1 - Wednesday, 16 November 2022
Wind speed
Wind Speed, m/s
Time

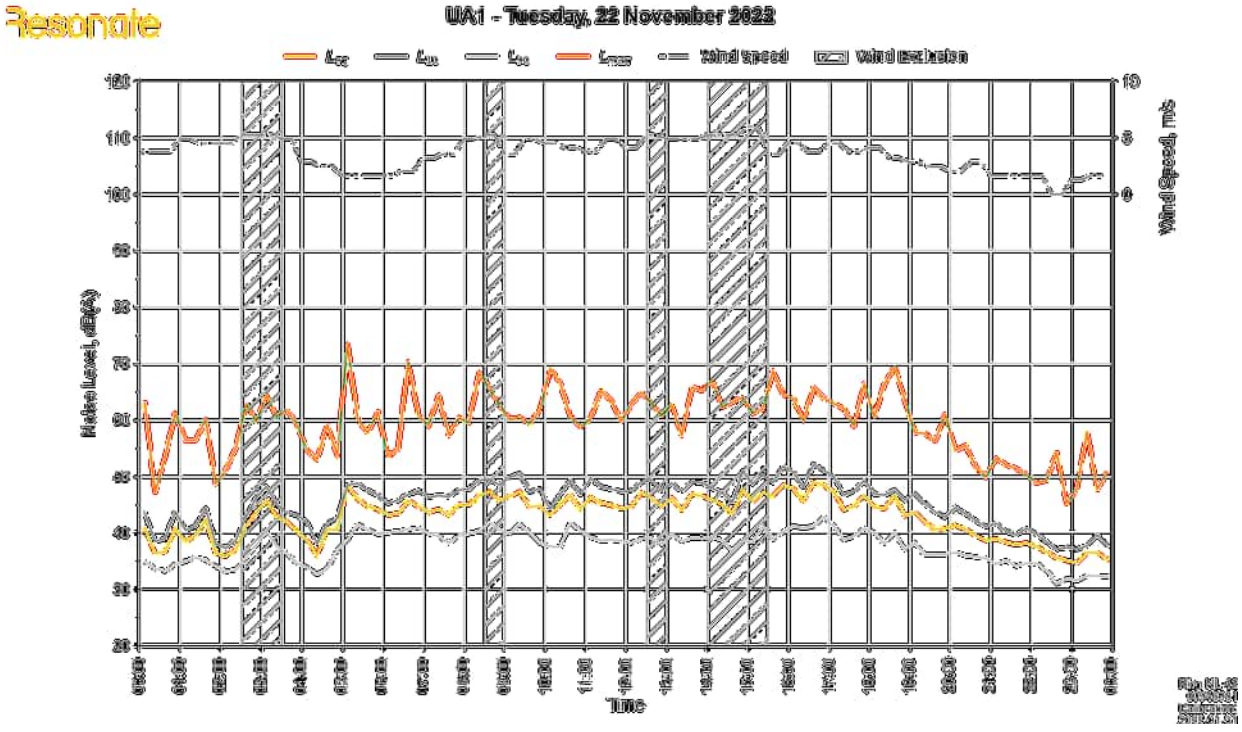

UA1 - Thursday, 17 November 2022
Wind speed
Wind Speed, m/s
Noise Level, dB(A)
Time

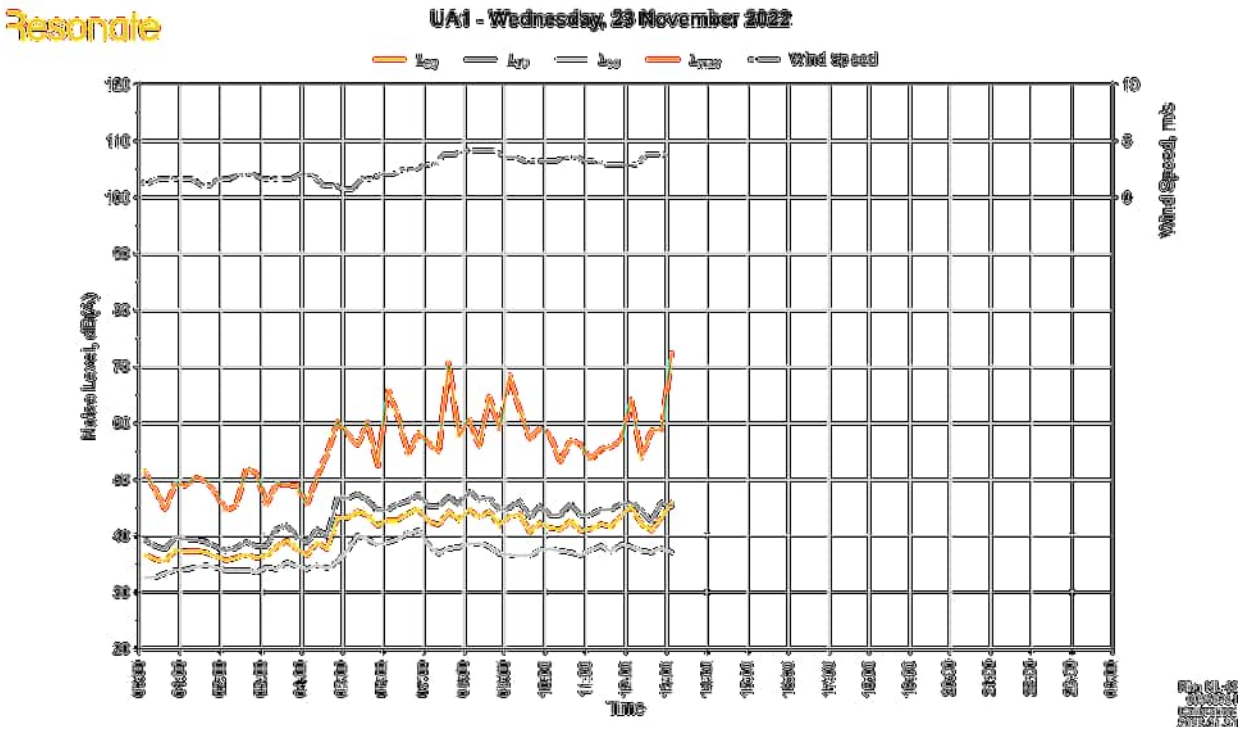

UA1 - Friday, 18 November 2022
Wind speed
Wind Speed, m/s
Noise Level, dB(A)
Time

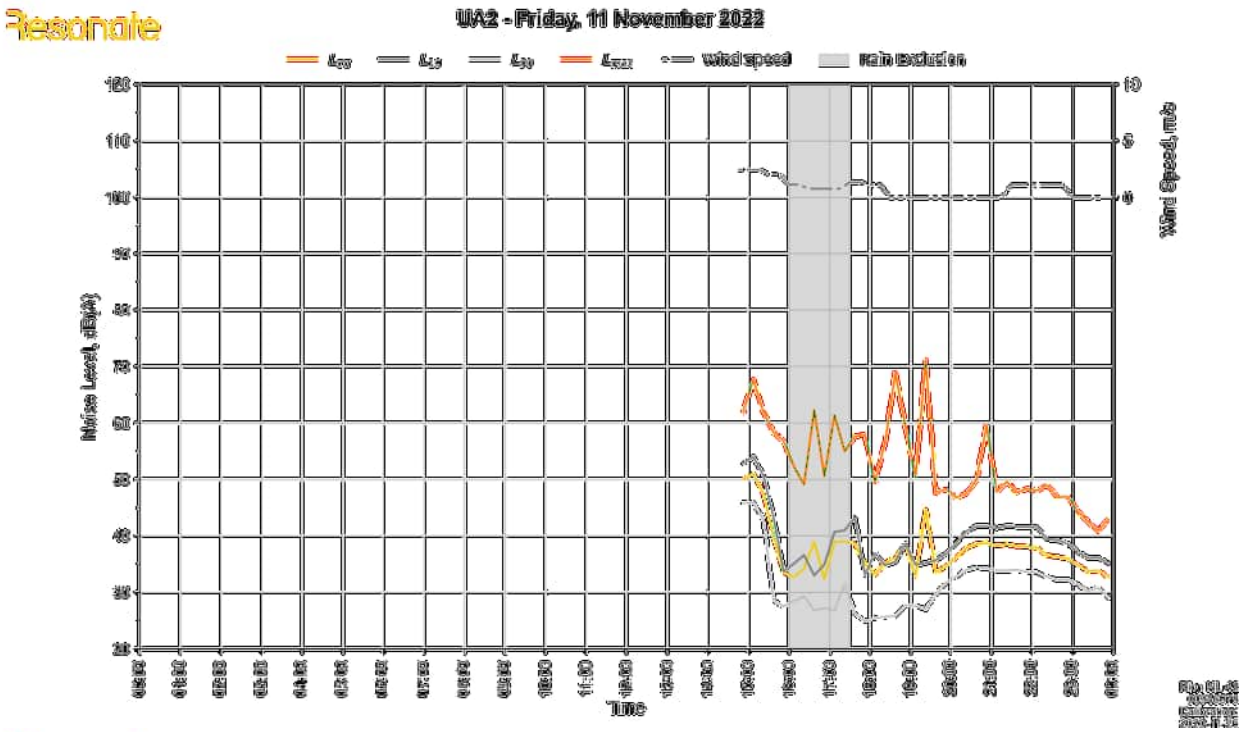

Resonate
UA1 - Saturday, 19 November 2022
Wind speed
Wind Speed, m/s
Time

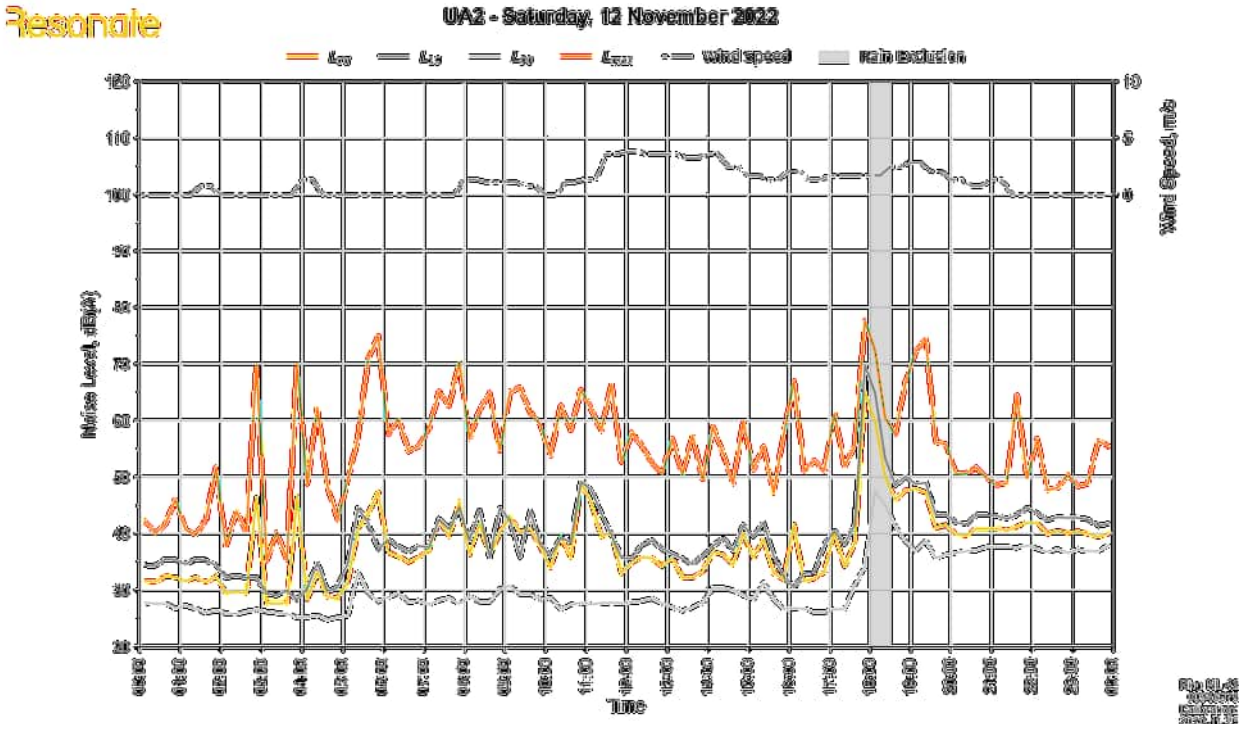

Resonate
UA1 - Sunday, 20 November 2022
Wind speed
Wind exclusion
Rain exclusion
Wind Speed, m/s
Time

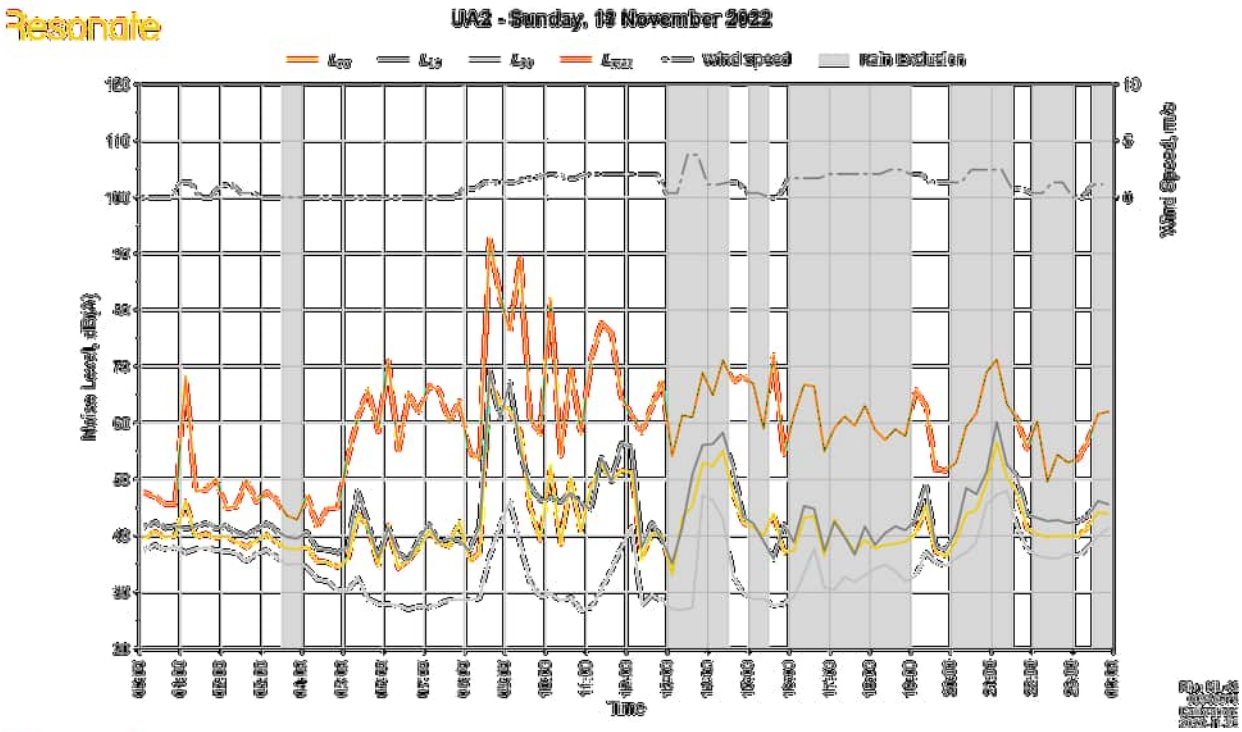

Resonate
UA1 - Monday, 21 November 2022
Wind speed
Wind direction
Wind Speed, m/s
Time

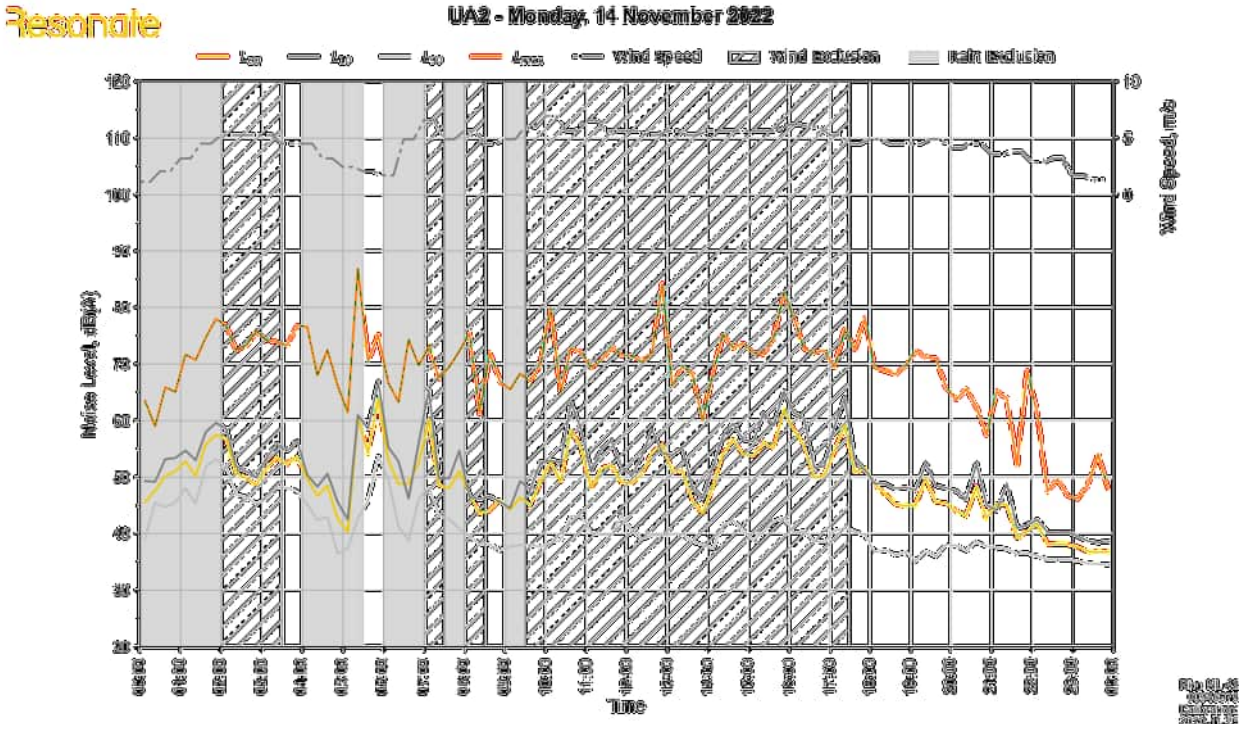

Resonate
UA1 - Tuesday, 22 November 2022
Wind speed
Wind direction
Wind Speed, m/s
Time

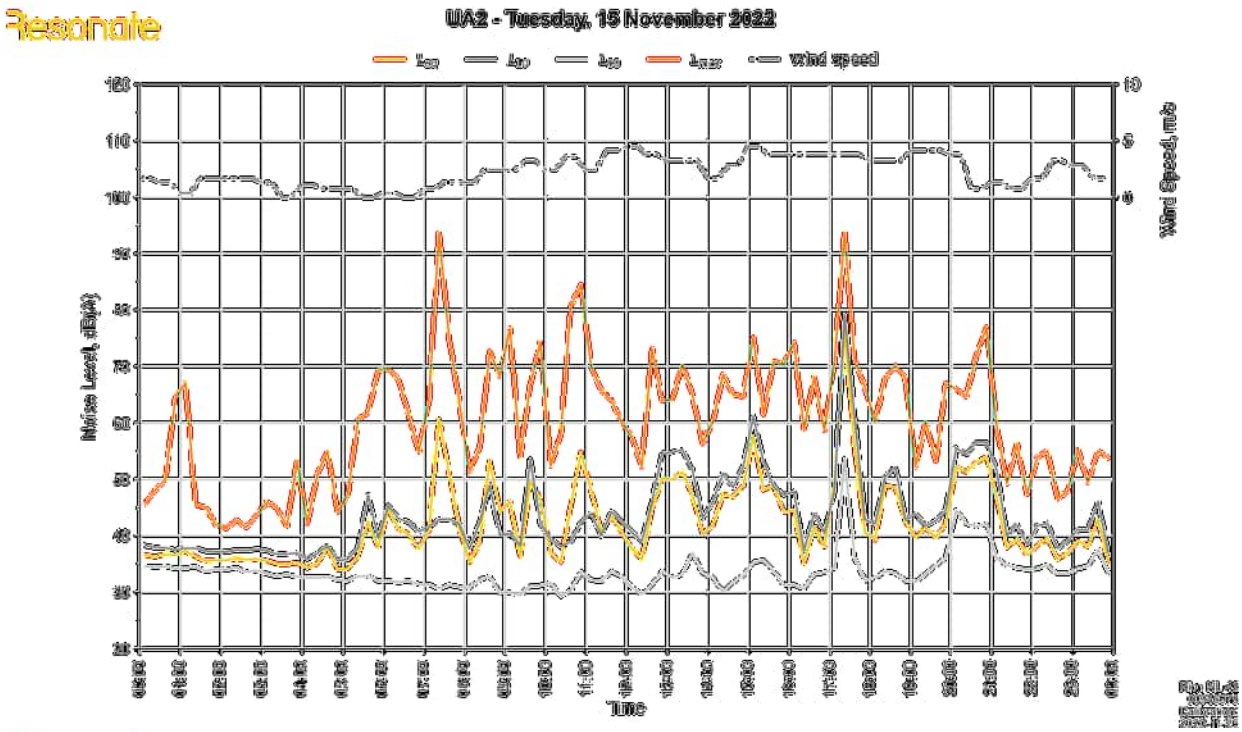

Resonate
UA1 - Wednesday, 23 November 2022
Wind speed
Wind Speed, m/s
Noise Level, dB(A)
Time

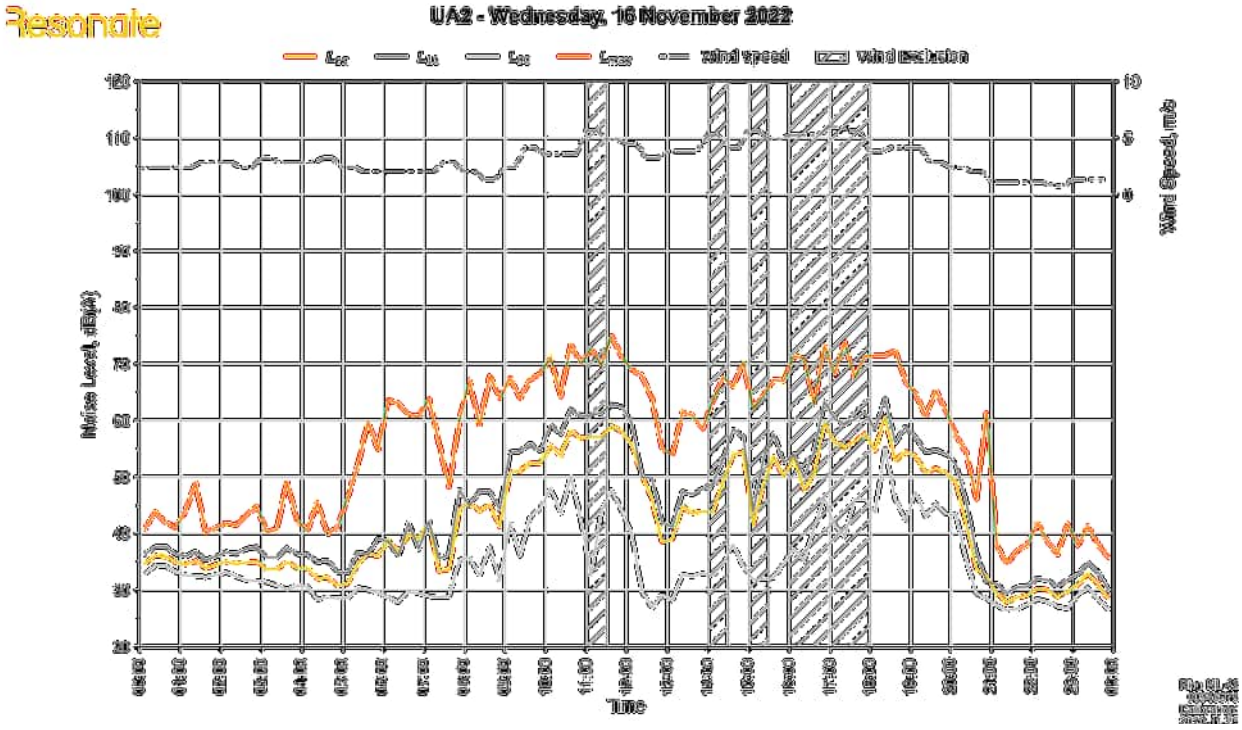

UA2 - Friday, 11 November 2022
Wind Speed, m/s
Time

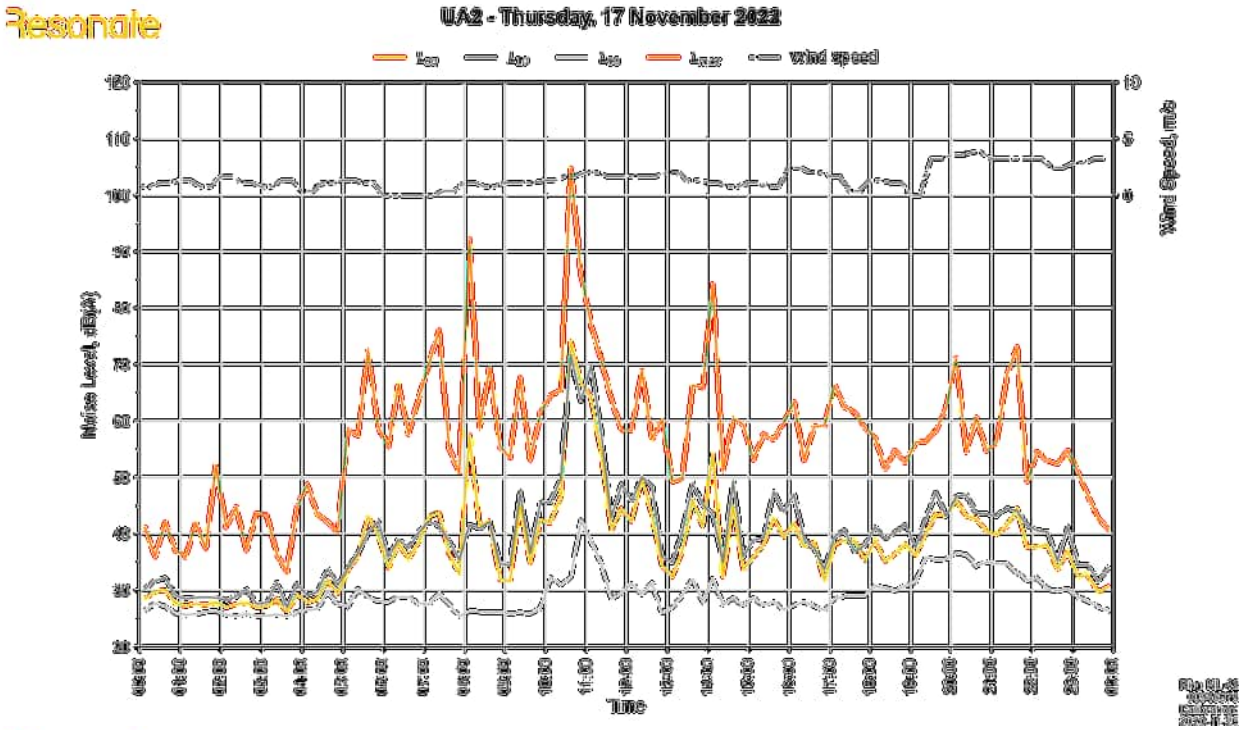

UA2 - Saturday, 12 November 2022
Wind Speed, m/s
Time

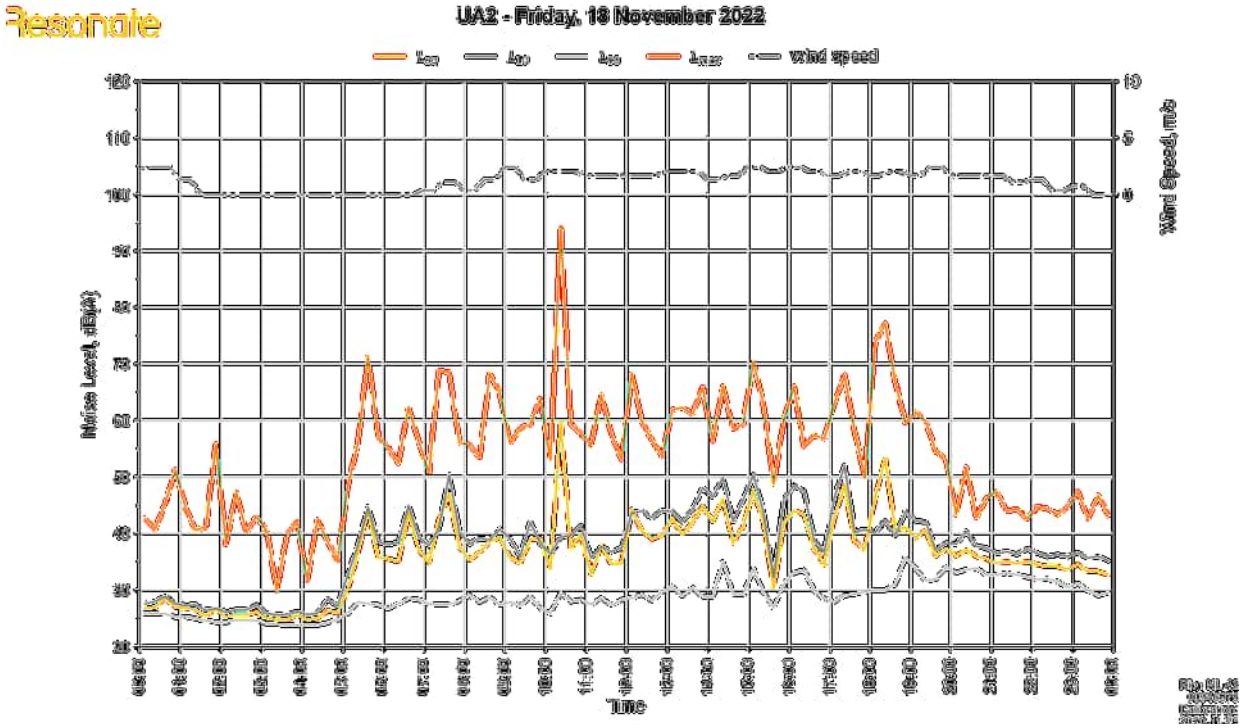

UA2 - Sunday, 13 November 2022
Wind speed
rain exclusion
Noise Level, dB(A)
Wind Speed, m/s
Time

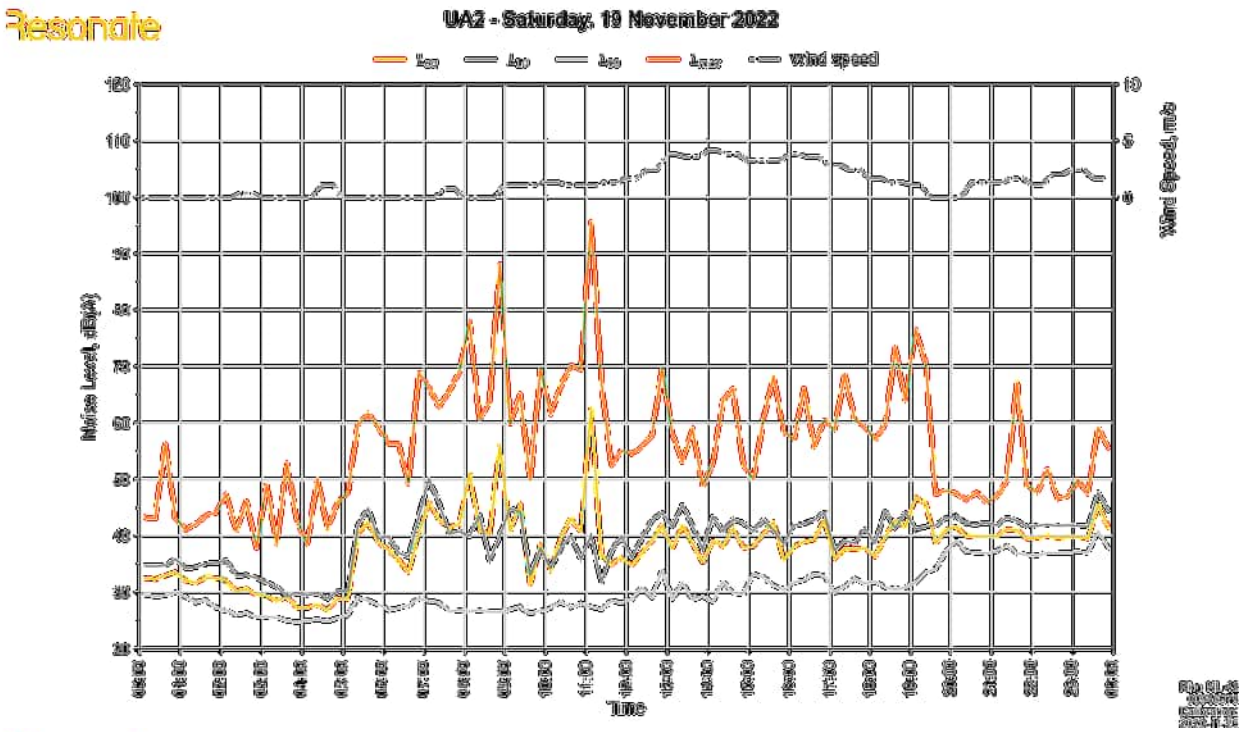

UA2 - Monday, 14 November 2022
wind speed
wind exclusion
rain exclusion
Noise Level, dB(A)
Wind Speed, m/s
Time

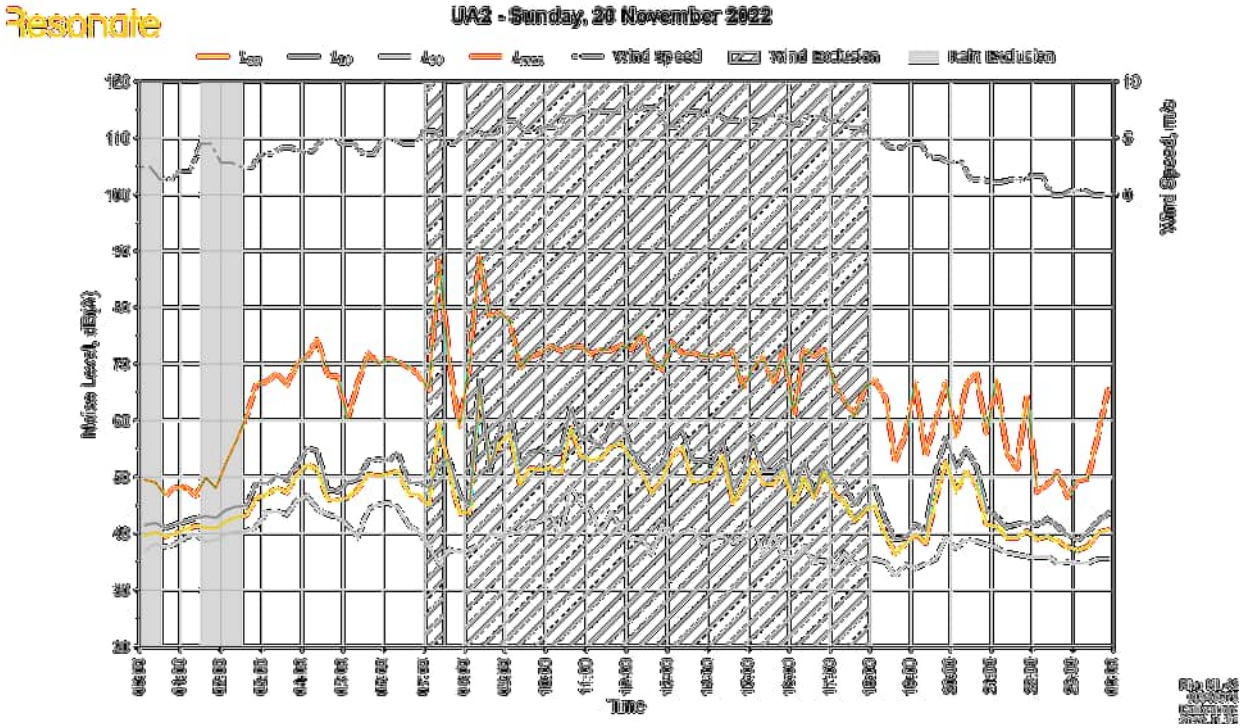

UA2 - Tuesday, 15 November 2022
wind speed
Wind Speed, m/s
Time

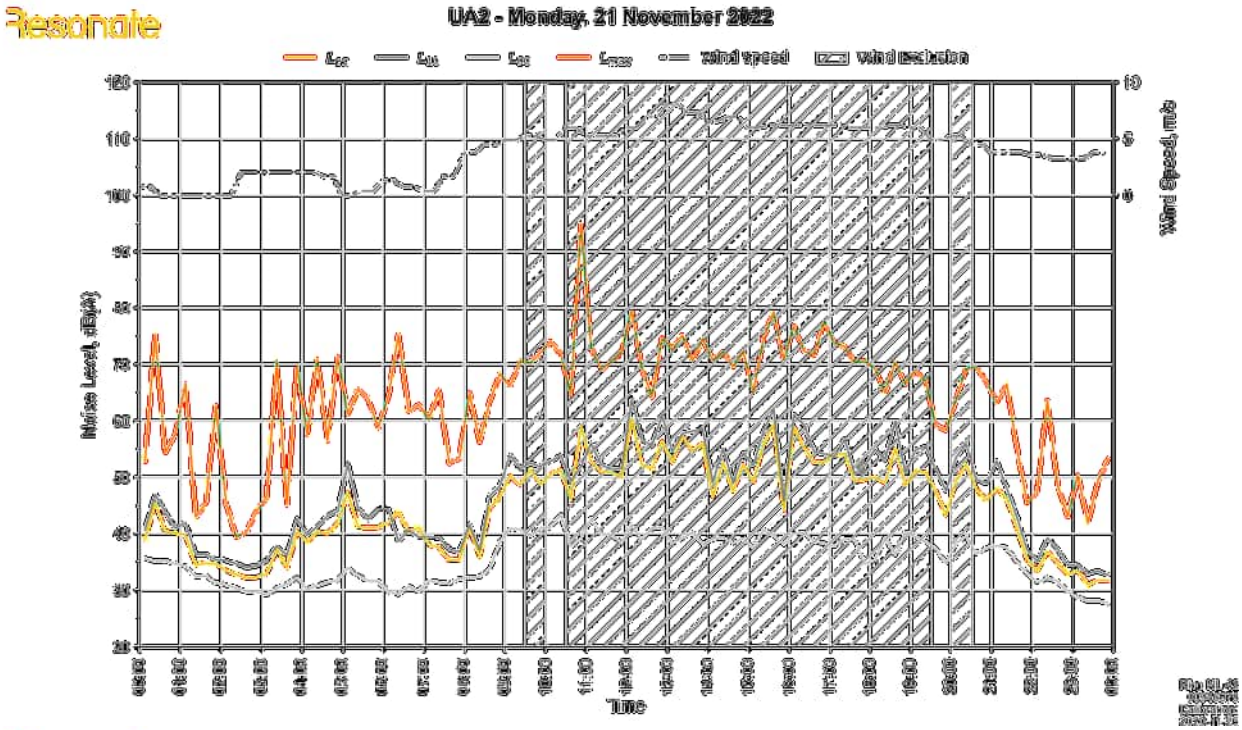

UA2 - Wednesday, 16 November 2022
wind speed
Wind Speed, m/s
Time

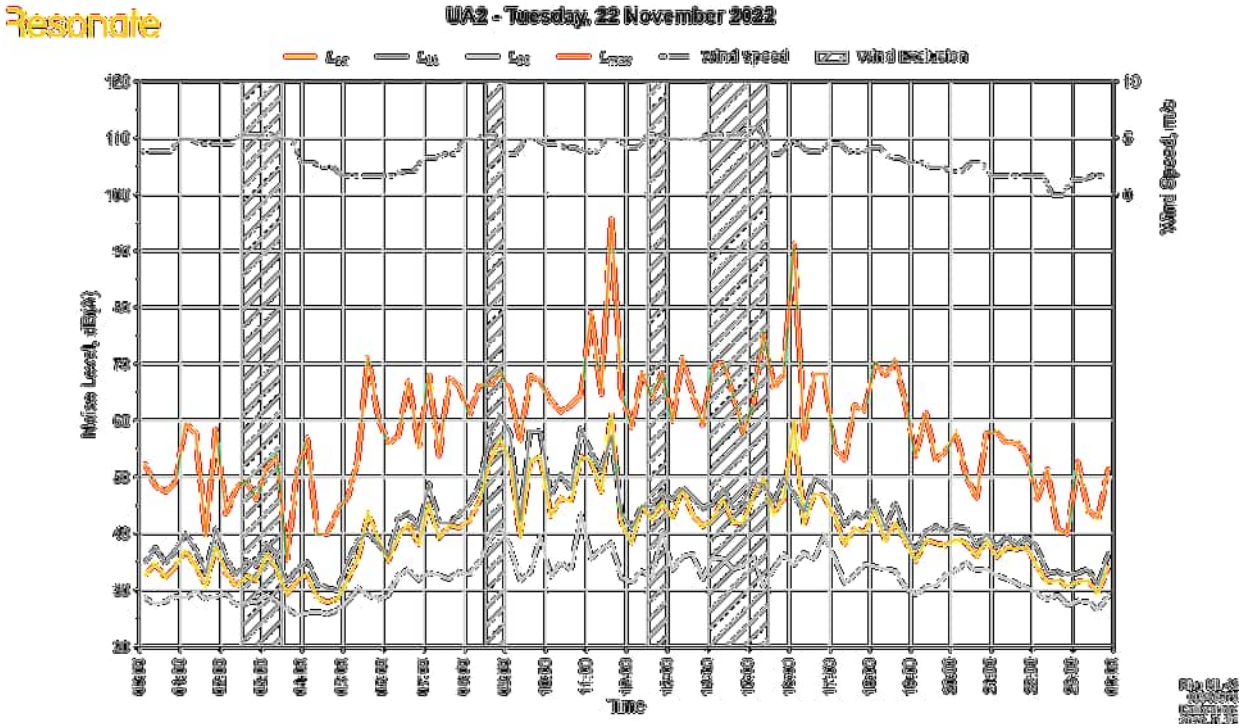

UA2 - Thursday, 17 November 2022
wind speed
Wind Speed, m/s
Noise Level, dB(A)
Time

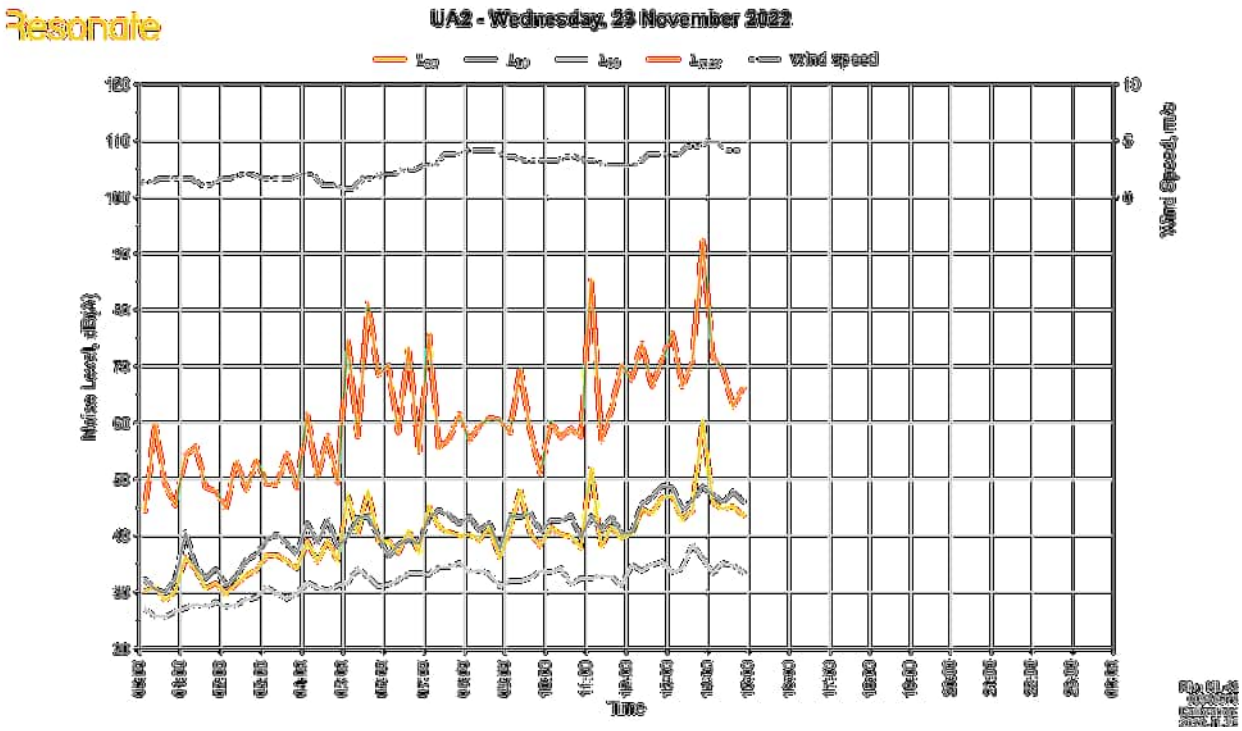

UA2 - Friday, 18 November 2022
wind speed
Wind Speed, m/s
Noise Level, dB(A)
Time

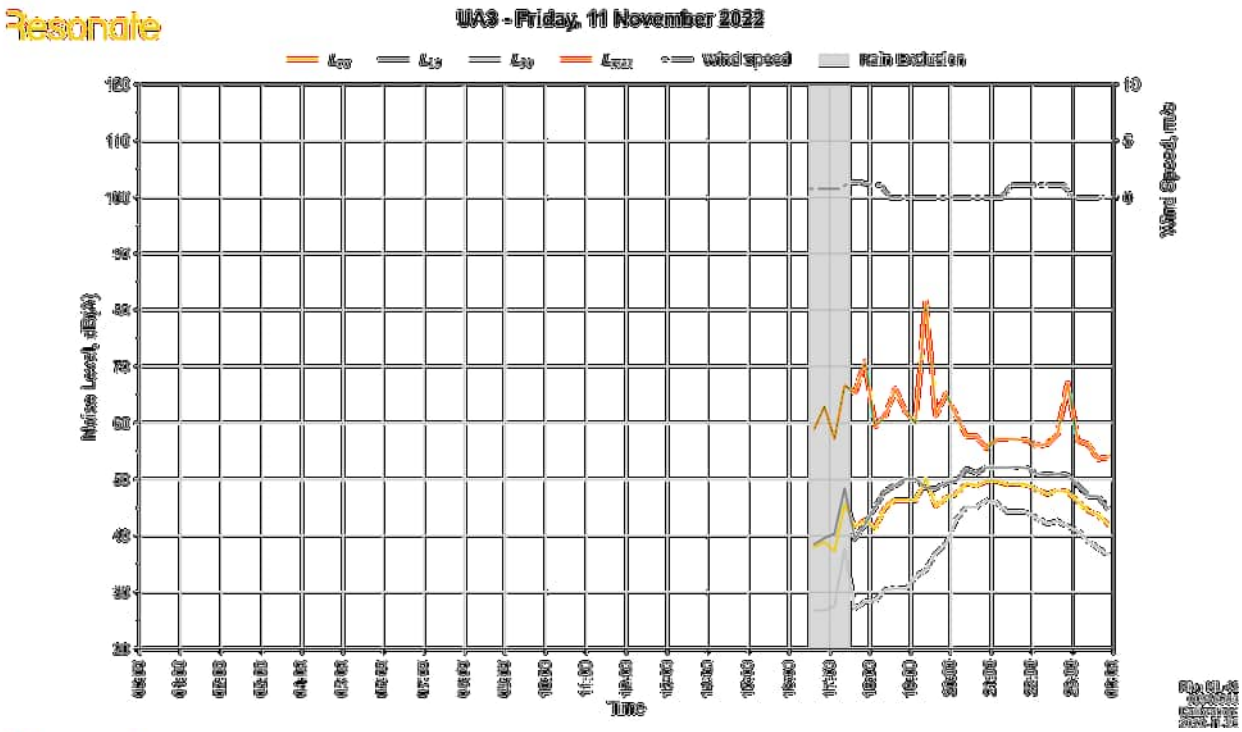

Resonate
UA2 - Saturday, 19 November 2022
wind speed
Noise Level, dB(A)
Wind Speed, m/s
Time

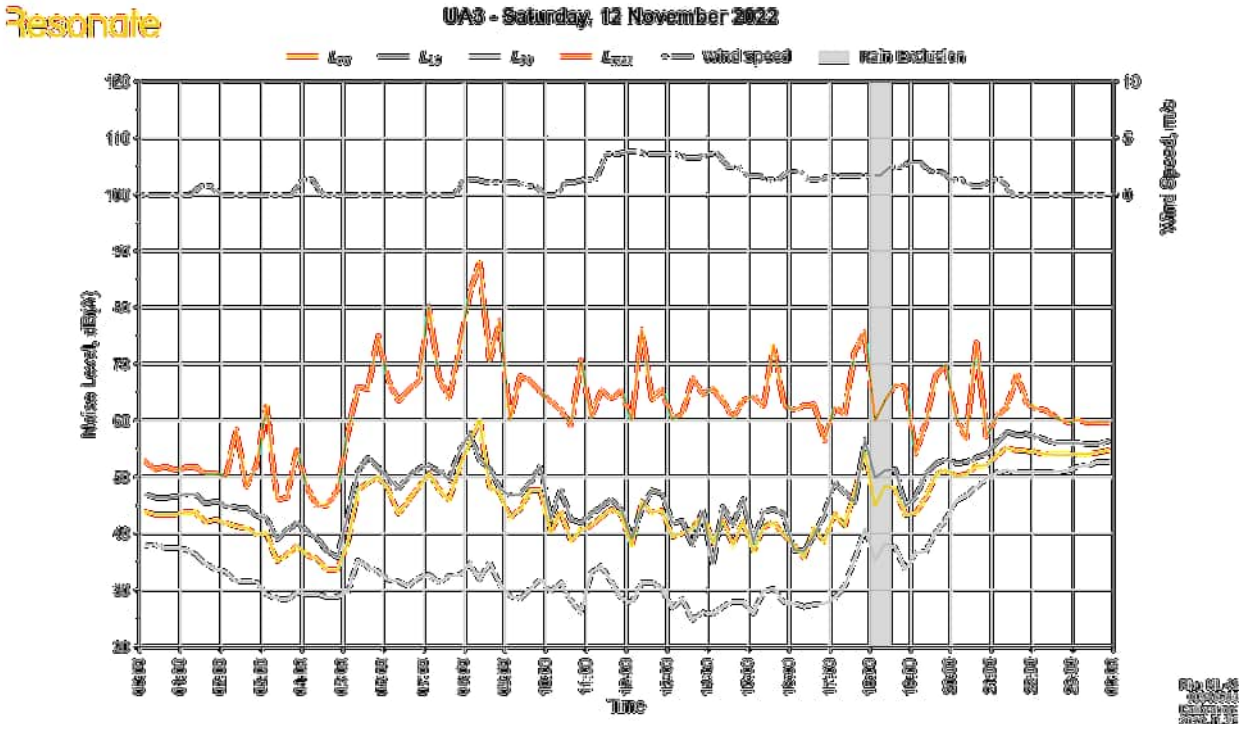

Resonate
UA2 - Sunday, 20 November 2022
wind speed
wind exclusion
rain exclusion
Noise Level, dB(A)
Wind Speed, m/s
Time

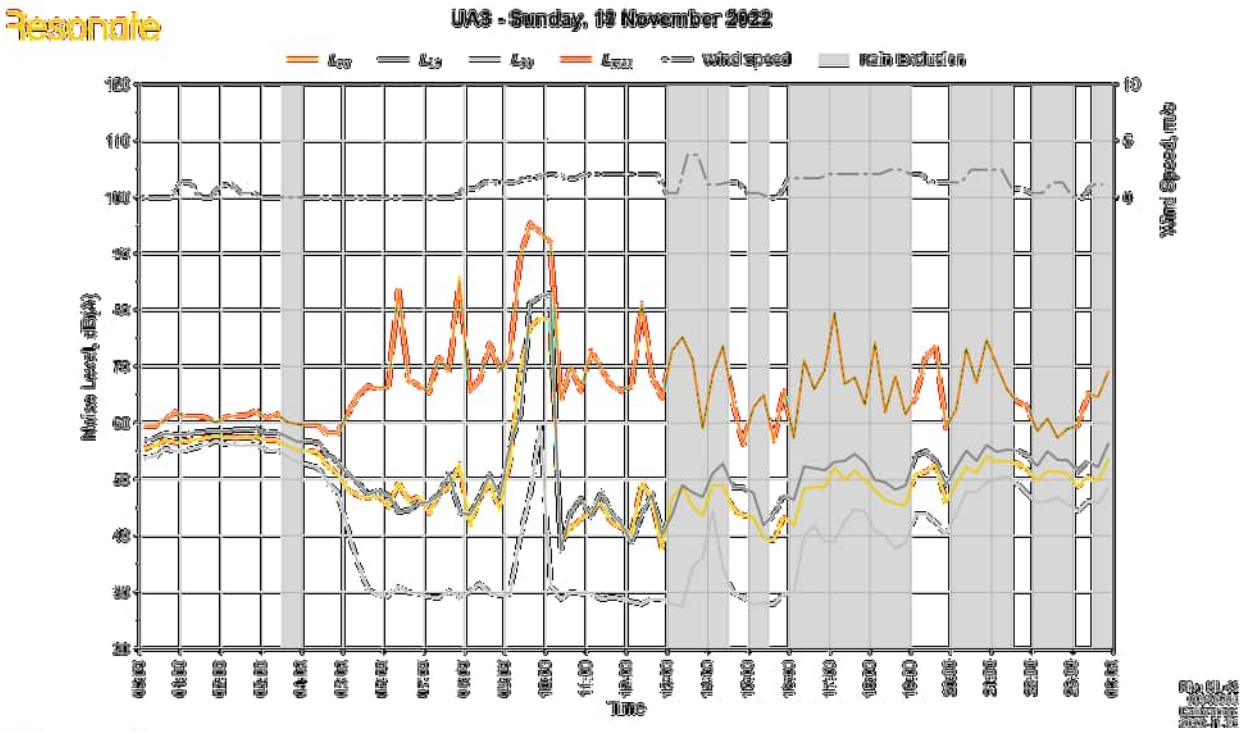

UA2 - Monday, 21 November 2022
Wind Speed, m/s
Time

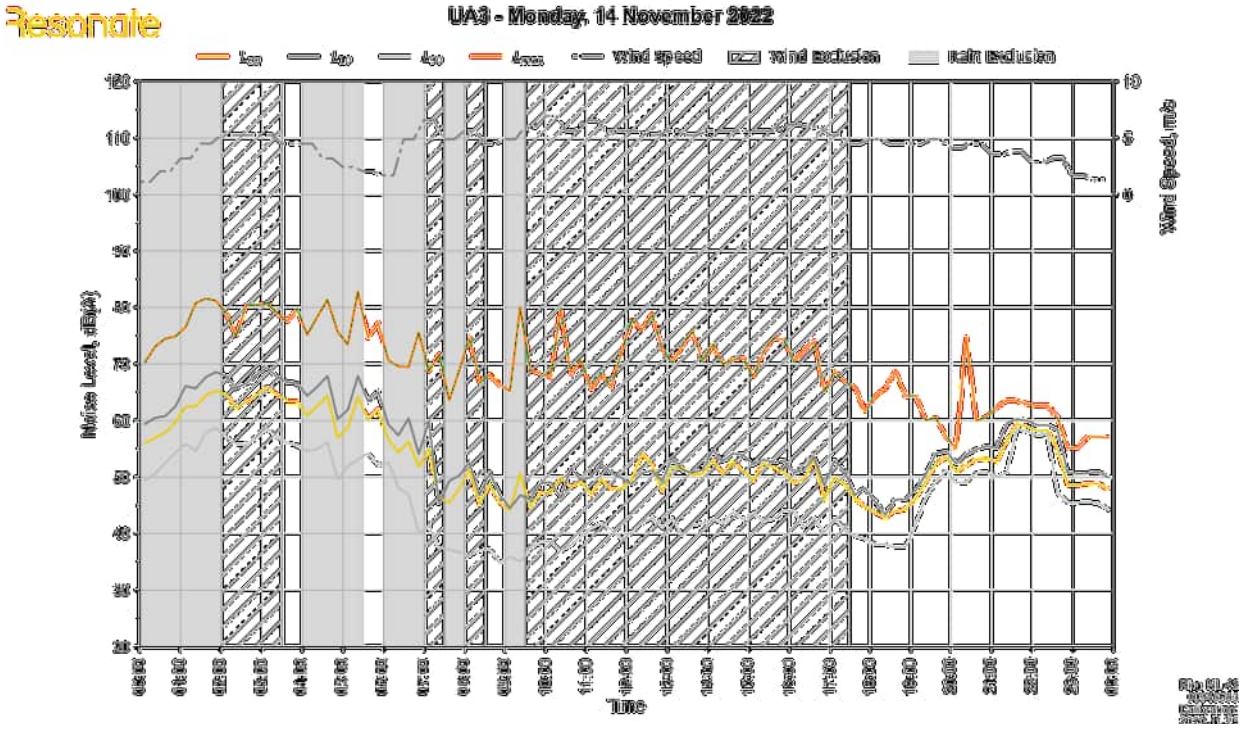

UA2 - Tuesday, 22 November 2022
Wind Speed, m/s
Time

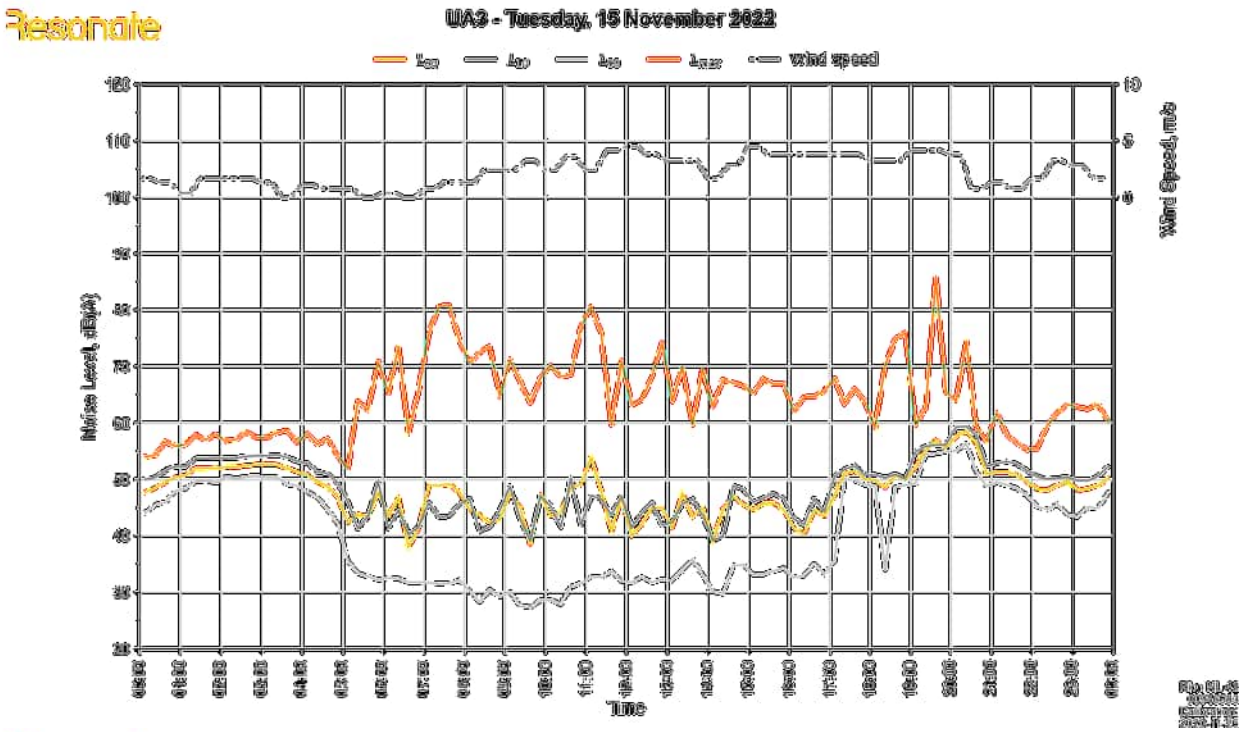

UA2 - Wednesday, 23 November 2022
wind speed
Noise Level, dB(A)
Wind Speed, m/s
Time

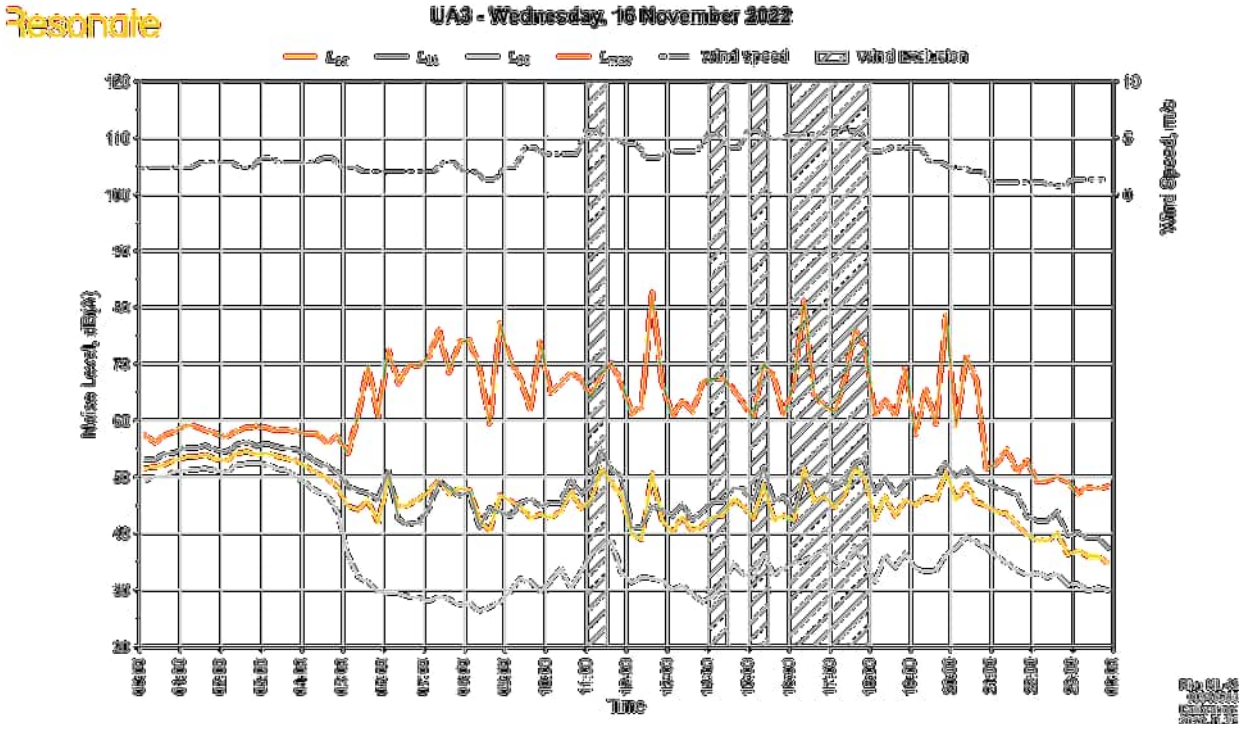

UA3 - Friday, 11 November 2022
Wind Speed, m/s
Time

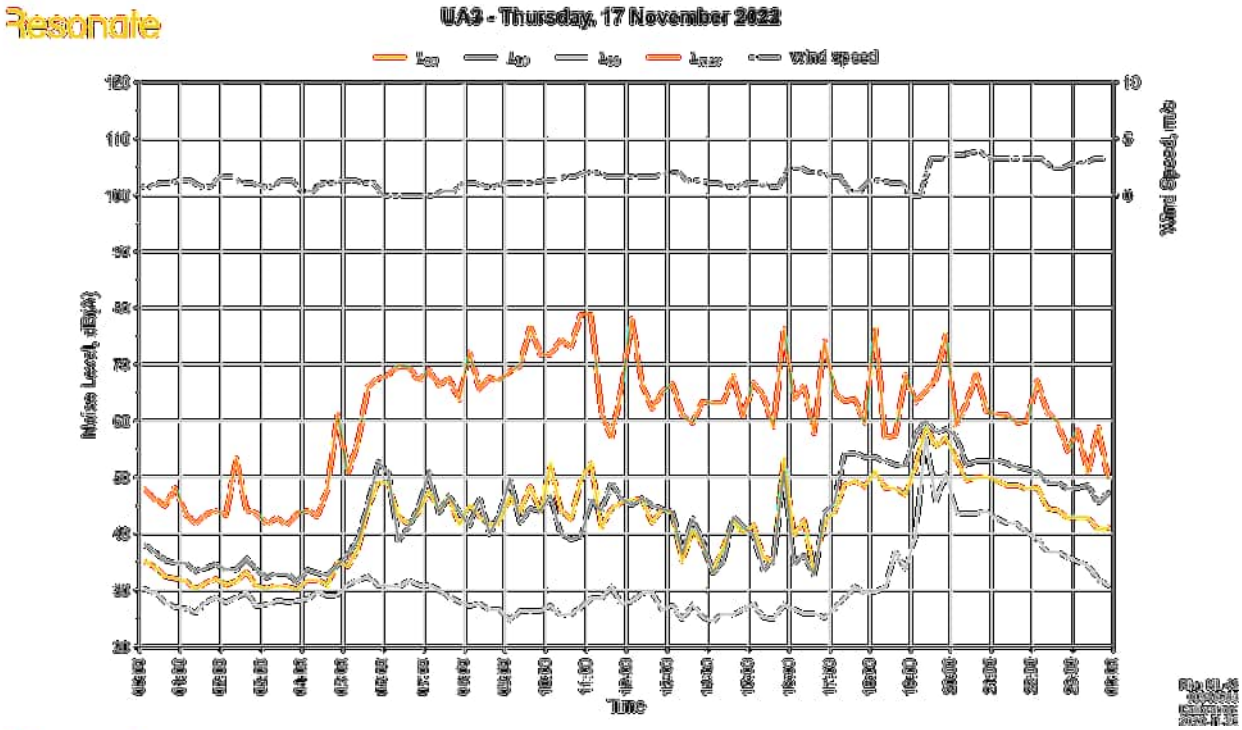

UA3 - Saturday, 12 November 2022
Wind Speed, m/s
Time

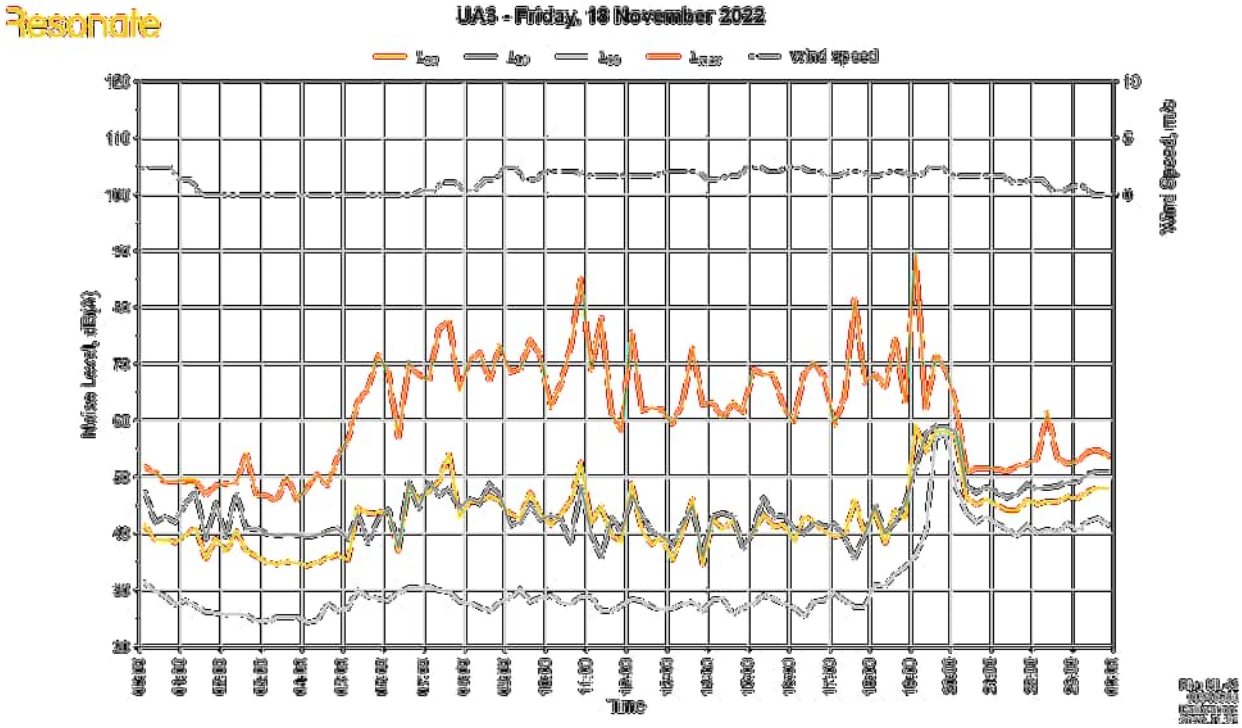

UA3 - Sunday, 13 November 2022
Wind speed
rain exclusion
Noise Level, dB(A)
Wind Speed, m/s
Time

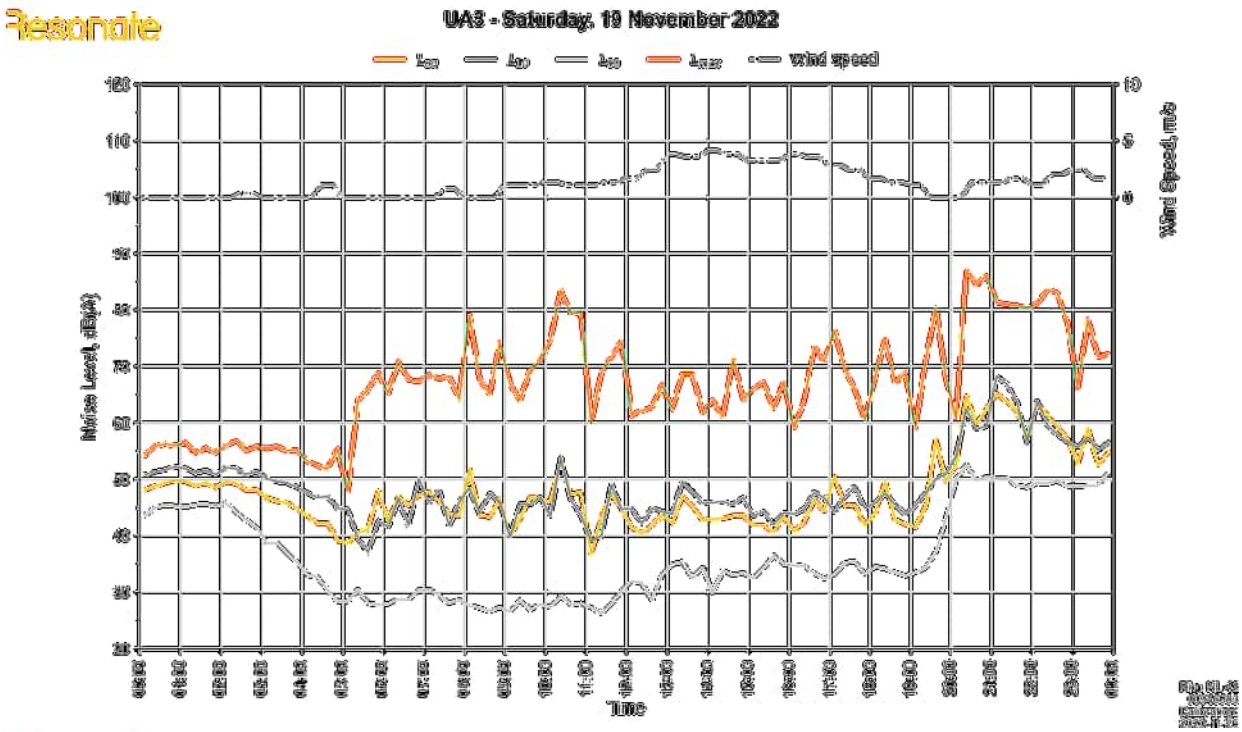

UA3 - Monday, 14 November 2022
wind speed
wind exclusion
rain exclusion
Noise Level, dB(A)
Wind Speed, m/s
Time

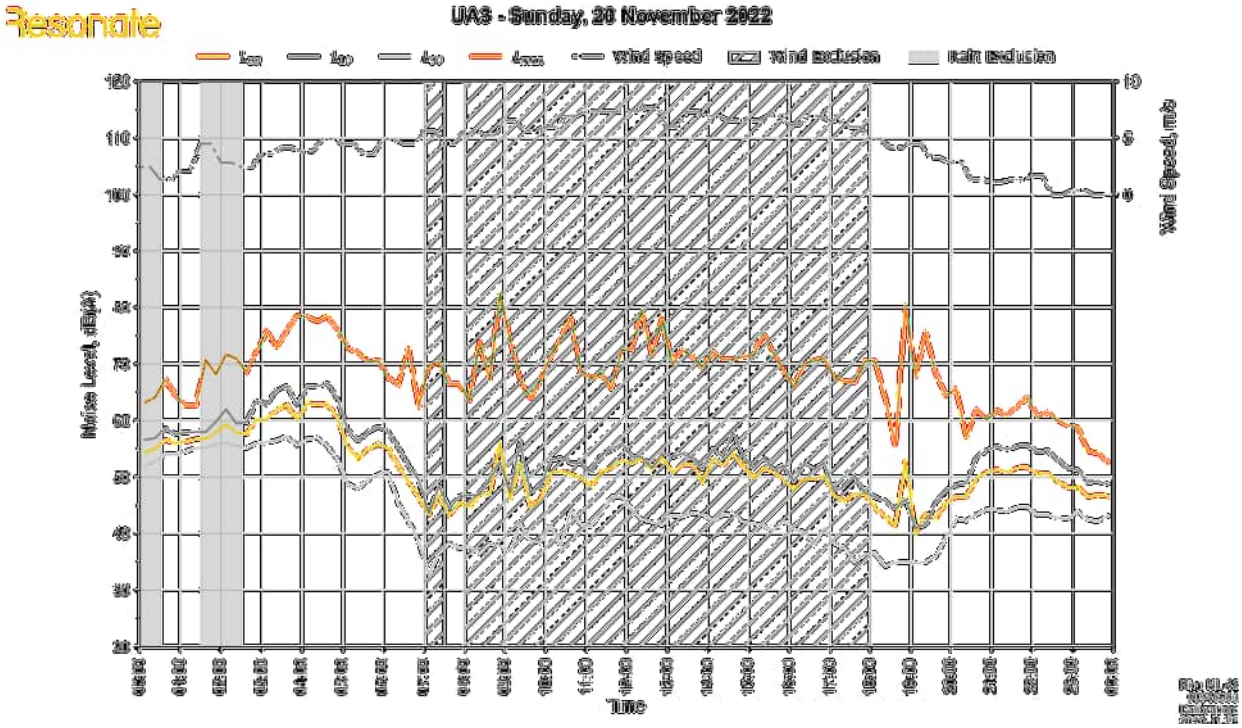

UA3 - Tuesday, 15 November 2022
Wind Speed, m/s
Time

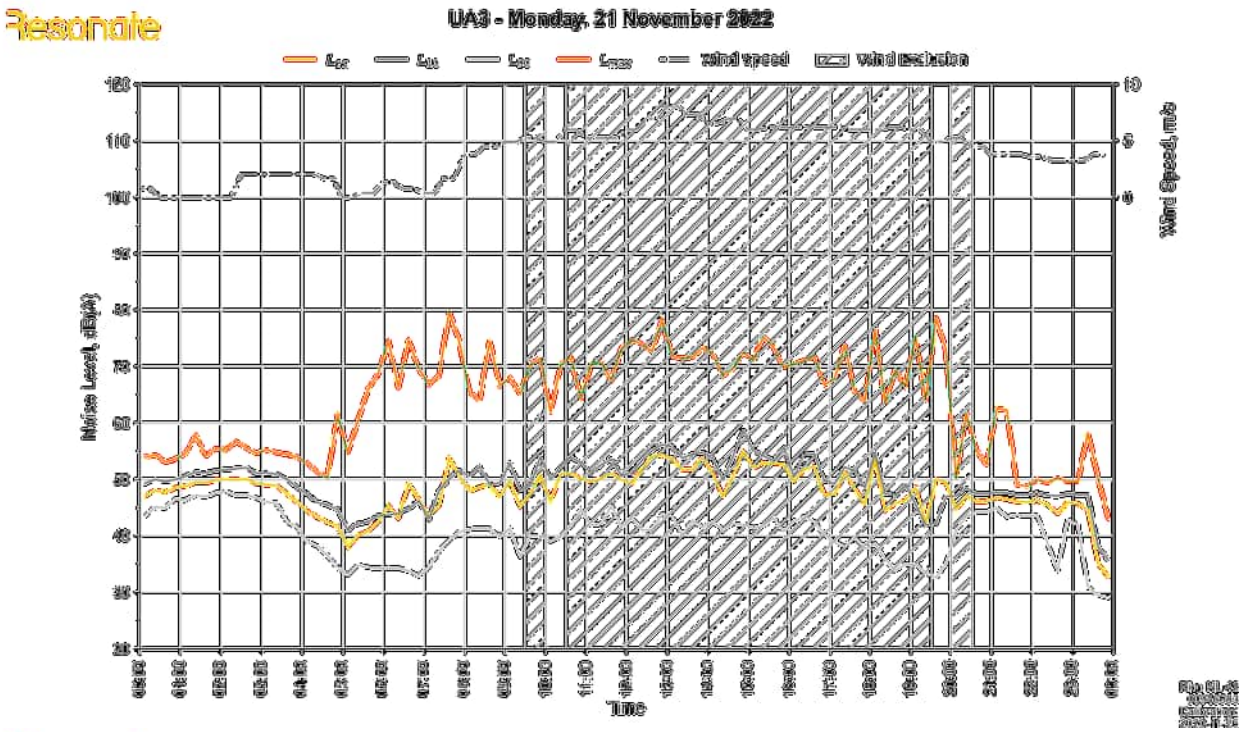

UA3 - Wednesday, 16 November 2022
Wind Speed, m/s
Time

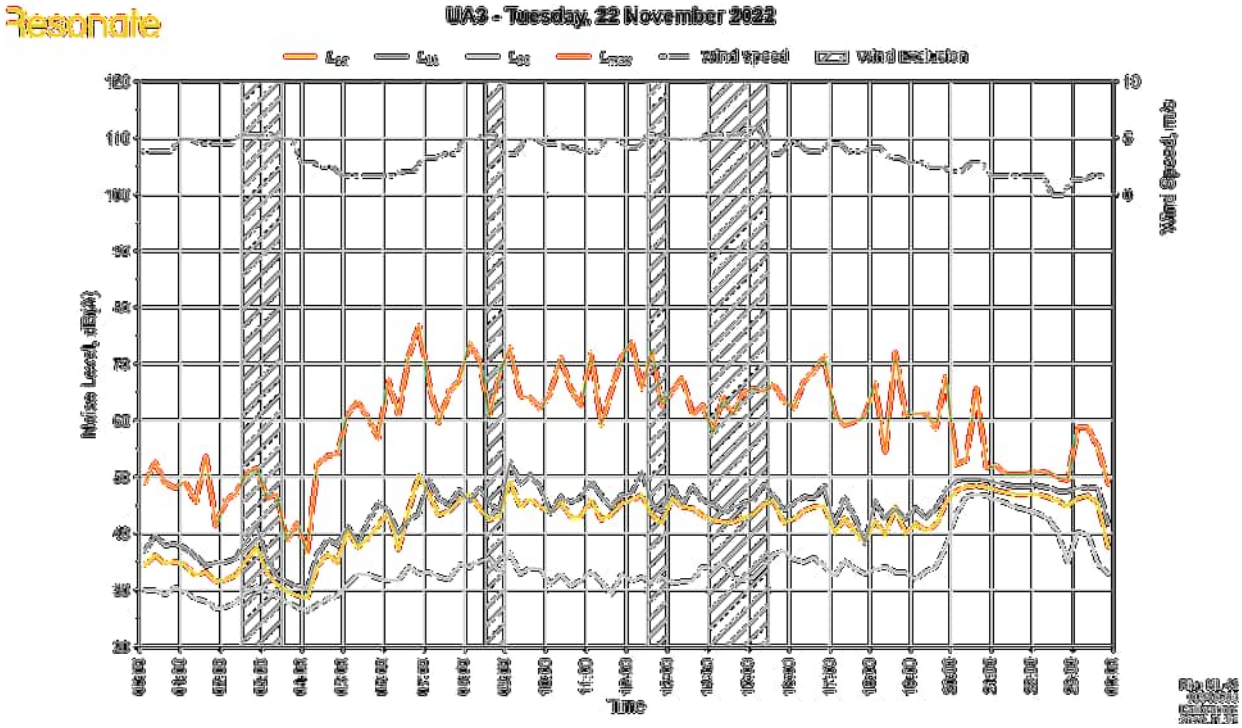

UA2 - Thursday, 17 November 2022
wind speed
Wind Speed, m/s
Time

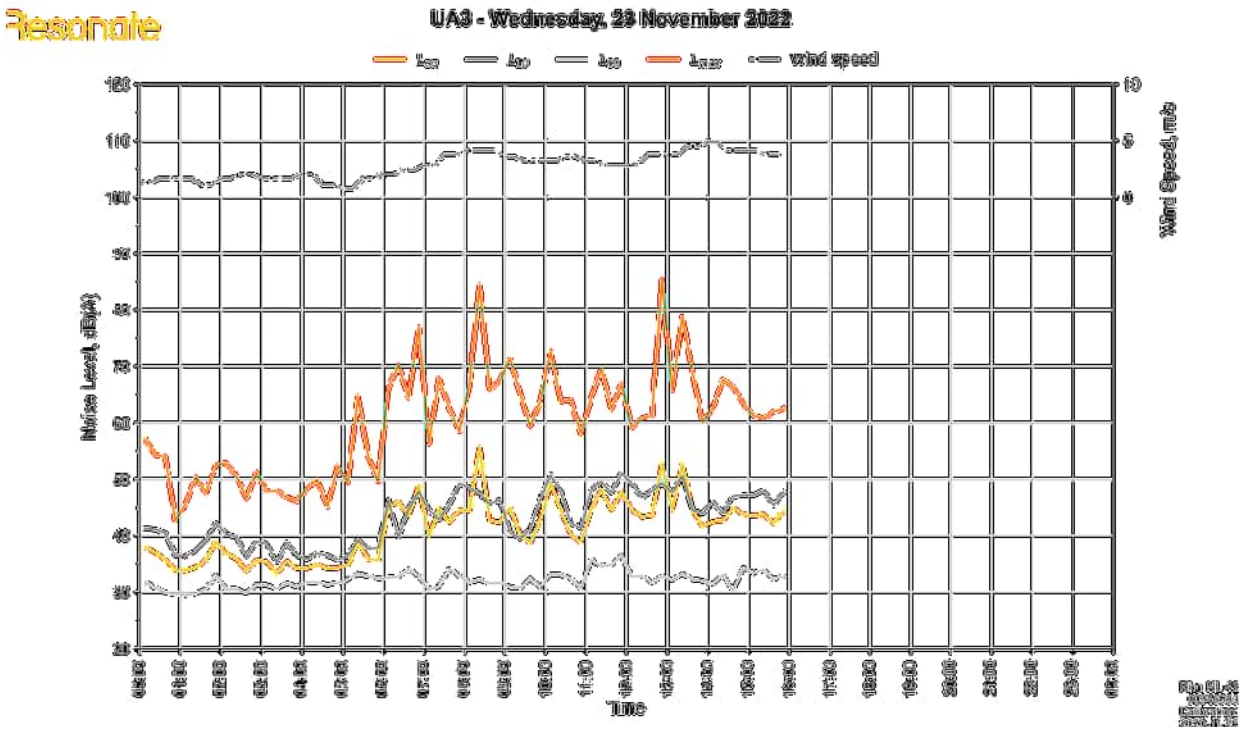

UA3 - Friday, 18 November 2022
wind speed
Wind Speed, m/s
Time


UA3 - Saturday, 19 November 2022
wind speed
Noise Level, dB(A)
Wind Speed, m/s
Time


UA3 - Sunday, 20 November 2022
wind speed
wind exclusion
rain exclusion
Noise Level, dB(A)
Wind Speed, m/s
Time


Resonate
UA3 - Monday, 21 November 2022
Wind Speed, m/s
Time


Resonate
UA3 - Tuesday, 22 November 2022
Wind Speed, m/s
Time


UA3 - Wednesday, 23 November 2022
wind speed
Wind Speed, m/s
Time

Appendix B – Predicted construction noise levels

ID	Type	NCA	Predicted noise level, dB(A)		Standard hours	Out-of-Hours criteria			Compliance				Sleep disturbance criteria, dB(A)		Compliance Sleep disturbance	
			Leq	Lmax[1]	Day	Day	Evening	Night	Day	Day (OOHW)	Evening	Night	Leq	Lmax impact	Leq	Lmax
13	RES	NCA 1	0	8	45	40	40	38	Yes	Yes	Yes	Yes	40	52	Yes	Yes
54	RES	NCA 1	0	8	45	40	40	38	Yes	Yes	Yes	Yes	40	52	Yes	Yes
56	RES	NCA 1	0	8	45	40	40	38	Yes	Yes	Yes	Yes	40	52	Yes	Yes
57	RES	NCA 1	0	8	45	40	40	38	Yes	Yes	Yes	Yes	40	52	Yes	Yes
58	RES	NCA 1	0	8	45	40	40	38	Yes	Yes	Yes	Yes	40	52	Yes	Yes
1	RES	NCA 2	22	30	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
2	RES	NCA 2	24	32	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
3	RES	NCA 2	22	30	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
4	RES	NCA 2	23	31	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
5	RES	NCA 2	22	30	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
6	RES	NCA 2	22	30	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
7	RES	NCA 2	21	29	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
8	RES	NCA 2	22	30	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
9	RES	NCA 2	18	26	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
10	RES	NCA 2	22	30	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
11	IND	NCA 2	23	31	75	75	75	75	Yes	Yes	Yes	Yes	n/a	n/a	n/a	n/a
14	RES	NCA 2	12	20	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
15	RES	NCA 2	16	24	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
18	RES	NCA 2	0	8	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
19	RES	NCA 2	25	33	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
20	RES	NCA 2	17	25	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
21	RES	NCA 2	28	36	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
23	RES	NCA 2	16	24	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
25	RES	NCA 2	23	31	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
27	RES	NCA 2	25	33	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
28	RES	NCA 2	15	23	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
30	RES	NCA 2	25	33	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
31	RES	NCA 2	22	30	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
55	RES	NCA 2	22	30	45	40	36	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
32	RES	NCA 3	30	38	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
34	RES	NCA 3	9	17	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
35	RES	NCA 3	26	34	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
36	RES	NCA 3	15	23	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
37	RES	NCA 3	27	35	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
38	RES	NCA 3	26	34	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
39	RES	NCA 3	26	34	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
40	RES	NCA 3	13	21	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
41	RES	NCA 3	14	22	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
42	RES	NCA 3	19	27	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
43	RES	NCA 3	11	19	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
44	RES	NCA 3	27	35	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
45	RES	NCA 3	16	24	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
46	RES	NCA 3	11	19	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
47	RES	NCA 3	27	35	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
48	RES	NCA 3	27	35	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
49	RES	NCA 3	27	35	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
50	RES	NCA 3	11	19	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
51	RES	NCA 3	13	21	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes
52	RES	NCA 3	25	33	45	40	39	35	Yes	Yes	Yes	Yes	40	52	Yes	Yes

1) Lmax is based on LAeq + 8 dB