

Rosefield Solar Farm

Bat Technical Study

EN010158/APP/8.5
March 2026
Deadline 1
Rosefield Energyfarm Ltd



Table of Contents

1. Introduction	1
1.1. Purpose of this document	1
1.2. Project Overview	1
1.3. Ecological context	2
2. Construction noise study	4
2.1. Introduction	4
2.2. Construction noise	4
2.3. Operational noise	9
2.4. Conclusion	13
3. Grazing study	14
3.1. Introduction	14
3.2. Overview	14
3.3. <i>Myotis</i> diet	14
3.4. Insects associated with sheep dung	15
3.5. Insects associated with sheep	15
3.6. Other considerations	15
3.7. Conclusion	16
4. Paired static detector study	17
4.1. Introduction	17
4.2. Purpose of the study	17
4.3. Methodology	18
4.4. Results	26
4.5. Discussion	36
4.6. Proposed Development implications	38
5. References	41

FIGURES

Figure 1: Site and Static Detector Locations	
---	--

APPENDICES

Appendix A: Ultrasonic Noise Monitoring Burwell Solar Farm	
---	--

Appendix B: EDF Coventry BESS Noise Verification Exercise.....

Appendix C: Photographs of detector deployment locations.....

Appendix D: Weather Records.....

Appendix E: Detailed survey results.....

Appendix F: R code for statistical analysis.....

Appendix G: Data inputs for statistical analysis.....

Appendix H: Barbastelle activity relative to sunset.....

Appendix I: The Bernwood Population of Bechstein’s Bats (Natural England)....

1. Introduction

1.1. Purpose of this document

- 1.1.1. This Bat Technical Study has been prepared on behalf of Rosefield Energyfarm Limited ('the Applicant') to support the application for the Development Consent Order (DCO) for the construction, operation (including maintenance), and decommissioning of Rosefield Solar Farm (hereafter referred to as the 'Proposed Development').
- 1.1.2. During the consultation process and within their Relevant Representation dated 12 December 2025, Natural England requested additional information to be provided relating to the following topics:
- Potential impacts to roosting bats from noise as a result of construction and decommissioning works (see **Section 2**).
 - Potential impacts to bat foraging habitat within Fields B6, B7, B8 and the relationship between bats and sheep grazing for grassland management (see **Section 3**).
 - Queries over data presented within **ES Volume 4, Appendix 7.16: Paired Static Detector Survey Report (2025) [EN010158/APP/6.4] [APP-102]** and data presented within **ES Volume 4, Appendix 7.10: Bat Activity Survey Report (2024) [EN010158/APP/6.4] [APP-096]**, particularly referencing the value of open fields, and an apparent increase in the relative activity of barbastelles (see Section 4).
 - Greater assurance regarding the accuracy of barbastelle identification from acoustic data, and comparison between the two datasets (see **Section 4**).
- 1.1.3. This document has been prepared to provide the finding of these studies and evaluation as to whether the results of the studies would change the conclusions of the assessment undertaken for bats presented within **ES Volume 2, Chapter 7: Biodiversity [EN010158/APP/6.2.2]**. The finding of the studies have not altered the conclusions of the assessment undertaken for bats. Further detail is provided in the subsequent sections.

1.2. Project Overview

- 1.2.1. The Proposed Development comprises the construction, operation (including maintenance), and decommissioning of solar photovoltaic ('PV') development and energy storage, together with associated infrastructure and an underground cable connection to the National Grid East Claydon Substation.
- 1.2.2. The Proposed Development would include a generating station with a total exporting capacity exceeding 50 megawatts ('MW').

1.2.3. The location of the Proposed Development is shown on **ES Volume 3, Figure 1.1: Location Plan [EN010158/APP/6.3] [APP-061]**. The Proposed Development would be located within the Order Limits (the land shown on the **Works Plans [EN010158/APP/2.3.3]** within which the Proposed Development can be carried out). The Order Limits plan is provided as **ES Volume 3, Figure 1.2: Order Limits [EN010158/APP/6.3] [APP-061]**. Land within the Order Limits is known as the 'Site'.

1.3. Ecological context

1.3.1. The Site predominantly comprises arable fields interspersed with hedgerows, ditches, lines of trees, grassland and small areas of woodland, with occasional small buildings and ponds.

1.3.2. The wider landscape is largely arable with occasional villages, farm complexes, scattered residential properties and woodland.

1.3.3. The Site is located adjacent to both Sheephouse Wood Site of Special Scientific Interest (SSSI) and Finemere Wood SSSI. A further SSSI, Grendon and Diddersall Wood, is located 1.36km to the south-west of the Site. In addition, Ham Home-cum-Hamgreen Woods SSSI is located 3.2km south-west of the Site. Whilst outside of the Study area for national statutory designated sites, it has been included in Natural England's consideration of the proposed landscape-scale Bernwood SSSI (currently on hold) and is therefore of relevance to discussions concerning Bechstein's bat.

1.3.4. Two non-statutory designated sites are located within the Site; Romer Wood Local Wildlife Site (LWS) and Greatsea Wood LWS.

1.3.5. Six additional non-statutory designated sites are located outside of the Site, but directly adjacent/in close proximity. All six non-statutory designated sites relate to ancient woodland. These sites comprise:

- Shrub Woods LWS –directly adjacent to Parcel 1;
- Decoypond Wood LWS – directly adjacent to Parcel 1;
- Runts Wood LWS – directly adjacent to Parcel 2;
- Finemere Wildlife Trust Reserve (WTR) – south of Parcel 2;
- Home Wood, Middle Claydon LWS – adjacent to Interconnecting Cable Corridor; and
- Balmore Wood LWS – 95m west of Parcel 2.

1.3.6. All four SSSIs and the non-statutory designated sites are known to be of importance to a range of roosting and foraging bat species; in particular, the Bernwood population of Bechstein's bat (*Myotis bechsteinii*), whose home range includes much of the Site. A further rare UK bat species,

barbastelle (*Barbastella barbastellus*), has also been confirmed to use these woodlands.

2. Construction noise study


2.1. Introduction

- 2.1.1. Natural England are of the opinion that solar development has the potential to result in significant impacts to roosting bats from noise as a result of construction and decommissioning works, and that proposed mitigation measures will not be sufficient to reduce these impacts to an acceptable level. This has been articulated regularly by Natural England during the consultation process and within their Relevant Representation dated 12 December 2025 [\[RR-203\]](#).
- 2.1.2. Until recently, most measurements of noise were undertaken to determine impacts on human receptors rather than bats. Such measurements are typically 'weighted' to reflect the relative loudness of sounds as perceived by the human ear rather than unweighted noise levels. 'A-weighted' data (represented as dBA) emphasise sounds inaudible to bats whilst under-representing those audible to bats. However, there is increasing awareness of the need to use unweighted measurements and examples of such unweighted data are now available within the Bat Mitigation Guidelines (2025) [\[Ref.1\]](#).
- 2.1.3. The following presents a study of the risk of disturbance from construction noise generated by elements of the Proposed Development and also summarises a high-frequency unweighted noise study carried out at an operational solar farm.

2.2. Construction noise

- 2.2.1. The following structure within **Table 1** follows the examples set out in the Bat Mitigation Guidelines (2025) [\[Ref.1\]](#); this structure has been accepted as part of licence submissions for other projects, notably for the Bernwood section of HS2 which lies alongside the Proposed Development.
- 2.2.2. Noise data cited are taken from Case Study 38 of the Bat Mitigation Guidelines (2025) [\[Ref.1\]](#).

Table 1: Noise impacts from the installation of solar panels

Noise impacts from the installation of solar panels	
Description of the work	<p>The plant required will include HGV delivery vehicles, excavators, telehandlers, piling rigs, unloading cranes, Mobile Elevated Working Platforms(MEOWPs), as detailed within the Outline Construction Environmental Management Plan (CEMP) [EN010158/APP/7.2.2].</p> <p>Access roads would be created using excavators, dump trucks and vibrating rollers.</p> <p>It is likely that small areas of vegetation would need to be removed and chipped.</p> <p>Piling is required to install the frames for the panels. These will be small units to install driven or helical piles. A typical example is shown here.</p>
	
Bat survey results	<p>The Order Limits is adjacent to an important series of woodlands where there are both Bechstein’s bat and barbastelle (the latter not yet established as breeding). For this reason, the following assessment of noise impacts has been undertaken.</p>
Noise/vibration parameters	<p>Seasonal timing of construction works Collectively: all seasons</p>
	<p>Time of day Allowed working hours are 7am-7pm as detailed within the Outline CEMP [EN010158/APP/7.2.2].For the majority of the bats’ active season (broadly April to October, temperature dependent), these are daylight hours only (i.e. when bats are in roosts). There are only brief periods of overlap when these hours overlap with periods when bats would be active and foraging.</p>
	<p>Duration of works <i>Haul routes:</i> Limited in duration/extent at the start. <i>Piling:</i> In any one field, estimated up to two weeks on average (though fields vary in size). Working arrangements are not confirmed, as the contractor engaged would need to review all relevant constraints</p>

Noise impacts from the installation of solar panels

(including cost, resources, traffic management, etc). Thus, work could take place in just one field, more than one field in a parcel, or more than one parcel simultaneously.

The average install rates for piling is around 1MW per piling rig per week.

Increasing the rate would require more rigs and increase individual noise sources, but shorten the overall construction programme.

The number of rigs on site will be decided by the contractor; a shorter piling duration will require more rigs to deliver. The current construction programme assumes a minimum of six piling rigs.

The mini-piling rigs envisaged require a small team (3-4 people estimated).

Continuous/ intermittent

Haul routes:

Limited in duration/extent.

Piling:

Each contractor has different approaches to installation, with some contractors piling whole areas before framing starts. Experience from other installations suggests that periods of piling (weeks) are followed by periods of frame installation, then more piling.

Frequency range

Haul routes:

No noise or vibration measurements are available for the specific kit to be used as this has not been selected. However, the Bat Mitigation Guidelines (2025) (PDF p 233) show the movements for a dozer (similar to an excavator) at 15-30m (measurements within 15m were not undertaken for safety reasons).

Measured levels did not exceed ~50 dB LZeq,T at any frequencies at distances greater than 15m (beyond one small spike that marginally exceeds this over a narrow frequency band at 12-14 kHz, (a similar peak is at ~33 kHz), probably caused by a squeal from the caterpillar tracks).

At frequencies >18 kHz, measured levels do not exceed 45 dB LZeq,T. A spike in the 31.4 kHz frequency band present at each set back distance does not exceed 35 dB LZeq,T.

Use of a chainsaw:

No noise or vibration measurements are available for the specific kit to be used as this has not been selected.

Noise impacts from the installation of solar panels

However, the Bat Mitigation Guidelines (2025) (PDF p 231) shows chainsaw noise measurements measured at 5-30m. Measured levels do not exceed ~65 dB LZeq,T at any frequencies, at distances of greater than 5m. Measured levels do not exceed ~50 dB LZeq,T at any frequencies, at distances greater than 15m.

Piling:

No noise or vibration measurements are available for the specific kit to be used as this has not been selected. However, the Bat Mitigation Guidelines (2025) (PDF p 234) shows noise data for a full-size Giken 'silent' piling rig installing sheet piles. Unweighted noise measurements for that kit do not exceed ~35 dB LZeq at any frequencies, even at distances of 5m. This is a much larger piling rig than would be used here.

Online examples of mini-piling rigs can be found here:

<https://www.ivorking.co.uk/piling-solutions/bored-piling-solutions/mini-piling/>

<https://minipilingsystems.co.uk/guides/how-does-mini-piling-differ-from-other-types-of-piling/>

The second example notes "The installation process for mini piles generates significantly less noise and vibration compared to driven piling methods used for larger piles. This characteristic makes mini piling suitable for use near sensitive structures."

Intensity ('loudness' - using non-technical terms)

Likely to be low even at peak noise/vibration levels.

Noise and vibration propagation

Limited propagation of noise through air. A tree where bats roost may provide some protection against high-frequency noise, particularly if the bats are deep within a cavity.

Limited propagation of vibration via the ground; likely less than is experienced through the movements of the trees which support roosts (building roosts not affected in this location).

Baseline noise levels

Low (quiet rural area) except for the construction of HS2 to the west where a significant construction project is underway. That project has included piling along the edge of Sheephouse Wood using more 'intrusive' forms of piling (e.g. drop-hammer).

Noise impacts from the installation of solar panels

Bat parameters	Species' susceptibility	<p>The area supports a valuable woodland assemblage, including species that hunt by passive listening, and other Annex II species. The woodland assemblage includes species likely to be more sensitive to noise.</p> <p>Areas of woodland supporting breeding roosts are located immediately adjacent to the redline boundary; however, buffer zones have been incorporated.</p> <p>Tree-roosting bats use a number of different trees during the season and generally use individual trees only for short periods of time. They will therefore have options for roosting outside of the area affected by noise, which is reasonably small in the context of the whole roost resource.</p>
	Roost type	All types including breeding for some species including Bechstein's bat.
	Habitat	The areas where panels will be installed are adjacent to an important series of woodlands; however, the areas that will support panels is largely arable, connected by hedgerows.
	Pre-development experience of population	Likely to be habituated to some level of noise/vibration given HS2 construction, at least in the western-most parcels.
Evaluation of likely impacts	<p><i>Creation of haul routes:</i></p> <p>Although data are not available for the kit to be used, the data that is available suggests there will be negligible impacts from noise or vibration at the setback distances envisaged. The works are of short duration in any one location.</p> <p>A location-specific assessment may be required if there are potential roosts within 15m of haul routes.</p> <p><i>Piling:</i></p> <p>The works are of short duration in any one location.</p> <p>Although data are not available for the kit to be used, the data that is available suggests there will be negligible impacts from noise or vibration, even for roosts within treelines/hedgerows or on the woodland edge.</p> <p>Given the likely low noise/vibration generation (even at 5m, which is less than the actual buffer between the works and any habitat that could support roosts) and the small area affected at any one time/location, impacts to even breeding roosts are considered unlikely.</p>	

Noise impacts from the installation of solar panels

There is evidence to suggest that torpid bats are not as affected by anthropogenic noise [Ref.2] and appear to tolerate some vibration. Thus, the likelihood of displacing hibernating bats, if present, is similarly low.

The works will happen during the daytime, so impacts to foraging/commuting are unlikely. There may be a small area of overlap where sunset is before 6 or 7pm, but this will be limited in extent.

Noise mitigation measures required

[NOTE: this does not consider mitigation for other receptors that may be present, most likely nesting birds, or standard actions such as tool-box talks.]

No restrictions on timings necessary, subject to an assessment of potential tree roosts undertaken prior to construction works, detailed and secured within the **Outline CEMP [EN010158/APP/7.2.2]**. However, trees tend to be occupied for short periods of time, reducing the requirement for anything other than short-term restrictions (if that).

However, there will be additional personnel and vehicles compared to the baseline and these will need to be managed/minimised to avoid disruption (parked away from woodland and other sensitive areas), detailed and secured within the **Outline CEMP [EN010158/APP/7.2.2]**.

If there is any 'night-time' working (likely only when sunset is before 7pm), the lighting of sensitive habitats should be avoided, detailed and secured within the **Outline CEMP [EN010158/APP/7.2.2]**.

Licensing

As disturbance is unlikely, even for the low threshold of disturbance for offences which derive from domestic legislation, a licence is unlikely to be required.

In the absence of a licence, a Legally Protected Species Protection Plan is recommended detailed and secured within the **Outline CEMP [EN010158/APP/7.2.2]**.to be provided within the detailed Construction Environmental Management Plan (CEMP).

2.3. Operational noise

- 2.3.1. The following evaluation does not require the same structure as for construction noise as the impacts are limited. The data referenced in **Table 2** are taken from an evaluation of ultrasonic noise undertaken for Burwell Solar Farm for EDF Renewables (see **Appendix A**). This study measured unweighted high-frequency noise to determine the likelihood of impacts on bats (as recommended in Reason and Bentley(2020) [Ref. 3] and described further in the Bat Mitigation Guidelines (2025) [Ref.1].

Table 2: Operational noise and potential impact on bats.

Overview of Results	Potential for noise impacts on bats
12.1 String Inverter – Daytime Measurements	
<ul style="list-style-type: none"> ▪ The 1m reference measurements for the string inverter show pronounced noise emissions at 14 kHz and at harmonic frequencies e.g. 28 kHz, 42 kHz, 56 kHz and 70 kHz. The 14 kHz noise levels at the 1m reference measurement were in the range of 60 to 69 dB LZeq, with lower emissions at each subsequent harmonic frequency. 	<p>No impacts on roosting bats, as they will not be this close to the source, as there are buffers of at least 20m to woodlands (30m for statutory and locally designated wildlife sites) where most roosts will be located, detailed in and secured by the Design Commitments [EN010158/APP/5.9.3].</p>
<ul style="list-style-type: none"> ▪ The noise levels decay with increased distance from the string inverter. For the dominant 14 kHz frequency band, the noise levels at 15m setback and beyond are typically in the range of 40 to 45 dB LZeq. 	<p>This level of noise is likely to be audible to bats (and not at the extremes of audibility – so within ‘normal’ hearing sensitivity).</p> <p>The noise levels do decay with distance, but there is some noise above 40dB at that one frequency band at all distances measured.</p> <p>As per Bat Mitigation Guidelines (2025) Case study 38, PDF p237) [Ref.1], “field measurements from natural daytime sounds in rural locations ...suggest levels of 40 dB or more in the frequency range 8 to 20 kHz are not uncommon, with readings from gently rustling reeds at a distance of around 10 m resulting in approximately 50 dB in this frequency range. Storm events (high winds, heavy rain) would generate higher levels of sound”.</p> <p>This does not take the character of the sound into account, but the noise emissions are likely here to be predictable, being both continuous and around a narrow frequency range. So whilst there would be a change in the local environment, it would be unlikely to be startling and there something to which bats could habituate.</p> <p>The noise could affect bats in tree-roosts, but there would be some level of protection (absorption) of the sound from surrounding vegetation and the</p>

Overview of Results

Potential for noise impacts on bats

structure of the roost itself. There are also buffers of at least 20m to woodlands (30m for statutory and locally designated wildlife sites) where most roosts will be located detailed in and secured by the **Design Commitments [EN010158/APP/5.9.3]**.

On balance, impacts to roosting bats are considered unlikely (*potentially* temporary on commissioning). There is some evidence of habituation (see Bat Mitigation Guidelines (2025) para 4.3.7, PDF p 40 [Ref.1]).

- For the harmonic frequencies at 28 kHz, 42 kHz, 56 kHz and 70 kHz, the noise levels at setback distances beyond 10m were below 30 dB LZeq in all instances.

No impacts on roosting bats; bats not foraging at this time.

12.2 String Inverter – Twilight Measurements

- There were no apparent ultrasonic noise emissions from the string inverter during both rounds of twilight noise measurements. The measured noise levels presented in the graphical outputs for the twilight period are considered to represent the noise floor of the measurement system.

No impacts on roosting or foraging bats.

12.3 Transformer Station – Daytime Measurements

- The daytime measurements for the transformer station identify pronounced noise emissions at 14 kHz for both the setback measurements and the 1m reference measurements. The 14 kHz noise levels were below 40 dB LZeq in all instances.

No impacts on roosting bats (the anomalies are explained); bats not foraging during the daytime.

- For certain measurements, the 14 kHz noise levels at the setback measurements were higher than the corresponding 1m reference measurement. This would imply that the source of the ultrasonic may not have been entirely attributable to the transformer station or there were localised screening effects close to the unit.

12.4 Transformer Station – Twilight Measurements

Overview of Results

Potential for noise impacts on bats

- During the first round of twilight measurements for the transformer station, discrete noise emissions were evident at 14 kHz. This occurred at the 5m, 10m and 15m setback distance measurements.

- At the 5m and 10m setback distances, the 14 kHz noise level levels were very low at less than 20 dB LZeq for both the setback measurement and the 1m reference measurement.

- At the 15m setback, the 14 kHz levels were elevated relative to the 5m and 10m setback distances. For this measurement, the level recorded at 15m was higher than the corresponding 1m reference measurement. This would imply that the source of the ultrasonic noise may not have been entirely attributable to the transformer station or there were localised screening effects close to the unit.

- There were no apparent ultrasonic noise emissions at other setback distances. The measured noise levels presented in the graphical outputs for these setback distances are considered to represent the noise floor of the measurement system.

- There were no apparent ultrasonic noise emissions during the second round of twilight measurements for the transformer station. The measured noise levels presented in the graphical outputs for the second round of twilight measurements are considered to represent the noise floor of the measurement system.

No impacts on roosting or foraging bats (the anomalies are explained within the report and do not affect the conclusions).

2.3.2. A separate study of an existing operational battery energy storage site (BESS) in Coventry on behalf of EDF concluded that audible and ultrasonic noise from the BESS units was only dominant within 5m of the source, with other louder sources, such as nearby transformers/Inverters and the M6 motorway, having a greater impact at longer distances (see **Appendix B**).

2.3.3. The combined noise from the 19 BESS units and 10 transformers/ Inverters was calculated to be between 47-53 dB in the human audible range and 56-58 dB in the ultrasonic range at the receptor location. While the ultrasonic levels exceed the '*Bat Mitigation Guidelines*' example of

"*gently rustling reeds*" (50 dB), the effects of air absorption, which were not fully factored into the calculations, would likely reduce these levels to be much lower in practice.

2.4. Conclusion

- 2.4.1. This study presents an evaluation of the risk of disturbance from construction noise generated by elements of the Proposed Development. The study summarises a high-frequency unweighted noise study carried out at an operational solar farm. Neither construction nor operation are considered to represent a significant source of noise disturbance; however, some pre-construction assessments may be required depending on haul route layout and programme.
- 2.4.2. For the most part, as disturbance is unlikely, even for the low threshold of disturbance for offences which derive from domestic legislation, a licence is unlikely to be required. In the absence of a licence, a Legally Protected Species Protection Plan is recommended detailed and secured within the **Outline CEMP [EN010158/APP/7.2.2]** is recommended, to be provided within the detailed Construction Environmental Management Plan.

3. Grazing study

3.1. Introduction

- 3.1.1. Natural England are of the opinion that solar development within Fields B6, B7, B8 would result in a loss of foraging habitat for bats, in particular Bechstein's bats, as these are currently pasture grazed by cattle, of which the dung may contribute to the insect foraging resource for bats. The concern from Natural England refers to these fields as a block rather than specific issues relating to individual fields.
- 3.1.2. This has been articulated regularly by Natural England during the consultation process and within their Relevant Representation dated 12 December 2025 [\[RR-203\]](#).

3.2. Overview

- 3.2.1. There are multiple studies providing evidence that the presence of herbivores in a landscape has a positive effect on bat abundance, in species including those from the *Myotis* genus [\[Ref. 4, Ref.5\]](#). This is due to increased forage for bats in the form of insects associated with the presence of dung, as well as the livestock itself, in the landscape [\[Ref. 6\]](#) and [\[Ref.7\]](#). In the context of cattle, these have been demonstrated to include flies (*Diptera*) attracted to the large herbivores [\[Ref. 8\]](#), including nocturnal or crepuscular blood-sucking forms such as mosquitoes (*Culicidae*), blackflies (*Simuliidae*) and biting midges (*Ceratopogonidae*) [\[Ref. 9\]](#) and [\[Ref.10\]](#), as well as *Coleoptera*, *Diptera* and *Hymenoptera* attracted to the dung [\[Ref. 11\]](#).
- 3.2.2. The majority of studies have been conducted on cattle, whilst the relationship between bats and sheep has not been investigated. Whether the positive correlation found between cattle and bats can be extended to sheep, however, may be deduced by establishing the forage of *Myotis* species and investigating whether those insects are associated with sheep.

3.3. *Myotis* diet

- 3.3.1. *Myotis* species, including Bechstein's bats, have been found to feed predominantly on *Diptera*, as well as *Lepidoptera*, *Coleoptera* and *Trichoptera* [\[Ref. 12\]](#) and [\[Ref.13\]](#). Slight variations between *Myotis* species has been found, with Bechstein's bats shown to feed mostly on woodland families of *Diptera* and *Lepidoptera*, while other *Myotis* species foraged mainly on *Diptera* [\[Ref.14\]](#). Other studies found that *Coleoptera* made up a significant proportion of the *Myotis* diet [\[Ref.15\]](#). However, the majority of these species were ground beetles, not species in the *Scarabaeidae* family (many associated with dung). Therefore, perhaps the *Diptera* associated with animals and dung are likely to be the significant

attraction, rather than the dung beetles, to *Myotis* species. However, variation in diet in these studies could be due to varied availability of some insect groups in the area. From faecal analyses of the Bernwood Bechstein's bats, many of the prey items identified are associated with multiple habitat types.

3.4. Insects associated with sheep dung

- 3.4.1. A study investigating insect communities associated with sheep dung showed a total of 29,347 individuals belonging to 12 orders of arthropods, with the most abundant orders being *Coleoptera* (60% of individuals), *Hymenoptera* (accounting for 34% of individuals) and *Diptera* (5.6% mainly larvae) [Ref.11].
- 3.4.2. Investigating *Diptera* specifically, sheep dung has been demonstrated to support a wide range of species [Ref.16]. Sheep dung has also been demonstrated to support a diverse range of *Coleoptera* in the family *Scarabaeidae* [Ref.17].
- 3.4.3. In a study comparing species-richness of dung beetles between cattle, sheep and goat dung, sheep dung was shown to support a species-richness comparable to that of cattle dung, with some species preferring sheep or goat dung over cattle [Ref.18].

3.5. Insects associated with sheep

- 3.5.1. Regarding animal-specific insects rather than dung-specific, a comparison between *Diptera* species found on cattle and those found on sheep showed no significant difference [Ref.19].

3.6. Other considerations

Management

- 3.6.1. Studies have demonstrated that different types of livestock management will affect the impact that livestock has on bat populations [Ref.20], showing organic farming, including organic livestock farms, support higher species-richness and abundance of bat species than conventionally managed farms, due to absence of pesticides, antibiotics and wormers [Ref.21].

Climate

- 3.6.2. It has been suggested that climate plays a role in dung preference in dung beetles, due to water content being significantly reduced in hot climates making smaller droppings less hospitable for dung insects than larger ones that are able to retain more moisture [Ref.22]. In hot climates such as southern Spain, cattle dung is found to host greater abundance of dung

beetles than sheep [Ref.23], whereas in more temperate climates such as western Germany and Ireland, sheep droppings were found to be preferable [Ref.24]. In humid pastures in Brazil, dung beetle preference for sheep over cattle dung has also been found [Ref.25].

3.7. Conclusion

- 3.7.1. Studies widely indicated that there is a positive correlation between livestock and bats, including *Myotis* species, due to increased forage when herbivores are present. Multiple studies have demonstrated this relationship with cattle; however, the relationship between bats and sheep specifically has not been investigated. Despite this, extrapolating from knowledge of the diet of *Myotis* species and the insect communities associated with sheep and sheep dung, it is possible to predict this relationship. The diet of *Myotis* bats is predominantly made up of *Diptera*, as well as *Coleoptera*, *Lepidoptera* and *Trichoptera* species. Studies investigating insect communities associated with sheep dung and sheep have demonstrated that large populations of *Diptera* and *Coleoptera*, comparable to those found to be associated with cattle, are supported by sheep also. It is therefore suggested that the effect of sheep in a landscape on the abundance of *Myotis* bat species would echo that of cattle. This could be further enhanced by management methods which support greatest insect populations.
- 3.7.2. The Applicant is aware of the importance of the grazed fields as a foraging resource for bats and this has informed mitigation and management proposals, with low-intensity cattle-grazing the preferred option for managing grassland fields in mitigation areas and low-level sheep-grazing in panel areas. Consequently, there is likely to be more grazing across the entire site than is currently present, i.e., within the proposed design there will be more grassland fields that will be managed through grazing than are currently present.

4. Paired static detector study

4.1. Introduction

- 4.1.1. In meetings, Natural England raised two queries over data presented within **ES Volume 4, Appendix 7.16: Paired Static Detector Survey Report (2025) [EN010158/APP/6.4] [APP-102]** and data presented within **ES Volume 4, Appendix 7.10: Bat Activity Survey Report (2024) [EN010158/APP/6.4] [APP-096]**, particularly referencing the potential value of open fields (which had not been directly surveyed by static detectors), and an apparent increase in the relative activity of barbastelles since the earlier data had been collected.
- 4.1.2. Natural England also asked for greater assurance regarding the accuracy of barbastelle identification from acoustic data, and comparison between the two datasets. This has been articulated by Natural England during the consultation process and within their Relevant Representation dated 12 December 2025 **[RR-203]**.
- 4.1.3. The Applicant therefore reviewed further the data collected to address these information gaps specifically (prior to DCO Application submission), to determine if there was any evidence of a greater importance for barbastelle than previously anticipated and, if so, whether that would change the overall impact assessment detailed within **ES Volume 2, Chapter 7: Biodiversity [EN010158/APP/6.2.2]**.

4.2. Purpose of the study

- 4.2.1. This section of the Bat Technical Study presents the results of a paired bat static detector (hereafter referred to as 'detector') surveys carried out in connection with the Proposed Development. Paired detector surveys were undertaken in three locations within the Order Limits (hereafter 'the Site') in October 2024 and in two locations within the Site in May 2025.
- 4.2.2. The Site and survey locations are shown on **Figure 1**.
- 4.2.3. The primary aim of these surveys was to enable an analysis of levels of bat activity between boundary features within the Site (i.e. woodland edge and tree lines) and areas of open habitat (i.e. within fields).
- 4.2.4. Linear boundary features, in particular woodland edges, hedgerows and lines of trees, are considered to be of considerable value to bats, supporting their movement through the landscape between roosting and foraging locations **[Ref. 26]**. However, the extent to which bats will also use more open areas, i.e. the centre of agricultural fields, has received less scientific study **[Ref. 27]**.

- 4.2.5. A study has therefore been conducted to investigate how bat activity differs within the open and boundary features within the Site, since open areas would be impacted by the Proposed Development, while the majority of boundary features would be retained and protected by buffer zones. Three fields and their adjacent boundaries were chosen for the study.
- 4.2.6. As shown in **Table 3**, two of the fields chosen for the study were arable fields, while one was grazed by a non-organic cattle herd. Grazed fields, particularly those grazed by organic cattle, are often considered to be more attractive to bats than those that are not grazed or those that are grazed by non-organic cattle, as, without the use of anthelmintics, cattle dung can support a range of invertebrate species that bats prey on¹. In addition, it has been suggested that the presence of cattle themselves may impact bat activity, with one study finding that cattle-grazed pasture was an important habitat for common pipistrelle, serotine and at least some *Myotis* due, not only to the presence of dung and the associated insects, but as a result of the presence of the cattle themselves [**Ref. 6**].
- 4.2.7. While this report touches upon the differences in activity levels observed between these arable and grazed areas, this was not the primary purpose of the study design; for this reason, definitive conclusions cannot be drawn.
- 4.2.8. Due to the proximity of woodlands known to be of particular importance to Bechstein's bat and barbastelle, specific consideration is given in this report to these species, while the remaining bat species recorded are considered together as an 'All other species' group.

4.3. Methodology

Field surveys

- 4.3.1. Each pair of detectors comprised one detector which was placed along a boundary feature (i.e. woodland edge or tree line) and one detector which was placed within a field (i.e. in the open). During each survey period, detectors were deployed simultaneously for a period of at least five consecutive nights, in line with good practice guidance [**Ref. 28**].
- 4.3.2. The detector deployment locations are illustrated on **Figure 1** and in **Appendix C** and are summarised in **Table 3** below, along with details of the deployment periods.

¹ Sheep and horse dung also offer some opportunities for invertebrates; however, some invertebrate species show a preference for fresh dung and both sheep and horse dung tend to dry out quicker than cattle dung, so grazing by livestock of this nature may be more valuable to bats where it is undertaken in more shaded locations, such as across parkland [**Ref. 3**].

Table 3: Paired Detector Deployment Locations and Timings

Site Location	Description	Position	Survey Period 1	Survey Period 2
Field D28	On the south-eastern corner of Runt's Wood	Boundary	24/10/24 – 29/10/24	14/05/25 – 22/05/25
	Within Field D28	Arable field		
Field D29	On the tree line between Finemere Wood and Runts Wood	Boundary	24/10/24 – 29/10/24	14/05/25 – 22/05/25
	Within Field D29	Arable field		
Field B8	On the northern boundary of Sheephouse Wood	Boundary	24/10/24 – 29/10/24	N/A ²
	Within Field B8	Grazed field		

- 4.3.3. The field locations at Field D28 and Field D29 were in agricultural use and planted with crops at the time of both survey periods.
- 4.3.4. The field location at Field B8 comprised grassland which is known to be grazed on a rotational basis by cattle from spring to the autumn. Cattle were not present at the time of the October 2024 survey and it is not known how recently Field B8 was grazed by cattle prior to the October survey. Access was not permitted to this location during the May 2025 deployment (for safety reasons whilst grazing was in progress).
- 4.3.5. Detectors were deployed for six nights in Survey Period 1, while in Survey Period 2, this was extended to nine nights. Bat registrations have been converted to mean registrations per hour' (MRPH) for each deployment period, thereby enabling the data across the two periods to be compared.
- 4.3.6. Full spectrum Wildlife Acoustic Song Meter SM4BAT-FS detectors with omnidirectional microphones were used. Each had a microphone mounted at a height between 1 and 2m to maximise the probability of recording bat calls in addition to reducing the likelihood of interference from insects and

² Access not granted to this location during the spring (2025) deployment.

moving vegetation. Each detector was set to record bats from half an hour before sunset to half an hour after sunrise.

- 4.3.7. Detectors were deployed when the weather forecast indicated suitable weather conditions for foraging and commuting bats (i.e. sunset temperatures of 10°C or above, with no heavy rain or strong winds). The actual weather conditions during each survey period are detailed in **Appendix D**.

Analysis and verification

Verification

- 4.3.8. Recordings were processed using the British Trust for Ornithology (BTO) Acoustic Pipeline, a machine-learning process that enables the automated identification of bat echolocation calls. The BTO Acoustic Pipeline considers recordings of no more than 5 seconds in length and provides an identification on each occasion that a bat species is identified. For the purposes of this analysis, each bat species identification is considered to represent a bat ‘registration’.
- 4.3.9. The results provided by the BTO Acoustic Pipeline were then subject to manual verification to determine the accuracy of the automated identification process. Manual verification specifically focused on barbastelle and *Myotis* (including Bechstein’s bat) identifications, since these species are of particular interest in the context of the Proposed Development.
- 4.3.10. Recordings selected for manual verification were viewed in Kaleidoscope Viewer© software and analysed by an experienced bat call analyst to determine whether key call parameters (e.g. call shape, peak frequency, call duration etc.) reflected those expected for the given identification. All manual verification was undertaken by an experienced ecologist with over 10 years’ experience in UK bat echolocation call analysis.
- 4.3.11. **Table 4** below summarises the extent of the manual verification undertaken across the October 2024 and May 2025 datasets.

Table 4: Manual verification undertaken for the October 2024 and May 2025 datasets

Deployment	Manual verification approach (number of registrations checked; 5-second sound files)		
	Barbastelle	Bechstein’s bat	Other <i>Myotis</i>
October 2024	All (724)	N/A (none recorded)	All (113)

Deployment	Manual verification approach (number of registrations checked; 5-second sound files)		
	Barbastelle	Bechstein's bat	Other <i>Myotis</i>
May 2025	All (231)	All (32)	All (3,145)

- 4.3.12. The BTO Acoustic Pipeline outputs consider *Myotis* identifications to the species level. However, as it is not always possible to reliably identify individual species of the *Myotis* genus solely from their echolocation calls, manual verification focused on whether the BTO species-level identification accurately reflected calls that would be expected for the wider *Myotis* genus. As such, all confirmed *Myotis* species identifications are considered to have the potential to be from a Bechstein's bat. However, there is a thriving (and increasing) population of Natterer's bats (*Myotis nattereri*) in Finemere Wood, and roosts of Daubenton's bat (*Myotis daubentonii*) and whiskered bat (*Myotis mystacinus*) are known from Sheephouse / Decoypond Woods (HS2 data), which are all *Myotis* species.
- 4.3.13. Full details of the survey results are provided in **Appendix E** of this report.

Activity analysis

- 4.3.14. A calculation of the MRPH was undertaken for barbastelle, '*Myotis*³', 'All other species⁴' and 'Total species⁵', to enable the consistent comparison of relative levels of bat activity. This was undertaken by summing the total bat registrations for a given species (or group of species) recorded at a specific detector location within a given survey period and dividing this by the total hours of monitoring for that detector location, within that survey period.
- 4.3.15. MRPH have also been calculated across all boundary and all field locations in October 2024 and May 2025 to provide an overview of activity levels. This has been calculated by summing the number of registrations from all boundary or field detector locations across the survey period

³ Comprising BTO Acoustic Pipeline species level identifications for Bechstein's bat, Brandt's bat (*Myotis brandti*), Daubenton's bat, Natterer's bat and whiskered bat.

⁴ Comprising brown long-eared bat, common pipistrelle (*Pipistrellus pipistrellus*), Leisler's bat (*Nyctalus leisleri*), Nathusius's pipistrelle (*Pipistrellus nathusii*), noctule (*Nyctalus noctula*), serotine (*Eptesicus serotinus*) and soprano pipistrelle (*Pipistrellus pygmaeus*).

⁵ Comprising all species identifications (barbastelle, brown long-eared bat, common pipistrelle, Leisler's bat, *Myotis* sp., Nathusius's pipistrelle, noctule, serotine and soprano pipistrelle.

under consideration and dividing this by the total number of survey hours from all the relevant detector locations within the survey period. As detailed above this has been calculated for barbastelle, 'Myotis.', 'All other species' and 'Total species'.

Determining significance

- 4.3.16. To determine whether variations between the number of registrations recorded at the boundaries and within the fields represent significant differences, statistical analyses have been undertaken on the 2024/2025 data.
- 4.3.17. The 2024/2025 data comprised several key features that required consideration in the selection of an appropriate statistical test, namely that:
- The data comprised two sample types (boundary data and field data),
 - The data was non-parametric (i.e. was not normally distributed); and,
 - The data contained a number of zero values
- 4.3.18. On the basis of these data features, the Wilcoxon Rank-Sum test was identified as the most suitable statistical analysis approach by an experienced statistician with 10 years' experience in quantitative biology.
- 4.3.19. The Wilcoxon Rank-Sum test compares the distribution of values between groups by ranking all observations from lowest to highest and then evaluates whether these ranks are randomly distributed between the groups, resulting in a 'U statistic'.
- 4.3.20. Statistical significance was then analysed by comparing the calculated 'U statistic' to its expected distribution under a null hypothesis of there being no difference between the two groups (boundary and field).
- 4.3.21. The statistical analysis was applied in R and the code and data table used for the tests are provided in **Appendix F** and **G** of this report.
- 4.3.22. A significance level of 0.05 was selected, in line with standard practice when undertaking statistical analyses, including for bat data [Ref. 28]. Where the p-value (determined from the calculated 'U' statistic) is below the significance level of 0.05, an observed variation has a less than 5% likelihood of resulting from chance and the associated null hypothesis can be rejected.
- 4.3.23. The Wilcoxon Rank-Sum test was run on the total number of registrations recorded per night across a given survey period, rather than the MRPH value calculated for narrative discussion elsewhere in this report. This was done to reduce the error propagation associated with the values used for the statistical test.

- 4.3.24. The Wilcoxon Rank-Sum test was run 20 times to enable comparison between each combination of boundary and field data by survey period, location and species/species group.

Barbastelle activity timing analysis

- 4.3.25. To analyse how barbastelle activity varied throughout the course of a night, confirmed barbastelle registrations were extracted from the collected data and split across 15-minute periods of time between sunset and sunrise.
- 4.3.26. The number of confirmed barbastelle registrations recorded in each 15-minute period was then converted to a graphical form to allow for a visual representation of the first registration, last registration and peak periods of barbastelle activity.
- 4.3.27. This process was undertaken for each detector location and deployment period. The results from either the six (October 2024) or nine (May 2025) nights of survey were collated to produce a single graphical output for a given detector location during a given deployment period.

Limitations

- 4.3.28. Detectors cannot distinguish between large numbers of bats moving through an area and small numbers of bats making repeated passes within an area. Therefore, high levels of bat activity can be generated by a large number of commuting bats, a small number of foraging bats flying past the detector on multiple occasions or even individual bats flying close to a detector on multiple occasions. Therefore, the analysis of results has been based not on an analysis of the likely number of bats using an area, but instead a measure of relative activity that can be applied in a consistent and repeatable format across datasets, namely MRPH and the statistical analysis of differences in the total number of registrations per night between boundary and field detectors across a specific survey period.
- 4.3.29. As already noted, it is often not possible to reliably identify individual species of *Myotis* solely from their echolocation calls and therefore these species have been grouped for the purposes of analysis. In determining the potential implications of the results for individual *Myotis* species, it has been assumed that any or all of these identifications could represent Bechstein's bat activity, the *Myotis* species considered to be of most significant consideration for the Proposed Development, although this is unlikely to be the case given other *Myotis* species are known to be present (see **Paragraph 4.3.12**).
- 4.3.30. There are a number of variables that affect the 'detectability' of a bat, ranging from its biology and ecology to the environmental conditions and

the condition of the equipment. There are, therefore, limitations in drawing certain conclusions about bat activity on a site from the use of bat detectors and sound analysis alone. The detection rate of bat calls varies, with a bias towards loud bat calls, so that quieter calls such as those from brown long-eared bat (*Plecotus auritus*), tend to be under-recorded (a smaller volume of air around the detector is sampled for quieter species).

- 4.3.31. It should also be noted that, when commuting or foraging along boundary features, bats are likely to pass in relatively close proximity to that feature, increasing the likelihood that registrations will be recorded by a detector placed there. However, when bats are foraging more widely within an open area, any one detector will only sample a relatively small volume of the air surrounding it and therefore, only part of the overall field. There is, therefore, an inherent bias that could only be addressed by a large number of detectors. However, as the question under analysis here relates to the value of each location type for foraging bats, and the open fields were relatively homogeneous, small numbers of commuting bats across open fields, which may be at greater risk of not being picked up, are of limited interest.
- 4.3.32. Data was analysed using the BTO Acoustic Pipeline and a sub-set of the most relevant data manually verified by an appropriately experienced ecologist. Manually verified data focused on the accuracy of identification for the *Myotis* genus and barbastelle and did not consider any 'noise' files, i.e. recordings for which the BTO Acoustic Pipeline did not make any bat identifications. While it is possible that a small number of bat identifications, including for *Myotis* and/or barbastelle could be present within these 'noise' files, the identification accuracy levels found through manual verification (see **Section 4.4** below), which included calls of varying quality, suggests that any such missed calls should be limited in number and are considered unlikely to result in a substantial change in how the data has been interpreted.
- 4.3.33. No manual verification was undertaken of species other than barbastelle and *Myotis* as these species are grouped together as 'All other species' for the purpose of this analysis and therefore the accuracy of these recordings is of lesser impact to the overall study. As detailed above, while it is possible that a small number of barbastelle and/or *Myotis* registrations could be present within these 'All other species' files the accuracy levels found via manual verification of barbastelle and *Myotis* identifications means that any such inaccurately assigned registrations should be limited in number and are considered unlikely to result in a substantial change in how the data has been interpreted.
- 4.3.34. Activity levels of some individual species were very low, limiting the extent to which these could be robustly analysed. This primarily related to several of the individual species that made up the 'All other species' group, which were not analysed individually. It is recognised that statistical results may

have been strongly influenced by the behaviours of the dominant species within this group, rather than being representative of statistically significant variations in the behaviours of all individual species within the group.

- 4.3.35. Access restrictions meant it was not possible to deploy the Field B8 (grazed grassland) detectors during the second survey period. Therefore, this report only considers activity levels from October 2024 for the grazed field.
- 4.3.36. A request was made to compare barbastelle data collected in 2024/2025 to that collected by surveys undertaken in 2022/2023. However, the surveys undertaken in 2022/2023 used a 15-second recording length while surveys undertaken in 2024/2025 used a 5-second recording length, in line with the recommended approach to data collection where automated identification processes are to be used. This means that there is the potential for the data in 2024/2025 to identify up to three times more registrations than the data in 2022/2023, even if activity levels were actually consistent between the two survey periods. This is discussed further below in relation to apparent variations in the level of barbastelle activity recorded.
- 4.3.37. In addition, the 2022/2023 surveys were undertaken between June and September, while the later surveys were undertaken only in October and May and the detector positions different. A statistical comparison would therefore not be valid.
- 4.3.38. Direct comparisons have been made between the boundary and field detectors from a given location during a given survey period. Although broader comparisons could be made, the October and May surveys were undertaken at different points in the annual bat life cycle and with variations in weather conditions (see **Appendix D**). Both factors would be expected to influence recorded bat activity. In May, bats are in the process of forming maternity colonies. In October, mating and feeding to build up winter reserves will occur but, as the weather declines, bats begin seeking out hibernation sites and (temperature-dependent), may have periods of torpor. Higher levels of bat activity are typically recorded during a May survey period than would be observed during an October survey period, irrespective of the detector position.
- 4.3.39. In relation to the weather during the two survey periods, the temperature at sunset ranged from 10 °C to 15 °C for both the October 2024 and May 2025 survey periods. However, brief periods of light rain were recording during three of the six survey nights in October 2024, either around sunset or towards midnight, while survey nights during May 2025 experienced light rain during the early hours of the morning on only a single survey night. As such bats, may have experienced less optimal foraging conditions during the October 2024 surveys (the extent of the variation is

not considered to be sufficient to skew the overall findings, only to influence overall activity levels).

- 4.3.40. The Wilcoxon Rank-Sum test was used to analyse whether bat activity recorded at a boundary detector differed significantly from that recorded at its paired field detector. The power of this test generally increases with sample size. The October 2024 survey was based on six survey nights, while the May 2025 survey was based on nine survey nights; in addition (as noted), bats are typically more active in May than in October. As a result, statistical comparisons based on the May 2025 data are likely to be more robust than those based on the October 2024 data, as the larger sample size provides greater confidence that apparent variations in activity actually indicate statistically significant variations.
- 4.3.41. The analysis of barbastelle activity timing collates the number of barbastelle registrations confirmed as being correct at a given detector during a given deployment period. As such this data does not indicate the nature of barbastelle activity on each individual night during a survey period but instead provides a collated overview of how the barbastelle activity across a survey period falls between the hours of sunset and sunrise.

4.4. Results

Manual verification

- 4.4.1. The BTO Acoustic Pipeline identified 13 different species across the two survey periods, including five species-level *Myotis* identifications (Bechstein's bat, Brandt's bat, Daubenton's bat, Natterer's bat and whiskered bat).
- 4.4.2. BTO Acoustic Pipeline outputs were manually verified in line with the methodology detailed in **Section 4.3**. This comprised a manual verification of all barbastelle and all *Myotis* identifications (the latter to genus not species).
- 4.4.3. Manual verification of all 955 BTO Acoustic Pipeline barbastelle identifications found 935 of these to be correct (i.e. an accuracy level of 98%). Incorrect barbastelle identifications were removed from the analysis and have not been considered further in the results provided in this report.
- 4.4.4. Manual verification of all 3,290 BTO Acoustic Pipeline *Myotis* identifications⁶ found 3,123 of these to be correct (i.e. an accuracy level of 95%). Incorrect *Myotis* identifications (at the genus not species level) were

⁶ Of which the BTO Acoustic Pipeline identified 32 as Bechstein's bat, 41 as Brandt's bat, 741 as Daubenton's bat, 180 as Natterer's bat and 2,296 as whiskered bat

removed from the analysis and have not been considered further in the results provided in this report.

Within month results

October 2024 activity levels

- 4.4.5. Following manual verification, a total of 3,478 bat identifications were found to have been recorded across the paired detectors at the three locations monitored during the October 2024 survey period. This comprised 2,841 identifications across the three boundary detectors and 637 identifications across the three field detectors.
- 4.4.6. **Table 5** below summarises the results of the October 2024 survey period in the form of the MRPH recorded in each location.
- 4.4.7. The total number of registrations for each species/species group, along with the number of active survey hours within each survey period on which the MRPH have been calculated, are presented in **Table 10** in **Appendix E**.

Table 5. October 2024 mean registrations per hour (MRPH)

Location	Position	MRPH			
		Barbastelle	<i>Myotis</i>	All Other Species	Total Species
Field D28	Boundary	1.71	0.23	1.80	3.74
	Arable field	0.00	0.15	0.30	0.45
Field D29	Boundary	0.99	0.32	10.97	12.29
	Arable field	0.00	0.36	5.39	5.74
Field B8	Boundary	5.27	0.11	10.32	15.71
	Grazed field	0.07	0.07	0.79	0.93
Locations combined	Boundary	2.66	0.22	7.70	10.58
	Field	0.02	0.19	2.16	2.37

- 4.4.8. Consistently higher levels of barbastelle activity were recorded by boundary detectors compared to field detectors across all three locations during the October 2024 survey period, with the MRPH indicating that the

greatest levels of barbastelle activity in October 2024 were recorded at Field B8, both in terms of activity along the boundary and within the field.

- 4.4.9. Barbastelle were present along the boundary features in all three locations but were not recorded by the field detectors in Field D29 and Field D28. While barbastelle were recorded within Field B8, activity here was 78 times lower than that recorded by the paired boundary detector.
- 4.4.10. The MRPB recorded for *Myotis* indicated consistently low levels of activity and minimal variation between activity levels on the boundary features and within the fields.
- 4.4.11. As shown in **Table 5**, within each pair of detectors, 'All other species' activity levels were consistently higher at the boundary detector than at the field detector. While this variation was lowest at Field D29, the boundary detector here still recorded double the activity levels recorded by the paired field detector. Elsewhere, boundary detector activity levels ranged from approximately six (Field D28) to 13 (Field B8) times that recorded by the paired field detector.
- 4.4.12. For the combined 'All other species' group, the highest levels of bat activity in October 2024 were recorded by the boundary detector at Field B8 (15.67 MRPB), closely followed by the boundary detector at Field D29 (12.26 MRPB). The lowest overall bat activity was recorded by the field detector at Field D28, with MRPB of 0.45; almost half of these registrations relating to common pipistrelle activity.

May 2025 activity levels

- 4.4.13. Following manual verification, a total of 30,362 bat identifications were found to have been recorded across the paired detectors at the two locations monitored during the May 2025 survey period. These comprised 28,131 identifications across the two boundary detectors and 2,231 identifications across the two field detectors. **Table 6** below summarises the results of the May 2025 survey period in the form of the MRPB recorded in each location.
- 4.4.14. The total number of registrations for each species/species group, along with the number of active survey hours within each survey period on which the MRPB have been calculated, are presented in **Table 11** in **Appendix E**.

Table 6. May 2025 MRPH

Location	Position	MRPH			
		Barbastelle	<i>Myotis</i>	All Other Species	Total Species
Field D28	Boundary	2.10	5.87	231.81	239.78
	Arable field	0.04	0.33	16.15	16.51
Field D29	Boundary	0.47	30.40	71.37	102.24
	Arable field	0.00	0.02	10.59	10.61
Locations combined	Boundary	1.29	18.13	151.59	171.01
	Field	0.02	0.18	13.37	13.56

- 4.4.15. Barbastelle activity levels in May 2025 were, as in October 2024, consistently higher at the boundary detectors than at the field detectors, with the highest MRPH recorded at Field D28.
- 4.4.16. In comparison to the October 2024 data, barbastelle activity levels at Field D28 were slightly higher in May 2025 across both the boundary and field detectors. However, barbastelle activity levels in May 2025 on the boundary at Field D29 were approximately half those recorded in the same location in October 2024 (on both occasions, activity levels were very low. No barbastelle activity was recorded by the field detector at Field D29 during either survey period.
- 4.4.17. While, for the purposes of this analysis, all *Myotis* recordings have been grouped, the May 2025 data represents the only occasion in which the BTO Acoustic Pipeline specifically identified Bechstein’s bat, with the system identifying five Bechstein’s bat registrations from the boundary detector at Field D28 and 26 from the boundary detector at Field D29.
- 4.4.18. Across the *Myotis* genus group, activity along boundary features was greatest at Field D29, consistent with the findings from October 2024. However, unlike the findings from October 2024, activity from both boundary detectors was considerably greater than that recorded on their respective paired field detectors (almost 18 times greater at Field D28 and 1,520 times greater at Field D29).
- 4.4.19. The same overall increase in activity levels in May 2025 compared to October 2024 was observed for the ‘All other species’ group. As shown in **Table 6**, within both pairs of detectors ‘All other species’ activity levels were consistently higher at the boundary detector than at the field

detector. As with the October 2024 data, this variation was lowest at Field D29, although here boundary feature activity levels were still nearly seven times higher than that recorded by the field detector. At Field D28 boundary activity was over 14 times higher than that recorded by the field detector, with this largely due to the high levels of common pipistrelle activity recorded by the boundary detector.

- 4.4.20. Across all species, the highest levels of bat activity in May 2025 were recorded by the boundary detector at Field D28 (239.78 MPRH) while the next highest level of activity was recorded from the boundary detector at Field D29 at 102.24 MPRH, representing a notable increase in total activity levels across both locations, compared to that recorded for these locations in October 2024. Similarly, although activity levels within the fields were lower than on the boundary features in both locations during May 2025, field activity levels were consistently higher in May 2025 than any field activity levels recorded during October 2024.

Statistical analysis

- 4.4.21. **Table 7** presents the p-values that have been calculated from performing the Wilcoxon Rank-Sum test on the total number of registrations recorded at the boundary and field detectors at a given location for a given species/ species group over a given survey period.
- 4.4.22. Where the p-value is less than 0.05, this indicates that there is a statistically significant difference between recorded activity levels on the boundary feature and in the field, since the probability of the results being due to chance is less than 5%. Statistically significant results are indicated in bold red text in **Table 7** below.

Table 7. p-values derived from comparing total registrations recorded on boundary features and in fields by survey period, location and species/species group*.

Survey period	Location	p-value (4.d.p) ⁷			
		Barbastelle	<i>Myotis</i>	All other species	Total bats
October 2024	Field D28	0.0740	0.5597	0.2885	0.2885
October 2024	Field D29	0.0284	0.9338	0.0656	0.0927
October 2024	Field B8	0.0097	0.4984	0.0538	0.0303
May 2025	Field D28	0.0003	0.0004	0.0004	0.0004

⁷ While the rest of the data in this study has been reported to 2.d.p, p-values here have been reported to 4.d.p, to clearly illustrate whether a result indicates a statistically significant variations, as some of the numbers are very low.

Survey period	Location	p-value (4.d.p) ⁷			
		Barbastelle	Myotis	All other species	Total bats
May 2025	Field D29	0.0005	0.0004	0.0004	0.0004

**p-values in bold red text indicate statistically significant differences in activity*

- 4.4.23. The tests identified statistically significant variations in levels of activity between the boundary and field detectors across all species groups and both locations in May 2025.
- 4.4.24. The pattern is less clear in the October 2024 data, with statistically significant variations seen only in barbastelle activity at Field D29 and Field B8 and across the combination of ‘Total bats’ at Field B8. Variations in bat activity at Field D28 were not shown to be statistically significant for any of the species/species groups considered.

Species trends between months

Barbastelle activity

- 4.4.25. As illustrated in **Plate 1**, barbastelle activity showed a relatively consistent pattern of activity, with no barbastelle activity recorded from field detectors on three of the five deployments, while boundary detectors recorded barbastelle activity on all occasions.
- 4.4.26. The variations illustrated in **Plate 1** represent statistically greater levels of recorded activity at boundary detectors, compared to field detectors, on all but one occasion, indicating a general pattern of greater reliance on the boundary features and very limited use of the open field areas, across both survey periods.
- 4.4.27. Despite the apparent variation at Field D28 in October 2024, a statistically significant variation was not found due to the way barbastelle activity was distributed throughout the survey period⁸.

⁸ The boundary detector at Field D28 in October 2024 recorded 153 barbastelle registrations, compared to the 0 barbastelle registrations recorded by the paired field detector. However, 121 of the boundary registrations were from a single night, while across four of the remaining five nights the variations between the two detectors did not exceed one registration. Therefore, on most nights variations observed between the two detectors were of insufficient scale to enable a statistically significant difference to be identified.

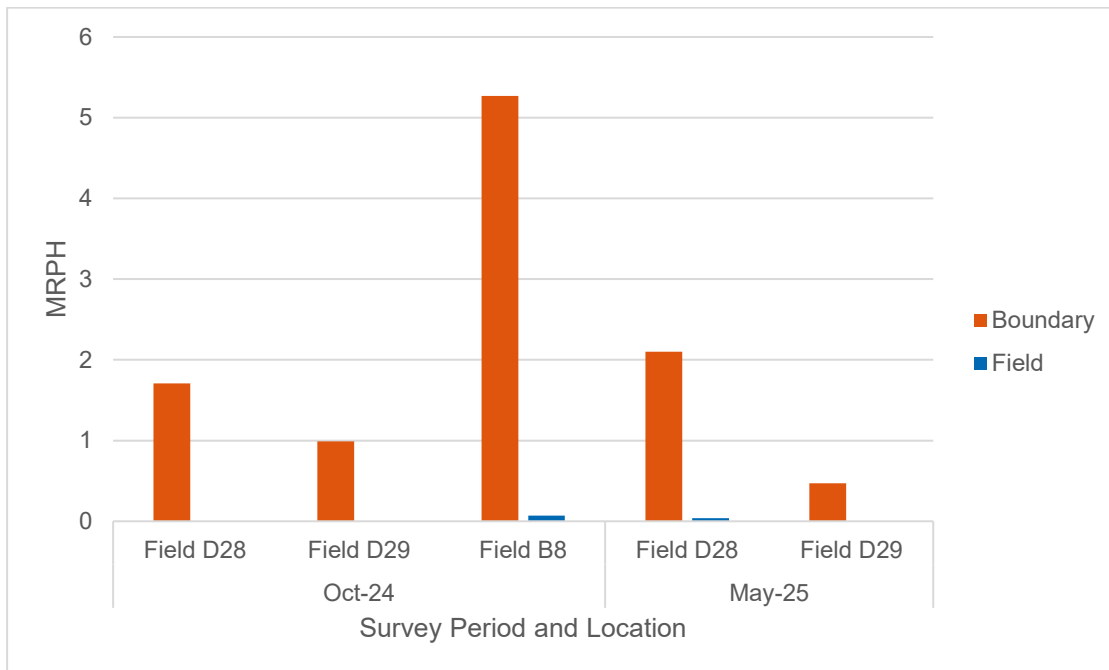


Plate 1. MRPH for barbastelle at boundary and field detectors during each survey period at each location.

- 4.4.28. As illustrated in **Plate 1**, barbastelle activity peaked at Field B8 in October 2024 (5.27 MRPH); however, due to access restrictions it is not possible to determine whether a similar peak in barbastelle activity occurred here during the May 2025 survey period. For the two locations monitored in both survey periods, activity levels were relatively consistent.
- 4.4.29. As shown on **Plate 13, Plate 14, Plate 15, Plate 17, and Plate 19** in **Appendix H**, at the boundary detectors, the first barbastelle activity was consistently recorded between 30 minutes and 1 hour after sunset across all detectors and both survey periods, with the timing of peak activity on boundary detectors often reflected sustained period(s) of activity.
- 4.4.30. In October 2024 this period of activity was normally distinct from the period of first activity and typically occurred slightly later in the night (i.e. approximately 4.5 hours after sunset) than in May 2025, where the periods of greatest activity often occurred directly following the first barbastelle recordings (i.e. approximately 1 to 2 hours after sunset).
- 4.4.31. The timing of first barbastelle activity on field detectors was slightly later, at 1.5 hours after sunset and never exceeded more than 2 registrations in any 15-minute period (see **Plate 16** and **Plate 18** in **Appendix H**).

Myotis activity

- 4.4.32. As illustrated in **Plate 2**, *Myotis* demonstrated clear variations in the activity levels recorded by boundary detectors between the October 2024

and May 2025 survey periods. However, this pattern is not reflected in activity levels recorded by the field detectors, where consistently very low levels of *Myotis* activity was recorded across both survey periods.

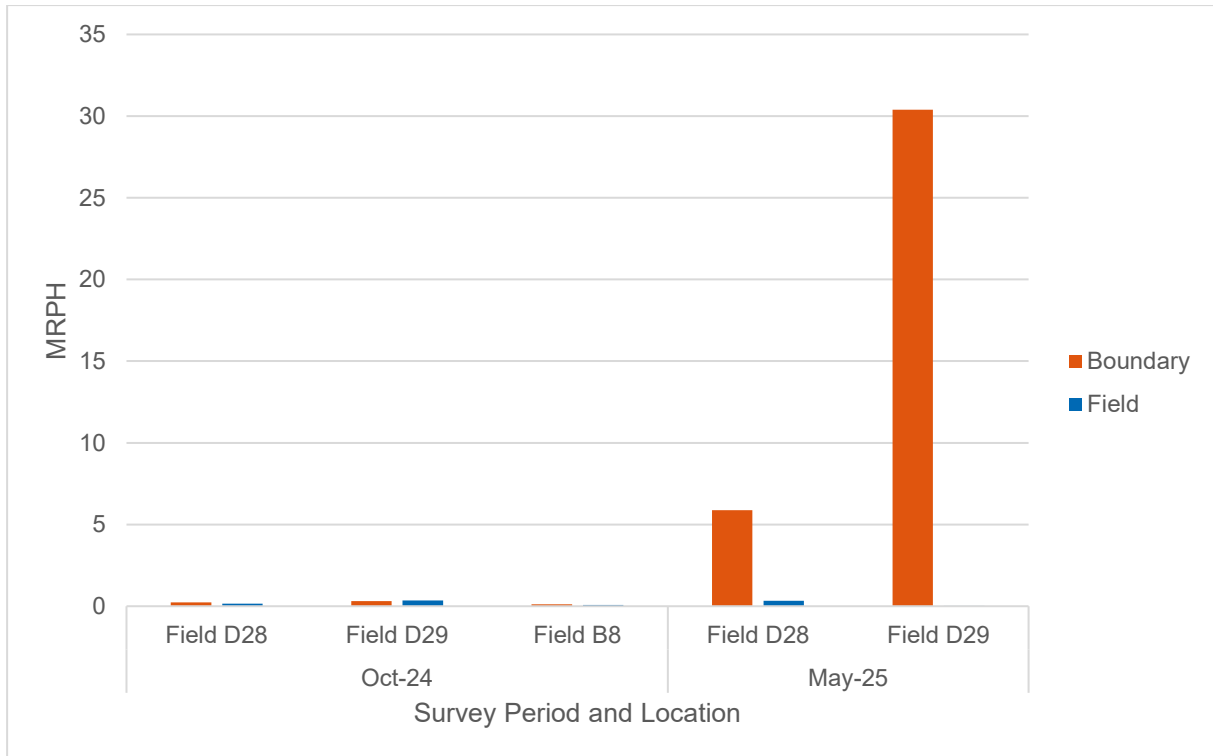


Plate 2. MRPB for *Myotis* at boundary and field detectors during each survey period at each location.

'All other species' activity

- 4.4.33. As illustrated in **Plate 3**, levels of 'All other species' activity followed a similar pattern to that observed for *Myotis*, with the number of registrations recorded from boundary detectors notably increasing in May 2025 relative to October 2024. The field detectors also recorded higher levels of activity, on average, in May 2025 compared to October 2024, although this was far less notable in scale.

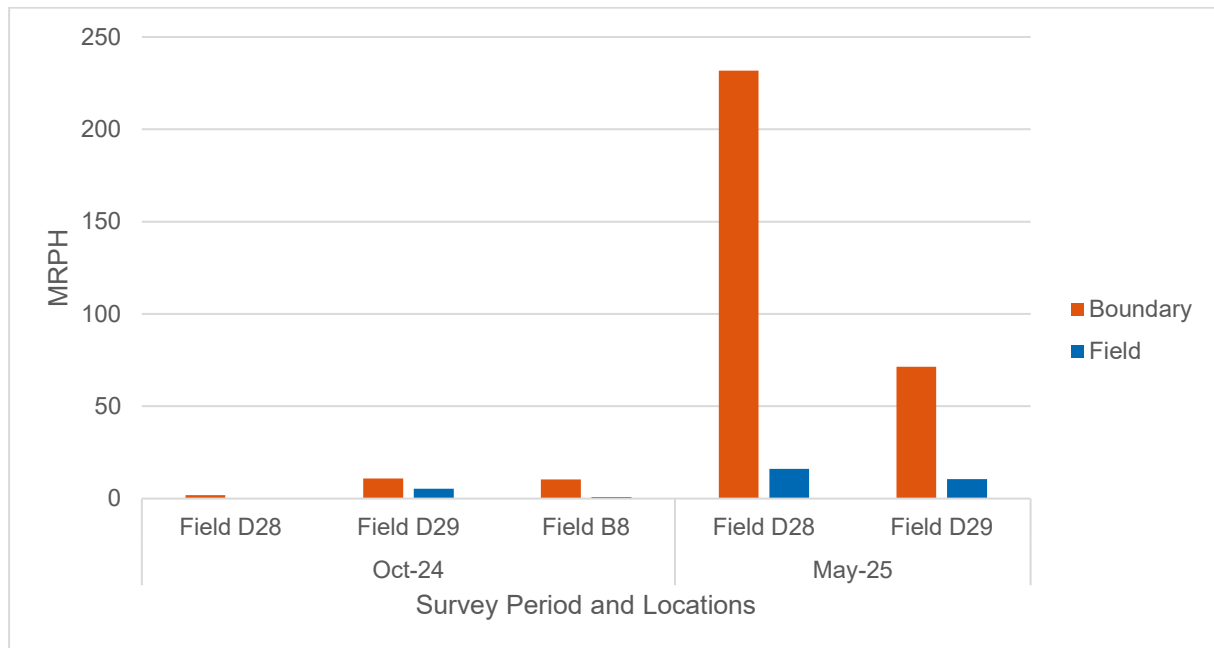


Plate 3. MRPH for 'All other species' at boundary and field detectors during each survey period at each location.

Total bat activity

4.4.34. As shown in **Plate 4**, patterns in levels of 'Total bat' activity, which comprises all species recorded across the Site, reflect the same broad patterns seen for *Myotis* and the 'All other species' group.

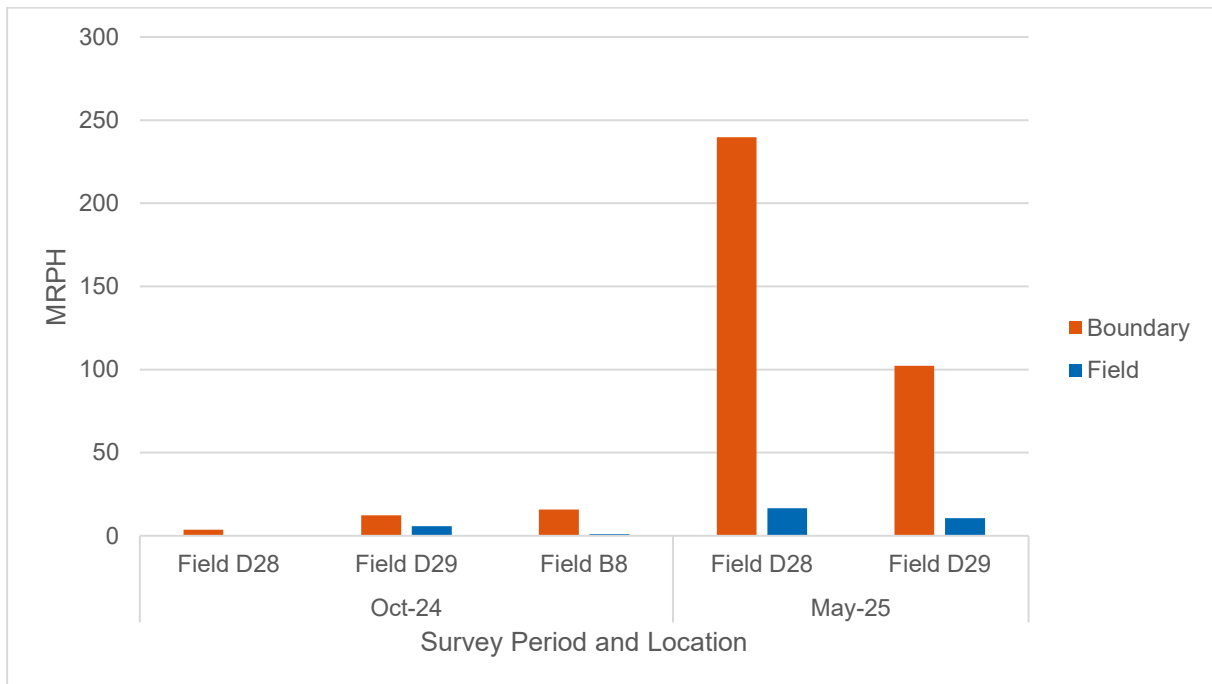


Plate 4. MRPH for ‘Total bats’ at boundary and field detectors during each survey period at each location.

Comparing grazed and arable areas – October 2024

- 4.4.35. Although not an aim of this study, the selection of sites included two locations where the field comprised arable land (Field D28 and Field D29) and one location where the field comprised non-organic cattle-grazed grassland (Field B8). Queries have subsequently been raised about variations that may occur between open fields that are subject to different uses and management activities (i.e. arable versus grazed).
- 4.4.36. For several reasons, the current study is unable to answer this later question: the data has been drawn from three paired samples, and the grazed field at Field B8 could only be surveyed in October 2024 when bat activity is typically lower. In addition, information on the last date of grazing within Field B8 was not available and, as such, the October 2024 data may not usefully represent a comparison of a recently grazed grassland to an arable field⁹.

⁹ Further investigation of this question would require a much larger and longer-term study given the inherent variability of bat activity in and around the Bernwood area. It would also require detailed records of where and when animals had grazed, so could not be applied retrospectively to existing data. There would also be significant health, safety and welfare issues to overcome.

4.4.37. For illustrative purposes only, **Plate 5** below illustrates the results of the October 2024 field detector data across the three locations surveyed, noting the different field types.

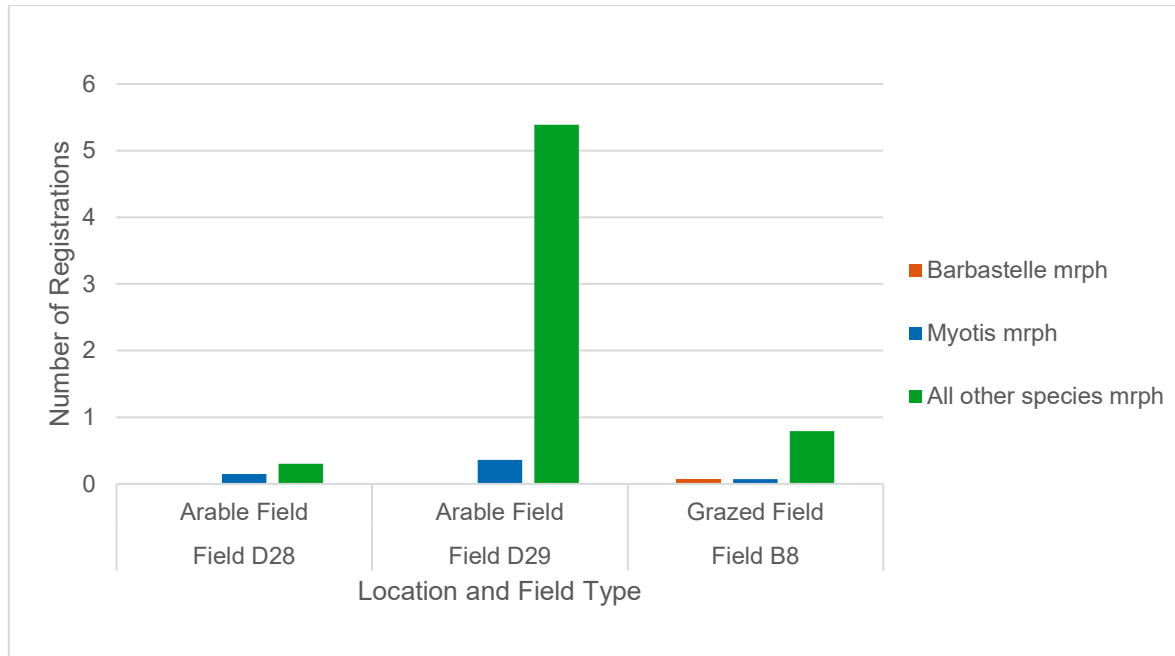


Plate 5. MRPH for barbastelle, *Myotis*. and ‘All other species’ from field detectors in October 2024 separated into arable and grazed fields.

4.5. Discussion

Barbastelle

- 4.5.1. The level of consistency seen in barbastelle activity between the two survey periods (October 2024 and May 2025) suggests that notable variations in how barbastelle use the surveyed areas of the site throughout the year are unlikely to occur.
- 4.5.2. The timing of barbastelle activity at the boundary detectors reflects the presence of known barbastelle roosts within the landscape and reported average emergence timings for barbastelle (24 minutes after sunset [Ref 29]). Furthermore, the sustained periods of activity indicated by the timings of peak activity are potentially indicative of foraging along these boundary features.
- 4.5.3. At the field detectors, however, the consistently low levels of barbastelle activity indicate that barbastelle activity within the fields is unlikely to represent foraging activity and instead is considered most likely to indicate individual or small numbers of barbastelle commuting through these open areas.

- 4.5.4. The MRPH recorded in 2024 and 2025 might appear, superficially, to indicate an increase in the levels of barbastelle activity when considered against the barbastelle activity levels recorded in 2022 and 2023, where the closest survey locations to those used in 2024 / 2025 did not record barbastelle activity in excess of 0.65 on any occasion¹⁰.
- 4.5.5. However, each recording made in 2022/2023 reflects a 15-second period, while recordings made in 2024/2025 each reflect a 5-second period. As detailed in **Paragraph 4.3.36** above, this therefore means that the two datasets cannot be directly compared as there is the potential for data in 2024/2025 to identify up to three times more 'activity' than the same duration of data recorded in 2022/2023. Applying this to the 0.65 MRPH recorded in 2022/2023 means a comparable level of activity in 2024/2025 could, theoretically, be as high as 1.95 MRPH, similar to the activity levels recorded for barbastelle in 2024/2025. Furthermore, variations in the timing of surveys (in relation to the bats' life cycle) and analysis method may also contribute to variations in activity levels.

Myotis

- 4.5.6. The clear variations in activity levels recorded on the boundary detectors in October 2024 compared to May 2025 are considered to indicate likely variations in how these parts of the Site are used by the genus during different periods of their annual lifecycle, with potentially less reliance evidenced during the late mating and early hibernation periods.
- 4.5.7. The absence of a similar pattern from the field detectors, where activity levels for *Myotis* remained consistently very low suggests that these open field areas do not form an important resource for *Myotis* bats at either surveyed time of year.
- 4.5.8. The absence of any statistically significant variation in *Myotis* activity during the October 2024 survey period is expected given the very low levels of activity recorded across both boundary and field detectors. Meanwhile, the statistically greater levels of *Myotis* activity recorded by boundary detectors, relative to field detectors, for both locations surveyed in May 2025, demonstrates that where significant variations do occur, they indicate greater use of boundary features than areas of open habitat.

¹⁰ Based on the detector at Parcel 1 West B being the closest 2022 / 2023 survey location to Field D28 (380m to the north west) and Field D29 (340m to the north-east) and recording a peak of 0.32 MRPH in August 2023 (comprising 0.1 MRPH for confirmed barbastelle identifications and 0.12 MRPH for possible barbastelle identifications) and the detector at Parcel 2 South-west A being the closest 2022 / 2023 survey location to Field B8 (200m to the east) and recording a peak of 0.65 MRPH in August 2023 (comprising 0.37MRPH for confirmed barbastelle identifications and 0.28 MRPH for possible barbastelle identifications).

'All other species'

- 4.5.9. The increase in 'All other species' activity at the boundary detectors in May 2025 compared to October 2024 indicates likely variations in how these boundary features are used, by at least some of the species within this group, during the different periods of their annual lifecycle.
- 4.5.10. It should be noted that the 'All other species' category comprises a diverse range of seven bat species, with some species recording such low levels of activity that, if they were to be considered independently, the data would be unsuitable for statistical analysis (e.g. Leisler's bat or Nathusius' pipistrelle in October 2024). Meanwhile some species recorded levels of activity that were considerably higher than other species within this group and these results will have disproportionately influenced the resulting statistical analyses. This is particularly the case for common pipistrelle activity on the boundary at both locations surveyed in May 2025 (16,770 registrations at Field D28 and 4,310 registrations at Field D29). It is the inclusion of this activity that is likely to have resulted in the statistically significant differences identified for the 'All other species' group in May 2025.

Total bat activity

- 4.5.11. As discussed above in relation to the 'All other species' group, much of the variation seen from the boundary detectors in locations surveyed in May 2025 is as a result of high levels of common pipistrelle activity, with this activity likely to be driving the scale of statistical significance seen for both locations surveyed in May 2025. However, the statistically significant result recorded for Total bat activity at Field B8 in October 2024 is likely to have been driven not by common pipistrelle activity levels (128 registrations) but in this case by soprano pipistrelle (792) and barbastelle (472) registrations.

Comparing grazed and arable areas – October 2024

- 4.5.12. There is no indication from the data collected that the grazed field was used more than the arable fields, or at a level that suggested it provided additional value compared to its boundary feature. One potential factor in the absence of such a trend may be that the Site is grazed by a conventional, and not an organic cattle herd.
- 4.5.13. It should, however, be noted that, in line with the limitations detailed above, these results are illustrative only and are not statistically testable.

4.6. Proposed Development implications

- 4.6.1. The Proposed Development has been designed such that woodlands will be retained with a 30m buffer to the development and the majority of

hedgerows and other boundary features within the Site will be retained, with a buffer of between 10 and 15m to the development created on either side of these features.

- 4.6.2. These buffer zones have been designed to maintain connectivity throughout the Site and minimise the risk of displacing commuting bats. The resulting buffers will be wider than the distance over which the echolocation calls of Bechstein's bat are likely to operate, giving some indication that these buffers should be adequate/effective.
- 4.6.3. In addition to the buffers around boundary features, which this study has shown are likely to be used by at least some bat species for foraging as well as commuting, there will be a 5m wide area located between the security fence and first set of panels. This area will be sown to meadow grassland and not subject to intensive management. Indeed, these areas may be managed through light sheep grazing where achievable, providing additional width to the commuting buffers and potentially offering foraging opportunities.
- 4.6.4. Where statistically significant differences have been identified, these relate to greater activity along the boundary features. Notably, the field detectors activity levels exceeded 1 MRPB on only three occasions^{11,12}, indicating that the open field areas are unlikely to currently provide an important or regularly used landscape feature for any of the bat species recorded.
- 4.6.5. The data collected therefore suggests that the focus of mitigation measures on retaining and buffering boundary features should be effective in enabling key landscape features to remain available, and suitable, for a range of bat species.
- 4.6.6. This is particularly notable for barbastelle where all but one of the paired static deployments showed statistically higher levels of activity at the boundary detector compared to the field detector. Meanwhile, barbastelle field activity levels were consistently below 0.5 MRPB, indicating that the open areas surveyed were unlikely to provide an important foraging resource for barbastelle in their current form.
- 4.6.7. The focus of bat activity on boundary features relative to open fields shown by much of the data collected in this study also reflects the fact that, for most fields under current management across the Site, the invertebrate biomass will be relatively low due to standard agricultural practices, so it is unlikely that the land adjacent to most existing boundary

¹¹ Considering barbastelle, *Myotis*, and 'All other species' results ('Total bat' results are not included in this statement to prevent duplication).

¹² All three occasions where MRPB exceeded 1 related to the 'All other species' results (Field D29 in October 2024 (5.39 MRPB) and May 2025 (10.15 MRPB) and Field D28 in May 2025 (16.15 MRPB)).

features, such as hedgerows, offers a hugely valuable resource at present. In other words, their value is the boundary feature structure and connections to the wider landscape, which are being retained.

- 4.6.8. With regards to Bechstein's bat, a bat of material consideration for this project and analysed here as part of the *Myotis* genus, this species is typically viewed as a bat of wooded environments, primarily roosting in deciduous semi-natural or ancient woodlands [Ref. 30], and foraging in mature broadleaved woodland [Ref. 31]. In line with this pattern of activity approximately 60% of the species Bechstein's bat prey on are associated with trees and shrubs [Ref. 32]. This is reflected in the statistically significant results for May 2025 which found higher levels of activity at the boundary detector and that *Myotis* activity levels within the fields did not exceed 0.4 MRPH any point in the surveys undertaken.
- 4.6.9. As such, while there is evidence to suggest that some Bechstein's bats forage in open fields [Ref. 33], with 32% of the herbivorous species that Bechstein's bats prey on found to be associated with grasses and flowering plants [Ref. 32], the results of this (limited) study do not provide any evidence to show that the open field areas surveyed are likely to provide an important foraging resource for bats of the *Myotis* genus, including Bechstein's bat, at present.
- 4.6.10. However, it is recognised that Bechstein's bat can be under-recorded¹³, and measures to ensure sufficient open habitat of value would be available for them, and other bat species, have been incorporated into the development design. Specifically, the grassland habitat that is being removed will be replaced by more than twice as much grassland of greater value, at a landscape-scale within the core sustenance zone of Bechstein's bat. Mitigation of the loss of foraging resource is therefore not solely dependent on the provision of buffer zones around boundary features. Much of this mitigation is to be provided between Runts Wood and Finemere Wood, which is close to a number of identified Bechstein's roosts.
- 4.6.11. In relation to questions regarding how bat activity may vary within open field areas depending on the use and management of the field, there is insufficient data available from this study to draw any conclusions¹⁴.

¹³ Although the assumption made in this report that any or all of the *Myotis* registrations could be Bechstein's bat is considered to offset this risk to a degree

¹⁴ Further investigation of this question would require a much larger and longer-term study given the inherent variability of bat activity in and around the Bernwood area. It would also require detailed records of where and when animals had grazed, so could not be applied retrospectively to existing data. There would also be significant health, safety and welfare issues to overcome.

5. References

- Ref. 1:** Reason, P.F. and Wray, S. (2025). UK Bat Mitigation Guidelines: a guide to impact assessment, mitigation and compensation for developments affecting bats. Version 1.2. Chartered Institute of Ecology and Environmental Management, Ampfield.
- Ref. 2:** Luo, J., Clarin, B.-M., Borissov, I.M. & Siemers, B.M. (2013) Are torpid bats immune to anthropogenic noise? *Journal of Experimental Biology*. jeb.092890. doi:10.1242/jeb.092890.
- Ref. 3:** Reason, P. and Bentley, C. (2020). Noise impacts on bats - a sound assessment? *In Practice - Bulletin of the Chartered Institute of Ecology and Environmental Management*, 108: 15-18. Available [here](#).
- Ref. 4:** Szabadi K. L., Kurali A., Rahman N.A.A., Froidevaux J.S.P., Tinsley E., Jones G., Gorfol T., Estock P. and Zsebok S. (2023). The use of solar farms by bats in mosaic landscapes: Implications for conservation. *Global Ecology and Conservation*. 44.
- Ref. 5:** Morelock, S. and Carter, R. (2024). Cattle Rotational Grazing Effects on Bat Activity in Southern Appalachia
- Ref. 6:** Downs, N.C., and Sanderson, L.J. (2010). Do Bats Forage Over Cattle Dung or Over Cattle?. *Acta Chiroperologica*. 349-358. <https://doi.org/10.3161/150811010X537936>
- Ref. 7:** Anderson, M., Norton, L. and Mathews, F. (2020). Grassland management affects vegetation structure, bats and their beetle prey. *Diversity*, 12(10), p.406.
- Ref. 8:** Ancillotto, L., Ariano, A., Nardone, V., Budinski, I., Rydell, J. and Russo, D. (2017). Effects of free-ranging cattle and landscape complexity on bat foraging: implications for bat conservation and livestock management. *Agriculture, Ecosystems & Environment*, 241, pp.54-61.
- Ref. 9:** Davies, L. (1957). A study of the blackfly, *Simulium ornatum* Mg.(Diptera), with particular reference to its activity on grazing cattle. *Bulletin of entomological Research*, 48(2), pp.407-424.
- Ref. 10:** Steelman CD. (1976). Effects of external and internal arthropod parasites on domestic livestock production. *Annu Rev Entomol*. 1976;21:155-78. doi: 10.1146/annurev.en.21.010176.001103. PMID: 2093.
- Ref. 11:** Piñero, F.S. and Avila, J.M. (2004). Dung-insect community composition in arid zones of south-eastern Spain. *Journal of Arid Environments*, 56(2), pp.303-327.
- Ref. 12:** Clare, E.L., Barber, B.R., Sweeney, B.W., Hebert, P.D.N. and Fenton, M.B. (2011). Eating local: influences of habitat on the diet of little brown bats (*Myotis lucifugus*). *Molecular Ecology*, 20(8), pp.1772-1780.
- Ref. 13:** Brack Jr, V. and LaVal, R.K. (2006). Diet of the gray myotis (*Myotis grisescens*): variability and consistency, opportunism, and selectivity. *Journal of Mammalogy*, 87(1), pp.7-18.

- Ref. 14:** Vaughan, N. (1997). The diets of British bats (*Chiroptera*). Mammal review, 27(2), pp.77-94.
- Ref. 15:** Graclik, A. and Wasielewski, O. (2012). Diet composition of *Myotis myotis* (*Chiroptera, Vespertilionidae*) in western Poland: results of fecal analyses. Turkish Journal of Zoology, 36(2), pp.209-213.
- Ref. 16:** PP, L. (1985). Flies (*Diptera*) developing in sheep droppings in Hungary. Acta Zoologica Academiae Scientiarum Hungaricae, 31(4), pp.367-379
- Ref. 17:** Correa, C.M.D.A., Puker, A., Korasaki, V. and Oliveira, N.G.D. (2013). Dung beetles (*Coleoptera, Scarabaeinae*) attracted to sheep dung in exotic pastures. Revista Brasileira de Entomologia, 57, pp.113-116.
- Ref. 18:** Errouissi, F., Haloti, S., Jay-Robert, P., Janati-Idrissi, A. and Lumaret, J.P. (2004). Effects of the attractiveness for dung beetles of dung pat origin and size along a climatic gradient. Environmental Entomology, 33(1), pp.45-53.
- Ref. 19:** Papp, L. (1993). Flies (*Diptera*) on and in pasture dung in Hungary: a further contribution. Folia Entomologica Hungarica, 54, pp.107-114. Skidmore, P., 1991. Insects of the British cow-dung community (pp. 166-pp).
- Ref. 20:** Wickramasinghe, L.P., Harris, S., Jones, G. and Vaughan, N. (2003). Bat activity and species richness on organic and conventional farms: impact of agricultural intensification. Journal of Applied ecology, 40(6), pp.984-993.).
- Ref. 21:** Hutton, S.A. and Giller, P.S. (2003). The effects of the intensification of agriculture on northern temperate dung beetle communities. Journal of applied ecology, 40(6), pp.994-1007.
- Ref. 22:** Lumaret, J.P. and Kirk, A. (1987). Ecology of dung beetles in the French Mediterranean region (*Coleoptera: Scarabaeidea*). Acta Zoologica mexicana (ns), (24), pp.1-55.
- Ref. 23:** Martín-Piera, F. and Lobo, J.M. (1996). A comparative discussion of trophic preferences in dung beetle communities. Miscel·lània Zoològica, pp.13-31.
- Ref. 24:** Wassmer, T. (1995). Selection of the spatial habitat of coprophagous beetles in the Kaiserstuhl area near Freiburg (SW-Germany). Acta (Ecologica, 1995, 16 (4), 461, p.478.
- Ref. 25:** Correa, C.M., Peres, N.D. and Holdbrook, R. (2020). Patterns of alimentary resource use by dung beetles in introduced Brazilian pastures: Cattle versus sheep dung. Entomological Science, 23(3), pp.271-279.
- Ref. 26:** Blary, C., Kerbiriou, C., Le Viol, I and Barré, K. (2021). Assessing the importance of field margins for bat species and communities in intensive agricultural landscapes. Agriculture, Ecosystem and Environment. 319. <https://doi.org/10.1016/j.agee.2021.107494>
- Ref. 27:** Finch, D., Schofield, H and Mathews, F. (2020). Habitat Associations of Bats in an Agricultural Landscape: Linear Features Versus Open Habitats. Animals, 10(10), 1856. <https://doi.org/10.3390/ani10101856>

Ref. 28: Collins, J. (2023). Bat Surveys for Professional Ecologists: Good Practice Guidelines (4th edition). The Bat Conservation Trust, London.

Ref. 29: Zeale, M., Davidson-Watts I., and Jones, G. (2012). Home range use and habitat selection by barbastelle bats (*Barbastella barbastellus*): implications for conservation. *Journal of Mammalogy* 93(4): 1110-1118. <https://doi.org/10.1644/11-MAMM-A-366.1>

Ref. 30: Dietz, M and Pir, J. (2011). Distribution, Ecology and Habitat Selection by Bechstein's Bat (*Myotis bechsteinii*) in Luxembourg. *Ökologie der Säugetiere*. 6 <https://doi.org/10.13140/2.1.4985.8562>

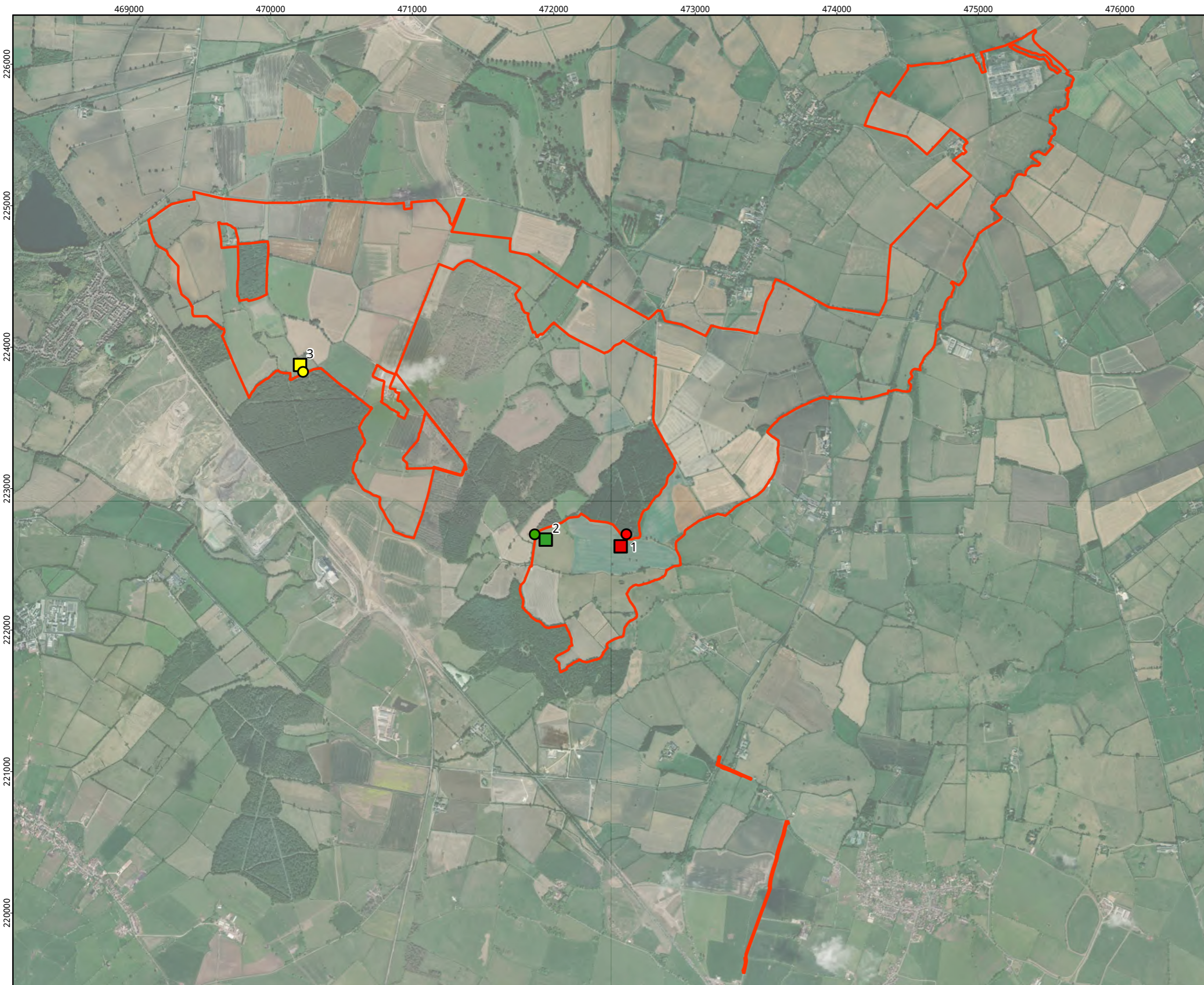
Ref. 31: Scofield, H. and Morris, C. (2000). Ranging behaviour and habitat preferences of female Bechstein's bat, *Myotis bechsteinii* (Kuhl, 1818)

Ref. 32: Andrews H & McGill J (2022). Account of Bat Prey Species Associations (BPSA) for bats resident in the British Isles – 2022. AECOL – Andrews Ecology, Barnstaple. Available online: [AECOL-2022-BAT-PREY-SPECIES-ASSOCIATIONS-v2-25th-August.pdf](#)

Ref. 33: Wright, P. (2018). Monitoring population size, structure and change in Bechstein's bat (*Myotis bechsteinii*): combined approaches using molecular and landscape ecology. Available online: <https://www.proquest.com/openview/1274d38b84eba1cb628cfaa04232ff9c/1?cbl=51922&diss=y&pq-origsite=gscholar> (Accessed April 2025).

Figures





LEGEND:

- Order Limits
- Bat Static Detector Location**
- 1: Field D28 (field)
- 1: Field D28 (hedgerow)
- 2: Field D29 (field)
- 2: Field D29 (hedgerow)
- 3: Field B8 (field)
- 3: Field B8 (hedgerow)

Coordinate System: British National Grid
 Projection: Transverse Mercator
 Datum: OS GB 1936
 Units: Meter



02	04/03/2026	Deadline one	TG	RJ	PT
Rev	Date	Description	Drn	Chk	App

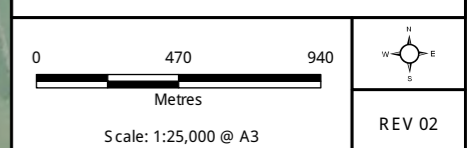
Rosefield Solar Farm



DOCUMENT:
 Rosefield Solar Farm Bat Technical Study

TITLE:
 Site and Static Detector Locations

FIGURE NUMBER:
 1



Appendix A

Ultrasonic Noise Monitoring Burwell
Solar Farm





ULTRASONIC NOISE MONITORING

BURWELL SOLAR FARM

EDF Renewables
2061760-RSKA-RP-001-(01)



General notes

Project Name:	Burwell Solar Farm
Title:	Ultrasonic Noise Monitoring
Client:	EDF Renewables
Issue Date:	23 July 2025
Report No.	2061760-RSKA-RP-001-(01)

Revision:	Description:	Author(s):	Reviewer:	Date:
01	First Issue	Mark Underhill	Matthew Thomson	23 July 2025

Author(s): Mark Underhill

Technical reviewer:

Matthew Thomson

Signature:

[Redacted Signature]

Signature:

[Redacted Signature]

Date: 23 July 2025

Date:

23 July 2025



Contents

1	Introduction	4
2	Noise Monitoring Methodology	5
2.1	General Procedure	5
2.2	PV Equipment.....	5
2.3	Measurement Locations	5
2.5	Measurement Periods.....	8
2.6	Noise Monitoring Equipment.....	8
2.7	Weather Conditions	8
3	Results – String Inverter, Daytime (Round 1)	9
3.1	Graphical outputs.....	9
4	Results – String Inverter, Daytime (Round 2)	13
4.1	Graphical outputs.....	13
5	Results – String Inverter, Daytime (Round 3)	17
5.1	Graphical outputs.....	17
6	Results – String Inverter, Twilight (Round 1)	21
6.1	Graphical outputs.....	21
7	Results – String Inverter, Twilight (Round 2)	25
7.1	Graphical outputs.....	25
8	Results – Transformer Station, Daytime (Round 1)	29
8.1	Graphical outputs.....	29
9	Results – Transformer Station, Daytime (Round 2)	33
9.1	Graphical outputs.....	33
10	Results – Transformer Station, Twilight (Round 1)	37
10.1	Graphical outputs.....	37
11	Results – Transformer Station, Twilight (Round 2)	41
11.1	Graphical outputs.....	41
12	Overview of Results.....	45
12.1	String Inverter – Daytime Measurements	45
12.2	String Inverter – Twilight Measurements	45
12.3	Transformer Station – Daytime Measurements	45
12.4	Transformer Station – Twilight Measurements	45
13	Measured Noise Levels – 12.5Hz to 20kHz Range	46
13.1	Overview.....	46
13.2	Surveyor Observations	47
14	Noise Survey Limitations	48
	Appendix A – Glossary.....	49
	Appendix B – Windshield Comparative Measurements	50



1 Introduction

For proposed solar developments, there may be a requirement to establish the impact of noise emitting infrastructure on bat activity and bat roost sites in the surrounding area. There is currently insufficient published data for the proposed infrastructure to inform the noise assessment for bats, and as a result, EDF Renewables (EDF) instructed RSK Acoustics to carry out a series of short-term attended ultrasonic measurements using specialist equipment at one of EDF's existing solar sites at Burwell, near Cambridge.

In terms of noise emitting equipment, the Burwell Solar Farm comprises string inverters and associated transformer stations, but does not include Battery Energy Storage System (BESS) units or central inverters. To obtain ultrasonic noise data for BESS units, it is intended that measurement data will be taken by a third-party consultant at an existing BESS site operated by EDF. On this basis, the BESS survey does not form part of these works.

Noise measurements were taken in accordance with the guidance set out in CIEEM's UK Bat Mitigation Guidelines, and consider a range of setback distances to establish the attenuation with increased distance from the noise emitting equipment.

A glossary of relevant acoustic terminology is provided within Appendix A.



Figure 1: Ultrasonic noise monitoring at Burwell



2 Noise Monitoring Methodology

2.1 General Procedure

A series of short-term attended noise measurements were undertaken on 17/18 July 2025 at an existing EDF solar facility at Burwell, near Cambridge. The monitoring captured the noise emissions generated by a string inverter unit and a transformer station operating at the site.

The noise monitoring was undertaken during both daytime and twilight periods, and comprised a range of horizontal setback distances from the selected item of solar equipment.

Each short-term measurement was undertaken using monitoring equipment capable of collecting data in 1/48-octave frequency bands from 5 kHz up to 80 kHz, following the guidance of CIEEM's UK Bat Mitigation Guidelines Version 1.1, dated December 2023. Given the steady state operation of the units, each measurement was taken over a period of approximately one-minute.

2.2 PV Equipment

The PV equipment that was subject to noise monitoring is defined in Table 1 and shown in Figure 2.

Equipment type	Equipment specification
String inverter	Huawei SUN2000-215KTL-H0 Smart String Inverter
Transformer station	Huawei STS-6000K-H1 Smart Transformer Station

Table 1: Burwell PV equipment subject to noise monitoring



Figure 2: Burwell solar equipment subject to noise monitoring

2.3 Measurement Locations

Given the scale of the Burwell site and the number of noise emitting items of PV equipment across it, it was necessary to carefully consider the string inverter and transformer station that were subject to noise monitoring. The objective of the noise monitoring was to obtain a dataset from an individual unit of each type, with no significant influence from other noise emitting sources in the locality.



Following a review of the Burwell PV development plans, the PV equipment set out in Table 2 were subject to monitoring.

Equipment item	Burwell Equipment Reference	Approximate coordinates	
		Easting	Northing
String inverter	INV 4-1-15-1	557663	267610
Transformer station	STS-4	557708	267675

Table 2: Burwell PV equipment locations

Consecutive ultrasonic noise measurements were taken at a range of horizontal setback distances from the two items of equipment. Noise measurements were taken at 1m, 2m, 3m, 4m, 5m, 7.5m, 10m, 12.5m, 15m, 17.5m, 20m, 22.5m, 25m, 27.5m and 30m from each unit. Throughout all of the setback measurements, a concurrent reference measurement was taken at a distance of 1m from the unit; the purpose of the reference measurement was to establish if noise emissions varied due to a change in operating duty.

For the purposes of this summary report, the results of measurements taken at 5m, 10m, 15m, 20m, 25m and 30m have been presented, together with the corresponding 1m reference levels.

In addition to the ultrasonic noise monitoring, measurements were also taken using a conventional sound level meter located 1m from each unit. The noise emissions in the 12.5 Hz to 20 kHz frequency range were measured throughout the duration of each round of ultrasonic measurements.

The approximate noise monitoring locations are presented in Figure 3.

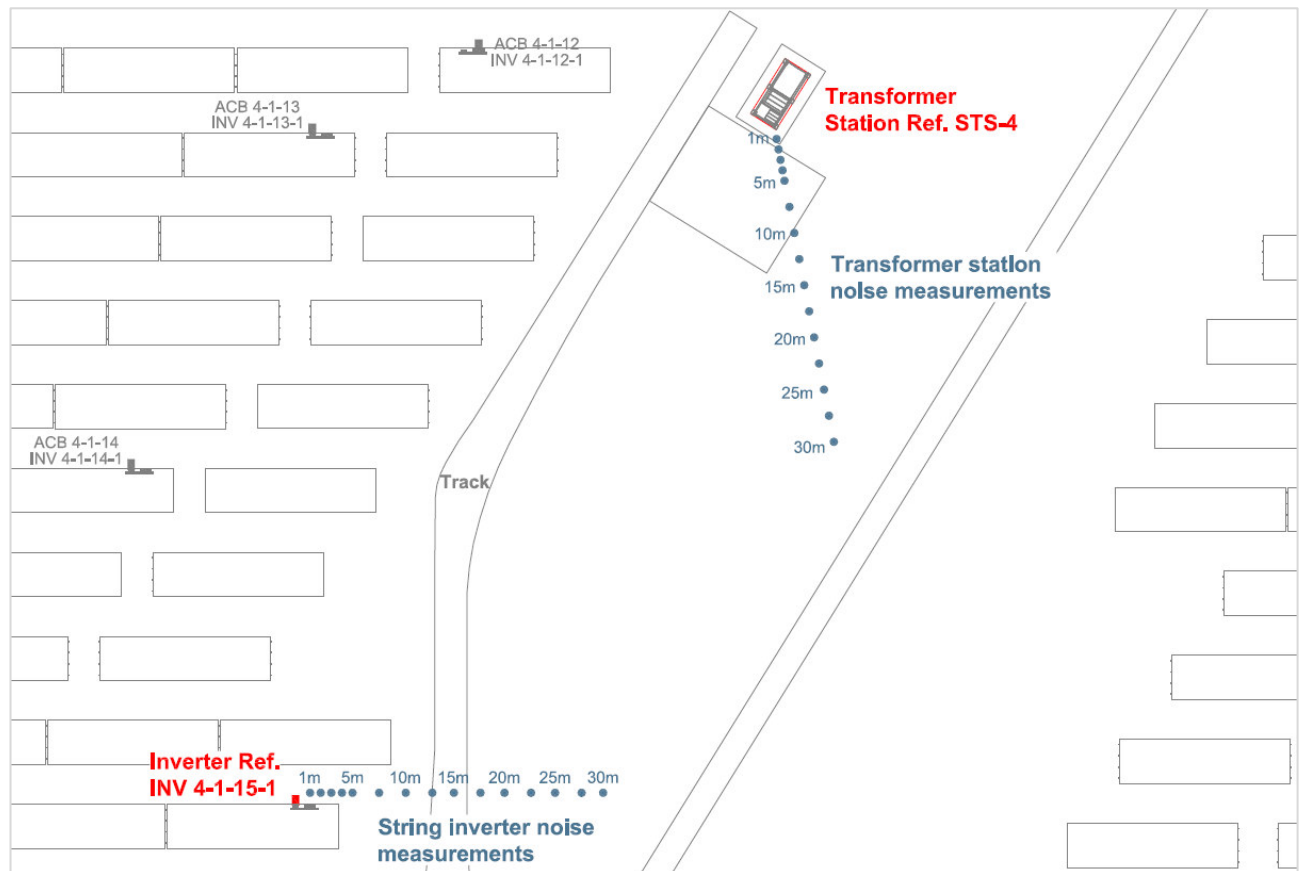


Figure 3: Noise monitoring locations





Figure 4: String inverter monitoring - daytime



Figure 5: Transformer monitoring - daytime



Figure 6: String inverter monitoring - twilight



Figure 7: Transformer monitoring - twilight



2.5 Measurement Periods

Table 3 presents the measurement periods taken for the two items of PV equipment.

Equipment item	Period	Date and time of measurements
String inverter	Daytime	Round 1 – 18/06/2025, 10:55 to 11:37 hrs
		Round 2 – 18/06/2025, 12:24 to 12:57 hrs
		Round 3 – 18/06/2025, 14:01 to 14:24 hrs
	Twilight	Round 1 – 17/06/2025, 22:25 to 22:57 hrs
		Round 2 – 18/06/2025, 00:05 to 00:39 hrs
Transformer station	Daytime	Round 1 – 17/06/2025, 17:29 to 18:11 hrs
		Round 2 – 18/06/2025, 13:07 to 13:36 hrs
	Twilight	Round 1 – 17/06/2025, 21:31 to 22:06 hrs
		Round 2 – 17/06/2025, 23:07 to 23:46 hrs

Table 3: Measurement periods

2.6 Noise Monitoring Equipment

The noise measurements were undertaken using the following equipment.

Equipment	Instrument	Serial Number	Calibration date
Sound level meter (Ultrasonic)	SINUS Apollo 4-channel analyser	7555	07/09/2023
	MM310 microphone	1177	14/05/2025
	MM310 microphone	1178	14/05/2025
Sound level meter (Conventional)	Rion NL-52	464742	31/03/2025
Calibrator	Rion NC-75	34524164	05/09/2024

Table 4: Noise monitoring equipment

The equipment used has a calibration history that is traceable to a certified calibration institution. Calibration certificates are available on request. The calibration of the sound level meters was field checked prior to commencing measurements and upon completion; no significant calibration drift was observed. To minimise wind induced noise, the MM310 microphones incorporated a 70mm diameter windshield.

2.7 Weather Conditions

During the daytime periods, the weather conditions were sunny with scattered clouds and low wind speeds of varying direction. There was no precipitation. During the twilight periods, there was generally clear skies and very low wind speeds.



3 Results – String Inverter, Daytime (Round 1)

3.1 Graphical outputs

The following graphical outputs are provided for the first round of daytime string inverter measurements:

- Figure 8: String inverter, daytime measurement (Round 1), 5m setback
- Figure 9: String inverter, daytime measurement (Round 1), 10m setback
- Figure 10: String inverter, daytime measurement (Round 1), 15m setback
- Figure 11: String inverter, daytime measurement (Round 1), 20m setback
- Figure 12: String inverter, daytime measurement (Round 1), 25m setback
- Figure 13: String inverter, daytime measurement (Round 1), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



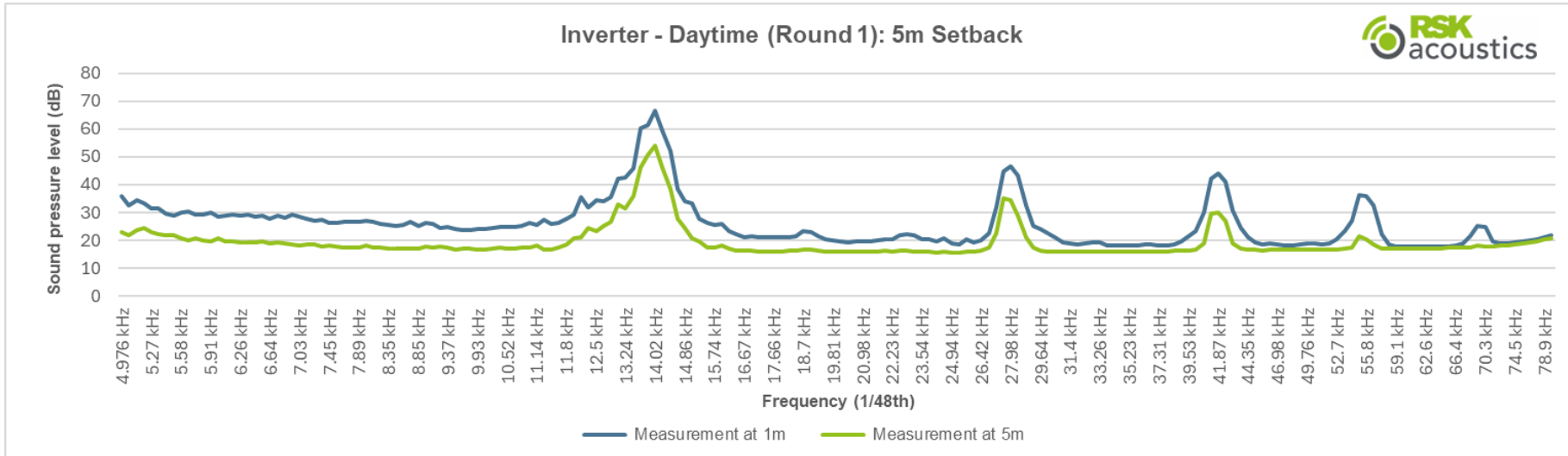


Figure 8: String inverter, daytime measurement (Round 1), 5m setback

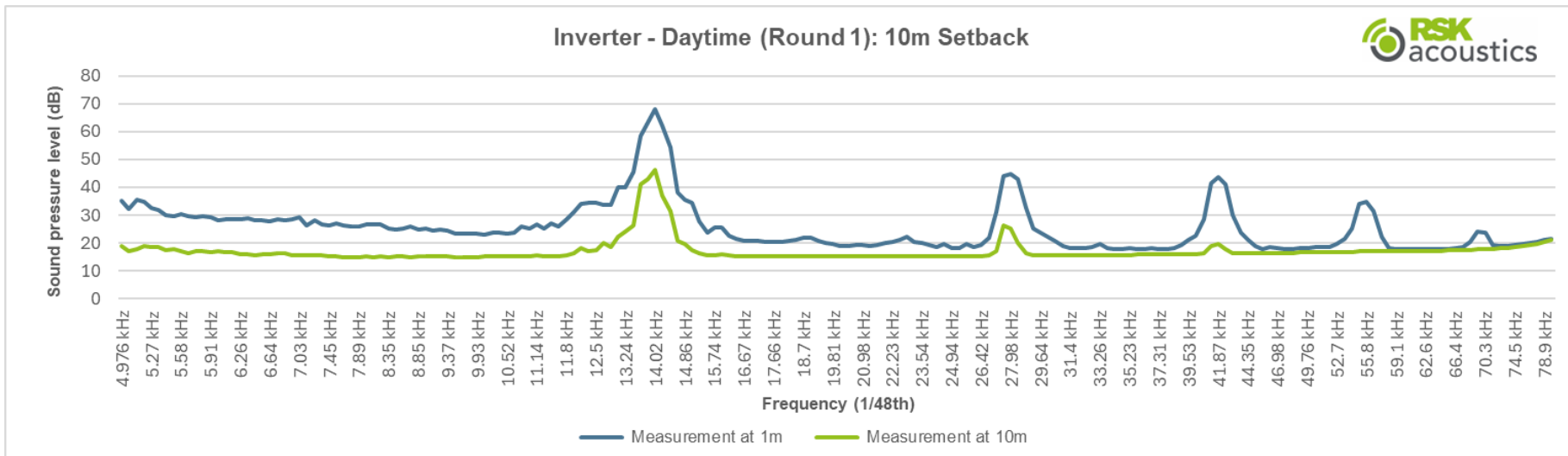


Figure 9: String inverter, daytime measurement (Round 1), 10m setback



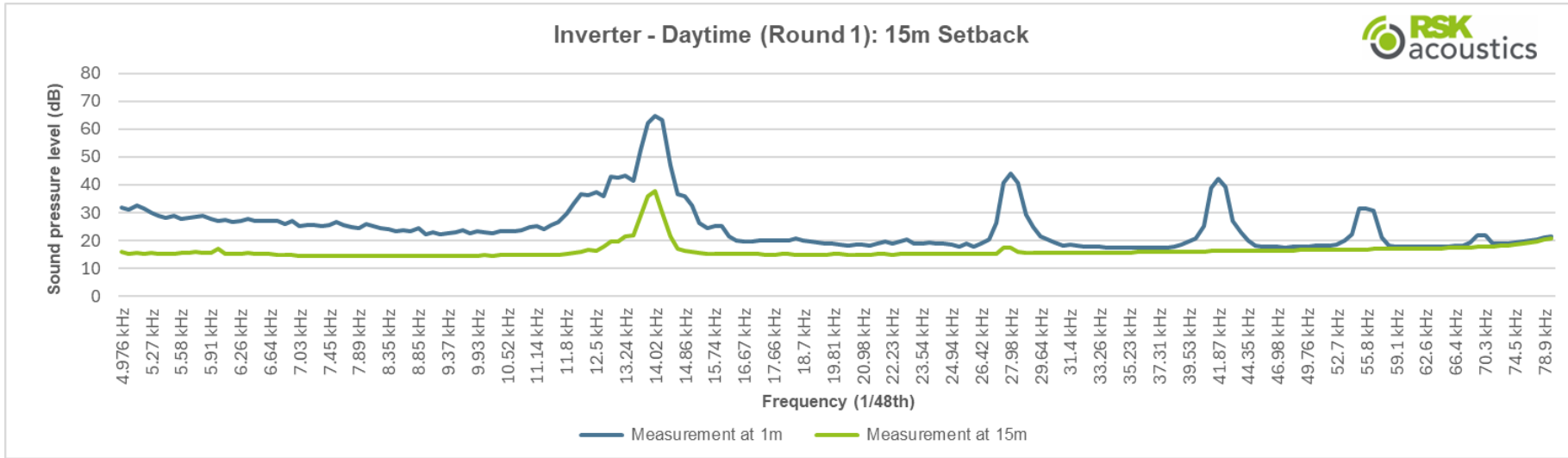


Figure 10: String inverter, daytime measurement (Round 1), 15m setback

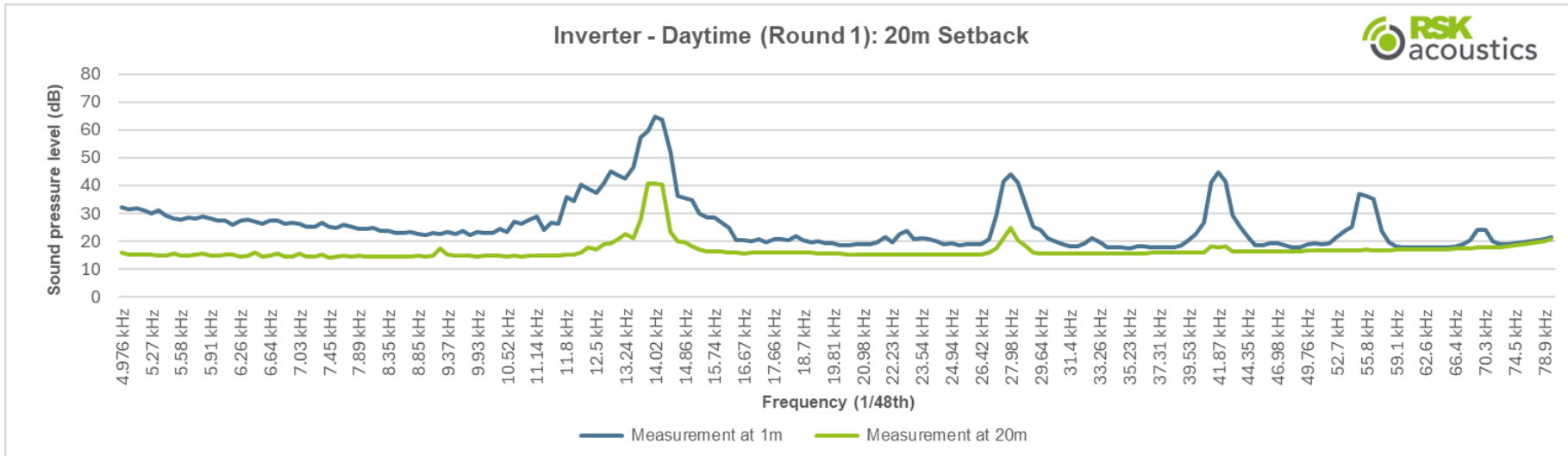


Figure 11: String inverter, daytime measurement (Round 1), 20m setback



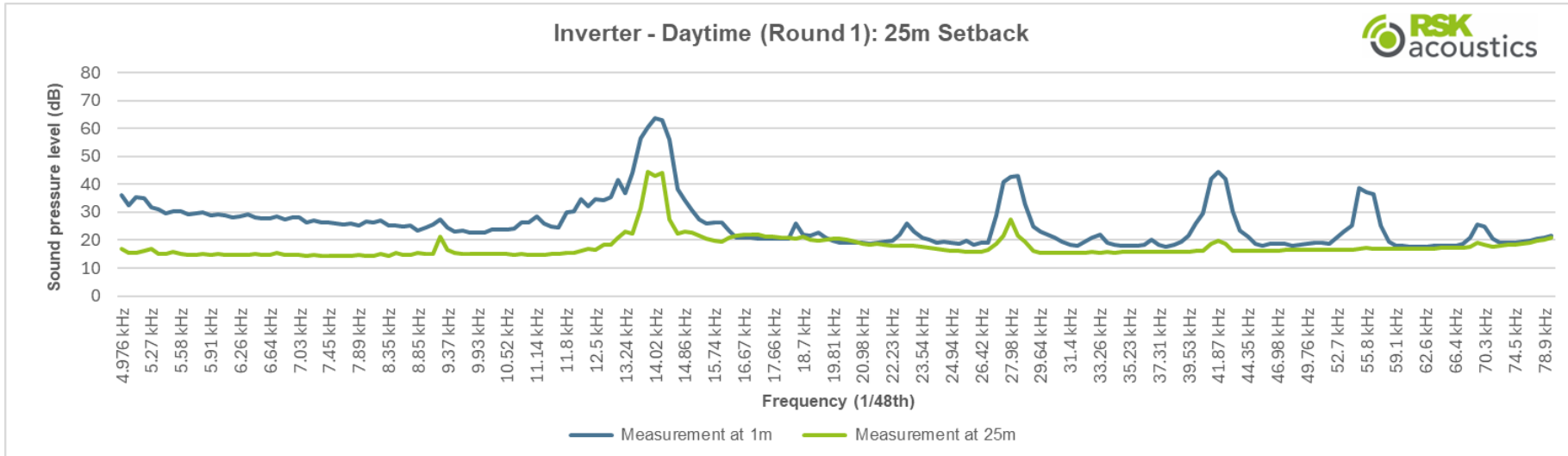


Figure 12: String inverter, daytime measurement (Round 1), 25m setback

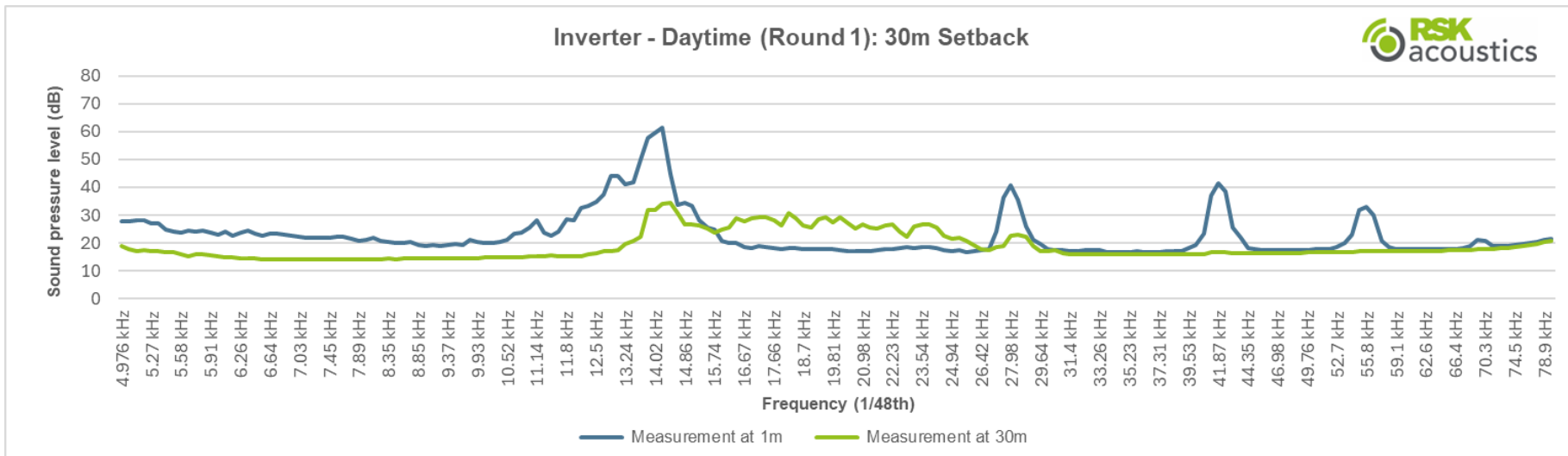


Figure 13: String inverter, daytime measurement (Round 1), 30m setback



4 Results – String Inverter, Daytime (Round 2)

4.1 Graphical outputs

The following graphical outputs are provided for the second round of daytime string inverter measurements:

- Figure 14: String inverter, daytime measurement (Round 2), 5m setback
- Figure 15: String inverter, daytime measurement (Round 2), 10m setback
- Figure 16: String inverter, daytime measurement (Round 2), 15m setback
- Figure 17: String inverter, daytime measurement (Round 2), 20m setback
- Figure 18: String inverter, daytime measurement (Round 2), 25m setback
- Figure 19: String inverter, daytime measurement (Round 2), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



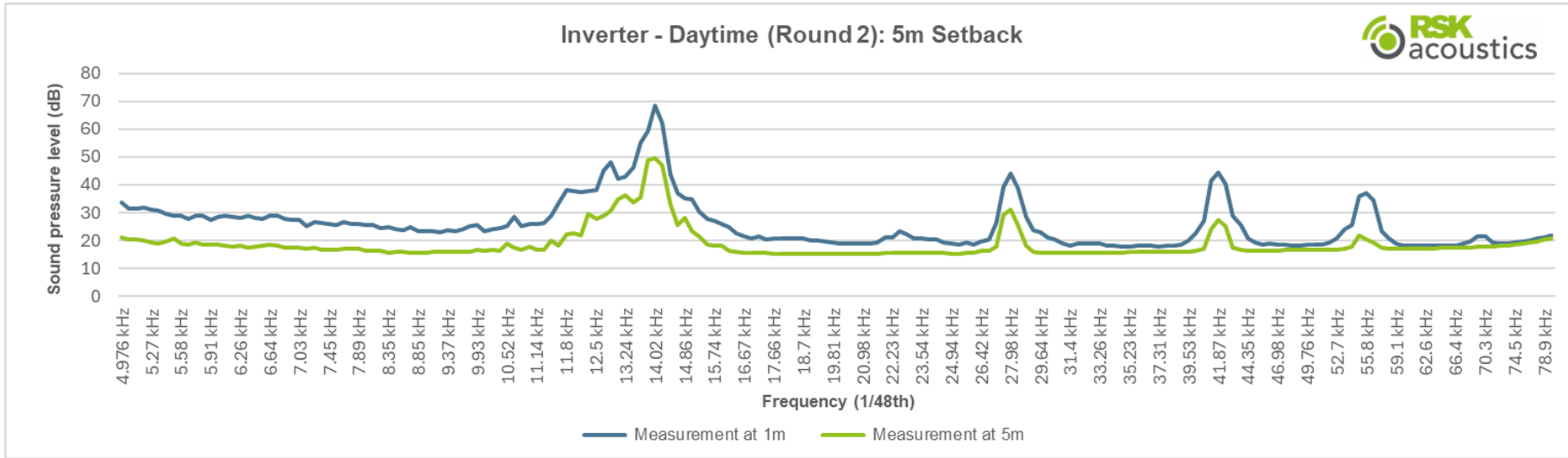


Figure 14: String inverter, daytime measurement (Round 2), 5m setback

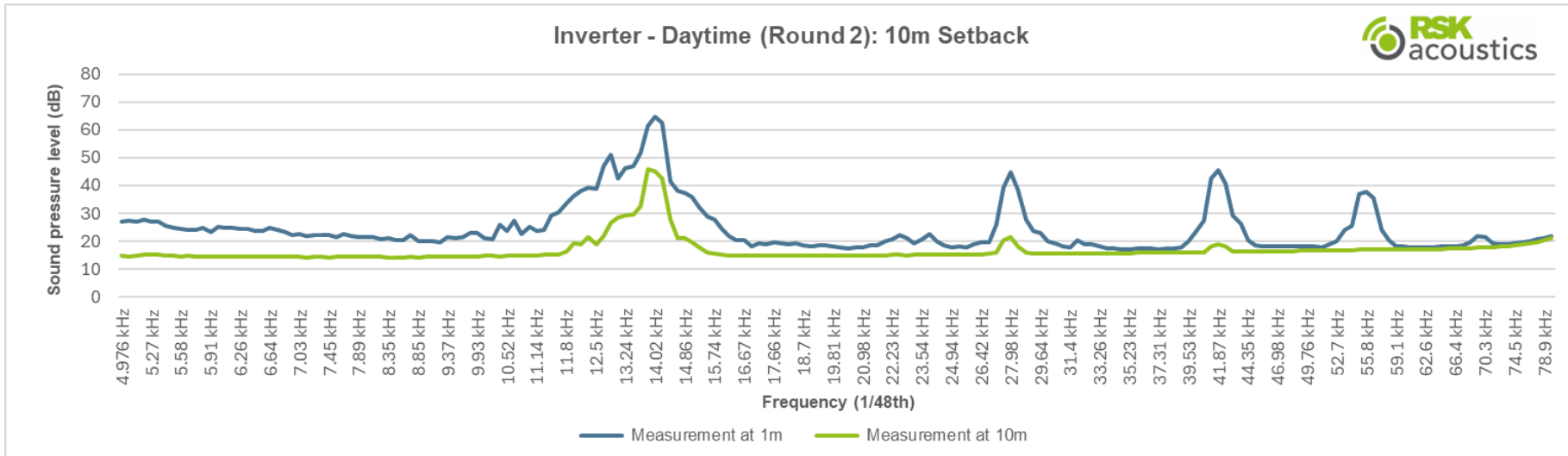


Figure 15: String inverter, daytime measurement (Round 2), 10m setback



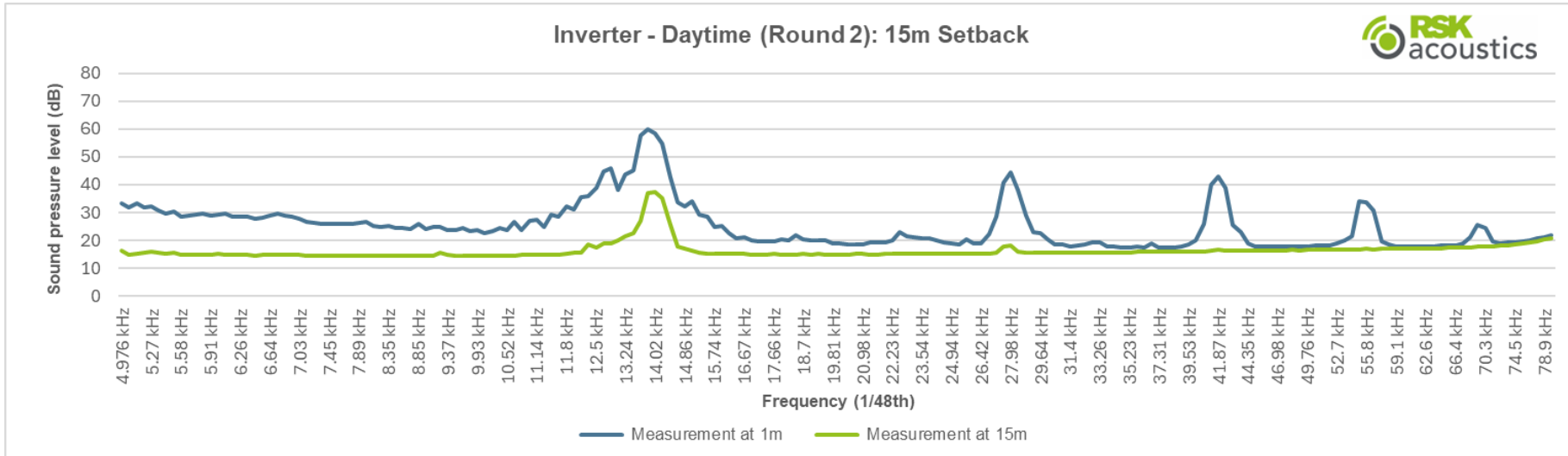


Figure 16: String inverter, daytime measurement (Round 2), 15m setback

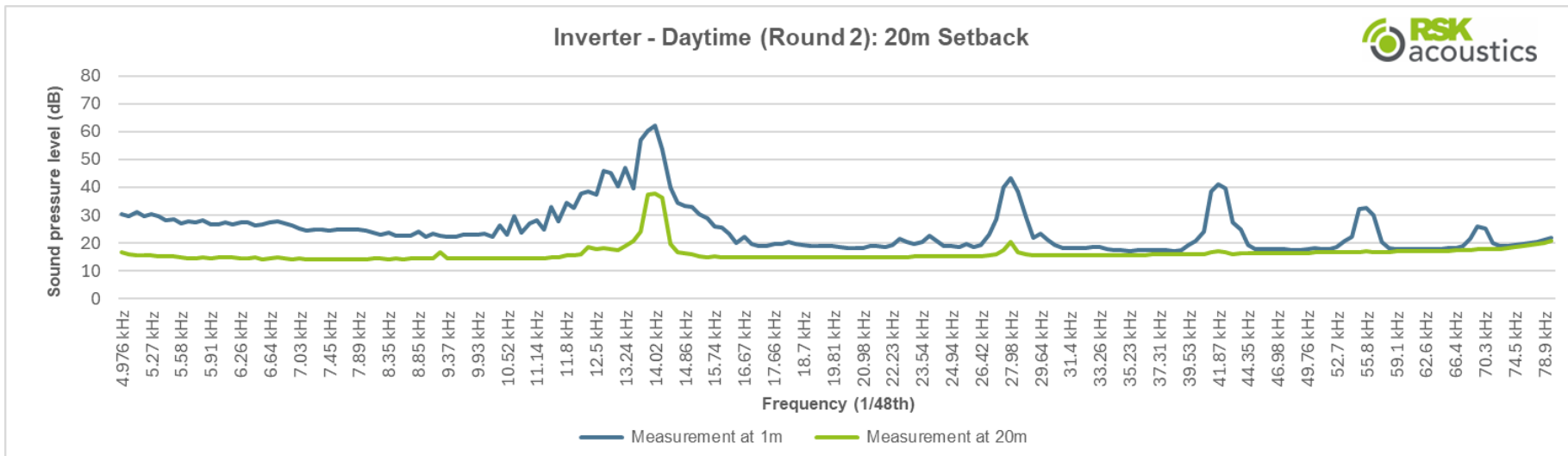


Figure 17: String inverter, daytime measurement (Round 2), 20m setback



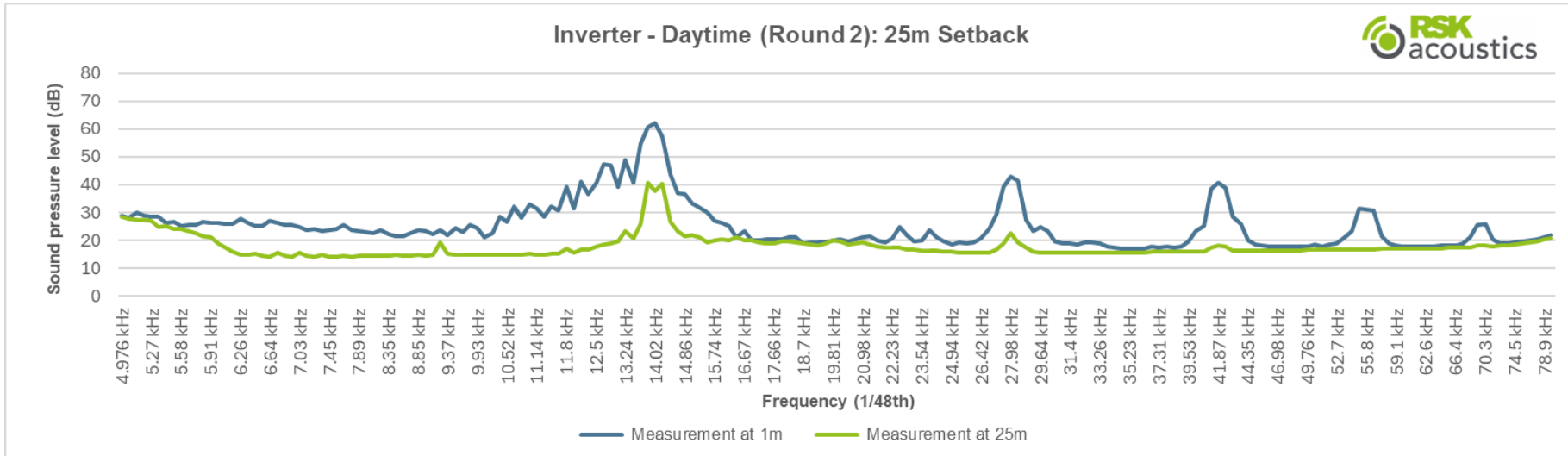


Figure 18: String inverter, daytime measurement (Round 2), 25m setback

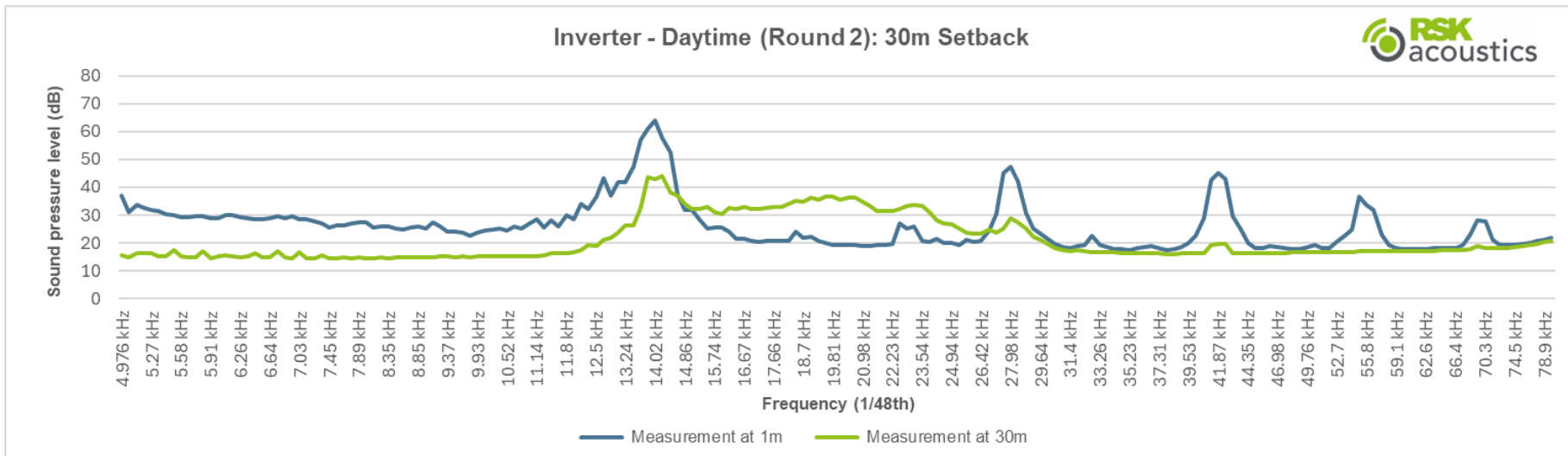


Figure 19: String inverter, daytime measurement (Round 2), 30m setback



5 Results – String Inverter, Daytime (Round 3)

5.1 Graphical outputs

The following graphical outputs are provided for the third round of daytime string inverter measurements:

- Figure 20: String inverter, daytime measurement (Round 3), 5m setback
- Figure 21: String inverter, daytime measurement (Round 3), 10m setback
- Figure 22: String inverter, daytime measurement (Round 3), 15m setback
- Figure 23: String inverter, daytime measurement (Round 3), 20m setback
- Figure 24: String inverter, daytime measurement (Round 3), 25m setback
- Figure 25: String inverter, daytime measurement (Round 3), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



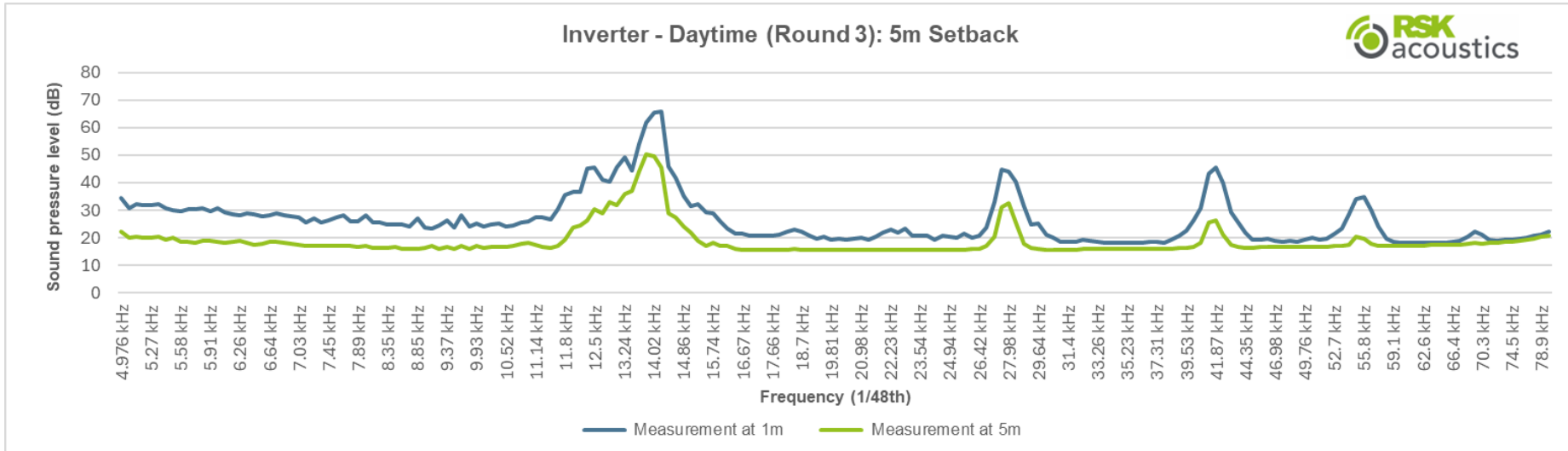


Figure 20: String inverter, daytime measurement (Round 3), 5m setback

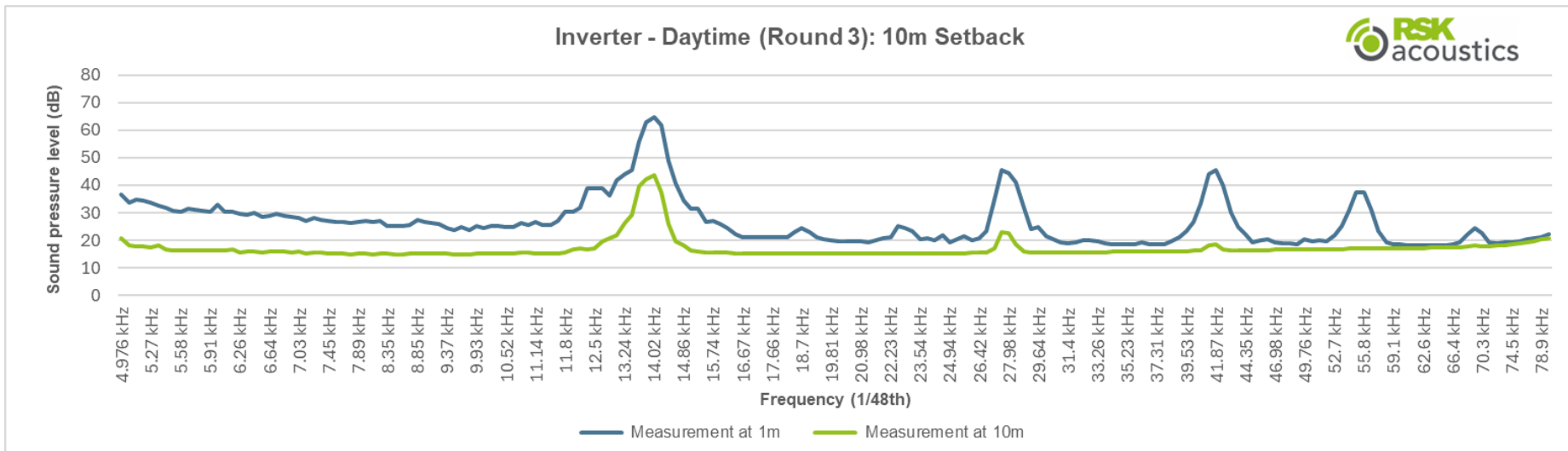


Figure 21: String inverter, daytime measurement (Round 3), 10m setback



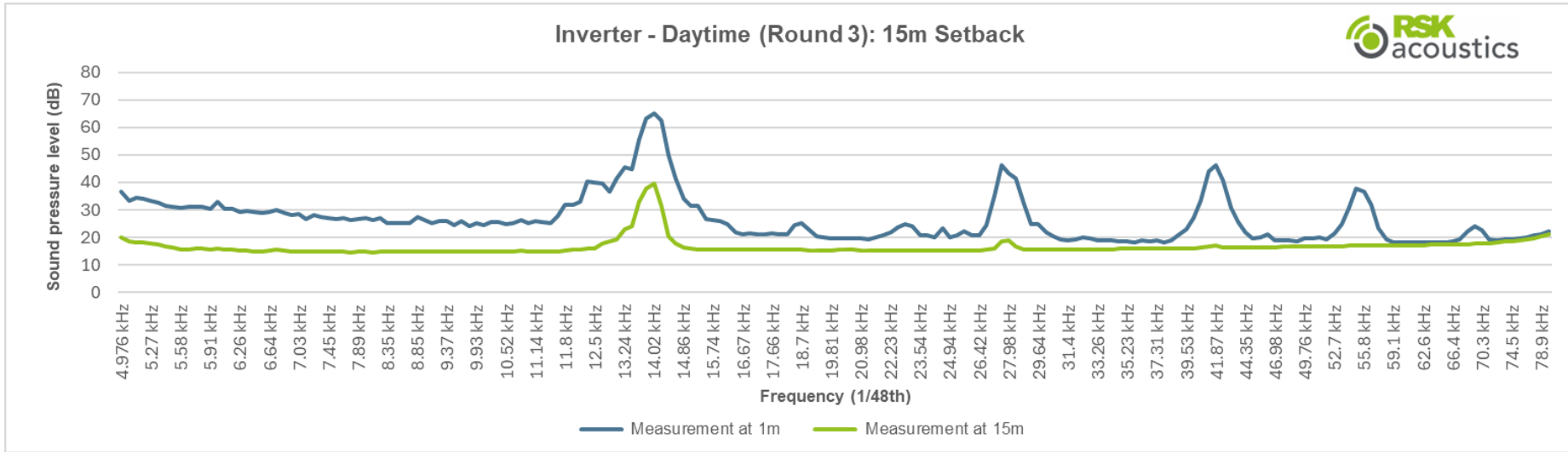


Figure 22: String inverter, daytime measurement (Round 3), 15m setback

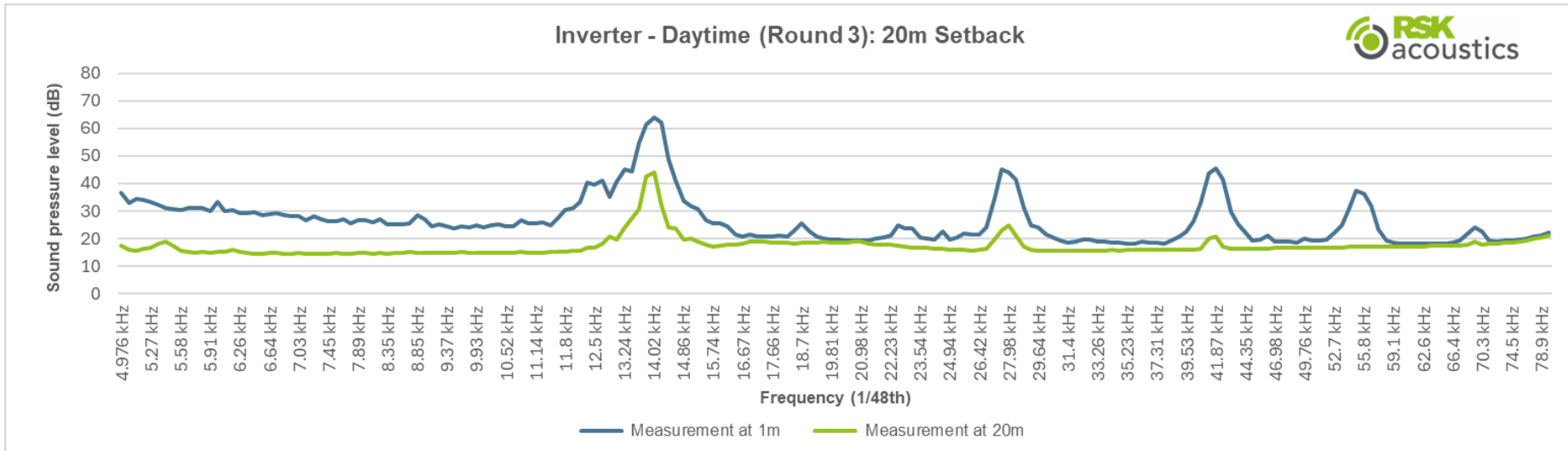


Figure 23: String inverter, daytime measurement (Round 3), 20m setback



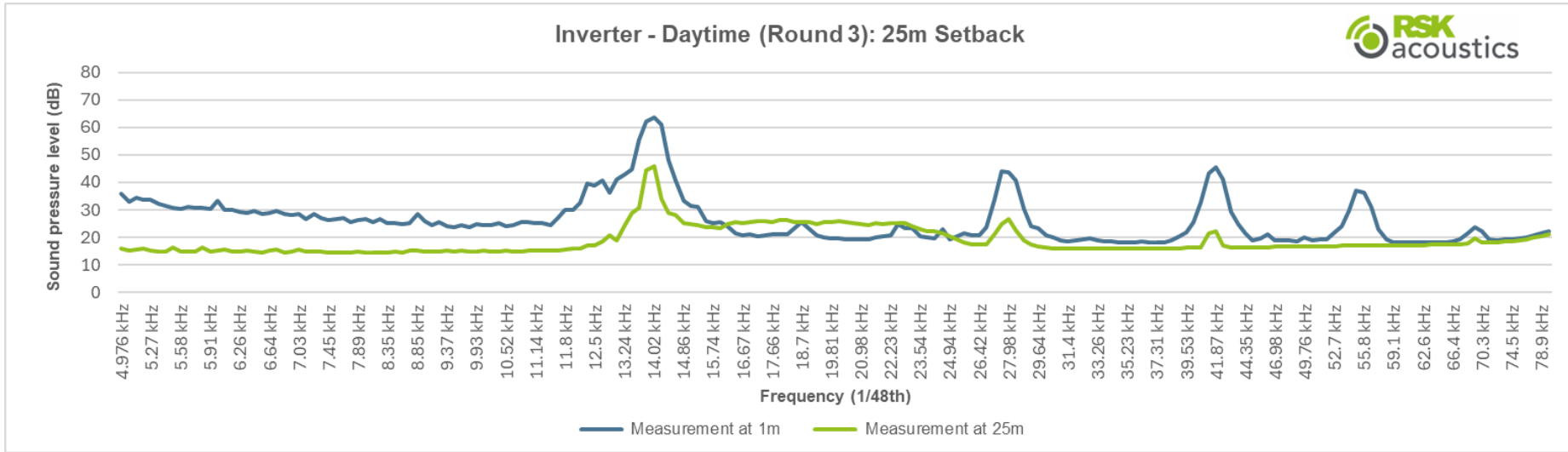


Figure 24: String inverter, daytime measurement (Round 3), 25m setback

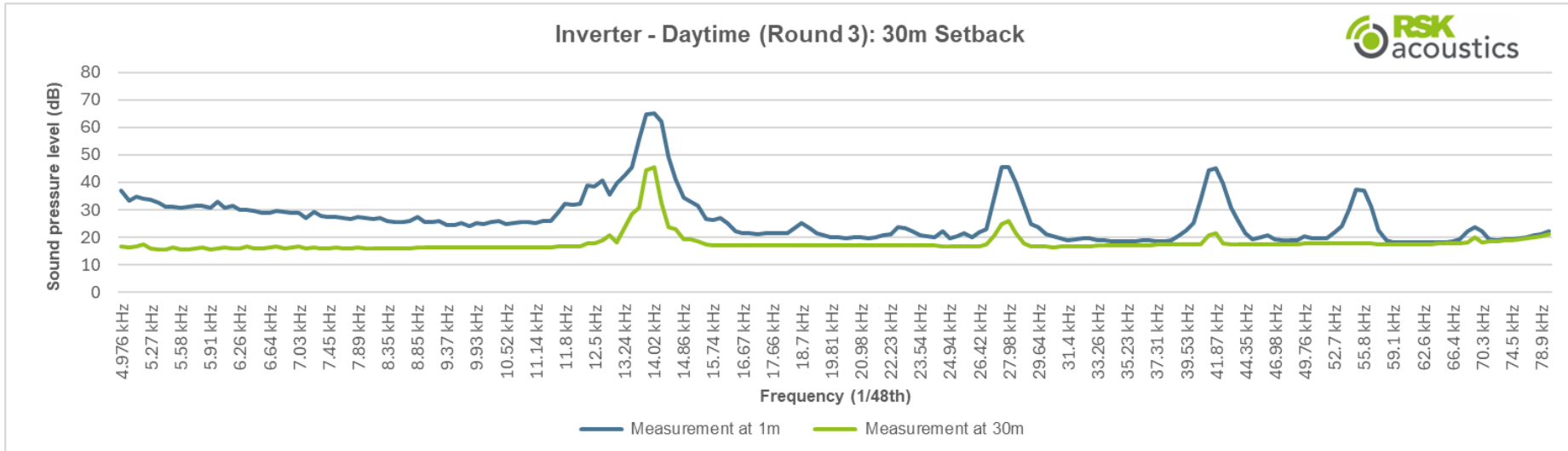


Figure 25: String inverter, daytime measurement (Round 3), 30m setback



6 Results – String Inverter, Twilight (Round 1)

6.1 Graphical outputs

The following graphical outputs are provided for the first round of twilight string inverter measurements:

- Figure 26: String inverter, twilight measurement (Round 1), 5m setback
- Figure 27: String inverter, twilight measurement (Round 1), 10m setback
- Figure 28: String inverter, twilight measurement (Round 1), 15m setback
- Figure 29: String inverter, twilight measurement (Round 1), 20m setback
- Figure 30: String inverter, twilight measurement (Round 1), 25m setback
- Figure 31: String inverter, twilight measurement (Round 1), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



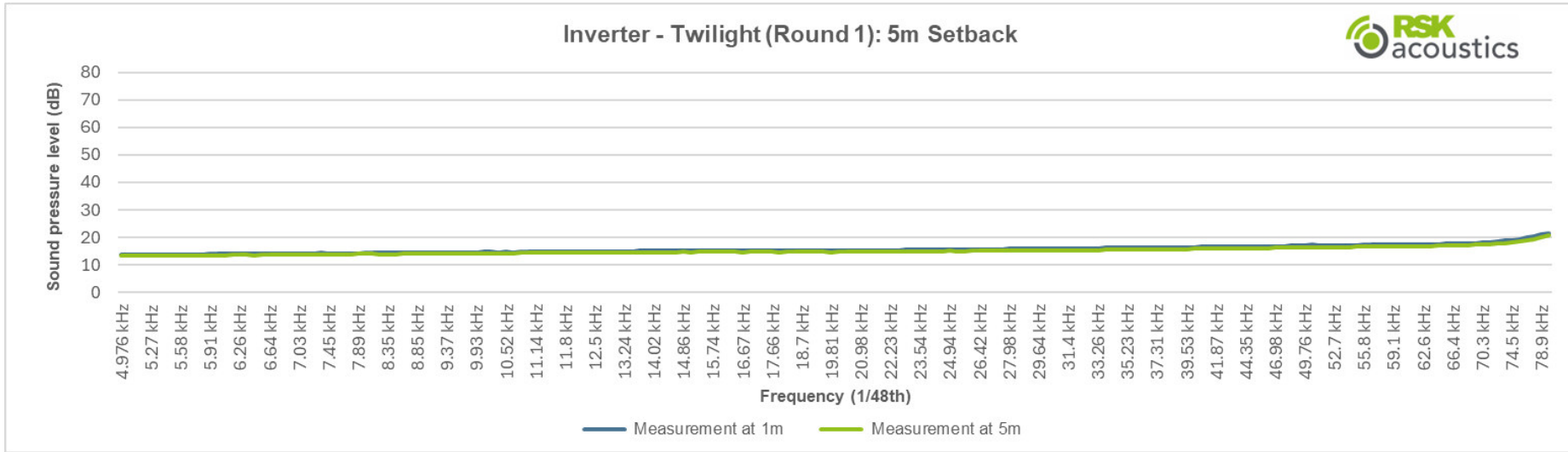


Figure 26: String inverter, twilight measurement (Round 1), 5m setback

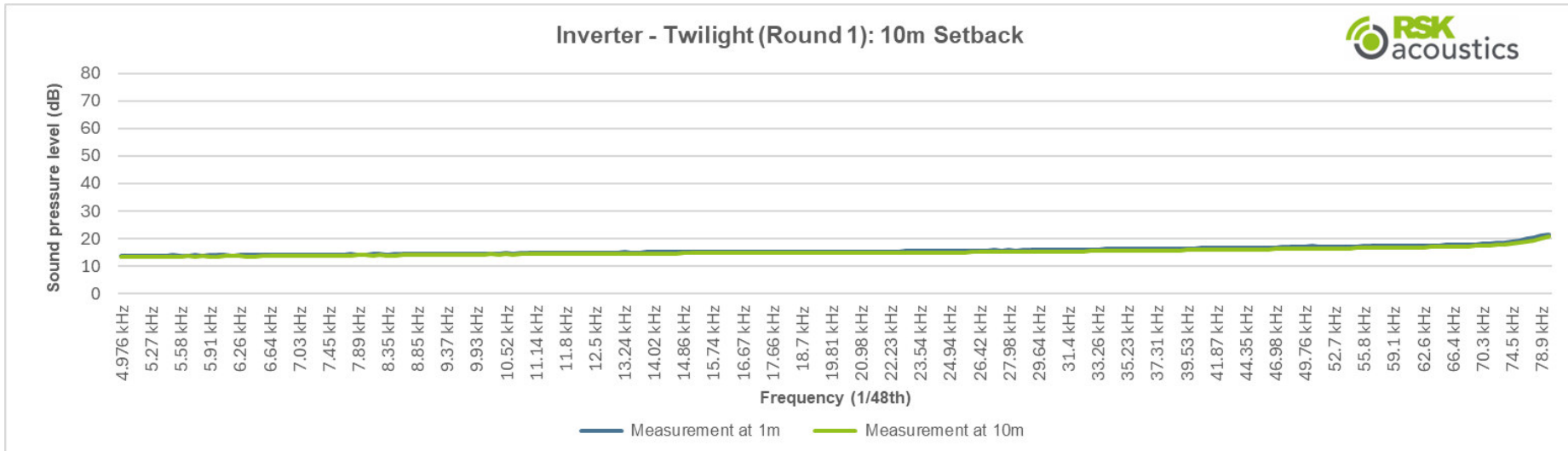


Figure 27: String inverter, twilight measurement (Round 1), 10m setback



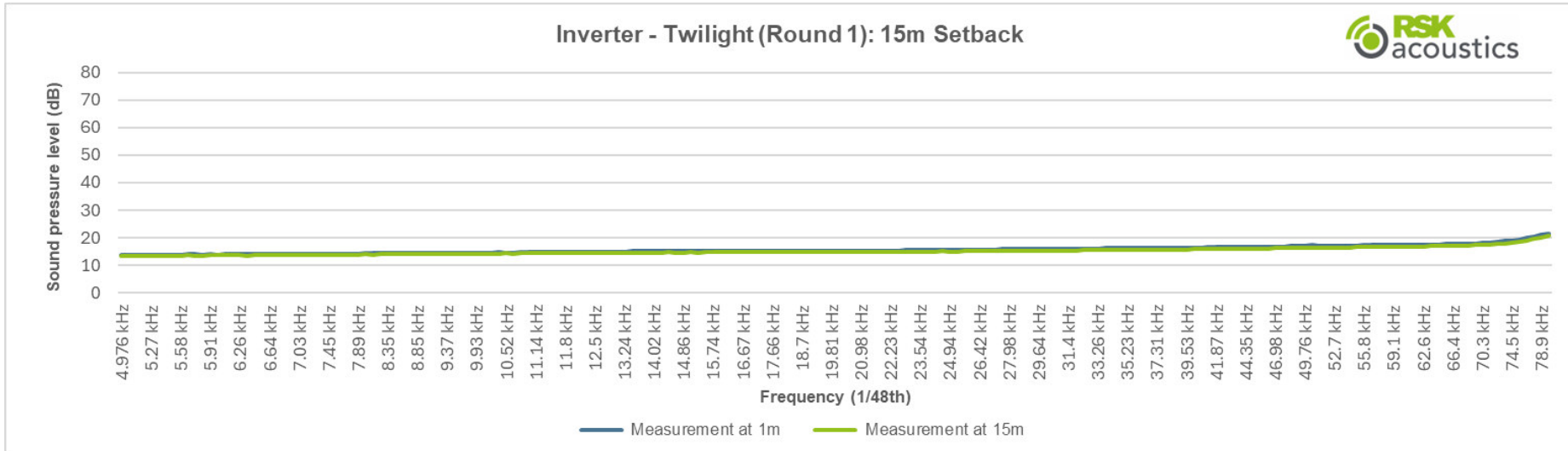


Figure 28: String inverter, twilight measurement (Round 1), 15m setback

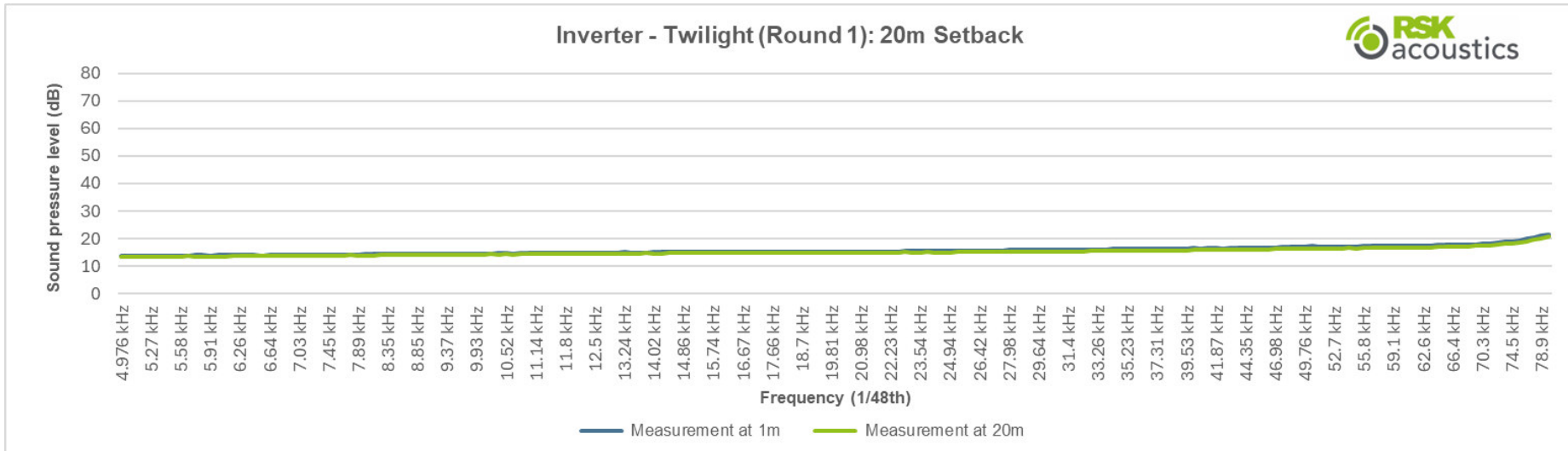


Figure 29: String inverter, twilight measurement (Round 1), 20m setback



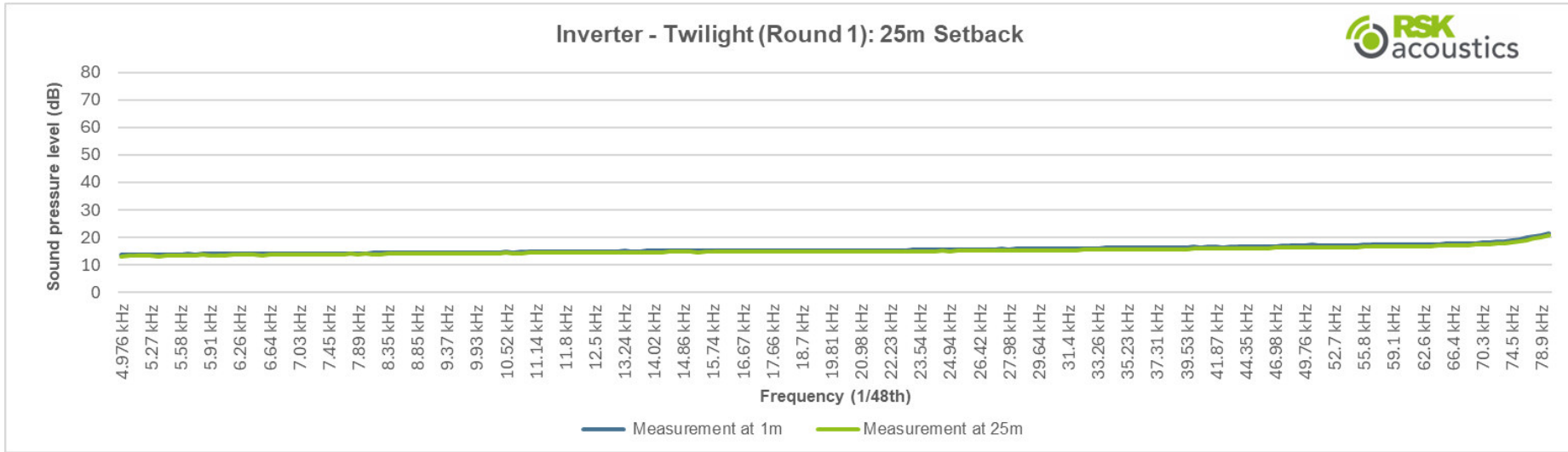


Figure 30: String inverter, twilight measurement (Round 1), 25m setback

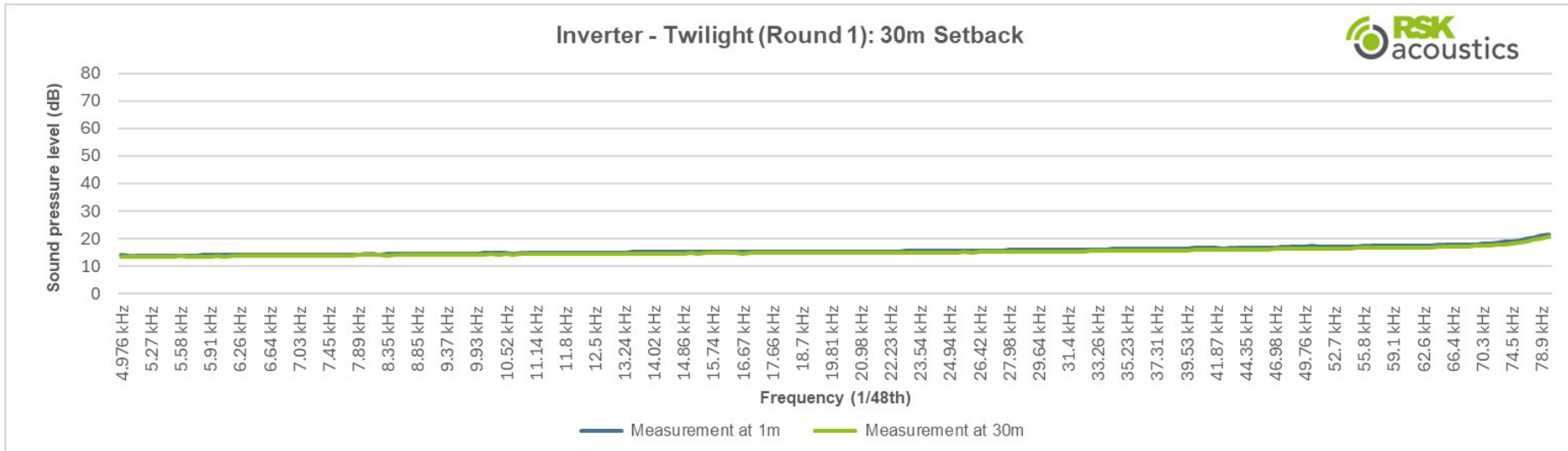


Figure 31: String inverter, twilight measurement (Round 1), 30m setback



7 Results – String Inverter, Twilight (Round 2)

7.1 Graphical outputs

The following graphical outputs are provided for the second round of twilight string inverter measurements:

- Figure 32: String inverter, twilight measurement (Round 2), 5m setback
- Figure 33: String inverter, twilight measurement (Round 2), 10m setback
- Figure 34: String inverter, twilight measurement (Round 2), 15m setback
- Figure 35: String inverter, twilight measurement (Round 2), 20m setback
- Figure 36: String inverter, twilight measurement (Round 2), 25m setback
- Figure 37: String inverter, twilight measurement (Round 2), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



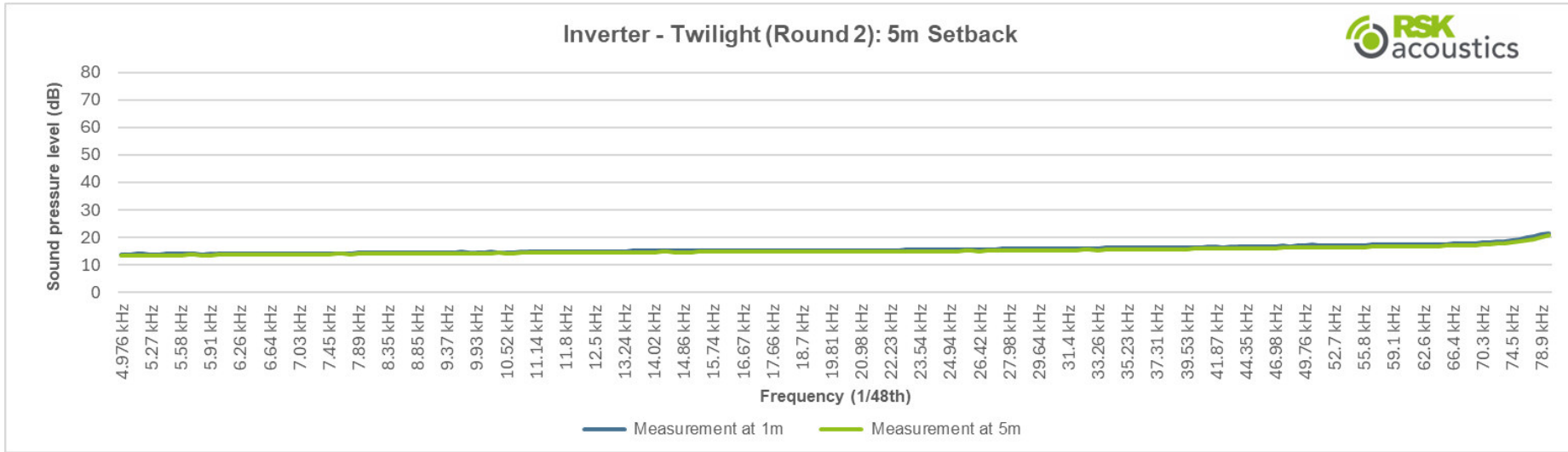


Figure 32: String inverter, twilight measurement (Round 2), 5m setback

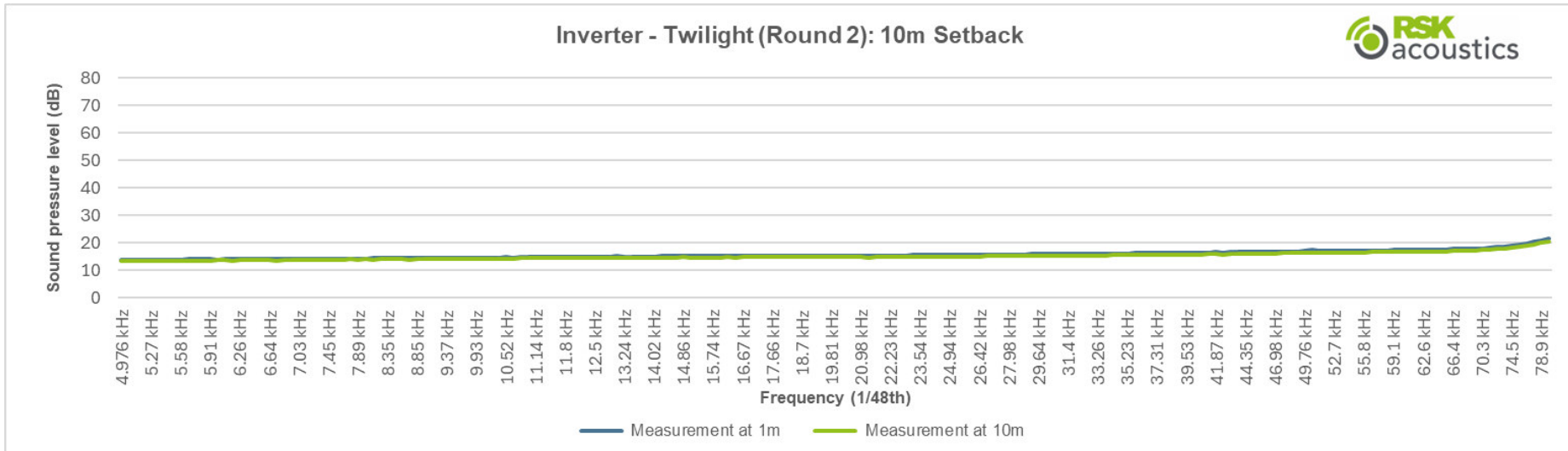


Figure 33: String inverter, twilight measurement (Round 2), 10m setback



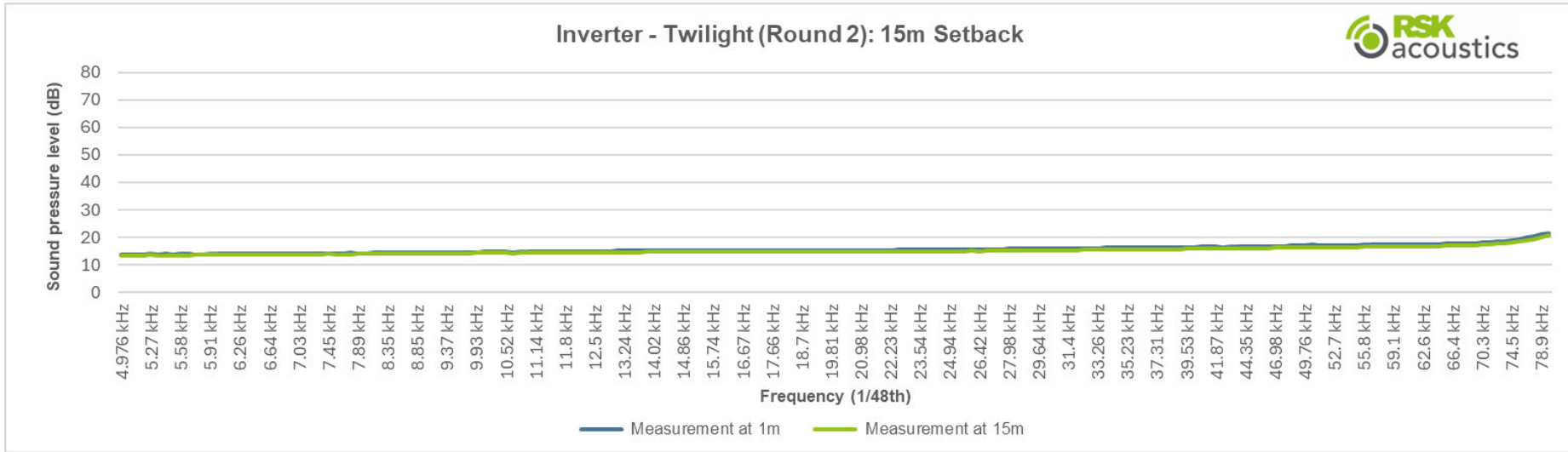


Figure 34: String inverter, twilight measurement (Round 2), 15m setback

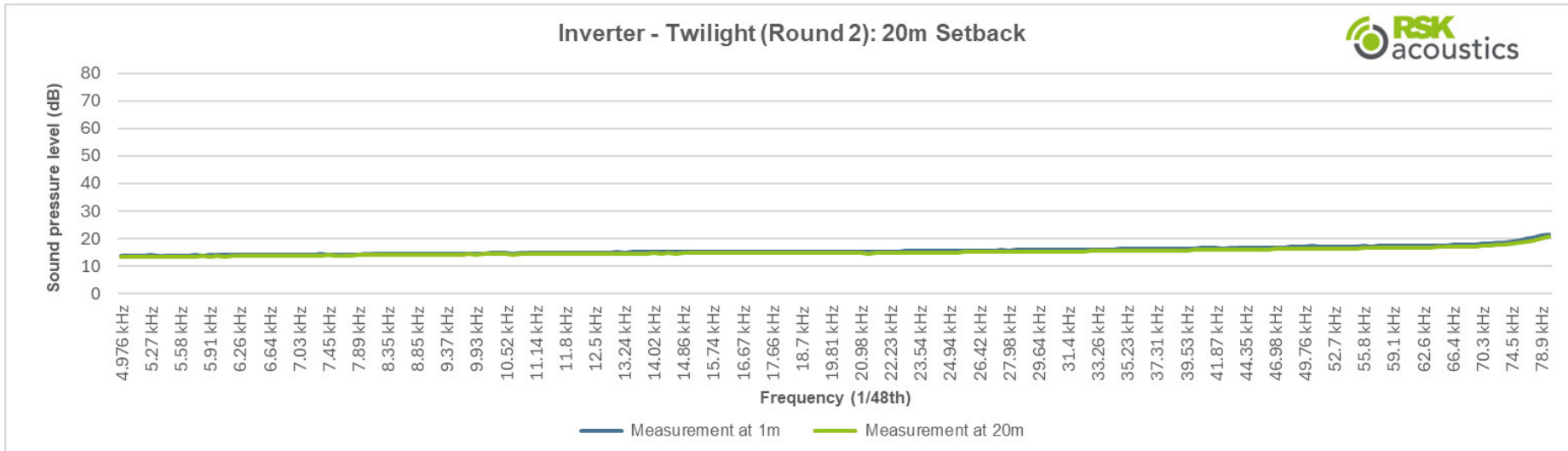


Figure 35: String inverter, twilight measurement (Round 2), 20m setback



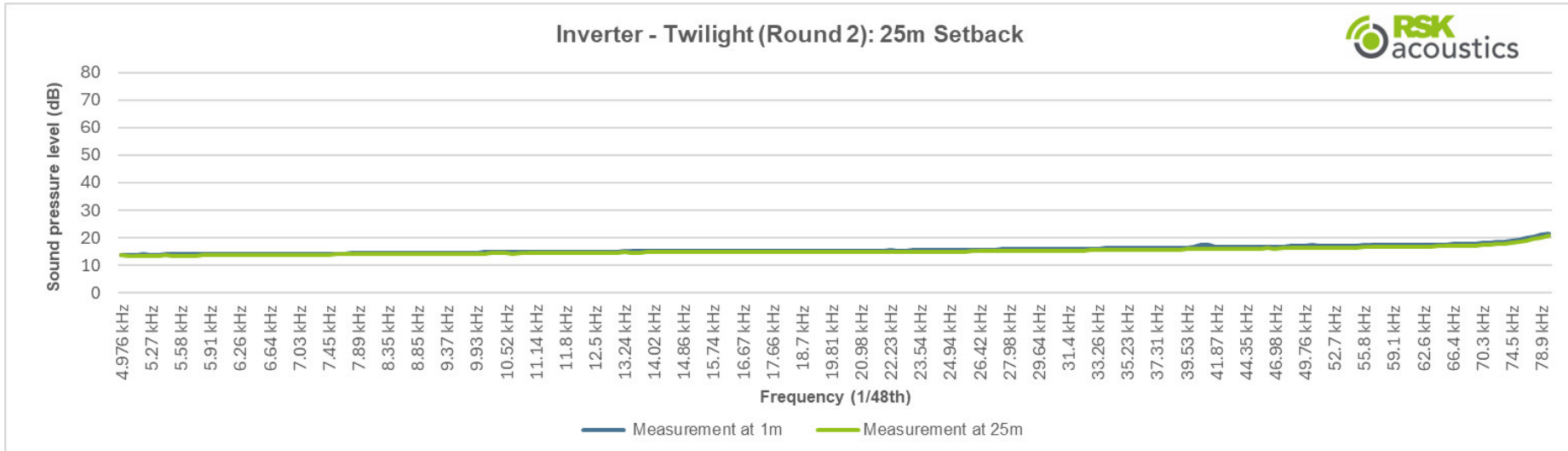


Figure 36: String inverter, twilight measurement (Round 2), 25m setback

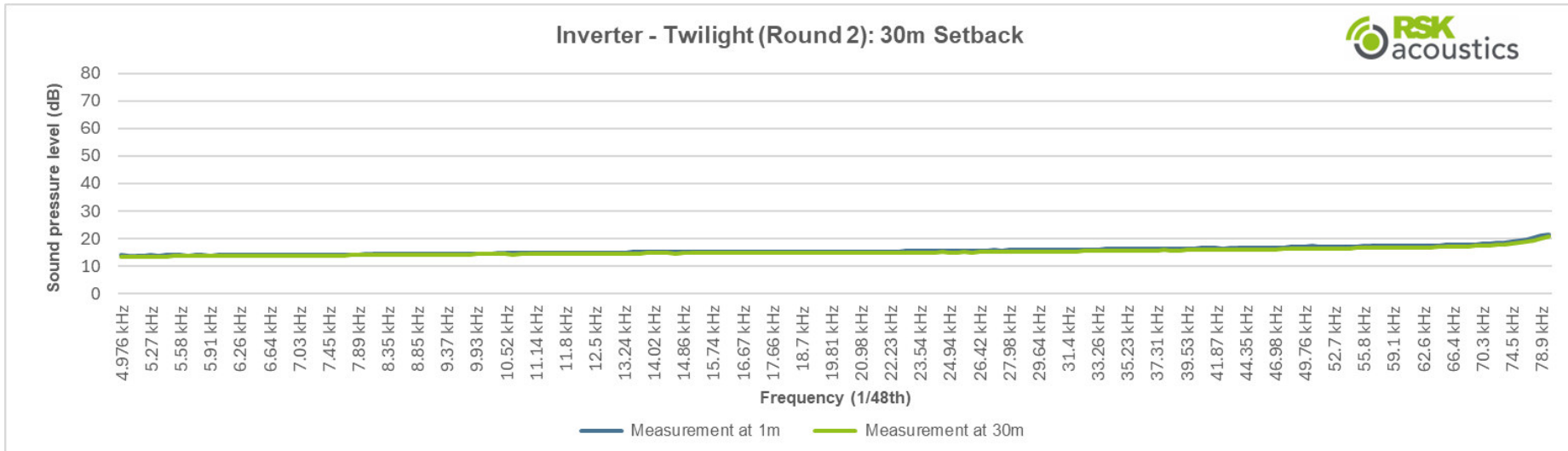


Figure 37: String inverter, twilight measurement (Round 2), 30m setback



8 Results – Transformer Station, Daytime (Round 1)

8.1 Graphical outputs

The following graphical outputs are provided for the first round of daytime transformer station measurements:

- Figure 38: Transformer station, daytime measurement (Round 1), 5m setback
- Figure 39: Transformer station, daytime measurement (Round 1), 10m setback
- Figure 40: Transformer station, daytime measurement (Round 1), 15m setback
- Figure 41: Transformer station, daytime measurement (Round 1), 20m setback
- Figure 42: Transformer station, daytime measurement (Round 1), 25m setback
- Figure 43: Transformer station, daytime measurement (Round 1), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



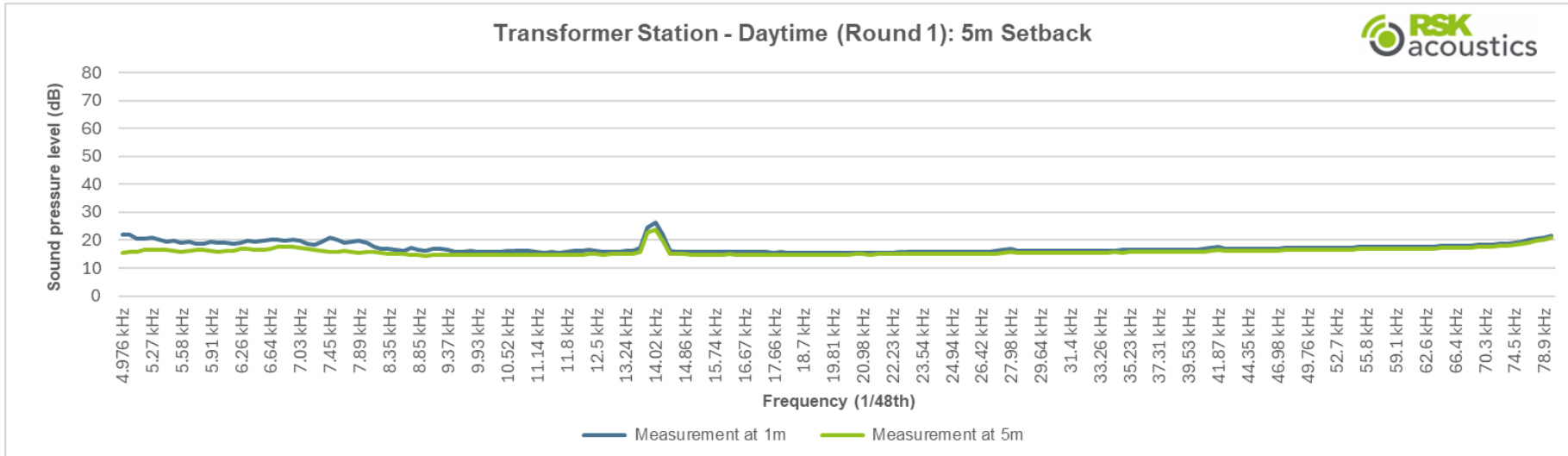


Figure 38: Transformer station, daytime measurement (Round 1), 5m setback

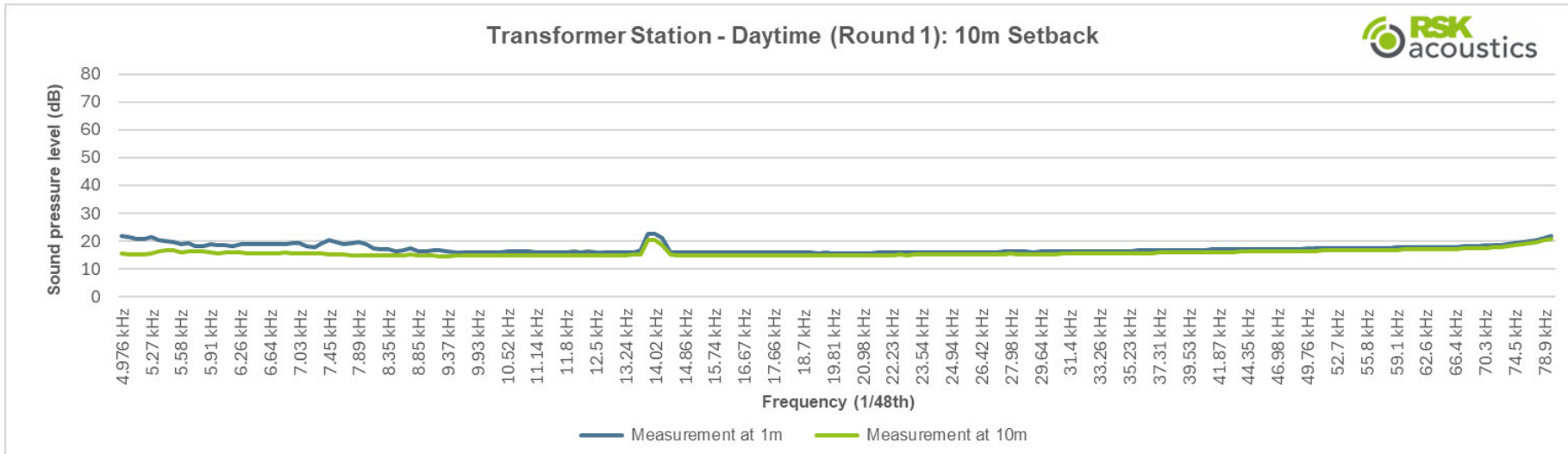


Figure 39: Transformer station, daytime measurement (Round 1), 10m setback



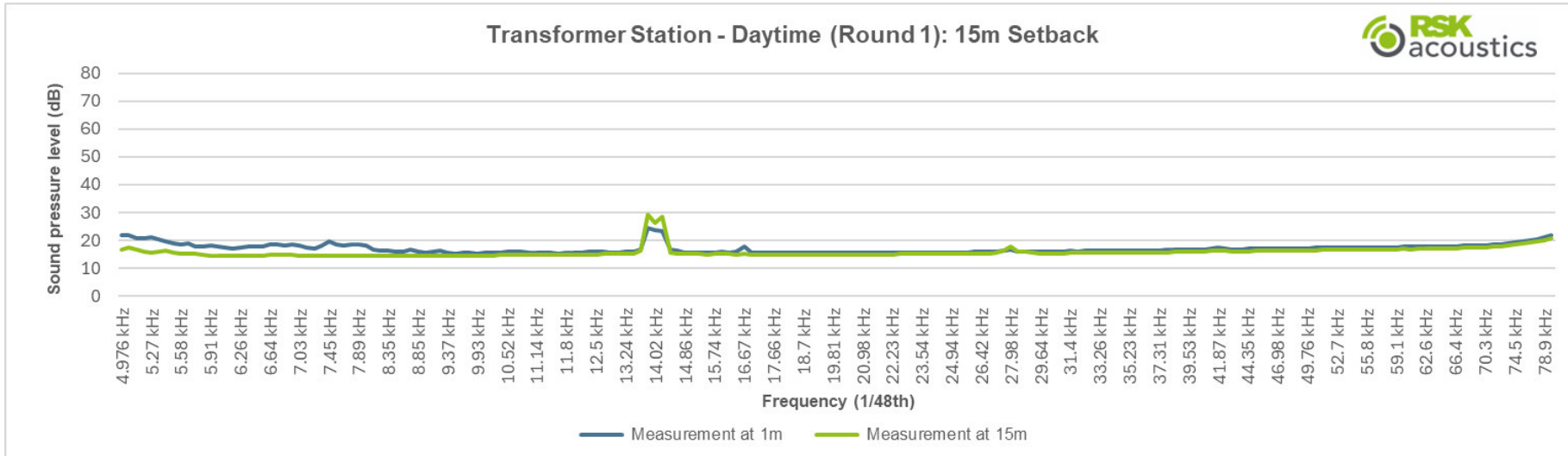


Figure 40: Transformer station, daytime measurement (Round 1), 15m setback

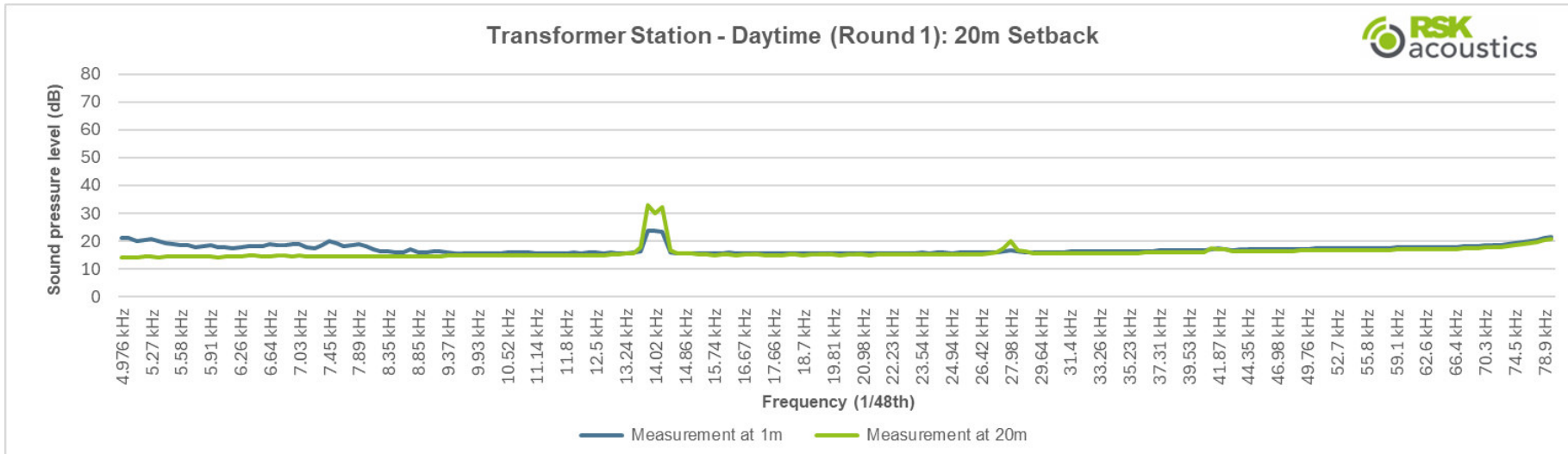


Figure 41: Transformer station, daytime measurement (Round 1), 20m setback



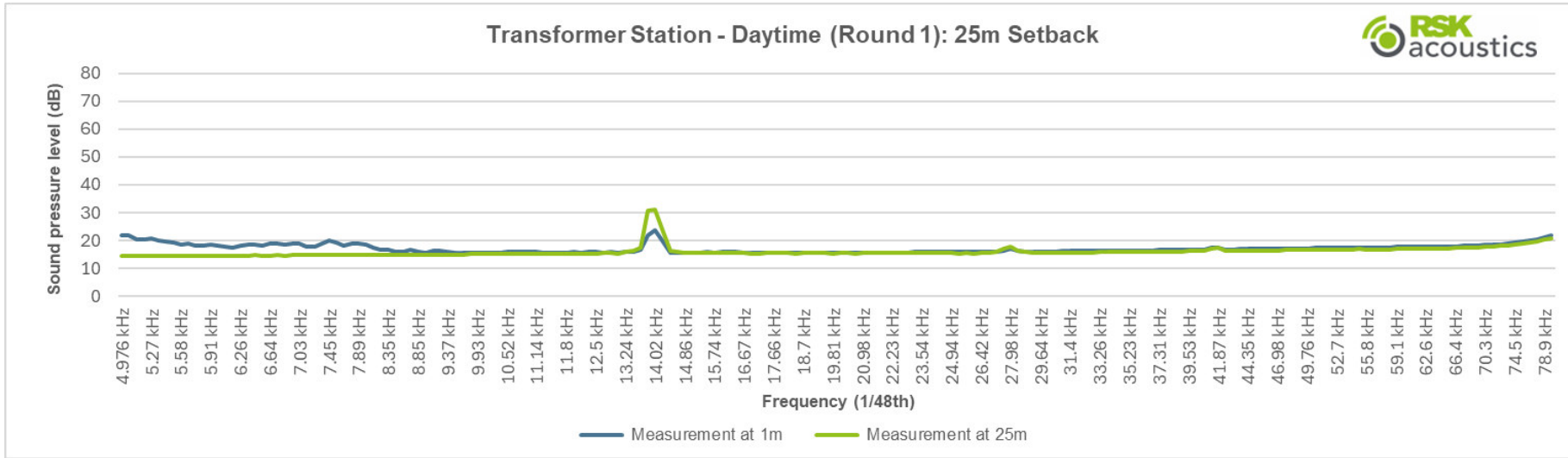


Figure 42: Transformer station, daytime measurement (Round 1), 25m setback

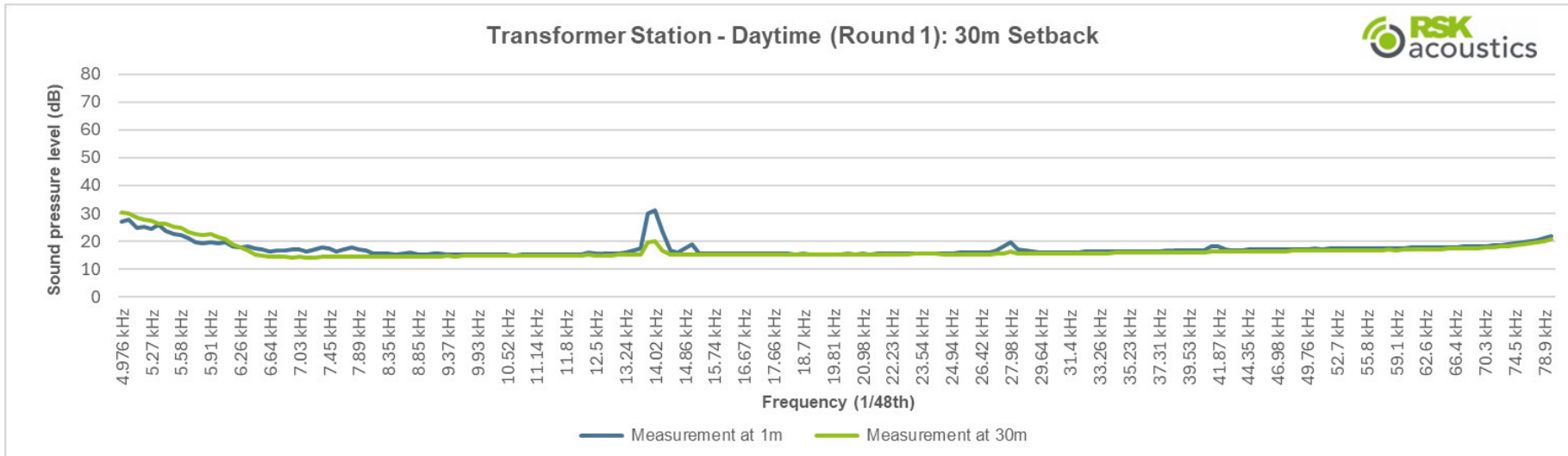


Figure 43: Transformer station, daytime measurement (Round 1), 30m setback



9 Results – Transformer Station, Daytime (Round 2)

9.1 Graphical outputs

The following graphical outputs are provided for the second round of daytime transformer station measurements:

- Figure 44: Transformer station, daytime measurement (Round 2), 5m setback
- Figure 45: Transformer station, daytime measurement (Round 2), 10m setback
- Figure 46: Transformer station, daytime measurement (Round 2), 15m setback
- Figure 47: Transformer station, daytime measurement (Round 2), 20m setback
- Figure 48: Transformer station, daytime measurement (Round 2), 25m setback
- Figure 49: Transformer station, daytime measurement (Round 2), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



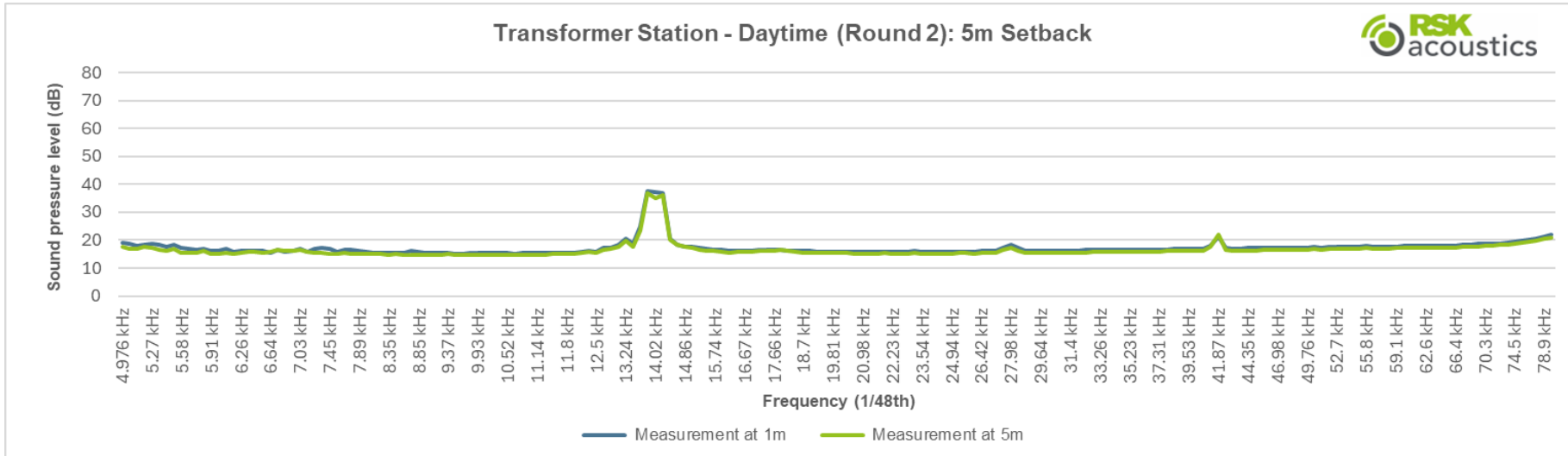


Figure 44: Transformer station, daytime measurement (Round 2), 5m setback

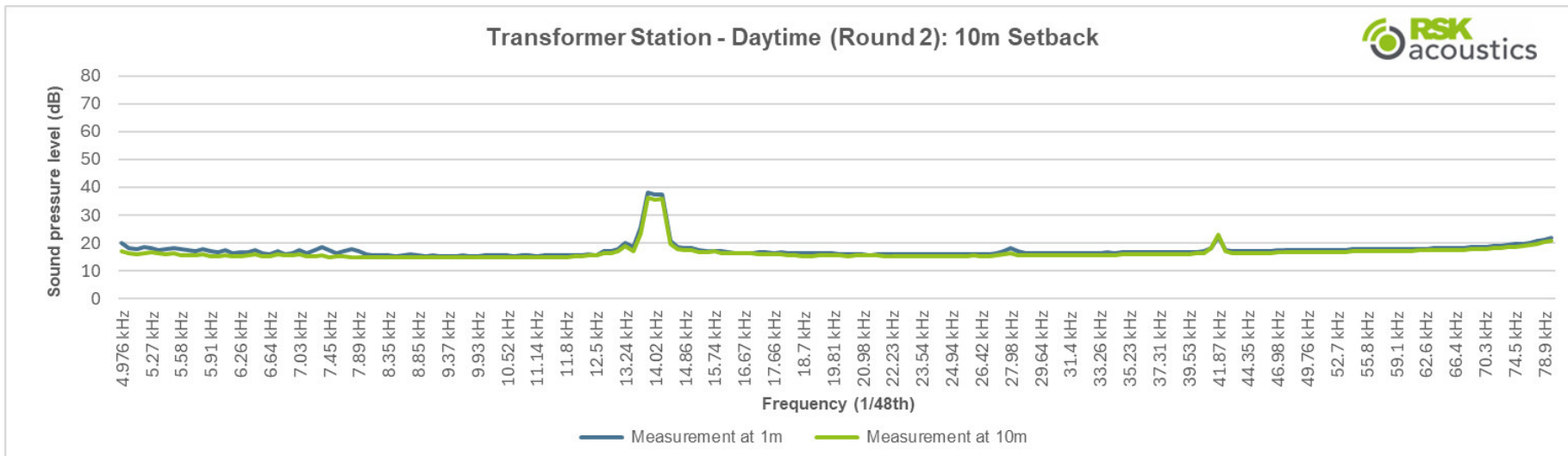


Figure 45: Transformer station, daytime measurement (Round 2), 10m setback



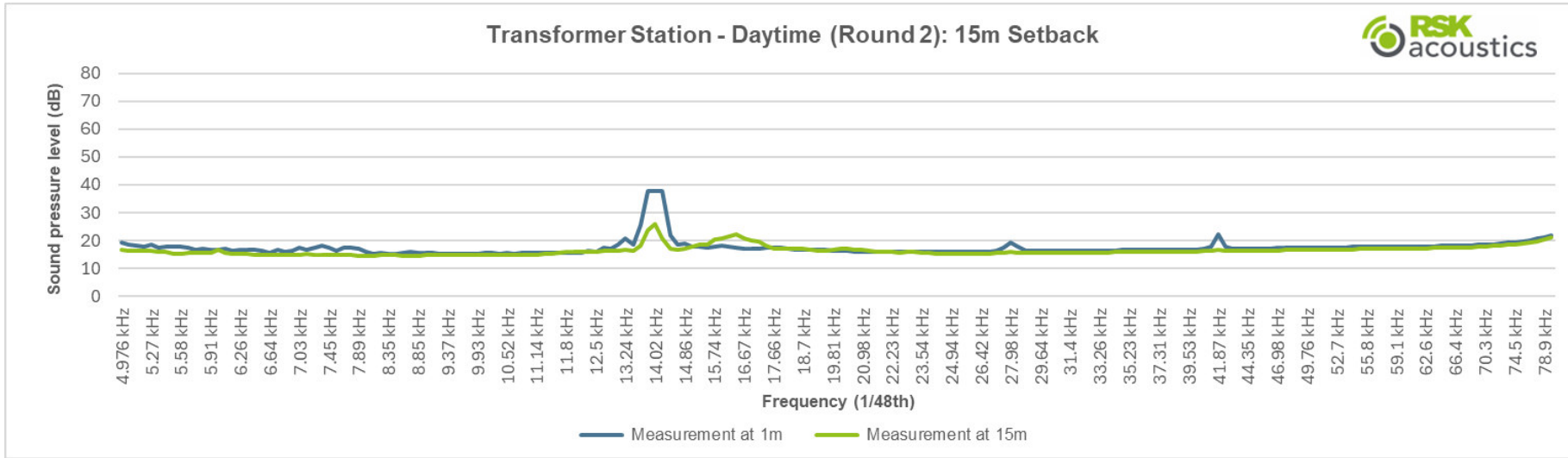


Figure 46: Transformer station, daytime measurement (Round 2), 15m setback

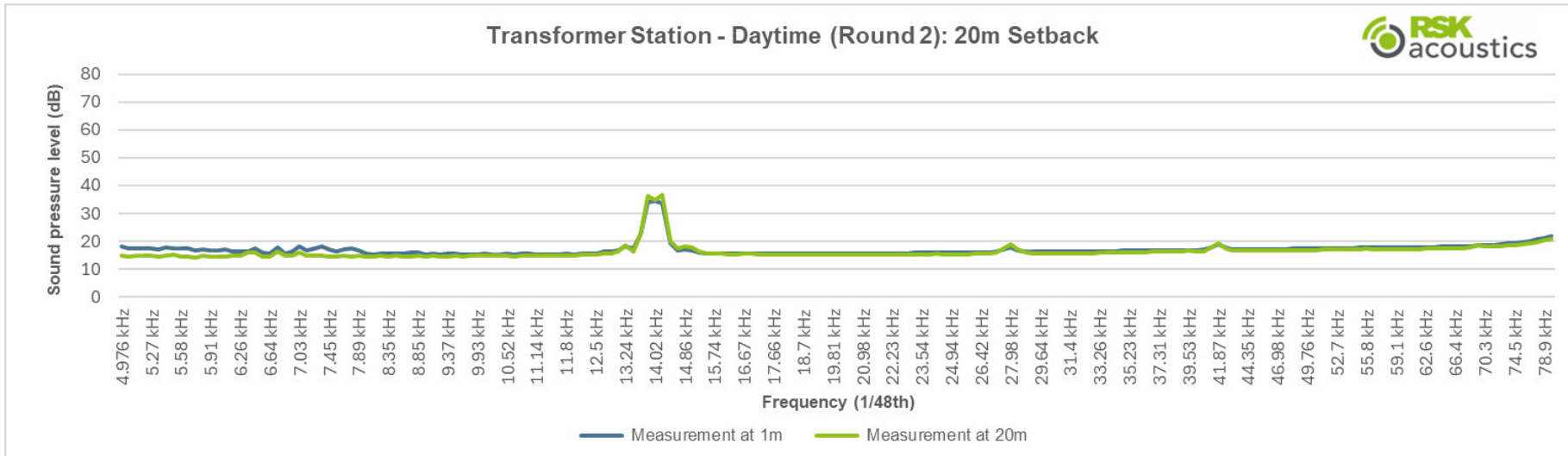


Figure 47: Transformer station, daytime measurement (Round 2), 20m setback



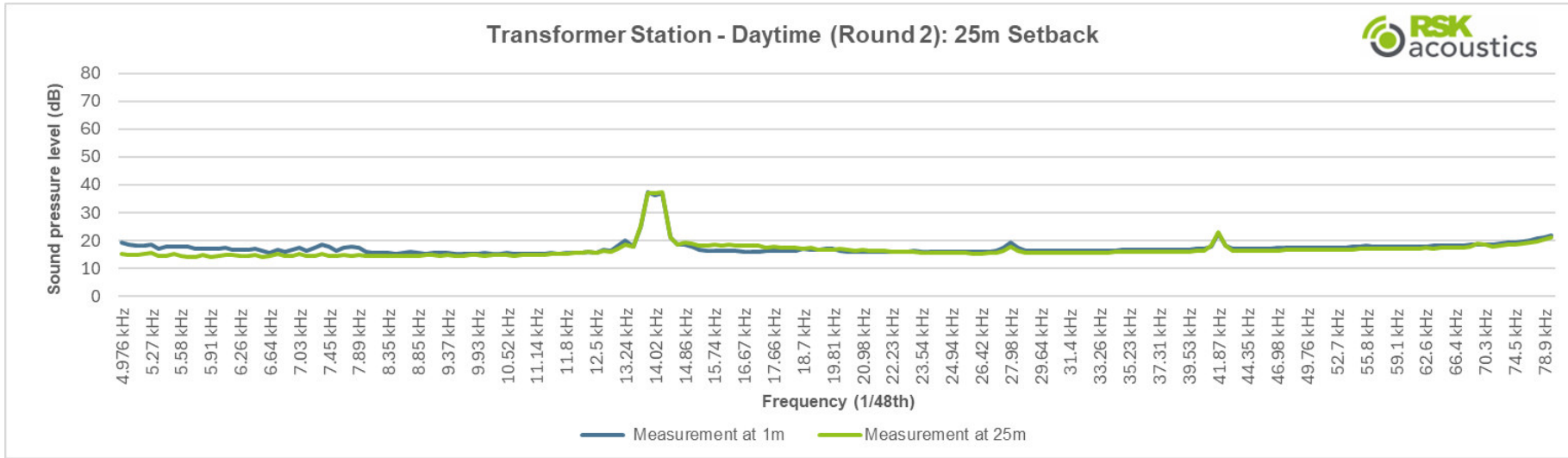


Figure 48: Transformer station, daytime measurement (Round 2), 25m setback

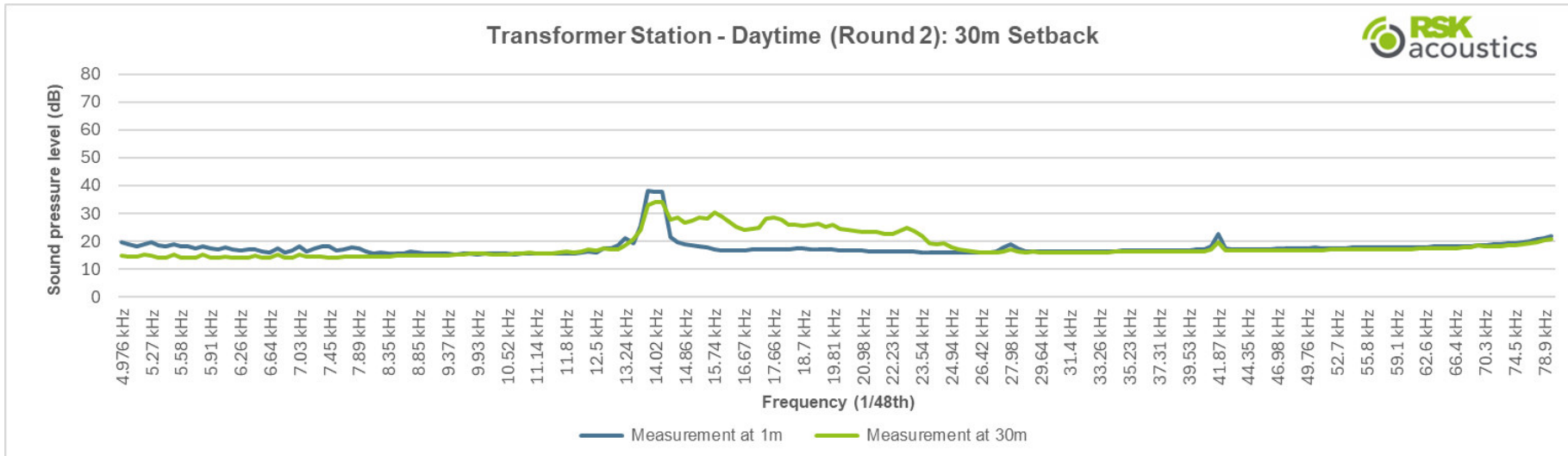


Figure 49: Transformer station, daytime measurement (Round 2), 30m setback



10 Results – Transformer Station, Twilight (Round 1)

10.1 Graphical outputs

The following graphical outputs are provided for the first round of twilight transformer station measurements:

- Figure 50: Transformer station, twilight measurement (Round 1), 5m setback
- Figure 51: Transformer station, twilight measurement (Round 1), 10m setback
- Figure 52: Transformer station, twilight measurement (Round 1), 15m setback
- Figure 53: Transformer station, twilight measurement (Round 1), 20m setback
- Figure 54: Transformer station, twilight measurement (Round 1), 25m setback
- Figure 55: Transformer station, twilight measurement (Round 1), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



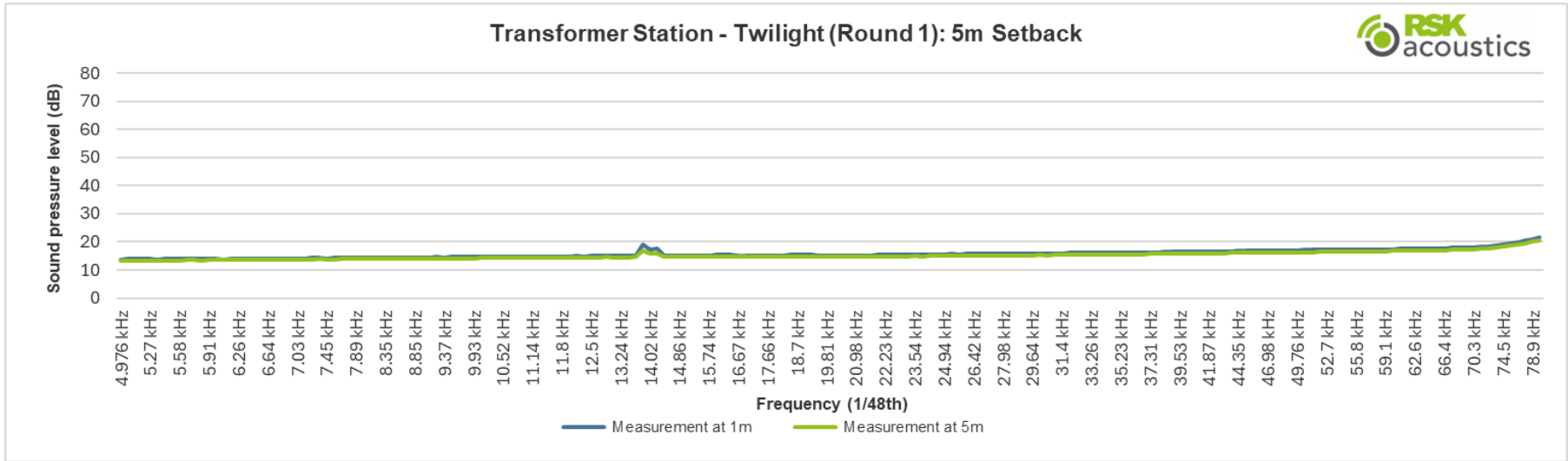


Figure 50: Transformer station, twilight measurement (Round 1), 5m setback

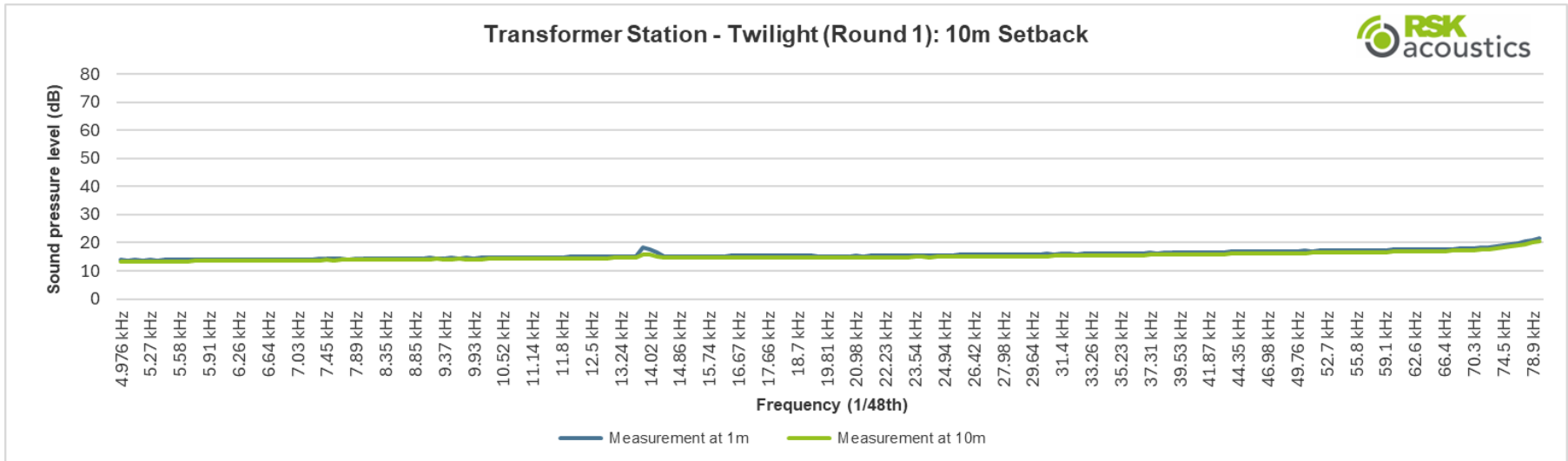


Figure 51: Transformer station, twilight measurement (Round 1), 10m setback



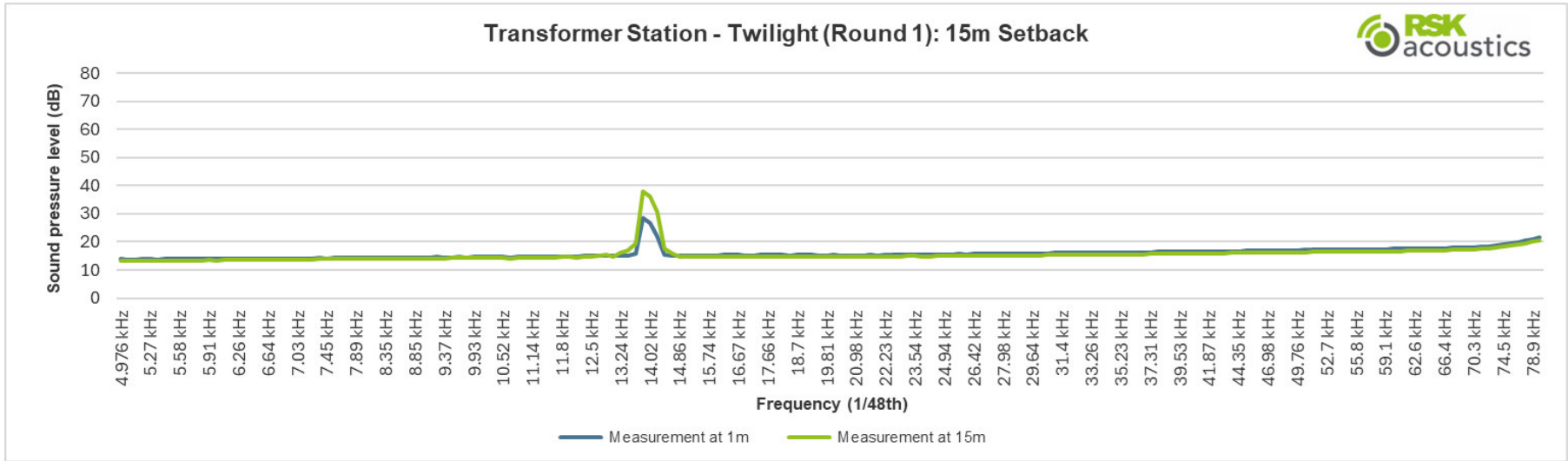


Figure 52: Transformer station, twilight measurement (Round 1), 15m setback

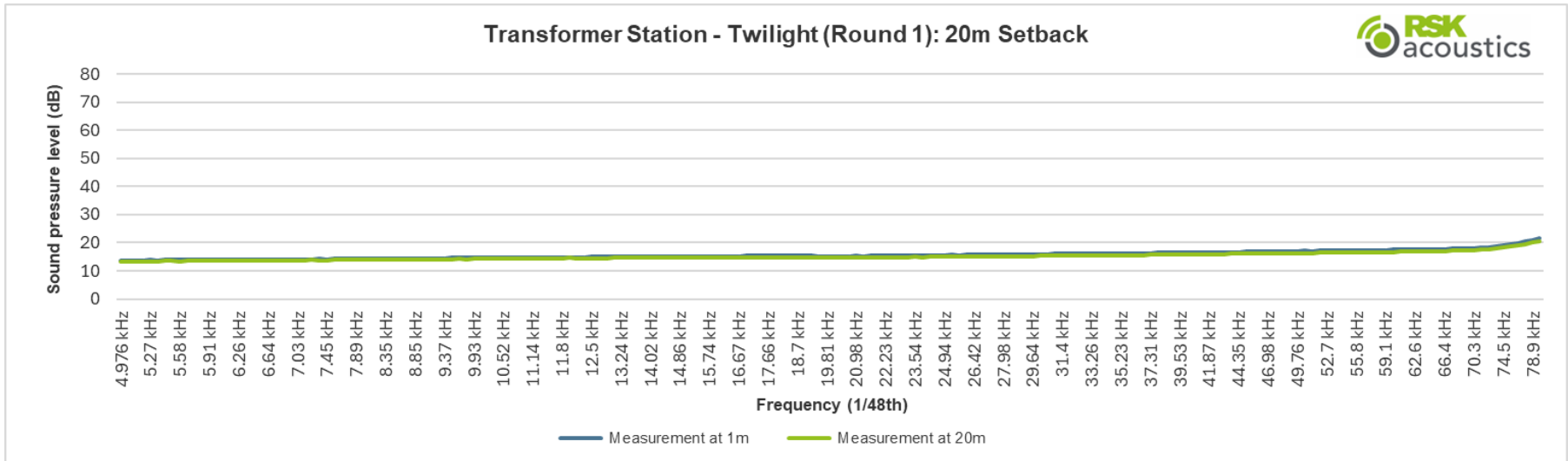


Figure 53: Transformer station, twilight measurement (Round 1), 20m setback



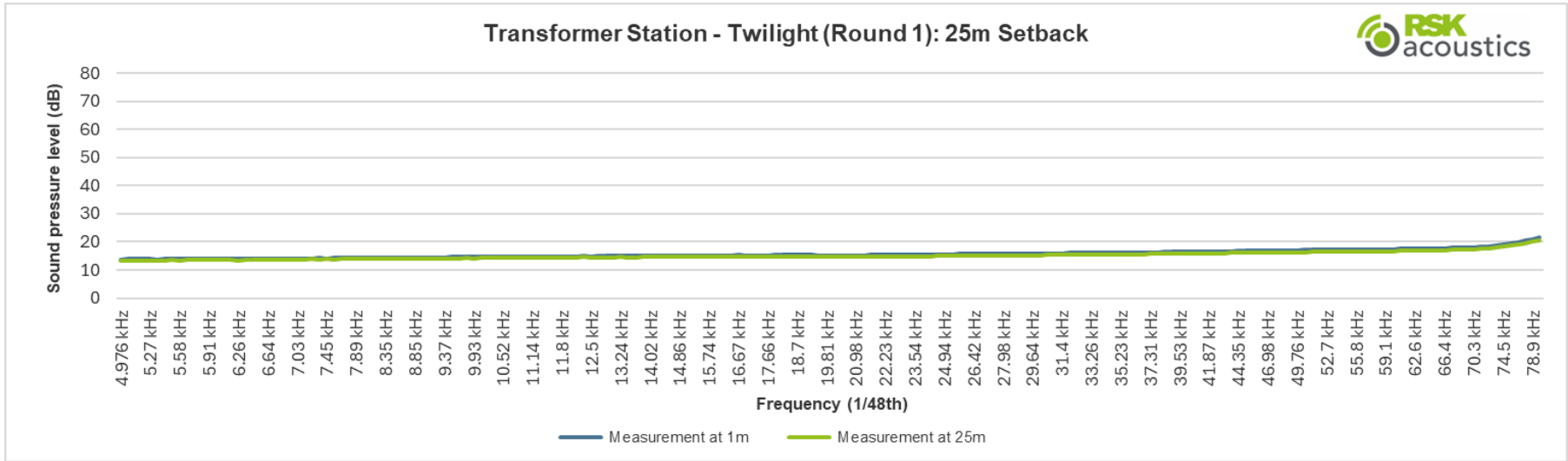


Figure 54: Transformer station, twilight measurement (Round 1), 25m setback

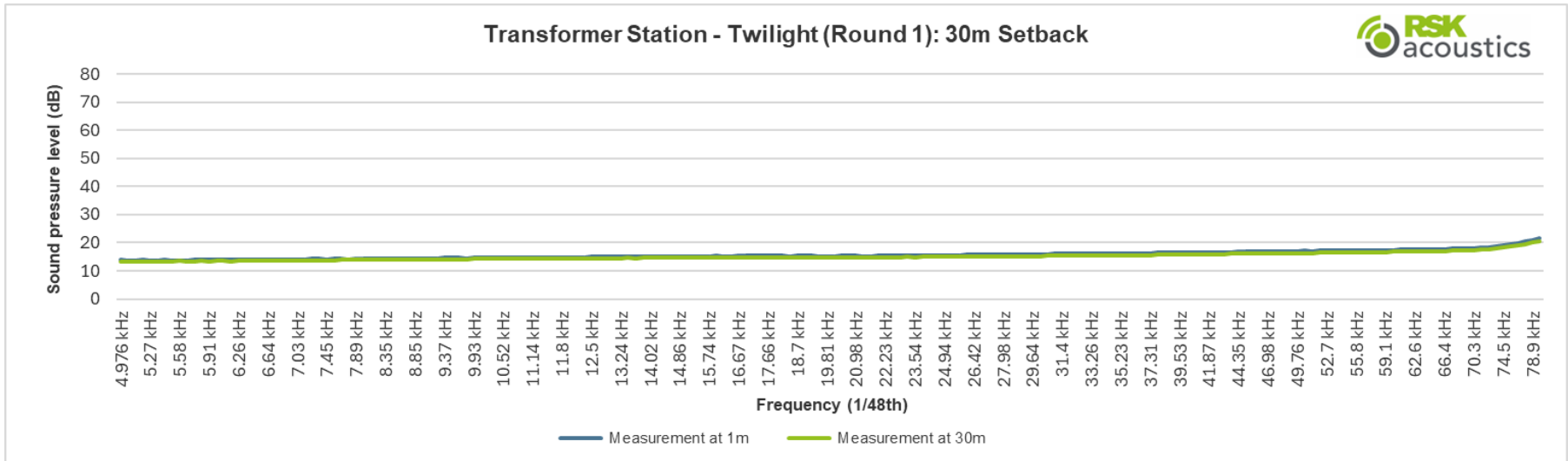


Figure 55: Transformer station, twilight measurement (Round 1), 30m setback



11 Results – Transformer Station, Twilight (Round 2)

11.1 Graphical outputs

The following graphical outputs are provided for the second round of twilight transformer station measurements:

- Figure 56: Transformer station, twilight measurement (Round 2), 5m setback
- Figure 57: Transformer station, twilight measurement (Round 2), 10m setback
- Figure 58: Transformer station, twilight measurement (Round 2), 15m setback
- Figure 59: Transformer station, twilight measurement (Round 2), 20m setback
- Figure 60: Transformer station, twilight measurement (Round 2), 25m setback
- Figure 61: Transformer station, twilight measurement (Round 2), 30m setback

All measurement data is presented as unweighted noise levels, dB L_{Zeq}.



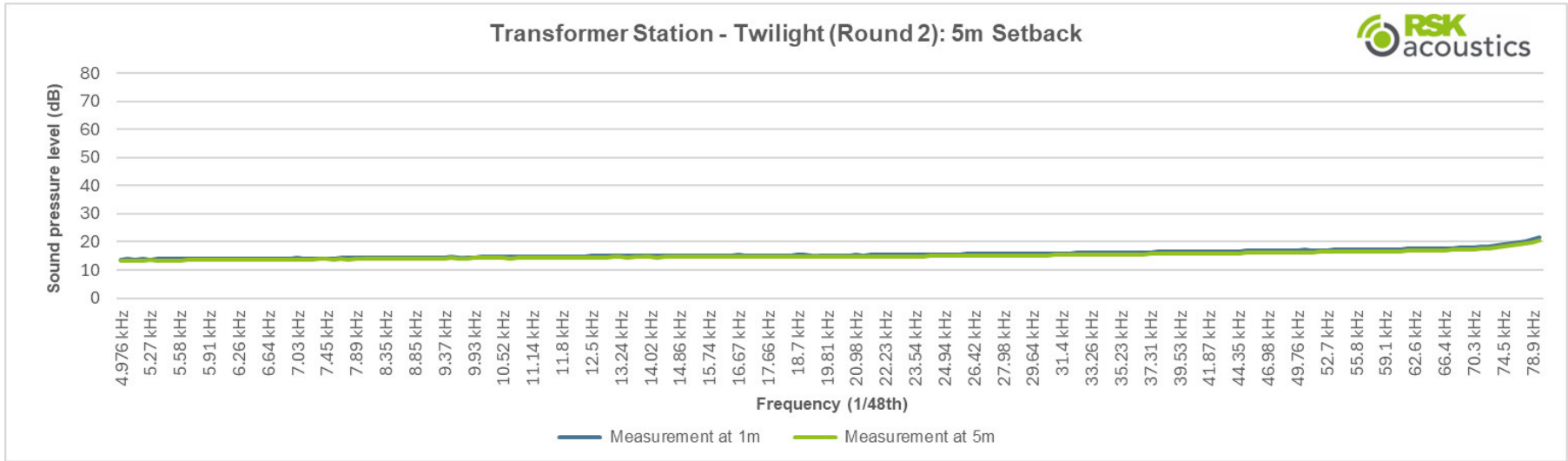


Figure 56: Transformer station, twilight measurement (Round 2), 5m setback

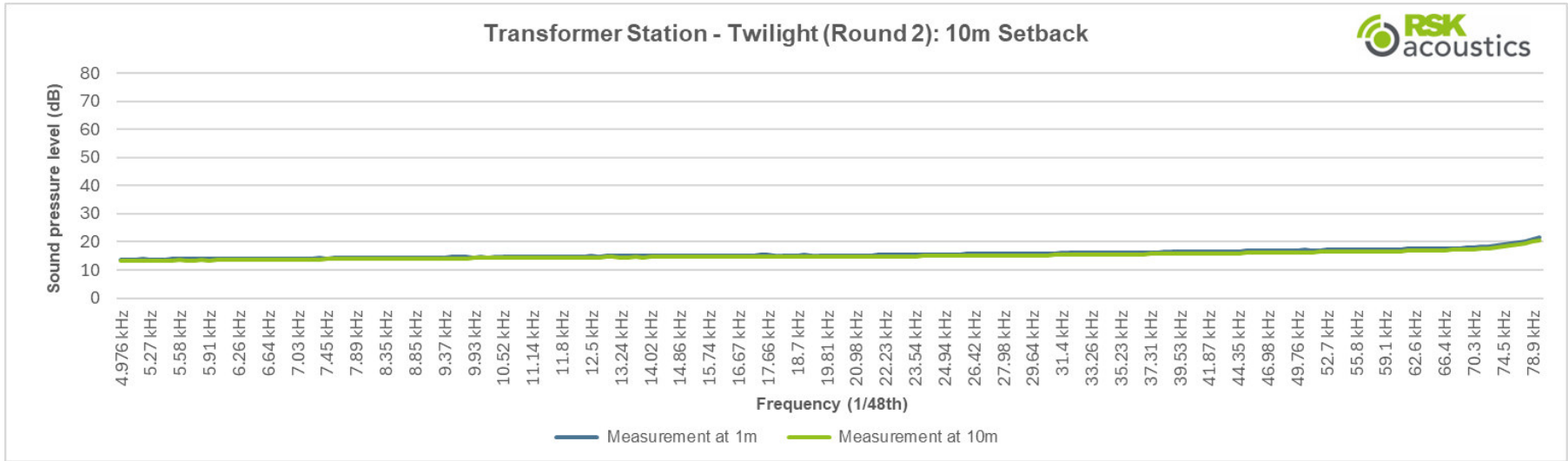


Figure 57: Transformer station, twilight measurement (Round 2), 10m setback



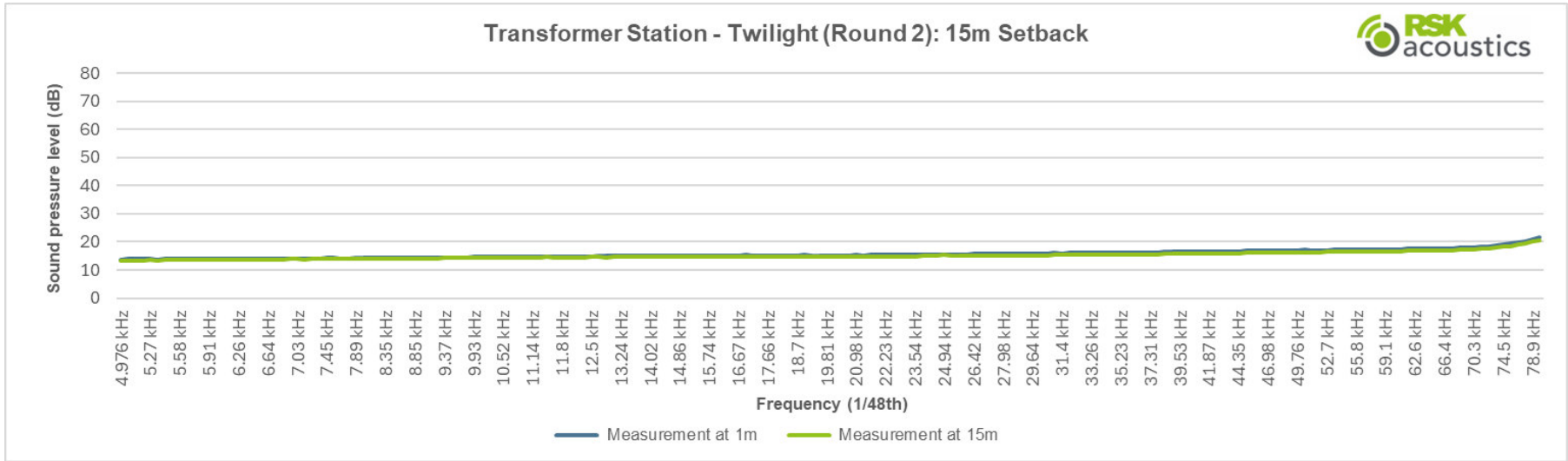


Figure 58: Transformer station, twilight measurement (Round 2), 15m setback

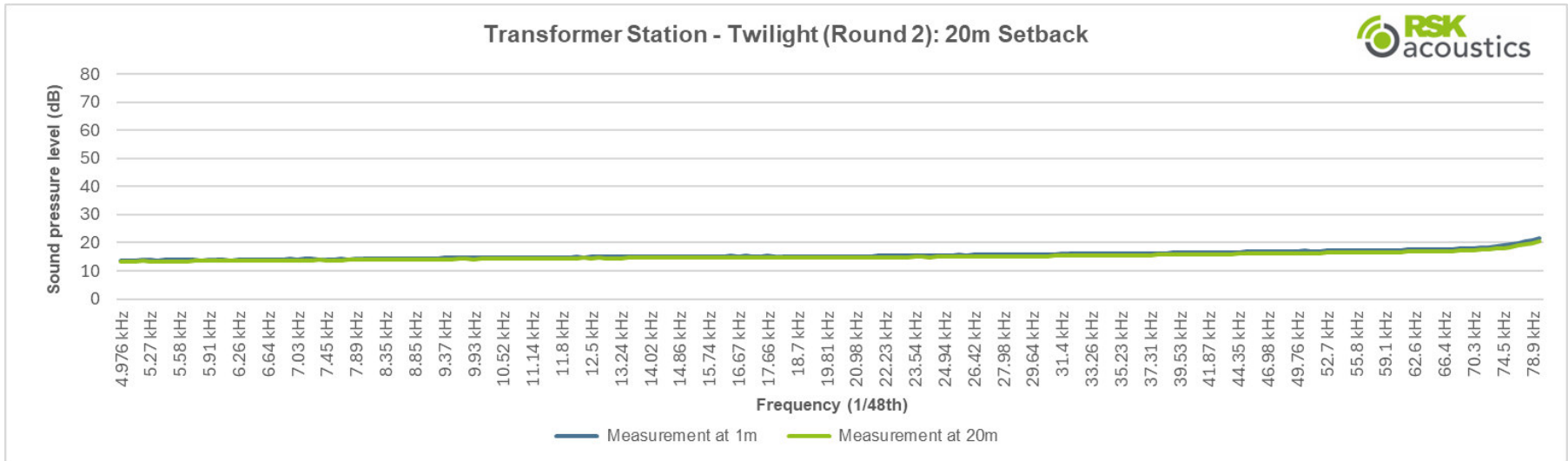


Figure 59: Transformer station, twilight measurement (Round 2), 20m setback



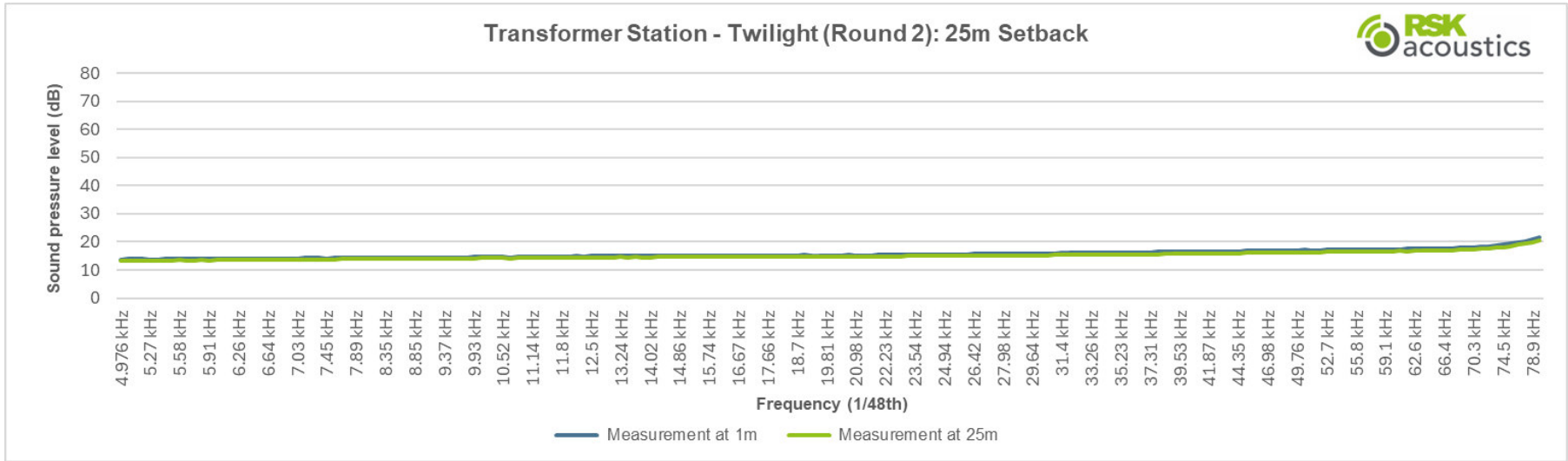


Figure 60: Transformer station, twilight measurement (Round 2), 25m setback

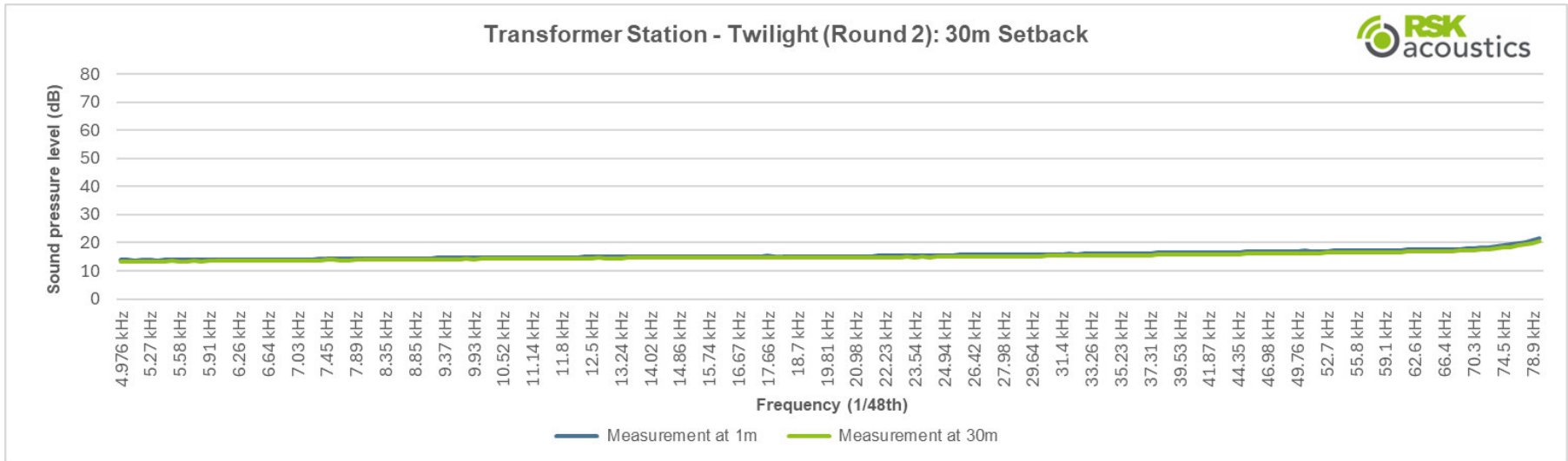


Figure 61: Transformer station, twilight measurement (Round 2), 30m setback



12 Overview of Results

12.1 String Inverter – Daytime Measurements

- The 1m reference measurements for the string inverter show pronounced noise emissions at 14 kHz and at harmonic frequencies e.g. 28 kHz, 42 kHz, 56 kHz and 70 kHz. The 14 kHz noise levels at the 1m reference measurement were in the range of 60 to 69 dB L_{Zeq} , with lower emissions at each subsequent harmonic frequency.
- The noise levels decay with increased distance from the string inverter. For the dominant 14 kHz frequency band, the noise levels at 15m setback and beyond are typically in the range of 40 to 45 dB L_{Zeq} .
- For the harmonic frequencies at 28 kHz, 42 kHz, 56 kHz and 70 kHz, the noise levels at setback distances beyond 10m were below 30 dB L_{Zeq} in all instances.

12.2 String Inverter – Twilight Measurements

- There was no apparent ultrasonic noise emissions from the string inverter during both rounds of twilight noise measurements. The measured noise levels presented in the graphical outputs for the twilight period are considered to represent the noise floor of the measurement system.

12.3 Transformer Station – Daytime Measurements

- The daytime measurements for the transformer station identify pronounced noise emissions at 14 kHz for both the setback measurements and the 1m reference measurements. The 14 kHz noise levels were below 40 dB L_{Zeq} in all instances.
- For certain measurements, the 14 kHz noise levels at the setback measurements were higher than the corresponding 1m reference measurement. This would imply that the source of the ultrasonic may not have been entirely attributable to the transformer station or there were localised screening effects close to the unit.

12.4 Transformer Station – Twilight Measurements

- During the first round of twilight measurements for the transformer station, discrete noise emissions were evident at 14 kHz. This occurred at the 5m, 10m and 15m setback distance measurements.
- At the 5m and 10m setback distances, the 14 kHz noise level levels were very low at less than 20 dB L_{Zeq} for both the setback measurement and the 1m reference measurement.
- At the 15m setback, the 14 kHz levels were elevated relative to the 5m and 10m setback distances. For this measurement, the level recorded at 15m was higher than the corresponding 1m reference measurement. This would imply that the source of the ultrasonic noise may not have been entirely attributable to the transformer station or there were localised screening effects close to the unit.
- There was no apparent ultrasonic noise emissions at other setback distances. The measured noise levels presented in the graphical outputs for these setback distances are considered to represent the noise floor of the measurement system.
- There was no apparent ultrasonic noise emissions during the second round of twilight measurements for the transformer station. The measured noise levels presented in the graphical outputs for the second round of twilight measurements are considered to represent the noise floor of the measurement system.



13 Measured Noise Levels – 12.5 Hz to 20 kHz Range

13.1 Overview

As noted in Section 2, in addition to the ultrasonic noise measurements, measurements were also taken using a conventional sound level meter located at a distance of 1m from the string inverter and transformer station. The noise emissions in the 12.5 Hz to 20 kHz frequency range were measured throughout the duration of each round of ultrasonic measurements and were taken to enable comparison with manufacturer’s data, where necessary.



Figure 62: Example of noise levels measured using different measurement systems

Table 5 presents the measurements taken within the 12.5 Hz to 20 kHz frequency range.

Equipment	Period	Measurement round	Measurement duration	Measured noise level at 1m
String inverter	Daytime	Daytime, Round 1	10:55 to 11:37 hrs	63 dB $L_{Aeq,T}$
		Daytime, Round 2	12:24 to 12:57 hrs	63 dB $L_{Aeq,T}$
		Daytime, Round 3	14:01 to 14:24 hrs	65 dB $L_{Aeq,T}$
	Twilight	Twilight, Round 1	22:25 to 22:56 hrs	35 dB $L_{Aeq,T}$
		Twilight, Round 2	00:13 to 00:39 hrs	32 dB $L_{Aeq,T}$
Transformer station	Daytime	Daytime, Round 1	17:27 to 18:11 hrs	55 dB $L_{Aeq,T}$
		Daytime, Round 2	13:07 to 13:32 hrs	54 dB $L_{Aeq,T}$
	Twilight	Twilight, Round 1	21:31 to 22:05 hrs	45 dB $L_{Aeq,T}$
		Twilight, Round 2	23:07 to 23:45 hrs	43 dB $L_{Aeq,T}$

Table 5: Measured noise levels (12.5 Hz to 20 kHz frequency range)



13.2 Surveyor Observations

During the daytime measurement periods, the noise emissions generated by both the string inverter and transformer station were the dominant source of noise when close to each item of equipment. The prominence of the noise emissions reduced with increased setback distance, however, they were perceptible throughout. Other noise contributions included bird song/calls, aircraft movements and distant road traffic.

During the twilight measurement periods, there was no perceptible noise from the string inverter. The transformer station continued to generate noise, albeit quieter than the daytime period.



14 Noise Survey Limitations

Given the nature of the noise monitoring that has been undertaken, there are inherent limitations, as noted below:

- **Measurement locations and source directivity** - Given the presence of PV panels across the site, in addition to other noise emitting equipment that could influence the measurements, the areas available to carry out the noise monitoring were limited. These factors have served to dictate the horizontal alignment of the noise monitoring positions as shown in Figure 3, and therefore it has not been feasible to take the directivity of noise emissions from the unit into account.
- **Extraneous noise data** – The noise monitoring was undertaken within an existing solar park facility, as opposed to measurements being taken within a controlled environment e.g. an anechoic chamber. As a result, the measurements included extraneous noise sources, including distant road traffic, birds, aircraft.
- **Equipment specifications** – The measured noise levels obtained for PV equipment at the Burwell Solar Farm are representative of the specific units that have been subject to monitoring. However, it is expected that the resultant noise levels would generally be representative of other similar items of equipment.
- **Windshield correction** – Windshields were used for the ultrasonic microphones to control wind induced noise on the microphone, however, there is no windshield correction provided by the manufacturer which covers the full ultrasonic frequency range and therefore this has not been accounted for within the results.

To address this, a series of concurrent measurements were taken with two microphones situated side by side; one microphone included a windshield and the other did not (refer to Figure 63 below). This provided comparative datasets for a range of setback distances to establish the potential screening effects provided by the microphone windshield. Based on the graphical outputs presented in Appendix B, it is considered that the windshield does not significantly affect the dataset.



Figure 63: Comparative measurements 'with' and 'without' windshields



Appendix A – Glossary

Term	Definition
dB	Decibel. Scale for expressing sound pressure level. It is defined as 20 times the logarithm of the ratio between the root mean square pressure of the sound field and a reference pressure i.e. 2×10^{-5} Pascal.
Frequency	The repetition rate of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted as kHz, e.g. 2 kHz = 2000 Hz. Human hearing ranges approximately from 20 Hz to 20kHz. The bat hearing range is expected to be up to 80kHz.
$L_{eq,T}$	<p>Sound levels tend to fluctuate, and as such an 'instantaneous' measurement like sound pressure level cannot fully describe many real-world situations. A summation can be made of the measured sound energy over a certain period, and a notional steady level can be calculated which would contain the same total energy as the fluctuating sound.</p> <p>This notional level is termed the equivalent continuous sound level L_{eq}. L_{eq} can be determined over any time period, which is indicated as $L_{eq,T}$ where T is the time period (e.g. $L_{eq,1min}$).</p>
Frequency weightings	<p>Frequency weighting networks, which are generally built into sound level meters, attenuate the signal at some frequencies and amplify it at others.</p> <p>The A-weighting network approximately corresponds to human frequency response to sound. Sound levels measured with the A-weighting network are expressed in dB(A) or L_{Aeq}.</p> <p>The Z-weighting is linear i.e. unweighted across the measured frequency range. Sound levels measured with the Z-weighting network are expressed in dB(Z) or L_{Zeq}.</p>
Octave bands	To define the frequency content of a noise, the spectrum is divided into frequency bands, and the sound pressure level is measured in each defined band.



Appendix B – Windshield Comparative Measurements



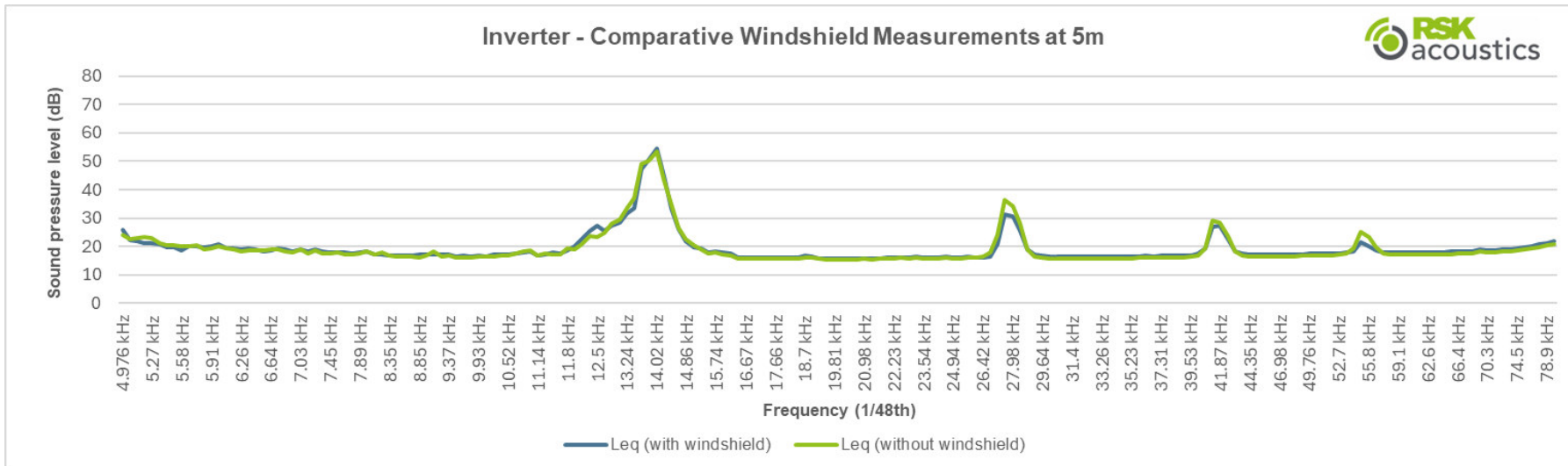


Figure 64: Comparative string inverter measurements 'with' and 'without' windshield, 5m setback

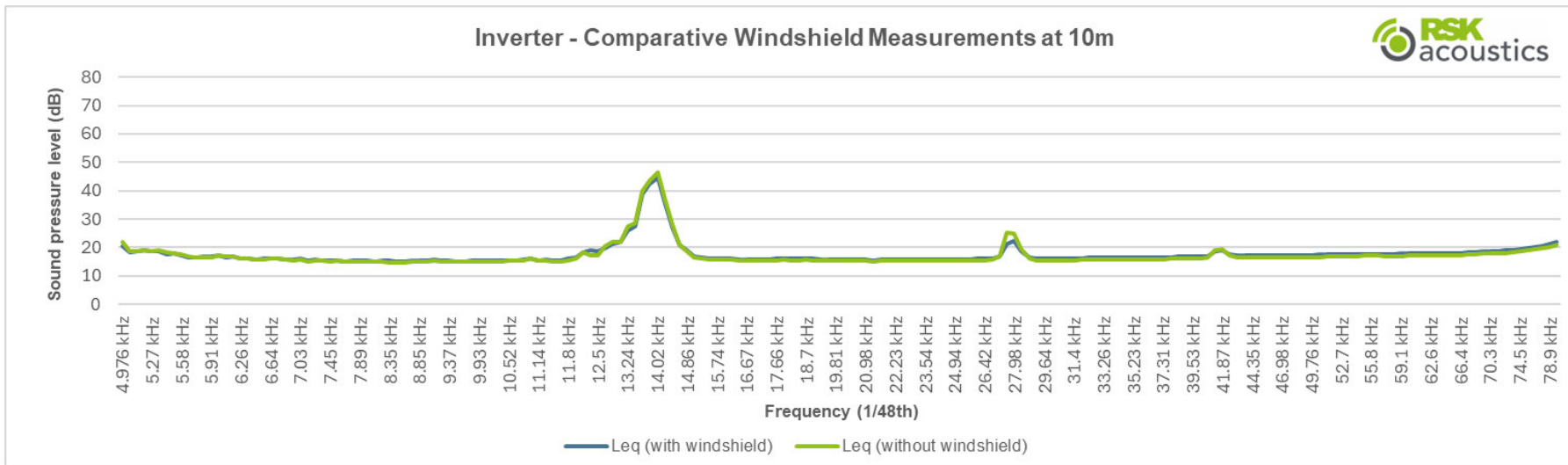


Figure 65: Comparative string inverter measurements 'with' and 'without' windshield, 10m setback



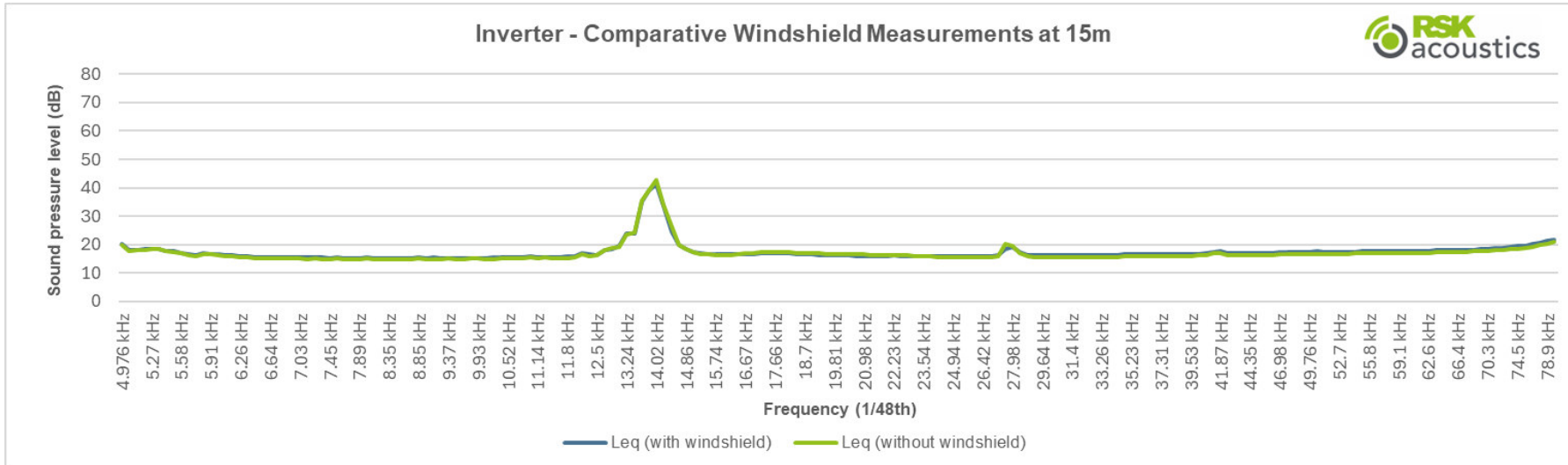


Figure 66: Comparative string inverter measurements 'with' and 'without' windshield, 15m setback

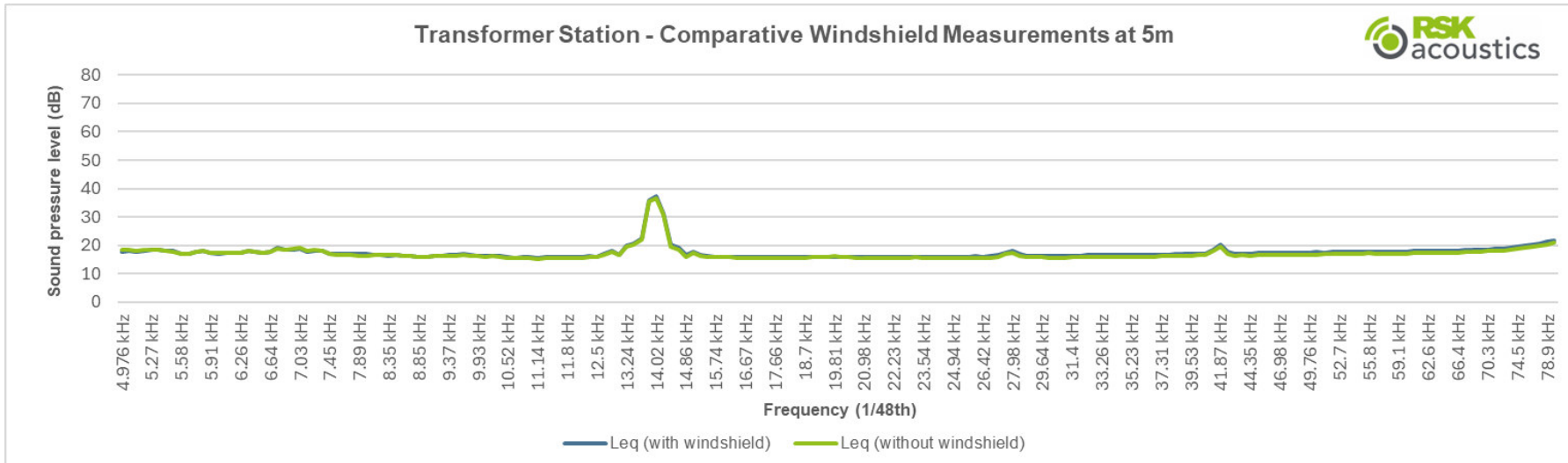


Figure 67: Comparative transformer station measurements 'with' and 'without' windshield, 5m setback



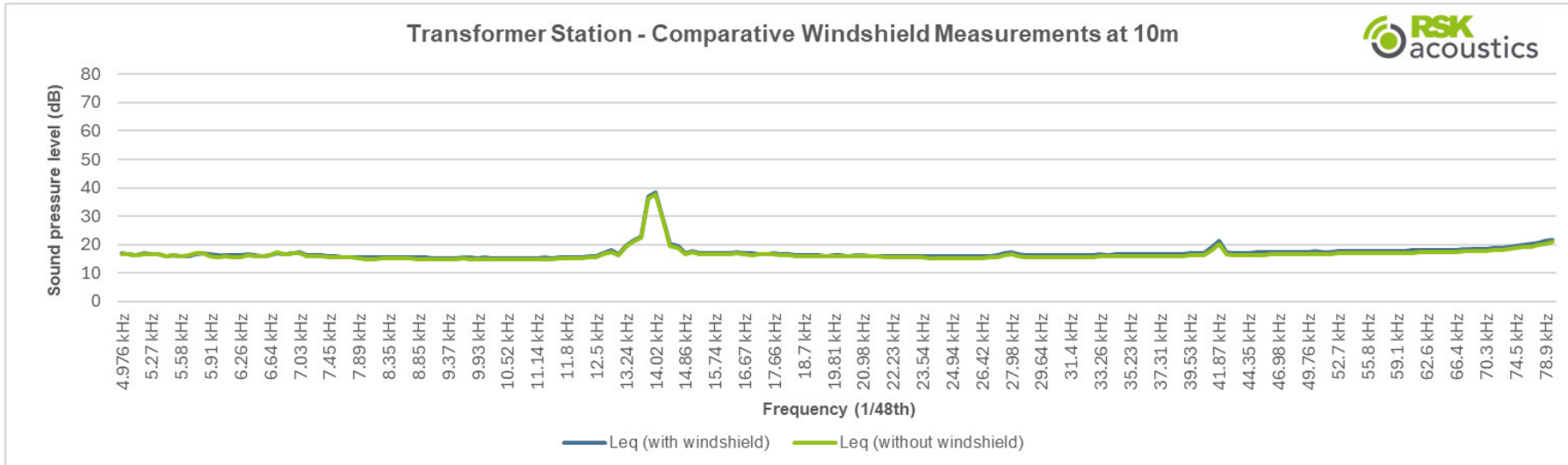


Figure 68: Comparative transformer station measurements 'with' and 'without' windshield, 10m setback

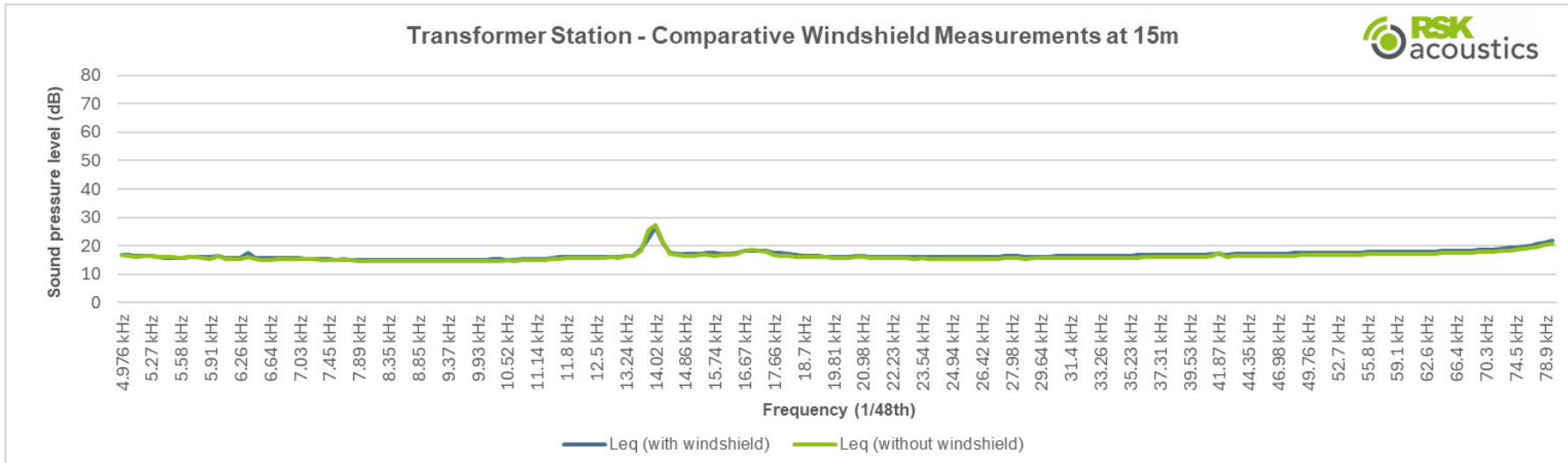


Figure 69: Comparative transformer station measurements 'with' and 'without' windshield, 15m setback





Appendix B

EDF Coventry BESS Noise
Verification Exercise





EDF Coventry

BESS Noise Verification Exercise

Pivoted Power LLP

Alexander House, 1 Mandarin Road, Rainton Bridge Business Park, Houghton Le Spring, Sunderland, DH4 5RA

Prepared by:

SLR Consulting Limited

Broadwalk House, Southernhay West, Exeter, EX1 1GE

SLR Project No.: 403.065866.00001

Client Reference No: UK.085250

24 September 2025

Version: 1

Revision Record

Version	Date	Prepared By	Checked By	Authorised By
1	24 September 2025	A. Tomlinson MIOA	M. Dawson MIOA	M. Dawson MIOA

Basis of Report

This document has been prepared by SLR Consulting Limited (SLR) with reasonable skill, care and diligence, and taking account of the timescales and resources devoted to it by agreement with Pivoted Power LLP (the Client) as part or all of the services it has been appointed by the Client to carry out. It is subject to the terms and conditions of that appointment.

SLR shall not be liable for the use of or reliance on any information, advice, recommendations and opinions in this document for any purpose by any person other than the Client. Reliance may be granted to a third party only in the event that SLR and the third party have executed a reliance agreement or collateral warranty.

Information reported herein may be based on the interpretation of public domain data collected by SLR, and/or information supplied by the Client and/or its other advisors and associates. These data have been accepted in good faith as being accurate and valid.

The copyright and intellectual property in all drawings, reports, specifications, bills of quantities, calculations and other information set out in this report remain vested in SLR unless the terms of appointment state otherwise.

This document may contain information of a specialised and/or highly technical nature and the Client is advised to seek clarification on any elements which may be unclear to it.

Information, advice, recommendations and opinions in this document should only be relied upon in the context of the whole document and any documents referenced explicitly herein and should then only be used within the context of the appointment.



Executive Summary

A survey has been undertaken to evaluate the sound levels (in both the human audible frequency range, and the ultrasonic frequency range) of an existing operational battery energy storage site (BESS) in Coventry.

The measured sound levels have been used to assess the potential impacts upon the local bat population, utilising the guidance set out in the '*UK Bat Mitigation Guidelines – A guide to impact assessment, mitigation and compensation for developments affecting bats*' version 1.1.

The outcomes of the assessment of noise from the BESS units (and transformers/Inverters) found that audible and ultrasonic noise from the BESS units was only dominant within 5 meters of the source, with other louder sources, such as nearby transformers/Inverters and the M6 motorway, having a greater impact at longer distances.

The combined noise from the 19 BESS units and 10 transformers/Inverters was calculated to be between 47-53 dB in the human audible range and 56-58 dB in the ultrasonic range at the receptor location. While the ultrasonic levels exceed the '*Bat Mitigation Guidelines*' example of "*gently rustling reeds*" (50 dB), the effects of air absorption, which were not fully factored into the calculations, would likely reduce these levels to be much lower in practice. The operational BESS site noise is also significantly below the levels from other examples in the guidelines, such as hydraulic piling, which is considered to have no significant effect on bats. Additionally, because the site is located next to a similar, larger National Grid Facility, local bat populations are likely already accustomed to similar noise sources. Therefore, it's concluded that noise associated with the BESS site will not have any significant negative impact on the local bat population.



Table of Contents

Basis of Report	i
Executive Summary	ii
1.0 Introduction	1
1.1 Site Description	2
2.0 Guidance and Standards	3
2.1 Bat Mitigation Guidelines	3
3.0 Noise Survey	5
3.1 Survey Dates	5
3.2 Equipment and Measurements	5
3.3 BESS Noise Measurements – Results	6
3.3.1 Human Audible Frequency Range	7
3.3.2 Ultrasonic Frequency Range	9
3.4 Receptor Noise Measurements – Results	0
4.0 Analysis of Results	1
4.1 Noise Source Identification and Dominance	1
4.2 Unexpected Sound Propagation	1
4.2.1 Reconciling Noise Measurements at the Nearby Receptor Location	1
4.2.2 Discussion in Relation to the Bat Mitigation Guidelines	1
4.2.3 Context of Existing Site Conditions	2
5.0 Closure	3

Tables in Text

Table A: Sound Monitoring Equipment	5
Table B: BESS Noise Measurement Results	8
Table C: Ultrasonic Noise Measurement Results	9
Table D: Receptor Noise Measurement Results (dB)	0

Figures in Text

Figure A: Site Overview – Red Line Boundary in Red	2
Figure B: North BESS Unit Measurements	6
Figure C: South BESS Unit and Transformer/Inverter Measurements	7
Figure D: North BESS Unit – Octave Band Measurement Results	0
Figure E: South BESS Unit – Octave Band Measurement Results	1
Figure F: Transformer/Inverter – Octave Band Measurement Results	2



Figure G: Bat Mitigation Guidelines – Hydraulic Drop Hammer Piling Example 2

Appendices

Appendix A Glossary of Terminology

A.1 Acoustic Terminology

Appendix B Noise Survey Results



1.0 Introduction

SLR Consulting Limited (SLR) has been appointed by Pivoted Power LLP (PP) to undertake a noise verification exercise and assess impacts upon the local bat population in relation to the as-installed Battery and Energy Storage Systems (BESS) installed at their Coventry site, off the B4109, CV2 1NQ.

This report details:

- A summary of the results of the noise survey conducted at the site.
- An assessment of the measured noise levels against the relevant guidance.

Whilst reasonable effort has been made to ensure that this report is easy to understand, it is necessarily technical in nature. To assist the reader, a glossary of terminology is provided in **Appendix A**.



1.1 Site Description

The Site is located on Parrots Grove to the north east end of Coventry, and is adjacent to a National Grid Asset.

An illustrative masterplan image of the proposed Site is shown in **Figure A**.

Figure A: Site Overview – Red Line Boundary in Red



2.0 Guidance and Standards

2.1 Bat Mitigation Guidelines

In 2023 the Chartered Institute of Ecology and Environmental Management (CIEEM) issued a document called ‘*UK Bat Mitigation Guidelines – A guide to impact assessment, mitigation and compensation for developments affecting bats*’ version 1.1. This document provides, amongst other information, guidance on protocol for noise impact assessments on Bats.

In case study 38, the interpretation section indicates that “*levels of 40 dB or more in the 8 to 20 kHz frequency range are not uncommon*” and that “*gently rustling reeds at a distance of around 10m result in approximately 50 dB*” in the same frequency range.

The document then goes on to indicate that “*It’s possible that non-natural, unfamiliar, or unpredictable noise exceeding 50 dB L_{Zmax} could begin to have deleterious effects (e.g., increased stress) on roosting bats*”. The document clarifies that “*However, this doesn’t mean disturbance should be considered significant as soon as construction noise exceeds that level*”.

The document provides some additional guidance in regards to contextually relevant aspects relating to bat noise impacts:

- “*In most locations, there will be some level of human-generated noise that bats are accustomed to (e.g., traffic or agricultural activities).*”
- “*For roosts, the surrounding structure (building or tree) is likely to provide some protection against high-frequency noise, especially when bats are deep within a cavity.*”
- “*A higher-level stimulus would be required to be detectable at frequencies near the upper and lower limits of a bat’s auditory capabilities. Note that ‘detectable’ does not equate to ‘disturbing’ or even ‘noticeable’.*”

In addition, case study 38 provides details of an example survey undertaken on a construction site, which advises the following method:

“Measurements were made using an Apollo™ frequency analyzer (frequency range 8kHz-80kHz) at setback distances between 10m and 40m. Two ‘Microtech Gefell MM 310’ microphones, which have a high-frequency measurement capacity, were used. Measurements were taken at the nearest safe distance with a clear line of sight to the activity. For the same activity, measurements were repeated at 5m increments until the sound was no longer dominant or the location became unsafe. Measurement distances are represented as different coloured lines in the figures below.

Results are presented as an average Z-weighted sound pressure level at each 1/48th octave band from 5kHz to 80kHz, denoted as $L_{Zeq,T}$. The preliminary data in this case study are presented as $L_{Zeq,T}$ over short periods (~30 seconds) and are, in some instances, comparable to the L_{Zmax} noise metric.”

The document goes on to discuss possible factors that should be considered towards assessing whether a noise source would have ‘deleterious effects’ on roosting bats. In this regard the document states that:

“It is possible audible non-natural, unfamiliar or unpredictable noise exceeding 50 dB L_{Zmax} could begin to have deleterious effects (e.g. increased stress) on roosting bats”. However, the document substantiates that the presence of such sources and noises would “not mean that disturbance should be considered significant”.

In addition, the document provides several factors that should be noted and given weight in any assessment of significance, which are listed below:



- *“In most locations, there will be some level of anthropogenic noise to which bats are accustomed (for example, traffic or agricultural activities).*
- *For roosts, the surrounding structure (building or tree) is likely to provide some protection against high-frequency noise, particularly where bats are deep within a cavity.*
- *A higher-level stimulus would be required to be detectable at frequencies close to the upper and lower frequency limits of a bat’s auditory capabilities (noting that ‘detectable’ does not equate to ‘disturbing’ or even ‘noticeable’). For more detail, see Reason and Bentley (2020); Harvey & Associates (2019).*
- *For bats in flight, given high sound levels produced by other bats’ echolocation, the more relevant frequency range (i.e. one which disturbs bats to the extent that they change their behaviour) is likely to be that which overlaps with echolocation, and likely at higher sound levels than 50 dB. On that basis, none of the activities above would cause sufficient noise to result in disturbance to bats in flight.*
- *The character of the sound as well as the bat species needs to be considered.”*



3.0 Noise Survey

Monitoring was undertaken in four principal formats:

- Noise level measurements in the near vicinity of an operational BESS unit(s).
- Noise level measurements at set distances from an operational BESS unit(s).
- Ultrasonic noise level measurements at set distances from an operational BESS unit(s).
- Noise level measurements at a nearby residential receptor location during the operation of an operational BESS unit(s).

The locations and associated measurement results are presented in the following sub sections, along with the survey dates and equipment used.

3.1 Survey Dates

An operational noise survey was undertaken at the site on Wednesday 13th August 2025.

3.2 Equipment and Measurements

Sound pressure level measurements were carried out using the following equipment listed in **Table A** conforming to Class 1 acoustic accuracy for sound level meters and matched calibrators.

The sound level meters were calibrated before the measurements using the handheld acoustic calibrator and the calibration was checked upon completion of the survey. No significant drift was observed with calibration offsets of ≤ 0.1 dB. The calibration chain of equipment has been maintained to traceably to national standards, no greater than one year for sound calibrators and two years for sound level meters.

Table A: Sound Monitoring Equipment

Useage	Description	Manufacturer	Type	Serial Number	Laboratory Calibration Date	Certificate Number
BESS noise measurements	Sound Level Meter	Cirrus	CR:171B	G303390	2023-12-08	204524
	Pre-Amplifier	Cirrus	MV:200F	8945F		204524
	½" Pre-Polarised Microphone	Cirrus	MK:224	214218D		204524
	Calibrator	Cirrus	CR:515	97661	2025-02-19	TCRT25/1156
Residential receptor measurements	Sound Level Meter	Cirrus	CR:171B	G301839	2023-10-26	201509
	Pre-Amplifier	Cirrus	MV:200F	10630F		201509
	½" Pre-Polarised Microphone	Cirrus	MK:224	217396D		201511
	Calibrator	Cirrus	CR:515	93674	2025-07-11	TCRT25/1538
	Pre-Amplifier	MTG	MK301E	0666	2024-10-11	100178



Useage	Description	Manufacturer	Type	Serial Number	Laboratory Calibration Date	Certificate Number
Ultrasonic Measurements	¼" Pre-Polarised Microphone	MTG	MV310	0560		
	Calibrator	Svantek	SV33B	112405	2025-05-01	100230

3.3 BESS Noise Measurements – Results

For ease of reference in the following sub-sections, measurements were undertaken at the locations shown on Figure B and Figure C.

Figure B: North BESS Unit Measurements

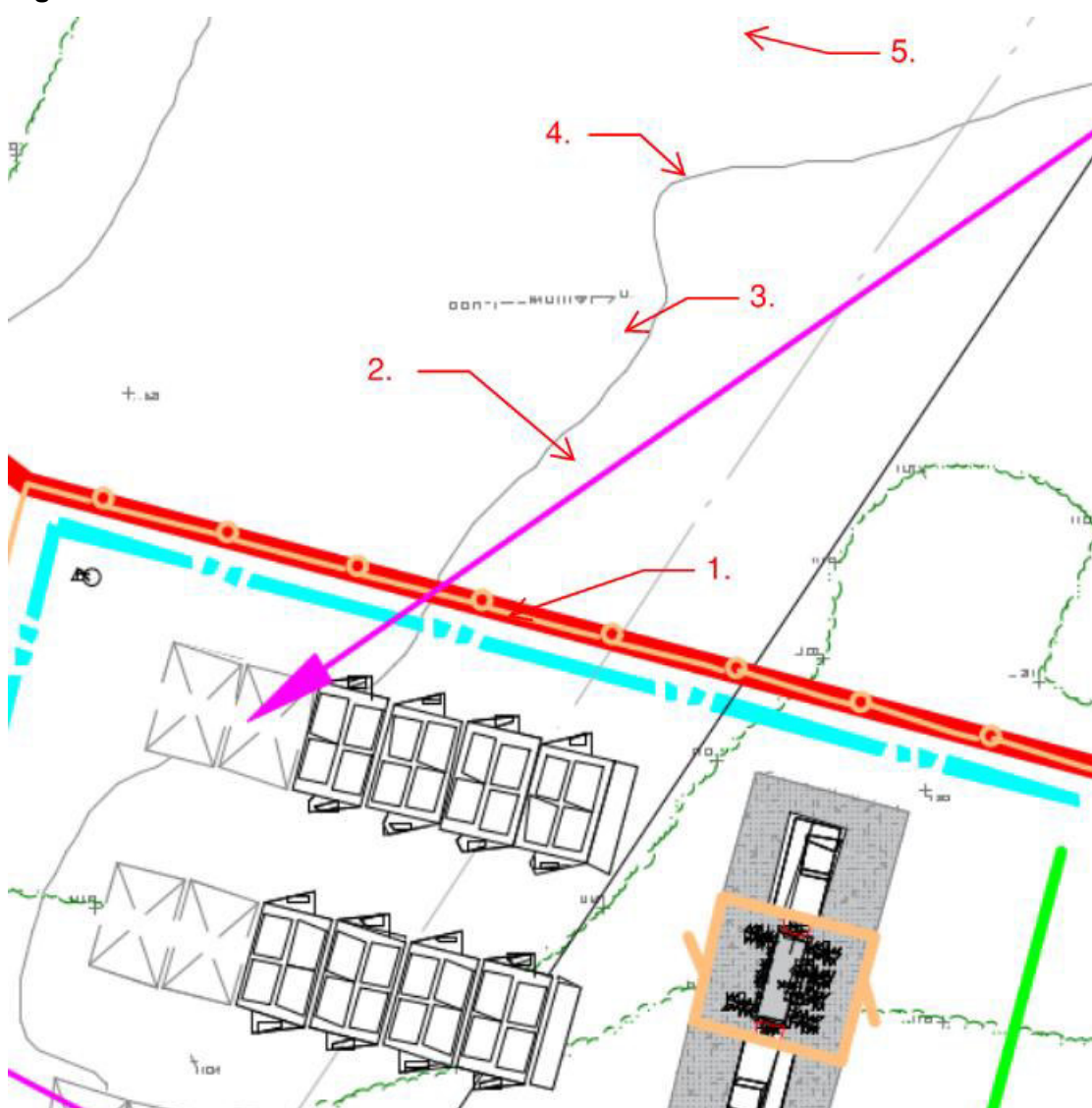
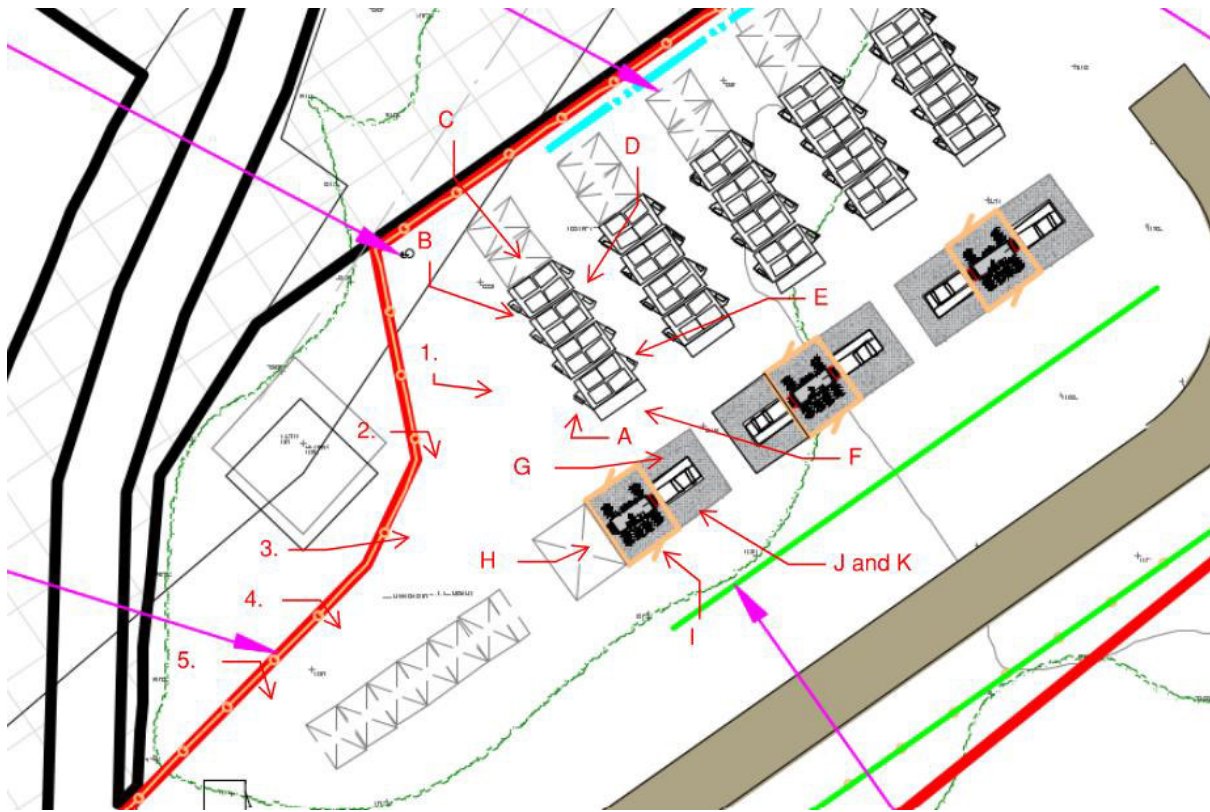


Figure C: South BESS Unit and Transformer/Inverter Measurements



3.3.1 Human Audible Frequency Range

A summary of the environmental sound survey results is presented in



Table B.

During the survey of the BESS units, the survey engineer noted that noise emanating from the BESS unit was relatively insignificant beyond 5m from the unit. Although remaining at a relatively low level, a specific set of plant items at the site became the dominant noise source; the transformer/Inverter. These units were positioned in a row alongside the BESS units. In addition, it was also noted that extraneous noise emanating from the M6 motorway contributed significantly to the measured levels at all measurement locations beyond those measured at 1m from the BESS unit and the transformer/Inverter (measurements at locations A-K on **Figure C**).

It was noted that, during the 5m measurement of the north most BESS unit, the transformer/Inverter was not visible and therefore screened from the measurement location, whereas in the measurements at 10m and beyond, more of the transformer/Inverter units became visible and therefore contributed increasingly to the measured levels.

A similar effect was true for the south most BESS unit measurements.

The above was not possible to mitigate due to the terrain of the site and the relatively constant operation of the transformer/Inverter units and noise emanating from the M6.



Table B: BESS Noise Measurement Results

Plant Item	Measurement Location (See Figure B and Figure C)	Distance from Unit (m)	$L_{Aeq,5min}$ (dB)	L_{AFmax} (dB)	$L_{A90,1min}$ Range (dB)
North most BESS Unit	1	5	54	57	52 - 53
	2	10	55	76	53 - 53
	3	15	57	61	56 - 56
	4	20	57	65	54 - 56
	5	25	59	71	56 - 58
South most BESS Unit	1	5	60	64	57 - 59
	2	10	57	67	55 - 57
	3	15	58	63	57 - 57
	4	20	58	63	56 - 57
	5	25	58	64	55 - 56
Adjacent to battery Unit 19	A	1	65	66	64
	B	1	65	66	64
	C	1	60	62	60
	D	1	68	70	68
	E	1	66	67	65
	F	1	61	62	60
On site, adjacent to transformer/Inverter	G	1	63	64	62
	H	1	63	64	62
	I	1	62	63	61
	J	1	68	71	67 - 71
On site, adjacent to transformer/Inverter w/ ultrasonic	K	1	70	71	69 - 69



3.3.2 Ultrasonic Frequency Range

A summary of the environmental sound survey results is presented in **Table C**.

As discussed in **Section 3.3.1**, due to the highly directional nature of ultrasonic sound, the contribution of the transformer/Inverter units is evident on the measurement results beyond 10m from the respective units.

Table C: Ultrasonic Noise Measurement Results

Position	Measurement Location (See Figure B and Figure C)	Distance from Unit (m)	L_{ZEq} (dB)	L_{ZFMax} (dB)
North most BESS Unit	1	5	66	81
	2	10	65	78
	3	15	67	81
	4	20	73	93
	5	25	71	89
South most BESS Unit	1	5	68	80
	2	10	66	76
	3	15	68	74
	4	20	67	80
	5	25	66	75
Transformer/Inverter	K	1	79	83

In addition to the above, graphical representations of the octave band measurements for the measurements presented in **Table C** are presented in **Figure D**, **Figure E**, and **Figure F**.



Figure D: North BESS Unit – Octave Band Measurement Results

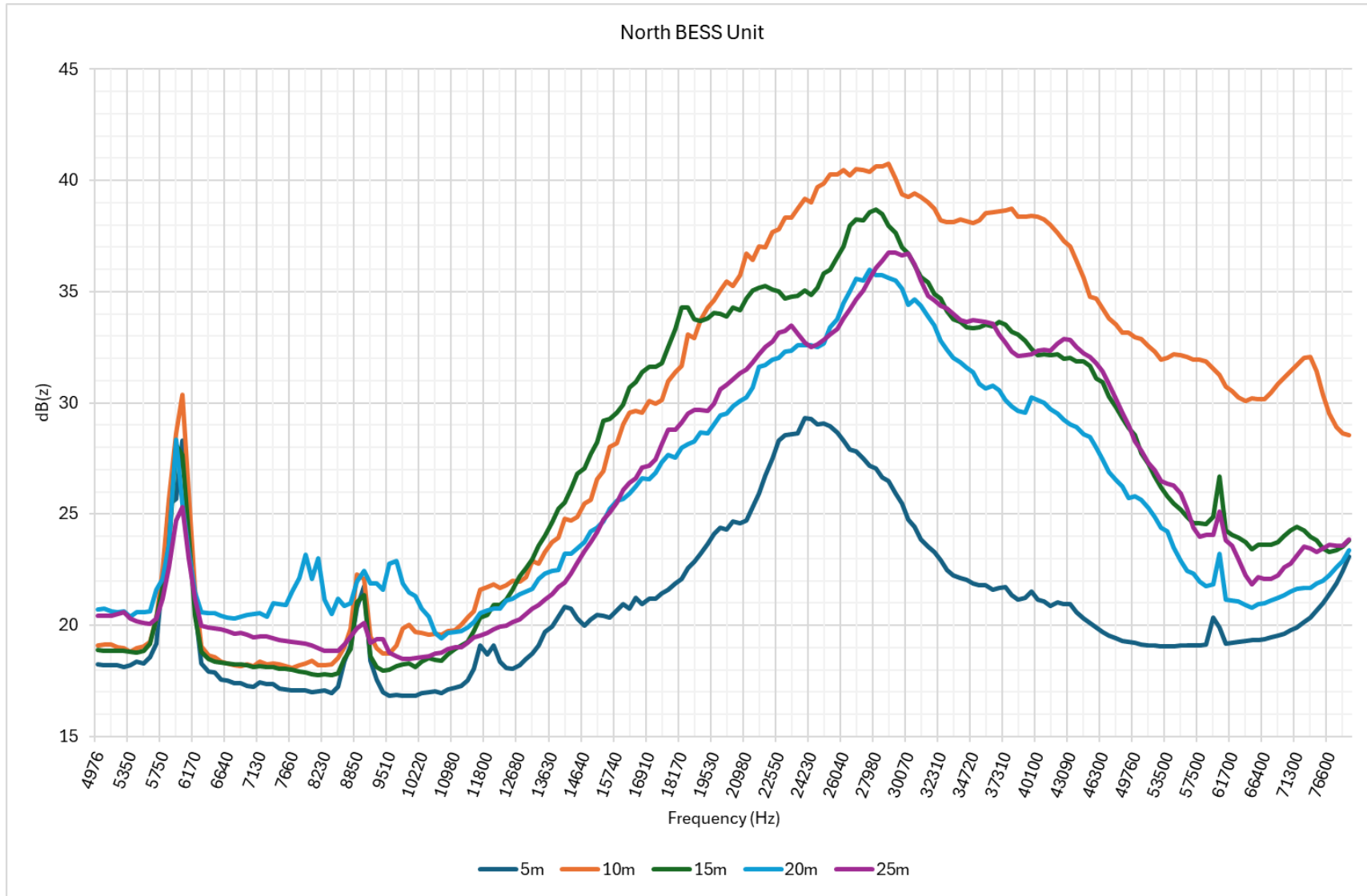


Figure E: South BESS Unit – Octave Band Measurement Results

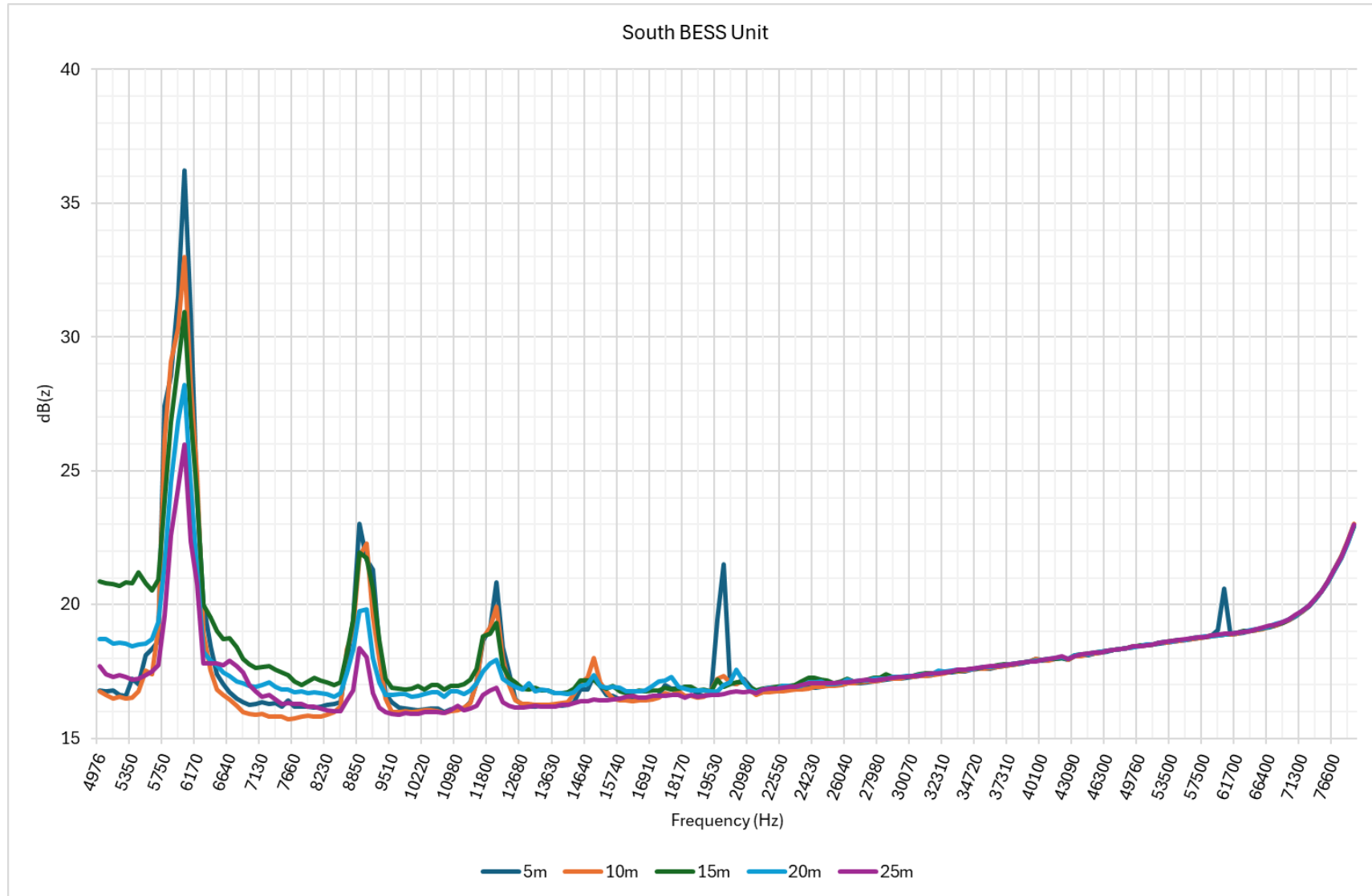
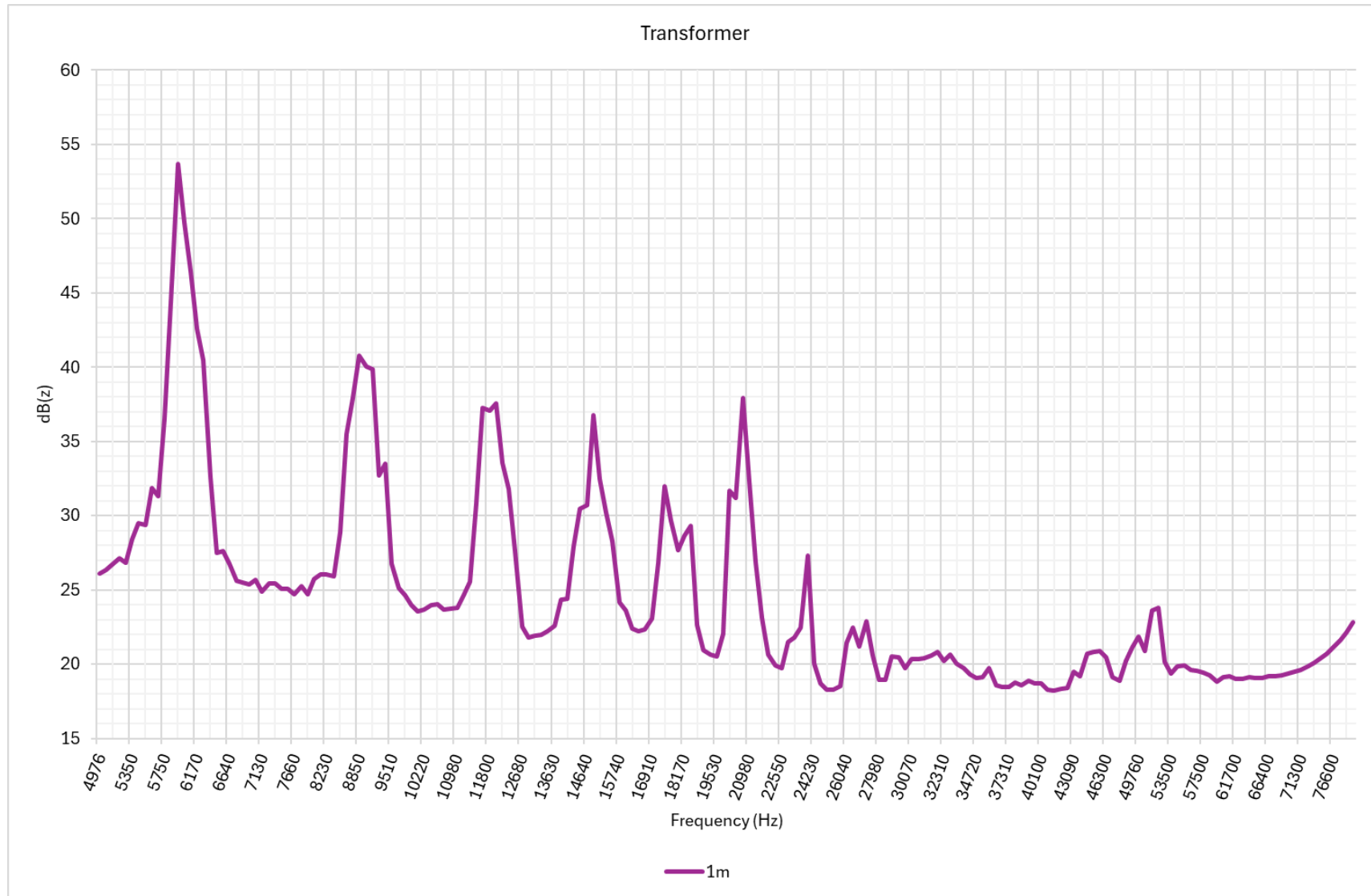


Figure F: Transformer/Inverter – Octave Band Measurement Results



3.4 Receptor Noise Measurements – Results

A summary of the environmental sound survey results is presented in **Table D**.

Table D: Receptor Noise Measurement Results (dB)

Period, T	Ambient Sound Level, $L_{Aeq, T}$	Maxima, L_{AFmax}	Background Sound Level, $L_{A90, T}$
16:30 – 16:45	55	62	53
16:45 – 17:00	55	61	54
17:00 – 17:15	55	63	53
17:15 – 17:30	55	61	53
17:30 – 17:45	56	68	54
17:45 – 18:00	54	63	52
18:00 – 18:15	54	62	53
18:15 – 18:30	53	59	52
18:30 – 18:45	54	75	52
18:45 – 19:00	53	59	51
19:00 – 19:15	53	61	52
19:15 – 19:30	54	60	52

It was noted during the survey at the receptor location that the operations from site were not able to be heard due to the ambient noise emanating from M6 motorway nearby.



4.0 Analysis of Results

4.1 Noise Source Identification and Dominance

As discussed in **Section 3.3.1**, noise emanating from the BESS units was only dominant at distances no further than 5m from the units. This was due to the presence of the operating transformer/Inverter units nearby, and the underlying contribution from the M6 motorway (approximately 300-400m to the southwest of the site).

4.2 Unexpected Sound Propagation

It would typically be expected that sound within the human audible frequency range would reduce by approximately 3-6 dB per doubling of distance from a specific sound source, depending on the absolute distance. This would effectively mean that the contribution of noise from the BESS unit(s) would be 3-6 dB lower at 10m than at 5m, and 3-6 dB lower again at 20m than at 10m. This was not the case.

This is evident in the measurement results from both the human audible range, and the ultrasonic range whereby, counterintuitively, the measured levels increase with distance from the BESS units at measurement distance beyond 10m. However, due to the additional air absorption effects upon ultrasonic frequencies, the ultrasonic levels beyond 20m from the BESS units (and also the transformers/Inverters) begin to reduce. The same would be true for the human audible frequency range likely beyond 30m.

It can be seen from the measurements nearby the transformer/Inverter that this source is clearly a significant noise source nearby the plant item in both the human audible and ultrasonic frequency range. However, demonstrably this source could not be heard at the noise sensitive receptor location to the east of the site, 80m from the north most BESS unit. Calculations would indicate that the geometric spreading reduction from 5m away a BESS unit so the receptor location would be approximately 24 dB. As the ultrasonic frequency spectrum propagates at an increased reduction per distance, the effects of which are dominated by air absorption, the contributions from the BESS site within the ultrasonic frequency spectrum would benefit from at least the same degree of geometric spreading reduction. This assumption is conservative and does not factor that most units are further away than this, and are screened in varying degrees.

4.2.1 Reconciling Noise Measurements at the Nearby Receptor Location

Based on the calculated sound propagation effects described above, this would result in contributions from the BESS site, at the receptor location of circa 33-40 dB $L_{Aeq,T}$ from each unit in the human audible frequency range, and 42-44 dB $L_{Zeq,T}$ from each unit in the ultrasonic frequency range. With regards to the transformers/Inverters, applying the same logic (38 dB of geometric spreading at 80m relative to 1m) would result in contributions at the receptor location of of circa 32 dB $L_{Aeq,T}$ from each unit in the human audible frequency range, and 41 dB $L_{Zeq,T}$ from each unit in the ultrasonic frequency range.

On the basis that there are 10 no. transformer/Inverter units and 19 no. BESS units, this would result in a potential total contribution¹ at the receptor location of 47-53 dB $L_{Aeq,T}$ in the human audible frequency range, and 56-58 dB $L_{Zeq,T}$ in the ultrasonic frequency range.

4.2.2 Discussion in Relation to the Bat Mitigation Guidelines

The Bat Mitigation Guidelines set out in **Section 2.1** which indicates that “*gently rustling reeds at a distance of around 10m result in approximately 50 dB*”. The ultrasonic

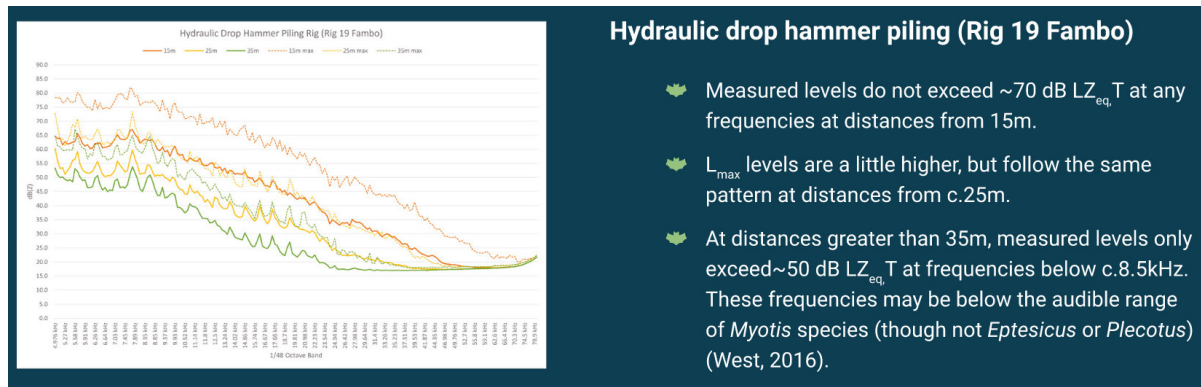
¹ $10 \cdot \log_{10}(N)$ where N is the number of units; $10 \cdot \log_{10}(10) = 10$ dB, $10 \cdot \log_{10}(19) = 13$ dB



measurement results exceed this by 6-8 dB based on the conservatively calculated levels. In practice, due to the unaccounted for air absorption, the levels would be far lower than this and likely be mathematically indiscernible from the example of the ‘gently rustling reeds’ which the bat mitigation guidelines refers to.

Of relevance, the Bat Mitigation Guidelines refers to specific measurements such as that reproduced in **Figure G**.

Figure G: Bat Mitigation Guidelines – Hydraulic Drop Hammer Piling Example



The document then goes on to conclude that “...none of the activities...would cause sufficient noise to result in disturbance to bats in flight.” On the basis that all the measured levels presented in this document are below that presented in **Figure G** at comparative distances (as well as several other noise source examples), it would be reasonable to determine that there would be no significant deleterious effects upon bats in flight from the operation of the BESS site.

4.2.3 Context of Existing Site Conditions

In regards to this site in particular, the operation of the BESS units and transformer/Inverter equipment are not dissimilar (but on a significantly smaller scale) than the existing National Grid site equipment and operations to the north.

As such, bats within the vicinity of this existing site will be tolerant of similar noise sources. It is therefore considered that there would be no significant adverse effects upon the local bat wildlife specifically relating to noise outputs from the operational BESS site.



5.0 Closure

The assessment has required a suitable level of technical ability and has been undertaken by a Suitably Qualified Person (SQP). An individual with all the following credentials has been considered a SQP for this assessment:

- Has a minimum of three years' verifiable experience (within the last five years) of providing noise impact assessments in planning. Such experience has clearly demonstrated a practical understanding of factors affecting acoustics in relation to the proposed development use and in the built environment in general, including acting in an advisory capacity to provide recommendations and design advice in planning, and;
- Holds a recognised acoustic qualification and membership of an appropriate professional body. The primary professional body for acoustics in the UK is the Institute of Acoustics.

This assessment has been led and managed by a SQP as defined above.

Where some elements of the assessment (e.g. measurements) have been carried out by an acoustician who does not meet the requirements above, this has been undertaken with the direct guidance and supervision of a SQP who has reviewed, agreed and overseen the measurement methodology and any results obtained.

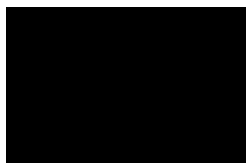
The SQP confirms that the relevant measurements and calculations:

- Represent good industry practice in accordance with available guidance.
- Are appropriate given the development being assessed and scope of works proposed.
- Avoid invalid, biased and exaggerated claims.

The checker and author of this document confirm that they both comply with the definition of a SQP defined in this Section.

Regards,

SLR Consulting Limited



Aaron Tomlinson BEng (Hons) MIOA
Principal Acoustic Consultant

Michelle Dawson MIOA
Technical Director- Acoustics &
Vibration





Appendix A Glossary of Terminology

EDF Coventry

BESS Noise Verification Exercise

Pivoted Power LLP

SLR Project No.: 403.065866.00001

24 September 2025

The human ear can detect a very wide range of pressure fluctuations, which are perceived as sound. In order to express these fluctuations in a manageable way, a logarithmic scale called the decibel, or dB scale is used. The decibel scale typically ranges from 0dB (the threshold of hearing) to over 120 dB. An indication of the range of sound levels commonly found in the environment is given in the following table.

Table A-1: Sound Levels Commonly Found in the Environment

Sound Level	Location
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 40 dB(A)	Living room during the day
40 to 50 dB(A)	Typical office
50 to 60 dB(A)	Inside a car
60 to 70 dB(A)	Typical high street
70 to 90 dB(A)	Inside factory
100 to 110 dB(A)	Burglar alarm at 1m away
110 to 130 dB(A)	Jet aircraft on take off

A.1 Acoustic Terminology

dB (decibel) The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure (of 20 μ Pa).

dB(A) A-weighted decibel. This is a measure of the overall level of sound across the audible spectrum with a frequency weighting (i.e. 'A' weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.

$L_{Aeq, T}$ $L_{Aeq, T}$ is defined as the notional steady sound level which, over a stated period T , would contain the same amount of acoustical energy as the A-weighted fluctuating sound measured over that period.

$L_{A10, T}$ & L_{A90} If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The Ln indices are used for this purpose, and the term refers to the level exceeded for $n\%$ of the time. Hence L_{10} is the level exceeded for 10% of the time and as such can be regarded as the 'average maximum level'. Similarly, L_{90} is the 'average minimum level' and is often used to describe the background noise. It is common practice to use the L_{10} index to describe traffic noise.

$L_{Amax(F)}$ $L_{Amax(F)}$ is the maximum A-weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.





Appendix B Noise Survey Results

EDF Coventry

BESS Noise Verification Exercise

Pivoted Power LLP

SLR Project No.: 403.065866.00001

24 September 2025

Table B-2: Measured sound Levels – Human Audible Frequency Range

Date	Start Time	Duration (mm:ss)	Unit	Location	L _{Aeq} (dB)	L _{AFMax} (dB)	L _{AF90} (dB)	1:1 Octave							
								63 Hz (dB)	125 Hz (dB)	250 Hz (dB)	500 Hz (dB)	1 kHz (dB)	2 kHz (dB)	4 kHz (dB)	8 kHz (dB)
13/08/2025	16:54	01:00	North BESS Unit	1	53	55	52	58	52	49	51	51	41	38	33
	16:55	01:00			54	56	52	57	51	48	51	51	41	37	32
	16:56	01:00			54	56	54	58	51	49	51	52	42	38	32
	16:57	01:00			54	57	53	58	51	49	51	51	41	38	33
	16:58	01:00			53	55	53	58	51	50	51	51	41	38	33
	16:59	01:00			54	56	53	58	51	50	51	51	42	39	33
	17:00	01:00			55	62	53	57	51	50	51	52	44	41	36
	17:02	01:00			56	62	55	59	53	50	52	53	44	39	37
	17:03	01:00			56	60	54	58	53	49	52	54	44	39	38
	17:04	01:00		2	54	57	53	58	52	49	50	53	43	38	34
	17:05	01:00			54	57	53	58	52	49	51	52	43	37	33
	17:06	01:00			55	57	54	58	52	50	51	53	43	38	33
	17:07	01:00			55	58	54	58	52	50	52	53	44	38	33
	17:08	01:00			54	55	53	57	51	49	50	51	42	37	33
	17:09	01:00			58	76	54	63	63	54	54	56	47	42	37
	17:10	01:00			55	58	54	57	51	47	51	53	43	38	36
	17:11	01:00			55	63	54	56	51	47	51	53	44	41	42
	17:12	01:00			54	58	53	57	51	46	50	53	43	36	31
	17:13	01:00		3	57	59	56	59	52	48	53	55	44	37	32
	17:14	01:00			56	59	55	57	51	48	52	55	44	35	31
17:15	01:00	57	61		55	62	56	56	54	55	44	37	32		
17:16	01:00	55	58		54	60	52	46	52	54	43	38	33		
17:17	01:00	56	59		55	58	52	47	52	54	44	37	31		
17:18	01:00	56	57		56	58	52	47	52	54	44	39	36		



Date	Start Time	Duration (mm:ss)	Unit	Location	L _{Aeq} (dB)	L _{AFMax} (dB)	L _{AF90} (dB)	1:1 Octave								
								63 Hz (dB)	125 Hz (dB)	250 Hz (dB)	500 Hz (dB)	1 kHz (dB)	2 kHz (dB)	4 kHz (dB)	8 kHz (dB)	
	17:19	01:00			58	61	56	56	52	46	54	56	46	39	38	
	17:20	01:00			58	61	56	56	51	46	55	56	46	37	31	
	17:21	01:00		4	58	61	54	65	56	48	55	56	46	40	35	
	17:22	01:00			57	59	56	61	52	46	54	55	45	38	34	
	17:23	01:00			57	59	56	60	52	46	54	56	45	36	32	
	17:24	01:00			58	60	56	58	52	46	54	56	45	35	30	
	17:25	01:00			57	60	56	61	54	47	54	55	45	36	32	
	17:26	01:00			57	59	56	60	53	47	54	55	45	39	35	
	17:27	01:00			57	61	56	57	52	47	53	55	45	37	35	
	17:28	01:00			55	61	54	56	51	45	52	54	43	37	35	
	17:29	01:00			55	58	54	55	50	44	52	54	43	34	29	
	17:30	01:00			58	65	56	57	57	54	55	56	45	36	32	
	17:31	01:00			5	58	61	56	60	55	50	55	56	45	38	31
	17:32	01:00				56	59	52	67	57	46	54	55	45	38	33
	17:33	01:00		58		62	57	57	53	46	55	56	45	37	30	
	17:34	01:00		58		60	57	60	53	47	54	56	46	38	32	
	17:35	01:00		57		60	56	57	54	49	55	55	45	37	30	
	17:36	01:00		58		60	57	58	53	47	55	56	46	35	31	
	17:37	01:00		57		66	56	57	53	45	54	56	46	37	33	
	17:38	01:00		57		60	56	59	53	45	53	56	45	35	30	
	17:39	01:00		59		63	57	62	59	53	56	56	46	36	31	
	17:40	01:00		60		71	56	65	60	59	59	57	48	40	33	
	17:59	01:00		60		63	59	61	56	52	56	58	47	38	37	
	18:00	01:00		60		63	59	60	55	52	57	59	48	41	37	
	18:01	01:00		60	63	59	61	56	54	56	58	48	40	37		
	18:02	01:00		60	63	58	59	55	52	55	58	47	41	38		



Date	Start Time	Duration (mm:ss)	Unit	Location	L _{Aeq} (dB)	L _{AFMax} (dB)	L _{AF90} (dB)	1:1 Octave							
								63 Hz (dB)	125 Hz (dB)	250 Hz (dB)	500 Hz (dB)	1 kHz (dB)	2 kHz (dB)	4 kHz (dB)	8 kHz (dB)
	18:03	01:00			59	61	58	59	56	52	55	58	47	41	38
	18:04	01:00	South BESS Unit	1	60	63	59	62	56	52	56	59	48	39	37
	18:05	01:00			59	63	58	61	56	52	56	57	47	39	37
	18:06	01:00			60	62	58	61	57	52	56	58	47	39	37
	18:07	01:00			60	62	59	61	56	52	57	59	48	39	37
	18:08	01:00			60	63	59	62	56	52	58	59	48	39	37
	18:09	01:00			60	64	59	60	55	52	57	58	48	43	41
	18:10	01:00			60	63	59	59	56	52	57	59	49	45	44
	18:11	01:00			58	59	57	59	57	52	53	56	45	41	34
	18:12	01:00			2	58	60	57	60	57	52	54	56	45	40
	18:13	01:00		58		61	57	60	57	52	54	56	46	41	34
	18:14	01:00		57		60	56	60	57	52	53	55	45	40	33
	18:15	01:00		57		58	56	60	57	52	53	54	44	40	33
	18:16	01:00		56		59	55	60	58	52	52	54	44	40	33
	18:17	01:00		57		61	56	60	61	54	53	54	46	44	42
	18:18	01:00		57		67	55	59	60	53	53	54	47	43	42
	18:19	01:00		3		58	60	57	60	60	53	54	56	47	39
	18:20	01:00			58	60	57	61	61	54	55	56	47	40	32
	18:21	01:00			59	62	58	60	63	56	55	57	48	41	34
	18:22	01:00			59	60	58	61	63	55	55	56	47	41	34
	18:23	01:00			58	60	58	60	62	54	54	56	47	41	33
	18:24	01:00	59		62	57	60	62	55	55	56	48	44	43	
	18:25	01:00	58		63	57	62	61	53	54	56	47	42	41	
	18:26	01:00	58		61	56	60	61	53	53	54	47	46	45	
	18:26	01:00	58		63	57	60	60	53	54	56	47	43	42	
	18:27	01:00	4	58	60	57	60	60	54	55	56	46	39	32	



Date	Start Time	Duration (mm:ss)	Unit	Location	L _{Aeq} (dB)	L _{AFMax} (dB)	L _{AF90} (dB)	1:1 Octave							
								63 Hz (dB)	125 Hz (dB)	250 Hz (dB)	500 Hz (dB)	1 kHz (dB)	2 kHz (dB)	4 kHz (dB)	8 kHz (dB)
	18:28	01:00			58	61	57	60	60	53	54	56	46	39	31
	18:29	01:00			58	59	57	60	60	53	54	56	46	38	31
	18:30	01:00			57	59	56	61	60	53	53	55	45	38	31
	18:31	01:00			58	60	57	61	60	53	55	56	46	39	31
	18:32	01:00			59	60	58	60	60	53	56	56	47	39	35
	18:33	01:00			57	63	56	59	59	51	52	55	46	43	42
	18:34	01:00		5	56	57	55	58	59	51	51	54	44	37	29
	18:35	01:00		5	56	58	55	58	59	51	52	54	45	37	30
	18:36	01:00		5	57	60	56	59	59	52	53	56	46	38	30
	18:37	01:00		5	58	60	57	59	59	52	54	57	47	36	29
	18:38	01:00		5	58	60	57	59	59	52	53	56	46	37	30
	18:39	01:00		5	59	64	57	59	59	53	55	56	47	41	40
	18:40	01:00		5	58	61	57	60	59	52	53	56	46	37	35
	18:41	01:00		5	58	60	57	59	59	51	53	56	47	36	29
	18:42	01:00		5	57	59	56	59	59	51	52	56	46	37	29
	18:43	01:00		5	58	62	56	60	59	53	53	56	47	42	41
	18:44	01:00	1m from BESS Unit 19	A	65	66	64	65	72	64	63	61	55	51	42
	18:45	01:00	1m from BESS Unit 19	B	65	66	64	66	69	64	63	60	54	48	40
	18:47	01:00	1m from BESS Unit 19	C	60	62	60	63	64	60	57	57	49	45	35
	18:49	01:00	1m from BESS Unit 19	D	68	70	68	66	74	72	65	62	58	55	45
	18:50	01:00	1m from BESS Unit 19	E	66	67	65	67	73	67	65	60	57	54	43
	18:51	01:00	1m from BESS Unit 19	F	61	62	60	66	65	58	58	57	50	53	42
	18:54	01:00	1m from Transformer/Inverter	G	63	64	62	68	64	64	59	59	51	52	43
	18:56	01:00	1m from Transformer/Inverter	H	63	64	62	64	64	57	61	60	49	46	37
	18:57	01:00	1m from Transformer/Inverter	I	62	63	61	66	62	59	59	57	49	53	46
	18:59	01:00	1m from Transformer/Inverter	J	65	67	63	70	69	63	59	58	54	59	51



Date	Start Time	Duration (mm:ss)	Unit	Location	L_{Aeq} (dB)	L_{AFMax} (dB)	L_{AF90} (dB)	1:1 Octave							
								63 Hz (dB)	125 Hz (dB)	250 Hz (dB)	500 Hz (dB)	1 kHz (dB)	2 kHz (dB)	4 kHz (dB)	8 kHz (dB)
	19:03	01:00			70	71	69	73	72	69	61	61	58	66	51
	19:04	01:00	1m from transformer/Inverter cooling equipment	K	69	71	69	73	72	70	62	61	57	65	51
	19:05	01:00			70	71	69	73	72	70	62	62	57	65	51
	19:06	01:00			70	71	69	73	72	70	62	62	58	66	52
	19:07	01:00			70	71	69	73	72	70	62	62	58	66	52
	19:08	01:00			70	71	69	73	73	70	62	62	58	66	52
	19:09	01:00			70	71	69	73	73	70	62	62	57	66	52



EDF Coventry BESS Site
Results of noise logging survey at Location 1 - Receptor
Wednesday 13 August 2025 to Wednesday 13 August 2025

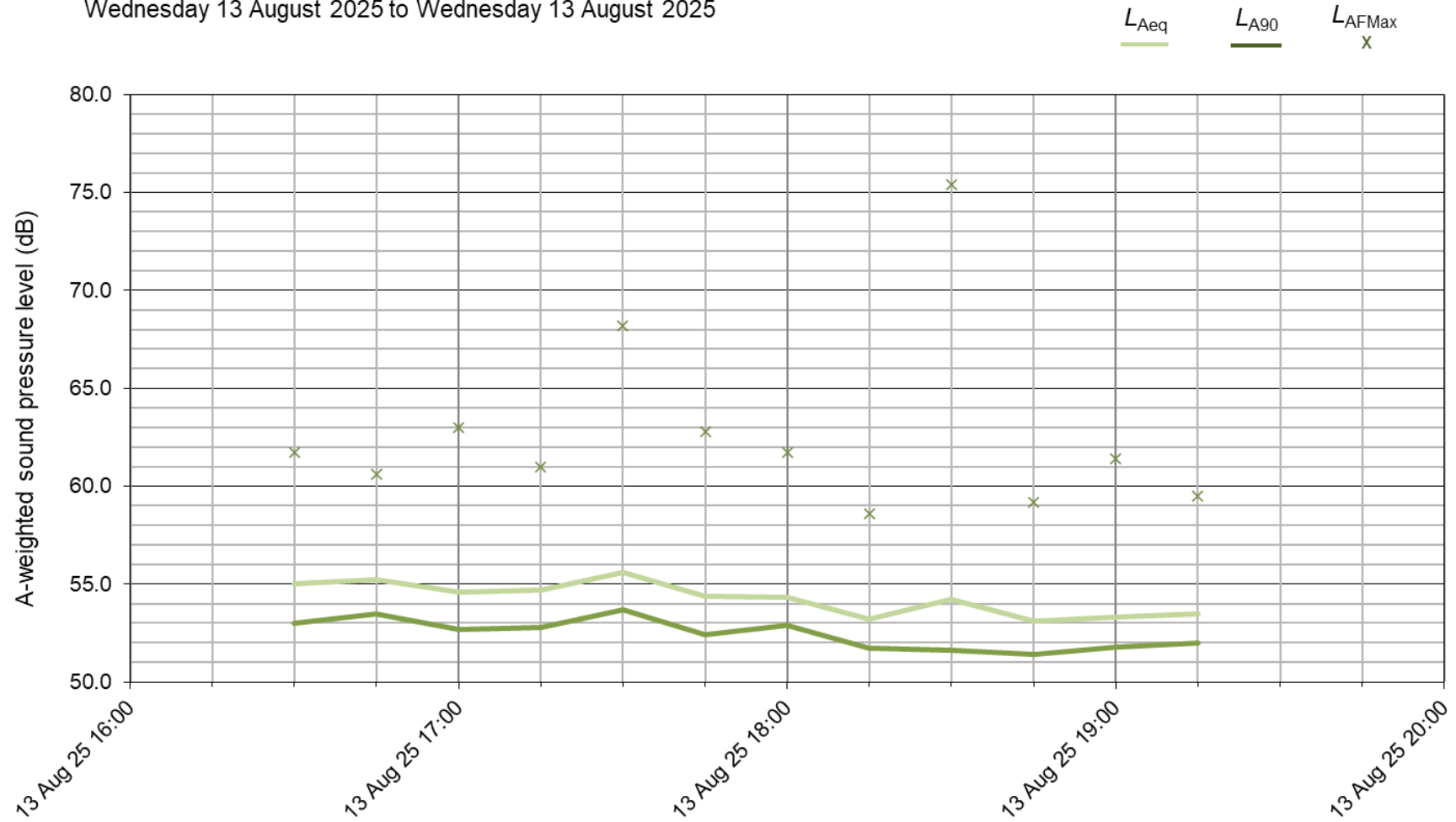


Table B-3: Measured sound Levels – Ultrasonic Frequency Range

Position		South BESS Unit					North BESS Unit					Transformer
Location		1	2	3	4	5	1	2	3	4	5	K
Distance		5m	10m	15m	20m	25m	5m	10m	15m	20m	25m	1m
LZEq		68	66	68	67	66	66	65	67	73	71	79
LZFMax		80	76	74	80	75	81	78	81	93	89	83
Duration (s)		300	300	300	300	300	300	300	300	300	300	300
1:48 Octave	4976 (Hz)	17	17	21	19	18	18	19	19	21	20	26
	5050 (Hz)	17	17	21	19	17	18	19	19	21	20	26
	5120 (Hz)	17	17	21	19	17	18	19	19	21	20	27
	5200 (Hz)	17	17	21	19	17	18	19	19	21	21	27
	5270 (Hz)	17	16	21	19	17	18	19	19	21	21	27
	5350 (Hz)	17	17	21	18	17	18	19	19	20	20	28
	5420 (Hz)	17	17	21	19	17	18	19	19	21	20	29
	5500 (Hz)	18	18	21	19	17	18	19	19	21	20	29
	5580 (Hz)	18	17	21	19	17	19	19	19	21	20	32
	5660 (Hz)	19	19	21	19	18	19	20	20	22	20	31
	5750 (Hz)	27	26	24	22	20	22	22	22	22	21	37
	5830 (Hz)	29	29	27	25	23	25	26	24	24	23	44
	5910 (Hz)	32	30	29	27	24	26	29	28	28	25	54
	6000 (Hz)	36	33	31	28	26	28	30	28	25	25	50
	6090 (Hz)	31	28	27	24	22	25	26	24	23	23	47
	6170 (Hz)	24	25	24	21	21	21	22	20	21	21	43
	6260 (Hz)	20	19	20	18	18	18	19	19	21	20	40
	6360 (Hz)	18	18	20	18	18	18	19	18	21	20	33
6450 (Hz)	17	17	19	18	18	18	19	18	21	20	28	
6540 (Hz)	17	17	19	17	18	18	18	18	20	20	28	
6640 (Hz)	17	16	19	17	18	18	18	18	20	20	27	
6730 (Hz)	16	16	18	17	18	17	18	18	20	20	26	



Position	South BESS Unit					North BESS Unit					Transformer
6830 (Hz)	16	16	18	17	17	17	18	18	20	20	26
6930 (Hz)	16	16	18	17	17	17	18	18	20	20	25
7030 (Hz)	16	16	18	17	17	17	18	18	21	19	26
7130 (Hz)	16	16	18	17	17	17	18	18	21	19	25
7230 (Hz)	16	16	18	17	17	17	18	18	20	19	25
7340 (Hz)	16	16	18	17	16	17	18	18	21	19	25
7450 (Hz)	16	16	17	17	16	17	18	18	21	19	25
7550 (Hz)	16	16	17	17	16	17	18	18	21	19	25
7660 (Hz)	16	16	17	17	16	17	18	18	22	19	25
7770 (Hz)	16	16	17	17	16	17	18	18	22	19	25
7890 (Hz)	16	16	17	17	16	17	18	18	23	19	25
8000 (Hz)	16	16	17	17	16	17	18	18	22	19	26
8120 (Hz)	16	16	17	17	16	17	18	18	23	19	26
8230 (Hz)	16	16	17	17	16	17	18	18	21	19	26
8350 (Hz)	16	16	17	17	16	17	18	18	20	19	26
8470 (Hz)	16	16	17	17	16	17	19	18	21	19	29
8600 (Hz)	18	18	18	17	16	18	19	18	21	19	36
8720 (Hz)	19	19	19	18	17	19	20	19	21	19	38
8850 (Hz)	23	22	22	20	18	21	22	21	22	20	41
8980 (Hz)	22	22	22	20	18	22	22	21	22	20	40
9110 (Hz)	21	20	21	18	17	18	20	19	22	19	40
9240 (Hz)	18	18	19	17	16	18	19	18	22	19	33
9370 (Hz)	17	16	17	17	16	17	19	18	22	19	33
9510 (Hz)	16	16	17	17	16	17	19	18	23	19	27
9650 (Hz)	16	16	17	17	16	17	19	18	23	19	25
9790 (Hz)	16	16	17	17	16	17	20	18	22	18	25
9930 (Hz)	16	16	17	17	16	17	20	18	21	18	24
10070 (Hz)	16	16	17	17	16	17	20	18	21	19	24



Position	South BESS Unit					North BESS Unit					Transformer
10220 (Hz)	16	16	17	17	16	17	20	18	21	19	24
10370 (Hz)	16	16	17	17	16	17	20	19	20	19	24
10520 (Hz)	16	16	17	17	16	17	20	18	20	19	24
10670 (Hz)	16	16	17	17	16	17	20	18	19	19	24
10820 (Hz)	16	16	17	17	16	17	20	19	20	19	24
10980 (Hz)	16	16	17	17	16	17	20	19	20	19	24
11140 (Hz)	16	16	17	17	16	17	20	19	20	19	25
11300 (Hz)	16	16	17	17	16	18	20	19	20	19	26
11470 (Hz)	17	17	18	17	16	18	21	20	20	19	31
11630 (Hz)	19	19	19	18	17	19	22	20	21	20	37
11800 (Hz)	19	19	19	18	17	19	22	20	21	20	37
11970 (Hz)	21	20	19	18	17	19	22	21	21	20	38
12140 (Hz)	18	18	18	17	16	18	22	21	21	20	34
12320 (Hz)	17	17	17	17	16	18	22	21	21	20	32
12500 (Hz)	16	16	17	17	16	18	22	22	21	20	28
12680 (Hz)	16	16	17	17	16	18	22	22	21	20	23
12860 (Hz)	16	16	17	17	16	18	22	23	22	21	22
13050 (Hz)	16	16	17	17	16	19	23	23	22	21	22
13240 (Hz)	16	16	17	17	16	19	23	24	22	21	22
13430 (Hz)	16	16	17	17	16	20	23	24	22	21	22
13630 (Hz)	16	16	17	17	16	20	24	25	22	21	23
13820 (Hz)	16	16	17	17	16	20	24	25	22	22	24
14020 (Hz)	16	16	17	17	16	21	25	26	23	22	24
14230 (Hz)	16	17	17	17	16	21	25	26	23	22	28
14430 (Hz)	17	17	17	17	16	20	25	27	23	23	30
14640 (Hz)	17	17	17	17	16	20	25	27	24	23	31
14860 (Hz)	17	18	17	17	16	20	26	28	24	24	37
15070 (Hz)	17	17	17	17	16	20	27	28	24	24	32



Position	South BESS Unit					North BESS Unit					Transformer
15290 (Hz)	17	17	17	17	16	20	27	29	25	25	30
15510 (Hz)	17	17	17	17	16	20	28	29	25	25	28
15740 (Hz)	16	16	17	17	16	21	28	30	26	26	24
15960 (Hz)	16	16	17	17	17	21	29	30	26	26	24
16190 (Hz)	16	16	17	17	17	21	30	31	26	26	22
16430 (Hz)	16	16	17	17	17	21	30	31	26	27	22
16670 (Hz)	17	16	17	17	17	21	30	31	27	27	22
16910 (Hz)	16	16	17	17	17	21	30	32	27	27	23
17150 (Hz)	17	17	17	17	17	21	30	32	27	27	27
17400 (Hz)	17	17	17	17	17	21	30	32	27	28	32
17660 (Hz)	17	17	17	17	17	22	31	32	28	29	30
17910 (Hz)	17	17	17	17	17	22	31	33	28	29	28
18170 (Hz)	17	17	17	17	17	22	32	34	28	29	29
18430 (Hz)	17	17	17	17	17	23	33	34	28	30	29
18700 (Hz)	17	17	17	17	17	23	33	34	28	30	23
18970 (Hz)	17	17	17	17	17	23	34	34	29	30	21
19250 (Hz)	17	17	17	17	17	24	34	34	29	30	21
19530 (Hz)	19	17	17	17	17	24	35	34	29	30	21
19810 (Hz)	22	17	17	17	17	24	35	34	29	31	22
20100 (Hz)	17	17	17	17	17	24	35	34	30	31	32
20390 (Hz)	17	17	17	18	17	25	35	34	30	31	31
20680 (Hz)	17	17	17	17	17	25	36	34	30	31	38
20980 (Hz)	17	17	17	17	17	25	37	35	30	31	32
21290 (Hz)	17	17	17	17	17	25	36	35	31	32	27
21600 (Hz)	17	17	17	17	17	26	37	35	32	32	23
21910 (Hz)	17	17	17	17	17	27	37	35	32	32	21
22230 (Hz)	17	17	17	17	17	27	38	35	32	33	20
22550 (Hz)	17	17	17	17	17	28	38	35	32	33	20



Position	South BESS Unit					North BESS Unit					Transformer
22880 (Hz)	17	17	17	17	17	29	38	35	32	33	22
23210 (Hz)	17	17	17	17	17	29	38	35	32	33	22
23540 (Hz)	17	17	17	17	17	29	39	35	33	33	22
23880 (Hz)	17	17	17	17	17	29	39	35	33	33	27
24230 (Hz)	17	17	17	17	17	29	39	35	33	33	20
24580 (Hz)	17	17	17	17	17	29	40	35	32	33	19
24940 (Hz)	17	17	17	17	17	29	40	36	33	33	18
25300 (Hz)	17	17	17	17	17	29	40	36	33	33	18
25670 (Hz)	17	17	17	17	17	29	40	37	34	33	19
26040 (Hz)	17	17	17	17	17	28	40	37	34	34	21
26420 (Hz)	17	17	17	17	17	28	40	38	35	34	22
26800 (Hz)	17	17	17	17	17	28	41	38	36	35	21
27190 (Hz)	17	17	17	17	17	28	40	38	35	35	23
27580 (Hz)	17	17	17	17	17	27	40	39	36	36	21
27980 (Hz)	17	17	17	17	17	27	41	39	36	36	19
28390 (Hz)	17	17	17	17	17	27	41	39	36	36	19
28800 (Hz)	17	17	17	17	17	27	41	38	36	37	21
29220 (Hz)	17	17	17	17	17	26	40	38	35	37	20
29640 (Hz)	17	17	17	17	17	25	39	37	35	37	20
30070 (Hz)	17	17	17	17	17	25	39	37	34	37	20
30510 (Hz)	17	17	17	17	17	24	39	36	35	36	20
30950 (Hz)	17	17	17	17	17	24	39	36	34	35	20
31400 (Hz)	17	17	17	17	17	24	39	35	34	35	21
31850 (Hz)	17	17	17	18	17	23	39	35	33	35	21
32310 (Hz)	17	17	17	18	17	23	38	35	33	34	20
32780 (Hz)	17	17	18	18	18	23	38	34	32	34	21
33260 (Hz)	18	18	18	18	18	22	38	34	32	34	20
33740 (Hz)	18	18	18	18	18	22	38	34	32	34	20



Position	South BESS Unit					North BESS Unit					Transformer
34230 (Hz)	18	18	18	18	18	22	38	33	32	34	19
34720 (Hz)	18	18	18	18	18	22	38	33	31	34	19
35230 (Hz)	18	18	18	18	18	22	38	33	31	34	19
35740 (Hz)	18	18	18	18	18	22	39	34	31	34	20
36260 (Hz)	18	18	18	18	18	22	39	33	31	34	19
36780 (Hz)	18	18	18	18	18	22	39	34	31	33	18
37310 (Hz)	18	18	18	18	18	22	39	34	30	33	18
37860 (Hz)	18	18	18	18	18	21	39	33	30	32	19
38400 (Hz)	18	18	18	18	18	21	38	33	30	32	19
38960 (Hz)	18	18	18	18	18	21	38	33	30	32	19
39530 (Hz)	18	18	18	18	18	21	38	32	30	32	19
40100 (Hz)	18	18	18	18	18	21	38	32	30	32	19
40680 (Hz)	18	18	18	18	18	21	38	32	30	32	18
41270 (Hz)	18	18	18	18	18	21	38	32	30	32	18
41870 (Hz)	18	18	18	18	18	21	38	32	30	33	18
42470 (Hz)	18	18	18	18	18	21	37	32	29	33	18
43090 (Hz)	18	18	18	18	18	21	37	32	29	33	20
43710 (Hz)	18	18	18	18	18	21	36	32	29	33	19
44350 (Hz)	18	18	18	18	18	20	36	32	29	32	21
44990 (Hz)	18	18	18	18	18	20	35	32	28	32	21
45640 (Hz)	18	18	18	18	18	20	35	31	28	32	21
46300 (Hz)	18	18	18	18	18	20	34	31	27	31	20
46980 (Hz)	18	18	18	18	18	20	34	30	27	31	19
47660 (Hz)	18	18	18	18	18	19	34	30	27	30	19
48350 (Hz)	18	18	18	18	18	19	33	29	26	30	20
49050 (Hz)	18	18	18	18	18	19	33	29	26	29	21
49760 (Hz)	18	18	18	18	18	19	33	29	26	28	22
50500 (Hz)	18	18	18	18	18	19	33	28	26	28	21



Position	South BESS Unit					North BESS Unit					Transformer
51200 (Hz)	18	19	19	19	19	19	33	27	25	27	24
52000 (Hz)	19	19	19	19	19	19	32	27	25	27	24
52700 (Hz)	19	19	19	19	19	19	32	26	24	27	20
53500 (Hz)	19	19	19	19	19	19	32	26	24	26	19
54200 (Hz)	19	19	19	19	19	19	32	25	24	26	20
55000 (Hz)	19	19	19	19	19	19	32	25	23	26	20
55800 (Hz)	19	19	19	19	19	19	32	25	22	25	20
56600 (Hz)	19	19	19	19	19	19	32	25	22	24	20
57500 (Hz)	19	19	19	19	19	19	32	25	22	24	19
58300 (Hz)	19	19	19	19	19	19	32	25	22	24	19
59100 (Hz)	19	19	19	19	19	20	32	25	22	24	19
60000 (Hz)	21	19	19	19	19	20	31	27	23	25	19
60900 (Hz)	19	19	19	19	19	19	31	24	21	24	19
61700 (Hz)	19	19	19	19	19	19	31	24	21	24	19
62600 (Hz)	19	19	19	19	19	19	30	24	21	23	19
63600 (Hz)	19	19	19	19	19	19	30	24	21	22	19
64500 (Hz)	19	19	19	19	19	19	30	23	21	22	19
65400 (Hz)	19	19	19	19	19	19	30	24	21	22	19
66400 (Hz)	19	19	19	19	19	19	30	24	21	22	19
67300 (Hz)	19	19	19	19	19	19	30	24	21	22	19
68300 (Hz)	19	19	19	19	19	20	31	24	21	22	19
69300 (Hz)	19	19	19	19	19	20	31	24	21	23	19
70300 (Hz)	20	20	20	20	20	20	31	24	22	23	19
71300 (Hz)	20	20	20	20	20	20	32	24	22	23	20
72300 (Hz)	20	20	20	20	20	20	32	24	22	24	20
73400 (Hz)	20	20	20	20	20	20	32	24	22	23	20
74500 (Hz)	20	21	21	21	21	21	31	24	22	23	20
75500 (Hz)	21	21	21	21	21	21	30	23	22	23	21



Position		South BESS Unit					North BESS Unit					Transformer
	76600 (Hz)	21	21	21	21	21	21	30	23	22	24	21
	77700 (Hz)	22	22	22	22	22	22	29	23	23	24	22
	78900 (Hz)	22	22	22	22	22	22	29	24	23	24	22
	80000 (Hz)	23	23	23	23	23	23	29	24	23	24	23





Appendix C

Photographs of detector
deployment locations



Appendix C: Photographs of detector deployment locations

Field D29



Plate 6. Boundary detector at Field D29



Plate 7. Field detector at Field D29

Field B8



Plate 8. Boundary detector at Field B8



Plate 9. Field detector at Field B8

Field D28



Plate 10. Boundary detector at Field D28



Plate 11. Field detector at Field D28

Appendix D

Weather Records



Appendix D: Weather records

Table 8. Weather conditions during the October 2024 surveys. Records taken from Bicester via www.timeanddate.com as the closest location to the Site for historical weather data.

Survey Period	Date (survey nights)	Sunset Sunrise	Sunset Temperature (°C)	Wind Speed (mph)	Overnight rain	Five days preceding survey period
October 2024	24/10/2024 – 25/10/2024	17:51 07:45	15	7-16	None	Largely mild, with sunset temperature ranging from 12 to 16°C. Wind speeds at sunset varied from 5 to 16 mph, but averaged 8 mph. One night of light rain (18th), otherwise clear or foggy.
	25/10/2024 – 26/10/2024	17:49 07:47	14	1 – 13	None	
	26/10/2024* – 27/10/2024	17:47 07:49	13	1 - 7	Light rain for approx. 30 mins around 23:20	
	27/10/2024 – 28/10/2024	16:45 06:50	10	0 - 10	None	
	28/10/2024 – 29/10/2024	16:43 06:52	14	2 - 14	Drizzle at sunset. Light rain at 19:20 for approx. 1 hour	
	29/10/2024 – 30/10/2024	16:41 06:56	14	2 - 7	Light rain at sunset for approx. 30 mins	

*clocks changed

Table 9. Weather conditions during the May 2025 surveys. Records taken from Bicester via www.timeanddate.com as the closest location to the Site for historical weather data.

Survey Period	Date (survey nights)	Sunset Sunrise	Sunset Temperature (°C)	Wind Speed (mph)	Overnight rain	Five days preceding survey period
May 2025	14/05/2025 – 15/05/2025	20:50 05:12	13	2 - 16	None	Largely mild, with sunset temperature ranging from 11 to 18°C. Wind speeds at sunset varied from 5 to 13 mph, but averaged 8 mph. One night of heavy rain (the night of 11 th to 12 th) and one of light rain (12 th to 13 th).
	15/05/2025 – 16/05/2025	20:51 05:10	12	2 – 15	None	
	16/05/2025 – 17/05/2025	20:53 05:09	14	1 – 14	None	
	17/05/2025 – 18/05/2025	20:54 05:07	13	1 – 13	None	
	18/05/2025 – 19/05/2025	20:56 05:06	11	1 – 12	None	
	19/05/2025 – 20/05/2025	20:57 05:05	15	3 - 10	None	
	20/05/2025 – 21/05/2025	20:59 05:03	15	0 – 9	None	
	21/05/2025 – 22/05/2025	21:00 05:02	12	1 – 14	Light rain between 02:50 and 09:20	
	22/05/2025 – 23/05/2025	21:02 05:01	10	0 - 13	None	

Appendix E

Detailed survey results



Appendix E. Detailed survey results

Table 10. October 2024 paired static detector survey results in the form of MRPH and total number of identifications.

Location	Position	Registrations per hour ¹⁵ , (Total registrations)							
		Barbastelle	Brown long-eared bat	Common pipistrelle	Leisler's bat	Myotis sp.	Nathusius' pipistrelle	Noctule	Soprano pipistrelle
Field D28	Boundary	1.71 (153)	0.02 (2)	1.16 (104)	0 (0)	0.23 (21)	0 (0)	0.02 (2)	0.59 (53)
Field D28	Field	0 (0)	0.01 (1)	0.21 (19)	0 (0)	0.15 (13)	0 (0)	0.02 (2)	0.06 (5)
Field D29	Boundary	0.99 (89)	0.11 (10)	9.66 (865)	0 (0)	0.32 (29)	0.03 (3)	0.1 (9)	1.06 (95)
Field D29	Field	0 (0)	0.12 (11)	4.72 (422)	0 (0)	0.36 (32)	0.06 (5)	0.06 (5)	0.44 (39)
Field B8	Boundary	5.27 (472)	0.35 (31)	1.43 (128)	0.02 (2)	0.11 (10)	0.02 (2)	0.21 (19)	8.29 (792)
Field B8	Field	0.07 (6)	0.03 (3)	0.10 (9)	0.03 (3)	0.07 (6)	0 (0)	0.29 (26)	0.34 (30)

¹⁵ Where all barbastelle and *Myotis* species identifications have been manually verified, but other species have not been reviewed; for these, the identifications made by the BTO Pipeline are taken as correct.

Table 11. May 2025 paired static detector survey results in the form of MRPH and total number of identifications

		Registrations per hour ¹⁶ , (Total identifications)								
Location	Position	Barbastelle	Brown long-eared bat	Common pipistrelle	Leisler's bat	Myotis sp.	Nathusius' pipistrelle	Noctule	Serotine	Soprano pipistrelle
Field D28	Boundary	2.10 (173)	0.13 (11)	203.89 (16,770)	1.05 (86)	5.87 (483)	1.43 (118)	14.50 (1,193)	1.99 (164)	8.80 (724)
Field D28	Field	0.04 (3)	0.17 (14)	6.54 (538)	0.97 (80)	0.33 (27)	0.17 (14)	7.73 (636)	0.43 (35)	0.13 (11)
Field D29	Boundary	0.47 (29)	0.86 (71)	52.40 (4,310)	0.29 (24)	30.40 (2,500)	0.38 (31)	9.16 (753)	1.12 (92)	7.16 (589)
Field D29	Field	0 (0)	0.68 (56)	1.09 (90)	0.32 (24)	0.02 (2)	0.01 (1)	7.19 (591)	1.23 (101)	0.07 (6)

¹⁶ Where all barbastelle and *Myotis* species identifications have been reviewed, but other species have not been reviewed; for these, the identifications made by the BTO Pipeline are taken as correct.

Appendix F

R code for statistical analysis



Appendix F: R code for statistical analysis

Plate 12. R code used to conduct the Wilcoxon Rank-Sum tests

```
script_for_p_values.R x results x bats x
Source on Save Run
1 #run the libraries once everytime you restart R
2 library(dplyr)
3 library(purrr)
4 library(tidyr)
5
6 setwd("C:/Users/jdickinson/OneDrive - RSK Group/Documents/wilding/Rosefield solar")
7 #change to the file location of your dataset you can only run this once every session
8
9 bats <- read.csv("Statistical analysis hedges and fields.csv", header = TRUE, sep = ",")
10 #change the file name to match what your spreadsheet is called, please make sure this is a csv.
11
12 head(bats)
13 #this is just to check that your data looks what like you expect.
14 #You can also do this by clicking on the blue arrow next to the data set to see
15
16 vars_to_test <- c("Barbastelle", "Myotis_sp", "All_other_sp", "Total_bats")
17 # Note: If want to use this script again for stat test, replace variables in line above.
18 #It doesn't matter if there are more variables in spreadsheet, just add them all into the line above.
19
20 results <- bats %>%
21   filter(H_or_F %in% c("H", "F")) %>% # ensure only H & F
22   #this filter function should be changed to whatever you are comparing against.
23   group_by(Year, Location) %>%
24   #These are the variables you want to separate out in your dataset.
25   summarise(tests = list(
26     map(vars_to_test, function(v) {
27       sub <- pick(everything())
28
29       # Only run test if both H and F exist and have >0 non-NA values
30       if (
31         length(unique(sub$H_or_F)) == 2 &&
32         #this is the heading of the variable for comparison
33         sum(!is.na(sub[[v]])) > 1
34       ) {
35         test <- wilcox.test(
36           formula = as.formula(paste(v, "~ H_or_F")),
37           #this is the heading of the variable for comparison
38           data = sub, exact = FALSE
39         )
40       }
41
42       tibble(
43         variable = v,
44         w = test$statistic,
45         p_value = test$p.value
46       )
47     } else {
48       tibble(
49         variable = v,
50         w = NA,
51         p_value = NA
52       )
53     }
54   })
55 ),
56 .groups = "drop"
57 ) %>%
58 unnest(tests)
59
60 results <- results %>%
61 unnest(tests)
62
63 view(results)
64
65 write.csv(results, "your chosen file name.csv", row.names=FALSE)
66 #this exports all the p value results into a table in excel.
```

Appendix G

Data inputs for statistical analysis



Appendix G. Data inputs for statistical analysis

Table 12. Data inputs for the Wilcoxon Rank-Sum tests in R

Year	Location	Hedgerow (H) or Field (F)	Number of identifications			
			Barbastelle	<i>Myotis_sp</i>	All_other_s p	Total_bats
2024	Field D28	H	31	8	42	81
2024	Field D28	H	0	0	0	0
2024	Field D28	H	0	0	1	1
2024	Field D28	H	1	4	7	12
2024	Field D28	H	0	2	6	8
2024	Field D28	H	121	7	105	233
2024	Field D28	F	0	8	18	26
2024	Field D28	F	0	0	0	0
2024	Field D28	F	0	0	0	0
2024	Field D28	F	0	1	1	2
2024	Field D28	F	0	0	0	0
2024	Field D28	F	0	4	8	12
2024	Field D29	H	3	8	484	495
2024	Field D29	H	0	0	162	162
2024	Field D29	H	4	5	151	160
2024	Field D29	H	1	3	57	61
2024	Field D29	H	0	0	32	32
2024	Field D29	H	81	13	96	190
2024	Field D29	F	0	15	364	379
2024	Field D29	F	0	0	4	4
2024	Field D29	F	0	0	28	28
2024	Field D29	F	0	1	21	22
2024	Field D29	F	0	0	11	11
2024	Field D29	F	0	16	54	70

Year	Location	Hedgerow (H) or Field (F)	Number of identifications			
			Barbastelle	<i>Myotis_sp</i>	All_other_s p	Total_bats
2024	Field B8	H	187	2	797	986
2024	Field B8	H	2	0	6	8
2024	Field B8	H	100	4	20	124
2024	Field B8	H	167	2	48	217
2024	Field B8	H	6	0	12	18
2024	Field B8	H	10	2	41	53
2024	Field B8	F	3	0	41	44
2024	Field B8	F	0	0	5	5
2024	Field B8	F	0	1	2	3
2024	Field B8	F	1	0	5	6
2024	Field B8	F	0	2	3	5
2024	Field B8	F	2	3	15	20
2025	Field D28	H	27	68	2898	2993
2025	Field D28	H	41	167	3209	3417
2025	Field D28	H	17	79	3456	3552
2025	Field D28	H	6	54	2613	2673
2025	Field D28	H	20	18	1838	1876
2025	Field D28	H	32	34	1544	1610
2025	Field D28	H	7	33	2116	2156
2025	Field D28	H	18	20	904	942
2025	Field D28	H	5	10	508	523
2025	Field D28	F	0	1	218	219
2025	Field D28	F	0	2	202	204
2025	Field D28	F	1	3	218	222
2025	Field D28	F	0	2	118	120
2025	Field D28	F	0	4	151	155

Year	Location	Hedgerow (H) or Field (F)	Number of identifications			
			Barbastelle	<i>Myotis_sp</i>	All_other_s p	Total_bats
2025	Field D28	F	2	8	185	195
2025	Field D28	F	0	4	101	105
2025	Field D28	F	0	1	96	97
2025	Field D28	F	0	1	39	40
2025	Field D29	H	5	369	1183	1557
2025	Field D29	H	6	382	877	1265
2025	Field D29	H	2	295	556	853
2025	Field D29	H	4	222	965	1191
2025	Field D29	H	6	211	400	617
2025	Field D29	H	6	229	347	582
2025	Field D29	H	4	294	1000	1298
2025	Field D29	H	0	238	350	588
2025	Field D29	H	6	260	192	458
2025	Field D29	F	0	0	89	89
2025	Field D29	F	0	1	86	87
2025	Field D29	F	0	1	102	103
2025	Field D29	F	0	2	146	148
2025	Field D29	F	0	1	102	103
2025	Field D29	F	0	6	77	83
2025	Field D29	F	0	3	100	103
2025	Field D29	F	0	0	88	88
2025	Field D29	F	0	1	81	82

Appendix H

Barbastelle activity relative to sunset



Appendix H: Barbastelle activity relative to sunset¹⁷¹⁸

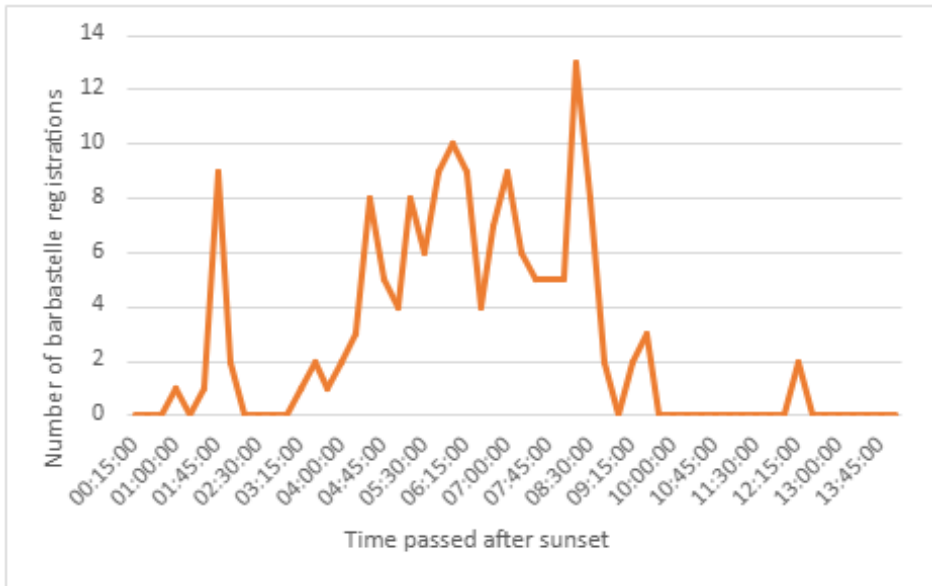


Plate 13. Number of barbastelle registrations per 15-minute interval, starting at sunset, recorded by the boundary detector at Field D28 in October 2024.

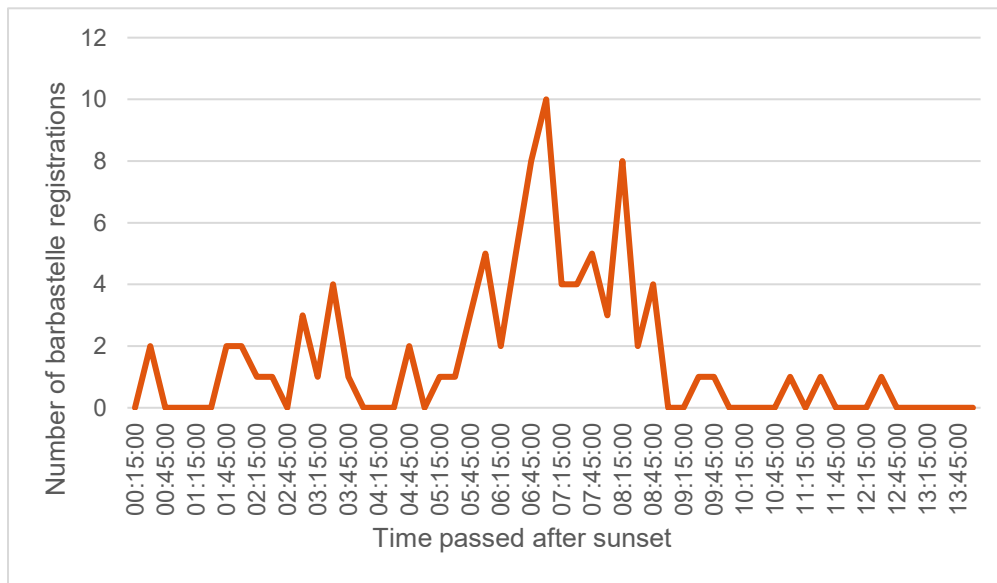


Plate 14. Number of barbastelle registrations per 15-minute interval, starting at sunset, recorded by the boundary detector at Field D29 in October 2024.

¹⁷ Note. No graphs are provided for the field detector at Field D28 in October 2024, the field detector at Field D29 in October 2024 or the field detector at Field D29 in May 2025 as there were no barbastelle registrations recorded at any time during these deployments. No graphs are provided for either detector position at Field B8 in May 2025 as access restrictions prevented this location from being surveyed.

¹⁸ Graphs have been produced to reflect varying y axis (i.e. time passed after sunset) lengths in line with the varying time between sunset and sunrise in October 2024 (approximately 14 hours on average) and May 2025 (approximately 8.25 hours on average).

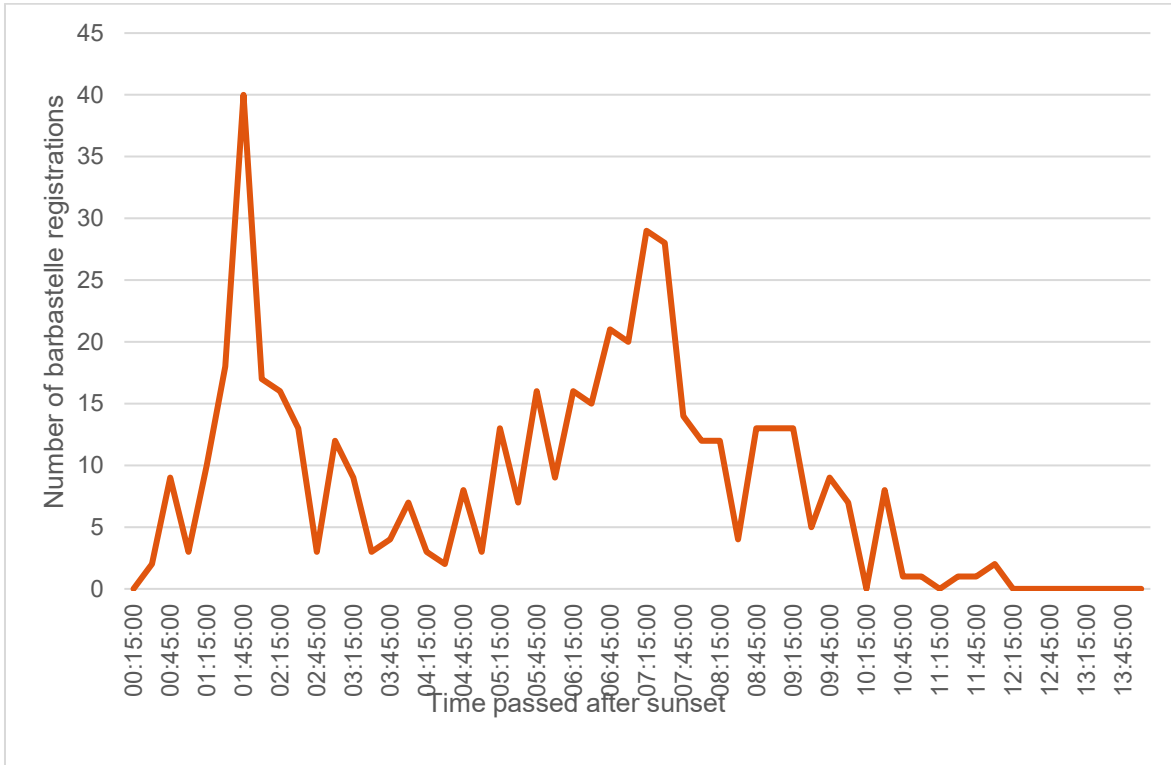


Plate 15. Number of barbastelle registrations per 15-minute interval, starting at sunset, recorded by the boundary detector at Field B8 in October 2024.

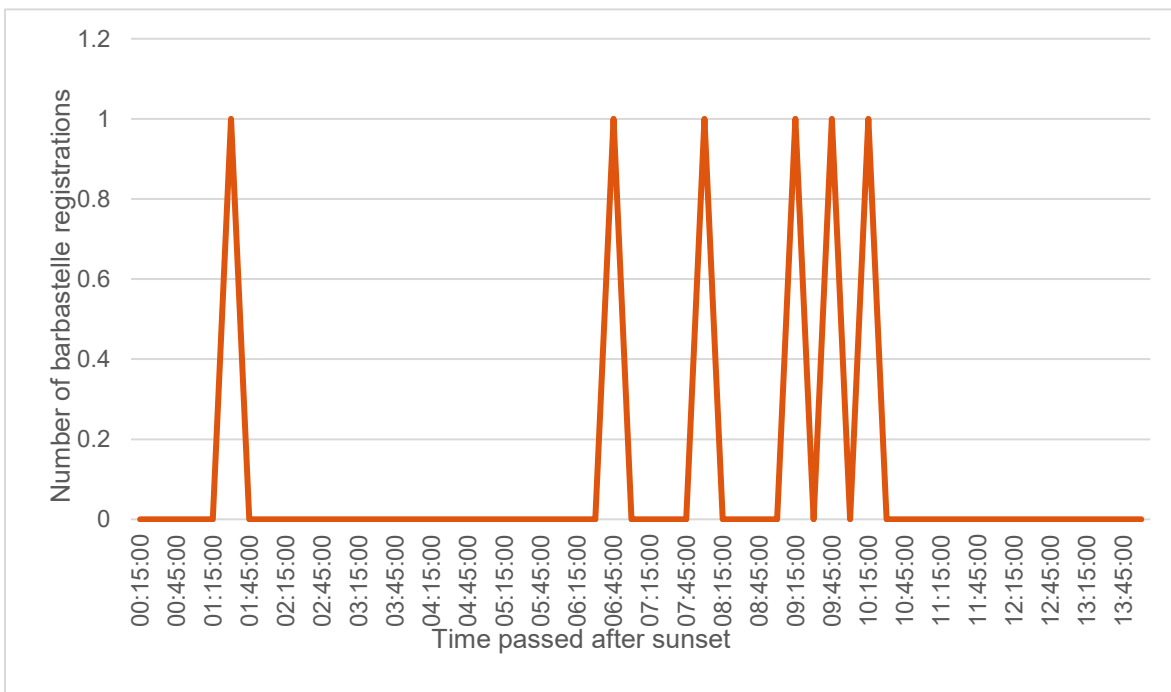


Plate 16. Number of barbastelle registrations per 15-minute interval, starting at sunset, recorded by the field detector at Field B8 in October 2024

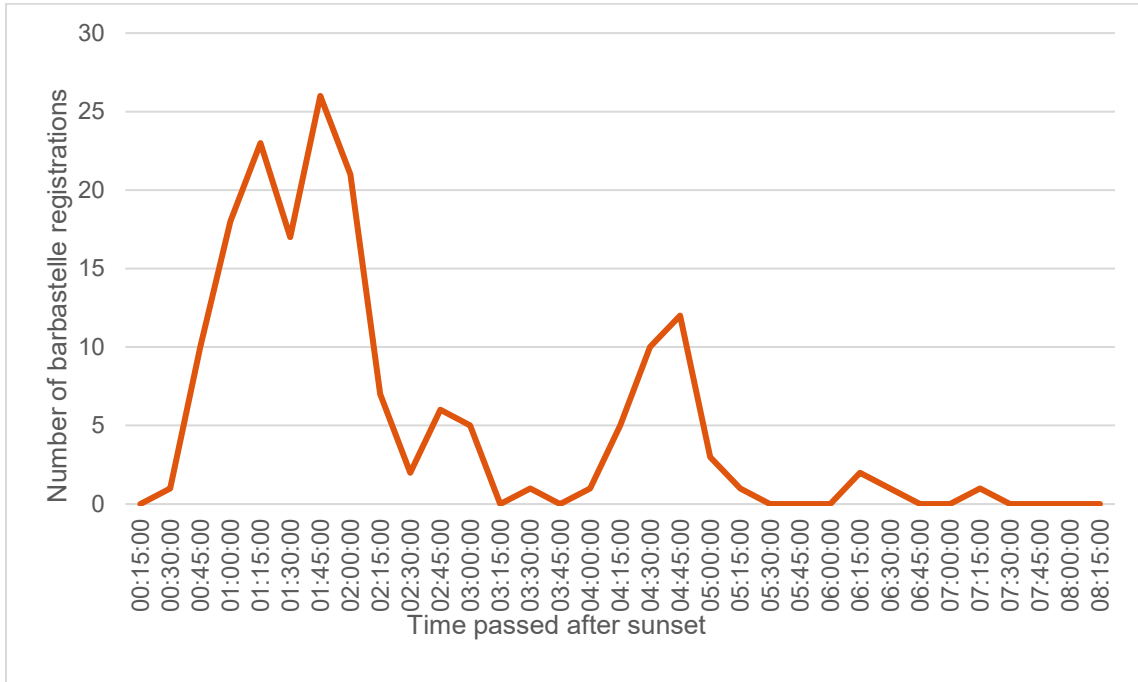


Plate 17. Number of barbastelle registrations per 15-minute interval, starting at sunset, recorded by the boundary detector at Field D28 in May 2025

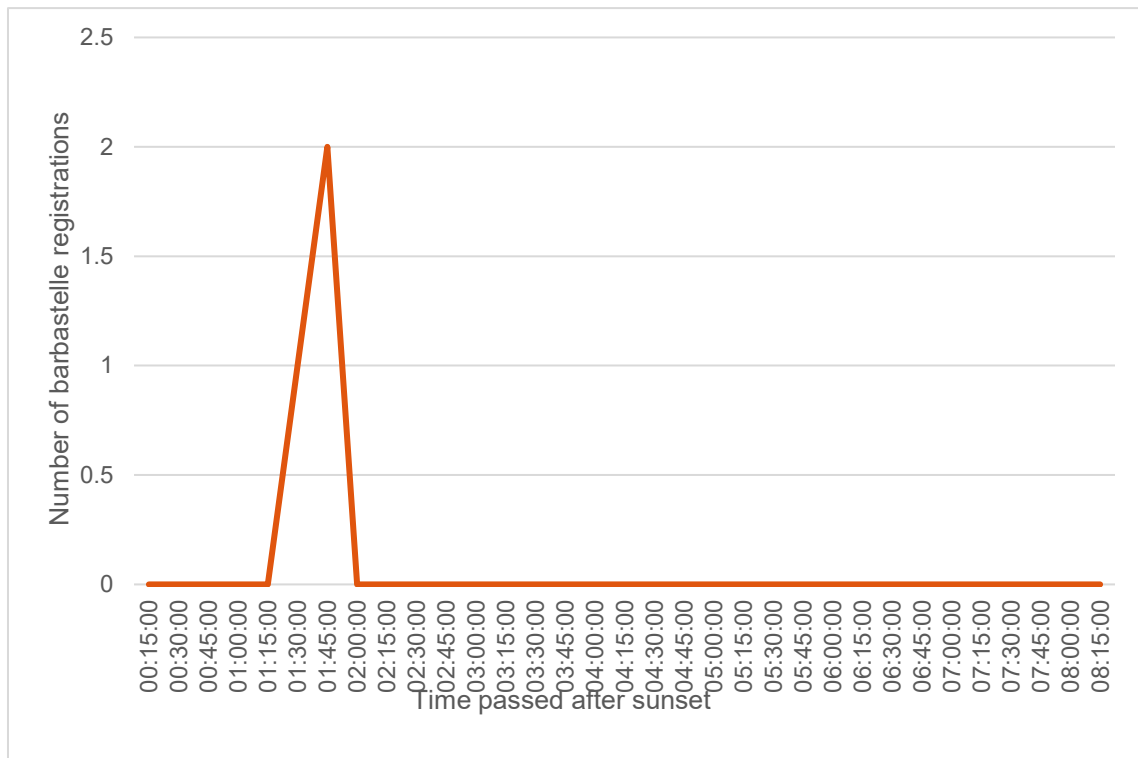


Plate 18. Number of barbastelle registrations per 15-minute interval, starting at sunset, recorded by the field detector at Field D28 in May 2025

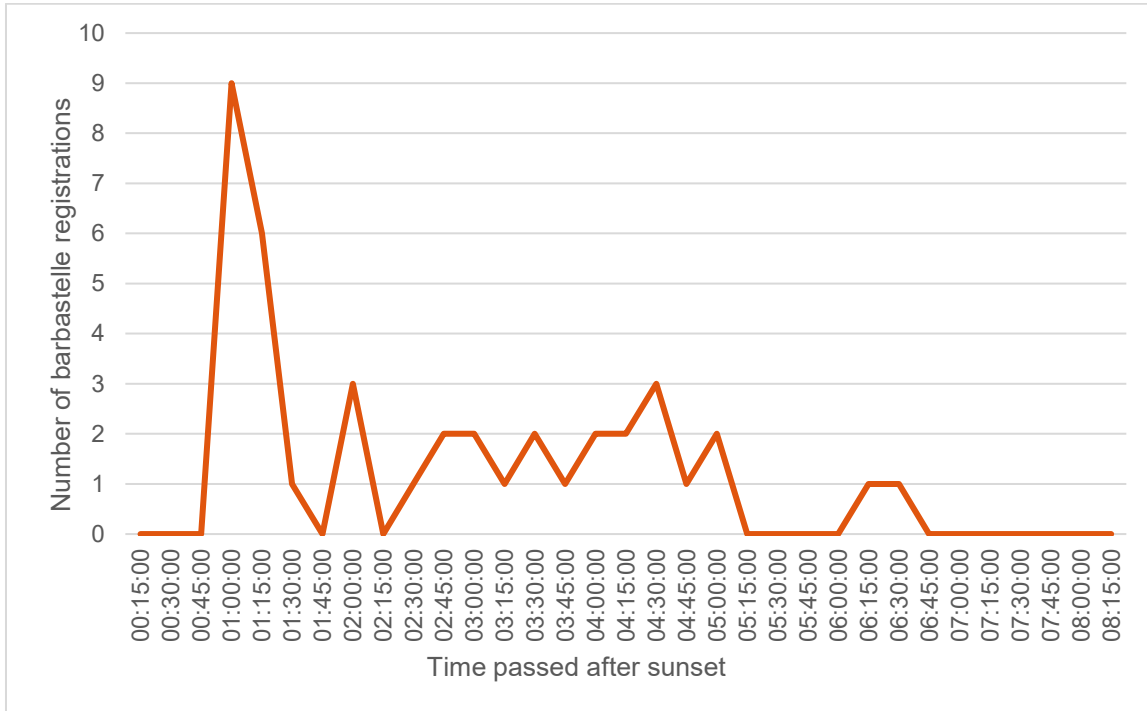


Plate 19. Number of barbastelle registrations per 15-minute interval, starting at sunset, recorded by the boundary detector at Field D29 in May 2025.

Appendix I

The Bernwood Population of
Bechstein's Bats (Natural England)



The Bernwood Population of Bechstein's Bats

A Non-Technical Summary of the Evidence

June 2024

Natural England Commissioned Report NECR558

About Natural England

Natural England is here to secure a healthy natural environment for people to enjoy, where wildlife is protected and England's traditional landscapes are safeguarded for future generations.

Further Information

This report can be downloaded from the [Natural England Access to Evidence Catalogue](#). For information on Natural England publications or if you require an alternative format, please contact the Natural England Enquiry Service on 0300 060 3900 or email enquiries@naturalengland.org.uk.

Copyright

This publication is published by Natural England under the [Open Government Licence v3.0](#) for public sector information. You are encouraged to use, and reuse, information subject to certain conditions.

Natural England images and photographs are only available for non-commercial purposes. If any other photographs, images, or information such as maps, or data cannot be used commercially this will be made clear within the report.

For information regarding the use of maps or data see our guidance on [how to access Natural England's maps and data](#).

© Natural England 2024

Catalogue code: NECR558

Report details

Author(s)

Stephanie Murphy, Nick Deykin, Jon Riley, and Tom McArthur

Natural England Project Manager

Trevor Mansfield, Team Leader, Thames Solent Area Team

Contractor

Sylvan Limited – Specialists in Biodiversity

Keywords

Bernwood, Bechstein's bat, SSSI, woodland

Acknowledgements

Natural England would like to thank all the landowners and land managers in the Bernwood area, and their representatives for giving permission to carry out surveys on their land. Their cooperation in facilitating the surveys is significant and appreciated. Thank you also to the many field surveyors and data analysts who contributed so much for over a decade of field research.

Natural England would like to make a special thanks to the North Bucks Bat Group and also the Bernwood Forest Bechstein's Group, particularly Chris Damant, Toby Thorne and, and Jo Hodgkins. Following the first recording of a Bechstein's Bat in Buckinghamshire in 2009, the breeding population of Bechstein's bats at Bernwood was first recorded in 2010. Subsequently the Bernwood Forest Bechstein's Project was established as an informal bat research group, to carry out further investigations into the distribution and ecology of Bechstein's bats in the area. Since 2010, the project has continued to survey Bernwood Forest woodlands and has been involved in establishing a national working group for Bechstein's bats with annual field meetings to exchange information. Their hard work and support have been significant.

Finally, Natural England would also like to thank the authors, for distilling the detailed monitoring evidence so clearly and succinctly in this report.

Citation

Natural England. 2024. The Bernwood Population of Bechstein's bat: A Non-Technical Summary of the Evidence. NECR558. Natural England.

Foreword

Natural England is reviewing the SSSI designations at Bernwood, Buckinghamshire. Bernwood is a largely agricultural landscape of woodlands, pastures and ancient hedgerows situated between Bicester and Aylesbury. Natural England are looking to expand the existing SSSI designations to protect Bechstein's bat maternity colonies known to be present in the area and also to notify for habitat and invertebrate interest. As part of this work Natural England has collected detailed monitoring information over several years, recording how Bechstein's bats are using the landscape at Bernwood. Natural England commissioned this report to provide a non-technical summary of that evidence.

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Executive summary

A single male Bechstein's bat recorded in 2009 in south Buckinghamshire represented the first record for the county. Surveys in the Bernwood area during 2010 confirmed the county's first breeding population and led to significant research and field surveys that were completed between 2011 and 2022. This Non-Technical Summary simplifies and explains the subsequent data, particularly how Bechstein's bat use the Bernwood area, why the area is important for the species and why this Bechstein's bat population is important to the future of the species in the UK.

Bechstein's bat is one of the UK's rarest bats. The species' core range is in southern England from Gloucestershire to Sussex, although breeding individuals have been recorded as far north as Herefordshire and Worcestershire. It is highly reliant on old-growth deciduous, oak-dominated, semi-natural woodlands that are often greater than 25 ha in extent. Such woodland was once common across the UK but is now very uncommon. The current population of Bechstein's bat in England has been estimated at 21,600 individuals. However, it has also been estimated that given the extent of suitable habitat in England, the favourable population of Bechstein's bats should be 28,000. Bechstein's bats in England are, therefore, not in a favourable conservation status.

The Bernwood area comprises a cluster of 12 deciduous, oak-dominated woodlands and numerous associated copses in Buckinghamshire. The intervening farmland is dominated by pasture, with some arable and is well connected by hedgerows, tree lines and riparian habitats including watercourses and ponds. Four of the woodlands have previously been designated as Sites of Special Scientific Interest (SSSI) for ancient woodland and their invertebrate assemblages. The eight remaining woodlands are Local Wildlife Sites.

Bat trapping and radio-tracking surveys between 2011 and 2022 identified a single population of Bechstein's bats that comprised at least three breeding colonies. The three breeding colonies are centred on three woodlands currently designated as SSSI; Finemere Wood SSSI, Grendon and Doddershall Woods SSSI and Ham Home-cum-Ham Green Woods SSSI. Approximately 20% of the 57 maternity roosts recorded were, however, located outside the existing SSSIs and supported a greater average number of bats than the maternity roosts located within the SSSIs. Comparison between the bat numbers in maternity roosts within and outside of the existing SSSI woodlands demonstrates that the roosts outside the SSSI are extremely important for the healthy functioning of the Bernwood Bechstein's population.

Using the data collected over the 12 years of field surveys, it is estimated that the Bernwood population of Bechstein's bats is approximately 300 individuals, which represents 1.4% of the population in England. It is one of the largest known populations in England and is at the northern edge of its UK distribution, and its European range. The data confirms that the population is stable and viable. However, the reduced genetic diversity and higher levels of inbreeding confirmed through genetic research confirms that

the population is genetically and geographically isolated. The nearest known maternity population is approximately 50 kilometres to the south-east.

The data confirms that Bechstein's bat maternity colonies use multiple roosts throughout the breeding season. Bats from all three colonies regularly moved between different roosts and were frequently recorded foraging and roosting in the same habitat. The evidence illustrates that bats from each colony shared woodlands but that they never shared or swapped roosts. Each roost remained unique to each colony. This behaviour indicates the presence of one interacting population comprising three colonies rather than three separate populations.

The home range and Core Sustainance Zone (as detailed on page 26) for the Bernwood population extends far beyond these discrete woodland blocks and currently existing SSSI boundaries. Bechstein's bats were recorded commuting, foraging and roosting several kilometres away. The 12 woodlands comprise a small percentage of the total area of the Bernwood population home range (5.8%) and Core Sustainance Zone (4.5%).

The survey data demonstrated that all 12 woodlands in the Bernwood area are important core foraging habitat. While the bats generally preferred to forage in and around the woodlands close to their maternity roosts, they frequently fed throughout the Bernwood area. For example, both the Finemere Wood SSSI colony and the Grendon and Doddershall SSSI colony foraged regularly and together within Sheephouse Wood, Decoypond Wood, Romer Wood and Greatsea Wood.

Bechstein's bats also foraged regularly along natural, vegetated linear features. The linear features provide connectivity for bats to move between their roosts and their core foraging habitat. The hedgerows, tree lines, watercourses and intervening agricultural land are therefore important foraging resources in their own right, and vital in supporting the resilience of the Bernwood population.

The faecal DNA analysis of Bechstein's bats at Bernwood confirms that approximately two-thirds to three-quarters of their diet comprises invertebrate prey associated with woodland. The remaining quarter to a third comprise species associated with open habitats or wetland habitats. The research illustrated that every woodland within the Bernwood area, including those not currently designated as SSSI, and the intervening pasture and arable habitats are integrally important to the vitality and reproductive success of the Bernwood population.

Bechstein's bats are rare in the UK and while the population in the Bernwood area is large, it is genetically and geographically very isolated. The population is therefore vulnerable to continual expansion of built developments, habitat fragmentation and loss, uncoordinated land management and the effects of climate change. The Aylesbury Link Railway Line passes through the Bernwood area, and the Calvert Landfill Site and Energy from Waste facility are immediately south of the railway. HS2 Phase 1 is being constructed parallel to the Aylesbury Link Railway and other developments are proposed. The population is vulnerable and the effects of local land use change, differing land management techniques

and climate change are being felt already. In order for the Bernwood population to develop resilience to these pressures, it will be important to ensure that the habitat requirements of Bechstein's bats are put to the forefront in the future planning and management of the various woodland blocks and connecting commuting corridors within the Bernwood area.

Contents

Introduction	10
Overview	10
Bechstein’s Bat Ecology	10
Bechstein’s Bat – Conservation Status and UK Context	11
Data Validity	12
The Bernwood Area	13
The Bernwood Bechstein’s Population	17
Population size and status.....	17
Bechstein’s Bat Activity.....	19
Roosting	19
Maternity Roosts.....	19
Commuting.....	22
Foraging	24
Home range analysis and Core Sustenance Zones	26
Causes of Change in the Bernwood Area.....	28
Overview	28
Changes in habitat from new 2016 infrastructure	28
Habitat Management	31
Climate change.....	32
Future development.....	33
Conclusions	33
References	36
Appendices	38
Appendix 1: Habitat descriptions of the 12 woodlands that make up the Bernwood area	38

List of figures

Figure 1: Bechstein’s bat known maternity colony and hibernation sites and UK distribution	41
Figure 2: Bernwood area woodland complex.....	42
Figure 3: Bechstein’s bat roosts locations.....	43
Figure 4: Key Bechstein’s bat commuting routes	44
Figure 5: Bernwood area’s Bechstein’s bat home range and foraging areas.....	45

List of tables

Table 1: Areas of woodlands in the Bernwood area	16
Table 2: Maternity roosts recorded outside the existing SSSIs.....	20
Table 3: The core foraging areas for the Finemere Wood SSSI and Grendon and Doddershall Woods maternity colonies.....	25

Introduction

Overview

Natural England is considering the notification of a Site of Special Scientific Interest (SSSI) for a population of Bechstein's bat in Buckinghamshire. The population inhabits areas of ancient woodland and surrounding habitat in the Bernwood area, approximately five miles east of Bicester.

A proportion of the area is already notified as four separate SSSIs, and will, with additional habitats used by the Bechstein's bat population for roosting, foraging and commuting, form part of a single new, larger SSSI. The existing SSSIs are notified for ancient woodland and invertebrates. The new SSSI will be notified for its Bechstein's bat maternity colonies as well as the ancient woodland, semi-natural deciduous woodland, lowland wet meadow grassland, the Black Hairstreak butterfly and other invertebrate interest.

The population of Bechstein's bats in the Bernwood area is at or very close to the northern edge of the species' current UK distribution, and its European range. It is one of the largest known populations of Bechstein's bats in the UK and is located at least 50 kilometres to the north-west and at least 60km to the north from the nearest known breeding population. The population is genetically isolated (Wright *et al.* 2018), although stable. However, the landscape is changing, largely as a result of local development but also different land management regimes and potentially climate change.

A single male Bechstein's bat was recorded in 2009 in south Buckinghamshire and represented the first record for the county. Surveys in 2010 confirmed a breeding population in the Bernwood Forest and justified a significant increase in research and surveys from 2011. A large amount of the data is now available and continues to be collected but given its volume it can be difficult to understand and interpret. The research and data collection was not systematically planned for any one reason. The purpose of the surveys changed each year, the methods utilised, and the survey locations varied, and the data was collated in multiple formats, including written reports, geo-spatial data, thermal imaging files and audio recordings.

This Non-Technical Summary summarises the evidence enabling the technical data and the subsequent analysis and conclusions to be readily accessible. This Non-Technical Summary explains how Bechstein's bat use the Bernwood area, why the area is important for the species and why this Bechstein's bat population is important to the future of the species in the UK.

Bechstein's Bat Ecology

Bechstein's bat *Myotis bechsteinii* is a medium-sized European bat species belonging to the Vespertilionidae family. The species' is long-lived with some individuals exceeding 20

years of age. Its range includes much of Europe, from the United Kingdom and Spain in the west to Greece and Poland in the east.

Bechstein's bats prefer old-growth woodland, which has been subject to significant decline in the recent past. Suitable woodland, including ancient woodland, is today limited in extent, isolated and fragmented. Despite the species natural range across Europe, the species is often restricted to isolated woodlands. There is very little information on the population trends of Bechstein's bat, but it is understood that the species is declining, largely because of the loss, degradation and severance of suitable woodland. Human disturbance and potentially climate change may compound these affects.

During the summer, female Bechstein's bats form maternity colonies within natural cavities in old deciduous trees, usually oak trees. Maternity colonies are groups of females that roost together to give birth and raise their young. Female Bechstein's bats have one pup per year but they don't necessarily breed every year. Colonies tend to move roosts every few nights and can use up to 60 different tree roosts throughout the breeding period (Natural England, 2023). Bechstein's bat maternity roosts usually number between 15 to 50 individuals, although roosts comprising up to 90 bats have been recorded. There is increasing evidence that females frequently select mature oak trees situated in hedgerows or isolated in arable fields during the summer, outside but close to woodlands. It is believed that Bechstein's bats may preferentially select exposed trees over sheltered trees in woodlands, as the internal micro-climate will be warmer, ideal for raising young. Male Bechstein's bats tend to roost alone or in small groups and frequently stay in the same roost for two weeks or more. Unlike the females, males often roost in younger trees or small woodlands.

Bechstein's bats forage for insects during the night and usually along woodland edges. Bechstein's bats rarely fly more than 1.5km to feed and in good habitat, such as the Bernwood area, they tend to forage within 300m of their roost. Foraging is primarily associated with the same woodland habitats within which they roost. Bechstein's bats also forage while flying between locations and therefore also depend on hedgerows, tree lines, watercourses, ponds and open habitat when searching for prey.

During the winter Bechstein's bats hibernate in hollow trees and in underground shelters, but little is known about their hibernating ecology.

Bechstein's Bat – Conservation Status and UK Context

The International Union for the Conservation of Nature (IUCN) predicts that the species' population at a global level has declined approximately 30% during the past 15 years. Consequently, the IUCN categorises the Bechstein's bats as Near Threatened. Near Threatened describes species that are close to qualifying for or likely to qualify as Vulnerable, Endangered or Critically Endangered in the near future.

Bechstein's bat is included on the list of habitats and species of principal importance in England. The list enables public bodies to be aware of biodiversity conservation in their

policy or decision making and supports nature recovery. Publishing the list is a legal duty under Section 41 of the Natural Environment and Rural Communities (NERC) Act.

Bechstein's bat is one of the UK's rarest bats. It is highly reliant on deciduous, oak-dominated, semi-natural woodlands that are often greater than 25 ha in extent, comprise a diversity of tree ages, a well-developed understorey and a diversity of vegetative structure (Natural England, 2023).

In the UK, the Bechstein's bat's core range is in southern England from Gloucestershire to Sussex, although breeding individuals have been recorded as far north as Herefordshire and Worcestershire (Natural England, 2023), see **Figure 1**. The current population of Bechstein's bat in England has been estimated at 21,600 individuals, with a confidence interval of 10,200 - 55,000, (Natural England, 2023). This figure is entirely derived from expert opinion and informed by data from 75 roosts using parameters such as roost size, sex ratios and roost density to estimate population size within the perceived species range (Natural England, 2023). The population size is therefore an estimate only.

A separate assessment (Natural England, 2023) estimated what the favourable population of Bechstein's bats in England should be given the extent and condition of suitable habitat. Habitat suitability modelling assessed the species' natural range and distribution, the estimated population and the extent and quality of habitat necessary for the long-term maintenance of the species. The assessment concluded that the favourable population size in England would be 28,000 individuals. This estimate is approximately 6,400 individuals greater than the current estimated population. Based on a comparison between the current population estimate and the favourable population size, Bechstein's bat is not in a favourable conservation status. Favourable conservation status is the situation when the species can be regarded as thriving in England and can be expected to thrive sustainably in the future.

The population in England is currently assessed as Least Concern (Mathews & Harrower 2020). This is largely because there is no evidence of recent declines in population and no evidence of a contraction in range. Rather, there has been a consistent increase in the number of records, which is likely due to increased survey effort and the growing use of tools such as acoustic lures. Therefore, the Least Concern assessment should be treated with caution.

Data Validity

The data used to inform this Non-Technical Summary was collected over a twelve-year period between 2011 and 2022. From 2012, most of the data was collected on behalf of HS2 Limited and as such, the objective, or objectives, for the surveys evolved annually. The data requirements were very different in the earlier years for HS2 when the project was being designed, compared with the requirements in later years when construction was commencing. The technical teams however, including the Bechstein's bat specialists leading the surveys remained consistent between 2012 and 2020. Professional and

independent consultant bat workers were always employed and worked closely with Natural England. All work was completed within Natural England's licencing requirements for bat field work.

Field surveys comprised radio tracking surveys, emergence surveys, bat filming emergence surveys, static surveys, crossing point surveys, thermal imaging surveys, infrared surveys, tree climbing surveys, the ringing of bats, and faecal DNA analysis. Not all survey types were used every year and some years comprised very little field work. Surveys during 2012 and 2013 sought to identify important roosts, map core foraging areas and commuting routes, and understand the likely population size. Access was not always possible to the SSSI woodlands in these years and where breeding female Bechstein's bats were captured outside these woodlands and roosting within, a precautionary approach was adopted, where the presence of breeding roosts were assumed present. These roosts have been included within this summary. Access was made available to all woodlands from 2014 onwards. Fewer surveys were completed between 2015 and 2017 when the HS2 Act was being passed through Parliament. Surveys during 2017 and 2018 were used to define a baseline against which all future surveys could be compared. The purpose of the surveys in 2018 and 2022 were largely informed by and aligned with the construction programme and its locations.

Survey success was occasionally affected by inclement weather, access permissions, unplanned activities such as nearby shooting events, and equipment failure. The survey methodologies, including the frequency of the surveys and the number of surveyors or surveyor devices were often designed to compensated for unexpected failures or survey abortions. No surveys were planned or completed during the winter months so data on hibernation or potential hibernation roosts is not available.

Despite the varying survey objectives and difficulties with survey consistency across a twelve-year period, the data used to inform this Non-Technical Summary is valid. Data validity is partially ensured through the number of repeat surveys. Twelve years of surveys are more than sufficient to identify broad trends and compensate for the occasional inaccuracy or error. The data was also routinely reviewed and analysed by Bechstein's bat experts, consultant bat workers and Natural England. It is evident therefore that the broad conclusions drawn in 2012, 2013, 2014, 2015 and 2016 are consistent with the surveys completed between 2017 and 2018 and subsequently with the 2022 surveys.

The Bernwood Area

The Bernwood area is part of the former Royal Hunting Forest of Bernwood, which during the 12th century comprised 400km² of woodland across Buckinghamshire and Oxfordshire. The remaining areas of woodland 'the former Bernwood Forest' consists of areas of Ancient and Semi-Natural and Planted Ancient Woodland Sites that extend for approximately 21km from the northeast of Oxford to approximately 7km southwest of Wilmslow, south of the village of Calvert.

The Bernwood area, which is the subject of this Non-Technical Summary, is immediately north of the A41 and is the most north-easterly part of the former Bernwood Forest. It is located between Quainton and Calvert, Buckinghamshire and includes 12 separate woodlands, of which four are SSSI, and are summarised below. The remaining eight woodlands that are not SSSI's are all designated as Local Wildlife Sites.

To the southwest, between the A41 and M4 are several comparatively widely spaced ancient woodlands including Rushbed Wood and Railway Cutting SSSI. The largest and most contiguous constituent woodlands are between Oxford and the M4. They include Shabbington Wood Complex SSSI (the largest relict of the former Bernwood Forest), Waterperry Wood SSSI, Holly Wood SSSI, Holton Wood SSSI and Stanton Great Wood SSSI.

The 12 woodland blocks in the Bernwood area, see **Figure 2**, have a combined extent of 348 ha. They consist of semi-natural and planted ancient woodland, all of which is Lowland Deciduous Woodland Priority Habitat¹ that is situated in a largely agricultural landscape. The Aylesbury Link Railway Line passes through this area, and the Calvert Landfill Site and Energy from Waste facility are immediately south of the railway. The topography of the Bernwood area is gently undulating with areas approximately 110-120m above sea level (ASL) in the northeast of the area giving way to lower lying areas, approximately 70-20m ASL to the centre and southwest of the area.

Nine of the 12 woodland blocks comprising Finemere Wood, Runts Wood, Balmore Wood, Greatsea Wood, Romer Wood, Home Wood, Sheephouse Wood, Decoypond Wood and Shrubs Wood are to the north of the railway. The average minimum distance between these woodland blocks is approximately 350m. The three remaining areas of woodlands comprising Grendon and Diddershall, Ham Home-cum-Ham Green Woods and Hewins Wood are to the south of the railway. There is a greater average minimum distance of approximately 550m between these woodlands.

The available information on the 12 woodlands is summarised in the habitat descriptions in Appendix 1. The woodlands are predominantly deciduous, oak-dominated, semi-natural woodlands with areas of plantation and extensive rides and are variously designated as SSSI and non-statutory Local Wildlife Sites (LWS). They vary considerably in terms of their age and density of trees, extent of felling and restocking, and the diversity and structure of shrub layer and ground flora.

¹ Priority habitats and priority species refer to those identified in the former UK Biodiversity Action Plan that form the basis for the list of habitats and species of principal importance in England. This includes 56 habitats for which the Environment Act 2021 introduces a strengthened 'biodiversity duty' to conserve and enhance biodiversity in England.

Overall, conditions that provide the optimum roosting and foraging habitat for Bechstein's bat are well represented in the Bernwood area, including a well-developed understorey and trees of different stages of maturity. The diversity of tree ages within these woodlands is of particular importance as it includes abundant old deciduous trees with natural cavities that are suitable for the formation of maternity roost sites, and younger trees that will provide an ongoing supply of roost sites as they age. Eight of the 12 woodlands are greater than 25 ha in extent, which further enhances their suitability to support Bechstein's maternity colonies (Natural England, 2023). **Table 1** presents the extent of each woodland block within the Bernwood area (of note, Balmore Wood, Greatsea Wood and Romer Wood form a contiguous block of woodland).

Table 1: Areas of woodlands in the Bernwood area²

Woodland name	Area (hectares)	
Finemere Wood SSSI	46.2	
Grendon and Doddershall Woods SSSI	69.5	
Ham Home-cum-Ham Green Wood SSSI	23.0	
Sheephouse Wood SSSI	58.9	
Decoypond Wood	8.6	
Hewins Wood	1.9	
Home Wood	37.5	
Runts Wood	25.9	
Shrubs Wood	8.1	
Balmore Wood	29.5	68.8
Greatsea Wood	13.3	
Romer Wood	26.0	
Total area of woodland	348.4	

The four woodland blocks that are designated as SSSI cover approximately 198 ha (56% of the woodland in the Bernwood area), and include:

- Finemere Wood (46.2ha): designated for Ancient Pedunculate Woodland, Black Hairstreak and Wood White Butterflies.
- Grendon and Doddershall Woods (69.5ha): designated for Broadleaved Woodland and Butterflies.

² The areas recorded here may differ from those shown in NERR130 'Bernwood Focus Area NVC Surveys of Woodland and Grassland sites', due to differences in recording open habitat and other areas of non-woodland habitat.

- Sheephouse Wood (59.8ha): designated for Ancient Pedunculate Oak Woodland and invertebrate fauna.
- Ham Home-cum-Hamgreen Woods (23.0ha) – designated for Woodland and Black Hairstreak Butterfly.

The intervening farmland is predominantly used for pasture and arable production, as well as areas of permanent grassland managed for nature conservation, most notably Finemere Meadows Nature Reserve. These habitats provide relatively undisturbed conditions that are necessary for the population of Bechstein's bats to move between roosts and foraging areas. The Bernwood area contains a range of linear habitats such as mature overgrown species-rich hedgerows; tree and scrub-lined streams, ponds and ditches, and wooded bridleways and railway cuttings. Many of the natural linear features act as 'dark corridors' along which bats can safely move between roosts and foraging areas. These dark corridors and the associated agricultural land either side provide essential habitat connectivity for Bechstein's bats between the woodland areas and are described below in a description of commuting corridors in the discussion of Bechstein' bat behaviour in the Bernwood area.

The Aylesbury Link Railway Line and the Calvert Landfill Site and Energy from Waste facility are subject to significant changes in scale and operation. Change is particularly associated with the construction and operation of parts of HS2 Phase 1 and East West rail along the existing railway alignment, ongoing use and restoration of the landfill and construction of new railway sidings for the energy from waste facility. Where necessary these changes have a commensurate level of mitigation and compensation so that adverse effects on the Bechstein's bat population can be avoided. However, the scale and nature of consented and proposed development in the Bernwood area means that all the habitats necessary for the favourable conservation status of the Bechstein's bat population should be identified and appropriately protected.

The Bernwood Bechstein's Population

Population size and status

Bat trapping and radio-tracking surveys between 2011 and 2022 identified 57 separate maternity roosts across the Bernwood area. Bat roost dusk emergence surveys on these maternity roosts recorded roost sizes ranging from 7 to 95 individuals. Based on this data, the maximum size of the Bernwood population is estimated to be approximately 300 individuals.

The methodology used to estimate the population size in the Bernwood area is the same method used to provide an estimate of the Bechstein's bat population across the UK (Mathews *et al.* 2018). The typical maternity roost density across the survey area was multiplied by twice the typical number of adult females per roost, i.e. it was assumed that all bats in pre-maternity roosts were female and that males would be in equal numbers in

the surrounding habitat. It should be noted, however, that no definitive data was available on the exact sex ratio of the Bernwood population.

Population estimates are available for several other known Bechstein's bat maternity or hibernation sites in the UK (JNCC, 2024). These include three of the nine Special Areas of Conservation (SAC)³ that are designated for the presence of Bechstein's bat:

- Bath and Bradford-on-Avon SAC – minimum 20, maximum 20
- Bracket's Coppice SAC, Dorset – minimum 51, maximum 100, and
- Briddlesford Copses SAC, Isle of Wight - minimum 51, maximum 100.

At approximately 300 individuals, the Bernwood population therefore represents one of the largest known Bechstein's bat populations in the UK.

The population of approximately 300 individuals in the Bernwood area represents more than 1% of the estimated 21,600 population of Bechstein's bat in England (1.40%). While both estimates were derived using the same methodology, it is acknowledged that the degree of error variation is unknown. However, even with an error variation of 20%, the Bernwood population would still represent more than 1% of the UK population. Moreover, the position of this colony at the edge of its European range increases its vulnerability to environmental changes, which could result in the population becoming unviable.

The past twelve years of research confirmed that Bechstein's bat maintain a viable population in the Bernwood area and that is the most north-easterly population in the UK (Wright *et al.* 2018). The nearest breeding record of Bechstein's bats to the Bernwood area comprises a breeding colony at Black Park County Park in South Buckinghamshire, 50km south-east and a breeding colony at Grafton Wood SSSI, approximately 70 km north-west.

Research into the genetic structure and diversity of eight populations of Bechstein's bat in England by Wright *et al.* (2018) showed that the Bernwood population exhibited less genetic diversity and higher levels of inbreeding than the other populations included in the study. This is likely to be due to the geographical isolation of the Bernwood population and strongly indicates that there is no interaction between the Bernwood population and the other known populations in England (Wright *et al.* 2018). It might reflect landscape scale fragmentation of woodland cover in Buckinghamshire and Oxfordshire resulting in the

³ Special Areas of Conservation (SACs) are protected areas in the UK designated under the Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales

isolation of the Bernwood area, that has prevented breeding between the Bernwood Bechstein's population and those further west and south (Wright et al in prep).

The Bernwood population is therefore likely to be more sensitive to changes in the landscape, including habitat loss, fragmentation and degradation. Furthermore, given their sedentary nature, there is currently no evidence that Bechstein's bat will successfully adapt to warmer conditions caused by climate change by movement of populations to cooler locations further north. The surveys undertaken between 2011– 2022 varied in coverage area of the Bernwood area making any fluctuations in population size difficult to ascertain. However, taking the survey data from years where area coverage was similar, the data does show that roost sizes and the Bernwood population has remained stable with no significant declines.

Bechstein's Bat Activity

Roosting

The surveys undertaken at the Bernwood area between 2011 – 2022 were undertaken between the months of May to September and covered the period before bats gave birth (pre-maternity), i.e. May to early-June, and the period after bats had given birth (post-maternity), i.e. July to September. Bechstein's bats maternity colonies begin to form in early April and most young are born in June (Natural England, 2023). Adult male bats tend to roost alone or in small groups throughout the breeding period but from the end of August and early-September maternity colonies tend to disperse and male and female bats interact at the entrance of underground sites in what is known as 'swarming' behaviour. Mating and hibernation will also occur at these underground sites.

The roosts identified in the Bernwood area during the surveys undertaken between 2011 – 2022 comprised 57 confirmed maternity roosts and 81-day roosts (i.e. roosts where individual or low numbers of bats (1-5) rest during the daytime). All roosts were recorded in trees and no Bechstein's bats were recorded roosting in the many bat boxes that are present throughout Finemere Wood and Sheepphouse Wood.

The summary of information on Bechstein's roosts below considers maternity roosts only, see **Figure 3: Bechstein's bat roosts**. No information on hibernation sites has been obtained and data on the numbers and use of day or transitory roosts does not contribute significantly to the understanding of Bechstein's bat activity in the Bernwood area.

Maternity Roosts

Three distinct maternity colonies were identified during the surveys undertaken within the Bernwood area. A maternity colony is a group of reproductive female bats that roost together and give birth to, nurse and wean their young. The three colonies are listed below

with the number of separate maternity roosts, the peak and average emergence counts recorded and the number of emergence surveys that informed the data:

- Finemere Wood SSSI and its immediate surroundings comprised 12 maternity roosts with a peak count of 68 bats and an average of 32 bats during 16 emergence surveys
- Grendon and Doddershall Woods SSSI and its immediate surroundings comprised 29 maternity roosts with a peak count of 75 bats and an average of 32 bats during 40 emergence surveys, and
- Ham Home-cum-Ham Green Woods SSSI and its immediate surroundings comprised 10 roosts with a peak count of 95 and an average of 29 bats during 11 emergence surveys.

It is of note that the seven maternity roosts within and adjacent to Knapps Hook Farm were used by the same breeding females that occupied roosts in Grendon and Doddershall wood SSSI and its immediate surroundings. The Grendon and Doddershall wood maternity colony therefore comprises 22 maternity roosts in and immediately around the Grendon and Doddershall woods and seven maternity roosts at Knapps Hook Farm, approximately 1km to the southeast.

A further six single and isolated maternity roosts were recorded outside Finemere Wood, Grendon and Doddershall Woods and Ham Home-cum-Ham Green Woods, see **Figure 3**. It is very likely that these roosts are functionally linked with one of the three maternity colonies but there is insufficient evidence to confirm which. Further, one of these roosts was first identified in 2022 and no subsequent survey data is available. It is expected that future survey and assessment will help inform which colonies these breeding females belong to.

Of the 57 maternity roosts across the three colonies, 44 were recorded in the existing SSSIs and 13 were recorded outside the SSSIs in old deciduous trees located in hedgerows, in small areas of woodland, along watercourses, standing alone in arable fields and one on the edge of Home Wood, see **Table 2** and **Figure 3**. The maternity roosts located outside of the woodland were consistently found to support greater average number of bats than those in the existing SSSI woodlands.

Table 2: Maternity roosts recorded outside the existing SSSIs

Ref	Roost Location	Peak emergence count	Associated Maternity Colony (<i>Assumed</i>)
1	Woodland immediately south of Knapps Hook Farm	66	Grendon and Doddershall Woods SSSI

Ref	Roost Location	Peak emergence count	Associated Maternity Colony (Assumed)
2	Woodland copse east of Knapps Hook Farm	75	Grendon and Doddershall Woods SSSI
3	Woodland copse east of Knapps Hook Farm (<i>a separate roost in the same woodland as Ref 2 above</i>)	33	Grendon and Doddershall Woods SSSI
4	Woodland immediately east of Knapps Hook Farm	37	Grendon and Doddershall Woods SSSI
5	Small copse south-west of Knapps Hook Farm	9	Grendon and Doddershall Woods SSSI
6	Small copse south-west of Knapps Hook Farm (<i>a separate roost in the same woodland as Ref 4 above</i>)	75	Grendon and Doddershall Woods SSSI
7	Woodland immediately west of Knapps Hook Farm	42	Grendon and Doddershall Woods SSSI
8	Isolated tree west of Ham Home-cum-Ham Green Woods	95	<i>Ham Home-cum-Ham Green Woods SSSI</i>
9	Isolated tree south of Greatsea Wood and north-west of Finemere Wood	34	<i>Finemere Wood SSSI</i>
10	Isolated tree north of Finemere Wood	14	<i>Finemere Wood SSSI</i>
11	Home Wood	11	<i>Finemere Wood SSSI</i>
12	Isolated tree north-west of Grendon and Doddershall Woods	48	<i>Grendon and Doddershall Woods SSSI</i>
13	Isolated roost 2.3km west of Grendon and Doddershall Woods	13	<i>Grendon and Doddershall Woods SSSI</i>

The maternity roosts close to but outside Finemere Wood were up 125m from the SSSI boundary with peak counts of 68 bats and average count of 44 bats based on seven

separate roost surveys. The maternity roosts close to but outside Grendon and Doddershall Woods were up to 500m from the SSSI boundary with peak counts of 75 bats and an average count of 51 bats based on three separate roosts surveys. Comparison of the numbers of bats present in maternity roosts within and outside of the SSSI woodlands clearly demonstrates that the roosts beyond the boundaries of the existing SSSI form an extremely important resource for the healthy functioning of the Bernwood Bechstein's population.

Bechstein's bat maternity colonies regularly switch between different roosts throughout the breeding period. This regular dissolution and re-merging of maternity colonies throughout the breeding period is known as fission-fusion dynamics and is thought to reduce parasite load and provide more favourable microclimatic conditions which contribute to the healthy functioning of the colony and breeding success (Kerth *et al.* 2001; Reckardt and Kerth 2007).

The 2011 to 2022 field surveys demonstrated that each maternity colony exhibited roost switching behaviour within their respective SSSI woodlands, and associated roosts outside of the woodlands, throughout the breeding period. Bats from different colonies were recorded sharing the same woodland but never the same roost. Individual roosts always remained unique to each colony. Bats from the colony at Grendon and Doddershall Woods SSSI were recorded roosting within Decoypond Wood to the northwest, and a bat from the colony in Ham Home-cum-Ham Green Woods SSSI was recorded in a maternity roost in unnamed woodland northwest of Grendon and Doddershall Woods SSSI. A further small maternity roost of 13 bats was recorded 2.3km from the Grendon and Doddershall Woods SSSI which supported a bat that was also recorded in a day roost in the Grendon and Doddershall Woods SSSI. The roost switching behaviour between two of the colonies and other areas of woodland in the Bernwood area indicates the presence of one interacting population rather than three wholly separate colonies.

Commuting

The radio-tracking surveys carried out between 2011 – 2022 demonstrated how Bechstein's bats use natural linear features to commute throughout the home range in the Bernwood area. They provide connectivity for Bechstein's bats that enable them to move between roosts and foraging areas in the Bernwood area and are also a part of the foraging resource in the home range. Key commuting corridors within the Bernwood area, for which use by Bechstein's bats was recorded regularly during the 2011 – 2022 survey period, are summarised below and illustrated in **Figure 4**.

This information reflects baseline conditions, prior to the start of construction of HS2 Phase 1, East West Rail and Greatmoor Siding. Information on the landscape level changes caused by these projects is provided in the final section of this report.

The former Aylesbury Link Railway: Parts of the largely wooded former goods line through the Bernwood area that provided a commuting route for Bechstein's bat and

indirectly linked the four woodland SSSIs with a north-south connection and several of the other described commuting corridors.

The River Ray: A stretch of the River Ray comprising an incised tree and hedgerow lined stream extending east from Grendon and Doddershall Woods SSSI and then north, over the Aylesbury Link railway line close to a crossing point provided by Adams Underbridge, to Finemere Wood SSSI, provides a commuting route for bats between these woodlands.

Hewins Wood Bridleway: Hewins Wood bridleway (Bridleway GUN/28) comprises a public right of way lined on both sides with mature trees and hedgerows that runs parallel to Hewins Wood and extends northeast for approximately 700m. A ditch also runs parallel along the full extent of the bridleway in this area. Hewins Wood bridleway provides a commuting route for bats to move from Grendon and Doddershall Woods SSSI across the Aylesbury Link railway line, close to Grendon Junction and Benfields overbridge. Here the habitat connectivity links with two other commuting routes and the 'Mega Ditch' which extends northwest, towards Sheephouse Wood SSSI, and east along vegetation towards Finemere Wood SSSI.

Mega Ditch: The Mega Ditch comprises a wide and deep, vegetated drainage channel that extends from the northern end of Hewins Wood Bridleway and then runs along the western side of the Aylesbury Link Railway northwest to link southern edge of Sheephouse Wood SSSI, where it joins the Muxwell Brook, another commuting route described below.

Finemere Wood SSSI to Hewins Wood Bridleway: This strip of vegetation comprised mature hedgerows and secondary deciduous woodland that provided a commuting route for bats between the northern end of Hewins Wood Bridleway to the westernmost tip of Finemere Wood SSSI.

Muxwell Brook: The Muxwell Brook comprises a ditch system that extends north from Grendon and Doddershall Woods SSSI to Sheephouse Wood SSSI providing a commuting route for bats between these woodlands. In this location it comprises ditches adjacent to hedgerows bordering agricultural fields. Costello underbridge provided a crossing point of the Aylesbury Link Railway close to the culvert of the Muxwell Brook at the southern edge of Sheephouse Wood.

Three Points Lane: Three Points Lane comprises part of a public right of way that runs between Finemere Hill (approximately 160m northwest of Finemere Wood SSSI) and then west along the southern edge of Greatsea Wood and Romer Wood eventually connecting to Sheephouse Wood SSSI and Decoypond Wood to the west. This section of Three Points Lane is approximately 10m wide and is lined on either side with mature trees and hedgerows creating a high-quality commuting corridor for bats to move between Finemere Wood SSSI, Greatsea Wood and Romer Wood, Sheephouse Wood SSSI and Decoypond Wood.

The commuting routes, provide habitat links within and also beyond the Bernwood area to the wider landscape, for example, the River Ray provides a commuting corridor for

Bechstein's bats between Grendon and Doddershall Wood SSSI to a known roost to the west of the village of Grendon Underwood 2.5km to the west. Bats were also recorded using less frequently used commuting routes across the site between 2011 – 2022. The less used routes comprise mature hedgerows, treelines and watercourses and ditches that connect the 12 main woodlands within the Bernwood area.

The commuting corridors discussed above provide connectivity for Bechstein's bats between roosting and foraging habitat within the Bernwood area. These corridors therefore represent a vital component of the functionality and reproductive success of the Bernwood Bechstein's population. Due to the fragmented nature of the woodland habitats within the Bernwood area, these corridors comprise relatively thin linear strips of commuting habitat and as such are particularly vulnerable to disturbance.

Foraging

Radio tracking surveys undertaken between 2011 and 2022 identified important areas for foraging within the home range for the Bechstein's bat population in the Bernwood area. Core foraging areas are locations where bats spend the majority of their time searching for prey and are therefore critical to the population viability. In the Bernwood area the core foraging area largely centred on the 12 woodlands, particularly Decoypond Wood, Sheephouse Wood SSSI, Home Wood, Runts Wood, Greatsea Wood, Finemere Wood, Grendon and Doddershall Woods and Ham Home-cum-Ham Green Woods, see **Figure 5**.

The data gathered demonstrates that Decoypond Wood, Runts Wood and Greatsea Wood do not support maternity tree roosts, but they are functionally linked to provide critical foraging resource for two of the maternity colonies, namely the maternity roosts at Finemere Wood SSSI and its immediate surroundings and Grendon and Doddershall Woods SSSI and its immediate surroundings.

Core foraging areas also included some habitat adjacent to the woodlands, including pasture, hedgerows, treelines and watercourses. The most frequently used non-woodland core foraging areas included:

- habitat immediately north, south and west of Finemere Wood SSSI;
- habitat immediately east of Grendon and Doddershall Woods SSSI, and
- habitat immediately north, east and west of both Decoypond Wood and Sheehouse Wood SSSI.

The field surveys confirmed that some of the key commuting routes described above, see **Figure 4**, were also regularly used by foraging Bechstein's bats. The most frequently used commuting routes used for foraging included:

- the River Ray south of Finemere Wood SSSI
- the River Ray east of Grendon and Doddershall Woods SSSI

- part of Three Points Lane west of Finemere Hill, and
- hedgerows and treelines between Finemere Wood SSSI and Hewins Wood Bridleway.

In high quality habitat, Bechstein’s bats tend to forage close to their roosts and rarely fly further than 1,500m to forage (Natural England, 2023). Breeding females tend to utilise their own foraging areas of up to 2-3 ha of high-quality habitat and make repeated returns to their roost sites throughout the night (Natural England, 2023). The survey data showed that Bechstein’s bats mainly foraged within the woodland where their roosts were located and in close proximity to their roosts. This was demonstrated through the presence of core foraging areas for the Bernwood Bechstein’s bat population and the constituent woods. The varied structure and well-developed understorey of the woodlands that represent the majority of the core foraging habitat therefore provide a high-quality resource for Bechstein’s bats. The size of these woodlands provides ample opportunities for several breeding females to retain their own foraging territories.

However, the data also showed Bechstein’s bats roosting within one woodland and regularly commuting to other woodlands to forage. **Table 3** presents the woodlands that provided core foraging areas for two of the maternity colonies, Finemere Wood SSSI, and Grendon and Doddershall Woods SSSI. The maternity colony at Ham Home-cum-Ham Green Wood SSSI mainly foraged around Ham Home-cum-Ham Green wood itself.

Table 3: The core foraging areas for the Finemere Wood SSSI and Grendon and Doddershall Woods maternity colonies

Maternity roost location / colony	Locations of core foraging areas
Finemere Wood SSSI	Sheephouse Wood SSSI Decoypond Wood Shrubs Wood Home Wood Romer Wood Greatsea Wood Baltimore Wood Runts Wood
Grendon and Doddershall Woods SSSI	Sheephouse Wood SSSI Decoypond Wood Romer Wood Greatsea Wood Hewins Wood

The data shows that core foraging areas for breeding females from the Finemere Wood SSSI colony do not extend into the core foraging areas for the Grendon and Doddershall SSSI or Ham Home-cum-Ham Green Wood SSSI maternity colonies and vice-versa. Woodlands that do not support the maternity roosts of the three colonies are however, included in the core foraging areas for the Finemere Wood SSSI and the Grendon and Doddershall Woods SSSI colonies. The data therefore demonstrates that, although there are three separate colonies within the Bernwood area, all the woods represent important foraging areas and are therefore essential in supporting the viability and reproductive success of the Bernwood population. Although the core feeding areas of high value foraging habitat close to roost resource are likely to be important to breeding females whilst raising their pups; foraging areas for the entire Bernwood Bechstein's population (including male Bechstein's) comprised a much wider area within the wider Bernwood landscape. This was identified through the radio-tracking surveys carried out between 2011 – 2022.

Between 2017 and 2022 field surveys included DNA analysis of Bechstein's bat droppings to identify the invertebrate species present in their diet. The aim of the research was to provide qualitative comparative analysis of the composition of food items and, indirectly, habitat types being used by Bechstein's bats for foraging (HS2 Ltd, 2018 and HS2 Ltd, 2019). The results of the faecal DNA analysis have so far shown that the majority of the invertebrate prey species are associated with woodland habitats (69.4% - 74%), as expected given Bechstein's bats strong association with woodland. The remainder of the invertebrate prey species were associated with open habitats or wetland habitats (HS2 Ltd, 2018, HS2 Ltd, 2019, and HS2 Ltd 2023). As core and peripheral foraging areas overlap with these habitat types, the findings indicate that a proportion of foraging activity takes place in non-woodland habitat. A significant number of the species identified are associated with multiple habitat types so it was not considered possible to draw correlations between Bechstein's bat foraging and specific habitats (HS2 Ltd, 2018, HS2 Ltd, 2019, and HS2 Ltd 2023).

Home range analysis and Core Sustenance Zones

The home range of an animal is defined as the total area within which it lives and moves on a regular basis and contains all the resources that the animal requires to survive and reproduce. The home range of the Bechstein's bat population within the Bernwood area has been ascertained through bat trapping and radio-tracking studies between 2011 and 2022. The Bernwood area home range comprises an area of approximately 4,160 ha centred around the woodlands described above and shown on **Figure 2**.

A Core Sustenance Zone (CSZ) is a tool used to delineate the bat home range. It refers to the area surrounding a maternity roost within which habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost (BCT, 2016). The CSZ size for Bechstein's bat has been determined as being a 3km radius from each maternity roost. The collective CSZ area for all maternity roosts identified within the Bernwood area through bat trapping and radio-tracking studies between 2011

and 2022 is approximately 7,934 ha around the Bernwood area. The CSZ for the Bernwood population of Bechstein's bats is presented in **Figure 5**.

The majority of the habitats present within the Bernwood population home range and CSZ comprises arable and pastoral farmland. The percentage of woodland within the home range and CSZ is 8.5% and 4.5% respectively. These percentages of woodland within the home range and CSZ are considered small given the species strong association with the woodland and highlights how isolated the Bernwood Bechstein's population is and how susceptible it could be to change.

Causes of Change in the Bernwood Area

Overview

Information provided in preceding sections of this non-technical report provides baseline information on the Bernwood area and the characteristics and behaviour of population of Bechstein's bats it supports. The changes associated with infrastructure development have been acknowledged and are discussed below, with other causes of change, as they are relevant to the resilience and viability of the population. The main causes of change in the Bernwood area include:

- changes in the extent and distribution of roosting, commuting and foraging habitat from the removal and replacement (through compensation) of habitat associated with the new infrastructure, including
 - habitat fragmentation from severance of commuting routes and subsequent reinstatement (with interim measures to provide temporary connectivity)
 - disturbance of retained habitat and compensation during construction and operation
 - potential for killing and injury of bats during operation
- changes in land management associated with forestry, agricultural and nature conservation management practices
- ecological changes associated with climate change, and
- future, as yet unknown or unconsented developments that could affect the Bechstein's population

In summary, the changes in habitat extent and disturbance, risk of uncoordinated land management, habitat degradation resulting from climate change and the potential pressure from forthcoming development are all extremely relevant to the long-term viability of the Bechstein's bat population in the Bernwood area. With such a number and variety of possible future changes, measures are required to coordinate planning and management that will increase the resilience of the population.

Changes in habitat from new 2016 infrastructure

The development of HS2 Phase 1, East West Rail and the Greatmoor sidings has led to the loss of roosting, commuting and foraging habitat, predominantly from the removal of vegetation along the former Aylesbury Link Railway, and also the removal of parts of adjoining or parallel commuting corridors. The impacts on key commuting corridors includes:

- the temporary severance of the River Ray;
- the loss of parts of Hewins Wood Bridleway close to the railway alignment and habitat linkages across it provided by existing structures (for example Grendon Junction and Benfields overbridge);
- the Mega Ditch will no longer be available as a continuous bat commuting route post-construction;
- the loss of vegetation associated with Finemere Wood SSSI to Hewins Wood Bridleway; and
- the removal of a crossing point over the Aylesbury Link Railway at Costello underbridge, close to the culvert of the Muxwell Brook at the southern edge of Sheephouse Wood.

Disturbance associated with the new railway infrastructure may include increased noise and light pollution, exacerbated by habitat loss and fragmentation. Disturbance is highly likely to cause a reduction, or even cessation of the use of commuting corridors by Bechstein's bats. This could result in lowered functionality and reproductive success of the Bernwood population and lead to further fragmentation and isolation of colonies within the Bernwood area.

The mitigation for impacts on commuting habitat described above are part of a wider strategy to address the impacts of the construction and operation of the infrastructure of HS2 Phase 1, East West Rail and the Greatmoor sidings, and to account for the operation of the Greatmoor Energy from Waste Facility. The mitigation relies on the following broadly defined constituents:

- underbridges and green overbridges across the HS2 and East West Rail alignment to provide east/west connectivity between maternity colonies at, or close to the location of the habitat features and structures that bats were recorded using during the 2018-2022 surveys. Those provided to compensate for the loss of crossing points along Bechstein's commuting routes include:
 - the reinstatement of the underbridge close to the River Ray as the Adam's accommodation underbridge and planting to replace vegetation that has been removed, once construction is complete
 - reconnecting Hewins Wood Bridleway across the new railway infrastructure through the construction of Bridleway QUA/36 Accommodation Green Overbridge and Bridleway GUN/28 Accommodation Green Overbridge and associated planting
 - the replacement of vegetation associated with Finemere Wood SSSI to Hewins Wood Bridleway with planted trees
 - the replacement of Costello underbridge with Footpath CAG/2 Underbridge, with associated planting to link to Three Points Lane
- further crossing points are provided by greening the approaches to the Edgcott Road Overbridge to the south of the Bernwood area, the Footpath SCL/13 Green

Overbridge at the northern boundary of Sheephouse Wood, the Calvert Green Overbridge north of Decoypond Wood and School Hill Green Overbridge at School Hill immediately north of Calvert

- reinstating, strengthening and where necessary realigning the habitat corridors of which the crossing points noted above are a part, so that the connectivity of habitats used by Bechstein's bats and is reestablished in the landscape
- providing an alternative north-south green corridor to replace that associated with the Aylesbury Link Railway and the Mega Ditch, to the east of the new railways that links Finemere Wood, Sheephouse Wood, Decoypond Wood and Calvert Jubilee Nature Reserve. It includes planting to strengthen the commuting route along Three Points Lane and woodland creation between Finemere Wood and Sheephouse Wood that will provide a foraging resource and increase the value of the commuting route, and
- various measures to reduce the risk of killing and disturbing bats during the operational phase of the new infrastructure as Bechstein's bat commute through the Bernwood area, including:
 - planting to guide bats to new crossing points and corridors
 - the design of the green bridges to attract bats to fly along the middle of the structure rather than along the edges
 - vegetation management to discourage bats from flying along or close to the new railway corridor especially if they depart from established commuting routes
 - noise and light barriers to separate bats from sources of disturbance that could cause them to diverge from safe crossing points, and
 - the construction of the Sheephouse Wood Mitigation Structure that will stop bats from emerging from the western edge of Sheephouse Wood immediately into the railway corridor.

In addition to the compensation relating to the rail infrastructure, the Greatmoor Energy from Waste plant has a commitment to undertake major habitat restoration works across its land ownership, which includes the existing landfill site at Calvert. This will result in the planting of extensive new woodland and grassland creation south of Sheephouse Wood SSSI and Decoypond Wood.

The compensatory planting from the rail infrastructure construction works and the habitat restoration works from the Greatmoor Energy from Waste plant have the potential to provide increased habitat cover and connectivity for the Bernwood Bechstein's bat population.

Much of the mitigation described above is integral to maintaining the home range and CSZ of Bechstein's bats in the Bernwood area, as well as mitigating the specific impacts generated by the new infrastructure.

Habitat Management

There are different purposes and approaches to the management of the 12 main woodlands in the Bernwood area, with the potential to have both positive and negative influences on the Bernwood Bechstein's bat population.

As previously discussed in this report, breeding and foraging Bechstein's bats have specific habitat requirements including:

- woodlands over 25 ha in extent with high proportions of oak in the canopy
- mature oaks of differing age classes with holes and cavities
- well-developed understorey with a variety of native species, and
- streams or ditches retaining water within woodlands.

The woodlands within the Bernwood area (described in Appendix 1) that have been shown to support breeding colonies of Bechstein's bats and support foraging areas for Bechstein's bats each exhibit all or some of these features. Any future management that would negatively impact these characteristics would therefore have the potential to negatively affect the Bernwood Bechstein's population. Potential effects therefore need to be considered when thinning, clearing or coppicing are undertaken. To minimise any negative impacts, the following measures should be adopted (BCT, 2013):

- known roosts and mature and veteran trees with woodpecker holes or other suitable potential roosting features, e.g. hollows and cavities, should be protected and retained to ensure the retention of roosting habitat
- the clearance or coppicing of woodland understorey should be avoided or minimised to protect and retain the favourable conditions required by invertebrate prey species, and
- dead and fallen deadwood should be retained to further support invertebrate prey species.

The current management of the woodlands supporting the three maternity colonies, Finemere Wood, Grendon and Doddershall Woods and Ham Home-cum-Ham Green Wood SSSI does not at present appear to involve any forestry operations. The same is apparent for Sheephouse Wood SSSI. Due to their current SSSI designations, there are lists of operations requiring Natural England consent, which includes the introduction of or changes in tree or woodland management such as afforestation, planting, clear and selective felling, thinning, coppicing, modification of the stand or understorey, changes in species composition or the cessation of current management. The woodlands already designated as a SSSI are therefore, in theory, well protected. Little should therefore need to be done other than monitor the woodlands to ensure the natural regeneration of oak trees. The natural regeneration of oaks will maintain and improve the diversity and range of tree age classes required to provide ample natural roosting habitat (Greenaway and Hill, 2004).

Areas of plantation within woodlands have been shown to provide important foraging areas for the Bernwood Bechstein's bat population. The value of these areas for Bechstein's bats is dependent on a diverse woodland structure present, i.e. the presence of linked canopy cover with a well-developed understorey (Greenaway and Hill, 2004). Approaches to improving plantation management that are beneficial for Bechstein's bats are available from the Bat Conservation Trust's publication *Bechstein's bat, an introduction for woodland owners* (2013) and include:

- ensuring, by new planting where necessary, that all deciduous blocks in nursery colony areas have deciduous woodland connections
- creating minimum-intervention strips along all watercourses within woodlands
- zoning important areas as minimum-intervention continuous cover forestry areas, subject to selective felling of only the best sound hardwood timber on a slow continuing basis at appropriate times of year
- monitoring stands of trees used as nest sites by woodpeckers and leaving these stands as minimum-intervention areas
- leaving the immediate stand of trees surrounding potential roost trees, e.g. trees with woodpecker holes, hollow trees, and
- managing grasslands and glades within or adjacent to woodlands to increase ant numbers to encourage woodpeckers.

The responsibility for management of woodlands within the Bernwood area that are outside of SSSI currently lies with three different owners, whilst the extensive compensatory woodland planting described above will be managed on behalf of commercial organisations. Differing woodland management techniques and timings undertaken by these organisations could have a detrimental impact on the Bernwood population if, for example, uncoordinated concurrent forestry operations were carried out in different areas. A holistic approach to the management of the woodlands within the Bernwood area would therefore be beneficial to the resilience of the Bernwood Bechstein's bat population.

Climate change

Lowland mixed broadleaved woodland is expected to undergo changes in range, species composition and age structure caused by warmer, drier summers and milder, wetter winters (Ray et al. 2010). Within the Bernwood area, these changes could lead to several detrimental outcomes for the Bernwood population such as (Ray et al. 2010):

- reduction in oak and ash cover due to the colonisation of other tree species more tolerant to warmer summers and milder winters
- increase of mortality in older trees, and
- localised changes in ground flora and understorey composition.

These changes therefore have the potential to reduce roost and foraging habitat availability for Bechstein's bat within the Bernwood area. Whilst the precise extent and timing of changes caused by climate change are unpredictable, woodland management with a clear and robust plan for woodland resilience within the Bernwood area is necessary to maintain the suitability of the habitat for the Bechstein's population, which is already vulnerable due to its isolation.

Future development

Future known potential development within the Bernwood area includes a Nationally Significant Infrastructure project in the form of a 2,100 acre solar farm. This project would be constructed on agricultural land to the north of Sheephouse Wood SSSI and Decoypond Wood, between Sheephouse Wood SSSI and Greatsea Wood and north of Finemere Wood SSSI to Runts Wood and beyond to the village of Botolph Claydon. There is published research of solar farms affecting bat behaviour (Szabadi *et al* 2023) and, as such, a project of this scale could potentially affect or alter the Bechstein's bat's foraging behaviour in the Bernwood area. Part of the existing landfill site is also proposed for a smaller separate solar farm and the infrastructure investment could attract more development.

The impacts of the rail infrastructure schemes within the Bernwood area are subject to annual ecological monitoring surveys which began in 2022 and include annual passive bat monitoring surveys and four-yearly trapping and radio-tracking surveys until 2040. The impacts of the scheme and the success of the mitigation are not therefore currently fully understood. The cumulative impact of the developments within the Bernwood area may, however, have a serious detrimental impact on bat populations within the Bernwood area through increased noise, lighting and habitat loss and degradation.

Conclusions

The Bechstein's bat distribution in the UK comprises an area across southern England from Gloucestershire to Sussex, although breeding individuals have been recorded as far north as Herefordshire and Worcestershire (Natural England, 2023). The Bechstein's bat population in the Bernwood area represents the most north-easterly extent of the species known UK range and is geographically and genetically isolated. The closest known breeding populations are at Black Park County Park 50 km south-west and Grafton Wood SSSI 70 km north-west.

The adult population size for the Bechstein's bat in England is estimated at 21,600 individuals (Mathews *et al*. 2018). This estimate was based on expert opinion and data from 75 roosts and a total derived extent of available broadleaved woodland. A separate assessment (Natural England 2023), based on habitat suitability estimated that the favourable population size in England is 28,000 individuals. Given the discrepancy

between the two estimates, Bechstein's bat in England are not in a favourable conservation status.

Data collected during field surveys undertaken between 2011 and 2022 implies that the Bernwood Bechstein's bat population size is approximately 300 individuals, which is 1.4% of the UK population. A total of 57 maternity roosts were confirmed in the Bernwood area with roosts sizes ranging from 7 to 95 individuals.

The Bernwood population comprises three maternity colonies which are centred on Finemere Wood SSSI, Grendon and Doddershall Wood SSSI and Ham Home-cum-Ham Green Wood SSSI, respectively. The survey data does not indicate that these colonies interbreed with each other, but it does clearly show that they share common foraging areas within surrounding woodlands such as Sheepphouse Wood SSSI and therefore together, form one population.

Genetic research has shown that the Bernwood population exhibits higher levels of inbreeding and lower genetic diversity when compared with other populations within the UK and is genetically distinct to other populations studied in the UK. The population is however genetically viable and stable. Despite this, the geographic and genetic isolations of the Bernwood population makes it very vulnerable to future changes such as climate change, habitat loss and disturbance.

The current SSSI woodlands within the Bernwood area comprise Finemere Wood SSSI, Grendon and Doddershall Wood SSSI, Ham Home-cum-Ham Green Wood SSSI and Sheepphouse Wood SSSI. These SSSIs are not currently designated for bats and are primarily designated for the presence of rare invertebrate populations. The three maternity colonies are therefore indirectly afforded a certain degree of protection. The data confirms however, that the Bernwood population uses all of the other woodlands within the Bernwood area for foraging and roosting. Day roosts have been recorded in the majority of the woodlands. Maternity roosts associated with each colony have also been recorded within mature trees outside of the current SSSI boundaries. These roosts tend to have comparatively high numbers of individuals roosting within them and are therefore extremely functionally important to the colonies.

Also, of vital importance to these colonies and the Bernwood population, are the commuting corridors that link the various woodland blocks such watercourses, hedgerows and treelines. These corridors provide vital safe passage for bats to travel between roosting and foraging areas and provide an important foraging resource in their own right. These corridors comprise narrow and exposed linear strips of habitat and are therefore very vulnerable to disturbance through habitat loss, disturbance and light pollution.

Bechstein's bats are rare in the UK and while the population in the Bernwood area is very large, it is genetically and geographically isolated. The stability and management of the habitat in the Bernwood area and any future enhancements are therefore extremely important to the long-term viability of the Bechstein's bat population in the Bernwood area. Changes in the extent and connectivity of the area's woodland and surrounding habitats,

and associated changes in noise and light disturbance from current and forthcoming local developments, the risk of uncoordinated land management, and habitat degradation resulting from climate change are of relevance. With such a number and variety of possible future changes, coordinated measures in habitat planning and management are essential to increase the resilience of the population.

References

Alison Jukes (2023b) *Bernwood Area NVC surveys of woodland and grassland sites*. NERR130. Natural England.

Bat Conservation Trust (2012) *Bechstein's bat survey*. Bat Conservation Trust, London.

Bat Conservation Trust (2013) *Bechstein's bat, an introduction for woodland owners*. Bat Conservation Trust, London.

Bat Conservation Trust (2016) *Core Sustainance Zones: Determining zone size*. Bat Conservation Trust, London.

Dickins E., Damant C. (2015) *Bernwood Forest, Buckinghamshire – Summary and Review of Bechstein's Survey Results 2010-2014*. Bernwood Environmental Conservation Services.

Greenaway, F. & Hill, D. A. (2004) *Woodland management advice for Bechstein's bat and barbastelle bat*. English Nature Research Reports 658.

Martin Harvey (2022) *Bernwood Invertebrate Surveys 2021*. NECR426. Natural England.

Mathews F., Kubasiewicz L. M., Gurnell J., Harrower C. A., McDonald R. A. and Shore R. F. (2018) *A Review of the Population and Conservation Status of British Mammals. A report by the Mammal Society under contract to Natural England, Natural Resources Wales and Scottish Natural Heritage*. Natural England, Peterborough. ISBN 978-1-78354-494-3.

MATHEWS, F. & HARROWER, C. 2020. *IUCN – compliant Red List for Britain's Terrestrial Mammals. Assessment by the Mammal Society under contract to Natural England, Natural Resources Wales and Scottish Natural Heritage*. Natural England, Peterborough:

Natural England (2023a) *Definition of Favourable Conservation Status for Bechstein's bat*. RP2970. Natural England.

Natural England (2023c) *Bernwood Area Invertebrate Survey 2017-2021*. NERR129. Natural England.

Szabadi KL, Kurali A, Rahman NAA, Froidevaux JSP, Tinsley E, Jones G, Görföl T, Estók P & Zsebok S (2023) The use of solar farms by bats in mosaic landscapes: Implications for conservation. *Global Ecology and Conservation*, 44, Art. No: e02481.

Wright, P. G., Hamilton, P.B., Schofield, H., Glover, A., Damant, C., Davidson-Watts, I. and Mathews, F. (2018). Genetic structure and diversity of a rare woodland bat, *Myotis bechsteinii*: comparison of continental Europe and Britain. *Conservation Genetics*, 19 (4), 777-787.

Wright, P.G., Bellamy, C., Hamilton, P., Schofield, H.W., Finch, D., and Mathews, F. (2021). Characterising the relationship between suitable habitat and gene flow for *Myotis bechsteinii* and *Eptesicus serotinus* in Britain. *Landscape Ecology*, 36 (6).

HS2 Reports:

HS2 Ltd. (2013) London – West Midlands Environmental Statement - Volume 5 Technical appendix CFA12-13 Waddesdon to Chetwode, Bat trapping/radio tracking study – Bernwood Forest EC-006-002).

HS2 Ltd. (2014) Supplementary Environmental Statement 3 and Additional Provision 4 Environmental Statement - Volume 2 Community Forum Area 12 Waddesdon and Quainton.

HS2 Ltd. (2014) Supplementary Environmental Statement 3 and Additional Provision 4 Environmental Statement - Volume 2 Community Forum Area 13 Calvert Steeple Claydon Twyford Chetwode.

HS2 Ltd. (2015) ERM-Temple-Mott MacDonald EV RREP-020-000191 – Bernwood P02

HS2 Ltd. (2016) Sector C2- Waddesdon – Quainton. Technical Report Bat Trapping/Radio-Tracking Study 2015-Bernwood Forest. C252-ETM-EV-REP-020-000191

HS2 Ltd. (2017) Sector C2- Waddesdon – Quainton. Technical Report Bat Trapping/Radio-Tracking Study 2016-Bernwood Forest. P1C-ETM-EV-REP-000-000005_P01

HS2 Ltd. (2018), Technical Report: Bernwood Baseline Monitoring Survey report 2017. 1EW03-FUSEV-REP-C000-005183

HS2 Ltd. (2019), Enabling Works Central, AWS Bernwood Monitoring Survey Report 2018 and Annexes. 1EW03-FUS-EV-REP-C002-004017

HS2 Ltd. (2023) Bernwood Monitoring Strategy – Bernwood 2022 Monitoring Report. Pell Frischmann. 1MC12-EKF-EV-FRM-CS08-000117

Appendices

Appendix 1: Habitat descriptions of the 12 woodlands that make up the Bernwood area

Finemere Wood SSSI: Finemere Wood SSSI is owned and managed by a wildlife charity. Formerly owned by the Forestry Commission, the charity have undertaken major habitat restoration including the removal of conifers which were planted by the Forestry Commission for commercial timber extraction (Natural England, 2023b). This restoration work has allowed the woodland to recover well and ongoing management by the charity comprises areas of thinning and coppicing, ride-side coppicing and the maintenance of grassy glades (Natural England, 2023b).

Grendon and Doddershall Woods SSSI: Grendon and Doddershall Woods SSSI is owned and managed by a private estate. The woodlands comprise large areas of good-quality, oak dominated woodland with remnant coppice-with-standards structure (Natural England, 2023b). The woodlands are dominated by relatively uniform size and age oaks with a high canopy layer throughout. The woodland understorey is well-developed and comprises a good variety of shrub species. An extensive ride system criss-crosses the woodlands parts of which comprise species-rich grassland (Natural England, 2023b). Evidence of deer browsing is present within the woodlands (Natural England, 2023b).

Ham Home-cum-Ham Green Wood SSSI: Ham Home-cum-Ham Green Wood SSSI comprises a similar structure to Grendon and Doddershall Woods SSSI but is much smaller, has a more mixed canopy of oak and ash and has more variation in the structure of the rides and woodland edges. As Grendon and Doddershall Woods SSSI, it has a pronounced remnant coppice-with-standards structure in which mature oak is prominent in the canopy and well-developed understorey with a variety of shrub species (Natural England, 2023b). A section of the woodland that lies between the 'separate' woodland blocks named Ham Home Wood and Ham Green Wood is not designated as SSSI and comprises mixed broadleaved and coniferous woodland the majority of which has been recently felled (Natural England, 2023b). Evidence of deer browsing is present within the woodlands (Natural England, 2023b).

Sheephouse Wood SSSI: Sheephouse Wood SSSI is owned and managed by a private estate. The estate also own and manage Decoypond Wood, Shrubs Wood, Home Wood, Balmore Wood, Greatsea Wood, Romer Wood and Runts Wood. The woodland comprises mainly good-quality, oak dominated woodland with small areas of recent plantation and scrub (Natural England, 2023b). Many veteran or near-veteran trees are present within the woodland and the understorey is well-developed with a variety of shrub species. An extensive ride system is present through the woodland with woodland glades also present. Evidence of deer browsing is present within the woodland (Natural England, 2023b).

Decoypond Wood: Decoypond Wood is designated as a Local Wildlife Site (LWS). LWS are areas recognised as having high wildlife value or containing rare or threatened habitats and species. The woodland is dominated by mainly mature oak with no veteran trees present. The understorey comprises ash, hazel and hawthorn with much of the ash and hazel historically coppiced (Natural England, 2023b). Moderate levels of deer browsing are evident within the woodland (Natural England, 2023b).

Hewins Wood: Hewins Wood is designated as a LWS. The woodland comprises a mixture of even-aged oak with some pine. Trees present are mostly young with no old or veteran trees present within the main body of the woodland although some near veteran trees are present on the western boundary adjacent to a ditch (Natural England, 2023b). The woodland has a sparse understorey and no ride system.

Home Wood: Home Wood is designated as a LWS. Home Wood is a relatively large woodland within the complex and comprises areas of remnant coppice-with-standards structure, areas where standards have been harvested with the understorey thinned out or removed and some areas of recently felled and replanted trees (Natural England, 2023b). The woodland has an extensive ride system.

Romer, Greatsea and Balmore Woods: Romer, Greatsea and Balmore Woods are designated as LWSs. These woodlands are all managed plantation woodlands with areas of recent clear felling and areas of recent re-planting. Smaller blocks and strips of older undisturbed woodland are, however, present (Natural England, 2023b). The plantation areas comprise even-aged oak and pine with little structural diversity. The undisturbed areas comprise higher-quality woodland with mature oak, birch and ash with a hazel and hawthorn understorey (Natural England, 2023b).

Runts Wood: Runts Wood is designated as a LWS. The woodland canopy is dominated by oak with ash and sparse conifers are also present (Natural England, 2023b). The woodland is a managed plantation woodland with selective felling of young and mature ash recently undertaken (Natural England, 2023b). The understorey comprises mostly hazel and hawthorn and has been cleared in some areas (Natural England, 2023b). Evidence of deer browsing is present within the woodland (Natural England, 2023b).

Shrubs Wood: Shrubs Wood is designated as a LWS. The woodland is dominated by mature oak with some mature ash and old hazel coppice understorey. Most of the site comprises older, established woodland with a strip of more recent plantation in the middle of woodland comprising mixed tree species including oak, birch, ash and alder (Natural England, 2023b). The woodland is a managed plantation woodland and quite substantial felling works have been recently undertaken (Natural England, 2023b).

Figures

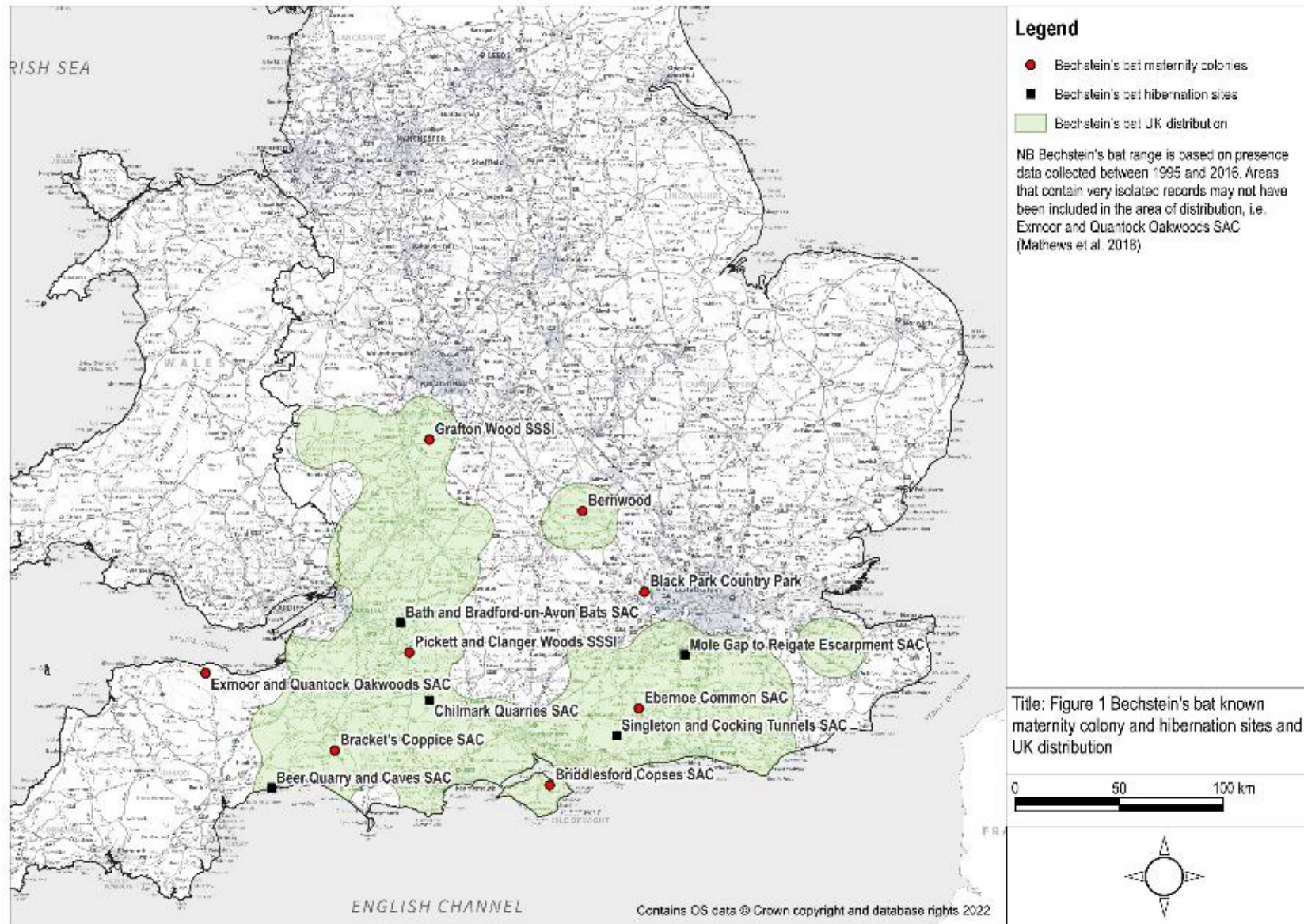


Figure 1: Bechstein's bat known maternity colony and hibernation sites and UK distribution

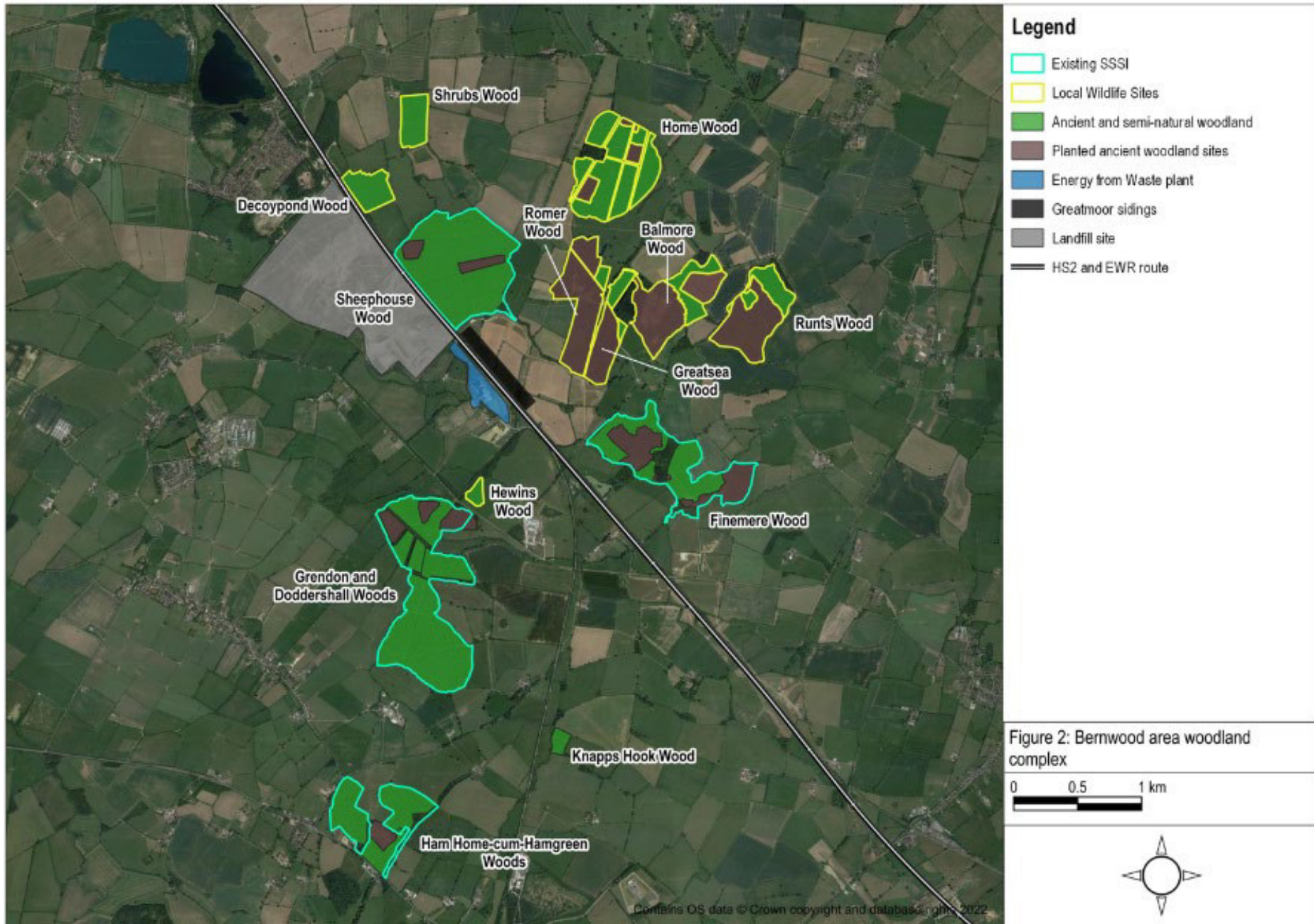


Figure 2: Bernwood area woodland complex

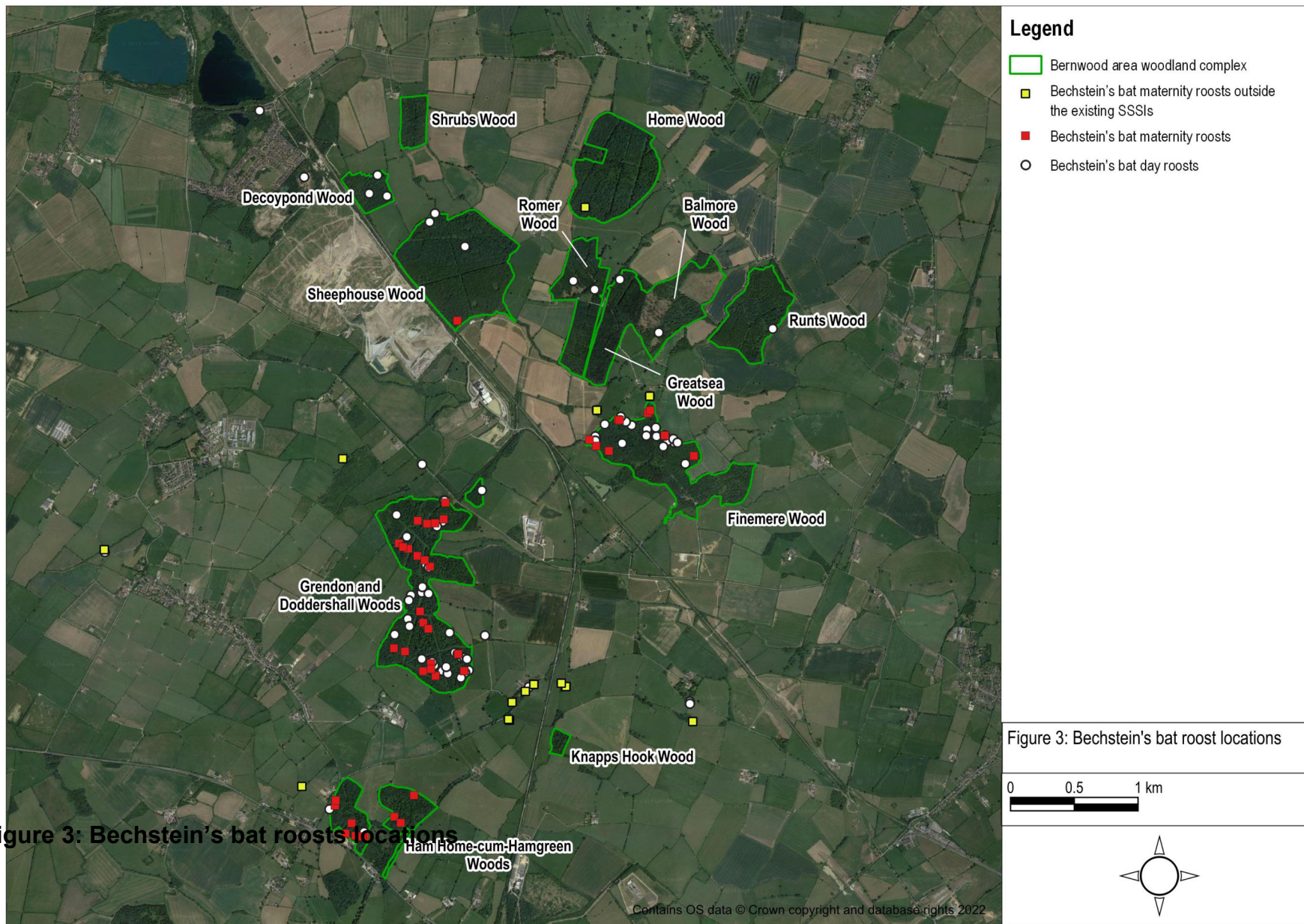


Figure 3: Bechstein's bat roost locations

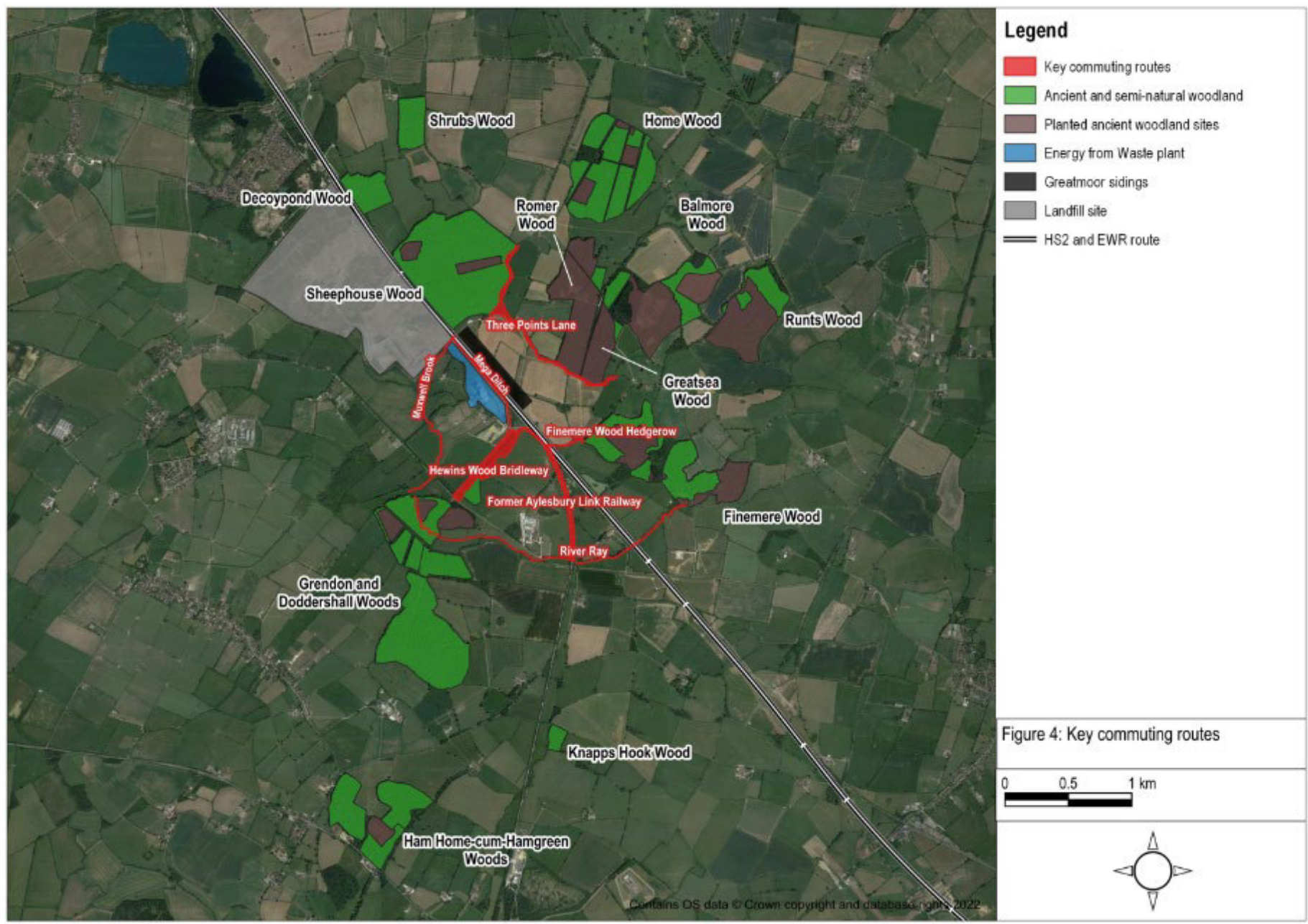


Figure 4: Key Bechstein's bat commuting routes

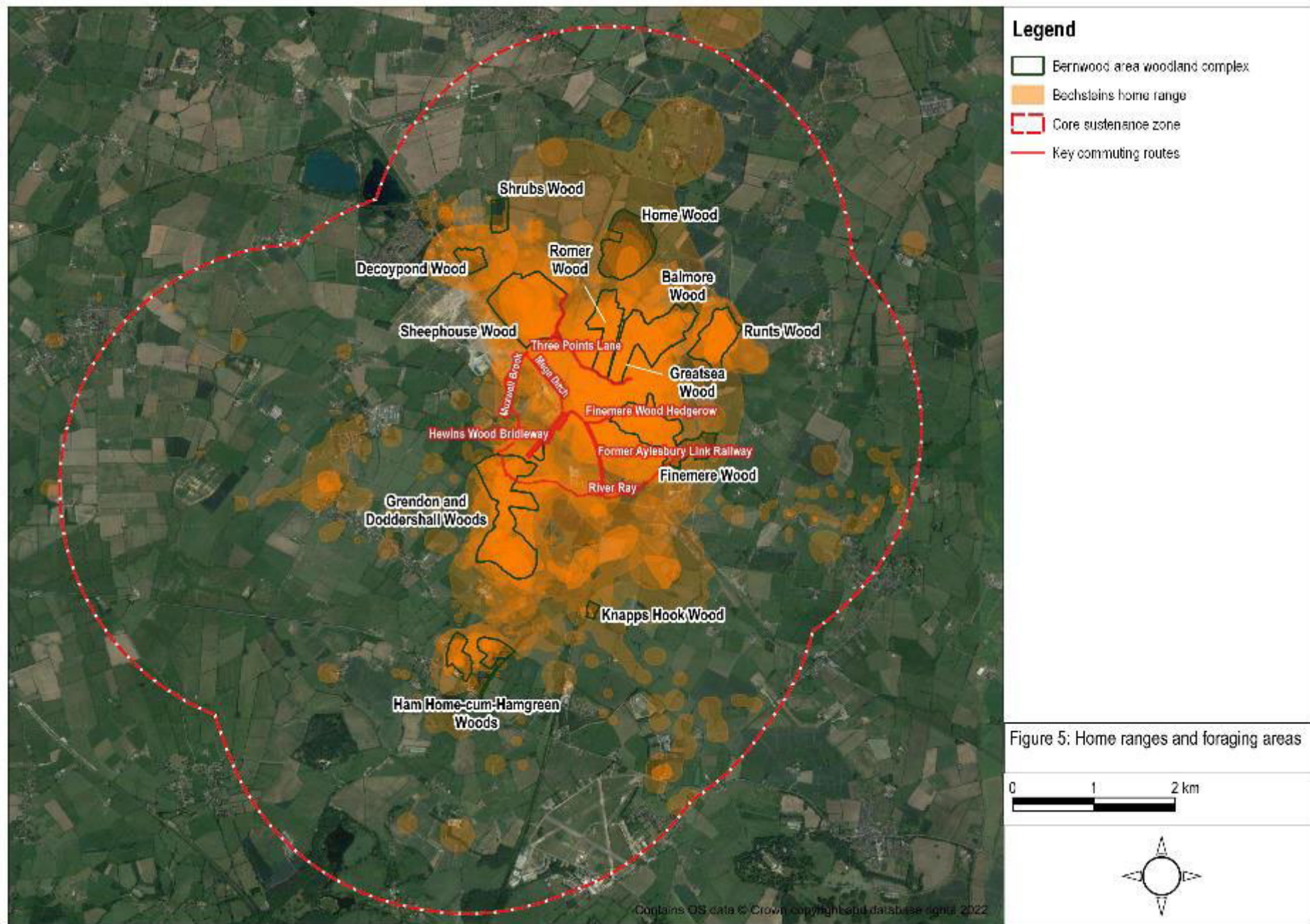


Figure 5: Bernwood area's Bechstein's bat home range and foraging areas





rosefieldsolarfarm.co.uk