MARSHALL DAY Acoustics

BIALA WIND FARM

POST-CONSTRUCTION NOISE ASSESSMENT

Rp 003 20200121 | 31 July 2023

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EXECUTIVE SUMMARY

This report presents the results of the post-construction noise compliance assessment for the Biala Wind Farm, as required by Condition 12 of the Development Consent.

This compliance assessment report is based on noise monitoring carried out on and in the vicinity of the Biala Wind Farm to evaluate noise levels associated with the development's wind turbines. The noise monitoring was conducted in accordance with the Development Consent, the NSW Noise Assessment Bulletin, and the approved Noise Compliance Test Plan (NCTP).

The noise monitoring commenced on 23 January 2023, and was originally intended to continue for a period of approximately six (6) weeks, as specified in the NCTP, to satisfy the reporting timeframes defined in the Development Consent. Due to the impact of factors such as wind turbine curtailments and weather conditions, the monitoring period was extended to May 2023 to enable the collection of the minimum number of valid periods specified under the NSW Noise Assessment Bulletin.

In accordance with the NCTP, the noise monitoring comprised;

- Unattended measurements at five (5) residential locations;
- Unattended measurements at three (3) intermediate locations generally positioned nearer to the wind farm; and
- Attended observations to assist with the assessment of the noise characteristics of the wind farm.

As the influence of background noise on total measured noise levels could not be quantified due to outdated background noise data, estimated wind farm noise levels were extrapolated at receiver locations based on measured noise levels at intermediate locations.

The results of the noise monitoring and compliance assessment demonstrated that:

- Total measured noise levels at receiver locations HN06, HN09 and HN12 were below the applicable noise criteria as specified by the development consent;
- Total measured noise levels at receiver locations HN13 and HN15 were below the applicable noise criteria at all wind speeds at or below 10 m/s. At wind speeds greater than 10 m/s, the outcomes of the compliance assessment were inconclusive due to the influence of background noise;
- Estimated wind farm noise levels based on measured noise levels at intermediate locations were below the applicable noise criteria at all assessed locations by a margin of at least 3.0 dB; and
- The assessment of special noise characteristics found that the application of a penalty was not warranted at any receiver locations.

The findings of the monitoring and compliance assessment therefore demonstrate that the Biala Wind Farm is compliant with the operation noise requirements specified in the Development Consent.

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1.0 INTRODUCTION

The Biala Wind Farm is an operational project located in the Upper Lachlan Shire Council region of New South Wales, approximately 17 km southwest of Crookwell.

The project comprises thirty-one (31) wind turbines, with a maximum tip height of 180 m, and associated infrastructure.

The Development Consent[1] details conditions for the control of environmental noise from the development including noise criteria and a requirement for noise compliance monitoring when the wind farm is operational. The wind farm formally commenced operating as of 4 November 2022.

Marshall Day Acoustics Pty Ltd (MDA) has been engaged by Goldwind Australia Pty Ltd (Goldwind) to conduct the noise compliance monitoring for the wind farm in accordance with:

- the Biala Wind Farm Noise Compliance Test Plan (NCTP)[2] which was prepared in accordance with Conditions 10 to 13 of the Development Consent. An earlier revision of this document[3] was provided to the Department of Planning, Industry and Environment (now the Department of Planning and Environment, DPE) for comment; and
- the NSW Department of Planning and Environment's publication *Wind Energy: Noise Assessment Bulletin - For State significant wind energy development*[4] (NSW Noise Assessment Bulletin).

The noise monitoring commenced in January 2023 and was originally expected to continue for a period of approximately six (6) weeks, as specified in the NCTP, in order to satisfy the reporting timeframes defined in the Development Consent. However, as a result of a number of factors such as wind turbine curtailments and weather conditions, the monitoring spanned an extended period to May 2023 to enable collection of a suitable quantity of valid noise monitoring data. The extended monitoring periods were agreed in consultation with DPE[5].

This report presents the results of the noise monitoring and an assessment of compliance with the operational noise requirements applicable to the wind turbines, as specified in Conditions 10 to 13 of the Development Consent.

The main potential source of ancillary infrastructure noise associated with the consented Biala Wind Farm was the proposed substation to the east of the wind turbine layout. However, the wind farm's transformer requirements were subsequently incorporated into a separate project with local consent (the Gullen Range Wind Farm), located approximately 11 km to the east. As a result, the originally proposed substation was removed from the Biala Wind Farm layout. Ancillary infrastructure noise is therefore not relevant for the Biala Wind Farm and is not included in this assessment.

This report is to be read in conjunction with the NCTP and the noise impact assessment report[6] prepared by others as part of the development application for the wind farm.

Acoustic terminology used throughout this report is presented in Appendix A.

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1 Development Consent issued 12 April 2017 (application number SSD 6039), as amended by Modification 1 dated 9 October 2018 and Modification 2 dated 9 January 2019

2 Rp 001 R02 20200121 - *Biala Wind Farm - Noise Compliance Test Plan* dated 2 December 2022

3 Rp 001 20200121 - *Biala Wind Farm - Noise Compliance Test Plan* dated 1 September 2021

4 NSW Department of Planning and Environment publication *Wind Energy: Noise Assessment Bulletin - For State significant wind energy development* dated December 2016

5 NSW Department of Planning and Environment correspondence dated 1 June 2023

6 DNV-GL Report 170223-AUME-R-01, Rev. D Biala Wind Farm Project – Wind Farm Noise Impact Assessment dated 5 June 2015

Site layout information is detailed in Appendix B.

The noise related Development Consent conditions that are relevant to the preparation of this report are reproduced in Appendix C, and the relevant DPIE/DPE correspondence concerning extended survey periods is reproduced in Appendix D.

2.0 WIND FARM DETAILS

The Biala Wind Farm consists of thirty-one (31) Goldwind GW140 wind turbines. Details of the installed wind turbines are outlined in Table 1 below.

Table 1: Goldwind GW140 details

Item	Detail
Rotor diameter	140 m
Hub height	110 m
Blade orientation	Upwind
Trailing edge serrations	Yes
Wind turbine regulation method	Variable rotation speed and adjustable blade pitch
Maximum rated power generating capacity	3.5 MW
Cut-in wind speed (hub height)	2.5 m/s
Rated power wind speed (hub height)	11 m/s
Cut-out wind speed (hub height)	20 m/s

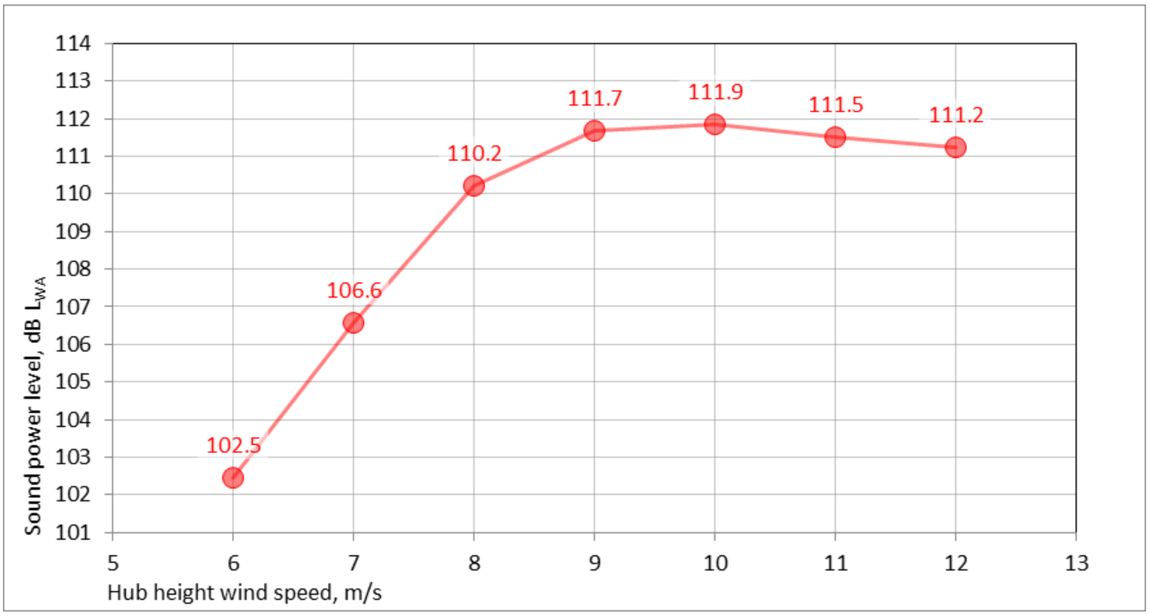
The noise emissions of wind turbines are described in terms of the sound power level for different wind speeds at the hub height. The sound power level is a measure of the total sound energy produced by each wind turbine and is distinct from the sound pressure level which depends on a range of factors such as the distance from the wind turbine. The overall sound power level represents the total noise emission of the wind turbine, including the secondary contribution of ancillary plant associated with the wind turbine (e.g. cooling fans and internal transformer)

Following the issue of the NCTP, updated sound power level data for the wind turbine model was provided by Goldwind. The overall sound power levels at hub height wind speeds ranging from 6 m/s to 12 m/s are shown in Figure 1.

The sound power level data provided by Goldwind does not include information regarding measurement uncertainty. To maintain a conservative approach, and consistent with current practice, MDA have applied a broadband uncertainty margin of +1.0 dB to the revised sound power level data, as presented in Figure 1.

Further details regarding the application of this data within the context of the compliance assessment can be found in Appendix E.

Figure 1: Goldwind GWA140 3.57MW - Sound power level versus wind speed at hub height, including uncertainty margin of 1.0 dB



As shown in the above figure, the sound power level at a hub height wind speed of 10 m/s represents the highest noise emission in the revised data. The provided sound power levels above 10 m/s and up to 12 m/s are consistent with expectations for modern variable speed pitch regulated wind turbines. Specifically, an increase in wind speed above the hub height wind speed corresponding to the highest sound power level would not result in an increase of sound power levels.

The critical wind speeds for noise assessment purposes are also typically lower than 12 m/s (on account of the increased background noise levels that are typically present at wind speeds greater than the rated power wind speed of the wind turbines).

3.0 NOISE CRITERIA

In accordance with Condition 10 of the Development Consent and the NCTP, noise levels associated with operation of the wind turbines must comply with the noise criteria reproduced in Table 2 when measured and assessed at the relevant non-associated receiver.

Table 2: Applicable noise criteria in accordance with the Development Consent, dB L_{Aeq}

Receiver	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	≥ 12
H03, H04	35	35	36	37	38	39	40	42	43	46
H05	35	35	35	35	35	37	38	39	41	43
H06	35	35	35	35	35	36	38	40	43	46
H07	35	35	36	37	38	40	41	44	46	50
H09	36	37	38	40	41	42	44	45	47	48
H11	35	35	35	36	37	39	40	42	43	46
H12	35	35	37	39	40	42	43	45	46	48
H13, H14	35	35	36	37	38	39	39	40	40	40
H15	35	35	35	35	36	36	37	37	38	39
H17	36	37	38	40	41	42	44	45	47	48
DA18	35	35	37	39	40	42	43	45	46	48
All other non-associated receivers	The higher of 35 dB L_{Aeq} or the existing background noise level (L_{A90}) plus 5 dB									

It should be noted that naming conventions for the project have changed since the Development Consent was issued. Receivers referred to using a 'H' identification in the Development Consent are referred to using a 'HN' identification in this report (i.e. H06 is referred to as HN06, H09 is referred to as HN09, etc.).

The criteria apply to the noise of the wind farm measured during all time periods (i.e. the noise criteria are not specified for separate time periods) and apply at non-associated residences (receivers) around the wind farm. At each receiver, the criteria apply at locations that are not less than 5 m from a vertical reflecting surface and not more than 30 m from the dwelling.

Per the NCTP, the following specific items are noted:

- The criteria apply to the noise solely related to the operation of the Biala Wind Farm when measured and assessed in accordance with the Development Consent.

  Condition 10 of the Development Consent specifies that the wind farm shall be measured in accordance with the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines 2009* (the SA 2009 Guidelines), modified by the provisions detailed in Appendix 4 of the Development Consent. However, Condition 10 also notes that if the guideline is replaced by an equivalent NSW guideline, then the noise is to be measured in accordance with the NSW guideline. The NSW Department of Planning and Environment subsequently published the NSW Noise Assessment Bulletin in December 2016.

The NSW Noise Assessment Bulletin is considered to be the 'equivalent NSW Guideline' referred to in Condition 10. Accordingly, wind farm noise levels associated with the Biala Wind Farm are to be measured in accordance with the NSW Noise Assessment Bulletin. It is however noted that the NSW Noise Assessment Bulletin continues to reference the SA 2009 Guidelines and includes the same modifying provisions detailed in Appendix 4 of the Development Consent.

- The noise criteria correspond to the values detailed in Appendix D of the noise impact assessment report prepared as part of the development application for the wind farm.
- The noise criteria are referenced to wind speeds measured at the site of the wind farm.

  Section 5.4 of the noise impact assessment report states that the background noise levels and noise criteria were determined from correlations with extrapolated wind speeds at 110 m above ground level at the development mast location M1[7]. To enable a meaningful assessment against these noise criteria, the measured post-construction noise levels must be correlated with the same wind speed reference (i.e. wind speeds at 110 m at the location of mast M1).

  The reference mast M1 was decommissioned during the construction of the wind farm and prior to installation of the new permanent meteorological masts at the site. Section 4.3 and Appendix F provide detailed information with respect to site wind speed data including full details regarding the analysis method.

- In accordance with the Development Consent, the criteria apply to the aggregated noise of the wind farm measured during all time periods (i.e. the noise criteria are not specified for separate time periods).

  The noise criteria specified in the Development Consent generally correspond to the values stated in the noise impact assessment report for all time periods (i.e. based on the aggregated background noise level data measured during all time periods). However, in some cases, the noise criteria in the Development Consent correspond to the levels presented in the noise impact assessment report for time periods which were limited to exclude recurring periods of elevated background noise during the day. It may therefore be necessary to consider measurement data obtained during similarly limited time periods in order to assess compliance. This is the case for HN09, where the noise criteria specified in the Development Consent correspond to the time period of 0700-1700 hrs.

In addition, the NCTP noted that the status of H11 (now referenced as HN11) has changed from non-associated to associated after the Development Consent was issued. However, Goldwind subsequently advised during the course of the compliance monitoring that no noise agreement was in place with HN11. Accordingly, the noise criteria specified in the Development Consent at HN11 are applicable. Had this change of status occurred prior to the issue of the NCTP, the location of HN11 would have triggered the requirement for noise monitoring to be undertaken. For this reason, a supplementary assessment of compliance at HN11 is presented in this report.

[7] M1 mast location coordinates: 716,182 E 6,172,281 N MGA 94 Zone 55

4.0 NOISE SURVEY AND ANALYSIS METHOD

This section provides a summary of:

- the noise monitoring locations;
- the noise survey method; and
- the noise analysis method.

Full details are documented in the NCTP.

4.1 Noise measurement locations

Based on the NCTP, the noise monitoring comprised:

- Unattended measurements at five (5) representative receivers (HN06, HN09, HN12, HN13 and HN15);
- Unattended measurements at three (3) intermediate locations positioned nearer to the wind farm (Int. HN06, Int. HN09 and Int. HN15); and
- Attended observations to inform an assessment of the noise characteristics of the wind farm.

The NCTP also referred to noise monitoring at receiver DA18. While not required for the technical assessment, this receiver was added to the NCTP at the request of the project owner. This request has since been withdrawn and DA18 has subsequently been removed from the compliance assessment. Demonstrating compliance at the five (5) representative receivers (HN06, HN09, HN12, HN13 and HN15) is sufficient to demonstrate that noise levels are compliant at other receivers.

The measurements at the intermediate locations provide a secondary reference for assessing noise levels if the results obtained at the receivers are inconclusive as a result of background noise levels. The intermediate locations also provide a reference point for repeat compliance testing if required.

All eight (8) monitoring locations are detailed in Table 3 and illustrated in Figure 2. The figure includes the predicted noise level contours[8], based on the installed wind turbines at the wind farm and the revised sound power data provided by Goldwind (see Section 2.0).

[8] Predicted noise level contours calculated using ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*, including adjustments applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise*.

Table 3: Noise monitoring locations

Location	Direction from wind farm	Nearest wind turbine ID	Distance from nearest wind turbine, m [1]
HN06	Northeast	T2	2,040
HN09	East	T4	2,011
HN12	Southeast	T30	2,036
HN13	Southwest	T31	2,356
HN15	Southwest	T23	2,381
Int. HN06	Northeast	T2	492
Int. HN09	East	T26	750
Int. HN15	Southwest	T23	409

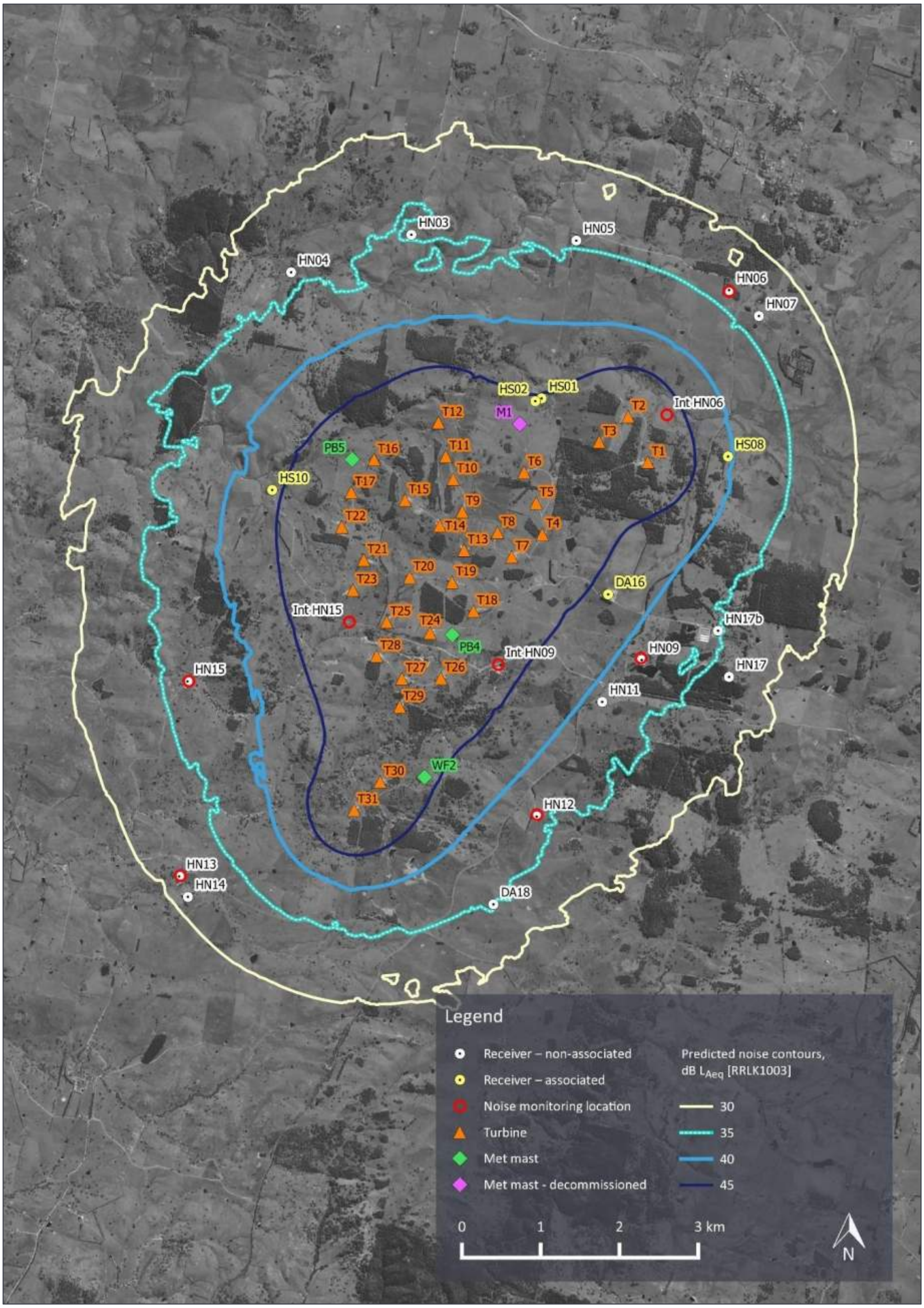
1 Distance as determined from the monitor location

The noise monitoring equipment at the receivers was positioned:

- Not less than 5 m from vertical reflecting surface; and
- On the wind farm side of the dwelling, and as near as practical to within 30 m from the dwelling while avoiding reflecting surfaces and localised sources of background noise.

Coordinates and photographs for the eight (8) monitoring locations are provided in Appendix M to Appendix T.

Figure 2: Monitoring locations



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4.2 Survey description

The survey comprised unattended noise measurements and attended observations as specified in Section 3.0 of the NCTP. Key elements of the survey are summarised in Table 4 below.

Table 4: Summary of key elements of the post construction noise survey

Item	Description
Monitoring locations	Five (5) receivers and three (3) intermediate locations as detailed in Section 4.1
Monitoring period	Generally, noise monitoring extended from 23/24/25 January 2023 to 03/04 April 2023, with an additional period at HN13 extending until 19 May 2023, due to failure of memory storage at this location. This equates to a minimum period of approximately nine (9) weeks of acquisition data for all locations; more than the six (6) week monitoring period suggested in the NSW Noise Assessment Bulletin and specified in the NCTP.
Attended observations	Attended observations were conducted on twenty (20) separate occasions with the objective of observing the noise characteristics of the wind farm and any other environmental noise sources which may influence the monitoring data. The NCTP requires a minimum of two (2) attended observations per unattended noise monitoring position.
Sound level meters	Class 1 automated sound loggers (most accurate class rating for field use). Microphones mounted at approximately 1.5 m above ground level and fitted with enhanced wind shielding systems based on the design recommendations detailed in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (IOA Good Practice Guide). See equipment specifications and calibration records in Appendix G.
Noise measurement data	A-weighted and C-weighted average and statistical sound pressure levels for consecutive 10-minute periods. In accordance with the NSW Noise Assessment Bulletin, the L_{A90} and L_{C90} measurement metrics are used for determining noise levels for direct comparison with the L_{Aeq} and L_{Ceq} criteria. One-third octave band frequency noise levels and a 2-minute audio sample every 10-minutes to aid the identification of extraneous noise influences and, if required, provide a basis for detailed frequency analysis.
Local wind speed and rainfall data	Local weather stations were installed beside HN06, HN12 and HN15 to concurrently record rainfall and wind speeds at microphone height during the period of deployment. Datasets were reviewed to identify periods when local weather conditions may have resulted in excessive extraneous noise at the microphone.Rainfall data for the extended deployment period of HN13 was taken from the nearest site met mast (WF2) as no local weather station was deployed at any noise monitoring location between 3 April and 19 May 2023.
Site wind speed data	Hub height wind speeds (110 m above ground level) at the location of the reference mast M1 were derived based on analysis conducted by Entura. This data was used by MDA for correlation with the measured noise levels. Further details of the site wind speed data are provided subsequently in Section 4.3 and Appendix F.

4.3 Site wind speed data

Reference mast M1 was the source of hub height wind speed data used to determine the noise criteria detailed in the Development Consent and noise impact assessment report. Wake-free data corresponding to the same location was therefore necessary to enable comparison of the noise levels measured before and after construction of the wind farm.

As detailed in the NCTP, mast M1 was decommissioned during construction, prior to commencement of the noise monitoring. It was therefore necessary for the wake-free wind data for location M1 to be developed from analysis and adjustment of wind speed data measured at other locations around the wind farm. The analysis was conducted by wind analysts Entura using detailed wind flow modelling of the site to quantify the change in wind speed across the site, accounting for the terrain profile of the site, wind direction, and the effect of the wind turbines. The dataset was synthesised using the method broadly summarised below.

The method comprised analysis and modelling-based adjustments of wind speeds measured at the operating met masts PB4, PB5 and WF2. The mast locations are indicated in Figure 2. The synthesised dataset at M1 only references adjusted measurement data from these masts for the wind directions in which they are not affected by the wake of the wind farm. Specifically, data from PB4 was referenced for wind directions from the southwest, PB5 was referenced for wind directions from the northeast, and WF2 was referenced for wind directions from the southwest. The M1 synthesised wind speed for wind directions in which both masts are not affected by the wind farm wake are determined from the average of the adjusted wind speeds from each mast.

Due to the reliance on modelling-based adjustments (in lieu of measurement-based transfer relationships between M1 and PB4, PB5 and WF2), Entura has advised that the wind speed determined from each method is subject to high uncertainty, particularly with respect to the wind speed in an individual 10-minute period. The utilised method is described by Entura as being *“the best available estimate of wind speed and direction at location M1 for the relevant period”* based on the available data.

Details of the data synthesis methods are described in the Entura correspondence reproduced in Appendix F.

The uncertainty of the wind data is also considered further in the compliance assessment section of this report, Section 6.0.

4.4 Data analysis

Analysis procedures in accordance with the Development Consent and NSW Noise Assessment Bulletin are specified in of the NCTP.

The procedures for each receiver monitoring location broadly involve:

- Collating the measured noise levels, site wind speeds, and local weather data into a single dataset;
- Filtering the dataset to remove measurement results affected by extraneous or atypical noise (e.g. rainfall, agricultural machinery, and atypically high insect noise in the vicinity of the microphone);
- Filtering the data for the critical range of site wind speeds for noise assessment purposes (the cut-in wind speeds when the wind turbines begin generating power through to the speed at which the maximum rated power is achieved);
- Identifying periods in which the wind farm's noise emissions may have been materially reduced by the effect the of wind turbine curtailment or shutdowns and, where applicable, filtering periods that are unrepresentative of normal operation from the data;
- Filtering the data for the wind directions when the monitoring location is downwind of the wind farm (when the contribution of the wind farm to total noise levels will be greatest);
- Assessing each 10-minute period for tonality and low-frequency to inform an assessment of whether penalties are warranted for the presence of special noise characteristics;
- Plotting a chart of noise levels versus wind speeds and determining the line of best fit to the data;
- Estimating the noise level contribution attributable to the operation of the wind farm; and
- Comparing the estimated noise level of the wind farm to the noise criteria to assess compliance with the Development Consent.

Further details of the key steps in the analysis of the data are summarised in Table 5.

Table 5: Noise data analysis summary

Process	Description
Data collation	Time stamps for each source of measurement data are reviewed to clarify start or end times and measurement time zone. Measured noise levels, site wind speeds and local weather conditions are then collated for each 10-minute measurement interval.
Local weather data filtering	10-minute intervals are identified and filtered from the analysis if rainfall was identified for any 10-minute measurement interval.
Extraneous noise filtering	The measured sound frequencies (one-third octave bands) in each 10-minute interval are used to identify periods that are significantly affected by bird or insect sounds. 10-minute intervals have been identified, and filtered from the analysis, when the following conditions[9] are satisfied: • The highest A-weighted one-third octave band noise level is within 5 dB of the broadband A-weighted noise level for that interval; and • The identified one-third octave band A-weighted noise level is greater than a level of 20 dB L_{A90}.
Wind turbine shut-downs	Any periods significantly affected by wind turbine shut-downs have been excluded from the regression analysis. Wind farm operational records supplied by Goldwind for the duration of the monitoring campaigns were reviewed. In general, any 10-minute period in which any relevant wind turbines[10] were not operating were removed from the analysis. Further information is provided in Section 4.5.
Downwind directions	The NCTP for the project was prepared prior to the establishment of the NSW Noise Assessment Bulletin, however, the Development Consent indicates that the NSW Noise Assessment Bulletin must apply. In accordance with the NSW Noise Assessment Bulletin the data is filtered to remove any periods in which the monitoring locations are not downwind of the wind farm. The downwind direction ranges for the monitoring locations are defined in Appendix H.
Wind speeds	In accordance with the NSW Noise Assessment Bulletin and the NCTP, the data is limited to a wind speed range that is inclusive of cut-in to the speed of rated power. Consistent with current practice, a wind speed range of 3 to 12 m/s was adopted for the assessment. Rated power at which power output of 3.57 MW is reached is formally designated as 11 m/s, however the wind turbine's noise emissions have reached their maximum at a hub height wind speed of 10 m/s, as presented in Figure 1 of Section 2.0.
Special noise characteristics	The noise measurement data for each 10-minute period of the filtered dataset (i.e. following the application of data filtering for rainfall and extraneous noise) is evaluated to inform an assessment of whether tonality or low frequency special noise characteristics are evident. The results of this analysis are then used to determine whether the occurrence of tonality and/or low frequency is a repeated characteristic which warrants the application of a 5 dB penalty adjustment to the wind farm noise level. Further information is provided in Section 4.6.

[9] Griffin, D., Delaire, C., & Pischedda, P. (2013). Methods of identifying extraneous noise during unattended noise measurements. *20th International Congress of Sound & Vibration*.

[10] Relevant turbines are those which are most likely to contribute to the total wind farm noise level at a measurement location. See Section 3.7.3 of the NCTP for further information.

Process	Description
Time periods	In accordance with the NSW Noise Assessment Bulletin, the noise data is assessed based on the aggreged data for all time periods (i.e. day and night-time periods combined) for all assessed receivers with the exception of HN09. Consistent with the time period used to determine the noise criteria specified in the Development Consent, the noise data at HN09 is assessed based on the data collected between 0700-1700 hrs only.
Regression analysis	Two datasets are plotted on a chart of noise levels versus wind speeds: • All data points that have been removed from the analysis using the above processes • The filtered dataset comprising all retained measurement data. A line of best fit is determined for the filtered data and, where applicable, any subgroups of the filtered data. The line of best fit is determined using a regression analysis of the range of noise levels and wind speeds or, where necessary, analysis of noise levels at individual wind speeds.
Estimation of wind farm noise level	The most recent background noise survey at receivers around the Biala Wind Farm was carried out between 4 September and 9 October 2014. The results of the background noise monitoring are documented in Appendix D of the noise impact assessment report. Inherent variability of the ambient noise environment means that the background noise levels that are present during post-construction noise monitoring can differ significantly from those measured prior to construction of the wind farm. Example factors that contribute to this variation include changes to vegetation in the vicinity of the monitoring location and changes in the populations and activity of local fauna (insects and birds in particular - noting that the extraneous filter that is used to address these noises is relatively cautious in that it only removes data when the measurement is clearly affected by an extraneous source). Due to the age of the background noise monitoring data, and changes to contemporary measurement practices (e.g. the use of enhanced wind shields as standard practice), the data is not suitable for making direct adjustments to the measured post-construction noise levels for the influence of background noise. In accordance with the NCTP, supplementary procedures are therefore used to provide an additional means of estimating the noise level attributable to the wind farm. In particular, per the guidance of the NSW Noise Assessment Bulletin, noise measurement data obtained at the intermediate locations (where wind farm noise is more reliably measurable amid the background noise) is extrapolated to the receivers using the noise model of the site. Procedures for the extrapolation of noise levels at intermediate locations are defined in Section 3.7.6 of the NCTP. Specifically, the extrapolations were conducted in accordance with ISO 1996-2:2017, supplemented by ISO 9613-2 for noise modelling purposes (see further details in Appendix E).

4.5 Wind turbine operations

The objective of the assessment is to assess whether the noise levels of the wind farm comply with the requirements of the Development Consent when all of the wind turbines are operating normally. It is therefore necessary to identify and remove any periods when noise levels may have been lower as a result of wind turbines being shut-down or operating at reduced power levels (e.g. due to wind turbine faults, maintenance activities or external grid restrictions on the amount of power able to be generated by the site).

To establish the profile of normal operations associated with the wind farm, the data recorded by the site's supervisory control and data acquisition (SCADA) system was reviewed. The SCADA data contains information about a range of wind turbine parameters including the average power output and the wind turbine nacelle wind speed (distinct from the hub height wind speed at the reference mast used for the assessment) in consecutive 10-minute intervals.

The review involved generating average power versus nacelle wind speed plots for each wind turbine for the duration of the noise monitoring period. An example plot is provided in Figure 3. The trends of these plots were reviewed to identify the typical range of power outputs for each wind turbine for each integer nacelle wind speed. If the SCADA data indicated that the power output of a wind turbine in a given 10-minute period was below the typical range, the wind turbine's operational status was designated as atypical for the period in question.

For the purposes of this analysis, a 'threshold curve' was determined which could be used to define whether each wind turbine's operation was typical or not in any given 10-minute period. The threshold curve was determined by:

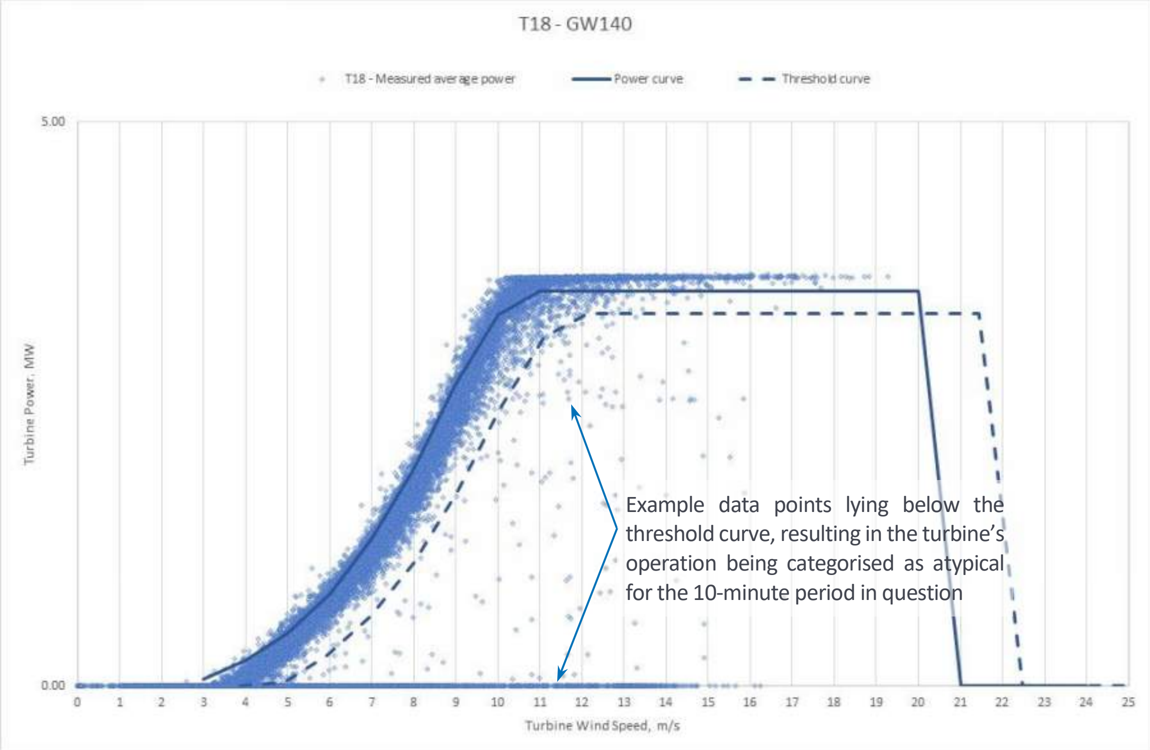
- Overlaying the power curve of the wind turbines (the relationship between wind turbine power and wind speed) on the plots for each wind turbine;
- Creating a new curve by applying offsets to the power curve (i.e. adjusting the position of the curve on the plots, by adjusting the power and/or wind speed values); and
- Iteratively adjusting the position of the new curve until it lies below all 10-minute data points (for all wind turbines) when the output of the wind turbine was consistent with the power curve, allowing for a notional margin below the power curve to reflect normal variations in wind turbine power relative the power curve (relative to nacelle wind speed).

Each wind turbine's power output for each 10-minute period was then compared to the threshold curve and determined to be typical or atypical, according to whether the measured average power output was above or below the threshold curve. The power curve of the wind turbines and the threshold curve used for the analysis are illustrated on the chart in Figure 3.

As an example of the analysis carried out for each wind turbine, Figure 3 also includes the 10-minute measured average power data for wind turbine 18. Wind turbine 18 was selected for this example on account of being one of the wind turbines observed noted to have the greatest number of atypical 10-minute periods.

The data for the nearest wind turbine to each of the eight (8) receiver noise monitoring locations is also provided in Appendix I.

Figure 3: Example SCADA data and threshold power curve - Wind turbine T18



To then determine whether a 10-minute period needed to be removed from the noise assessment, it was necessary to assess if any of the wind turbines flagged as atypical were 'relevant' to the total noise of the wind farm at the monitoring locations (i.e. whether a wind turbine flagged as atypical had the potential to change the total noise level at a noise monitoring location or, conversely, whether the wind turbine was far enough away to be inconsequential).

For this purpose, the 3-dimensional noise model[11] of the site was used to rank the relative noise contributions of each wind turbine to the total noise level at each monitoring location, and then classify the wind turbines as either 'relevant' or 'non-relevant'.

In accordance with the NCTP, non-relevant wind turbines for each monitoring location are those wind turbines with the lowest predicted noise levels which collectively result in a predicted noise level 15 dB lower than the total predicted noise level of the wind farm at the location in question. This means that if any or all of the non-relevant wind turbines were not operating in a given measurement period, the reduction in total noise level would be limited to 0.1 dB or less, and would therefore be inconsequential to the assessment outcome. Conversely, it means that the majority of the wind turbines in each 10-minute period must not be flagged as atypical in order for the period to be considered valid for noise assessment purposes. This data filtering approach means that periods when wind turbine shutdowns occurred were only retained when their effect on the measured noise levels would be immeasurably small.

The quantity of data available for the compliance assessment after applying these filters is dependent on the number of wind turbines curtailed, the specific turbines curtailed, the extent of curtailment per wind turbine and, in turn, the threshold curve used to designate whether a wind turbine has been curtailed.

A schedule of the relevant wind turbines for each noise monitoring location is provided in Appendix J.

[11] As described in Appendix E.

4.6 Special noise characteristics

In accordance with the Development Consent and the NSW Noise Assessment Bulletin, the following analysis methods were used to inform an assessment of whether tonality or low frequency special noise characteristics were evident:

- Tonality: ISO 1996-2:2007[12] using the method detailed in *Annex D Objective method for assessing the audibility of tones in noise – Simplified method*. This is identical to the method defined in the updated standard ISO 1996-2:2017

  The NSW Noise Assessment Bulletin also includes provisions for narrow band analysis of tonality if required. For this purpose, the NCTP nominates ISO/PAS 20065[13], as referenced in ISO 1996-2:2017.
- Low frequency: measured C-weighted noise levels (L_{C90}) associated with operation of the wind farm are compared with the 60 dB L_{Ceq} criterion detailed in the NSW Noise Assessment Bulletin.

In accordance with the NSW Noise Assessment Bulletin and the NCTP, tonality and/or low frequency is a repeated characteristic if it is present for more than 10 % of the time. The NSW Noise Assessment Bulletin is not prescriptive about the method to be used to assess whether special noise characteristics are present for more than 10 % of the time.

Consistent with general industry practice, the NCTP specifies that the analysis is applied to each wind speed. Specifically, tonality and/or low-frequency is analysed by determining whether they are present for more than 10 % of the time in each integer wind speed bin across the assessable range of wind speeds (a wind speed bin being a 1 m/s wide range centred on each integer wind speed from cut-in to rated power).

The procedures detailed above are prone to indicating false positives as a result of noise sources that are unrelated to the operation of the wind farm. For example, the sounds of birds or insects are frequently characterised by tonal noise that is readily detectable with the simplified method referred to in the NSW Noise Assessment Bulletin, and any tones identified at the corresponding frequencies would need to be removed. Similarly, C-weighted noise levels are prone to the influence of wind-induced turbulence at the microphone, or the low frequency noise of agriculture equipment and transportation.

Analysis was therefore required to address false positives. In particular, measured noise levels at the intermediate and receiver locations were compared to identify the instances where the trend of noise levels at an individual location was primarily related to noise sources located near the monitoring location, or a distant noise source unrelated to the operation of the wind farm. The tonality analysis was also limited to frequencies below 1 kHz to avoid high rates of false positives as a result of noise at the frequencies which are atypical of wind farm (at receiver distances) but commonly occur as a result of insects or birds.

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[12] ISO 1996-2:2007 *Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels* (ISO 1996-2:2007)

[13] ISO/PAS 20065:2016 *Acoustics – Objective method for assessing the audibility of tones in noise – Engineering Method* (ISO/PAS 20065)

5.0 WIND TURBINE NOISE MONITORING & ANALYSIS

This section presents the results of the wind turbine noise measurements, an assessment of special noise characteristics, and an assessment of compliance with the noise criteria.

It is important to note that the total measured noise levels at all locations are a combination of:

- Operational wind farm noise; and
- Background noise (i.e. the noise from all other sound sources not related to the wind farm).

The measured total noise levels will therefore be equal to, or greater than, the noise level that is solely attributable to the operation of the wind farm. In some instances, particularly at low or high wind speeds, total measured noise levels will be controlled by background noise and, as a result, the contribution of the wind turbines will be significantly less than the total measured noise levels. However, the noise criteria only apply to the noise level that is solely attributable the operation of the wind farm. This is an important point of context when comparing total measured noise levels with the noise criteria.

In accordance with the NSW Noise Assessment Bulletin, the L_{A90} and L_{C90} measurement metrics are used for determining noise levels for comparison with the L_{Aeq} and L_{Ceq} criteria. For consistency with the criteria, all data is presented in this section in terms of the equivalent noise levels (L_{Aeq} and L_{Ceq}), including measurement data that is based on the L_{A90} and L_{C90} metrics.

5.1 Measured total noise levels

The results of the unattended measurement data analysis for the five (5) receiver and three (3) intermediate locations are summarised in the following sub-sections. All measurement data has been analysed in accordance with the NSW Noise Assessment Bulletin and the NCTP, as summarised in Section 4.4 of this report.

The post-construction noise measurements summarised in this section correspond to the value of the line of best fit from the total measured noise level versus hub height wind speed chart. Importantly, the line of best fit is applied to the data points that have been retained for analysis after applying the filtering procedures described in Section 4.4 (i.e. filtering for extraneous noise, rainfall, atypical wind farm operation and limiting the data to downwind directions).

The detailed measurement and analysis results are presented in Appendix M to Appendix T, and include information such as the total number of data points collected, the number of data points included in the analysis, and statistical details relating to the line of best fit to the measurement data.

The regression line coefficients and coefficient of determination for the post-construction noise level line of best fit at each monitoring location are summarised in Appendix K.

A key point to note is that the trends of the measured noise levels at the receivers are indicative of background noise level variations rather than wind turbine noise. The influence of background noise on the measurements at the receivers is demonstrated by the larger variation in measured noise levels at receivers than generally occurred at the intermediate locations, primarily as a result the increased influence of background noise on the measurements with increasing distance from the wind turbines.

The most recent background noise survey at receivers around the Biala Wind Farm was carried out between 4 September and 9 October 2014. The results of the background noise monitoring are documented in Appendix D of the noise impact assessment report.

Due to the age of the background noise monitoring data, and changes to contemporary measurement practices (e.g. the use of enhanced wind shields as standard practice), the data is not suitable for making direct adjustments to the measured post-construction noise levels for the influence of background noise.

Given the above, and the use of intermediate monitoring locations for three (3) receivers, the following subsections provide estimates of the wind farm noise contribution using the method described in the NCTP and summarised earlier in Section 4.4.

In terms of the suitability of the wind speeds and directions at the site during the noise monitoring period, Appendix F presents historic wind rose data for the broader region, and the site wind rose for the duration of the noise monitoring period. The wind roses indicate that wind conditions at the site during the noise compliance monitoring period were generally consistent with long term trends for the site.

A summary of total measured noise levels at intermediate locations is presented in Table 6.

Table 6: Total measured noise levels at intermediate locations, dB L_{Aeq}

Location	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Intermediate HN06	32.8	35.5	37.5	39.1	40.4	41.5	42.7	44.1	45.9	48.1
Intermediate HN09	35.1	36.5	37.9	39.2	40.5	41.9	43.3	44.9	46.7	48.6
Intermediate HN15	34.4	37.9	40.5	42.4	43.8	45.0	46.1	47.2	48.7	50.7

Attended observations made at the intermediate locations describe clear audibility of noise associated with the wind turbines. The absence of background noise measurements at these locations means that the influence of background noise on measured post-construction noise levels cannot be quantified. However, while there is some variation in noise levels at each wind speed evident, it is still relatively minor when compared with receiver monitoring locations where background noise has had a greater influence on the measurements.

As the wind turbines are the primary contributing noise source to the measured noise levels at these location, total noise levels at intermediate locations provide a reliable basis for extrapolation of wind farm noise levels at distant locations.

A summary of total measured all-time noise levels at receiver locations is presented in Table 7.

The total measured noise levels at receiver HN09 for the reduced time period of 0700 to 1700 hrs, consistent with the time period associated with the noise criteria detailed in the Development Consent, are shown in Table 8.

Table 7: Total measured noise levels at receiver locations, dB L_{Aeq} (all-time)

Location	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
HN06	-[1]	29.2	29.4	30.3	32.0	34.1	36.6	39.3	41.9	44.5
HN09	30.3	30.3	31.1	32.4	34.2	36.1	38.0	39.8	41.1	41.9
HN12	29.2	30.0	31.3	33.1	35.1	37.3	39.5	41.5	43.3	44.6
HN13	29.1	30.8	32.0	32.9	33.9	35.1	36.8	39.4	43.0	48.0
HN15	-[1]	29.6	29.8	30.5	31.7	33.1	34.8	36.7	38.7	40.7

1 Outside valid wind speed range of the regression analysis

Table 8: Total measured noise levels at receiver HN09, dB L_{Aeq} (0700 to 1700 hrs)

Location	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
HN09	- [1]	32.9	33.1	34.1	35.7	37.7	39.8	41.8	43.4	44.4

1 Outside valid wind speed range of the regression analysis

The profile of the noise level versus wind speed chart provided in Appendix M to Appendix T shows wide variation in measured noise levels at most wind speeds. While the overall trend of the complete data sets exhibits a general increase in noise level with increasing hub-height wind speed, the range of variation in noise levels across all wind speeds suggests that measured noise levels at receiver locations and the hub-height wind speed data are generally limited in correlation.

Specifically, at HN13, measured noise levels increase significantly at hub height wind speeds above 10 m/s. A review was conducted of selected audio samples corresponding with the periods in which the hub-height wind speed was above 10 m/s and the measured noise level was above 45 dB L_{A90}. Operational wind farm noise was not audible in any of the reviewed samples, with measured L_{A90} noise levels primarily attributable to localised sources of wind noise such as nearby trees and foliage.

5.2 Estimated wind farm noise levels

Considering the potential influence from background noise on total measured noise, estimated wind farm noise levels summarised in Table 9 were extrapolated based on the total noise levels measured at intermediate locations presented in Table 6 and predicted noise level difference presented in Table 25 of Appendix E.

Table 9: Estimated wind farm noise levels, dB L_{Aeq}

Location	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
HN06	20.3	23.0	25.0	26.6	27.9	29.0	30.2	31.6	33.4	35.6
HN09	27.2	28.6	30.0	31.3	32.6	34.0	35.4	37.0	38.8	40.7
HN11	27.6	29.0	30.4	31.7	33.0	34.4	35.8	37.4	39.2	41.1
HN12	26.0	27.4	28.8	30.1	31.4	32.8	34.2	35.8	37.6	39.5
HN13	15.8	19.3	21.9	23.8	25.2	26.4	27.5	28.6	30.1	32.1
HN15	19.7	23.2	25.8	27.7	29.1	30.3	31.4	32.5	34.0	36.0

5.3 Special noise characteristics

Attended observations and subjective assessments were carried out during the survey at both receiver and intermediate monitoring locations to gauge the noise characteristics of the wind farm and identify any other environmental noise sources which may influence the monitoring data.

For completeness, an objective assessment of tonality and low frequency was also conducted for all retained 10-minute measurements following application of the data filtering processes described in Section 4.4, in accordance with the method detailed in Section 4.6.

The findings of the subjective and objective assessments are summarised in Appendix L and demonstrated that neither tonality nor low frequency were repeated characteristics of the wind farm.

For this reason, the application of special noise characteristics penalties is not considered warranted.

6.0 WIND TURBINE NOISE COMPLIANCE ASSESSMENT

The following sub-sections present an assessment of compliance for each receiver described in Section 5.0.

For all receiver locations at which noise monitoring was conducted, the compliance assessment has been based on both the total measured noise levels and the estimated wind farm noise levels, summarised in Section 5.1 and Section 5.2, respectively.

As discussed in Section 3.0, an additional compliance assessment has been provided for HN11, based on estimated wind farm noise levels.

Based on the analysis and discussion presented in Section 5.3, no special noise characteristic penalties have been applied to the estimated wind farm noise levels.

6.1 Receiver HN06

Table 10 presents the total measured noise levels at HN06. The results demonstrate compliance across the wind speed range by a minimum margin of 0.7 dB.

Table 10: HN06 total measured noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Measured post-construction	- [1]	29.2	29.4	30.3	32.0	34.1	36.6	39.3	41.9	44.5
Noise criteria	35.0	35.0	35.0	35.0	35.0	36.0	38.0	40.0	43.0	46.0
Min. compliance margin	- [1]	5.8	5.6	4.7	3.0	1.9	1.4	0.7	1.1	1.5

1 Outside valid wind speed range of the regression analysis

To account for the influence of background noise on the measurement results, an additional compliance assessment has been based on the estimated wind farm noise levels shown in Section 5.2. The results of this assessment are presented in Table 11 and further demonstrate compliance across the wind speed range by a minimum margin of 7.0 dB.

Table 11: HN06 estimated wind farm noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Estimated wind farm noise level	20.3	23.0	25.0	26.6	27.9	29.0	30.2	31.6	33.4	35.6
Noise criteria	35.0	35.0	35.0	35.0	35.0	36.0	38.0	40.0	43.0	46.0
Min. compliance margin	14.7	12.0	10.0	8.4	7.1	7.0	7.8	8.4	9.6	10.4

The results shown in Table 10 and Table 11 are also presented in Figure 15 of Appendix M.

6.2 Receiver HN09

Table 12 presents the total measured noise levels at HN09. The results demonstrate compliance across the wind speed range by a minimum margin of 5.2 dB.

Table 12: HN09 total measured noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Measured post-construction	30.3	30.3	31.1	32.4	34.2	36.1	38.0	39.8	41.1	41.9
Noise criteria	36.0	37.0	38.0	40.0	41.0	42.0	44.0	45.0	47.0	48.0
Min. compliance margin	5.7	6.7	6.9	7.6	6.8	5.9	6.0	5.2	5.9	6.1

To account for the influence of background noise on the measurement results, an additional compliance assessment has been based on the estimated wind farm noise levels shown in Section 5.2. The results of this assessment are presented in Table 13 and further demonstrate compliance with the applicable criteria across the wind speed range by a minimum margin of 7.3 dB.

Table 13: HN09 compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Estimated wind farm noise level	27.2	28.6	30.0	31.3	32.6	34.0	35.4	37.0	38.8	40.7
Noise criteria	36.0	37.0	38.0	40.0	41.0	42.0	44.0	45.0	47.0	48.0
Min. compliance margin	8.8	8.4	8.0	8.7	8.4	8.0	8.6	8.0	8.2	7.3

The results shown in Table 12 and Table 13 are also presented in Figure 18 of Appendix N.

6.3 Receiver HN12

Table 14 presents the total measured noise levels at HN12. The results demonstrate compliance across the wind speed range by a minimum margin of 2.7 dB.

Table 14: HN12 total measured noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Measured post-construction	29.2	30.0	31.3	33.1	35.1	37.3	39.5	41.5	43.3	44.6
Noise criteria	35.0	35.0	37.0	39.0	40.0	42.0	43.0	45.0	46.0	48.0
Min. compliance margin	5.8	5.0	5.7	5.9	4.9	4.7	3.5	3.5	2.7	3.4

To account for the influence of background noise on the measurement results, an additional compliance assessment has been based on the estimated wind farm noise levels shown in Section 5.2. The results of this assessment are presented in Table 15 and further demonstrate compliance with the applicable criteria across the wind speed range by a minimum margin of 7.6 dB.

Table 15: HN12 estimated wind farm noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Estimated wind farm noise level	26.0	27.4	28.8	30.1	31.4	32.8	34.2	35.8	37.6	39.5
Noise criteria	35.0	35.0	37.0	39.0	40.0	42.0	43.0	45.0	46.0	48.0
Min. compliance margin	9.0	7.6	8.2	8.9	8.6	9.2	8.8	9.2	8.4	8.5

The results shown in Table 14 and Table 15 are also presented in Figure 21 of Appendix O.

6.4 Receiver HN13

Table 16 presents the total measured noise levels at HN13. For wind speeds at or below 10 m/s, the results demonstrate compliance by a minimum margin of 0.6 dB. The results also indicate an inconclusive result at wind speeds above 10 m/s due to the presence of elevated noise levels. Further commentary regarding the measurement results at these wind speeds is given below.

Table 16: HN13 total measured noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11 [1]	12 [1]
Measured post-construction	29.1	30.8	32.0	32.9	33.9	35.1	36.8	39.4	43.0	48.0
Noise criteria	35.0	35.0	36.0	37.0	38.0	39.0	39.0	40.0	40.0	40.0
Min. compliance margin	5.9	4.2	4.0	4.1	4.1	3.9	2.2	0.6	-	-

1 Inconclusive result due to the influence of high background noise levels.

As the total measured noise levels above 10 m/s provide an inconclusive assessment result, further analysis has been completed to determine the primary source of the elevated noise levels.

A review was undertaken of selected audio samples corresponding with valid periods (following the filtering process described in Section 4.4) in which the hub-height wind speed was greater than 10 m/s and the measured noise level was above 45 dB L_{A90}. Noise associated with the operation of the wind farm was inaudible in all samples reviewed. Measured L_{A90} noise levels during these periods were primarily attributable to localised sources of wind noise such as nearby trees and foliage.

To allow for a numerical compliance assessment to be undertaken of noise associated with the operation of the wind farm alone, the estimated wind farm noise levels summarised in Section 5.2 have been compared with the relevant noise criteria. These results are shown in Table 17 and demonstrate compliance with the relevant noise criteria across the wind speed range by a minimum margin of 7.9 dB.

Table 17: HN13 estimated wind farm noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Estimated wind farm noise level	15.8	19.3	21.9	23.8	25.2	26.4	27.5	28.6	30.1	32.1
Noise criteria	35.0	35.0	36.0	37.0	38.0	39.0	39.0	40.0	40.0	40.0
Min. compliance margin	19.2	15.7	14.1	13.2	12.8	12.6	11.5	11.4	9.9	7.9

The results shown in Table 16 and Table 17 are also presented in Figure 24 of Appendix P.

6.5 Receiver HN15

Table 18 presents the total measured noise levels at HN15. For wind speeds at or below 10 m/s, the results demonstrate compliance by a minimum margin of 0.6 dB. The results also indicate an inconclusive result at wind speeds above 10 m/s due to the presence of elevated noise levels. Further commentary regarding the measurement results at these wind speeds is given below.

Table 18: HN15 total measured noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11 [1]	12 [1]
Measured post-construction	- [2]	29.6	29.8	30.5	31.7	33.1	34.8	36.7	38.7	40.7
Noise criteria	35.0	35.0	35.0	35.0	36.0	36.0	37.0	37.0	38.0	39.0
Min. compliance margin	- [2]	5.4	5.2	4.5	4.3	2.9	2.2	0.3	-	-

1 Inconclusive result due to the influence of high background noise levels.

2 Outside valid wind speed range of the regression analysis

As the total measured noise levels above 10 m/s provide an inconclusive assessment result, further analysis has been completed to determine the primary source of the elevated noise levels.

A review was undertaken of selected audio samples corresponding with valid periods (following the filtering process described in Section 4.4) in which the hub-height wind speed was greater than 10 m/s and the measured noise level was above 40 dB L_{A90}. Noise associated with the operation of the wind farm was inaudible in all samples reviewed. Measured L_{A90} noise levels during these periods were primarily attributable to localised sources of wind noise such as nearby trees and foliage.

To allow for a numerical compliance assessment to be undertaken of noise associated with the operation of the wind farm alone, the estimated wind farm noise levels summarised in Section 5.2 have been compared with the relevant noise criteria. These results are shown in Table 19 and demonstrate compliance with the applicable criteria across the wind speed range by a minimum margin of 3.0 dB.

Table 19: HN15 estimated wind farm noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Estimated wind farm noise level	19.7	23.2	25.8	27.7	29.1	30.3	31.4	32.5	34.0	36.0
Noise criteria	35.0	35.0	35.0	35.0	36.0	36.0	37.0	37.0	38.0	39.0
Min. compliance margin	15.3	11.8	9.2	7.3	6.9	5.7	5.6	4.5	4.0	3.0

The results shown in Table 18 and Table 19 are also presented in Figure 27 of Appendix Q.

6.6 Receiver HN11

Considering HN11 was not included in the noise survey, as discussed in Section 3.0, the estimated wind farm noise levels summarised in Section 5.2 have been compared with the relevant noise criteria. These results are shown in Table 20 and demonstrate compliance with the applicable criteria across the wind speed range by a minimum margin of 3.8 dB.

Table 20: HN11 estimated wind farm noise level compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Estimated wind farm noise level	27.6	29.0	30.4	31.7	33.0	34.4	35.8	37.4	39.2	41.1
Noise criteria	35.0	35.0	35.0	36.0	37.0	39.0	40.0	42.0	43.0	46.0
Min. compliance margin	7.4	6.0	4.6	4.3	4.0	4.6	4.2	4.6	3.8	4.9

6.7 Discussion

As shown in the preceding sections, total measured noise levels at HN06, HN09 and HN12 were below the noise criteria across the wind speed range by a minimum margin of 0.7 dB.

Total measured noise levels at HN13 and HN15 were below the noise criteria at wind speeds at or below 10 m/s. However, elevated noise levels at wind speeds greater than 10 m/s provided inconclusive results for the purposes of the compliance assessment and required further investigation in the form of audio sample listening.

Review of selected audio samples corresponding with the relevant wind speeds and noise levels at each location demonstrated that the elevated noise levels at these locations can be attributed to localised sources of background noise such as nearby trees and foliage. Noise associated with the operation of the wind farm was not audible in any of the reviewed samples.

In the absence of valid background noise monitoring data, the noise contribution from the wind farm at the receiver locations has been derived from the total measured noise levels at the intermediate locations. Further details regarding this process can be found in Section 5.2.

The results presented in the preceding sections demonstrate that the contribution of operational wind turbine noise associated with the Biala Wind Farm complies with the noise criteria specified in the Development Consent by a reasonable margin (at least 3.0 dB).

It should be noted that by demonstrating compliance with the noise criteria at the assessed receivers, it is expected that compliance is also achieved at other receivers within the vicinity of the wind farm.

The discussion presented previously in Section 4.3 of this report noted that the synthesised wake-free wind speeds provided for the noise compliance assessment are subject to high uncertainty. This introduces the potential that an estimated wind farm noise level derived at a given wind speed may actually occur at a higher or lower wind speed. However, considering the compliance margins presented in the preceding tables, this limitation is not expected to affect the compliance outcome.

APPENDIX A GLOSSARY OF TERMINOLOGY

A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
C-weighting	A set of frequency dependent adjustments which are used for measuring low frequency noise in accordance with the NSW Noise Assessment Bulletin
dB	Decibel. The unit of sound level.
Frequency	The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).
Hertz, Hz	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).
L_{Aeq}	The equivalent continuous (time-averaged) A-weighted noise level. This is commonly referred to as the average noise level.
L_{A90}	The A-weighted noise level equalled or exceeded for 90 % of the measurement period. This is commonly referred to as the background noise level.
L_{C90}	The C-weighted noise level equalled or exceeded for 90 % of the measurement period.
L_W	The sound power level. The level of total sound power radiated by a sound source.
L_{WA}	The A-weighted sound power level.
Special noise characteristics	Features of a sound which, when present, increase the likelihood of adverse reaction the sound. The NSW Noise Assessment Bulletin defines tonality and low frequency noise as special noise characteristics.
Tonality	Sound characterized by a single frequency component or narrow-band components that emerge audibly from the total sound (e.g. whines or hissing sounds).

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016[14]. Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report. For example, sound pressure levels measured using an “A” frequency weighting are expressed as dB L_A. Alternative ways of expressing A-weighted decibels such as dB or dB(A) are therefore not used within this report.

[14] ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures*

APPENDIX B SITE LAYOUT

Table 21: As-built wind turbine coordinates – MGA 94 zone 55

Wind Turbine ID	Easting, m	Northing, m
T1	717,807.96	6,171,797.70
T2	717,557.00	6,172,376.99
T3	717,189.02	6,172,054.98
T4	716,467.01	6,170,882.01
T5	716,388.91	6,171,280.44
T6	716,235.00	6,171,670.00
T7	716,079.03	6,170,598.00
T8	715,898.97	6,170,904.99
T9	715,451.01	6,171,169.97
T10	715,337.01	6,171,582.95
T11	715,242.04	6,171,872.04
T12	715,148.97	6,172,299.99
T13	715,473.97	6,170,680.01
T14	715,164.99	6,170,991.99
T15	714,725.00	6,171,315.99
T16	714,331.91	6,171,831.98
T17	714,042.02	6,171,415.00
T18	715,592.97	6,169,907.90
T19	715,322.02	6,170,273.99
T20	714,785.02	6,170,337.99
T21	714,200.98	6,170,555.96
T22	713,922.00	6,170,976.99
T23	714,063.97	6,170,174.95
T24	715,042.01	6,169,629.99
T25	714,491.00	6,169,769.01
T26	715,180.00	6,169,055.97
T27	714,685.00	6,169,049.00
T28	714,364.01	6,169,335.97
T29	714,656.97	6,168,692.00
T30	714,408.99	6,167,741.00
T31	714,079.02	6,167,383.99

APPENDIX C DEVELOPMENT APPLICATION CONDITIONS

The consolidated Development Consent for the Biala Wind Farm, dated 9 January 2019, specifies operational noise requirements in Conditions 10 to 13. The conditions are reproduced in Figure 4.

Figure 4: Development Consent extract – operational noise requirements

Operational Noise Criteria – Wind Turbines

10. The Applicant must ensure that the noise generated by the operation of wind turbines does not exceed the relevant criteria in Table 2 at any non-associated residence.

Table 2: Noise criteria dB(A)

Residence	***Criteria (dB(A)) with Reference to Hub Height Wind Speed (m/s)***									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12 or more**
H03, H04	35	35	36	37	38	39	40	42	43	46
H05	35	35	35	35	35	37	38	39	41	43
H06	35	35	35	35	35	36	38	40	43	46
H07	35	35	36	37	38	40	41	44	46	50
H09	36	37	38	40	41	42	44	45	47	48
H11	35	35	35	36	37	39	40	42	43	46
H12	35	35	37	39	40	42	43	45	46	48
H13, H14	35	35	36	37	38	39	39	40	40	40
H15	35	35	35	35	36	36	37	37	38	39
H17	36	37	38	40	41	42	44	45	47	48
DA18	35	35	37	39	40	42	43	45	46	48
All other non-associated residences	The higher of 35 dB(A) or the existing background noise level plus 5 dB(A)									

Note: To identify the residences referred to in Table 2, see the applicable figure in Appendix 2.

Noise generated by the operation of the wind turbines is to be measured in accordance with the relevant requirements of the South Australian Environment Protection Authority's *Wind Farms – Environmental Noise Guidelines 2009* (or its latest version), as modified by the provisions in Appendix 4. If this guideline is replaced by an equivalent NSW guideline, then the noise generated is to be measured in accordance with the requirements in the NSW guideline.

However, these criteria do not apply if the Applicant has an agreement with the relevant owner/s of these residences to generate higher noise levels, and the Applicant has advised the Department in writing of the terms of this agreement.

Operational Noise Criteria – Ancillary Infrastructure

11. The Applicant must ensure that the noise generated by the operation of ancillary infrastructure does not exceed 35 dB(A) $L_{Aeq(15\ minute)}$ at any non-associated residence.

Noise generated by the development is to be measured in accordance with the relevant requirements of the *NSW Industrial Noise Policy* (or its equivalent) as modified by the provisions in Appendix 4.

Operational Noise Monitoring

12. Within 6 months of the commencement of operations, the Applicant must:
    (a) undertake noise monitoring to determine whether the development is complying with the relevant conditions of this consent; and
    (b) submit a copy of the monitoring results to the Department and the EPA.

13. The Applicant must undertake further noise monitoring of the development if required by the Secretary.

Condition 10 and Condition 11 specify modification of the applicable measurement procedures according to the provisions of Appendix 4 of the Development Consent, reproduced in Figure 5.

Figure 5: Development Consent extract – Appendix 4 measurement provisions

APPENDIX 4
NOISE COMPLIANCE ASSESSMENT

PART A: SOUTH AUSTRALIAN WIND FARMS: ENVIRONMENTAL NOISE GUIDELINES 2009 (MODIFIED)

South Australian *Wind Farms: Environmental Noise Guidelines 2009* (Modified) refers to the South Australian EPA document modified for use in NSW.

The modifications are as follows:

Tonality
The presence of excessive tonality (a special noise characteristic) is consistent with that described in *ISO 1996.2: 2007 Acoustics — Description, measurement and assessment of environmental noise – Determination of environmental noise levels* and is defined as when the level of one-third octave band measured in the equivalent noise level $L_{eq(10minute)}$ exceeds the level of the adjacent bands on both sides by:

- 5dB or more if the centre frequency of the band containing the tone is in the range 500Hz to 10,000Hz;
- 8dB or more if the centre frequency of the band containing the tone is in the range 160 to 400Hz; and/or
- 15dB or more if the centre frequency of the band containing the tone is in the range 25Hz to 125Hz.

If tonality is found to be a repeated characteristic of the wind turbine noise, 5 dB(A) should be added to measured noise levels from the wind farm. If tonality is only identified for certain wind directions and speeds, the penalty is only applicable under these conditions. The tonal characteristic penalty applies only if the tone from the wind turbine is audible at the relevant receiver. Absence of tone in noise emissions measured at an intermediate location is sufficient proof that the tone at the receiver is not associated with the wind farm's operation. The assessment for tonality should only be made for frequencies of concern from 25 Hz to 10 KHz and for sound pressure levels above the threshold of hearing (as defined in *ISO 389.7: 2005 Acoustics - Reference zero for the calibration of audiometric equipment - Part 7: Reference threshold of hearing under free-field and diffuse-field listening conditions*).

Low Frequency Noise
The presence of excessive low frequency noise (a special noise characteristic) [i.e. noise from the wind farm that is repeatedly greater than 65 dB(C) during the day time or 60 dB(C)) during the night time at any relevant receiver] will incur a 5 dB(A) penalty, to be added to the measured noise level for the wind farm, unless a detailed internal low frequency noise assessment demonstrates compliance with the proposed criteria for the assessment of low frequency noise disturbance (UK Department for Environment, Food and Rural Affairs (DEFRA, 2005)) for a steady state noise source.

Notes:

- *For the purposes of these conditions, a special noise characteristic is defined as a repeated characteristic if it occurs for more than 10% of an assessment period. This equates to being identified for more than 144 minutes during any 24 hour period. This definition refers to verified wind farm noise only.*
- *The maximum penalty to be added to the measured noise level from the wind farm for any special noise characteristic individually or cumulatively is 5 dB(A).*

PART B: NOISE COMPLIANCE ASSESSMENT

Applicable Meteorological Conditions – Wind Turbines

1. The noise criteria in Table 2 of the conditions are to apply under all meteorological conditions.

Applicable Meteorological Conditions – Other Facilities

2. The noise criteria in condition 10 are to apply under all meteorological conditions except the following:
   a) wind speeds greater than 3 m/s at 10 m above ground level; or
   b) temperature inversion conditions between 1.5 ºC and 3ºC/100m and wind speeds greater than 2 m/s at 10 m above ground level; or
   c) temperature inversion conditions greater than 3ºC/100m.

APPENDIX D DPIE/DPE CORRESPONDENCE

[redacted]

From: no-reply@majorprojects.planning.nsw.gov.au
Sent: Thursday, 1 June 2023 8:45 AM
To: [redacted]
Cc: [redacted]
Subject: Communication regarding Noise Monitoring Report Submission Update SSD-6039-PA-27

Dea[redacted],

To[redacted]

I refer to you letter, submitted to the Department of Planning and Environment (Department) on 26 May 2023, in relation to providing an update on the submission of the Operational Noise Monitoring Report required in accordance with Schedule 3 Condition 12 for the Biala Wind Project SSD-6039 (Consent).
The Department requires no further information at this stage. The Department notes from your letter that you anticipate that the operational noise monitoring report will be prepared and submitted to the DPE by the end of July 2023 and will endeavour to update the Department should this expected timeframe change.
As previously stated the non-compliance with Schedule 3 Condition 12(b) will be assessed in accordance with the Departments Compliance Policy, once the noise monitoring report has been submitted to the Department via the major project website.
Should you wish to discuss the matter further, please conta[redacted]

Kind regards,

[redacted]

To sign in to your account click here or visit the Major Projects Website.
Please do not reply to this email.

Kind regards

The Department of Planning and Environment

NSW GOVERNMENT

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APPENDIX E SITE NOISE MODEL

Predicted noise levels determined using a digital noise model of the Biala Wind Farm was used to:

- Identify the wind turbines to be designated as 'relevant' for each noise monitoring location (related to the wind turbine operations filtering described in Section 4.5);
- Assist with determining whether or not the measured total noise levels at each location are likely to relate to the wind farm or the background environment; and
- Extrapolate noise levels measured at intermediate locations to corresponding receivers.

This appendix describes:

- The sound power levels referenced in the modelling; and
- The noise prediction method and input parameters.

E1 Sound power levels

Sound power level data associated with the Goldwind GW140 3.57MW has been provided by Goldwind.

The sound power level, including the addition of 1.0 dB uncertainty margin, is summarised in Table 22 for key wind speeds and represent the total emissions of the wind turbines, including the secondary contribution of ancillary plant associated with the wind turbines (e.g. cooling fans).

Table 22: Sound power levels including 1.0 dB uncertainty margin, dB L_{WA}

Description	Hub height wind speed, m/s						
	6	7	8	9	10	11	12
Sound power level	102.5	106.6	110.2	111.7	111.9	111.5	111.2

The sound frequency characteristics of the wind turbine was also provided by Goldwind. The reference spectrum used as the basis for this assessment is presented in Table 23 and corresponds to the highest overall sound power level presented in Table 22, being at a hub height wind speed of 10 m/s.

Table 23: Reference octave band sound power levels including 1.0 dB uncertainty margin, dB L_{WA}

Description	Octave band centre frequency, Hz							
	31.5	63	125	250	500	1,000	2,000	4,000
Reference spectra	76.3	87.9	97.2	101.6	105.9	107.6	105.1	96.7

E2 Prediction method and input parameters

Noise modelling was used to predict noise levels at receivers for atmospheric conditions which are favourable to sound propagation (i.e. increase noise levels at distant locations). Key elements of the wind turbine noise model are summarised in Table 24.

Table 24: Prediction method summary

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.2.
Method	International Standard ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the IOA Good Practice Guide.
Source characterisation	Each wind turbine is modelled as an incoherent point source of sound positioned at the proposed hub height of the wind turbines. The total sound of the wind farm is then calculated on the basis of simultaneous operation of all wind turbines and summing the contribution of each.
Terrain data	Site and immediate environs: 5 m interval elevation data provided by Goldwind. Surrounding environs: 10 m interval elevation data sourced from Geoscience Australia (data sourced 27 October 2020).
Terrain effects	Terrain adjustment applied in accordance with the IOA Good Practice Guide.
Ground conditions	The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. A value of G = 0.5 (50 % soft ground) was selected to provide a cautious representation of ground effect when predicting A-weighted noise levels.
Atmospheric conditions	Temperature 10°C and relative humidity 70 % This represents conditions which result in relatively low levels of atmospheric sound absorption and is chosen on the basis of the IOA Good Practice Guide. The calculations are based on sound speed profiles[15] which increase the propagation of sound from each wind turbine to each receiver location, whether as a result thermal inversions or wind directed toward each calculation point. The primary consideration for wind farm noise assessment is wind speed and direction. The noise level at each calculation point is assessed on the basis of being simultaneously downwind of every wind turbine at the site. Other wind directions in which part or the entire wind farm is upwind of the receiver will result in lower noise levels. In some cases, it is not physically possible for a receiver to be simultaneously downwind of each wind turbine and the approach is therefore conservative in these instances.
Receiver heights	1.5 m AGL It is noted that the IOA Good Practice Guide refers to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which results in lower noise levels. However, importantly, predictions in Australia do not generally subtract a margin recommended by the IOA Good Practice Guide to account for differences between L_{Aeq} and L_{A90} noise levels. The magnitude of these differences is comparable and therefore balance each other out to provide similar predicted noise levels. This approach has been shown to be valid for predicting noise level of wind farms expected to be measured using the L_{A90} parameter (as per the NSW Noise Assessment Bulletin).

15 The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

Detail	Description
Uncertainty	Consistent with current practice, a broadband uncertainty margin of +1.0 dB was applied to the sound power level provided by Goldwind have been applied to the wind turbine sound power data to account for typical test uncertainties. Further information is provided in Appendix E1. Per the NCTP, ±1 dB uncertainty margin was also factored in predictions used for extrapolations to account for variations in the tolerance of the calculations at intermediate and receiver distances (factored by application of +1 dB to the extrapolated level).

E3 Prediction level difference between intermediate and receiver monitoring locations

Procedures for the extrapolation of noise levels at intermediate locations are defined in Section 3.7.6 of the NCTP. Specifically, the extrapolations were conducted in accordance with ISO 1996-2:2017, using the noise prediction method and input parameters detailed in the preceding sections.

Difference in predicted noise levels between the intermediate and receiver monitoring locations used to extrapolate estimated wind farm noise levels at receiver locations based on total measured noise levels at intermediate locations are presented in Table 25.

Table 25: Difference in predicted noise levels between the intermediate and receiver monitoring locations

Receiver location	Relevant intermediate location	Predicted noise level difference, dB
HN06	Int. HN06	-13.5
HN09	Int. HN09	-8.9
HN11	Int. HN09	-8.5
HN12	Int. HN09	-10.1
HN13	Int. HN15	-19.6
HN15	Int. HN15	-15.7

APPENDIX F SITE WIND DATA

F1 Data sources

Details of the wind data sources provided for the noise monitoring period are summarised in Table 26.

Table 26: Site wind data sources

Item	Description
Extrapolated wind speed data files	The extrapolated wind speed data used for the analysis was provided in a file named *Biala_M1_predicted wind speed_20230614.xlsx* and received 14 June 2023 Separate Entura correspondence (memo dated 23 June 2023) also confirmed the synthesised wind data correspondence to hub height (110 m above ground level)
Time series	The extrapolated wind speed data file included confirmation that the timestamp of the data series represents the start of each 10-minute period and the data time zone is UTC + 10 (Australian Eastern Standard Time).

F2 Entura correspondence – M1 data synthesis procedures

This appendix reproduces correspondence prepared by wind analysts Entura who were commissioned by Goldwind to prepare a de-waked time series of wind speed data for the noise monitoring period.

entura

23 June 2023

Our ref: E310197-TR01

Justin Adcock

Marshall Day Acoustics

Dear Justin

Biala Wind Farm wake free record at M1 mast location

Entura was engaged by Marshall Day Acoustics to prepare a wake-free wind data set at the location of the M1 preconstruction mast at the Biala Wind Farm for use in a post-construction noise assessment.

Mast M1 was decommissioned prior to construction of the wind farm. Currently operating on site are three 110 m nominal height wind monitoring masts, referred to as PB4, PB5 and WF2. There is no overlapping record between the M1 mast and the currently operating masts. As such, a predicted record has been created at M1 using wind flow modelling to convert observations at the operating masts to the historic location. This method results in high uncertainty for the individual 10-minute values predicted.

Inputs

The following datasets were provided to Entura:

- Wind turbine as-built coordinates (20230517 - Biala as-built WTG locations - GDA94 - Z55.xlsx)
- Wind turbine dimensions
- Terrain contours and roughness map (BialaCombined_Elevation+Roughness.map)
- Wind monitoring mast datasets
    - M1 – maintenance report (September 2014), data from December 2010 – April 2018
    - WF2 – commissioning report (March 2020), data from April 2021 – May 2023
    - PB4 – commissioning report (February 2019), data from February 2019 – November 2019 and April 2021 – May 2023
    - PB5 – commissioning report (March 2019), data from February 2019 – November 2019 and April 2021– May 2023

Method

The three operating masts have a consistent setup for instruments, monitoring heights and orientations.

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The top anemometers at 109.1 m were combined based on wind direction to remove the effect of mast/lightning finial shadowing. Instantaneous shear extrapolation was used to calculate the wind speed at each mast at the hub height of 110 m.

Direction offsets were checked against mast commissioning reports, flow disturbances due to masts, and concurrent mast and mesoscale records. Minor corrections were made where appropriate.

The wake free sectors for each operating mast were calculated using the definition for wind turbine wake affected sectors given in IEC 61400-12 Ed 3, using the as-built wind farm layout, mast locations, and wind turbine dimensions. The combined wake free sectors for all masts are shown overlaid in Figure 1.

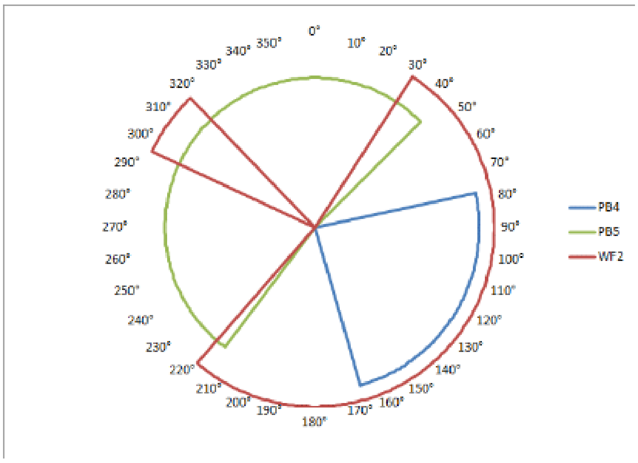


Figure 1: Wake free sectors

A wind flow model was created in WAsP, using the WAsP CFD calculation model, and 16 sector directional speedups were extracted from the model relating the wind speed at each mast location to the wind speed at the M1 location. Higher resolution direction sectors were tested but were not found to impact the output significantly.

Each operating mast's 110 m wind speed value for a given 10-minute period was scaled to the M1 location by applying the speedup from the wind flow model. If the wind direction indicated the data was from a wake free sector, the predicted M1 value was used. If multiple masts were wake free, their predictions for wind speed at M1 were averaged.

A similar process was used for combing the direction records from wake free masts, using vector averaging where multiple masts were wake free.

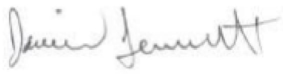
Output

The 10-minute timeseries of wind speed and direction at 110 m above ground level at the location of the M1 was derived and is the output of this process. Given the data available, this is the best available estimate of wind speed and direction at location M1 for the relevant period.

Uncertainty in the 10-minute values of the derived time-series is considered to be very high.

2

Yours sincerely



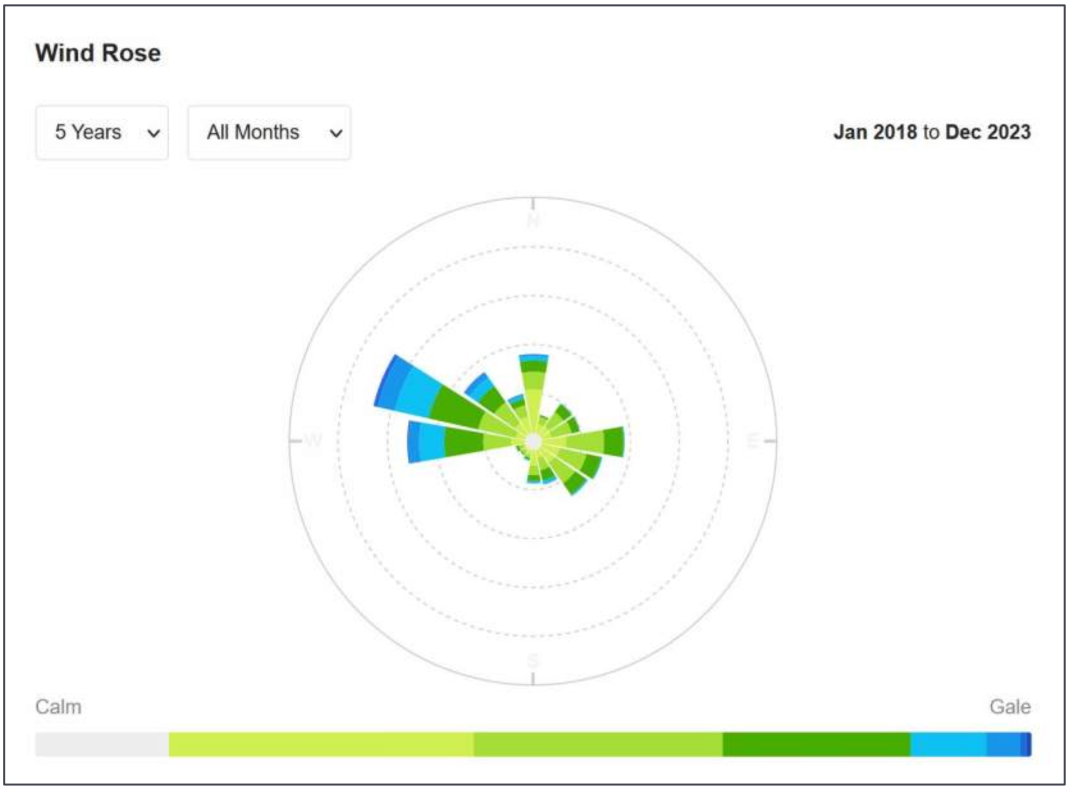
Daniel Bennett
Senior Renewable Engineer
daniel.bennett@entura.com.au

F3 Site wind speed and direction trends

F3.1 Broader area historic trend data

The following wind rose depicts wind speeds and directions over a 5-year period at the nearest Bureau of Meteorology weather station, located at Goulburn Airport, as sourced from WillyWeather.

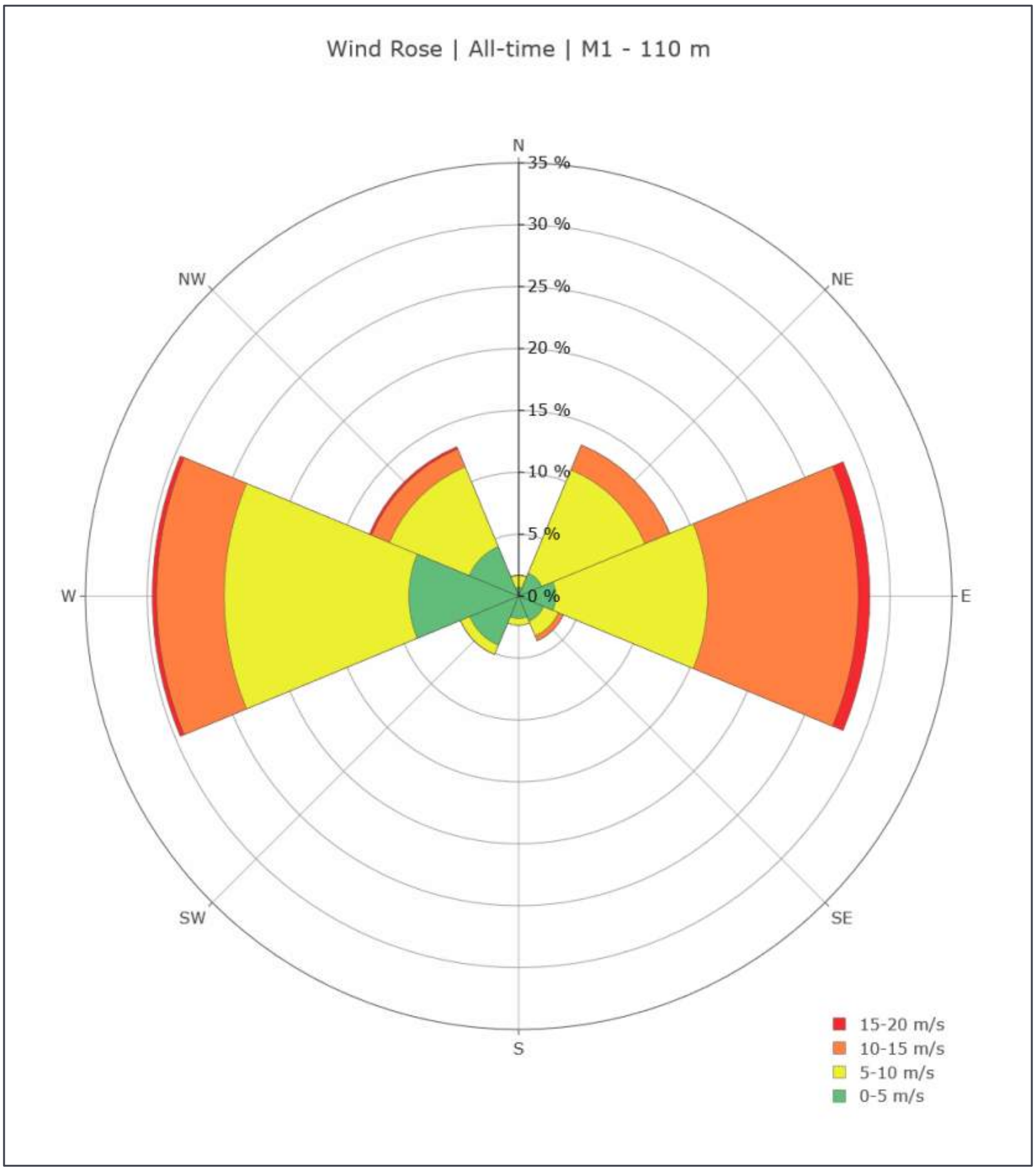
Given the distance between the Goulburn Airport (approx. 50 km) and the site of the wind farm, this data is indicative only.



F3.2 Biala Wind Farm noise monitoring period trend data

The following wind rose was generated using the wind data provided for the noise compliance assessment, filtered to remove the monitoring periods which were excluded at all noise monitoring locations on account of rainfall (all other filters for the noise monitoring data were applied on a location-specific basis and were therefore not applied to the wind data presented in the wind rose).

Figure 6: Biala Wind Farm noise monitoring period – M1 wind rose



APPENDIX G SURVEY INSTRUMENTATION

Table 27: Sound level measurement instrumentation summary

Item	Description
Equipment type	Automated/unattended integrating sound levels
Make & model	01dB DUO
Instrumentation class	Class 1 (precision grade) in accordance with AS/IEC 61672.1:2019[16]
Instrumentation noise floor	Less than 20 dB
Time synchronisation	Internal GPS clocks
Wind shielding	Enhanced wind shielding system based on the design recommendations detailed in the UK Institute of Acoustics guide. The system comprises an inner solid primary wind shield and an outer secondary large diameter hollow wind shield

[16] AS/IEC 61672.1-2019 *Electroacoustics - Sound level meters Specifications*, which is identical to IEC 61672.1:2.0 *Electroacoustics - Sound Level Meters - Part 1: Specifications* published in 2013

Table 28: Sound level meter installation records

Noise monitoring location	System	Unit serial number	Microphone serial number	Independent calibration date [1]	Calibration drift [2,3]	Measurement start date	Measurement end date
HN06	01dB DUO	10196	331724	22/06/2021	+0.27	25/01/2023	03/04/2023
HN09	01dB DUO	10417	144861	17/02/2022	+0.10	24/01/2023	03/04/2023
HN12	01dB DUO	10497	144850	15/07/2022	+0.31	25/01/2023	03/04/2023
HN13	01dB DUO	10498	207226	3/08/2022	-0.23	25/01/2023	20/02/2023
HN13	01dB DUO	10496	141230	28/07/2022	-0.03	22/03/2023	19/05/2023
HN15	01dB DUO	10770	162058	29/10/2021	+0.05	25/01/2023	03/04/2023
Int. HN06	01dB DUO	12691	331937	28/10/2021	-0.03	24/01/2023	04/04/2023
Int. HN09	01dB DUO	10419	144877	1/07/2022	+0.00	23/01/2023	13/03/2023
Int. HN15	01dB DUO	10409	224184	1/06/2021	-0.25	24/01/2023	14/02/2023
Int. HN15	01dB DUO	10302	446470	27/05/2022	+0.19	20/02/2023	04/04/2023

1 Independent (laboratory) calibration date to be within 2 years of measurement period as per AS 1055:2018[17]

2 Difference between reference level checks during deployment and collection of instruments

3 Calibration drift should not be greater than 1 dB as specified in AS 1055:2018

The reference calibration checks were conducted using a 01dB-Stell CAL21 calibrator S/N: 34164983 during deployment and retrieval of the monitors.

The calibration certificates associated with each sound level meter are included in Appendix U.

[17] AS 1055:2018 *Acoustics – Description and measurement of environmental noise*

Table 29: Local meteorological measurement instrumentation

Noise monitoring location	System	Unit serial number	Measurement start date	Measurement end date
HN15	LSI WSV 601	215520	25/01/2023	03/04/2023
HN06	Vaisala WXT 520	K1850003	25/01/2023	20/02/2023
HN06	Vaisala WXT 520	K2920005	20/02/23	03/04/2023
HN12	Vaisala WXT 520	K2920006	25/01/2023	03/04/2023

De-waked site wind speed data was provided by Entura, as detailed in in Section 4.3 and Appendix F

APPENDIX H DOWNWIND DIRECTIONS

Downwind conditions for each monitoring location are defined as directions that are equal to ±45° around a central downwind direction.

The 2003 SA Guidelines notes that a wind direction spread of 45 degrees either side (i.e. 90 degrees total) of the direct line between the nearest wind turbine and the relevant receiver is considered acceptable for defining downwind conditions (specifically for the purpose of compliance checking).

A 90-degree wide range has been used throughout this analysis. However, in some instances, alternative wind directions have been selected to provide a better representation of the wind directions in which noise levels from the proposed Biala Wind Farm would be expected to be highest.

Where applicable, the alternative wind directions were defined by selecting an alternative proposed wind turbine location, accounting of the arrangement of the wind turbines relative to each receiver in question. A summary of the downwind directions associated with the nearest wind turbine and the selected wind turbine for the analysis is presented in below.

The downwind direction ranges referenced in the analysis for each noise monitoring location are listed in Table 30.

Table 30: Downwind directions

Location	Central downwind direction, °	Downwind direction range, °
HN06 [1]	236	191 - 281
HN09	322	277 - 007
HN12	283	238 - 328
HN13	069	024 - 114
HN15	061	016 - 106
Int. HN06 [1]	234	189 - 279
Int. HN09	257	212 - 302
Int. HN15	37	352 - 082

1 Alternative wind direction defined to better represent the wind direction in which noise levels from the proposed Biala Wind Farm would be expected to be highest.

APPENDIX I SAMPLE SCADA DATA AND THRESHOLD POWER CURVES

Sample SCADA data and threshold power curves for the nearest wind turbine to each of the eight (8) receiver noise monitoring locations is also provided in Figure 7 to Figure 12.

Figure 7: Wind turbine T2 - nearest wind turbine to HN06 and Int. HN06 – SCADA data and threshold power curve

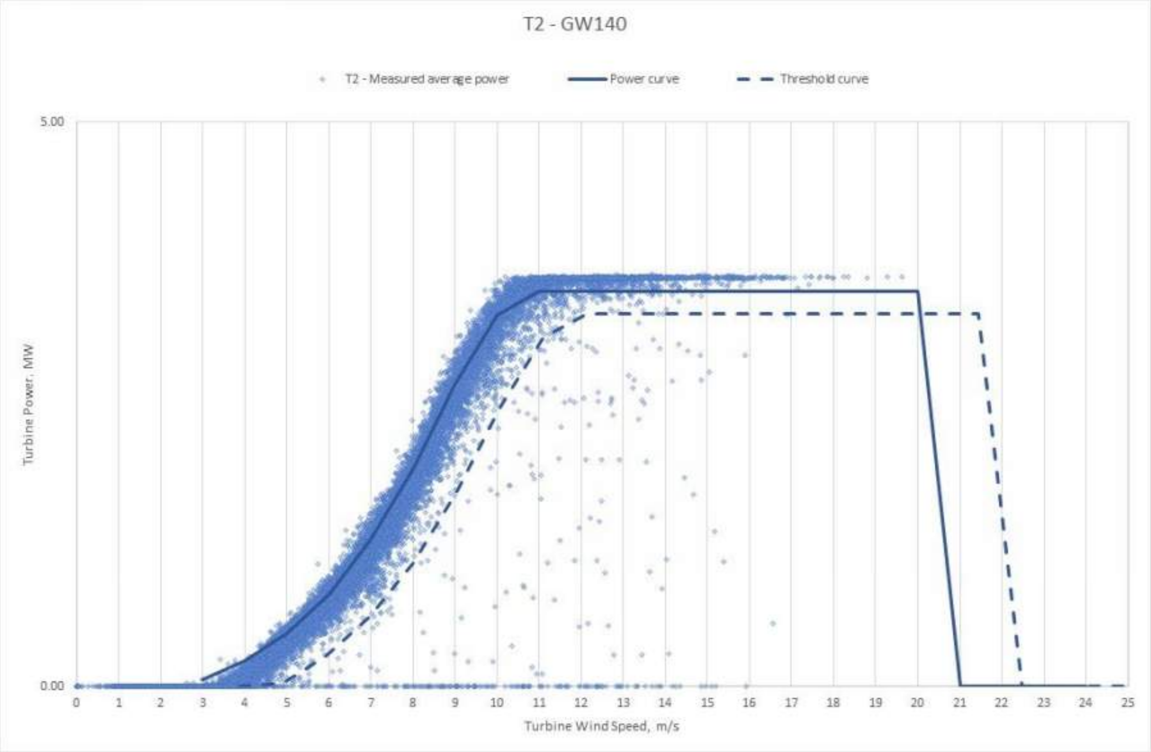


Figure 8: Wind turbine T4 - nearest wind turbine to HN09 – SCADA data and threshold power curve

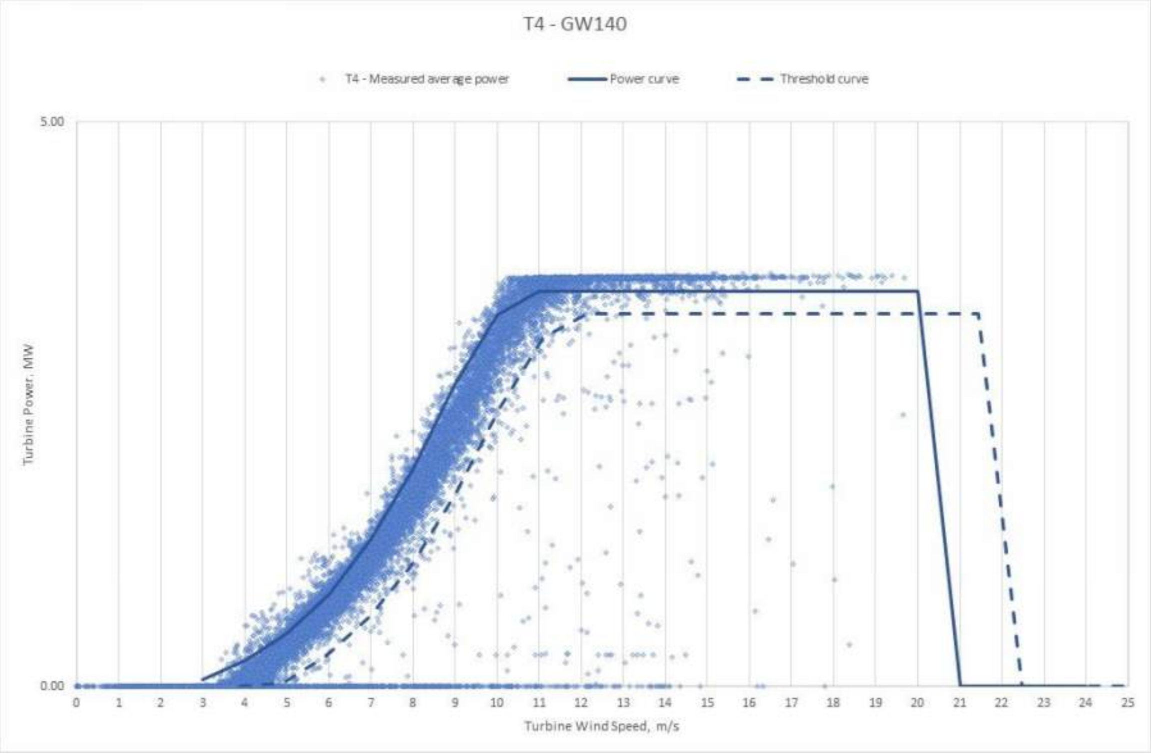


Figure 9: Wind turbine T30 - nearest wind turbine to HN12 – SCADA data and threshold power curve

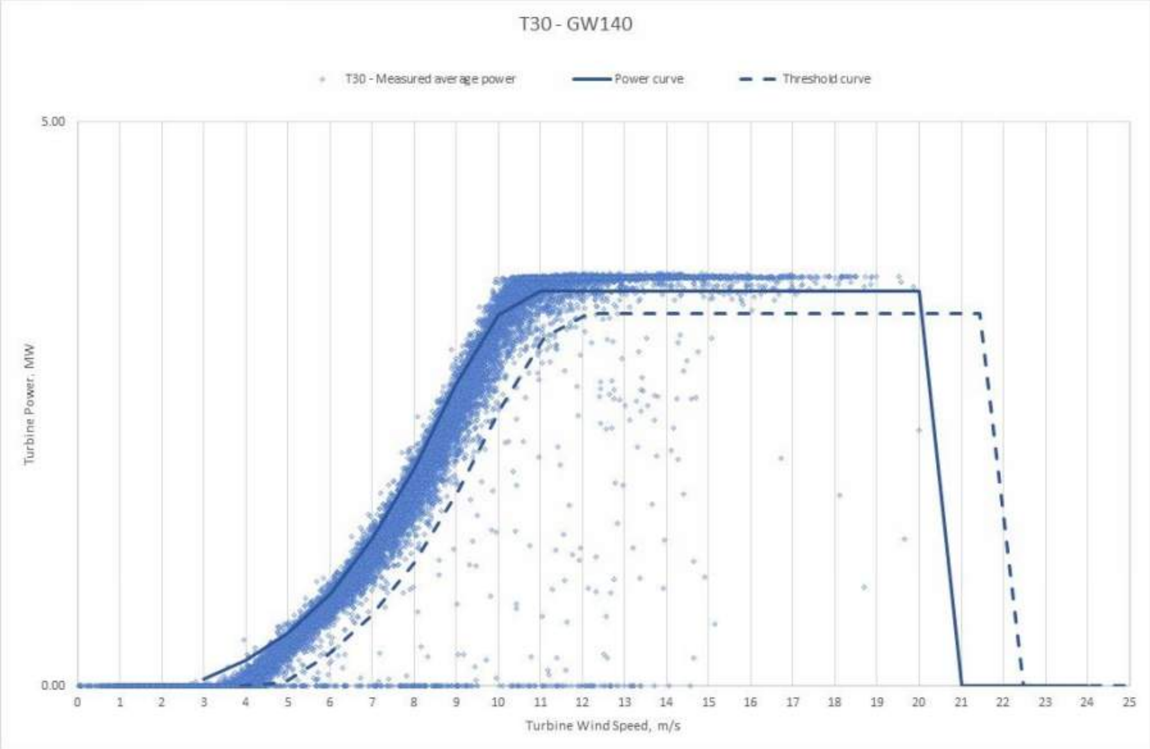


Figure 10: Wind turbine T31 - nearest wind turbine to HN13 – SCADA data and threshold power curve

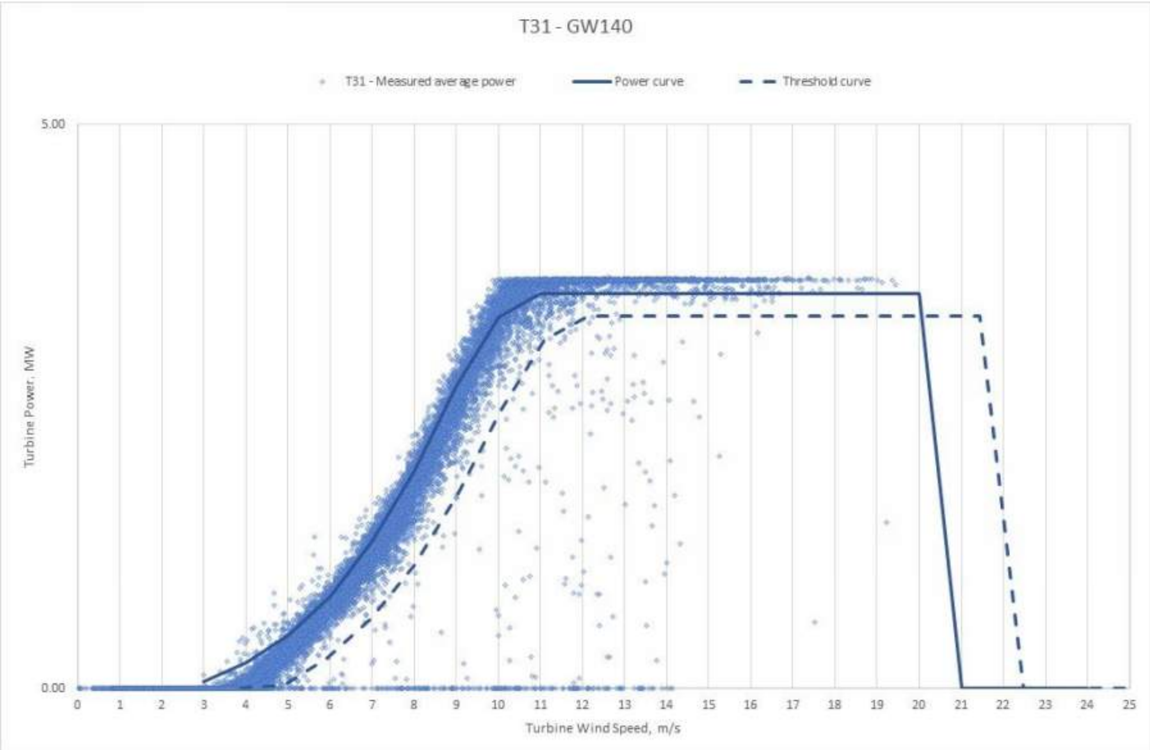


Figure 11: Wind turbine T23 - nearest wind turbine to HN15 and Int. HN15 – SCADA data and threshold power curve

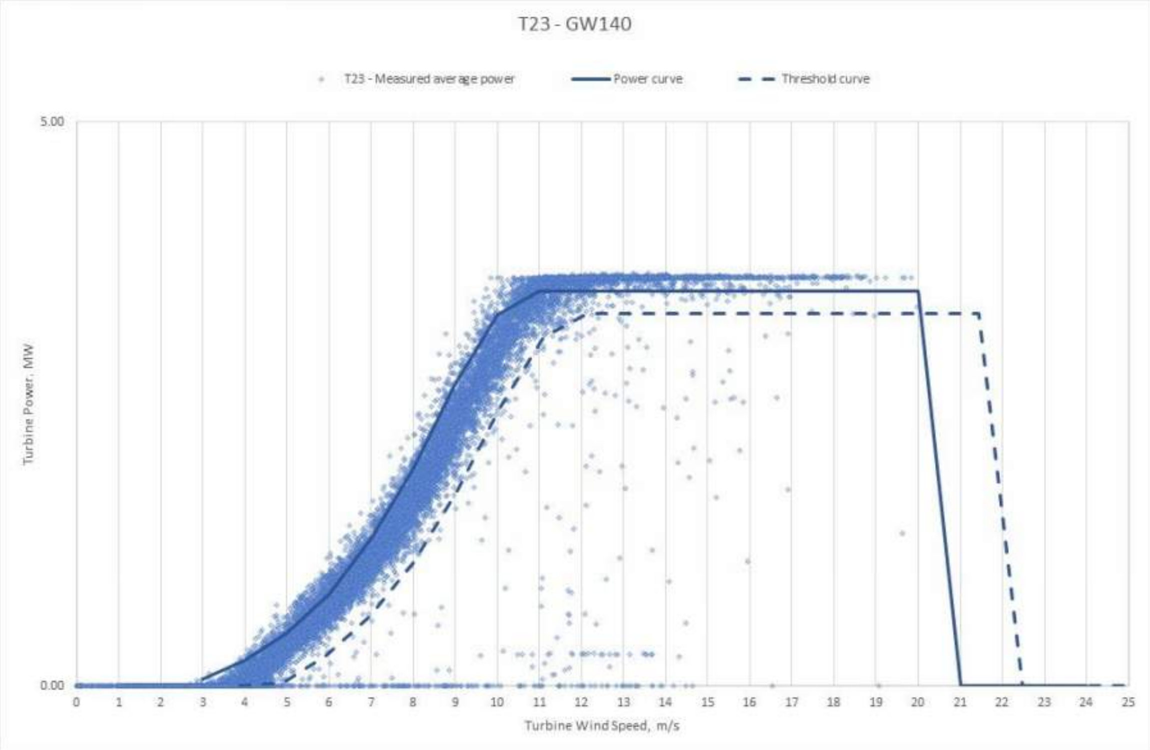
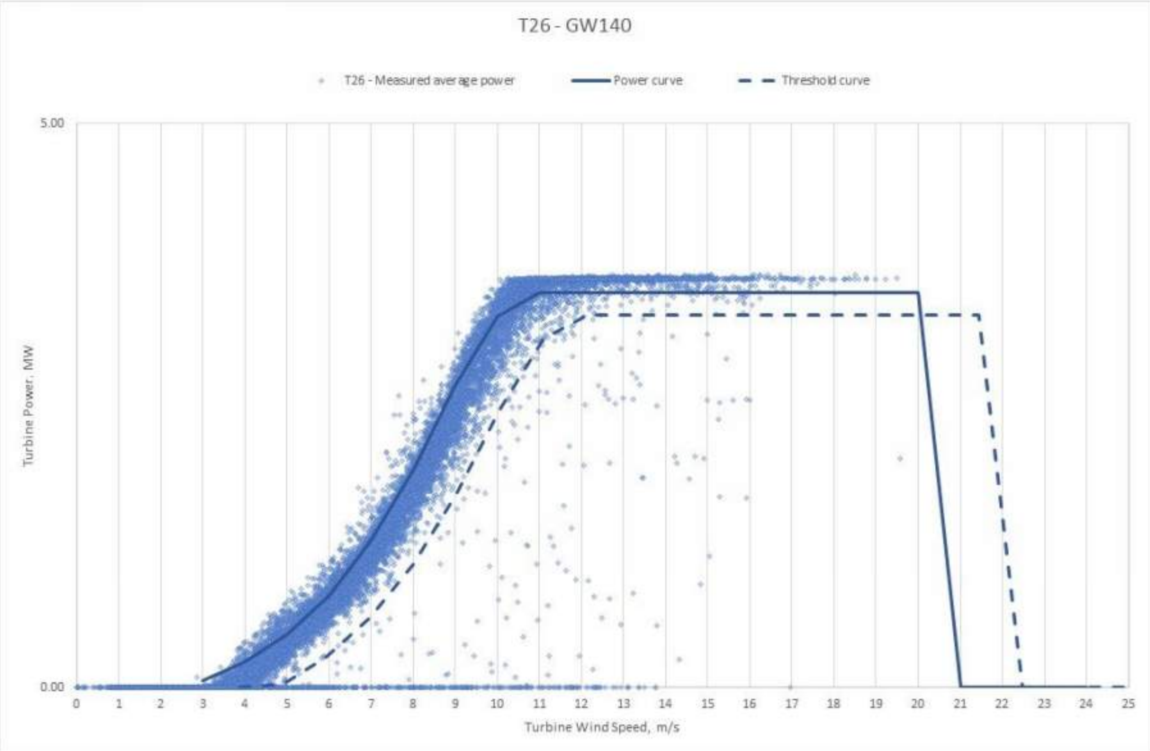


Figure 12: Wind turbine T26 - nearest wind turbine to Int. HN09 – SCADA data and threshold power curve



APPENDIX J RELEVANT WIND TURBINES SCHEDULE

Table 31: Number of relevant and non-relevant wind turbines

Wind turbines	HN06	HN09	HN12	HN13	HN15	Int. HN06	Int. HN09	Int. HN15
Relevant turbines	26	27	26	25	25	10	22	17
Non-relevant turbines	5	4	5	6	6	21	9	14

Table 32: Predicted noise levels, dB L_{Aeq} (the annotation "(R)" indicates a relevant wind turbine)

Description	HN06	HN09	HN12	HN13	HN15	Int. HN06	Int. HN09	Int. HN15
Total	34.3	38.6	37.4	32.3	36.2	47.8	47.5	51.9
Relevant turbines	34.2	38.4	37.2	32.2	36.1	47.7	47.4	51.8
Non-relevant turbines	18.2	22.7	22.1	16.6	20.5	32.5	32.1	36.6
T1	26.2 (R)	25.7 (R)	16.8 (R)	7.3	10.3	42.2 (R)	20.1	18.1
T2	28.4 (R)	22.7 (R)	15.4	7.0	10.2	45.1 (R)	18.7	15.7
T3	25.5 (R)	24.0 (R)	16.5 (R)	7.8	11.3	38.2 (R)	20.6	19.4
T4	19.4 (R)	28.6 (R)	20.6 (R)	10.6 (R)	14.3	27.5 (R)	30.5 (R)	24.6
T5	20.4 (R)	26.3 (R)	19.2 (R)	10.1	14.1	28.7 (R)	28.0 (R)	24.0
T6	21.0 (R)	24.1 (R)	17.9 (R)	9.7	13.9	29.0 (R)	25.8 (R)	23.4
T7	17.9 (R)	28.1 (R)	21.7 (R)	11.7 (R)	15.7 (R)	24.7 (R)	33.4 (R)	27.3
T8	18.2 (R)	26.1 (R)	20.4 (R)	11.5 (R)	15.9 (R)	25.0 (R)	31.0 (R)	27.4
T9	17.8 (R)	23.4 (R)	19.2 (R)	11.7 (R)	16.8 (R)	23.7	28.7 (R)	28.7 (R)
T10	18.3 (R)	19.7 (R)	17.8 (R)	11.1 (R)	16.3 (R)	23.9 (R)	26.1 (R)	27.1
T11	18.5 (R)	18.6 (R)	16.8 (R)	10.6 (R)	15.9 (R)	23.8 (R)	22.4	26.0
T12	18.9 (R)	17.3	15.6	9.9	15.2 (R)	23.5	20.3	22.2

Description	HN06	HN09	HN12	HN13	HN15	Int. HN06	Int. HN09	Int. HN15
T13	16.8 (R)	25.0 (R)	20.9 (R)	12.6 (R)	17.5 (R)	22.6	32.3 (R)	30.7 (R)
T14	16.7 (R)	22.8 (R)	19.5 (R)	14.5 (R)	19.9 (R)	22.1	29.3 (R)	31.0 (R)
T15	16.2 (R)	18.5 (R)	18.0 (R)	12.4 (R)	20.6 (R)	20.9	26.2 (R)	30.8 (R)
T16	16.0 (R)	16.3	14.0	11.8 (R)	20.2 (R)	19.9	22.8	26.1
T17	14.8 (R)	16.3	14.7	13.0 (R)	22.3 (R)	18.6	23.7	31.2 (R)
T18	15.4 (R)	27.4 (R)	24.5 (R)	15.9 (R)	18.0 (R)	18.9	40.6 (R)	31.7 (R)
T19	15.7 (R)	25.2 (R)	22.4 (R)	15.7 (R)	18.6 (R)	21.0	35.2 (R)	33.3 (R)
T20	14.7 (R)	22.6 (R)	21.2 (R)	16.6 (R)	22.6 (R)	19.5	31.8 (R)	37.8 (R)
T21	13.9 (R)	20.0 (R)	19.4 (R)	15.0 (R)	24.5 (R)	18.2	27.6 (R)	39.7 (R)
T22	13.9 (R)	16.6	15.7	14.3 (R)	24.3 (R)	17.9	24.8	35.1 (R)
T23	13.1 (R)	19.9 (R)	20.2 (R)	18.3 (R)	26.3 (R)	15.2	28.2 (R)	46.7 (R)
T24	13.9 (R)	24.6 (R)	24.7 (R)	17.7 (R)	20.5 (R)	16.8	37.9 (R)	36.9 (R)
T25	13.2 (R)	21.9 (R)	22.6 (R)	18.5 (R)	23.0 (R)	15.7	32.3 (R)	45.4 (R)
T26	13.0 (R)	25.4 (R)	27.9 (R)	18.5 (R)	20.1 (R)	15.7	40.7 (R)	33.6 (R)
T27	12.3	22.9 (R)	26.0 (R)	19.9 (R)	24.5 (R)	14.7	34.8 (R)	37.5 (R)
T28	12.3	21.5 (R)	23.7 (R)	20.0 (R)	26.2 (R)	14.5	32.0 (R)	43.9 (R)
T29	11.7	22.5 (R)	27.3 (R)	20.8 (R)	24.6 (R)	13.9	33.7 (R)	34.7 (R)
T30	9.9	20.3 (R)	28.5 (R)	24.0 (R)	24.3 (R)	11.6	28.0 (R)	28.3
T31	9.0	18.7 (R)	26.7 (R)	26.5 (R)	24.8 (R)	10.4	25.1	26.3

APPENDIX K SUMMARY OF POST-CONSTRUCTION NOISE LEVELS

Table 33: Regression equation coefficients –A-weighted noise levels

	Regression equation coefficients for post-construction noise equation of best fit $L_{A90} = a\,x^3 + b\,x^2 + c\,x + d$, where x = wind speed in m/s					
Location	**a**	**b**	**c**	**d**	**R^2**	**Valid wind speed range, m/s**
HN06	-0.04519	1.168	-7.744	44.43	0.29	4 - 12
HN09 (all-time)	-0.03388	0.8089	-4.47	37.43	0.64	3 - 12
HN09 (0700-1700 hrs)	-0.0412	1.048	-6.772	45.87	0.63	4 - 12
HN12	-0.02431	0.5953	-2.644	32.77	0.52	3 - 12
HN13	0.04056	-0.6937	4.76	20.67	0.34	3 - 12
HN15	-0.01131	0.4041	-2.741	35.01	0.65	4 - 12
Int. HN06	0.0295	-0.6941	6.604	18.06	0.58	3 - 12
Int. HN09	0.00866	-0.1677	2.405	28.95	0.69	3 - 12
Int. HN15	0.03163	-0.7852	7.544	18.64	0.60	3 - 12

APPENDIX L SPECIAL NOISE CHARACTERISTICS

L1 Attended observations

This section presents the findings of the attended observations which were carried out to gauge the noise characteristics of the wind farm and identify any other environmental noise sources which may influence the monitoring data.

The findings of the attended observations and subjective assessments are summarised in Table 34 and Table 35 along with the number of operational wind turbines and the site wind speeds at the times when the observations were made.

The data concerning the number of operational wind turbines was sourced from the site operational records (SCADA) data used for the operational analysis.

Hub-height site wind speeds have been sourced from the M1 met mast data set described in Section 4.3 and Appendix F.

Assessment of special noise characteristics is strictly only applicable to the assessment of noise levels at receivers. However, observations were also made at intermediate locations in some instances to provide an additional reference when considering the potential presence of special noise characteristics at receivers. Accordingly, for completeness, the summary includes the observations made at the intermediate locations. The commentary for these locations is based on evaluating whether any characteristics were evident at an intermediate location which may be relevant to receivers (e.g. tonality).

Table 34: Attended observations - summary of subjective assessments at receivers

Date and time	Location	Total turbines operating	Hub height wind speed and direction	Subjective assessment/comments
24 January 2023				
1136 hrs	HN09	31	2.6 m/s | 248°	Wind farm intermittently just audible Crosswind conditions No special audible characteristics observed.
25 January 2023				
0848 hrs	HN06	31	2.2 m/s | 251°	Wind farm inaudible Downwind conditions No special audible characteristics observed.
1116 hrs	HN12	25	4.7 m/s | 254°	Wind farm intermittently just audible Downwind conditions No special audible characteristics observed.
1329 hrs	HN15	30	6.2 m/s | 296°	Wind farm inaudible Crosswind conditions No special audible characteristics observed.
1557 hrs	HN13	31	5.8 m/s | 259°	Wind farm inaudible. Upwind conditions No special audible characteristics observed.

Date and time	Location	Total turbines operating	Hub height wind speed and direction	Subjective assessment/comments
14 February 2023				
1129 hrs	HN06	30	10.9 m/s | 91°	Wind farm inaudible Upwind conditions No special audible characteristics observed.
1310 hrs	HN12	30	11.7 m/s | 92°	Wind farm inaudible Upwind conditions No special audible characteristics observed.
1350 hrs	HN13	30	10.3 m/s | 89°	Wind farm inaudible Downwind conditions No special audible characteristics observed.
1443 hrs	HN15	30	9.3 m/s | 84°	Wind farm intermittently just audible Downwind conditions No special audible characteristics observed.
3 April 2023				
1132 hrs	HN06	30	6.7 m/s | 43°	Wind farm intermittently just audible Upwind conditions No special audible characteristics observed.
1256 hrs	HN09	31	5.6 m/s | 50°	Wind farm inaudible Crosswind conditions No special audible characteristics observed.
1439 hrs	HN12	29	4.7 m/s | 59°	Wind farm inaudible Upwind conditions No special audible characteristics observed.
1550 hrs	HN15	30	3.4 m/s | 83°	Wind farm audible Downwind conditions Intermittent tone audible from direction of wind farm Likely attributable to yaw brake maintenance issue Goldwind confirmed maintenance issue.
19 May 2023				
1328 hrs	HN13	30	5.3 m/s | 160°	Wind farm intermittently just audible Crosswind conditions No special audible characteristics observed.

Table 35: Attended observations - summary of subjective assessments at intermediate positions

Date and time	Location	Total turbines operating	Hub height wind speed and direction	Subjective assessment/comments
23 January 2023				
1807 hrs	Int. HN09	31	4.3 m/s | 119°	Wind farm clearly audible Crosswind conditions No special audible characteristics observed.
24 January 2023				
0900 hrs	Int. HN06	31	3.6 m/s | 305°	Wind farm clearly audible Crosswind conditions No special audible characteristics observed.
1550 hrs	Int. HN15	31	5.6 m/s | 296°	Wind farm clearly audible Crosswind conditions Tone observed. Attributed to yaw brake maintenance issue Goldwind confirmed maintenance issue.
14 February 2023				
1003 hrs	Int. HN15	29	10.7 m/s | 98°	Wind farm clearly audible Upwind conditions No special audible characteristics observed.
1030 hrs	Int. HN09	29	11.8 m/s | 94°	Wind farm clearly audible Crosswind conditions No special audible characteristics observed.
4 April 2023				
1639 hrs	Int. HN06	30	6.0 m/s | 93°	Wind farm clearly audible Upwind conditions No special audible characteristics observed.

The results in the above tables indicate that the wind farm was generally inaudible in a range of different conditions, and special noise characteristics were not typically observed.

Limited observations were noted in relation to tonal noise on a single visit to Int. HN15 and HN15. This noise source was not audible during other attended observations at these locations.

The NSW Noise Assessment Bulletin recognises that tonality associated with the operation of modern wind turbines is usually caused by a maintenance issue, and is not typical for well-designed or well-maintained wind turbines[18].

[18] The NSW Noise Assessment Bulletin makes reference to the *Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3)*, Environmental Protection Agency, Ireland (2011).

Maintenance issues during initial operation of a new wind farm project are not unusual, and the noise generation associated with the maintenance issue, thought to be related to a yaw brake fault, can be resolved through appropriate repairs or replacement.

Notwithstanding the above, an objective assessment of tonality is detailed in the following section.

L2 Tonality

The objective assessment of tonality was conducted for all retained 10-minute measurements following application of the data filtering processes described in Section 4.4, in accordance with the method detailed in Section 4.6. The percentages of all analysed 10-minute periods in which tonality was identified are summarised in Table 36.

Table 36: ISO 1996-2:2007 one-third octave tonality – percentage of periods with tonality (below 1 kHz)

Location	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
HN06	--	--	--	--	--	--	--	--	--	--
HN09	--	--	--	--	--	--	--	--	--	--
HN12	--	--	--	--	--	--	--	--	--	--
HN13	--	2.6	--	--	--	--	--	--	--	--
HN15	--	4.2	--	--	--	--	--	--	--	--

The objective assessment did not identify tonality at most locations and wind speeds.

The limited number of periods in which the objective assessment did identify tonality were subject to additional analysis. Listening tests were conducted in which the audio recordings taken during the relevant periods were reviewed. These tests confirmed that the tones identified in the 31.5 Hz and 50 Hz third octave bands at low wind speeds at HN13 and HN15 were associated with localised ambient noise sources rather than the operation of the wind turbines.

Tonality is therefore not considered to be a characteristic of the Biala Wind Farm.

L3 Low frequency

The objective assessment of low frequency was conducted for all retained 10-minute measurements following application of the data filtering processes described in Section 4.4, in accordance with the method detailed in Section 4.6. The percentages of all analysed 10-minute periods in which C-weighted noise levels were above the 60 dB L_{Ceq} threshold (based on measured L_{C90} levels) are summarised in Table 37.

Table 37: Receiver locations – percentage of periods exceeding 60 dB L_{Ceq} threshold

Location	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
HN06	--	--	2.5	--	--	--	--	--	--	--
HN09	--	--	--	--	--	--	--	--	--	--
HN12	--	--	--	0.9	--	0.9	--	--	--	--
HN13	--	--	--	--	--	--	--	--	0.6	1.5
HN15	--	--	--	--	--	--	--	--	--	--

The 90th percentile C-weighted levels at the receiver locations have also been summarised in Table 38.

An important point of context to this data is that the upper values represented by the 90th percentile data are sensitive to extraneous influences and cannot be corrected for the potential influence of background noise levels during the compliance monitoring.

Table 38: Receiver locations – 90th percentile of measured C-weighted levels, dB L_{C90}

Location	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
HN06	46.0	46.6	46.5	46.7	49.9	48.9	51.5	52.8	54.3	55.3
HN09	47.9	49.7	49.9	51.5	54.0	51.4	56.0	56.2	56.7	56.4
HN12	46.0	48.2	49.4	51.1	51.3	49.8	52.5	54.1	55.1	54.4
HN13	51.8	49.1	50.9	50.3	50.4	50.4	52.7	53.9	55.7	57.2
HN15	47.2	46.8	47.7	48.5	50.5	50.4	52.7	54.3	55.4	55.7

Low frequency is therefore not considered to be a characteristic of the Biala Wind Farm.

L4 Penalty adjustments

The results presented in the preceding sections demonstrate that neither tonality or low frequency were repeated characteristics of the wind farm.

For this reason, the application of special noise characteristics penalties is not considered warranted.

APPENDIX M RECEIVER HN06 DATA

M1 Receiver HN06 location data

Figure 13: Receiver HN06 aerial view – dwelling and noise monitor locations

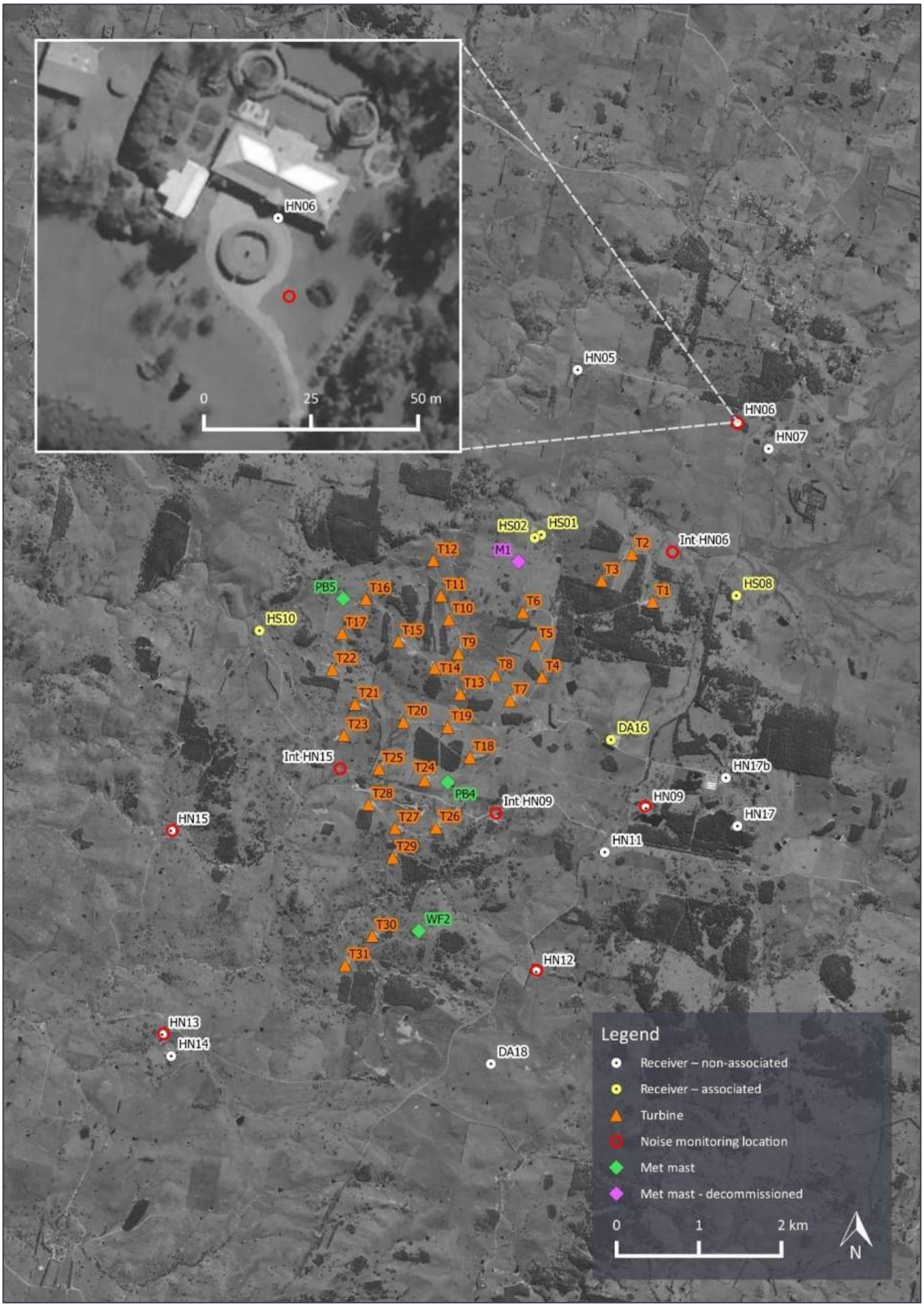


Table 39: Receiver HN06 noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	718,838	6,173,981
Noise monitoring location	718,841	6,173,963

Table 40: Receiver HN06 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

M2 Receiver HN06 measurement data summary

Table 41: Receiver HN06 noise level analysis summary

Description	Data points
Collected	8,854
Removed [1]	8,164
Retained	690

1 Removed data points due to rain, extraneous noise, atypical wind turbine operation, wind directions outside the downwind range or wind speeds outside assessment range

Figure 14: Receiver HN06 - post construction A-weighted noise level and wind speed time history

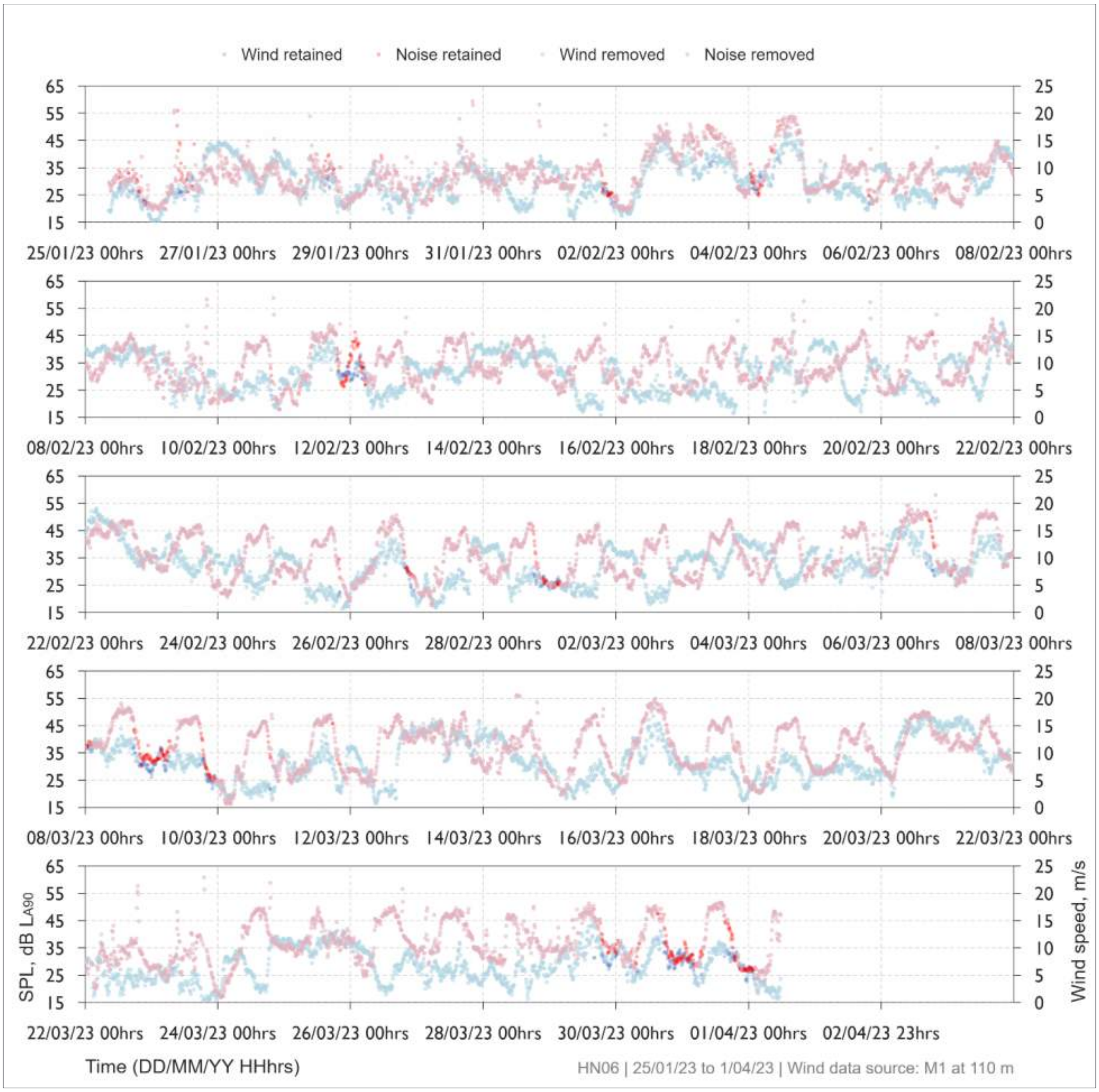
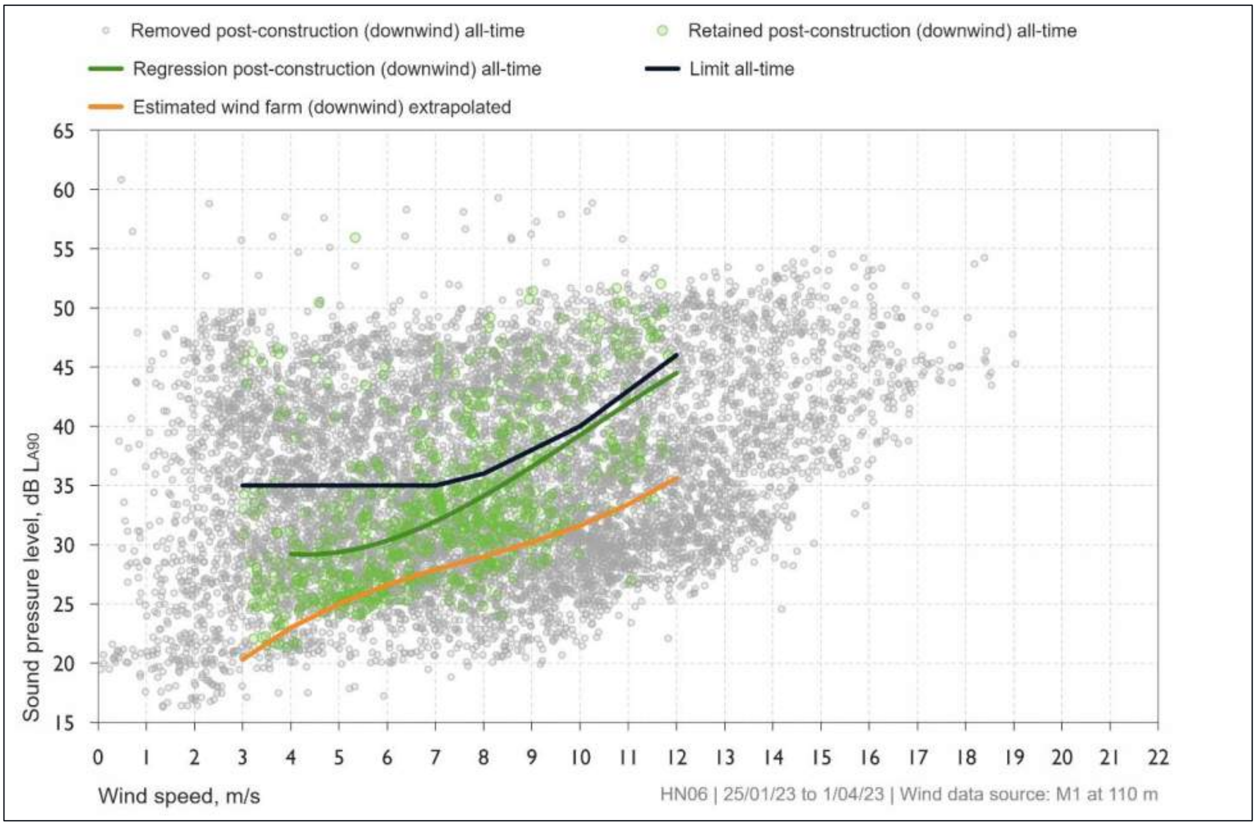


Figure 15: Receiver HN06 - post-construction A-weighted noise levels versus site wind speed



APPENDIX N RECEIVER HN09 DATA

N1 Receiver HN09 location data

Figure 16: Receiver HN09 aerial view – dwelling and noise monitor locations

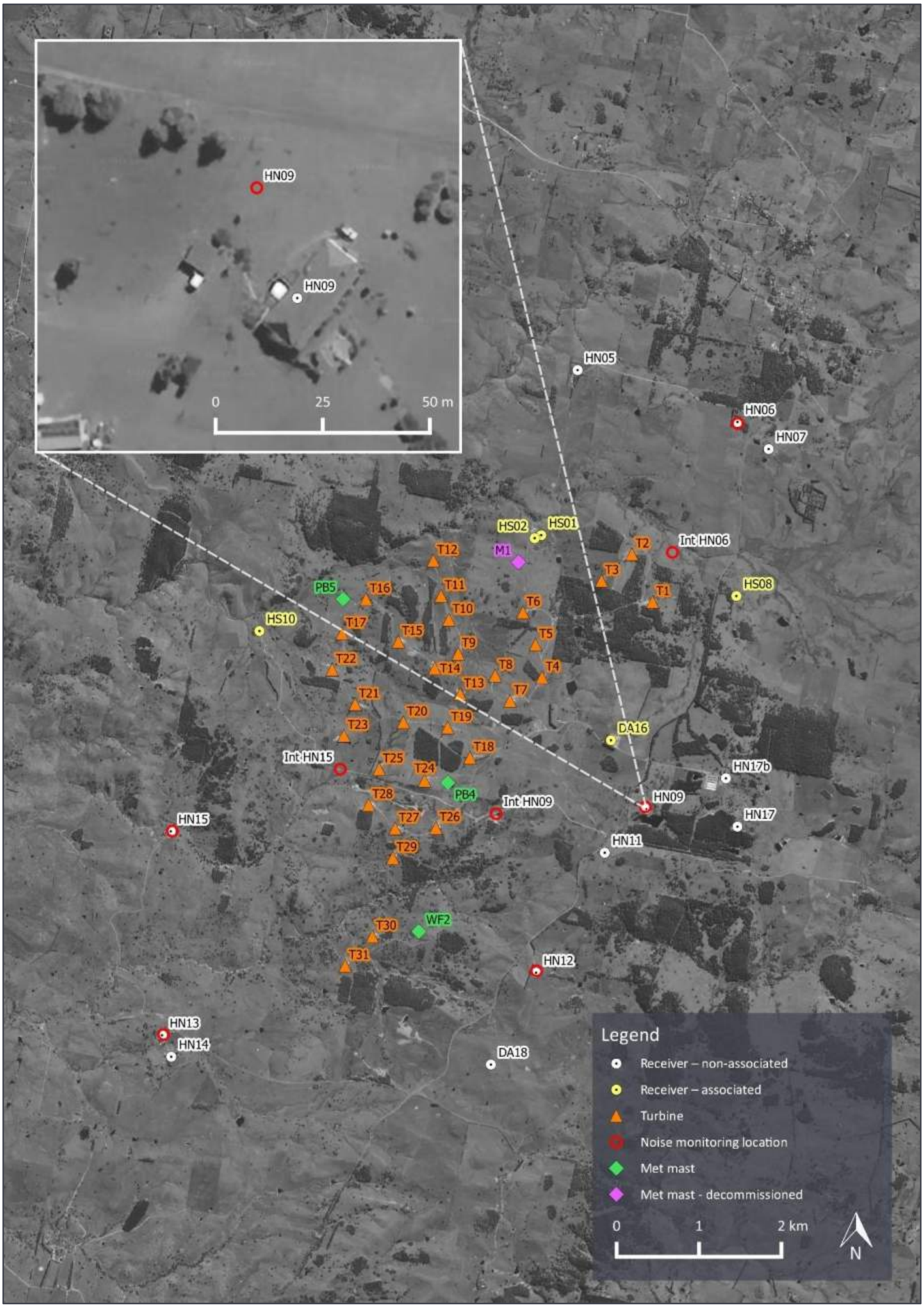


Table 42: Receiver HN09 noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	717,729	6,169,285
Noise monitoring location	717,720	6,169,311

Table 43: Receiver HN09 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

N2 Receiver HN09 measurement data summary

Table 44: Receiver HN09 noise level analysis summary

Description	Data points
Collected	9,068
Removed [1]	8,252
Retained	816

1 Removed data points due to rain, extraneous noise, atypical wind turbine operation, wind directions outside the downwind range or wind speeds outside assessment range

Figure 17: Receiver HN09 - post construction A-weighted noise level and wind speed time history

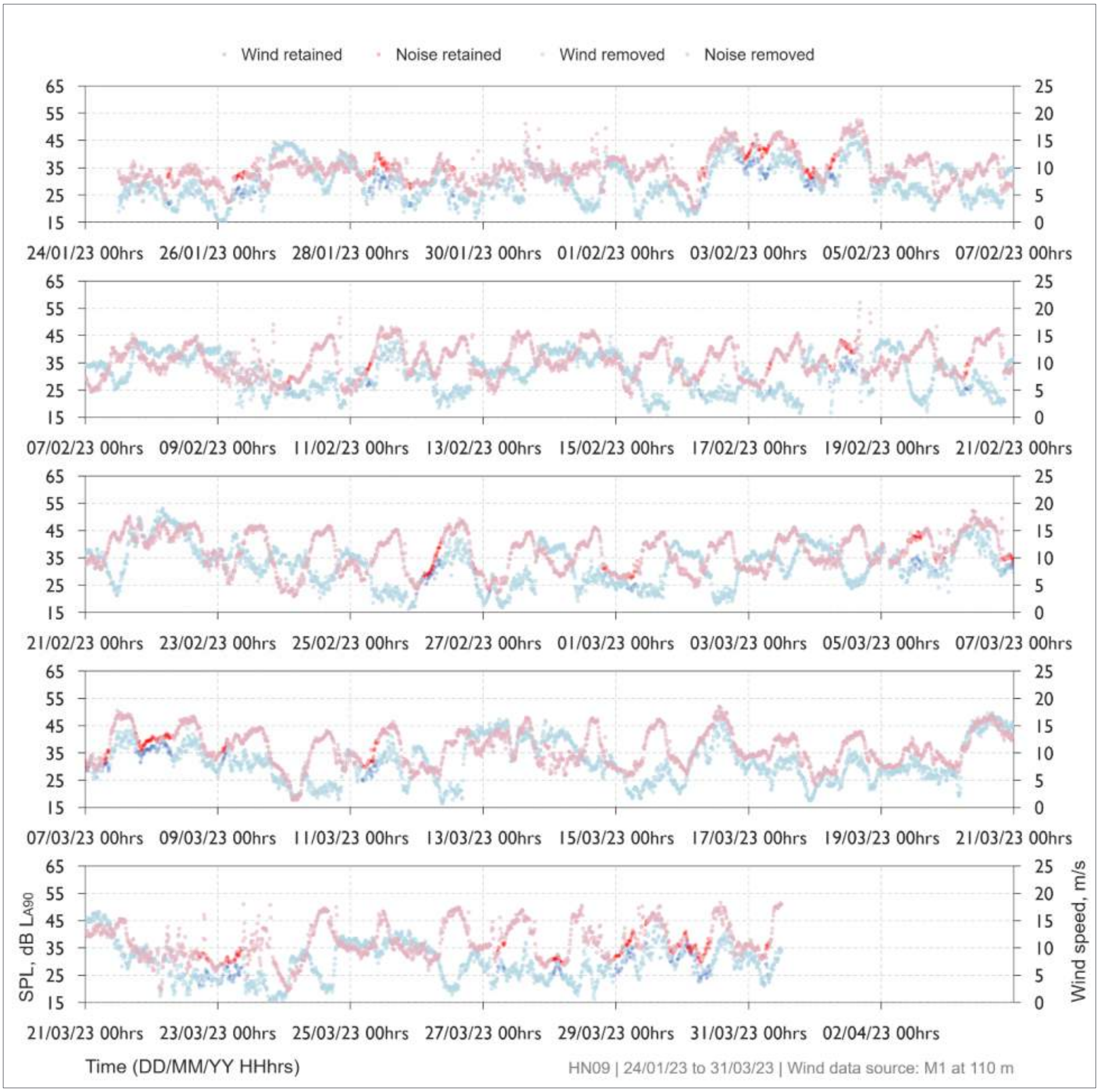
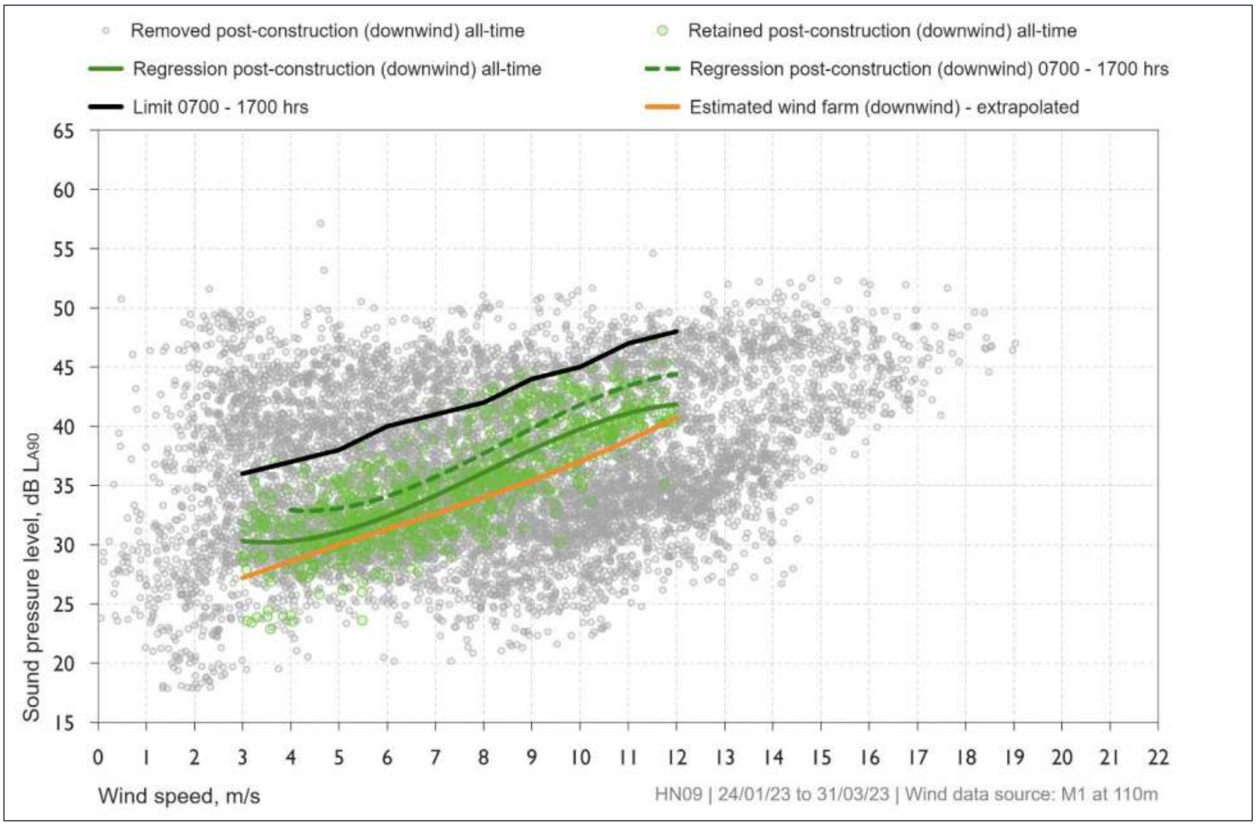


Figure 18: Receiver HN09 - post-construction A-weighted noise levels versus site wind speed



APPENDIX O RECEIVER HN12 DATA

O1 Receiver HN12 location data

Figure 19: Receiver HN12 aerial view – dwelling and noise monitor locations

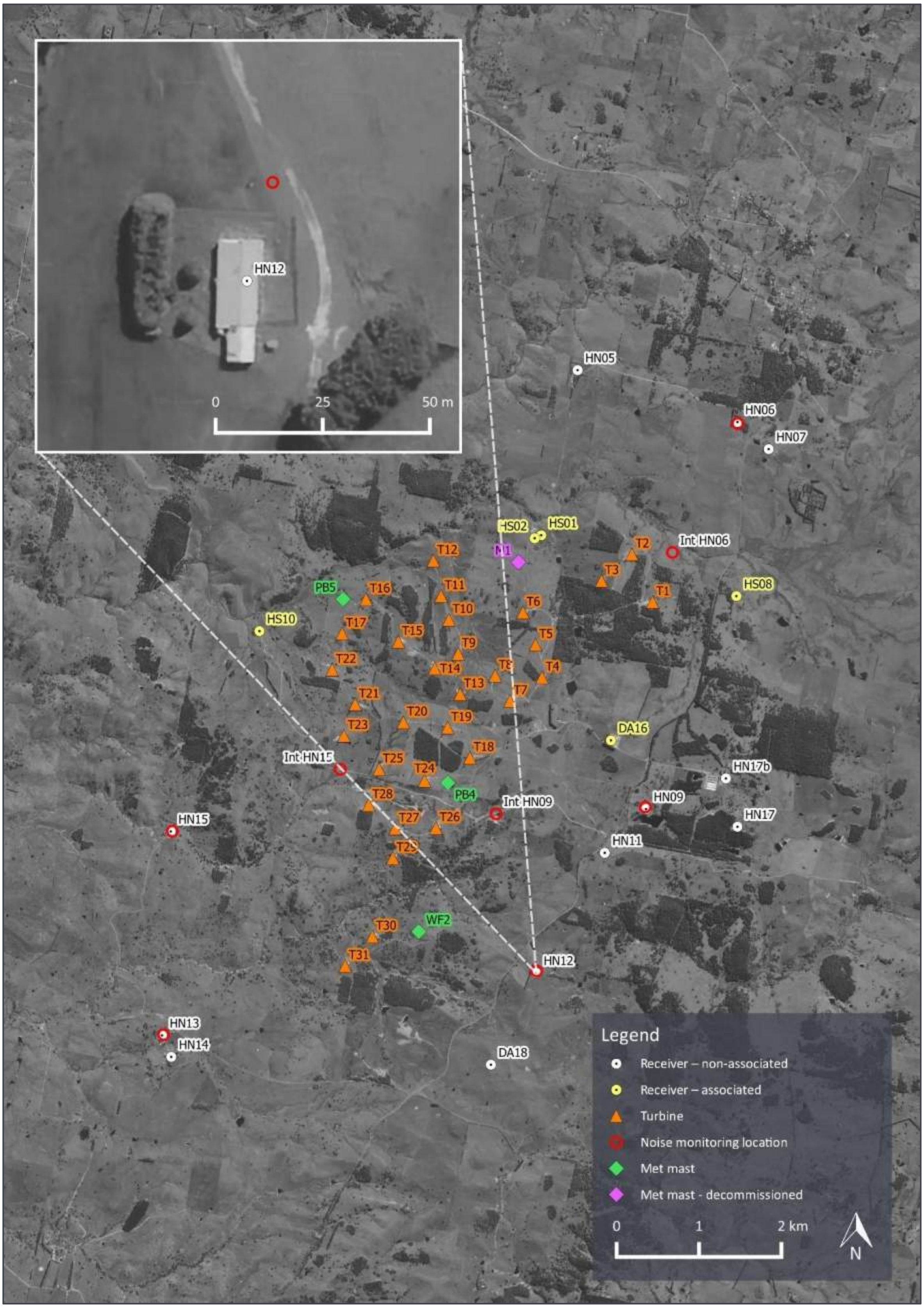


Table 45: Receiver HN12 noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	716,395	6,167,298
Noise monitoring location	716,401	6,167,321

Table 46: Receiver HN12 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

O2 Receiver HN12 measurement data summary

Table 47: Receiver HN12 noise level analysis summary

Description	Data points
Collected	9,260
Removed [1]	8,419
Retained	841

1 Removed data points due to rain, extraneous noise, atypical wind turbine operation, wind directions outside the downwind range or wind speeds outside assessment range

Figure 20: Receiver HN12 - post construction A-weighted noise level and wind speed time history

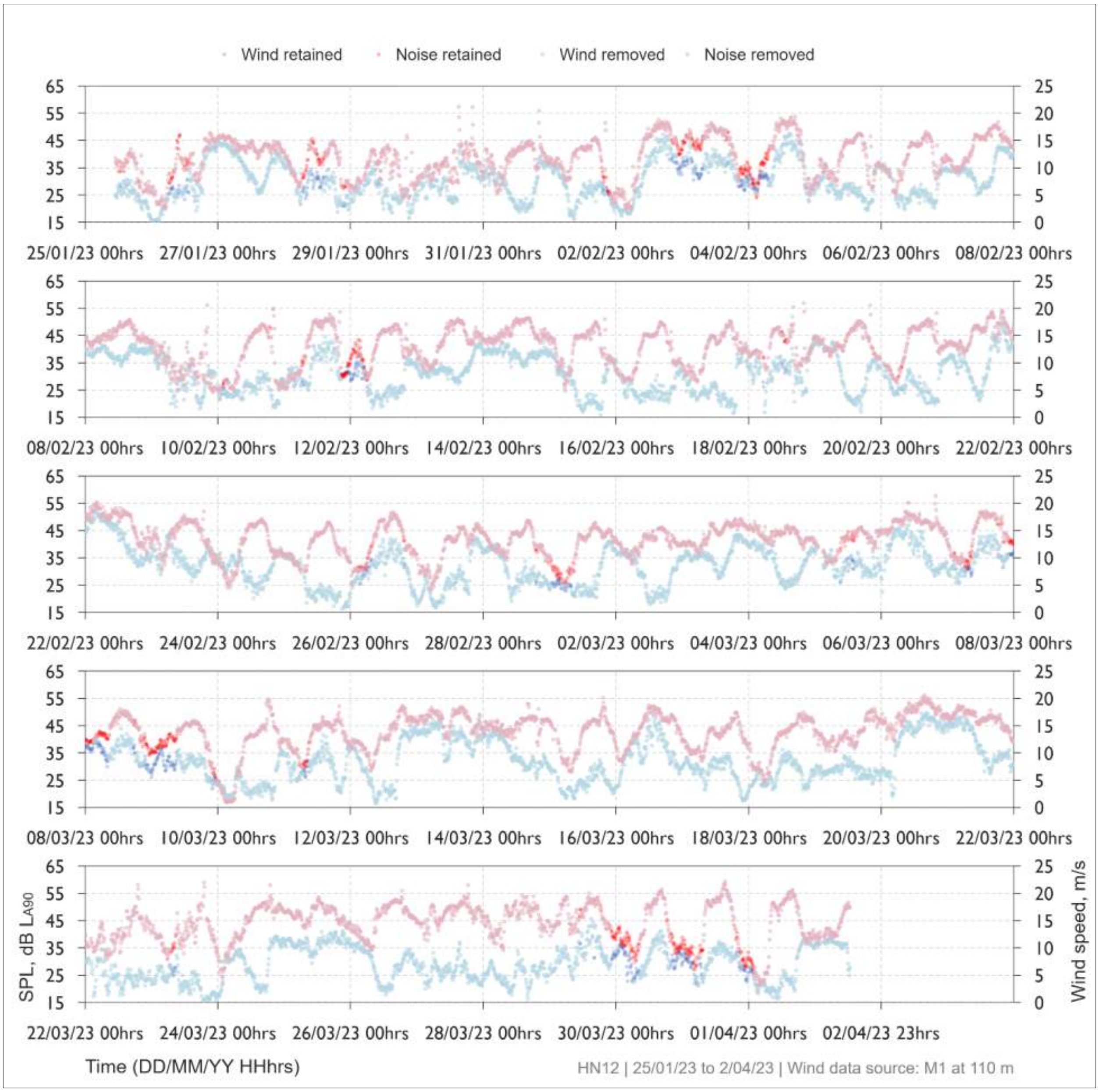
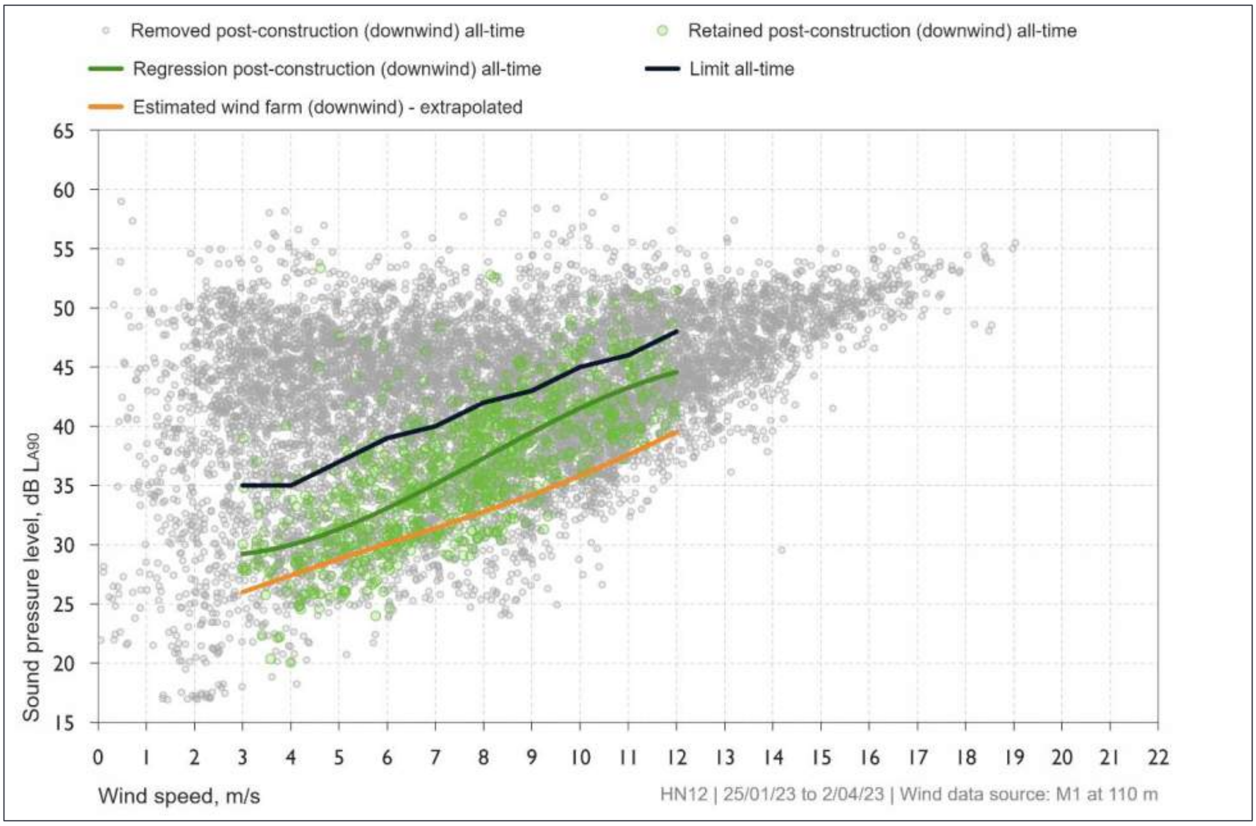


Figure 21: Receiver HN12 - post-construction A-weighted noise levels versus site wind speed



APPENDIX P RECEIVER HN13 DATA

P1 Receiver HN13 location data

Figure 22: Receiver HN13 aerial view – dwelling and noise monitor locations

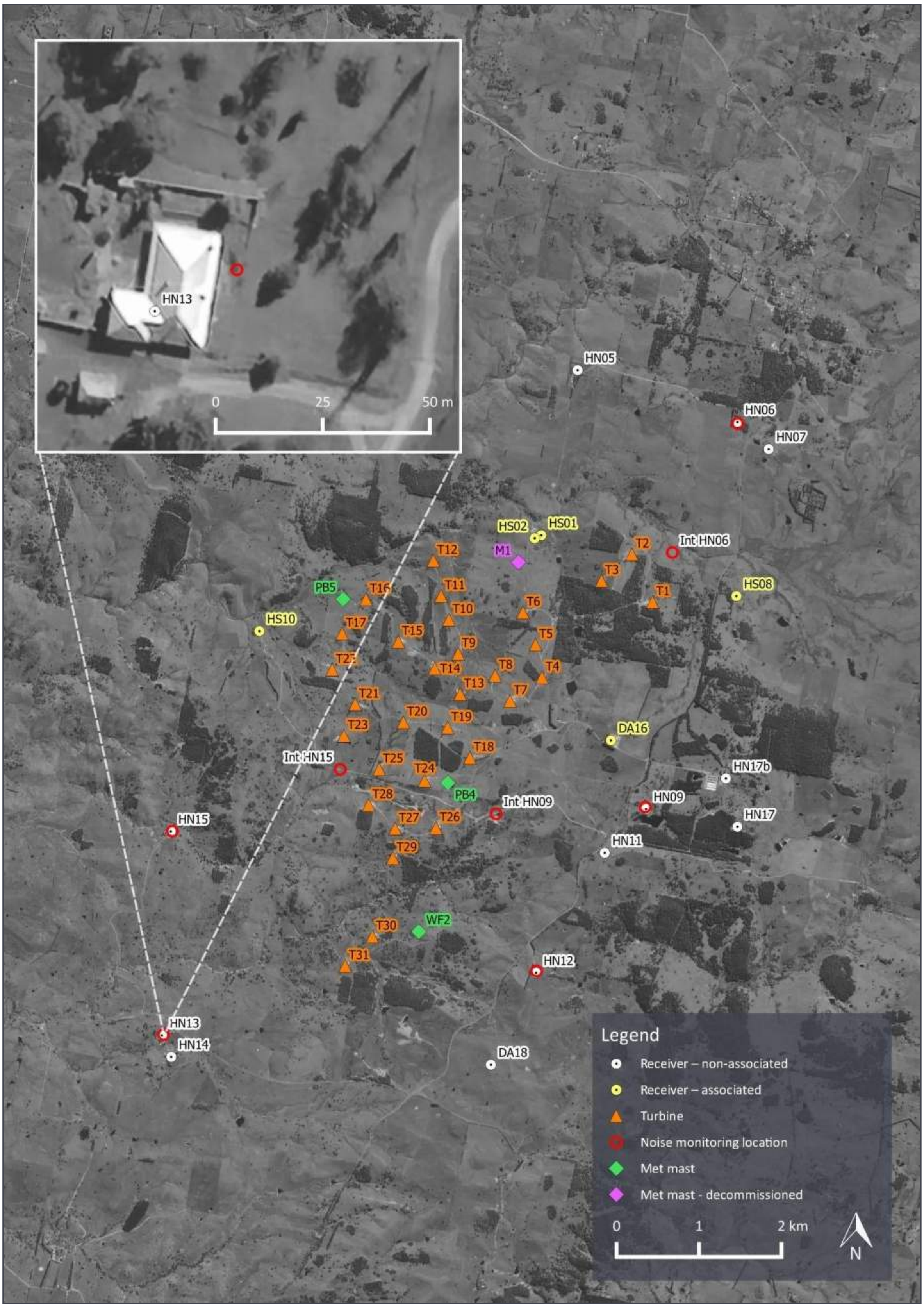


Table 48: Receiver HN13 noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	711,857	6,166,539
Noise monitoring location	711,876	6,166,549

Table 49: Receiver HN13 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

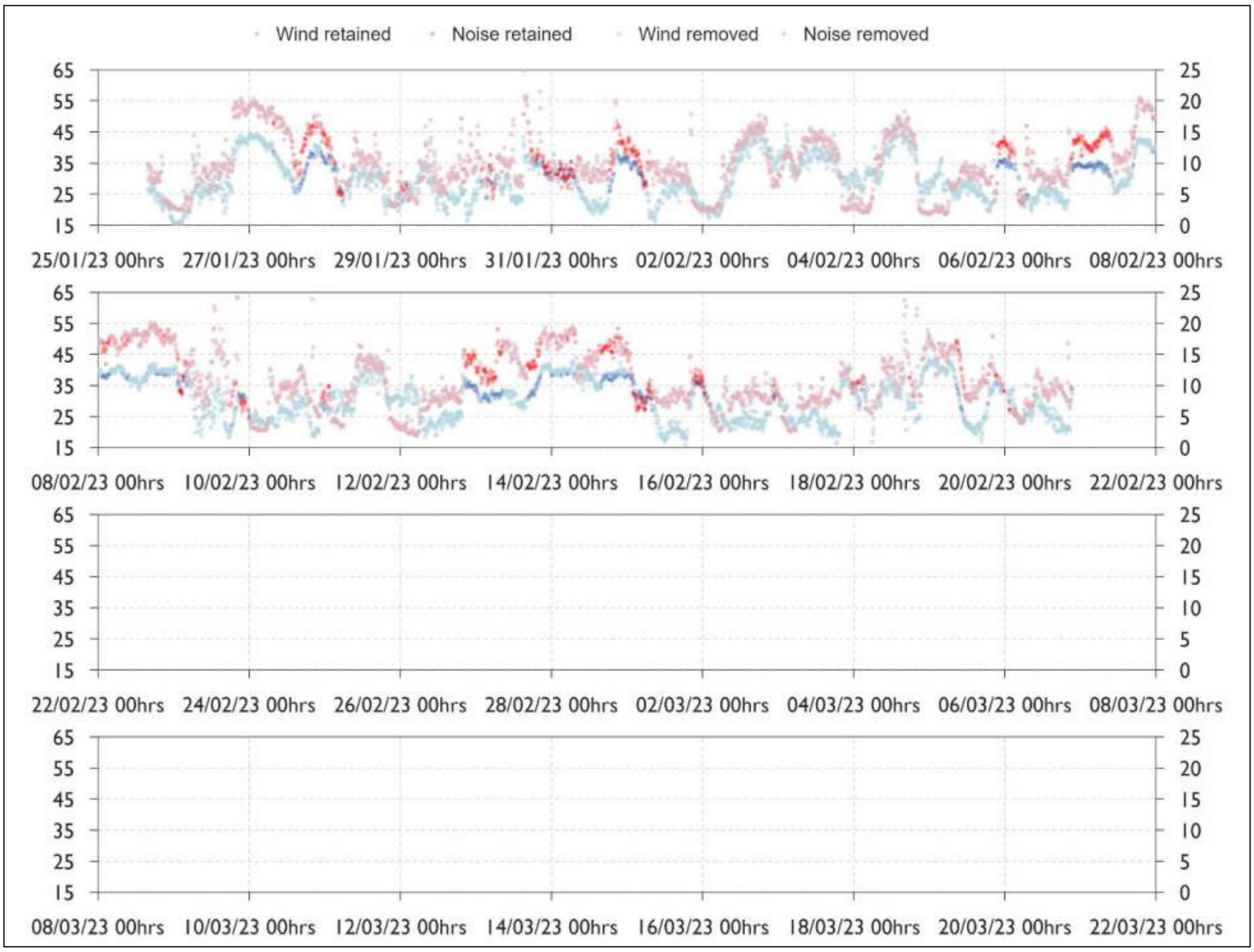
P2 Receiver HN13 measurement data summary

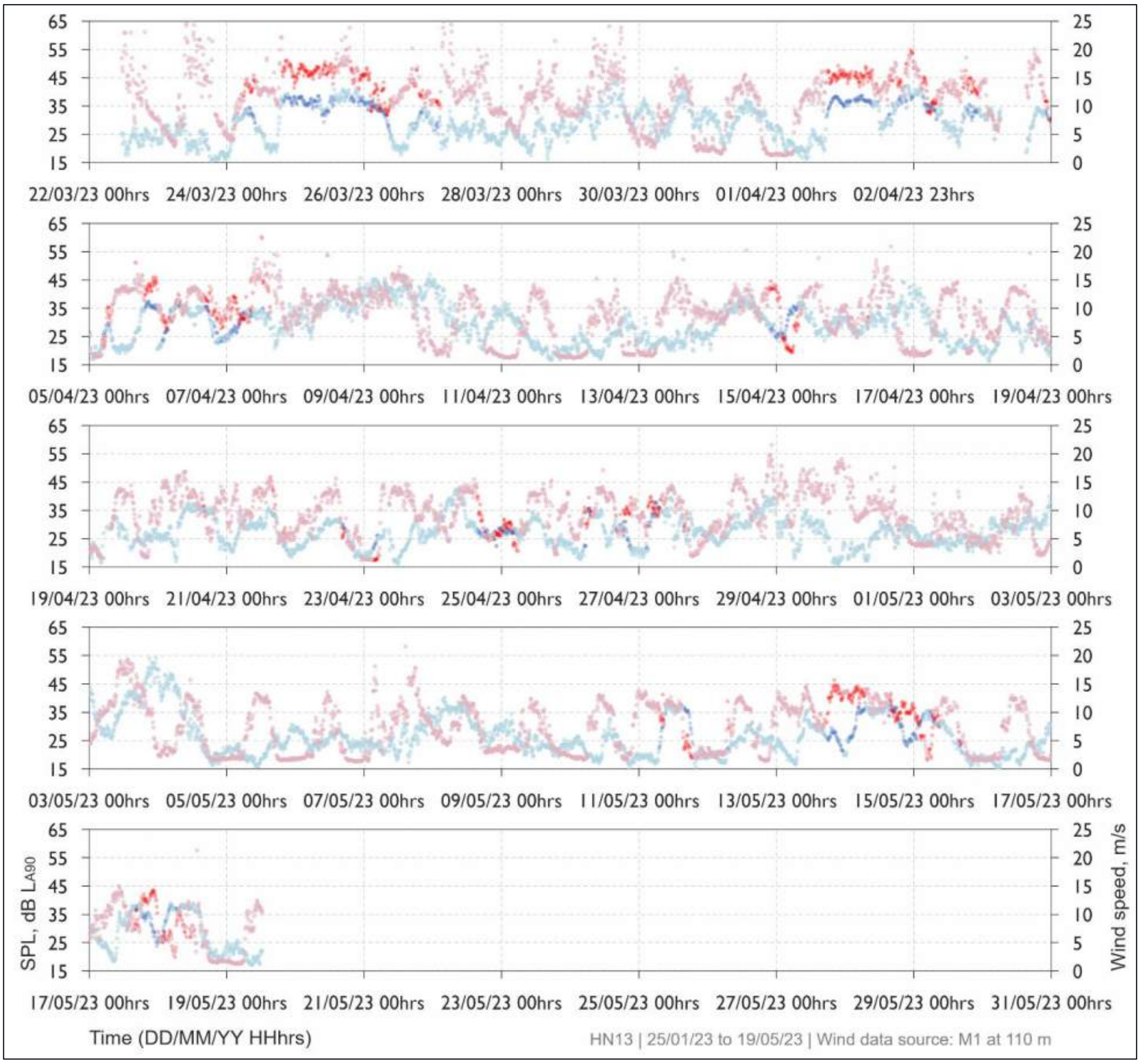
Table 50: Receiver HN13 noise level analysis summary

Description	Data points
Collected	11,547
Removed [1]	9,502
Retained	2,045

1 Removed data points due to rain, extraneous noise, atypical wind turbine operation, wind directions outside the downwind range or wind speeds outside assessment range

Figure 23: Receiver HN13 - post construction A-weighted noise level and wind speed time history




SPL, dB LA90
Wind speed, m/s
22/03/23 00hrs
24/03/23 00hrs
26/03/23 00hrs
28/03/23 00hrs
30/03/23 00hrs
01/04/23 00hrs
02/04/23 23hrs
05/04/23 00hrs
07/04/23 00hrs
09/04/23 00hrs
11/04/23 00hrs
13/04/23 00hrs
15/04/23 00hrs
17/04/23 00hrs
19/04/23 00hrs
21/04/23 00hrs
23/04/23 00hrs
25/04/23 00hrs
27/04/23 00hrs
29/04/23 00hrs
01/05/23 00hrs
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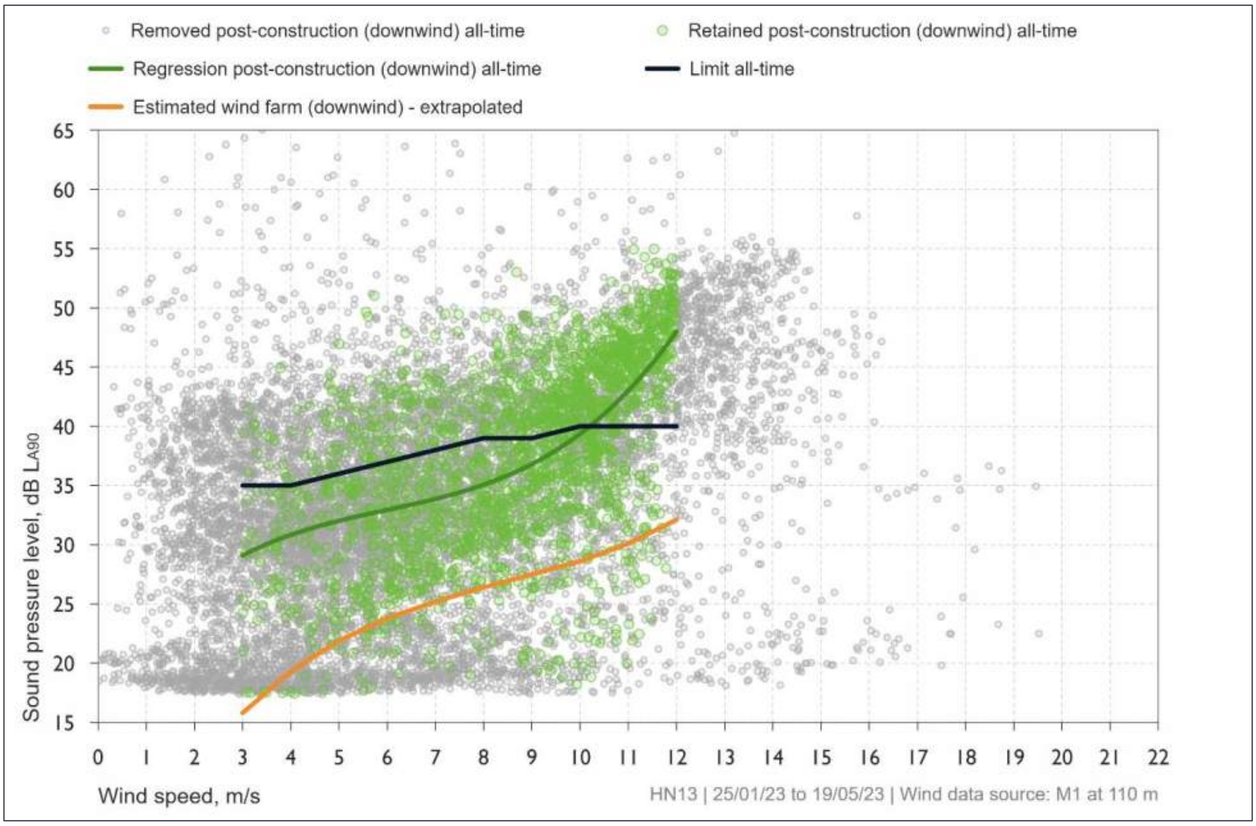
05/05/23 00hrs
07/05/23 00hrs
09/05/23 00hrs
11/05/23 00hrs
13/05/23 00hrs
15/05/23 00hrs
17/05/23 00hrs
19/05/23 00hrs
21/05/23 00hrs
23/05/23 00hrs
25/05/23 00hrs
27/05/23 00hrs
29/05/23 00hrs
31/05/23 00hrs
Time (DD/MM/YY HHhrs)
HN13 | 25/01/23 to 19/05/23 | Wind data source: M1 at 110 m

Figure 24: Receiver HN13 - post-construction A-weighted noise levels versus site wind speed



Note: Total measured noise levels show inconclusive result at wind speeds greater than 10 m/s due to the influence of background noise (see Section 5.2).

APPENDIX Q RECEIVER HN15 DATA

Q1 Receiver HN15 location data

Figure 25: Receiver HN15 aerial view – dwelling and noise monitor locations

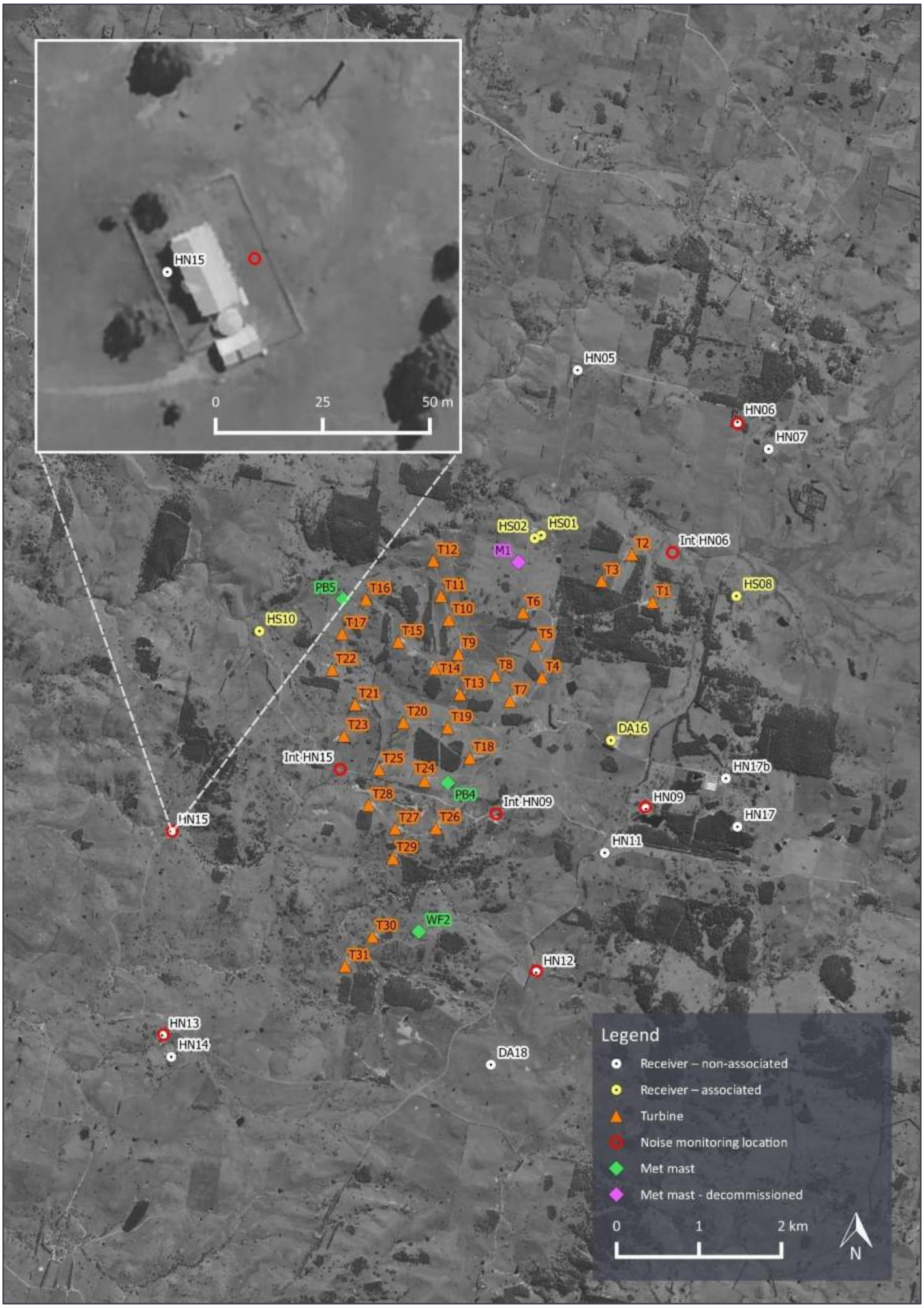


Table 51: Receiver HN15 noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	711,963	6,169,014
Noise monitoring location	711,983	6,169,017

Table 52: Receiver HN15 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

Q2 Receiver HN15 measurement data summary

Table 53: Receiver HN15 noise level analysis summary

Description	Data points
Collected	8,682
Removed [1]	7,392
Retained	1,290

1 Removed data points due to rain, extraneous noise, atypical wind turbine operation, wind directions outside the downwind range or wind speeds outside assessment range

Figure 26: Receiver HN15 - post construction A-weighted noise level and wind speed time history

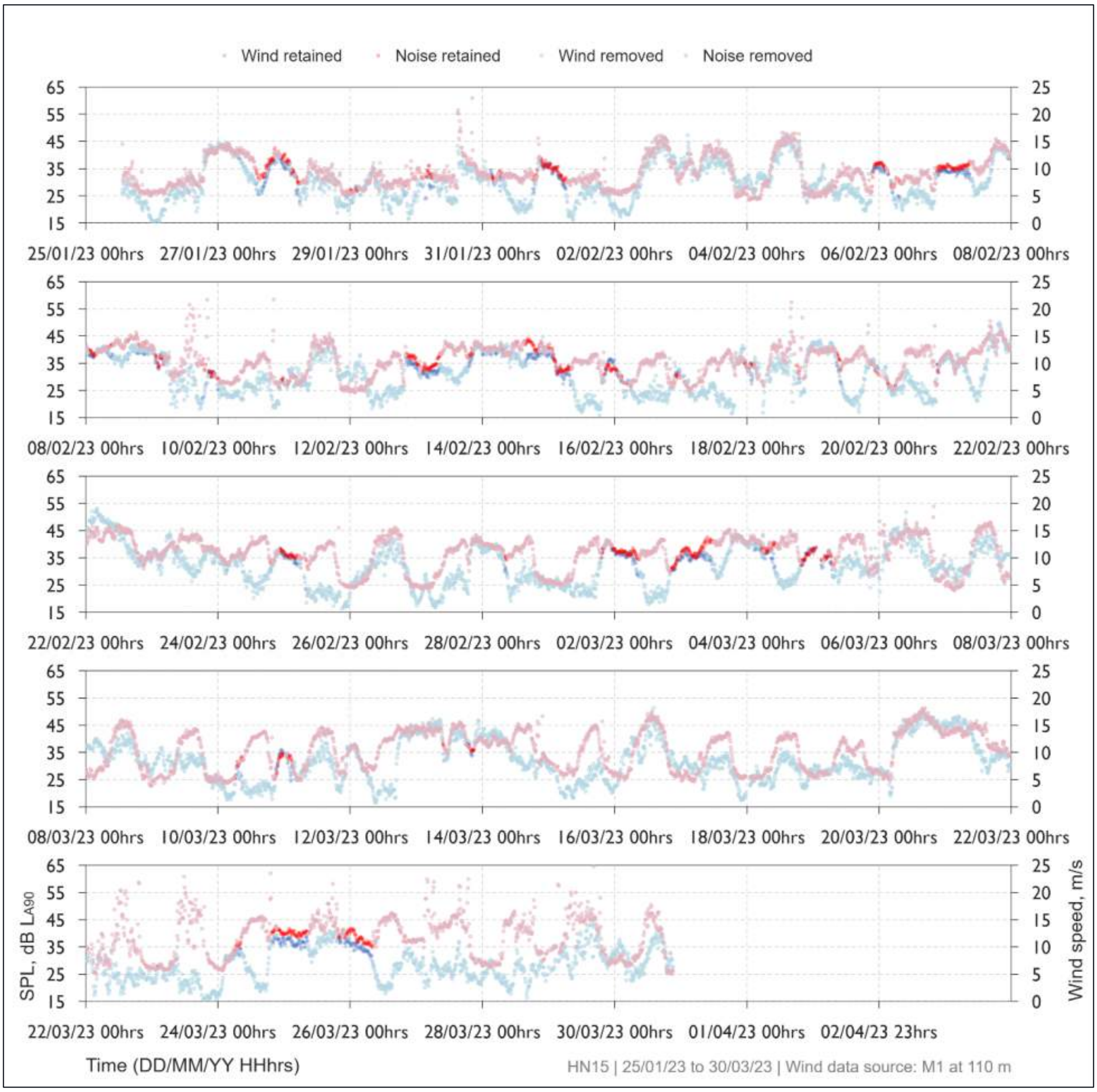
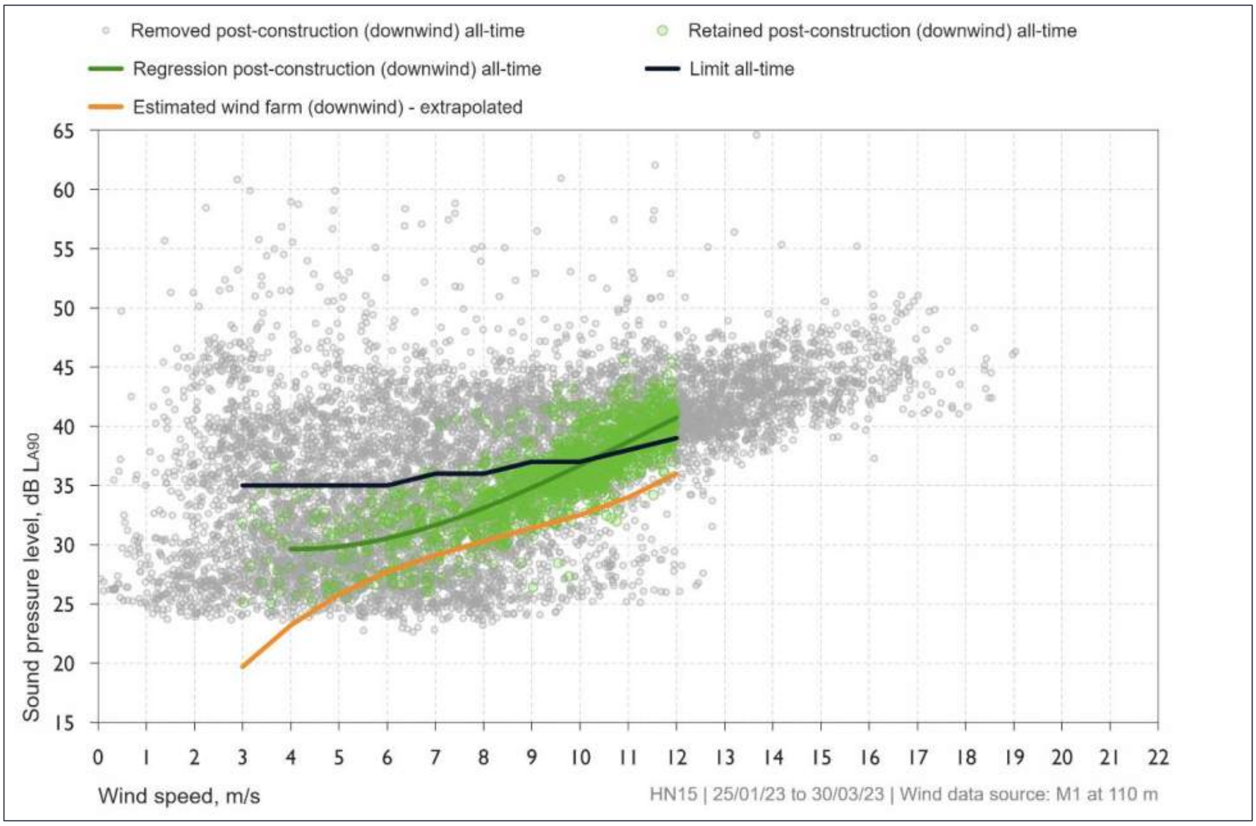


Figure 27: Receiver HN15 - post-construction A-weighted noise levels versus site wind speed



Note: Total measured noise levels show inconclusive result at wind speeds greater than 10 m/s due to the influence of background noise (see Section 5.2).

APPENDIX R INTERMEDIATE HN06 DATA

R1 Intermediate HN06 location data

Figure 28: Intermediate HN06 aerial view

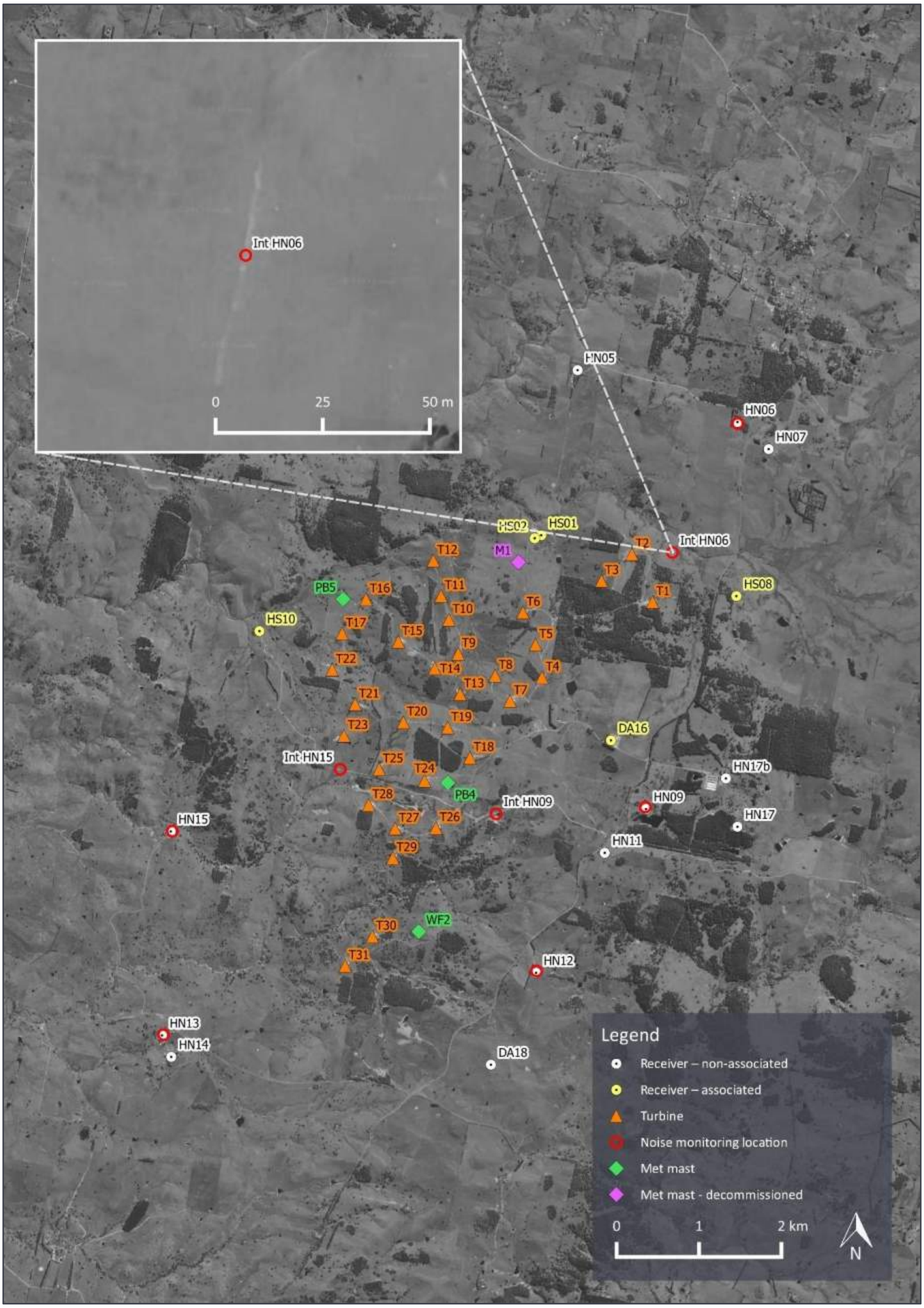


Table 54: Intermediate HN06 noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	718,838	6,173,981
Noise monitoring location	718,049	6,172,398

Table 55: Intermediate HN06 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

R2 Intermediate HN06 measurement data summary

Table 56: Intermediate HN06 noise level analysis summary

Description	Data points
Collected	9,341
Removed [1]	8,097
Retained	1,244

1 Removed data points due to rain, extraneous noise, atypical wind turbine operation, wind directions outside the downwind range or wind speeds outside assessment range

Figure 29: Intermediate HN06 - post construction A-weighted noise level and wind speed time history

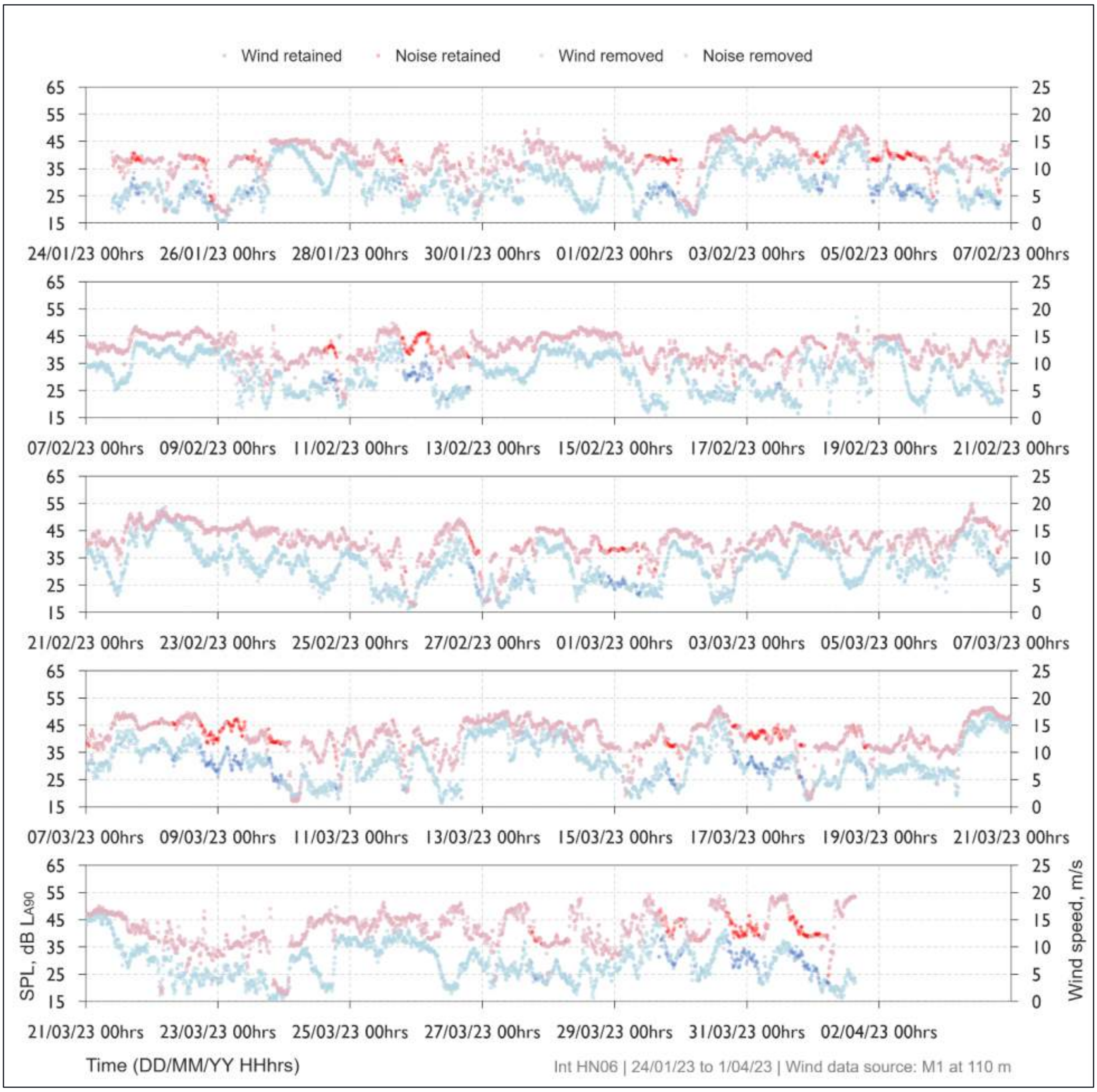
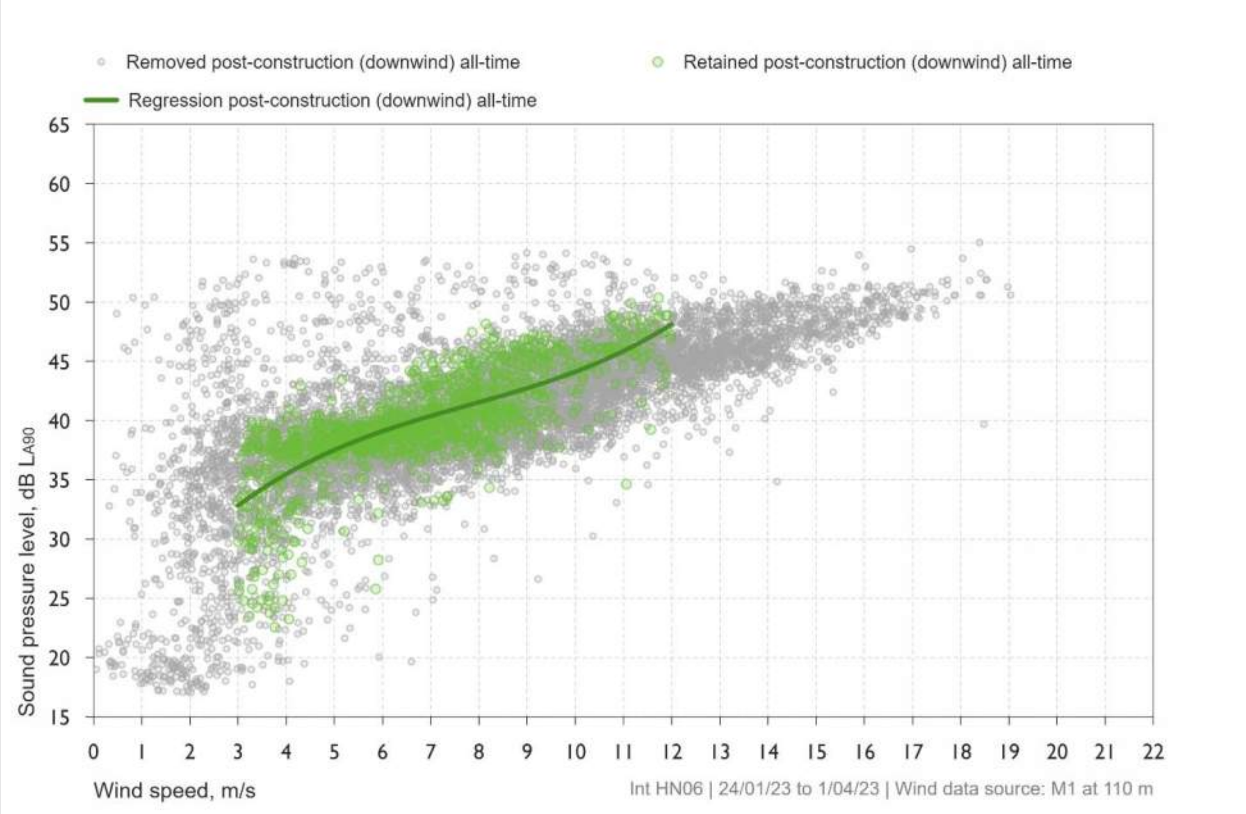


Figure 30: Intermediate HN06 - post-construction A-weighted noise levels versus site wind speed



APPENDIX S INTERMEDIATE HN09 DATA

S1 Intermediate HN09 location data

Figure 31: Intermediate HN09 aerial view

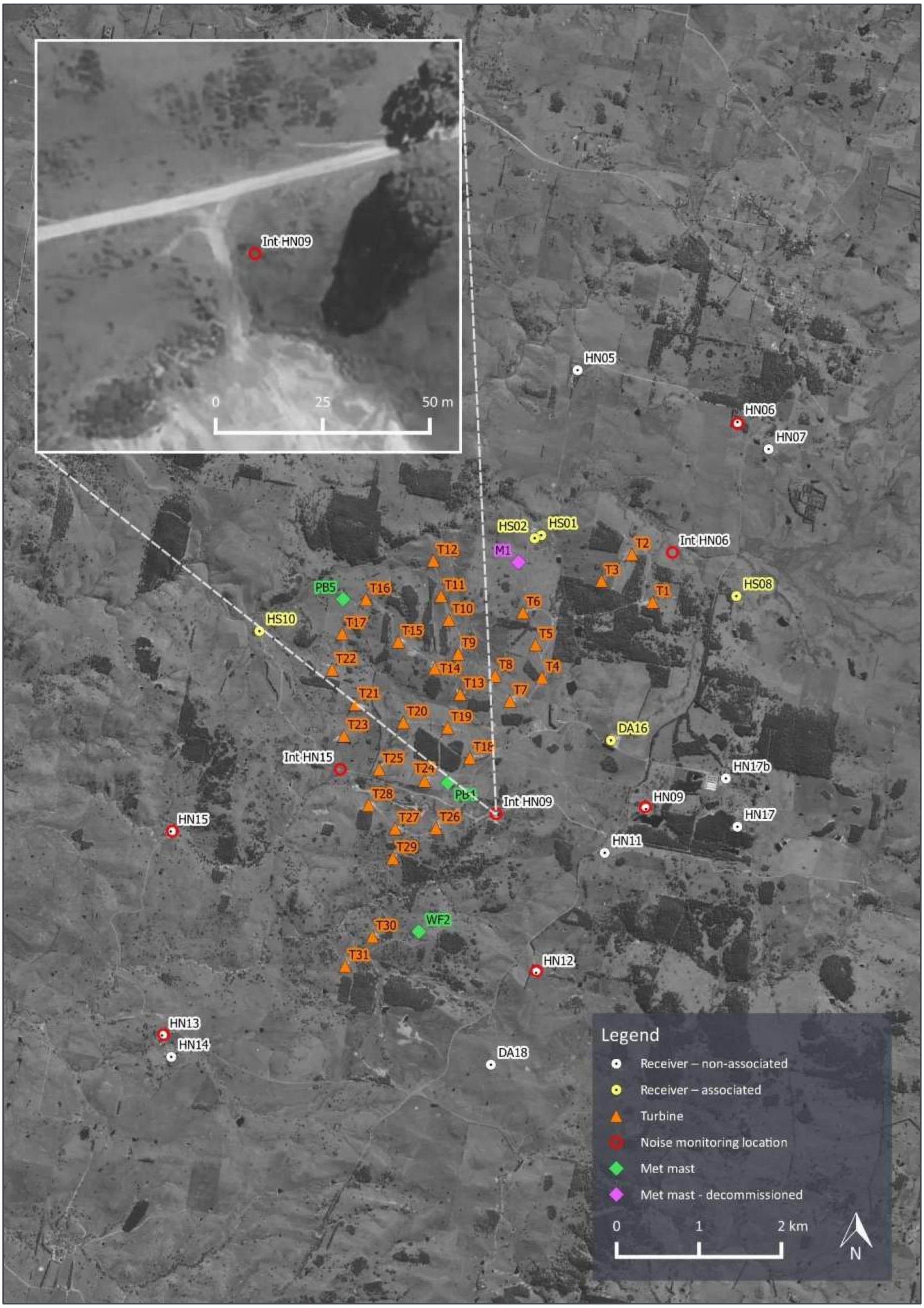
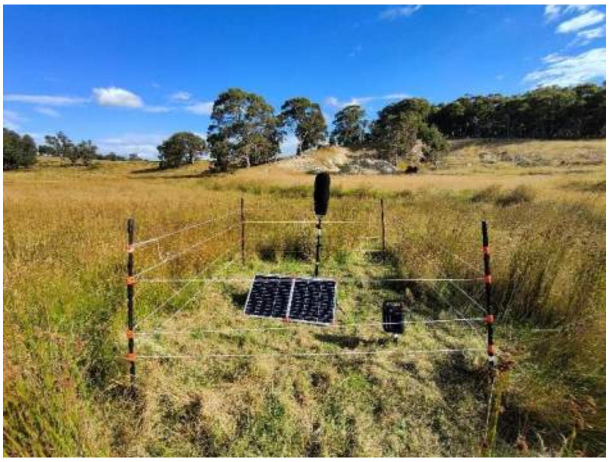


Table 57: Intermediate HN09 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	717,729	6,169,285
Noise monitoring location	715,910	6,169,227

Table 58: Intermediate HN09 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

S2 Intermediate HN09 measurement data summary

Table 59: Intermediate HN09 noise level analysis summary

Description	Data points
Collected	7,717
Removed [1]	6,402
Retained	1,315

1 Removed data points due to rain, extraneous noise, atypical wind turbine operation, wind directions outside the downwind range or wind speeds outside assessment range

Figure 32: Intermediate HN09 post construction A-weighted noise level and wind speed time history

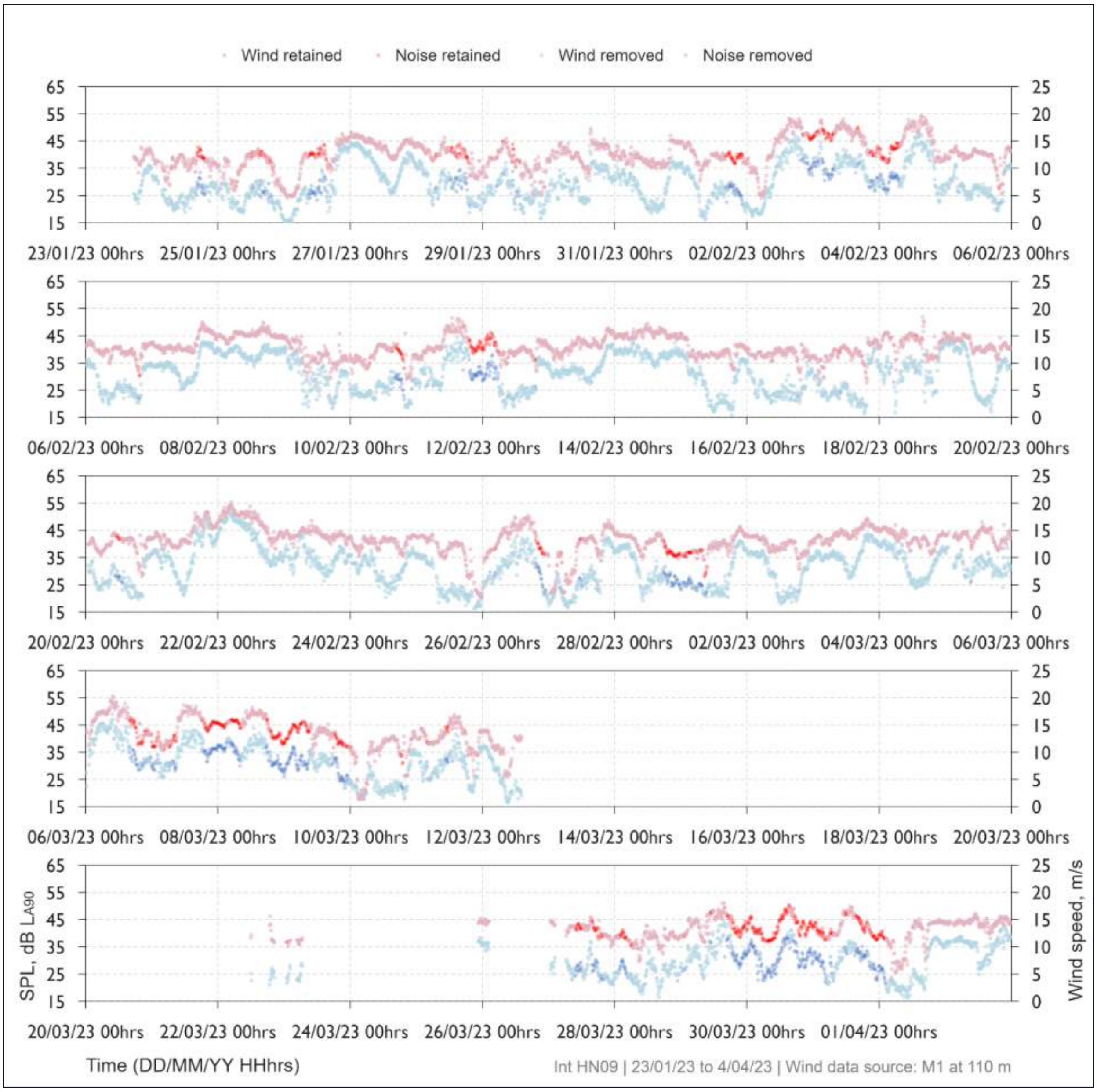
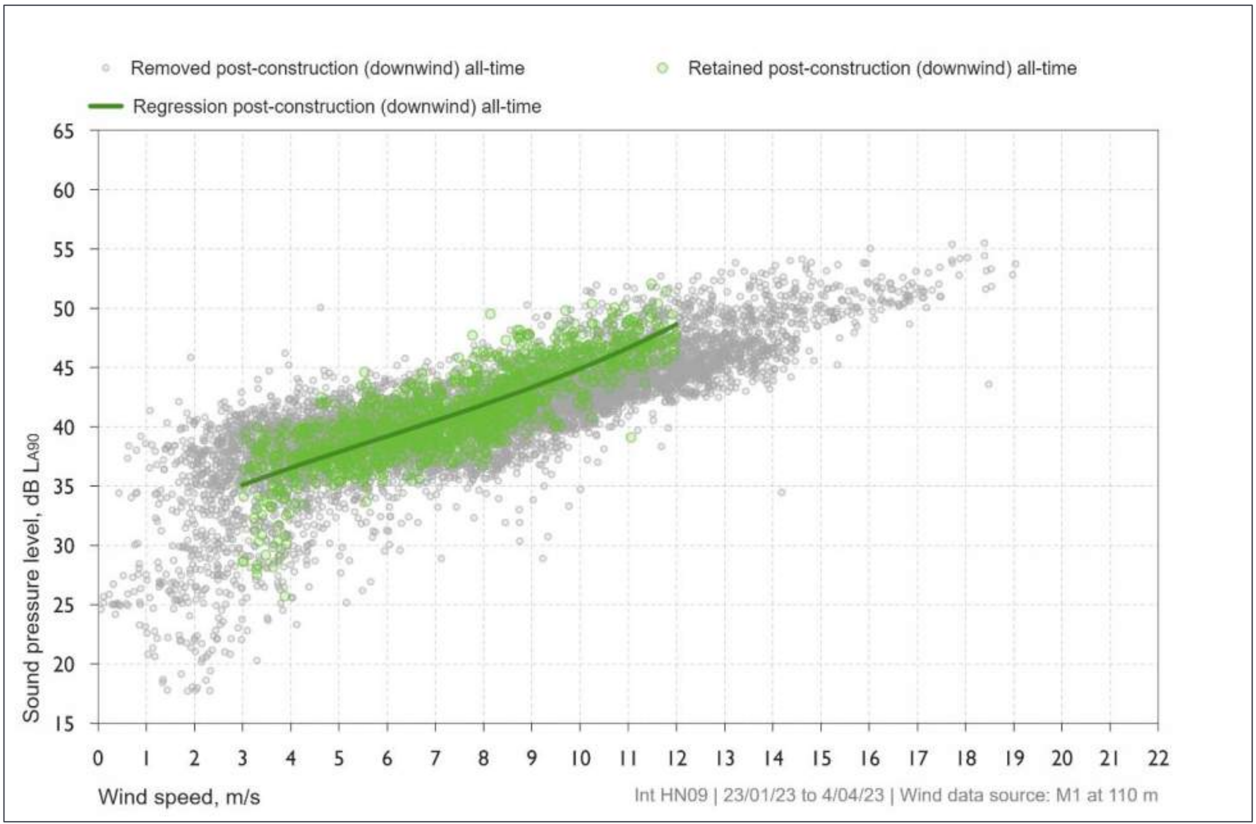


Figure 33: Intermediate HN09 - post-construction A-weighted noise levels versus site wind speed



APPENDIX T INTERMEDIATE HN15 DATA

T1 Intermediate HN15 location data

Figure 34: Intermediate HN15 aerial view

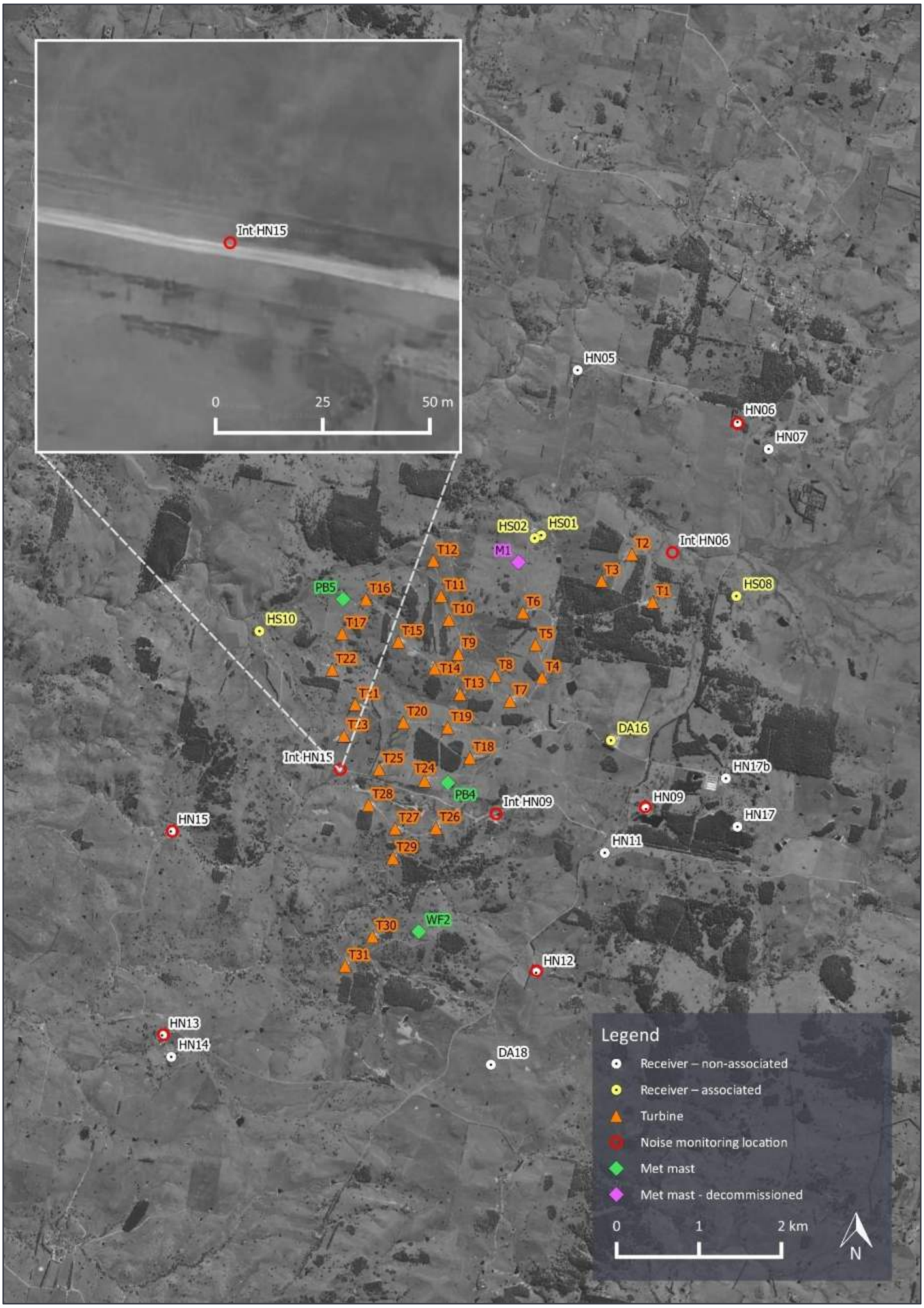


Table 60: Intermediate HN15 dwelling and noise monitor coordinates – MGA 94 Zone 55

Location	Easting, m	Northing, m
Dwelling location	711,963	6,169,014
Noise monitoring location	714,020	6,169,768

Table 61: Intermediate HN15 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

T2 Intermediate HN15 measurement data summary

Table 62: Intermediate HN15 noise level analysis summary

Description	Data points
Collected	8,756
Removed [1]	7,404
Retained	1,352

1 Removed data points due to rain, extraneous noise, atypical wind turbine operation, wind directions outside the downwind range or wind speeds outside assessment range

Figure 35: Intermediate HN15 post construction A-weighted noise level and wind speed time history

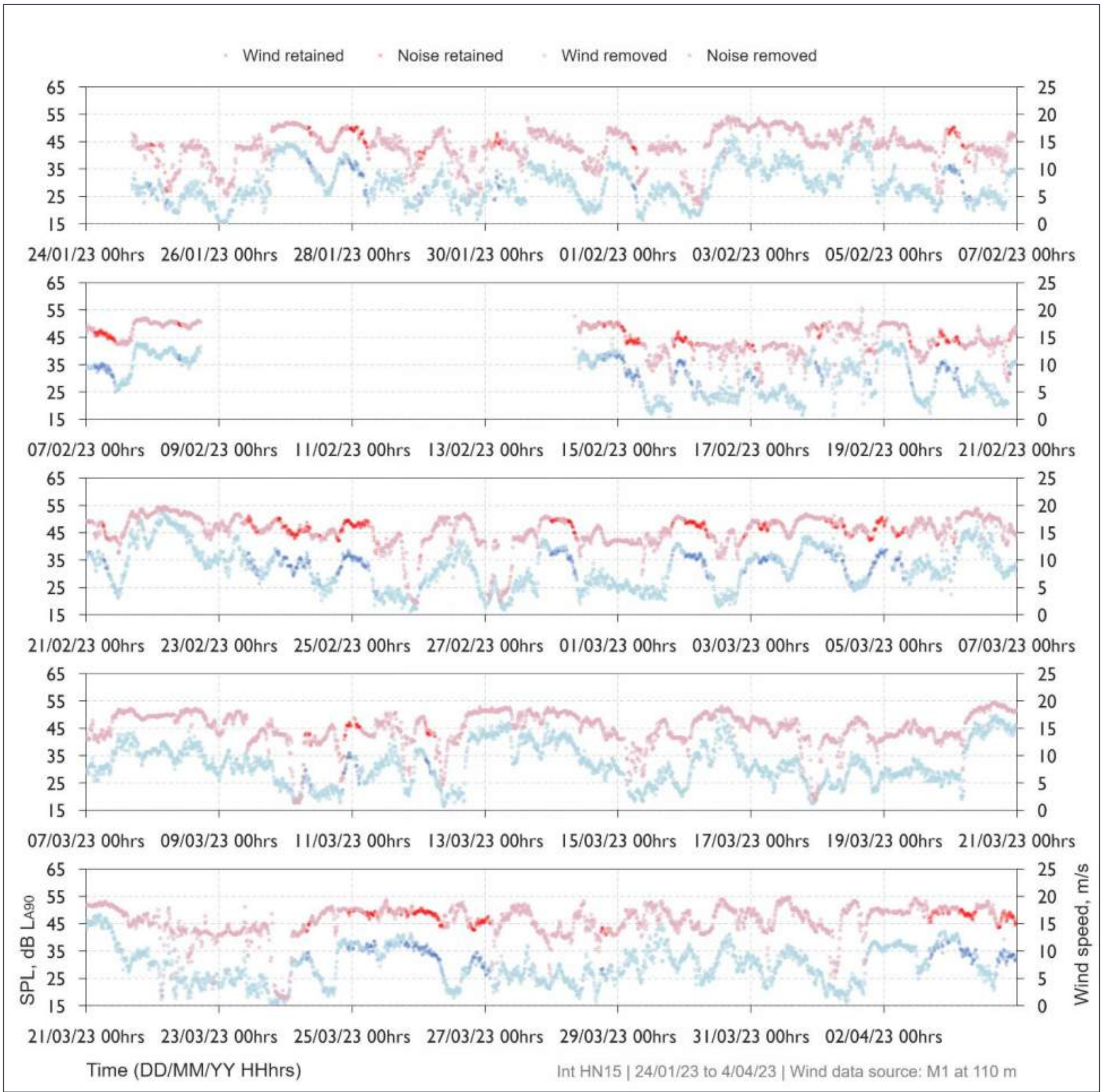
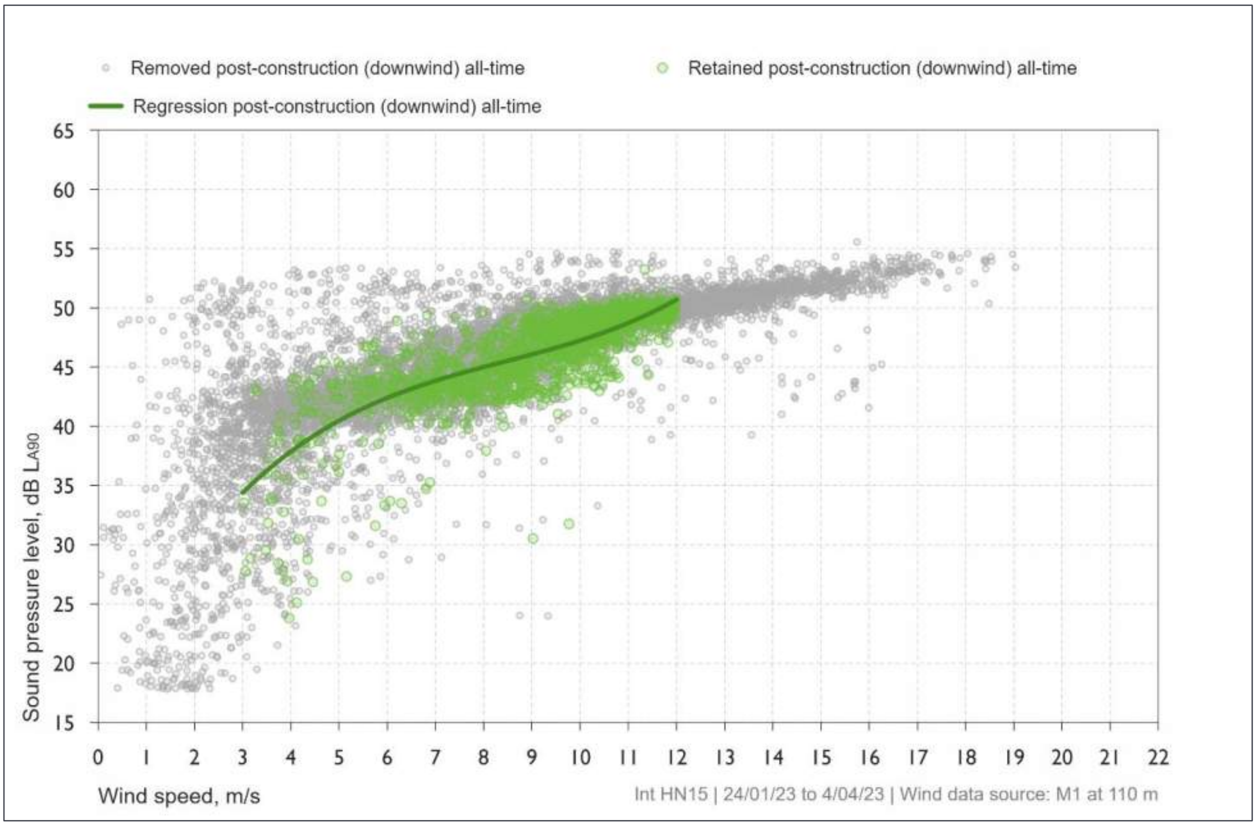


Figure 36: Intermediate HN15 - post-construction A-weighted noise levels versus site wind speed



APPENDIX U EQUIPMENT CALIBRATION CERTIFICATES

Figure 37: HN06 - 01dB DUO 10196 calibration certificate

CALIBRE TECHNOLOGY

THE CALIBRE TECHNOLOGY

ACOUSTIC & VIBRATION CALIBRATION CENTRE

CERTIFICATE OF CALIBRATION

Certificate Number: 4406

NATA Accreditation No: 20688

Customer: **Marshall Day Acoustics**
6 Gipps Street
Collingwood, VIC 3066

Test Object:	Manufacturer:	Model:	Serial No:	ID:
Sound Level Meter	01dB	Duo	10196	4406
Microphone	GRAS	GRAS40CD	331724	4406
Preamplifier	01dB	Included	10196	4406
Calibrator	None	-	-	-
Connecting Cable	None	-	-	-

Information:

Test Configuration:	Microphone on Preamp
Instrument Manual:	01dB Duo User Manual
Firmware Version:	V2.45
Class of Instrument:	Class 1
Source of Correction Data:	01dB and GRAS

Environmental Conditions:	Pressure	Temperature	Relative Humidity
Reference Conditions:	101.325 kPa	23.0 °C	50.0 % RH
Conditions Before Measurement:	102.45 kPa	22.9 °C	47.2 % RH
Conditions After Measurement:	102.37 kPa	24.6 °C	44.1 % RH

The laboratory environmental conditions remained within the acceptable limits as defined in IEC 61672.3 and IEC 61260 throughout the calibration test.

The measurements are performed according to the *IEC 61672 Sound level meters – Part 3: Periodic tests (2013)*, and *DIN 45657 Sound Level Meters – Requirements for Special Applications (2015)*. Where applicable testing has also been completed in accordance with *IEC 61260 Electroacoustics – Octave-band and fractional-octave-band filters (2016)*.

The expanded uncertainty of measurement is reported at approximately 95% confidence level with a coverage factor k, of 2.

Accredited for compliance with ISO/IEC 17025 - Calibration.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports

Date of Calibration: 22/06/21
Date of Issue: 23/06/21
Authorised Signatory:

Claire Richardson

Unit 2, 4 Tombo Street, Capalaba, QLD 4157
07 3245 1730
enquiries@calibretechnology.com.au
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NATA WORLD RECOGNISED ACCREDITATION No. 20688

Figure 38: HN09 - 01dB DUO 10417 calibration certificate

THE CALIBRE TECHNOLOGY

ACOUSTIC & VIBRATION CALIBRATION CENTRE

CERTIFICATE OF CALIBRATION

Certificate Number: 5000 **NATA Accreditation No: 20688**

Customer: **Marshall Day Acoustics**
6 Gipps Street
Collingwood, VIC 3066

Test Object:	**Manufacturer:**	**Model:**	**Serial No:**	**ID:**
Sound Level Meter	01dB	Duo	10417	5000
Microphone	GRAS	GRAS40CD	144861	5000
Preamplifier	01dB-Stell	Included	10417	5000
Calibrator	None	-	-	-
Connecting Cable	None	-	-	-

Information:

Test Configuration:	Microphone on Preamp
Instrument Manual:	01dB Duo User Manual
Firmware Version:	2.60
Class of Instrument:	Class 1
Source of Correction Data:	01dB and GRAS
Reference Level:	94 dB
Reference Level Range:	50 - 135 dB

Environmental Conditions:	**Pressure**	**Temperature**	**Relative Humidity**
Reference Conditions:	101.325 kPa	23.0 °C	50.0 % RH
Conditions Before Measurement:	101.60 kPa	24.5 °C	60.8 % RH
Conditions After Measurement:	101.25 kPa	22.4 °C	50.1 % RH

The laboratory environmental conditions remained within the acceptable limits as defined in IEC 61672.3 and IEC 61260 throughout the calibration test.

The measurements are performed according to the *IEC 61672 Sound level meters – Part 3: Periodic tests (2013)*, and *DIN 45657 Sound Level Meters – Requirements for Special Applications (2015)*. Where applicable testing has also been completed in accordance with *IEC 61260 Electroacoustics – Octave-band and fractional-octave-band filters (2016)*.

This certificate only relates to the test object calibrated. This certificate shall only be reproduced in full with the permission of Calibre Technology.

Accredited for compliance with ISO/IEC 17025 - Calibration.
The results of the tests, calibrations and/or measurements included in this document are traceable to the International System of Units (SI) via international or Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports.

Date of Calibration: 17/02/22
Date of Issue: 17/02/22
Authorised Signatory:

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NATA WORLD RECOGNISED ACCREDITATION No. 20688

Figure 39: HN12 - 01dB DUO 10497 calibration certificate

Ecotech
ACOEM Group

Doc ID: EMS 1403
Rev Date: 5/11/18

Calibration Report

TR-REP-10585.xls

ISSUED FOR : MARSHALL DAY ACOUSTICS
6 Gipps Street
Collingwood

3066 VIC
Australia

Name and location of the laboratory of tests:
Ecotech - 1492 Ferntree Gully Road, Knoxfield VIC 3180- Australia

TESTED INSTRUMENT

Designation :	Integrator Sound Level Meter		
Manufacturer :	01dB		
Type :	DUO	Serial number :	10497
		Identification number :	903413
		SWR :	25553
		Date of issue :	15/07/2022

This report includes 10 pages

The measurements are performed according to the IEC 61672-3, Electroacoustics, - Sound level meters – Part 3: Periodic tests.

REPORT APPROVED BY

Leigh Seymour

Authorised Signatory

X

ECOTECH Pty Ltd 1492 Ferntree Gully Road Knoxfield VIC 3180 Melbourne Australia ABN 32 005 752 081
+61 (0)3 9730 7800 email@ecotech.com ecotech.com
01dB ECOTECH METRAVIB ONEPROD FIXTURLASER MEAX brands of ACOEM Group

Figure 40: HN13 - 01dB DUO 10496 calibration certificate

THE CALIBRE TECHNOLOGY
ACOUSTIC & VIBRATION CALIBRATION CENTRE

CERTIFICATE OF CALIBRATION

Certificate Number: 5486 **NATA Accreditation No: 20688**

Customer: **Marshall Day**
6 Gipps Street
Collingwood, VIC 3066

Test Object:	Manufacturer:	Model:	Serial No:	ID:
Sound Level Meter	01dB	Duo	10496	5486
Microphone	GRAS	GRAS40CD	141230	5486
Preamplifier	01dB	Included	10496	5486
Calibrator	None	-	-	-
Connecting Cable	None	-	-	-

Information:

Test Configuration:	Microphone on Preamp
Instrument Manual:	Duo Smart Noise Monitor Manual DOC1112
Firmware Version:	V2.72
Class of Instrument:	Class 1
Source of Correction Data:	01dB
Reference Level:	94 dB
Reference Level Range:	50 - 135 dB

Environmental Conditions:	Pressure	Temperature	Relative Humidity
Reference Conditions:	101.325 kPa	23.0 °C	50.0 % RH
Conditions Before Measurement:	101.84 kPa	24.6 °C	33.8 % RH
Conditions After Measurement:	101.53 kPa	24.8 °C	34.5 % RH

The laboratory environmental conditions remained within the acceptable limits as defined in IEC 61672.3 and IEC 61260 throughout the calibration test.

The measurements are performed according to the *IEC 61672 Sound level meters – Part 3: Periodic tests (2013)*, and *DIN 45657 Sound Level Meters – Requirements for Special Applications (2015)*. Where applicable testing has also been completed in accordance with *IEC 61260 Electroacoustics – Octave-band and fractional-octave-band filters (2016)*.

This certificate only relates to the test object calibrated. This certificate shall only be reproduced in full with the permission of Calibre Technology.

Accredited for compliance with ISO/IEC 17025 - Calibration.
The results of the tests, calibrations and/or measurements included in this document are traceable to the International System of Units (SI) via international or Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports.

Date of Calibration: 28/07/22
Date of Issue: 29/07/22
Authorised Signatory:

Claire Richardson

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Figure 41: HN13 - 01dB DUO 10498 calibration certificate

THE CALIBRE TECHNOLOGY
ACOUSTIC & VIBRATION CALIBRATION CENTRE

CERTIFICATE OF CALIBRATION

Certificate Number: 5516

NATA Accreditation No: 20688

Customer: **Marshall Day Acoustics**
6 Gipps Street
Collingwood, VIC 3066

Test Object:	Manufacturer:	Model:	Serial No:	ID:
Sound Level Meter	01dB	DUO	10498	5516
Microphone	GRAS	GRAS40CD	207226	5516
Preamplifier	01dB	Included	10498	5516
Calibrator	None	-	-	-
Connecting Cable	None	-	-	-

Information:

Test Configuration:	Microphone on Preamp
Instrument Manual:	Duo Smart Noise Monitor Manual DOC1112
Firmware Version:	V2.72
Class of Instrument:	Class 1
Source of Correction Data:	01dB
Reference Level:	94 dB
Reference Level Range:	50 - 135 dB

Environmental Conditions:	Pressure	Temperature	Relative Humidity
Reference Conditions:	101.325 kPa	23.0 °C	50.0 % RH
Conditions Before Measurement:	101.93 kPa	24.0 °C	00.0 % RH
Conditions After Measurement:	101.93 kPa	24.0 °C	00.0 % RH

The laboratory environmental conditions remained within the acceptable limits as defined in IEC 61672.3 and IEC 61260 throughout the calibration test.

The measurements are performed according to the *IEC 61672 Sound level meters – Part 3: Periodic tests (2013)*, and *DIN 45657 Sound Level Meters – Requirements for Special Applications (2015)*. Where applicable testing has also been completed in accordance with *IEC 61260 Electroacoustics – Octave-band and fractional-octave-band filters (2016)*.

This certificate only relates to the test object calibrated. This certificate shall only be reproduced in full with the permission of Calibre Technology.

Accredited for compliance with ISO/IEC 17025 - Calibration.
The results of the tests, calibrations and/or measurements included in this document are traceable to the International System of Units (SI) via international or Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports.

Date of Calibration: 03/08/22
Date of Issue: 04/08/22
Authorised Signatory:

Claire Richardson

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NATA WORLD RECOGNISED ACCREDITATION No. 20688

Figure 42: HN15 - 01dB DUO 10770 calibration certificate

THE CALIBRE TECHNOLOGY
ACOUSTIC & VIBRATION CALIBRATION CENTRE

CERTIFICATE OF CALIBRATION

Certificate Number: 4740 **NATA Accreditation No: 20688**

Customer: **Marshall Day Acoustics**
6 Gipps Street
Collingwood, VIC 3066

Test Object:	Manufacturer:	Model:	Serial No:	ID:
Sound Level Meter	01dB	Duo	10770	4740
Microphone	GRAS	GRAS40CD	162058	4740
Preamplifier	01dB	Included	10770	4740
Calibrator	None	-	-	-
Connecting Cable	None	-	-	-

Information:

Test Configuration:	Microphone on Preamp
Instrument Manual:	01dB Duo User Manual
Firmware Version:	V2.50
Class of Instrument:	Class 1
Source of Correction Data:	01dB and GRAS

Environmental Conditions:	Pressure	Temperature	Relative Humidity
Reference Conditions:	101.325 kPa	23.0 °C	50.0 % RH
Conditions Before Measurement:	100.76 kPa	24.1 °C	51.1 % RH
Conditions After Measurement:	101.00 kPa	22.6 °C	51.7 % RH

The laboratory environmental conditions remained within the acceptable limits as defined in IEC 61672.3 and IEC 61260 throughout the calibration test.

The measurements are performed according to the *IEC 61672 Sound level meters – Part 3: Periodic tests (2013)*, and *DIN 45657 Sound Level Meters – Requirements for Special Applications (2015)*. Where applicable testing has also been completed in accordance with *IEC 61260 Electroacoustics – Octave-band and fractional-octave-band filters (2016)*.

The expanded uncertainty of measurement is reported at approximately 95% confidence level with a coverage factor k, of 2.

Accredited for compliance with ISO/IEC 17025 - Calibration.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports

Date of Calibration: 29/10/21
Date of Issue: 01/11/21
Authorised Signatory:

Claire Richardson

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Figure 43: Int. HN06 - 01dB DUO 12691 calibration certificate

THE CALIBRE TECHNOLOGY

ACOUSTIC & VIBRATION CALIBRATION CENTRE

CERTIFICATE OF CALIBRATION

Certificate Number: 4741 **NATA Accreditation No: 20688**

Customer: **Marshall Day Acoustics**
6 Gipps Street
Collingwood, VIC 3066

Test Object:	Manufacturer:	Model:	Serial No:	ID:
Sound Level Meter	01dB	Duo	12691	4741
Microphone	GRAS	GRAS40CD	331937	4741
Preamplifier	01dB	Included	12691	4741
Calibrator	None	-	-	-
Connecting Cable	None	-	-	-

Information:

Test Configuration:	Microphone on Preamp
Instrument Manual:	01dB Duo
Firmware Version:	2.50
Class of Instrument:	Class 1
Source of Correction Data:	01dB

Environmental Conditions:	Pressure	Temperature	Relative Humidity
Reference Conditions:	101.325 kPa	23.0 °C	50.0 % RH
Conditions Before Measurement:	101.15 kPa	23.8 °C	53.2 % RH
Conditions After Measurement:	100.77 kPa	23.7 °C	49.8 % RH

The laboratory environmental conditions remained within the acceptable limits as defined in IEC 61672.3 and IEC 61260 throughout the calibration test.

The measurements are performed according to the *IEC 61672 Sound level meters – Part 3: Periodic tests (2013)*, and *DIN 45657 Sound Level Meters – Requirements for Special Applications (2015)*. Where applicable testing has also been completed in accordance with *IEC 61260 Electroacoustics – Octave-band and fractional-octave-band filters (2016)*.

The expanded uncertainty of measurement is reported at approximately 95% confidence level with a coverage factor k, of 2.

Accredited for compliance with ISO/IEC 17025 - Calibration.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports

Date of Calibration: 28/10/21
Date of Issue: 1/11/21
Authorised Signatory:

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ilac-MRA NATA WORLD RECOGNISED ACCREDITATION No. 20688

Figure 44: Int. HN09 - 01dB DUO 10419 calibration certificate

THE CALIBRE TECHNOLOGY
ACOUSTIC & VIBRATION CALIBRATION CENTRE

CERTIFICATE OF CALIBRATION

Certificate Number: 5398 **NATA Accreditation No: 20688**

Customer: **Marshall Day Acoustics**
6 Gipps Street
Collingwood, VIC 3066

Test Object:	Manufacturer:	Model:	Serial No:	ID:
Sound Level Meter	01dB	Duo	10419	5398
Microphone	GRAS	40CD	144877	5398
Preamplifier	01dB-Stell	Not Stated	10419	5398
Calibrator	None	-	-	-
Connecting Cable	None	-	-	-

Information:

Test Configuration:	Microphone on Preamp
Instrument Manual:	Duo Smart Noise Monitor Manual DOC1112
Firmware Version:	2.60
Class of Instrument:	Class 1
Source of Correction Data:	01dB
Reference Level:	94 dB
Reference Level Range:	50 - 135 dB

Environmental Conditions:	Pressure	Temperature	Relative Humidity
Reference Conditions:	101.325 kPa	23.0 °C	50.0 % RH
Conditions Before Measurement:	102.13 kPa	23.9 °C	55.4 % RH
Conditions After Measurement:	101.86 kPa	24.9 °C	50.9 % RH

The laboratory environmental conditions remained within the acceptable limits as defined in IEC 61672.3 and IEC 61260 throughout the calibration test.

The measurements are performed according to the *IEC 61672 Sound level meters – Part 3: Periodic tests (2013)*, and *DIN 45657 Sound Level Meters – Requirements for Special Applications (2015)*. Where applicable testing has also been completed in accordance with *IEC 61260 Electroacoustics – Octave-band and fractional-octave-band filters (2016)*.

This certificate only relates to the test object calibrated. This certificate shall only be reproduced in full with the permission of Calibre Technology.

Accredited for compliance with ISO/IEC 17025 - Calibration.
The results of the tests, calibrations and/or measurements included in this document are traceable to the International System of Units (SI) via international or Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports.

Date of Calibration: 01/07/22
Date of Issue: 01/07/22
Authorised Signatory:

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Figure 45: Int. HN15 - 01dB DUO 10302 calibration certificate

Ecotech

ACOEM Group

Doc ID: EMS 1403
Rev Date: 5/11/18

Calibration Report

TR-REP-10576.xls

ISSUED FOR :

MARSHALL DAY ACOUSTICS
6 Gipps Street
Collingwood

3066 VIC
Australia

Name and location of the laboratory of tests:
Ecotech - 1492 Ferntree Gully Road, Knoxfield VIC 3180- Australia

TESTED INSTRUMENT

Designation :	Integrator Sound Level Meter		
Manufacturer :	01dB		
Type :	DUO	Serial number :	10302
		Identification number :	903128
		SWR :	025503
		Date of issue :	27/05/2022

This report includes 10 pages

The measurements are performed according to the IEC 61672-3, Electroacoustics, - Sound level meters – Part 3: Periodic tests.

REPORT APPROVED BY

Leigh Seymour

Authorised Signatory

ECOTECH Pty Ltd 1492 Ferntree Gully Road Knoxfield VIC 3180 Melbourne Australia ABN 32 005 752 081
+61 (0)3 9730 7800 email@ecotech.com ecotech.com
01dB ECOTECH METRAVIB ONEPROD FIXTURLASER MEAX brands of ACOEM Group

Figure 46: Int. HN15 - 01dB DUO 10409 calibration certificate

THE CALIBRE TECHNOLOGY
ACOUSTIC & VIBRATION CALIBRATION CENTRE

CERTIFICATE OF CALIBRATION

Certificate Number: 4341 **NATA Accreditation No: 20688**

Customer: **Marshall Day Acoustics**
6 Gipps Street, Collingwood, VIC 3066

Test Object:	Manufacturer:	Model:	Serial No:	ID:
Sound Level Meter	01dB	Duo	10409	4341
Microphone	GRAS	GRAS40CD	224184	4341
Preamplifier	01dB-Stell	Included	10409	4341
Calibrator	None	-	-	-
Connecting Cable	None	-	-	-

Information:

Test Configuration:	Microphone on Preamp
Instrument Manual:	01dB Duo User Manual
Firmware Version:	V2.45
Class of Instrument:	Class 1
Source of Correction Data:	01dB and GRAS

Environmental Conditions:	Pressure	Temperature	Relative Humidity
Reference Conditions:	101.325 kPa	23.0 °C	50.0 % RH
Conditions Before Measurement:	102.13 kPa	22.3 °C	45.1 % RH
Conditions After Measurement:	101.90 kPa	24.7 °C	44.1 % RH

The laboratory environmental conditions remained within the acceptable limits as defined in IEC 61672.3 and IEC 61260 throughout the calibration test.

The measurements are performed according to the *IEC 61672 Sound level meters – Part 3: Periodic tests (2013)*, and *DIN 45657 Sound Level Meters – Requirements for Special Applications (2015)*. Where applicable testing has also been completed in accordance with *IEC 61260 Electroacoustics – Octave-band and fractional-octave-band filters (2016)*.

The expanded uncertainty of measurement is reported at approximately 95% confidence level with a coverage factor k, of 2.

Accredited for compliance with ISO/IEC 17025 - Calibration.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports

Date of Calibration: 01/06/21
Date of Issue: 01/06/21
Authorised Signatory:

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