MARSHALL DAY Acoustics

COLLECTOR WIND FARM

POST-CONSTRUCTION NOISE ASSESSMENT

Rp 002 20201163 | 25 February 2022

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EXECUTIVE SUMMARY

This report presents the results of the post-construction noise compliance assessment for the Collector Wind Farm, as required by Condition E8 of the Project Approval.

This compliance assessment report is based on noise monitoring carried out on and in the vicinity of the Collector Wind Farm to evaluate noise levels associated with the development's substation and wind turbines. The noise monitoring was conducted in accordance with the Project Approval, the NSW Noise Assessment Bulletin, the NSW Noise Policy for Industry, and the approved Operation Noise Management Plan (ONMP) which was prepared to address Condition E20 of the Project Approval.

The noise monitoring was conducted between 9 June and 15 December 2021, equating to a period of approximately six (6) months at each location. The extended duration of the monitoring is significantly longer than both the minimum period specified in the ONMP and the period normally required for an assessment in accordance with the NSW Noise Assessment Bulletin. The extended survey durations were adopted following consultations with, and approval by, the Department of Planning, Industry and Environment (DPIE) to address factors including unplanned turbine curtailments and equipment damage by livestock. Approval of these survey extensions enabled a suitable quantity of data to be obtained for a representative assessment of compliance.

In accordance with the ONMP, the noise monitoring comprised:

- Unattended measurements at two (2) residential locations;
- Unattended measurements at six (6) intermediate locations generally positioned nearer to the wind farm; and
- Attended observations to assist the assessment of the noise characteristics of the wind farm.

Unattended measurements were also conducted for informative purposes at an additional receiver to the east of the wind farm. This additional location was nominated by RATCH Australia Corporation Pty Ltd in response to discussions with the Collector Wind Farm Community Consultative Committee.

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

- Noise levels associated with operation of the Collector Wind Farm's substation were below 30 dB L_{Aeq} at the nearest residential location (Receiver DD). Adjustments for special noise characteristics were not found to be warranted. The noise levels therefore comply with the 35 dB L_{Aeq} criterion specified in Condition E7 of the Project Approval
- Noise levels associated with operation of the Collector Wind Farm's wind turbines were below the applicable noise criteria specified by Condition E6 of the Project Approval. In particular, wind turbine noise levels at the nearest residential location (Receiver FF) to the east of the wind farm were below the wind speed dependent noise limits specified in the Project Approval; wind turbine noise levels at all other residential locations were below the minimum noise limit of 35 dB L_{Aeq}. Adjustments for special noise characteristics were not found to be warranted.

The findings of the monitoring and compliance assessments therefore demonstrate that the wind farm is compliant with the operational noise requirements of the Project Approval.

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1.0 INTRODUCTION

The Collector Wind Farm is an operational project located in the Upper Lachlan Shire, approximately 5 km northeast of Collector, NSW.

The project was developed by RATCH Australia Corporation Pty Ltd (RAC) and comprises fifty-four (54) wind turbines and associated infrastructure including a substation. The wind farm formally commenced operating as of 20 May 2021.

The consolidated Project Approval[1] for the Collector Wind Farm details conditions for the control of environmental noise from the development, including noise limits and noise compliance monitoring requirements.

Marshall Day Acoustics Pty Ltd (MDA) was engaged by RAC to conduct the noise compliance monitoring for the wind farm in accordance with:

- the Collector Wind Farm Operational Noise Management Plan[2] (ONMP) which was prepared in accordance with Condition E20 subclause a) of the Project Approval, and subsequently approved[3] by the Department of Planning, Industry and Environment (DPIE); and
- the NSW Noise Assessment Bulletin[4].

The noise monitoring commenced in June 2021 and was originally expected to continue for a period of approximately six (6) weeks, as specified in the ONMP, in order to satisfy the reporting timeframes defined in the Project Approval. However, as a result of a number of factors including unplanned wind turbine curtailments, equipment damage by livestock, and adverse weather conditions, the monitoring spanned a significantly extended period to December 2021 to enable collection of a suitable quantity of valid noise monitoring data. The extended monitoring periods were agreed in consultation with DPIE[5].

This report presents the results of the noise monitoring and an assessment of compliance with:

- the operational noise requirements applicable to the substation, as specified in Condition E7 of the Project Approval; and
- the operational noise requirements applicable to the wind turbines, as specified in Condition E6 of the Project Approval.

This report is to be read in conjunction with the ONMP and the background noise report[6].

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

Site layout information is detailed in Appendix B.

The noise related Project Approval conditions that are relevant to the preparation of this report are reproduced in Appendix E, along with relevant DPIE correspondence concerning the ONMP and extended survey periods.

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[1] The modified Project Approval refers to the Project Approval (Application No.: 10_0156) dated 2 December 2013 as amended by notices of modification dated 22 July 2016 (MOD 1), 15 May 2019 (MOD 2), and 16 August 2019 (MOD 3).

[2] MDA report Rp 001 R02 20201163 *Collector Wind Farm - Operation Noise Management Plan* dated 13 April 2021

[3] NSW Department of Planning Industry and Environment correspondence dated 14 April 2021

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

[5] NSW Department of Planning and Environment correspondence dated 10 September 2021 and 7 December 2021

[6] MDA report Rp 002 2015087ML *Collector Wind Farm - Background Noise Monitoring* dated 30 September 2015

2.0 WIND FARM DETAILS

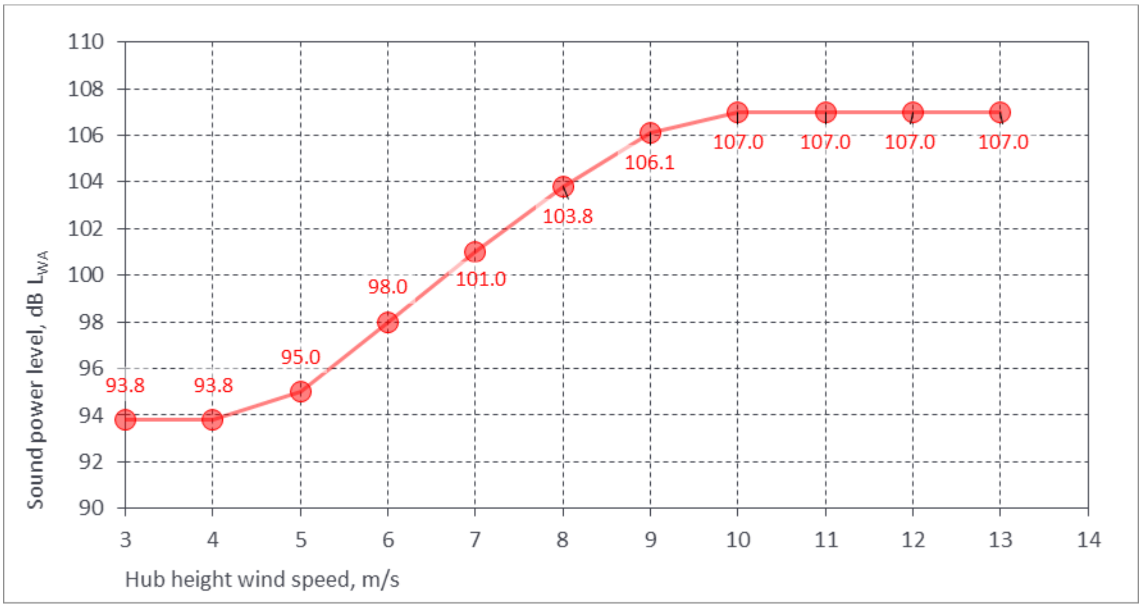
The Collector Wind Farm consists of fifty-four (54) Vestas V117 4.2MW wind turbines. Details of the installed turbines are outlined in Table 1 below.

Table 1: Collector Wind Farm wind turbine details – Vestas V117 4.2MW

Detail	Turbine model
Rotor diameter	117 m
Hub height	91.5 m
Blade orientation	Upwind
Turbine regulation method	Variable blade pitch
Maximum rated power generating capacity	4.2 MW
Cut-in wind speed (hub height)	3 m/s
Rated power wind speed (hub height)	14.5 m/s
Cut-out wind speed (hub height)	32 m/s

For modern variable speed pitch regulated wind turbines, the sound power level profile as a function of wind speed typically increases until it reaches rated power. At wind speeds approaching the speed of rated power (around 10 m/s at hub height), the sound power level[7] of the turbine no longer increases with increasing wind speed, as shown Figure 1.

Figure 1: Vestas V117 4.2MW - Sound power level versus wind speed at hub height



The substation is located at the northern end of the Collector Wind Farm, within the site boundary. The primary noise generating equipment within the substation is two (2) 145 MVA transformers and associated cooling equipment.

[7] Data sourced from Vestas Wind Systems A/S document No. 0067-7063 V05 *Performance Specification V117-4.0/4.2 MW 50/60 Hz Strong Wind*, dated 10 September 2018, and adjusted by the addition of +1 dB at each wind speed to provide a margin for typical values of test uncertainty.

3.0 NOISE CRITERIA

3.1 Substation

In accordance with Condition E7 of the Project Approval and the approved ONMP, noise levels associated with operation of the substation must comply with a noise limit of 35 dB $L_{Aeq(15\ minute)}$ when measured and assessed in accordance with the NSW EPA publication *Noise Policy for Industry* (NPfI) dated October 2017.

The noise limit applies at all non-associated residences (receivers) around the wind farm. At each receiver, the limit applies to locations that are not less than 3 m and not more than 30 m from the facade of the dwelling.

3.2 Wind turbines

In accordance with Condition E6 of the Project Approval and the approved ONMP, noise levels associated with operation of the wind turbines must comply with the noise limits detailed in Table 2 when measured and assessed in accordance with the NSW Noise Assessment Bulletin.

Table 2: Applicable noise criteria in accordance with Project Approval Condition E6, dB L_{Aeq}

Receiver	Hub height wind speed, m/s [1]										
	3	4	5	6	7	8	9	10	11	12	13
FF	35	35	35	35	37	39	41	43	45	47	49
Z	35	35	35	35	35	35	37	39	42	45	48
All other receivers	The higher of 35 dB or the background noise level (dB L_{A90}) plus 5 dB										

Note 1: Hub height de-waked wind speed at development mast location CS4

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

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 ONMP.

4.1 Substation

The substation of the Collector Wind Farm is located at the northern end of the turbine layout (Figure 2 of Section 4.2.1 illustrates the site layout).

Receiver DD is the nearest receiver to the substation, located over 2.5 km to the north. At this distance, the predicted noise level associated of the substation is well below the applicable noise limit (predicted level of 19 dB L_{Aeq}[8]) and therefore comparable to or lower than the background noise. Direct measurement of the noise associated with operation of the substation at the nearest receiver is therefore impractical.

In accordance with the ONMP, the noise monitoring therefore comprised unattended measurements at an intermediate location nearer to the substation. Specifically, Intermediate DD (see Figure 2), where background noise data was obtained previously in 2015, was selected as an intermediate reference point for monitoring both substation and wind turbine noise levels (wind turbine monitoring procedures discussed subsequently in Section 4.2).

The monitoring for the substation occurred concurrently with wind turbine noise monitoring and spanned an extended period from 9 June to 15 December 2021. Attended observations were also made during deployment and collection of the monitoring equipment, and during interim service visits.

Operational noise levels associated with the substation primarily consist of the steady noise contributions of the electrical elements of the transformers and any associated cooling plant. Accordingly, the measured underlying L_{A90} noise levels are suitable to inform an assessment of equivalent L_{Aeq} noise levels associated with the substation (the L_{A90} being less sensitive than the L_{Aeq} to transitory noise level increases as a result of ambient noise sources that are unrelated to the operation of the substation).

Further details of the measurement equipment and data collected are detailed in Section 4.2.2.

The results of the unattended monitoring at Intermediate DD were reviewed to gauge the potential contribution of the substation to the total measured noise levels.

In accordance with the ONMP, these results were then extrapolated the nearest Receiver DD using the procedure documented in Section 11.2 of ISO 1996-2:2017[9], in conjunction with the noise prediction method detailed in ISO 9613-2[10].

Further details of the noise modelling used for the extrapolation are provided in Appendix C.

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[8] Predicted substation noise level as detailed in the updated pre-construction noise assessment report MDA report Rp 001 R01 20180163 *Collector Wind Farm – Updated Noise Assessment* dated 30 October 2018

[9] ISO 1996-2:2017 A*coustics — Description, measurement and assessment of environmental noise — Part 2: Determination of environmental noise levels* (ISO 1996-2:2017)

[10] ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2)

4.2 Wind turbines

4.2.1 Noise measurement locations

In accordance with the ONMP, the noise monitoring comprised:

- Unattended measurements at two (2) representative receivers (receivers FF and Z);
- Unattended measurements at six (6) intermediate locations positioned nearer to the wind farm; and
- Attended observations to inform an assessment of the noise characteristics of the wind farm.

In addition to the locations specified in the ONMP, at the request of RAC, monitoring was also carried out at a location to the east of the wind farm (Receiver AA).

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 nine (9) monitoring locations are detailed in Table 3 and illustrated in Figure 2 below. The figure includes the predicted noise level contours presented in the ONMP, based on the installed turbines at the wind farm.

Table 3: Noise monitoring locations

Location	Direction from wind farm	Nearest turbine	Distance from nearest turbine, m [1]
Receiver AA	east	WTG62	2,452
Receiver FF	east	WTG45	2,134
Receiver Z	west	WTG17	2,241
Intermediate DD	north	WTG01	451
Intermediate FF	east	WTG45	383
Intermediate GG	west	WTG15	800
Intermediate J	south	WTG52	986
Intermediate W	southeast	WTG61	2,960
Intermediate Z	west	WTG36	749

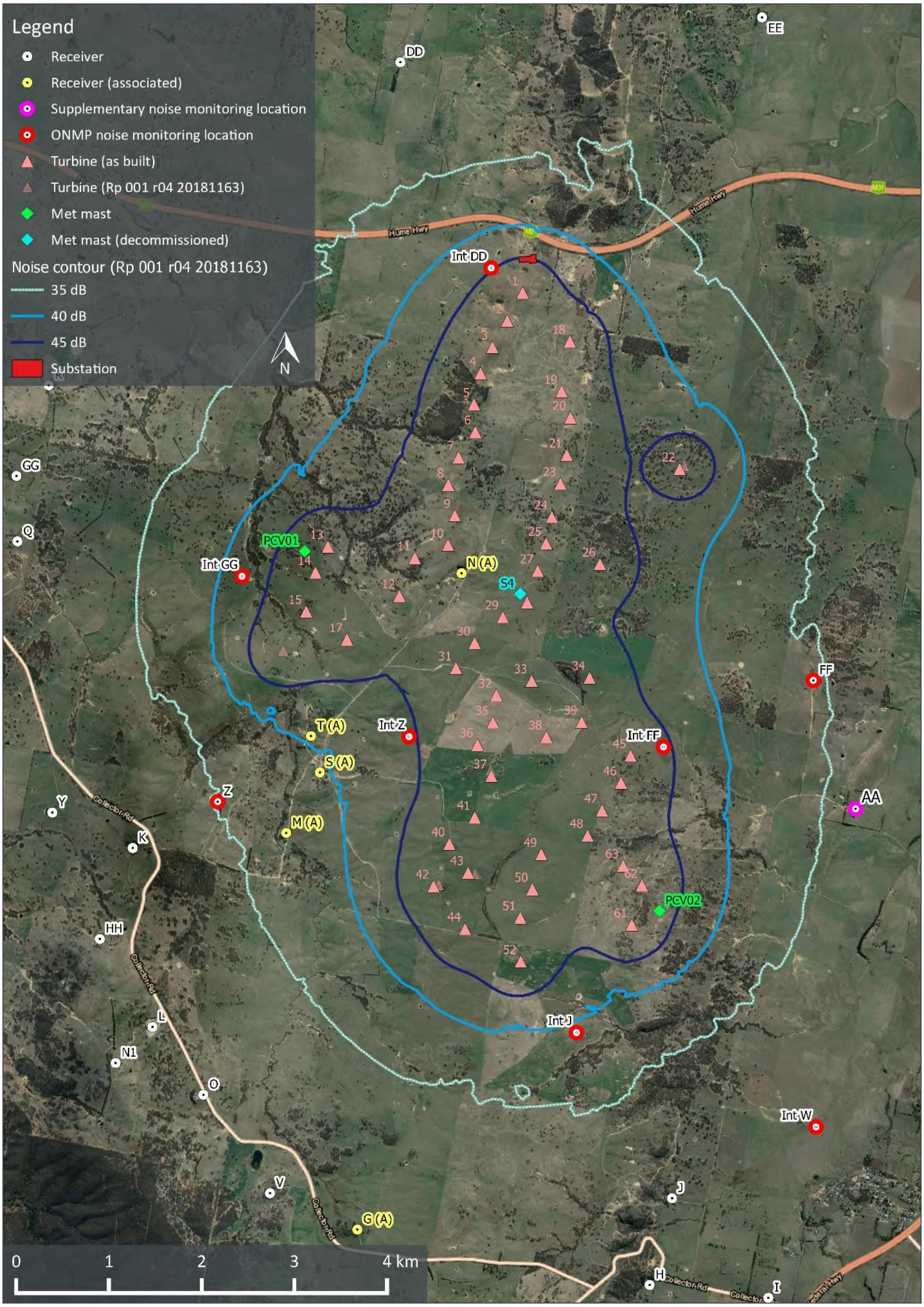
Note 1: Distance as determined from the monitor location

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 nine (9) monitoring locations are provided in Appendix J to Appendix R.

Figure 2: Monitoring locations



4.2.2 Survey description

The survey comprised unattended noise measurements and attended observations as specified in Section 5.0 of the ONMP. 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	Three (3) receivers and six (6) intermediate locations as detailed in Section 4.2.1
Monitoring period	The monitoring extended from 9 June 2021 to 15 December 2021, equating to a period of more than 6 months at each location; well beyond the six (6) week monitoring period suggested in the NSW Noise Assessment Bulletin and specified in the ONMP. Interim data reviews and analysis had identified that significant portions of the monitoring period were unsuitable for noise compliance assessment purposes as a result of the effects of unplanned turbine curtailments, equipment damage by livestock, and adverse weather conditions (high rainfall). Elevated fauna noise in connection with accumulated surface water (frogs), and overgrowth of vegetation in the vicinity of the monitors, also introduced additional extraneous noise and the potential for significant data exclusions. Additionally, attendance at site to address equipment damage was subject to COVID-19 related travel restrictions at the time. In light of these factors, the survey was extended twice to enable the collection of suitable data for compliance purposes. On both occasions, the extension was agreed in consultation with the DPIE (relevant correspondence is provided in Appendix E).
Attended observations	Attended observations were conducted on twelve (12) 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.
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 IOA good practice guide. See equipment specifications and calibration records in Appendix F.
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 Receiver FF and Intermediate GG to concurrently record rainfall and wind speeds at microphone height. This data was recorded to identify periods when local weather conditions may have resulted in excessive extraneous noise at the microphone (i.e. rainfall).
Site wind speed data	Hub height wind speeds (91.5 m above ground level) at the location of the development mast CS4[11] were provided to MDA for correlation with the measured noise levels. Further details of the site wind speed data are provided subsequently in Section 4.2.3 and in Appendix G.

[11] Met mast CS4 is designated as S4 in the ONMP and background noise monitoring report.

4.2.3 Site wind speed data

Development mast CS4 was the source of hub height wind speed data used to determine the noise limits detailed in the Project Approval and the background noise 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 ONMP, mast CS4 was decommissioned during construction, prior to commencement of the noise monitoring. It was therefore necessary for the wake-free wind data for location CS4 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 DNV 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 turbines. The dataset was synthesised using two methods broadly summarised below.

The first method comprised analysis and modelling-based adjustments of wind speeds measured at the operating met masts PCV01 and PCV02 (which were installed late in the construction programme) located to the west and southeast of the wind farm respectively. The mast locations are indicated in Figure 2. The synthesised data set at CS4 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 (e.g. data from PCV01 was referenced for wind directions from the west and, conversely, PCV02 was referenced for wind directions from the east). The CS4 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.

The second method comprised analysis and modelling-based adjustments of wind speeds measured at each wind turbine. Specifically, each turbine was used individually to calculate a wake-free wind speed at CS4. A composite synthesised wind speed for CS4 was then determined as the median of the fifty-four (54) calculated values for each 10-minute period from each of the turbines.

Due to the reliance on modelling-based adjustments (in lieu of measurement-based transfer relationships between CS4 and PCV01/PCV02), DNV 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. A comparison of the two methods by DNV indicated similar levels of uncertainty in the period-averaged wind speed data, but the uncertainty of the individual 10-minute data was lower for the turbine-based data set.

The comparison by DNV also indicated the turbine-based method tended to yield higher wind speeds than the mast-based method. Further comparisons by MDA indicated average wind speeds ranged from 0.6 to 1.0 m/s higher using the turbine-based method.

In recognition of the high uncertainty of each dataset, and despite the turbine-based method providing a reduced uncertainty for the 10-minute wind speed data, the data synthesised using the mast-based method was selected as the more conservative data set for the noise assessment (i.e. on account of this method indicating lower wind speeds on average – in assessment terms, this equates to a lower wind speed for a given noise level).

Details of the data synthesis methods are described in the DNV correspondence reproduced in Appendix G.

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

4.2.4 Data analysis

Overview

Analysis procedures in accordance with the Project Approval and NSW Noise Assessment Bulletin are specified in Section 5.7 of the ONMP.

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 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 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 limits to assess compliance with the Project Approval.

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[12] 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}.
Turbine shut-downs	Any periods significantly affected by turbine shut-downs have been excluded from the regression analysis. Wind farm operational records supplied by RAC for the duration of the monitoring campaigns were reviewed. In general, any 10-minute period in which any relevant turbines[13] were not operating were removed from the analysis. Further information is provided subsequently in this section.
Downwind directions	In accordance with the NSW Noise Assessment Bulletin and the ONMP, 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 Section 5.7.5 of the ONMP and subsequently in this section.
Wind speeds	In accordance with the NSW Noise Assessment Bulletin and the ONMP, the data is limited to a wind speed range that is representative of cut-in to the speed of rated power. Specifically, a wind speed range of 3 to 13 m/s was adopted for the assessment. Rated power is formally designated as 14 m/s, however a power output of 4.2 MW is reached by 13 m/s and the turbine's noise emissions have reached their maximum as of 10 m/s.
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 subsequently in this section.
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)

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

[13] Relevant turbines are those which are most likely to contribute to the total wind farm noise level at a measurement location. See Section 4.3.2 of this report and Section 5.3 of the ONMP for further information.

Process	Description
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 regression line of the total measured noise levels is adjusted for the potential influence of background by subtraction of the pre-construction noise levels detailed in the background noise monitoring report. This provides an initial estimate of the noise level attributable to the wind farm. However, additional estimation techniques are often required as a result of the residual effects of background noise levels. In particular, the effect of variations in background noise levels, unrelated to the operation of the wind farm, before and after construction of the development. In this respect, the background noise monitoring and analysis techniques are used to reduce the effect of these variations, and provide a representation of lower background noise levels for an area (e.g. through the removal of seasonal effects which may elevate noise, such as fauna noise or rainfall). However, even with these techniques, 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). In accordance with the ONMP, 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 5.7.7 of the ONMP. Specifically, the extrapolations were conducted in accordance with ISO 1996-2:2017, supplemented by ISO 9613-2 for noise modelling purposes. Further details are provided in Appendix C.

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 Project Approval 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 turbines being shutdown or operating at reduced power levels (e.g. due to 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 turbine parameters including the average power output and the 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 turbine for the duration of the noise monitoring period. An example plot is provided below in Figure 3. The trends of these plots were reviewed to identify the typical range of power outputs for each turbine for each integer nacelle wind speed. If the SCADA data then indicated that the power output of a turbine in a given 10-minute period was below the typical range, the 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 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 turbines (the relationship between turbine power and wind speed) on the plots for each 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 turbines) when the output of the turbine was consistent with the power curve, allowing for a notional margin below the power curve to reflect normal variations in turbine power relative the power curve (relative to nacelle wind speed).

Each 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 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 turbine, Figure 3 also includes the 10-minute measured average power data for turbine T51. Turbine 51 was selected for this example on account of being one of the turbines observed noted to have the greatest number of atypical 10-minute periods. The data for the nearest turbine to each of the three (3) receiver noise monitoring locations is also provided in Figure 4 to Figure 6.

Figure 3: Example power versus nacelle wind speed plot – turbine T51

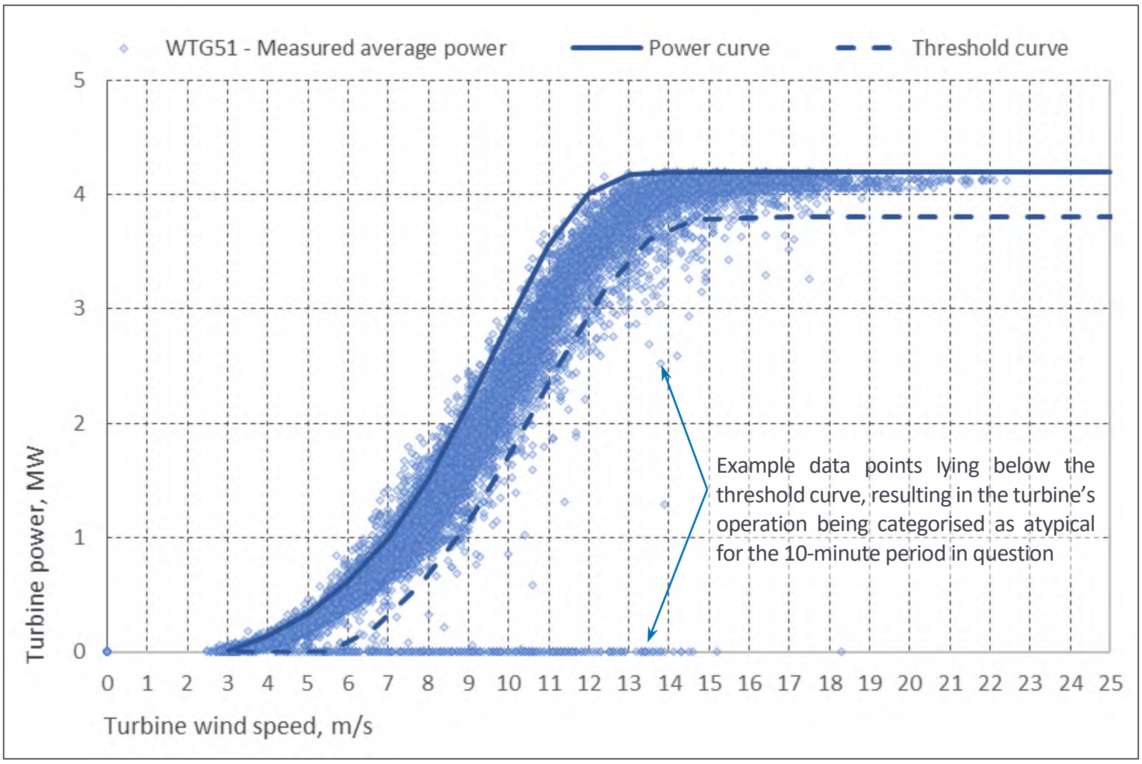


Figure 4: Turbine T62 - nearest turbine to Receiver AA – SCADA data and threshold power

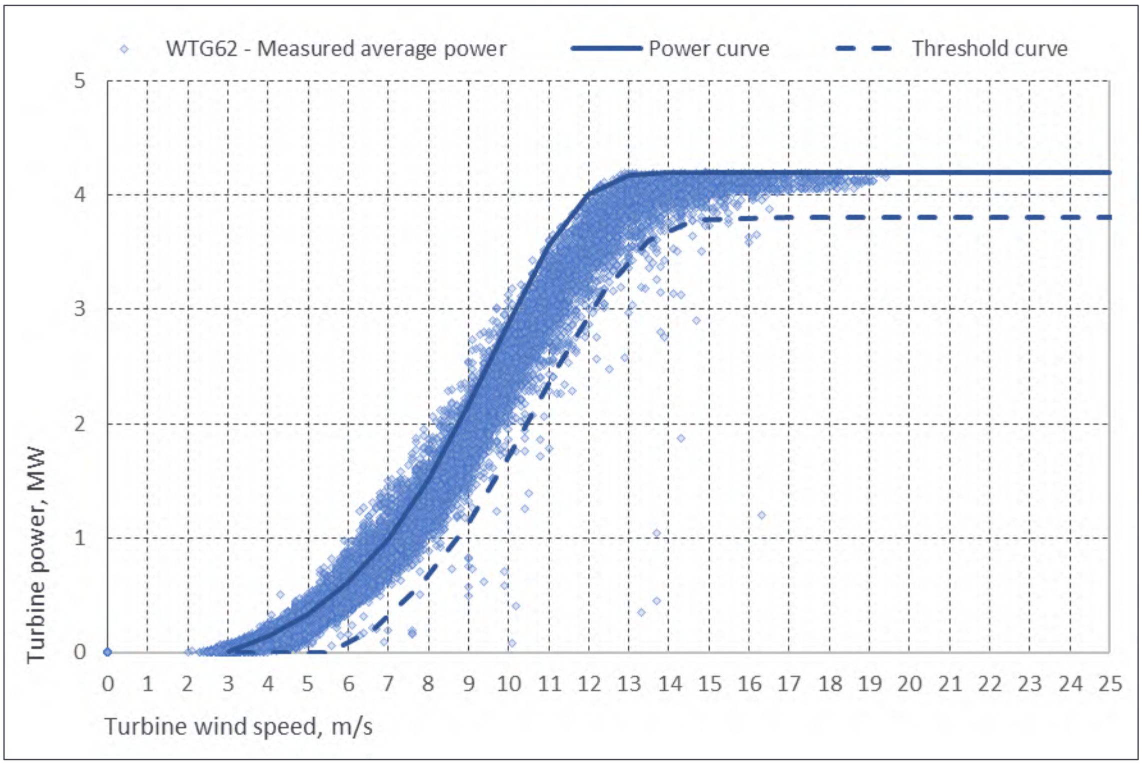


Figure 5: Turbine T45 - nearest turbine to Receiver FF – SCADA data and threshold power

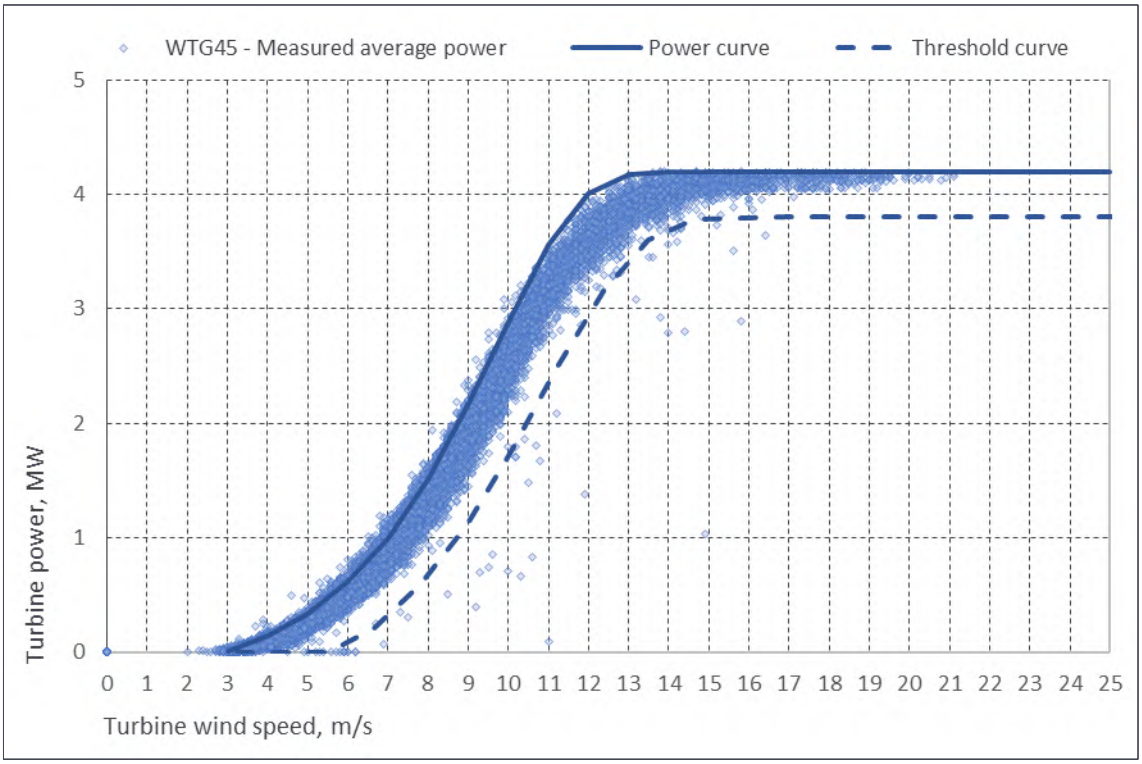
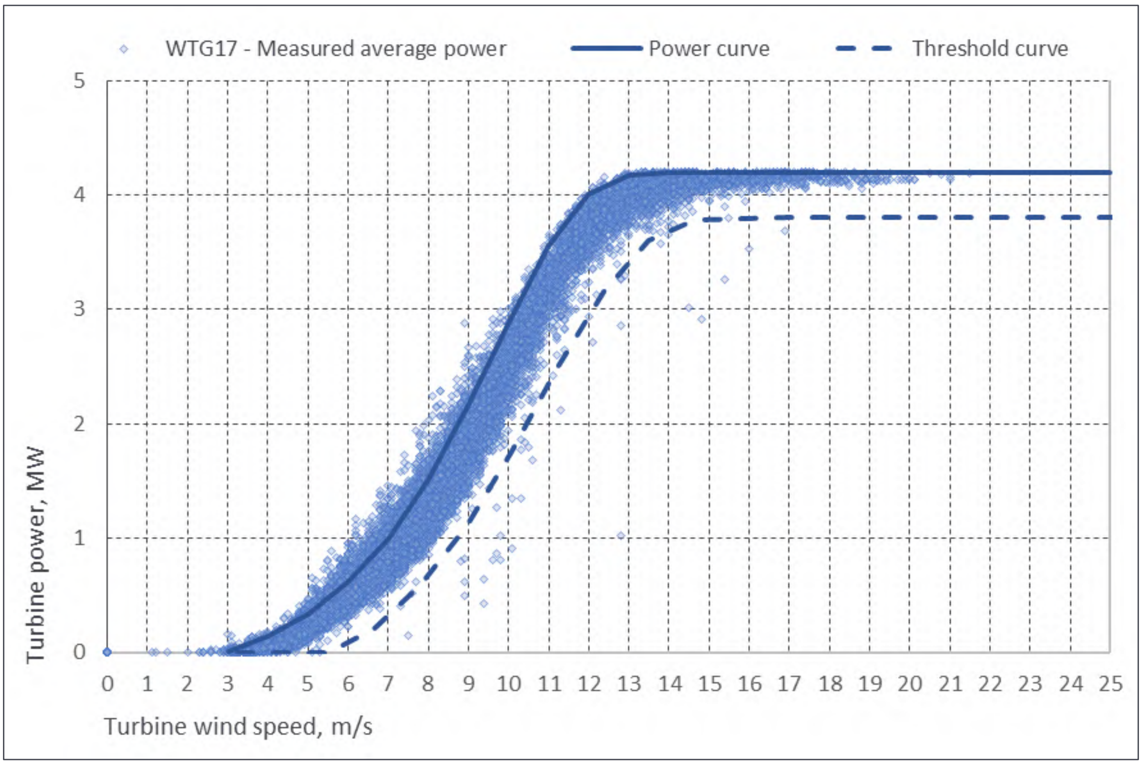


Figure 6: Turbine T17 - nearest turbine to Receiver Z – SCADA data and threshold power



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 turbines flagged as atypical were 'relevant' to the total noise of the wind farm at the monitoring locations (i.e. whether a turbine flagged as atypical had the potential to change the total noise level at a noise monitoring location or, conversely, whether the turbine was far enough away to be inconsequential).

For this purpose, the 3-dimensional noise model[14] of the site was used to rank the relative noise contributions of each turbine to the total noise level at each monitoring location, and then classify the turbines as either 'relevant' or 'non-relevant'. In accordance with the ONMP, non-relevant turbines for each monitoring location are those 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 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 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 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 turbines curtailed, the specific turbines curtailed, the extent of curtailment per turbine and, in turn, the threshold curve used to designate whether a turbine has been curtailed.

In some instances, application of these filters to noise monitoring data obtained during the initial period of operation of a wind farm, when residual commissioning faults are still being resolved, can result in the removal of most of the data. Refined or modified analysis methods are therefore sometimes required to facilitate an assessment of compliance that is representative of full power of the wind farm. Experience in the application of these procedures to sites in Australia is that refined threshold curve definitions can be used to avoid excessive data loss and enable a representative assessment.

The interim data reviews identified that the effects of unplanned curtailment during the initial period of operation of the Collector Wind Farm were a relevant consideration for the noise compliance assessment. This was one of the key reasons for seeking approvals from DPIE to extend the monitoring. Approval of the extended monitoring, in conjunction with the use of refined threshold curve definitions, enabled a representative quantity of data to be collected which could be assessed using the operational screening process defined in the ONMP. The additional data therefore negated the need for a modified screening processes.

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

[14] The same noise model as referenced in the ONMP to nominate suitable noise monitoring locations

Special noise characteristics

In accordance with the Project Approval 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[15] 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 ONMP nominates ISO/PAS 20065[16], as referenced in ISO 1996-2:2017.

- Low frequency: measured C-weighted noise levels (dB L_{C90}) associated with operation of the wind farm are compared with the 60 dB criterion detailed in the NSW Noise Assessment Bulletin.

In accordance with the NSW Noise Assessment Bulletin and the ONMP, 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 ONMP 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 1m/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.

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

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

5.0 SUBSTATION ASSESSMENT

5.1 Observations and measurement data

The nearest sensitive location to the substation is Receiver DD located over 2.5 km to the north of the substation.

Noise levels at the intermediate noise monitoring location near the substation (intermediate DD) were found to be controlled by the influence of road traffic noise levels associated with the Hume Highway and the operation of the wind turbines, depending on the wind speed and direction. This was evident from the range and trend of the measured noise levels; notably a much higher range of noise levels than expected from the substation, and a much wider range of variation in noise levels (in contrast, the noise emissions of a substation are typically steady in nature).

Wind speeds and directions which would increase the noise contribution of the substation at intermediate DD (i.e. winds from the east) were not available during the attended observations (wind directions for the site are typically from the west, as indicated in the wind roses provided in Appendix G, and as evident during the observations). It is however noted that the substation was inaudible at intermediate DD during all site visits. The formally recorded attended observations are summarised in Table 6.

Table 6: Attended observations at Intermediate DD

Date	Hub height wind speed and direction, m/s, degrees	Subjective assessment/comments
09/06/2021 0900 hrs	5.9, 306	Substation inaudible. Upwind conditions.
19/08/2021 1350 hrs	4.7, 305	Substation inaudible. Upwind conditions.

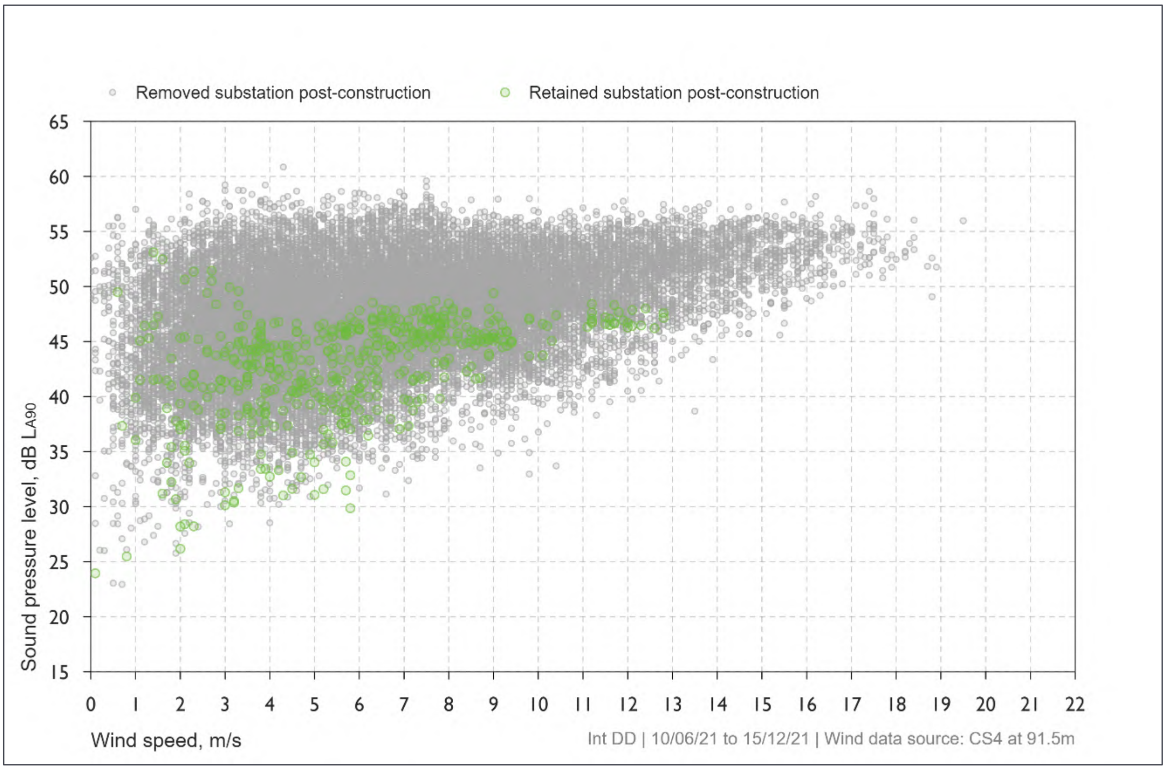
To investigate whether the noise contribution of the substation could be identified in the unattended measurements, the data was reviewed for a subset of conditions when the contribution of the substation would be highest and the ambient noise of traffic would be reduced. For this purpose, the noise level versus site wind speed correlation used for the wind turbine noise assessment was adapted to produce a dataset filtered by:

- Wind directions: the data was restricted to east to southeast wind direction range (specifically 100° to 150°) which corresponds to the measurement location being crosswind or downwind of the substation, and crosswind to upwind of the Hume Highway to the north of the site; and
- Time periods: the data was restricted to the night period from 0000 to 0500 hrs to consider periods when road traffic noise from the Hume Highway is likely to be lower.

The data is illustrated in Figure 7 and indicates a wide variation in the retained measurement data, with noise levels typically ranging between 25 and 55 dB L_{A90}. This is consistent with influence of noise attributable to both the Hume Highway and the wind turbines of the Collector Wind Farm. For context, it is noted that the pre-construction background noise levels at this location typically ranged from 25 to 50 dB L_{A90} at low wind speeds, primarily due to variations in the noise contribution of the Hume Highway.

The noise of the substation is therefore lower than the range of measurements indicated in Figure 7. In particular, it can be concluded that the noise of the substation was well below the typical upper measured level dB 47 dB L_{A90} at Intermediate DD. However, the specific contribution attributable to the substation cannot be quantified from these results. These findings are consistent with the noise modelling of the substation which indicated the predicted noise level at intermediate DD was low (31 dB L_{Aeq}).

Figure 7: Intermediate DD measurement data subset for substation



The above data is based on consecutive 10-minute measurement data. However, in light of the absence of any clear measurable contribution attributable to the substation, no additional meaningful insight to the noise level of the substation could be gained from reprocessing the data in the 15-minute intervals referred to in the NSW NPfI (particularly for the assessment of steady noise emissions associated with substation plant). The 10-minute data produced for the assessment of wind turbine noise was therefore also used to inform the compliance assessment of the substation noise.

In addition to A-weighted noise levels, the potential for tonality and low frequency noise characteristics of the substation was reviewed by analysing the same subset of data illustrated in Figure 8. The results indicated:

- Tonality was not detectable from an analysis in accordance with the one-third octave band procedure reference in the NPfI
- Low frequency was not evident at a level which would warrant assessment at Receiver DD. Upper C-weighted noise levels (90th percentile of all available samples) at Intermediate DD at low site wind speeds (≤ 3 m/s) were approximately 60 dB L_{C90}. At increased wind speeds, the noise levels ranged from 60 to 65 dB L_{C90}, primarily as a result of the wind turbines and road traffic noise. Irrespective, accounting for the much greater separating distance from the substation to the Receiver DD (over 2.5 km), C-weighted noise levels associated with the substation would be much lower than the 60 dB L_{Ceq} threshold referenced in the NPfI.

5.2 Compliance assessment

A conservative assessment of compliance is presented in Table 7 based on the upper range of noise levels measured at intermediate DD.

Table 7: Substation compliance assessment summary

Item	Description
Estimated substation noise level at Intermediate DD	<< 47 dB L_{Aeq}
Estimated substation noise level at Receiver DD based on extrapolation of upper level at Intermediate DD	<< 30 dB L_{Aeq}
Penalties (character related adjustments)	Not applicable
Noise limit	35 dB L_{Aeq}
Compliance	Yes

The results demonstrate that noise levels associated with operation of the substation comply with the noise criterion detailed in the Project Approval. The precise margin of compliance is not able to be quantified due to the influence of road traffic and wind turbine noise on the measurements. However, compliance would be achieved by at least 5 dB. This is consistent with the noise modelling of the substation which indicated the substation was predicted to result in very low noise levels at the nearest noise sensitive location, Receiver DD (14 dB L_{Aeq}). Accordingly, further investigation of noise levels associated with the substation was not considered warranted.

6.0 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 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.

6.1 A-weighted noise levels

The results of the unattended measurement data analysis for the six (6) intermediate and three (3) receiver locations are summarised the following sub-sections. All measurement data has been analysed in accordance with the NSW Noise Assessment Bulletin and the ONMP, as summarised in Section 4.2.4 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 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 4.2.4 (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 J to Appendix R, 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.

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; and
- Differences in the profile of the noise level versus wind speed charts at the intermediate locations and receivers, indicating different noise sources were controlling the measurements at these locations. In particular, the noise levels at the intermediate locations exhibit a ‘plateau’ in noise levels once the turbines have reached their maximum noise emissions; this is consistent with the characteristics of modern pitch-regulated variable speed turbines (see turbine sound power level data shown earlier in Section 2.0). At locations where turbine noise is a controlling noise source, this same profile would be evident. In contrast, the profiles of the noise level versus wind speed data at the receivers do not exhibit this characteristic, and instead show continued progressive increases in noise levels with wind speed; this indicates the effect of background noise on the measurements at the receivers.

Given the above, and the exclusive use of intermediate monitoring locations for some of the more distant receivers from the wind farm, the following subsections provide estimates of the wind farm noise contribution using the two methods described in the ONMP and summarised earlier in Section 4.2.4:

- An estimated determined by adjusting the measured post-construction noise level for the potential influence of background noise (where available); and
- An estimated determined by the extrapolation of data measured at a corresponding intermediate location.

As an additional point of context, the predicted noise levels from the site noise model are included for each location. Comparisons between the measurements and predictions at the intermediate locations are used to gauge the reliability of the modelling for extrapolating noise levels to distant locations. The predictions also provide additional information to assist the identification of locations where the total measured noise levels clearly relate to a noise source other than wind turbine noise.

In terms of the suitability of the wind speeds and directions at the site during the noise monitoring period, Appendix G 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 consistent with long term trends for the site.

6.1.1 Intermediate DD

Table 8: Intermediate DD - measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured pre-construction	38.1	37.7	37.6	37.7	37.9	38.0	37.9	37.3	36.2	34.4	31.7
Measured post-construction	41.9	41.4	41.3	41.6	42.2	42.9	43.8	44.6	45.3	45.8	46.1
Predicted wind farm	30.9	31.5	32.7	35.7	38.7	41.5	43.8	44.7	44.7	44.7	44.7
Estimated wind farm (background adjusted)	39.6	39.0	38.9	39.3	40.2	41.2	42.5	43.7	44.7	45.5	45.9

The results presented in Table 8 indicate close agreement between the predicted and estimated wind farm noise at Intermediate DD for hub height wind speeds of 8 m/s and above.

At wind speeds below 8 m/s, the estimated wind farm noise levels (background adjusted) are significantly higher than the predicted noise levels. This is likely to be attributable to variations in background noise levels associated with the Hume Highway (i.e. the pre-construction measured noise levels were lower than the actual background noise levels at the time of the post-construction measurement); primarily as this effect was not observed consistently at other intermediate locations around the wind farm. Further, the profile of the noise versus wind speed chart in Appendix J is relatively flat, indicating the influence of a background noise source which is independent of wind speed (and therefore not related to the wind turbines).

Accordingly, extrapolations based on the data measured at Intermediate DD are expected to overestimate the noise levels of the wind farm at distant locations for wind speeds below 8 m/s.

6.1.2 Intermediate FF

Table 9: Intermediate FF - measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured pre-construction	26.5	26.5	27.1	28.2	29.6	31.3	33.2	35.2	37.2	39.0	40.7
Measured post-construction	32.2	33.5	35.3	37.6	39.9	42.3	44.4	46.0	46.9	47.0	46.0
Predicted wind farm	32.5	33.1	34.3	37.3	40.3	43.1	45.4	46.3	46.3	46.3	46.3
Estimated wind farm (background adjusted)	30.9	32.5	34.6	37.1	39.5	41.9	44.1	45.6	46.4	46.2	44.5

The results presented in Table 9 indicate close agreement between the predicted and estimated wind farm noise at Intermediate FF across the wind speed range. Further, the profile of the noise level versus wind speed chart provided in Appendix K exhibits characteristics that are consistent with wind turbine noise; a progressive increase in noise levels with increasing wind speed, followed by a 'plateau' in noise levels at approximately 9m/s. The data also indicates less variation in noise levels at each wind speed when compared to other locations where background noise has had a greater influence on the measurements.

These results indicate that the data from intermediate FF provides a reliable basis for estimating the noise level of the wind farm at distant locations.

6.1.3 Intermediate GG

Table 10: Intermediate GG - measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured pre-construction	27.3	27.2	27.5	28.2	29.3	30.7	32.3	34.1	36.2	38.4	40.7
Measured post-construction	34.0	36.1	37.8	39.1	40.2	41.2	42.0	42.7	43.5	44.4	45.4
Predicted wind farm	27.4	28.0	29.2	32.2	35.2	38.0	40.3	41.2	41.2	41.2	41.2
Estimated wind farm (background adjusted)	33.0	35.5	37.4	38.7	39.8	40.8	41.5	42.0	42.6	43.2	43.6

The results presented in Table 10 indicate the estimated wind farm (background adjusted) was higher than predicted by the noise modelling at Intermediate GG, particularly at wind speeds below 8 m/s. However, the noise level versus wind speed chart provided in Appendix L indicates a wide variation in measured noise levels at most wind speeds, and the trend of the data differs from the profile expected for wind turbine noise.

These factors indicate that the differences between the predicted and estimated wind farm noise levels (background adjusted) are likely to relate to variations in background noise (i.e. the pre-construction measurements were lower than actually occurred at the time of the post-construction measurement). This means that the estimated wind farm noise level (background adjusted) is likely to be higher than the actual noise contribution of the wind farm.

Accordingly, extrapolations based on the data measured at Intermediate GG are expected to overestimate the noise levels of the wind farm at distant locations, particularly at wind speeds below 8 m/s.

6.1.4 Intermediate J

Table 11: Intermediate J - measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured pre-construction	25.0	23.0	23.0	24.0	25.0	28.0	31.0	33.0	35.0	36.0	36.0
Measured post-construction	27.5	29.6	31.8	34.0	36.2	38.2	40.0	41.4	42.5	43.1	43.1
Predicted wind farm	25.3	25.9	27.1	30.1	33.1	35.9	38.2	39.1	39.1	39.1	39.1
Estimated wind farm (background adjusted)	<27.5	28.5	31.2	33.5	35.9	37.8	39.4	40.7	41.6	42.2	42.2

The results presented in Table 11 indicate the estimated wind farm noise levels (background adjusted) were typically around 2-3 dB higher than predicted by the modelling at Intermediate J. However, the noise level versus wind speed chart provided in Appendix M indicates variations in measured noise levels at most wind speeds which are indicative of background noise influences. The trend of the overall dataset also indicates relatively constant increases in noise levels with increasing wind speeds, beyond the wind speeds when turbine noise emissions are expected to have reached their maximum.

These factors indicate that the differences between the predicted and estimated wind farm noise levels (background adjusted) are likely to relate to variations in background noise (i.e. the pre-construction measurements were lower than actually occurred at the time of the post-construction measurement). This means that the estimated wind farm noise levels (background adjusted) are likely to be higher than the actual noise contribution of the wind farm.

Accordingly, extrapolations based on the data measured at Intermediate J are expected to overestimate the noise levels of the wind farm at distant locations.

6.1.5 Intermediate W

Table 12: Intermediate W - measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured pre-construction	28.2	29.0	29.6	29.9	30.1	30.2	30.4	30.6	31.0	31.6	32.5
Measured post-construction	32.2	32.2	32.5	33.1	34.0	34.9	36.0	37.0	37.9	38.8	39.4
Predicted wind farm	16.1	16.7	17.9	20.9	23.9	26.7	29.0	29.9	29.9	29.9	29.9
Estimated wind farm (background adjusted)	30.0	29.3	<32.5	30.3	31.7	33.1	34.6	35.9	36.9	37.9	38.4

The results presented in Table 12 indicate the estimated wind farm noise levels (background adjusted) were significantly higher than predicted by the modelling at Intermediate W. However, the noise level versus wind speed chart provided in Appendix N indicates a profile that is not consistent with wind turbine noise, and very high level of variation in measured noise levels at all wind speeds which is clearly attributable to sources not related to the operation of the wind farm. For example, noise levels in excess of 55 dB $L_{A90,10min}$ were regularly measured right across the wind speed range, including at low wind speeds when the turbines were not operating. Importantly, these upper noise levels are higher than were measured at locations nearer to the wind farm, thus confirming the presence of noise sources nearer to the monitoring location that were controlling the range of the measured noise levels.

Observations while in attendance at the site indicated high levels of fauna noise (insects and particularly frogs), coinciding with large areas of accumulated surface water in the area around the monitoring location (the equipment was flooded in the final weeks of the noise monitoring). These factors support the conclusion that the measured noise levels were controlled by the influence of background noise and not related to the operation of the wind farm.

The above findings are consistent with expectations, as Intermediate W is located approximately 3 km southeast of the wind farm. The predicted wind farm noise levels at Intermediate W are therefore low and expected to be below the background noise.

These factors therefore indicate that the differences between the predicted and estimated wind farm noise levels (background adjusted) relate to variations in background noise (i.e. the pre-construction measurements were lower than actually occurred at the time of the post-construction measurement). This means that the estimated wind farm noise levels (background adjusted) are higher than the actual noise contribution of the wind farm

Accordingly, extrapolations based on the data measured at Intermediate W would significantly overestimate the noise levels of the wind farm at distant locations; to the extent that data from Intermediate W is not considered suitable for assessing noise levels at distant locations.

6.1.1 Intermediate Z

Table 13: Intermediate Z – measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured pre-construction	26.5	21.5	22.5	24.1	26.4	29.2	32.4	36.1	40.0	44.2	48.5
Measured post-construction	29.9	31.5	33.2	35.1	36.9	38.7	40.5	42.0	43.3	44.4	45.1
Predicted wind farm	30.5	31.1	32.3	35.3	38.3	41.1	43.4	44.3	44.3	44.3	44.3
Estimated wind farm (background adjusted)	27.3	31.0	32.8	34.7	36.5	38.2	39.8	40.7	40.6	<44.4	<45.1

The results presented in Table 13 generally indicate predicted noise levels comparable to or higher than the estimated wind farm noise levels (background adjusted), particularly at wind speeds equal to 8 m/s and above. Several factors may have contributed to this difference including:

- Turbine arrangement: turbines are located in multiple directions from Intermediate Z, meaning that simultaneous downwind propagation from every turbine, as factored in the noise modelling, is unlikely to occur in many instances. This is an aspect of the noise modelling that is conservative (i.e. will result in an overestimation of the noise level in practice);
- Turbine wind speed variations: at low to moderate wind speeds (particularly below 10 m/s), there is the potential for the turbines nearest to the intermediate monitoring location to experience lower wind speeds than the constant wind speed assumed for all turbines in the noise modelling. This is an aspect of the noise modelling that is conservative; and
- Background noise level variations: the pre-construction noise levels at high wind speeds, particularly at 12 and 13 m/s, were relatively high and appear to be overestimating the actual background noise level that occurred at the time of the measurements. This is evident from the post-construction noise level versus wind speed profile shown in Appendix O exhibiting a 'plateau' from around 9 m/s, consistent with wind turbine noise. In contrast, the pre-construction trend line suggests continued increases in noise level above 9 m/s, notably at levels above those actually measured post-construction

Based on experience and the balance of considerations, turbine wind speed variations at low to moderate wind speeds, and lower background noise levels at high wind speeds during the post-construction monitoring, are likely to be the main factors causing the estimated wind farm noise level (background adjusted) to be lower than predicted.

Accordingly, there is the potential for an extrapolation based on the data measured at Intermediate Z to underestimate the noise levels of the wind farm at distant locations.

6.1.2 Receiver AA

Table 14: Receiver AA – - measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured pre-construction [1]	--	--	--	--	--	--	--	--	--	--	--
Measured post-construction	31.5	33.2	34.9	36.7	38.5	40.2	41.9	43.3	44.7	45.8	46.6
Predicted wind farm	19.6	20.2	21.4	24.4	27.4	30.2	32.5	33.4	33.4	33.4	33.4
Estimated wind farm (background adjusted)	--	--	--	--	--	--	--	--	--	--	--
Estimated wind farm (extrapolated) [2]	19.0	20.6	22.7	25.2	27.6	30.0	32.2	33.7	34.5	34.3	32.6

Note 1: pre-construction data not available for Receiver AA

Note 2: extrapolated from the estimated wind farm noise level (background adjusted) at Intermediate FF

The results presented in Table 14 indicate the measured total post-construction noise levels are much higher than both the predicted and estimated contribution of the wind farm. This difference is attributable to the background noise level during the noise monitoring period.

Background noise level measurements were not conducted at Receiver AA prior to construction of the wind farm. However, it is noted that the post-construction noise levels at Receiver AA are higher than were measured at Receiver FF (also located to the east of the southern section of the wind farm), despite Receiver FF being nearer to the wind farm. The profile of the noise versus wind speed chart provided in Appendix P also indicates a relatively high level of variation in measured noise levels at most wind speeds, and indicates consistent increases in noise levels with wind speed above the speed at which the turbines have reached their highest noise emissions. These factors provide additional support that the total measured post-construction noise levels were controlled by the influence of background noise.

The above findings are consistent with expectations, as the highest predicted wind farm noise levels at Receiver AA are below 35 dB L_{Aeq}. Consistent with Receiver FF to the north, the predicted noise levels were therefore expected to be below the background noise levels at high wind speeds.

Given the above factors, the noise levels directly measured at Receiver AA are not representative of the noise contribution of the wind farm. An assessment of noise levels at this receiver is therefore more appropriately based on extrapolation of measurement data from an intermediate location (specifically, Intermediate FF).

6.1.3 Receiver FF

Table 15: Receiver FF – measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured pre-construction	26.7	27.6	28.9	30.4	32.3	34.3	36.4	38.5	40.6	42.6	44.5
Measured post-construction	28.3	30.3	32.6	35.1	37.6	39.8	41.6	42.9	43.3	42.7	41.0
Predicted wind farm	21.6	22.2	23.4	26.4	29.4	32.2	34.5	35.4	35.4	35.4	35.4
Estimated wind farm (background adjusted)	<28.3	<30.3	30.2	33.3	36.1	38.4	40.0	40.9	<43.3	<42.7	<41.0
Estimated wind farm (extrapolated) [1]	21.0	22.6	24.7	27.2	29.6	32.0	34.2	35.7	36.5	36.3	34.6

Note 1: extrapolated from the estimated wind farm noise level (background adjusted) at Intermediate FF

The results presented in Table 15 indicate:

- Measured total post-construction noise levels were higher than the predicted wind farm noise level. This is consistent with expectations, as the predicted noise levels of the wind farm are lower than the measured pre-construction noise levels;
- The predicted and estimated wind farm noise levels (extrapolated) exhibit very close agreement across the wind speed range. Again, this is consistent with expectations given that the noise levels measured at Intermediate FF indicated a profile consistent with wind turbine noise emissions; and
- The estimated wind farm noise level (background adjusted) is considerably higher than both the predicted and estimated wind farm noise level (extrapolated); notably by a much greater margin than the typical magnitude of modelling related uncertainties. However, the noise level versus wind speed chart provided in Appendix Q indicates a wide variation in measured noise levels at most wind speeds. The trend of the data also differs from the profile expected for wind turbine noise, particularly the relatively constant increase in noise level with increasing wind speed across the wind speed range. These factors indicate that the higher value of the estimated wind farm noise level (background adjusted) relate to variations in background noise (i.e. the pre-construction measurements were lower than actually occurred at the time of the post-construction measurement). This means that the estimated wind farm noise level (background adjusted) is higher than the actual noise contribution of the wind farm.

Given the above factors, the estimated wind farm noise level (background adjusted) is not considered representative of the noise contribution of the wind farm, and is not suitable for compliance assessment purposes. An assessment of noise levels at this receiver is therefore more appropriately based on extrapolation of measurement data from an intermediate location (specifically, Intermediate FF).

6.1.4 Receiver Z

Table 16: Receiver Z – - measured noise levels and estimated wind farm noise levels, dB L_{Aeq}

Description	Hub height wind speed, m/s										
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Measured pre-construction	21.9	21.9	23.0	24.9	27.4	30.3	33.2	36.0	38.3	40.0	40.7
Measured post-construction	28.9	30.7	32.1	33.3	34.3	35.3	36.5	37.8	39.6	41.8	44.6
Predicted wind farm	21.1	21.7	22.9	25.9	28.9	31.7	34	34.9	34.9	34.9	34.9
Estimated wind farm (background adjusted)	27.9	30.1	31.5	32.6	33.3	33.7	33.7	<37.8	<39.6	<41.8	42.3
Estimated wind farm (extrapolated) [1]	18.9	22.6	24.4	26.3	28.1	29.8	31.4	32.3	32.2	<36.0	<36.7

Note 1: extrapolated from the estimated wind farm (background adjusted) noise level at Intermediate Z

The results presented in Table 16 indicate relatively low predicted, estimated wind farm noise levels (background adjusted), and estimated wind farm noise levels (extrapolated); below 35 dB in all cases other than at wind speeds where a specific estimated value could not be determined (the higher wind speeds). In this respect, it is noted that the predicted wind farm noise levels are comparable to the measured pre-construction noise levels except at higher wind speeds where the predicted noise levels are much lower than the measured pre-construction noise levels.

The profile of the noise level versus wind speed chart provided in Appendix R indicates a wide variation in measured noise levels at most wind speeds. The overall trend of the complete data set also exhibits a relatively constant increase in noise level with increasing wind speed across the wind speed range.

These factors indicate that the estimated wind farm noise level (background adjusted) is likely to overestimate the noise contribution of the wind farm at most wind speeds. However, the estimated wind farm noise level (extrapolated) is not considered a reliable basis for assessing compliance, on account of the factors discussed Section 6.1.1. Accordingly, while the estimated wind farm noise level (background adjusted) is likely to overestimate the contribution of the wind farm, it is the appropriate reference for an assessment of compliance at Receiver Z.

6.1.5 Summary

Based on the findings outlined in the preceding sections, Table 17 summarises the estimated wind farm noise levels to be used as the basis for assessing compliance with the noise criteria.

The estimated wind farm noise levels (background adjusted) at the intermediate locations can generally be used to assess noise levels at distant receivers where measurements were not conducted. In particular, the data obtained at intermediate FF was found to provide a reliable basis for extrapolation to the receivers. However, the following was identified from the analysis:

- Extrapolations based on the estimated wind farm noise level (background adjusted) determined at Intermediate DD, Intermediate GG, and Intermediate J are likely to overestimate the noise contribution of the wind farm at distant locations. The estimates based on these intermediate locations are therefore conservative;
- Extrapolations based on the estimated wind farm noise level (background adjusted) at Intermediate W are not suitable on account of the likelihood that the noise contribution of the wind farm would be significantly overestimated. This is due to the effect of high levels of background noise during the post-construction monitoring period. While extrapolations based on data from Intermediate J are also likely to overestimate the noise contribution of the wind, the data from Intermediate J provides a more suitable basis for extrapolating to receivers to the south of wind farm; and
- Extrapolations based on the estimated wind farm noise level (background adjusted) determined at Intermediate Z are not suitable on account of the likelihood that the noise contribution of the wind farm would be underestimated at distant locations.

The estimated wind farm noise levels at receivers AA and FF are based on extrapolation of the estimated wind farm noise level (background adjusted) derived from the monitoring at Intermediate FF. This is due to the influence of background noise levels on the measured noise levels at both of these receivers.

In the case of Receiver Z, the estimated wind farm noise levels are based directly on the background adjusted values measured at the receiver. This is likely to overestimate the noise contribution of the wind farm, but is referenced in lieu of extrapolations as a result of the limitations of the data obtained at Intermediate Z.

Table 17: Derived wind farm noise levels, dB L_{Aeq}

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Int DD	39.6	39.0	38.9	39.3	40.2	41.2	42.5	43.7	44.7	45.5	45.9
Int FF	30.9	32.5	34.6	37.1	39.5	41.9	44.1	45.6	46.4	46.2	44.5
Int GG	33.0	35.5	37.4	38.7	39.8	40.8	41.5	42.0	42.6	43.2	43.6
Int J	<27.5	28.5	31.2	33.5	35.9	37.8	39.4	40.7	41.6	42.2	42.2
Receiver AA	19.0	20.6	22.7	25.2	27.6	30.0	32.2	33.7	34.5	34.3	32.6
Receiver FF	21.0	22.6	24.7	27.2	29.6	32.0	34.2	35.7	36.5	36.3	34.6
Receiver Z	27.9	30.1	31.5	32.6	33.3	33.7	33.7	<37.8	<39.6	<41.8	42.3

6.2 Special noise characteristics

6.2.1 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 18, along with the number of operational turbines and the site wind speeds at the times when the observations were made.

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

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 18: Attended observations - summary of subjective assessments

Date and time	Location	Total turbines operating	Hub height wind speed and direction, m/s, °	Subjective assessment/comments
09/06/2021 09:16	Int. DD	54	5.1, 307	Wind farm inaudible. Sub-station inaudible. Upwind conditions. No special characteristics observed.
09/06/2021 11:50	Int. FF	54	5.9, 309	Wind farm just audible. Downwind conditions. No special characteristics observed.
09/06/2021 14:15	Int. J	53	5.5, 297	Rain and hail. Special characteristics assessment not feasible.
09/06/2021 15:10	Int. GG	54	5.4, 323	Rain and hail. Special characteristics assessment not feasible.
09/06/2021 16:08	Int. Z	54	4.7, 314	Rain and hail. Special characteristics assessment not feasible.
10/06/2021 08:45	Z	52	7.9, 142	Wind farm inaudible. Crosswind conditions. No special characteristics observed.
10/06/2021 10:20	Int. W	52	8.2, 123	Wind farm inaudible. Upwind conditions. No special characteristics observed.
10/06/2021 12:00	AA	51	9.3, 111	Wind farm inaudible. Upwind conditions. No special characteristics observed.
10/06/2021 13:10	FF	51	8.2, 125	Wind farm inaudible. Upwind conditions. No special characteristics observed.
07/07/2021 12:23	Z	54	2.9, 71	Wind farm inaudible. Downwind conditions. No special characteristics observed.

Date and time	Location	Total turbines operating	Hub height wind speed and direction, m/s, °	Subjective assessment/comments
07/07/2021 14:45	FF	54	2.4, 88	Wind farm inaudible. Upwind conditions. No special characteristics observed.
20/08/2021 13:23	AA	53	8.6, 285	Wind farm inaudible. Downwind conditions. No special characteristics observed.
20/08/2021 14:02	FF	53	9.6, 293	Wind farm inaudible. Downwind conditions. No special characteristics observed.

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

6.2.2 Tonality

The objective assessment of tonality was conducted for all retained 10-minute measurements following application of the data filtering processes described in Section 4.2.4. The percentages of all analysed 10-minute periods in which tonality was identified are summarised in Table 19.

Consistent with the attended observations, the objective assessment did not identify tonality at most locations and wind speeds. The very small percentage of points in which tonality was identified would relate to transient ambient noise sources rather than operation of the wind. Tonality is therefore not considered to be a characteristic of the Collector Wind Farm.

Table 19: 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	13
Int DD	--	--	--	--	--	--	--	--	--	--	--
Int FF	--	0.2	--	0.2	0.2	--	--	--	--	--	--
Int GG	--	--	--	--	--	--	--	--	--	--	--
Int J	--	--	--	--	--	--	--	--	--	--	--
Int W	--	--	--	--	--	--	--	--	--	--	--
Int Z	--	--	--	--	--	--	--	--	--	--	--
Receiver AA	--	1.3	0.4	--	--	--	--	--	--	--	--
Receiver FF	--	--	--	--	--	--	--	--	--	--	--
Receiver Z	--	--	--	--	--	--	--	--	--	--	--

6.2.3 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 4.2.4. 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) was identified are summarised in Table 19.

An important point of distinction from tonality is that the identification of locations where noise levels are above 60 dB L_{Ceq} does not indicate that a wind farm contains a special noise characteristic. Noise levels above 60 dB L_{Ceq} would be identifiable at any wind farm site if sufficiently close to the turbines. The primary consideration for an assessment in accordance with the Project Approval and the NSW Noise Assessment Bulletin is whether noise levels above 60 dB L_{Ceq} repeatedly occur at a receiver as a result of the operation of the wind farm.

To investigate the contribution of the wind farm to the total C-weighted noise levels at the receivers, the C-weighted results at intermediate locations were analysed and extrapolated to the receivers. The results are also compared with the measured C-weighted noise levels at the receiver monitoring locations. For this purpose, it is necessary to determine the 90th percentile of the C-weighted measurement results to assess the level that is present for more than 10 % of the time (the threshold for determining whether levels above 60 dB L_{Ceq} are a repeated characteristic).

The 90th percentile C-weighted levels at the intermediate locations are summarised in Table 20. 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 20: Intermediate 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	13
Int DD	60.3	60.6	60.6	60.9	62.0	62.8	62.6	63.5	64.1	64.2	64.4
Int FF	51.5	53.9	56.4	59.4	61.5	63.7	64.5	65.5	66.3	66.3	67.0
Int GG	51.6	55.4	57.2	58.8	59.6	60.5	60.1	59.8	60.0	60.0	--
Int J	47.6	49.4	52.3	55.8	58.8	60.1	61.4	62.0	64.1	64.3	63.7
Int W	49.2	49.0	50.0	52.1	53.1	54.0	54.8	55.0	57.4	57.2	57.6
Int Z	51.1	52.4	56.0	57.7	58.6	59.4	60.9	60.9	62.8	--	--

To provide an indication of the of the reliability of C-weighted noise modelling for the site, Table 21 presents a comparison of the measured and predicted C-weighted noise levels at 10 m/s when the turbines have reached their highest noise emissions. The results generally indicate close agreement between the predicted and measured noise levels at most locations, including at the more distant location Intermediate W.

Table 21: Intermediate locations – measured and predicted dB L_{C90} at 10 m/s

Location	Measured	Predicted
Int DD	63.5	63.1
Int FF	65.5	64.9
Int GG	59.8	61.3
Int J	62.0	59.9
Int W	55.0	54.8
Int Z	60.9	64.0

The tables below present the estimated C-weighted noise levels at the receivers based on extrapolation of the 90th percentile C-weighted data at the intermediate locations. Comparisons with the measured and predicted C-weighted noise levels are also included for receivers AA, FF, and Z.

Table 22: Receiver AA - 90th percentile measured, predicted, and estimated C-weighted levels, dB L_{C90}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured post-construction	48.9	55.2	54.7	55.7	56.3	57.2	58.1	58.8	59.1	59.7	59.9
Predicted wind farm	--	--	--	--	--	--	--	56.6	--	--	--
Estimated wind farm [1]	44.2	46.6	49.1	52.1	54.2	56.4	57.2	58.2	59.0	59.0	59.7

Note: 1 Extrapolated from Intermediate FF

Table 23: Receiver FF - 90th percentile measured, predicted, and estimated C-weighted levels, dB L_{C90}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured post-construction	51.2	53.3	55.6	58.4	60.1	61.5	62.3	62.7	63.1	63.7	63.7
Predicted wind farm	--	--	--	--	--	--	--	58.3	--	--	--
Estimated wind farm [1]	45.9	48.3	50.8	53.8	55.9	58.1	58.9	59.9	60.7	60.7	61.4

Note: 1 Extrapolated from Intermediate FF

Table 24: Receiver Z - 90th percentile measured, predicted, and estimated C-weighted levels, dB L_{C90}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Measured post-construction	49.2	50.6	53.2	54.6	55.0	53.9	54.2	54.2	54.3	--	--
Predicted wind farm	--	--	--	--	--	--	--	57.9	--	--	--
Estimated wind farm [1]	46.0	47.3	50.9	52.6	53.5	54.3	55.8	55.8	57.7	--	--

Note: 1 Extrapolated from Intermediate FF

Table 25: Remaining receivers – estimated wind farm (extrapolated) 90th percentile C-weighted level, dB L_{C90}

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Receiver DD	53.2	53.5	53.5	53.8	54.9	55.7	55.5	56.4	57.0	57.1	57.3
Receiver GG	45.4	49.2	51.0	52.6	53.4	54.3	53.9	53.6	53.8	53.8	--
Receiver J	41.7	43.5	46.4	49.9	52.9	54.2	55.5	56.1	58.2	58.4	57.8
Receiver W	49.5	49.3	50.3	52.4	53.4	54.3	55.1	55.3	57.7	57.5	57.9

The results presented in Table 22 to Table 25 support that the 90th percentile C-weighted noise levels of the wind farm are generally below the 60 dB L_{Ceq} threshold. The exception is at Receiver FF from 11 to 13 m/s where the 90th percentile level is marginally higher by up to 1.4 dB.

6.2.4 Penalty adjustments

The results presented in Section 6.2.2 demonstrate that tonality is not a repeated characteristic of the wind farm.

The results presented in Section 6.2.3 support that low frequency is generally not a repeated characteristic of the wind farm in most instances. The only exception is at high wind speeds (11 to 13 m/s) at Receiver FF where the results indicate the C-weighted contribution of the wind farm may potentially be above the 60 dB L_{Ceq} threshold for marginally more than 10 % of the time. However, at these elevated wind speeds, the C-weighted data is subject to greater uncertainty as a result of the limitations of the microphone wind shield systems which are primarily designed for the reduction of wind-induced noise influences on A-weighted noise levels. This is particularly important when considering the upper range of the measurement data which is sensitive to the effects of extraneous noise sources. In this respect, an important point of context is that the upper pre-construction C-weighted noise levels at Receiver FF were also above 60 dB L_{C90} at 11 m/s and above.

In light of the above findings, penalties for special noise characteristics are not considered warranted. However, further consideration of the uncertainties relating to the C-weighted noise levels at Receiver FF for wind speeds from 11 to 13 m/s are discussed in subsequent sections.

7.0 WIND TURBINE NOISE COMPLIANCE ASSESSMENT

The following sub-sections present an assessment of compliance for each receiver where noise monitoring was conducted, in addition to the receivers represented solely by intermediate monitoring locations.

The compliance assessment is based on the estimated wind farm noise levels summarised in Section 6.1.5. In the case of the receivers represented solely by intermediate monitoring locations, the estimated wind farms noise levels at the intermediate locations have been extrapolated to the corresponding receivers.

Based on the analysis and discussion presented in Section 6.2, no special noise characteristic penalties have been applied to the estimated wind farm noise levels. However, the residual uncertainties relating to Receiver FF at high wind speeds are addressed in the concluding discussion of this section.

7.1 Receiver AA

An assessment of compliance at Receiver AA is presented in Table 26, accounting for indicative noise limits from Receiver FF to the north of Receiver AA. These limits have been referenced for indicative purposes only given the proximity of receivers AA and FF.

The results demonstrate compliance across the wind speed range by a minimum margin of 8.8 dB. Further, the estimated wind farm noise level at Receiver AA is below the minimum applicable limit of 35 dB at all wind speeds and is therefore compliant irrespective of the indicative noise limits.

Table 26: Receiver AA compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s										
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Estimated wind farm (extrapolated)	19.0	20.6	22.7	25.2	27.6	30.0	32.2	33.7	34.5	34.3	32.6
Indicative noise limit	35.0	35.0	35.0	35.0	37.0	39.0	41.0	43.0	45.0	47.0	49.0
Minimum compliance margin	16.0	14.4	12.3	9.8	9.4	9.0	8.8	9.3	10.5	12.7	16.4

7.2 Receiver FF

The results presented in Table 27 demonstrate compliance with the applicable limits across the wind speed range by a minimum margin of 6.8 dB.

Table 27: Receiver FF compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s										
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Estimated wind farm (extrapolated)	21.0	22.6	24.7	27.2	29.6	32.0	34.2	35.7	36.5	36.3	34.6
Noise limit	35.0	35.0	35.0	35.0	37.0	39.0	41.0	43.0	45.0	47.0	49.0
Minimum compliance margin	14.0	12.4	10.3	7.8	7.4	7.0	6.8	7.3	8.5	10.7	14.4

7.3 Receiver Z

The results presented in Table 28 demonstrate that compliance with the applicable limits across the wind speed range by a minimum margin of 1.3 dB.

Table 28: Receiver Z compliance assessment, dB L_{A90}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Estimated wind farm (background adjusted)	27.9	30.1	31.5	32.6	33.3	33.7	33.7	<37.8	<39.6	<41.8	42.3
Noise limit	35.0	35.0	35.0	35.0	35.0	35.0	37.0	39.0	42.0	45.0	48.0
Minimum compliance margin	7.1	4.9	3.5	2.4	1.7	1.3	3.3	>1.2	>2.4	>3.2	5.7

7.4 Receivers represented by intermediate locations

The extrapolated noise levels at receivers represented solely by intermediate locations are summarised in Table 29. The extrapolated noise levels include the addition of a +1 dB uncertainty margin, consistent with procedures described in Section 4.2.4. The analysis presented earlier in Section 6.1 established that extrapolations of the measurement data from the intermediate locations for these receivers were expected to overestimate the noise levels of the wind farm. Accordingly, the actual noise levels attributable to the operation of the wind farm are expected to be lower than those detailed in Table 29.

Notwithstanding the conservatism of these estimates, the extrapolated noise levels at all of these receivers are less than 35 dB L_{Aeq} across the wind speed range and therefore comply with the minimum applicable limit of 35 dB L_{Aeq}.

Table 29: Receivers represented by intermediate locations estimated wind farm noise level (extrapolated), dB L_{Aeq}

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Receiver DD	26.9	26.3	26.2	26.6	27.5	28.5	29.8	31.0	32.0	32.8	33.2
Receiver GG	21.9	24.4	26.3	27.6	28.7	29.7	30.4	30.9	31.5	32.1	32.5
Receiver J	<17.7	18.7	21.4	23.7	26.1	28.0	29.6	30.9	31.8	32.4	32.4
Receiver W	<18.0	19.0	21.7	24.0	26.4	28.3	29.9	31.2	32.1	32.7	32.7

7.5 Discussion

The results presented in the preceding sections demonstrate that operational wind turbine noise associated with the Collector Wind Farm complies with the Project Approval requirements.

The discussion presented previously in Section 4.2.3 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, at all locations other than Receiver FF, the estimated wind farm noise has been shown to be below 35 dB L_{Aeq} across the wind speed range. The noise levels at these receivers therefore comply with the minimum applicable limit irrespective of the wind speed; the uncertainties in the wind speed data are therefore inconsequential to the compliance outcomes for these locations.

In relation to Receiver FF, the estimated wind farm noise levels comply with the applicable limits by a significant margin of at least 6.8 dB. Given the large compliance margin, the site wind speed data would need to be around 5 m/s lower than the synthesised wind data to alter the compliance outcome. A wind speed difference of this magnitude may be plausible for individual 10-minute samples. However, a shift of the overall dataset by this magnitude is considered unlikely given that the noise level versus wind speed profile at Intermediate FF is consistent with the expected profile of the wind turbines (e.g. the noise versus wind speed profile indicates the noise level ‘plateaus’ at the expected range of wind speeds). The compliance margins at Receiver FF are therefore considered sufficient to accommodate the uncertainties of the wind data synthesis method.

The final point to consider is the finding presented in Section 6.2.4 that penalties for special noise characteristics were not considered warranted. This finding was based on tonality not being a repeated characteristic of the wind farm, and C-weighted noise levels being below 60 dB L_{Ceq} at the majority of locations and wind speeds. The exception is the potential for the C-weighted contribution of the wind farm to be above 60 dB L_{Ceq} for marginally more than 10 % of the time at Receiver FF for wind speeds from 11 to 13 m/s. Relevant factors to consider here are that the pre-construction noise levels for this location and wind speed range indicated upper noise levels above 60 dB L_{Ceq}; the upper C-weighted noise levels at these wind speeds are also prone to the influence of extraneous noise sources. However, the compliance margin at Receiver FF at these wind speeds ranges from 8.5 to 14.4 dB. Accordingly, while a penalty is not considered warranted, if a penalty were to apply at these wind speeds, the wind farm would still comply by a minimum margin of 3.5 dB.

8.0 SUMMARY

A post-construction noise compliance assessment for the Collector Wind Farm has been completed in accordance with the requirements of Condition E8 of the Project Approval.

The noise compliance assessment addressed operational noise associated with both the substation and wind turbines of the Collector Wind Farm.

The noise monitoring was conducted in accordance with the Project Approval, the NSW Noise Assessment Bulletin, the NSW Noise Policy for Industry, and the approved Operation Noise Management Plan which was prepared to address Condition E20 of the Project Approval.

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

- Noise levels associated with operation of the substation were below 30 dB L_{Aeq} at the nearest residential location (Receiver DD). Adjustments for special noise characteristics were not found to be warranted. The noise levels therefore comply the 35 dB L_{Aeq} criterion specified in Condition E7 of the Project Approval; and
- Noise levels associated with operation of the wind turbines were below the applicable noise criteria specified by Condition E6 of the Project Approval. In particular, wind turbine noise levels at the nearest residential location (Receiver FF) to the east of the wind farm were below the applicable wind speed dependent noise limits specified in the Project Approval; wind turbine noise levels at all other residential locations were below the minimum noise limit of 35 dB L_{Aeq}. Adjustments for special noise characteristics were not found to be warranted.

The findings of the monitoring and compliance assessments therefore demonstrate that the wind farm is compliant with the operational noise requirements of the Project Approval.

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[17]. 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 dBA or dB(A) are therefore not used within this report.

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

APPENDIX B SITE LAYOUT

Table 30: Wind turbine coordinates – MGA 94 Zone 54 (as built coordinates received 13 January 2021)

WTG ID	Easting, m	Northing, m	WTG ID	Easting, m	Northing, m
WTG1	718469.5	6143531.2	WTG29	718256.0	6140030.0
WTG2	718303.0	6143229.0	WTG30	717952.0	6139751.0
WTG3	718143.0	6142944.0	WTG31	717751.0	6139480.0
WTG4	718016.0	6142661.0	WTG32	718185.0	6139187.0
WTG5	717944.6	6142325.5	WTG33	718566.4	6139341.1
WTG6	717959.0	6142028.0	WTG34	719192.0	6139375.0
WTG7	717778.0	6141753.0	WTG35	718149.0	6138894.0
WTG8	717667.0	6141456.0	WTG36	717982.0	6138651.0
WTG9	717737.0	6141127.0	WTG37	718130.6	6138315.0
WTG10	717665.0	6140808.0	WTG38	718725.0	6138734.0
WTG11	717307.0	6140667.0	WTG39	719106.0	6138897.0
WTG12	717140.0	6140259.0	WTG40	717678.0	6137581.0
WTG13	716368.0	6140791.0	WTG41	717952.0	6137867.0
WTG14	716234.2	6140510.7	WTG42	717507.2	6137123.8
WTG15	716134.0	6140091.0	WTG43	717880.0	6137271.0
WTG17	716574.0	6139788.0	WTG44	717848.0	6136663.0
WTG18	718978.0	6143004.0	WTG45	719633.0	6138534.0
WTG19	718891.0	6142467.0	WTG46	719531.0	6138241.0
WTG20	718983.5	6142183.2	WTG47	719325.0	6137942.0
WTG21	718944.9	6141777.6	WTG48	719170.0	6137671.0
WTG22	720164.0	6141628.0	WTG49	718670.0	6137468.0
WTG23	718878.0	6141471.0	WTG50	718574.0	6137092.0
WTG24	718785.0	6141111.0	WTG51	718443.0	6136785.0
WTG25	718722.0	6140825.0	WTG52	718448.0	6136312.0
WTG26	719303.0	6140601.0	WTG61	719646.0	6136708.0
WTG27	718632.0	6140529.0	WTG62	719757.0	6137135.0
WTG28	718517.5	6140188.4	WTG63	719553.5	6137346.5

APPENDIX C SITE NOISE MODEL

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

- Identify the turbines to be designated as 'relevant' for each noise monitoring location (related to the turbine operations filtering described in Section 4.2.4);
- 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.

C1 Sound power levels

Sound power levels for the V117 4.2MW wind turbines were documented in the pre-construction noise assessment report[18]. The same data was used in the updated noise model (updated for the as-built turbine layout detailed in Appendix B) used to inform the post-construction compliance assessment documented in this report.

Sound power level data in the pre-construction noise assessment was originally sourced from Vestas Wind Systems A/S document No. 0067-7063 V05 *Performance Specification V117-4.0/4.2 MW 50/60 Hz Strong Wind*, dated 10 September 2018. The sound power data was adjusted by the addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The sound power levels (including the +1 dB adjustment) are summarised in Table 31 for key wind speeds and represent the total emissions of the turbines, including the secondary contribution of ancillary plant associated with the turbines (e.g. cooling fans).

Table 31: Sound power levels, dB L_{WA}

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Sound power level	93.8	93.8	95.0	98.0	101.0	103.8	106.1	107.0	107.0	107.0	107.0

The sound frequency characteristics of the turbines were originally sourced from Vestas Wind Systems A/S document No. 0067-7587 V02 *V117-4.0&4.2 MW Third octave noise emission (Strong wind & Typhoon)*, dated 3 December 2017. The reference spectrum used as the basis for this assessment is presented in Table 32 and corresponds to the highest overall sound power level presented in Table 31.

Table 32: Reference octave band sound power levels, dB L_{WA}

Description	Octave band centre frequency, Hz									
	16	31.5	63	125	250	500	1,000	2,000	4,000	8,000
Reference spectra	64.1	76.4	86.3	93.5	98.3	100.6	100.4	97.7	92.5	84.8

[18] MDA report Rp 001 R01 20180163 *Collector Wind Farm – Updated Noise Assessment* dated 30 October 2018

Sound power level data for the two 145 MVA primary transformers located in the substation at the north of the site was sourced from Australian Standard AS 60076-10:2009 *Power transformers – Part 10: Determination of sound levels* (AS 60076-10:2009) which provides a method for estimating transformer sound power levels.

The AS 60076-10:2009 estimated standard maximum sound power levels for the transformers are documented in Table 33. The sound power levels include the noise from ancillary plant such as cooling plant.

Table 33: AS 60076-10:2009 estimated maximum sound power levels

No. of transformers	Capacity per transformer, MVA	Sound power level, dB L_{WA}
2	145	96 (per transformer)

C2 Prediction method

The same noise model and general prediction method used for the wind turbines and transformers, subject to several specific settings for the wind turbine component of the noise model. The modelling was used to predicted noise levels 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 4.

Table 34: Prediction method summary

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.1
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 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* (UK 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 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: 0.5 m interval contour data acquired from an aerial survey of the site (LIDAR) in July 2013 Surrounding environs: 10 m interval contour data sourced from the NSW Department of Lands and Property Information (data sourced 21 July 2015)
Terrain effects	Terrain adjustment applied in accordance with the UK good practice guide.
Ground conditions	The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The following G values were selected to provide a cautious representation of ground effects: • A-weighted noise modelling: G = 0.5 (50 % soft ground) • C-weighted noise modelling: G = 0.0 (0 % soft ground / entirely reflective)
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 UK good practice guide. The calculations are based on sound speed profiles[19] which increase the propagation of sound from each 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 turbine and the approach is therefore conservative in these instances.
Receiver heights	1.5 m AGL
Uncertainty	A margin of +1 dB was applied to the wind turbine sound power data to account for typical test uncertainties. Per the ONMP, ±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).

[19] The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

APPENDIX D RELEVANT TURBINES SCHEDULE

Table 35: Number of relevant and non-relevant turbines

Turbines	AA	FF	Z	Int DD	Int FF	Int GG	Int J	Int W	Int Z
Non-relevant turbines	45	49	47	14	30	36	30	46	39
Relevant turbines	9	5	7	40	24	18	24	8	15

Table 36: Predicted noise levels, dB L_{Aeq} (the annotation "(R)" indicates a relevant turbine)

Description	AA	FF	Z	Int DD	Int FF	Int GG	Int J	Int W	Int Z
Total	33.4	35.4	34.9	44.7	46.3	41.3	39.1	29.9	44.3
Non-relevant turbines	17.9	19.4	19.5	29.7	31.0	26.1	23.8	14.5	28.9
Relevant turbines	33.2	35.3	34.8	44.5	46.1	41.1	39.0	29.8	44.2
WTG01	7.7	12.7	10.1	41.4 (R)	13	15.2	7.3	5.1	13.4
WTG02	8	13	10.8	38.3 (R)	13.5	16.2 (R)	7.7	5.4	14.3
WTG03	8.3	16.3 (R)	11.6	34.4 (R)	14.1	17.2 (R)	11.2	5.6	15.2
WTG04	8.5	13.6 (R)	12.3 (R)	31.2 (R)	14.6	18.1 (R)	8.7	5.9	16.1
WTG05	9	14 (R)	13 (R)	28.2 (R)	15.4	19.1 (R)	9.2	6.3 (R)	17.2
WTG06	9.5 (R)	14.5 (R)	13.6 (R)	26.1 (R)	16.2	19.7 (R)	9.8	6.7 (R)	18.2
WTG07	9.6 (R)	14.6 (R)	14.5 (R)	24.2 (R)	16.6	21 (R)	8.3	7 (R)	19.3
WTG08	9.8 (R)	14.7 (R)	15.4 (R)	22.4 (R)	17.2	22.1 (R)	8.8	7.3 (R)	20.6 (R)
WTG09	10.4 (R)	15.3 (R)	16 (R)	20.8 (R)	18.2	22.4 (R)	9.5	7.8 (R)	22.1 (R)
WTG10	10.7 (R)	15.5 (R)	17 (R)	17.4	18.8	23.1 (R)	10.2	8.2 (R)	23.9 (R)
WTG11	10.1 (R)	14.6 (R)	18.1 (R)	18.6	18.2	25.4 (R)	10.3	8.1 (R)	25.1 (R)
WTG12	10.2 (R)	14.5 (R)	19.7 (R)	15.1	18.5	26.5 (R)	11.1	8.5 (R)	27.9 (R)

Description	AA	FF	Z	Int DD	Int FF	Int GG	Int J	Int W	Int Z
WTG13	8.2	12.2	19.5 (R)	17.8	15.4	33 (R)	9.2	5	23.2 (R)
WTG14	8.2	12.1	20.9 (R)	16.7	15.5	35.3 (R)	9.6	5.2	24.4 (R)
WTG15	8.3	12	23.1 (R)	15.5	15.7	35.3 (R)	10.3	5.6	26.3 (R)
WTG17	9.4 (R)	13.2 (R)	23.2 (R)	15.2	17.3	29.6 (R)	11.5	6.5 (R)	30.3 (R)
WTG18	9.2	14.6 (R)	10.4	31.1 (R)	14.6	15	8.2	6	14.3
WTG19	10.1 (R)	15.7 (R)	11.5	25.9 (R)	16.1	16.1 (R)	9.1	6.7 (R)	15.9
WTG20	10.7 (R)	16.5 (R)	11.8	23.7 (R)	17.1	16.3 (R)	9.7	7.1 (R)	16.5
WTG21	11.5 (R)	17.4 (R)	12.5 (R)	21.5 (R)	18.4	16.9 (R)	10.5	7.7 (R)	17.8
WTG22	13.8 (R)	21.1 (R)	10.5	17.4	19.5	11.4	10.5	8.6 (R)	15.5
WTG23	12 (R)	17.9 (R)	13.2 (R)	20.1 (R)	19.3	17.4 (R)	11.1	8.2 (R)	18.8
WTG24	12.5 (R)	18.3 (R)	14 (R)	18.5	20.5 (R)	18 (R)	11.9	8.7 (R)	20.2 (R)
WTG25	12.9 (R)	18.6 (R)	14.6 (R)	17.4	21.6 (R)	18.4 (R)	12.6	9.1 (R)	21.5 (R)
WTG26	16.6 (R)	21.2 (R)	13.7 (R)	16	24.1 (R)	16.5 (R)	13.1 (R)	9.9 (R)	20.4 (R)
WTG27	15.2 (R)	18.8 (R)	15.3 (R)	16.4	22.7 (R)	18.8 (R)	13.3 (R)	9.5 (R)	23.1 (R)
WTG28	13.5 (R)	18.8 (R)	16.2 (R)	15.3	23.7 (R)	19.2 (R)	14.1 (R)	10 (R)	25.1 (R)
WTG29	13.1 (R)	18 (R)	17.2 (R)	14.8	23.2 (R)	20.1 (R)	14.5 (R)	10 (R)	27 (R)
WTG30	12.7 (R)	17.1 (R)	18.6 (R)	13.9	22.7 (R)	21.2 (R)	13.1 (R)	10.2 (R)	30.4 (R)
WTG31	12.4 (R)	16.5 (R)	19.7 (R)	13.1	22.3 (R)	21.7 (R)	13.6 (R)	10.4 (R)	34 (R)
WTG32	15.9 (R)	18 (R)	18.7 (R)	12.3	25.3 (R)	19.4 (R)	16.9 (R)	11.4 (R)	32.3 (R)
WTG33	16.8 (R)	19.4 (R)	17.3 (R)	12.7	27.4 (R)	18.3 (R)	16.6 (R)	11.6 (R)	28.5 (R)
WTG34	18.8 (R)	22.3 (R)	15.4 (R)	12.5	31.7 (R)	14.4	16.6 (R)	12.2 (R)	24.3 (R)

Description	AA	FF	Z	Int DD	Int FF	Int GG	Int J	Int W	Int Z
WTG35	16 (R)	17.8 (R)	19.2 (R)	11.5	25.5 (R)	19 (R)	17.8 (R)	11.9 (R)	33.7 (R)
WTG36	15.7 (R)	17.1 (R)	20.1 (R)	10.9	24.6 (R)	19.1 (R)	18.5 (R)	12.1 (R)	36 (R)
WTG37	16.2 (R)	17.3 (R)	19.7 (R)	10.1	25.3 (R)	17.9 (R)	19.9 (R)	12.9 (R)	33 (R)
WTG38	18 (R)	19.8 (R)	17.3 (R)	11	30.1 (R)	15	18.8 (R)	13 (R)	28.3 (R)
WTG39	19.1 (R)	21.6 (R)	16 (R)	11.3	33.6 (R)	14.1	18.2 (R)	13.2 (R)	25.5 (R)
WTG40	14.9 (R)	15.2 (R)	21.6 (R)	8.5	21.6 (R)	17.2 (R)	22 (R)	11.3 (R)	30.4 (R)
WTG41	15.7 (R)	16.3 (R)	20.4 (R)	9.1	23.6 (R)	17.3 (R)	21.4 (R)	13.4 (R)	31.5 (R)
WTG42	14.3 (R)	14.2 (R)	21.8 (R)	7.6	19.9	16.3 (R)	23.4 (R)	13.6 (R)	27.1 (R)
WTG43	15.4 (R)	15.3 (R)	20.3 (R)	7.9	21.7 (R)	16 (R)	24.1 (R)	14.2 (R)	27.4 (R)
WTG44	14.9 (R)	14.3 (R)	19.5 (R)	6.7	19.9	14.6	27 (R)	15 (R)	23.6 (R)
WTG45	21.8 (R)	23.8 (R)	14.7 (R)	10.1	43 (R)	12.3	19.4 (R)	14.7 (R)	22.3 (R)
WTG46	21.5 (R)	22.6 (R)	15 (R)	9.6	38.2 (R)	12.2	20.6 (R)	15.3 (R)	22.7 (R)
WTG47	20.6 (R)	20.9 (R)	15.6 (R)	9	33.3 (R)	12.3	22.3 (R)	15.7 (R)	23.3 (R)
WTG48	19.9 (R)	19.7 (R)	16.1 (R)	8.5	30.1 (R)	14.2	23.8 (R)	16.1 (R)	23.4 (R)
WTG49	18 (R)	17.8 (R)	17.6 (R)	8.2	26.2 (R)	14.9	24.9 (R)	15.5 (R)	25.2 (R)
WTG50	17.4 (R)	16.8 (R)	17.6 (R)	7.5	24.1 (R)	14.3	27.2 (R)	16.1 (R)	23.9 (R)
WTG51	16.7 (R)	18.9 (R)	17.7 (R)	7	22.3 (R)	13.9	29.1 (R)	16.3 (R)	22.9 (R)
WTG52	19.2 (R)	18 (R)	17 (R)	6.1	20.4 (R)	13	33 (R)	17.2 (R)	20.8 (R)
WTG61	20.7 (R)	21.5 (R)	14.2 (R)	6.6	24.9 (R)	11.8	29.7 (R)	19.7 (R)	19
WTG62	22.1 (R)	20 (R)	14.2 (R)	7.3	28 (R)	10.2	26.3 (R)	18.7 (R)	19.6
WTG63	21.4 (R)	20.1 (R)	14.8 (R)	7.7	29.3 (R)	10.9	25.4 (R)	17.7 (R)	20.8 (R)

APPENDIX E PROJECT APPROVAL CONDITIONS

This Appendix reproduces the Project Approval[20] requirements concerning environmental noise and relevant correspondence from the Department of Planning, Industry and Environment (DPIE).

E1 Project Approval

The Project Approval text is coloured to indicate modification approval changes, as per the legend reproduced from the Project Approval in **Figure 9**.

Figure 9: Project Approval extract – legend of text colours identifying modification approval changes

Red type represents 22 July 2016 modification (MOD 1)
Green type represents 15 May 2019 modification (MOD 2)
Blue type represents 16 August 2019 modification (MOD 3)

[20] The modified Project Approval refers to the Project Approval (Application No.: 10_0156) dated 2 December 2013 as amended by notices of modification dated 22 July 2016 (MOD 1), 15 May 2019 (MOD 2), and 16 August 2019 (MOD 3).

Figure 10: Project Approval extract – conditions E6 to E9

NOISE

Operational Noise Criteria – Wind Turbines

E6. The Proponent shall ensure that the noise generated by the operation of wind turbines does not exceed the relevant criteria in Table 4 at any non-associated residence.

Table 4 – 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**	**13**
FF	35	35	35	35	37	39	41	43	45	47	49
All other non-associated residences	The higher of 35 dB(A) or the existing background noise level ($L_{A90\ (10\text{-}minute)}$) plus 5 dB(A)										

Note: To identify the residences referred to in Table 4, see the figure in Attachment 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 Attachment 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.

Operational Noise Criteria – Ancillary Infrastructure

E7. The Proponent shall 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 project 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 Attachment 4.

Noise Monitoring

E8. Within 3 months of the commencement of operations, unless otherwise agreed by the Secretary, the Proponent shall:

(a) undertake noise monitoring to determine whether the project is complying with the relevant conditions of this approval; and

(b) submit a copy of the monitoring results to the Department and the EPA.

E9. The Proponent shall undertake further noise monitoring of the project if required by the Secretary.

Figure 11: Project Approval extract – Attachment 4 – noise compliance assessment requirements

ATTACHMENT 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 4 of the conditions are to apply under all meteorological conditions.

Applicable Meteorological Conditions – Other Facilities

2. The noise criteria in Condition E7 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 °C and 3°C/100m and wind speeds greater than 2 m/s at 10 m above ground level; or
    c) temperature inversion conditions greater than 3°C/100m.

Figure 12: Project Approval extracts – Attachment 5 statement of commitments – operational noise

Item	Impact	Objectives	Mitigation Task	Responsibility	Project Phase C	O	D
			contacted to identify the source of noise and suitable mitigation measures that may be required.				
2.09	Operational Noise	Turbine model / layout noise assessment	A revised noise assessment will be prepared for the final turbine model and layout, prior to commissioning to the wind farm.			✓	
2.10	Operational Noise	Reduction of turbine numbers as required	The wind farm layout will be determined by compliance of the chosen turbine model with the noise criteria applicable to the development, as outlined in the conditions of approval. If required, non-compliant turbines will be removed from the layout.	Proponent	✓	✓	
2.10A	Operational Noise	Monitor compliance with noise criteria	Within three months of commissioning, noise compliance monitoring would be undertaken to assess compliance with noise criteria.	Proponent		✓	
2.11	Operational Noise	Address any non-compliance with noise criteria	Where operational noise monitoring indicates the Proposal exceeds noise limits set in the development approval conditions, the following noise mitigation measures shall be implemented to achieve compliance. • using active noise control functions of turbines; • rectify any manufacturing defects or control settings so that noise can be reduced; or • if excesses still occur, acoustic treatment of non-involved receiver dwellings.	Proponent		✓	
2.12	Operational Noise	Monitoring the effectiveness of operational noise mitigation measures	Should any of the measures in item 2.12 be adopted, their effectiveness will be verified through noise monitoring in the first 12 months following the implementation of mitigation measures.			✓	
9.0	Health and Safety						
9.01	Wind farm noise	Manage community concerns with respect to wind farm noise	The Proponent will establish a complaints management system to respond to noise complaints from the community.	Proponent		✓	

E2 DPIE approval of time period for completion of compliance testing and reporting

NSW GOVERNMENT | Planning, Industry & Environment

Mr Neil Weston
Project Manager
RATCH-Australia Corporation Pty Limited
Level 7, 111 Pacific Highway,
North Sydney NSW 2060 Australia

18/01/2021

Dear Mr Weston

Project Approval MP10_0156 - Collector Wind Farm
Extension of Time for Noise Monitoring-Condition E8

I refer to your request MP10_0156-PA-10 for an extension of time for Noise Monitoring as required under condition E8 of MP10_0156 (the approval) for the Collector Wind Farm (the project).

The Department notes the reasons justifying the request provided in the letter dated the 12 January 2020.

Accordingly, the Planning Secretary grants an extension of time from 3 months to 5 months, from the commencement of operations, for the Proponent to;
(a) Undertake noise monitoring to determine whether the project is complying with the relevant conditions of the approval; and
(b) Submit a copy of the monitoring results to the Department and the EPA

If you wish to discuss the matter further, please contact myself on 0429400261 or at katrina.oreilly@planning.nsw.gov.au

Yours sincerely

Katrina O'reilly
Team Leader - Compliance
As nominee of the Planning Secretary

4 Parramatta Square, 12 Darcy Street, Parramatta 2150 | dpie.nsw.gov.au | 1

E3 DPIE approval of ONMP

Planning, Industry & Environment

Mr Neil Weston
Development Manager
Ratch Australia Developments Pty Ltd
Level 7
111 Pacific Highway
North Sydney, NSW, 2060

14/04/2021

Dear Mr Weston,

Collector Wind Farm (MP10_0156)
Operation Noise Management Plan

I refer to the Operation Noise Management Plan which was submitted in accordance with condition E20 of Schedule B of the approval for the Collector Wind Farm (MP10_0156).

The Department has carefully reviewed the document and is satisfied that it is generally consistent with the relevant conditions of consent.

Accordingly, the Planning Secretary has approved the Operation Noise Management Plan (Revision 2, dated 13 April 2021). Please ensure that the approved plan is placed on the project website at the earliest convenience.

If you wish to discuss the matter further, please contact Callum Firth at callum.firth@dpie.nsw.gov.au.

Yours sincerely

Nicole Brewer
Director
Energy Assessments

As nominee of the Planning Secretary

4 Parramatta Square, 12 Darcy Street, Parramatta 2150 | dpie.nsw.gov.au | 1

E4 DPIE approval of survey extension request September 2021

Neil Weston
Project Manager
RATCH Australia Corporation
Level 7, 111 Pacific Highway
North Sydney New South Wales 2060
Via email: neil.weston@ratchaustralia.com

10/09/2021

Dear Mr Weston

Collector Wind Farm (MP10_0156)
Extension of Time to complete Operational Noise Monitoring

I refer to your letter dated 11 August 2021 for a further extension of time to complete the Operational Noise Monitoring assessment as required under the Condition E8 of the project approval for the Collector Wind Farm (MP10_0156).

The Department notes that, although the noise monitoring period was extended on 18 January 2021 to a period of five months, the operational noise monitoring requires a further extension due to the following:

- less than 50% of noise monitoring data gathered has been validated through the screening process defined in the approved Operational Noise Management Plan;
- high levels of rainfall during the noise monitoring period have elevated background noise levels;
- turbine T51 was not operational for much of the noise monitoring programme due to an ongoing fault which has only recently been rectified;
- one of the nine noise monitoring stations has recently been found to be non-operational and replacement of the unit is not currently possible due to the COVID-19 public health orders, which restricts travel from Greater Sydney to NSW regional areas; and
- the continuing COVID-19 public health orders may create further delay in completing the noise monitoring assessment.

Accordingly, the Planning Secretary has granted an extension until 15 December 2021 to complete the operational noise monitoring assessment.

If you wish to discuss the matter further, please contact Natasha Homsey at natasha.homsey@planning.nsw.gov.au or on 02 8275 1264.

Yours sincerely

Nicole Brewer
Director
Energy Assessments
As nominee of the Planning Secretary

4 Parramatta Square, 12 Darcy Street, Parramatta 2150 | dpie.nsw.gov.au | 1

E5 DPIE approval of survey extension request December 2021

NSW GOVERNMENT | Planning, Industry & Environment

Mr Neil Weston
Project Manager
RATCH-Australia Developments Pty Ltd
Level 7, 111 Pacific Highway
North Sydney New South Wales 2060
07/12/2021

Dear Mr Weston

Collector Wind Farm - (MP10_0156)
Noise Monitoring Report extension request

I refer to your letter (MP10_0156-PA-19) requesting an extension of time to submit the Noise Monitoring Report for Collector Wind Farm (the project) as required under E8 of MP10_0156 (the approval).

The Department has reviewed your letter and accompanying information from Marshall Day Acoustics, dated 11 November 2021, and notes the reasons justifying the request. The Department has also liaised with the Environmental Protection Authority (EPA) who stated they had no objections to an extension being granted.

Accordingly, the Secretary has granted an extension of time until 25 February 2022 to submit the Noise Monitoring Report.

If you wish to discuss the matter further, please contact me on 0429400261 or at katrina.oreilly@planning.nsw.gov.au

Yours sincerely

Katrina O'Reilly
Team Leader - Compliance
Compliance
As nominee of the Secretary

APPENDIX F SURVEY INSTRUMENTATION

Table 37: Sound level measurement instrumentation summary

Item	Description
Equipment type	Automated/unattended integrating sound levels
Make & model	01dB CUBE & DUO
Instrumentation class	Class 1 (precision grade) in accordance with AS/IEC 61672.1:2019[21]
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

[21] 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 38: Sound level meter installation records

Monitoring location	System	Unit serial number	Microphone serial number	Independent calibration date [1]	Calibration drift [2,3]	Deployment date	Retrieval date
AA	01dB CUBE	10656	217460	28/04/2020	+0.31	10/06/2021	14/12/2021
FF	01dB CUBE	11277	292302	3/02/2020	-0.22	10/06/2021	14/12/2021
Z	01dB DUO	10419	144877	3/06/2021	-0.22	10/06/2021	29/10/2021
	01dB DUO	10496	141230	31/07/2020	+0.35	29/10/2021	14/12/2021
Int DD	01dB CUBE	11917	330738	9/09/2021	-0.93	09/06/2021	19/08/2021
	01dB CUBE	10655	217555	23/06/2021	+0.44	19/08/2021	15/12/2021
Int FF	01dB CUBE	11283	292442	20/02/2020	-0.07	10/06/2021	15/12/2021
Int GG	01dB DUO	10315	231546	27/05/2021	-0.40	09/06/2021	20/08/2021
	01dB DUO	10194	136832	25/11/2020	+0.38	20/08/2021	14/12/2021
Int J	01dB DUO	10302	446470	6/11/2021	-0.23	09/06/2021	07/07/2021
	01dB CUBE	11877	330712	25/08/2021	+0.20	07/07/2021	28/10/2021
	01dB CUBE	10518	207205	24/05/2021	+0.77	28/10/2021	15/12/2021
Int W	01dB CUBE	10513	255767	2/06/2021	-0.40	10/06/2021	14/12/2021
Int Z	01dB DUO	10417	144861	13/02/2020	+0.37	10/06/2021	20/08/2021
	01dB CUBE	10523	207224	23/06/2021	+0.74	20/08/2021	28/10/2021
	01dB CUBE	10512	255851	24/02/2021	+0.53	28/10/2021	15/12/2021

Note 1: Independent (laboratory) calibration date to be within 2 years of measurement period as per AS 1055:2018[22]
Note 2: Difference between reference level checks during deployment and collection of instruments
Note 3: Calibration drift should not be greater than 1 dB as specified in AS 1055:2018

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

The reference calibration checks were conducted using 01dB-Stell CAL21 and CAL31 calibrators during deployment and retrieval of the monitors.

Table 39: Wind speed measurement instrumentation

Wind speeds	Description
Local wind speeds	Vaisala WXT 520 Serial No. H5010003 (Deployed for entire survey period 10/06/2021 - 14/12/2021) Vaisala WXT 520 Serial No. M4511092 (Deployed for period 09/06/2021 – 20/08/2021. Demobilised due to animal damage) Vaisala WXT 520 Serial No. K4120002 (Deployed for remaining survey period 20/08/2021 – 14/12/2021)
Site wind speeds	De-waked site wind speed data provided by RAC. Further information provided in Appendix G.

APPENDIX G SITE WIND DATA

G1 Data sources

Details of the wind data sources provided for the noise monitoring period are summarised in Table 40.

Table 40: Site wind data sources

Item	Description
Extrapolated wind speed data files	The following data files were provided for the analysis: • Filename: *10269392_PC02_CS4_WakeFreeSynth_20220114.csv* (received 14 Jan 2022) • Filename: 10269392_PC02_CS4_WakeFreeSynth_20220211.csv (received 11 Feb 2022) Separate DNV correspondence (email dated 20 Jan. 2022) also confirmed the synthesised wind data correspondence to hub height (91.5 m above ground level)
Time series	The timestamp of the data series was confirmed to represent the start of each 10-minute period (see correspondence reproduced in this Appendix). Separate DNV correspondence (email dated 20 Jan. 2022) also confirmed the data time zone to be UTC + 10 (Australian Eastern Standard Time).

G2 DNV correspondence – CS4 data synthesis procedures

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

Neil Weston
RATCH Australia Corporation Pty Limited
Level 7, 111 Pacific Highway
North Sydney NSW 2060
Australia

DNV – Energy Systems
Project Development & Analytics
Level 12, 350 Queen Street
Melbourne VIC 3000
Tel: +61 3 8615 1515
ABN: 14 154 635 319

Date:
24 February 2022

Our reference:
10269392-AUME-L-03-B

Re: Collector Wind Farm Wake-Free Time Series DRAFT

Dear Neil Weston,

DNV Australia Pty Ltd (DNV) has been requested by RATCH Australia Corporation Pty Ltd ("the Customer") to create a wake-free time series (WFTS) at the location of the CS4 pre-construction mast at Collector Wind Farm (CWF).

As Mast CS4 was decommissioned during construction of the wind farm, and prior to the installation of the two power-performance (or power curve verification, PCV) masts currently in operation at the site (PCV01 and PCV02), there is no overlapping/concurrent data available between CS4 and the PCV masts. Due to this key limitation two potential wind data synthesis methodologies have been investigated and assessed for expected uncertainty.

The first methodology (A) investigated has involved synthesising a modelled WFTS from the two masts PCV01 and PCV02. The second approach (B) has leveraged turbine nacelle wind speed data from all 54 turbines in operation at CWF to generate an ensemble of wind speed and direction predictions.

For both methodologies it has been necessary to rely on wind flow modelling and results from the most recent energy production assessment (EPA)[1] to establish relationships between wind data at the two power-performance masts and the turbines, to the pre-construction mast.

Wind Data Inputs

The Customer has provided DNV with wind data from the two PCV masts. A brief description of the mast data is detailed below:

- PCV01: Wind direction data has been provided from 9th June 2021 to 15th December 2021. Wind speed data has been provided from 18th June 2021 to 15th December 2021.
- PCV02: Wind direction and wind speed data has been provided from 9th June 2021 to part of 6th December 2021.

Additionally, DNV has been provided with wind data from all turbines, which included nacelle anemometer and wind vane measurements from 9th June 2021 to 15th December 2021.

Data Synthesis Methodology

Synthesis from PCV Masts (A)

The wind speed time series at the two parallel anemometers of each mast were combined on a directional basis in order to mitigate flow disturbance from the mast structure.

[1] DNV, "Energy Production Assessment for the Collector Wind Farm", Document 10269392-AUME-T-01-A, 03 March 2021

DNV

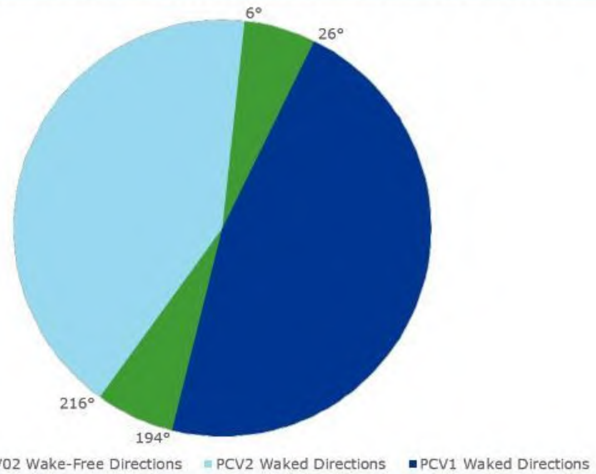
The wind flow model from the most recent EPA was used to estimate the long-term mean wind speed at Masts PCV01 and PCV02 based on blended prediction from the different measurement locations. These predictions were informed by analysis of measurements from wind monitoring devices installed across the site, and wind flow modelling across the site using the WAsP wind flow model with a directional resolution of 30° (12 sectors). This information was used to establish overall/all-directional wind speed ratios (or speed ups) between the CS4, PCV01 and PCV02 masts which were used as a reference for subsequent work detailed below.

However, in an effort to improve the accuracy of wind data synthesised at CS4, DNV conducted supplementary modelling with an increased directional resolution of 10° (36 sectors) to define the directional wind speed ratios (or speed ups) between Mast CS4 and Masts PCV01/PCV02. These were then adjusted to be consistent with the all-directional speed up produced from the model used in the recent EPA.

The resulting speed ups were then used to synthesise a wind speed time series at Mast CS4 based on the wind speed and direction measurements from Masts PCV01 and PCV02.

As the measurements from Masts PCV01 and PCV02 are expected to be affected by the wake of the surrounding turbines for certain wind direction sectors, DNV has used the wind farm model built for the previous EPA to model wakes from CWF and identify wake-free sectors for each mast. For this process, wake effects were assessed with a directional resolution of 2° (180 sectors). The modelled wake affected sectors for Masts PCV01 and PCV02 are illustrated in Figure 1.

Figure 1 Modelled wake affected sectors for Masts PCV01 & PCV02



The wake-free direction sectors illustrated above were used to define, for each 10-minute period, which of the two synthesised wind speed time series should be used. For cases where no wake effects were modelled at both masts, the two wind speed predictions were averaged. A similar approach was also used to assemble the wind direction time series, using the measured wind direction at either mast, or an average of the two measurements.

Synthesis from Wind Turbines (B)

DNV

The Customer has provided DNV with turbine nacelle wind speed and direction data for all turbines, and a series of adjustments have been applied to generate an ensemble of synthesised time series of wind speeds and directions at the location of the CS4 PCM.

1. Firstly, a nacelle anemometer transfer function was generated from the average of the transfer functions calculated from the three available Power Performance tests. This function was then applied to the measured wind speeds in order to remove the impact of the turbine on the nacelle anemometer wind speed measurements such that it approximately resembles a windspeed measured upstream of the turbine.
2. The wind farm model built for the most recent EPA was then used to predict wake effects, and estimate correction factors that could be used to remove surrounding wind turbine wake impacts on each nacelle anemometer's measurements.
3. Directional wind speed ratios (or speed ups) between each turbine location and CS4 PCM were extracted from the Project's wind flow model in order to synthesise windspeeds at CS4 from the predicted free-stream wind speeds at each turbine location.

The outcome of the process outlined above is an ensemble of 54 (one for each turbine) WFTS predictions at CS4. The time series provided along with this document was produced from the 10-minute median wind speed and wind directions predicted from all the turbines.

Uncertainty

DNV notes that the overall uncertainty of both WFTS created should be considered very high and, as such, used with caution. To assist with the interpretation of the accuracy of the two WFTS derived, DNV has made an attempt to quantify the uncertainties associated with both methodologies.

Synthesis from Power-Performance Masts (A)

Wind speeds at mast CS4 are subject to high uncertainty due to the following limitations:

- As there is no overlapping/concurrent data between the pre-construction mast and power-performance masts, there has been no previous relationship established between measurements at Mast CS4, and Masts PCV01 and PCV02. The wind speed relationships, and therefore the synthesised wind speeds, are solely based on relationships derived from previous analyses and wind modelling.
- The impact of wind turbine wakes on the synthesis process was mitigated by the approach outlined earlier in this document, but wind farm level blockage effects are still likely to affect the measurements at Masts PCV01 and PCV02.

Given these key limitations, the synthesis process used above is nonetheless considered a reasonable approach. The following uncertainty estimates are based on uncertainties associated with the modelling process used and a review of predicted wind speeds:

- Based on internal modelling, uncertainties associated with *annual average* wind speeds predicted at CS4 based on measurements from the PCV masts are estimated to be approximately 10% (one standard deviation). This was derived from expected uncertainties associated with measurement accuracy and spatial extrapolation.
- For wind directions where there were no wake effects expected at either PCV mast, the synthesised wind speeds at CS4 derived from PCV01 and PCV02 were compared. For these directions, the synthesised wind speeds from both PCV masts are expected to be similar. From

the differences observed in these wind speeds, a standard deviation of approximately 40% was calculated, which may provide a guide to the level of uncertainty associated with any single *10-minute average* wind speed synthesised at CS4. Additionally, it should be noted the sample size of this analysis was small and hence this uncertainty figure may not be representative.

Therefore, based on the information above, DNV expects that the uncertainty associated with *annual average* wind speeds synthesised at CS4 could be in the order of approximately 10% (implying a 95% confidence interval of ±20%), however uncertainties associated with *annual average* wind speeds for *specific wind direction sectors* are expected to be higher than 10%. Further, the uncertainty for a given *10-min average* wind speed <u>may be as high as 40%</u> (implying a 95% confidence interval of ±80%).

Synthesis from Wind Turbines (B)

The uncertainty estimates of this approach are based on uncertainties associated with modelling, measurements, as well as a statistical analysis of the synthesised wind speed time series, as described below:

- Uncertainties associated with any single *annual average* wind speed synthesised at CS4 based are estimated to be approximately 10% (one standard deviation), implying a 95% confidence interval of ±20%.
- Uncertainties associated with any individual *10-minute average* wind speeds synthesised at CS4, are estimated to range between approximately 10% and 30%, implying a 95% confidence interval of ±20% to ±60%.

Based on the information above, DNV note that, although the uncertainty associated with *annual average* wind speeds for the two proposed WFTS approaches are of a similar magnitude, the uncertainty of individual 10-minute predictions is expected to be improved by the ensemble approach using synthesis from the wind turbines (B).

Comparison of Wake Free Time Series

The WFTS created from the two approaches were compared to ensure relative agreement. Sample data periods are shown in Figure 2, and these periods illustrate that the WFTS resulting from approach A (WFTS-A) typically falls within two standard deviations (representing a 95% confidence interval) of the one derived from approach B (WFTS-B).

It is noted the standard deviations presented in Figure 3 reflect the statistical variation of the ensemble of synthesised time series, and do not include other potential contributions to the uncertainty associated with the time series.

Figure 3 shows the bias expressed as a percentage for each 10° direction sector. This has been calculated by subtracting the average wind speed for a given bin for WFTS-A from WFTS-B, and expressing it as a percentage relative to WFTS-B. As seen in Figure 2, the bias between the two WFTS is calculated to be as large as approximately -20%, peaking around wind directions from 60°-90°, with an average of approximately -9%.

DNV

Figure 2 Comparison of WFTS-A and WFTS-B (with confidence intervals shown).

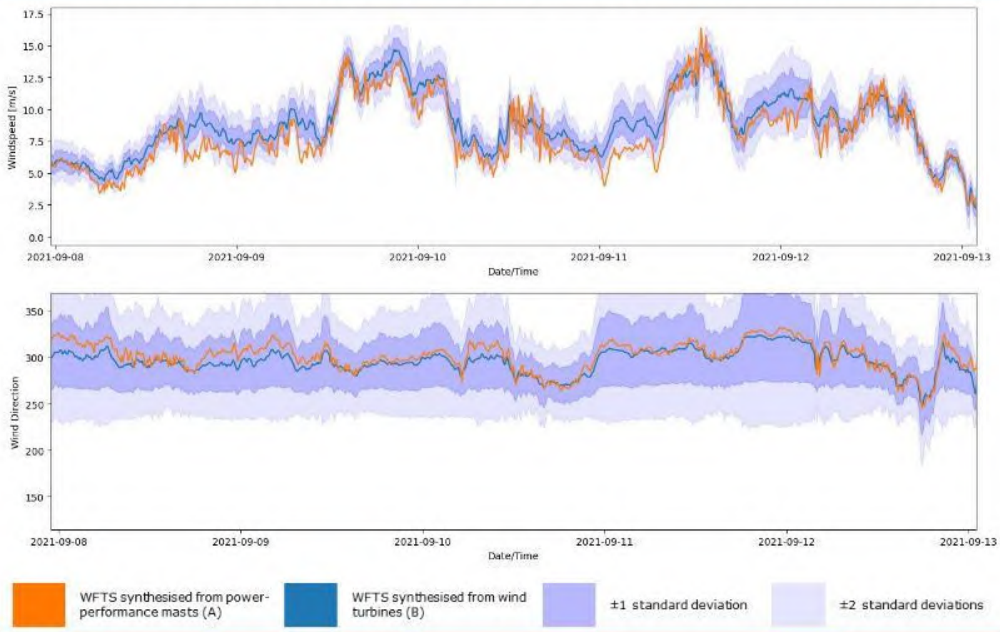
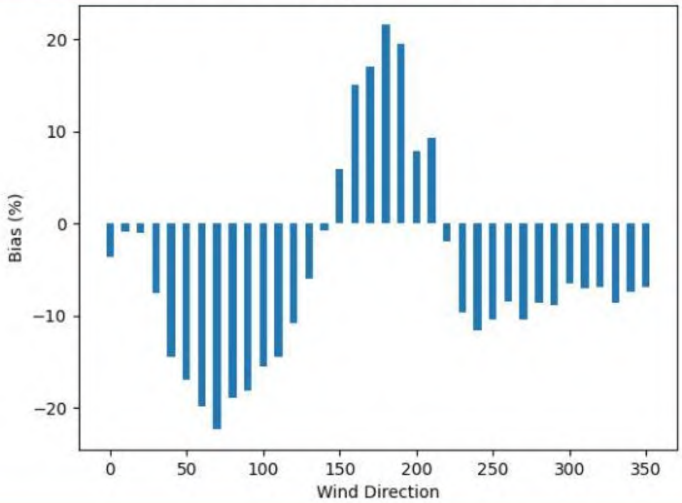


Figure 3 Bias of wind speed differences by wind direction (WFTS A minus WFTS B).



DNV

Summary

The two WFTS consisting of modelled wind speed and direction time series at Mast CS4 resulting from the processes described above were provided to the Customer along with this document. The modelled wind speeds are at hub height (91.5 metres). The timestamps used by the time series are representative of the start of each 10-min averaging period, with the time zone being at local time (Australian Eastern Standard Time).

Comparisons between the two WFTS show them to be in broad agreement, although with notable biases for some direction sectors and overall. Uncertainties associated with individual 10-minute averages generated via method B were estimated to be lower than for method A, however the uncertainty associated with annual averages is expected to be of similar magnitude for both approaches. Regardless, both time series should be treated as highly uncertain due to limitations outlined earlier in this document.

Sincerely
for DNV Australia Pty Limited

Victoria Lau
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Project Development & Analytics
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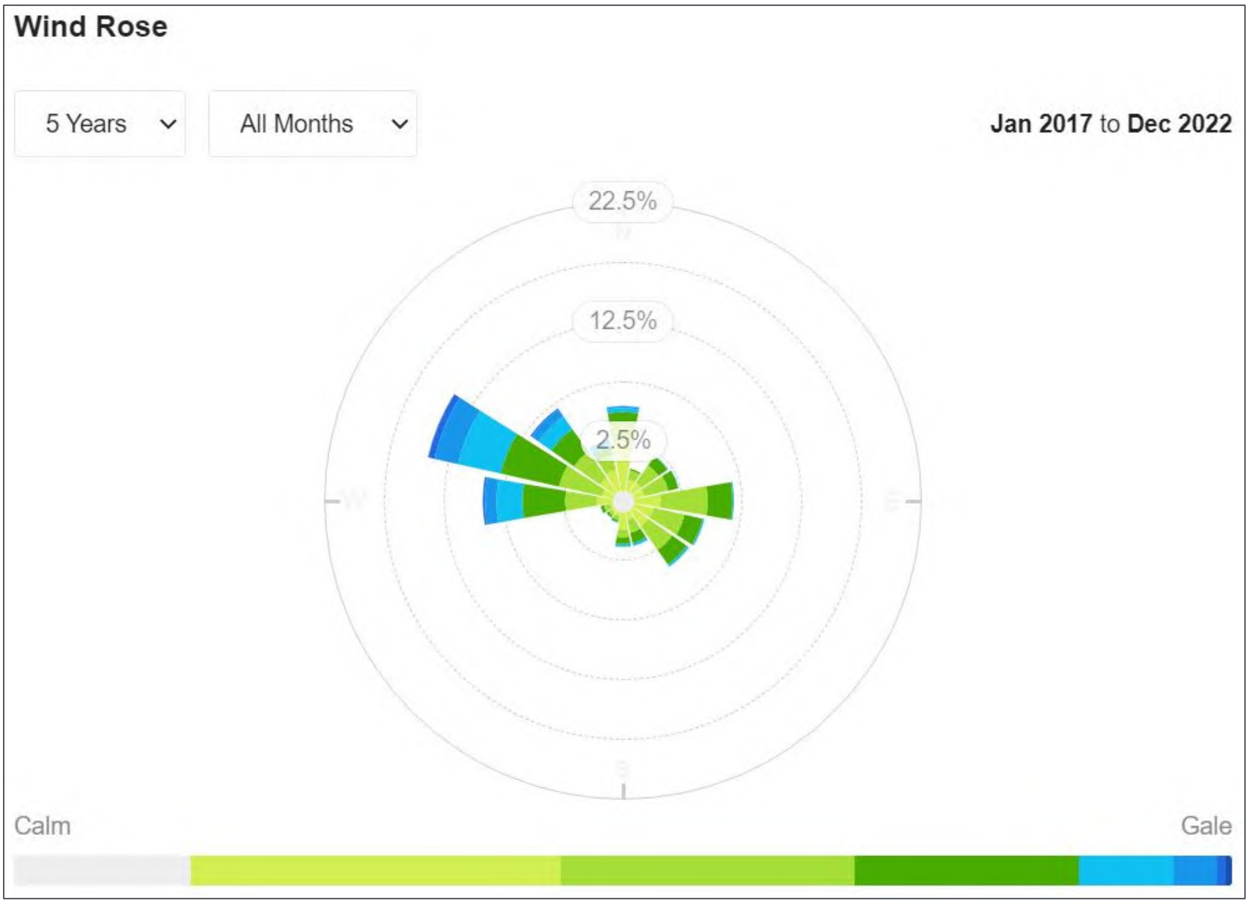
G3 Site wind speed and direction trends

G3.1 Broader area historic trend data

An indication of the general longer-term trend of wind speeds in the wider area, the following wind rose depicts wind speeds and directions over a 5-year period at the Goulburn airport, sourced from WillyWeather.

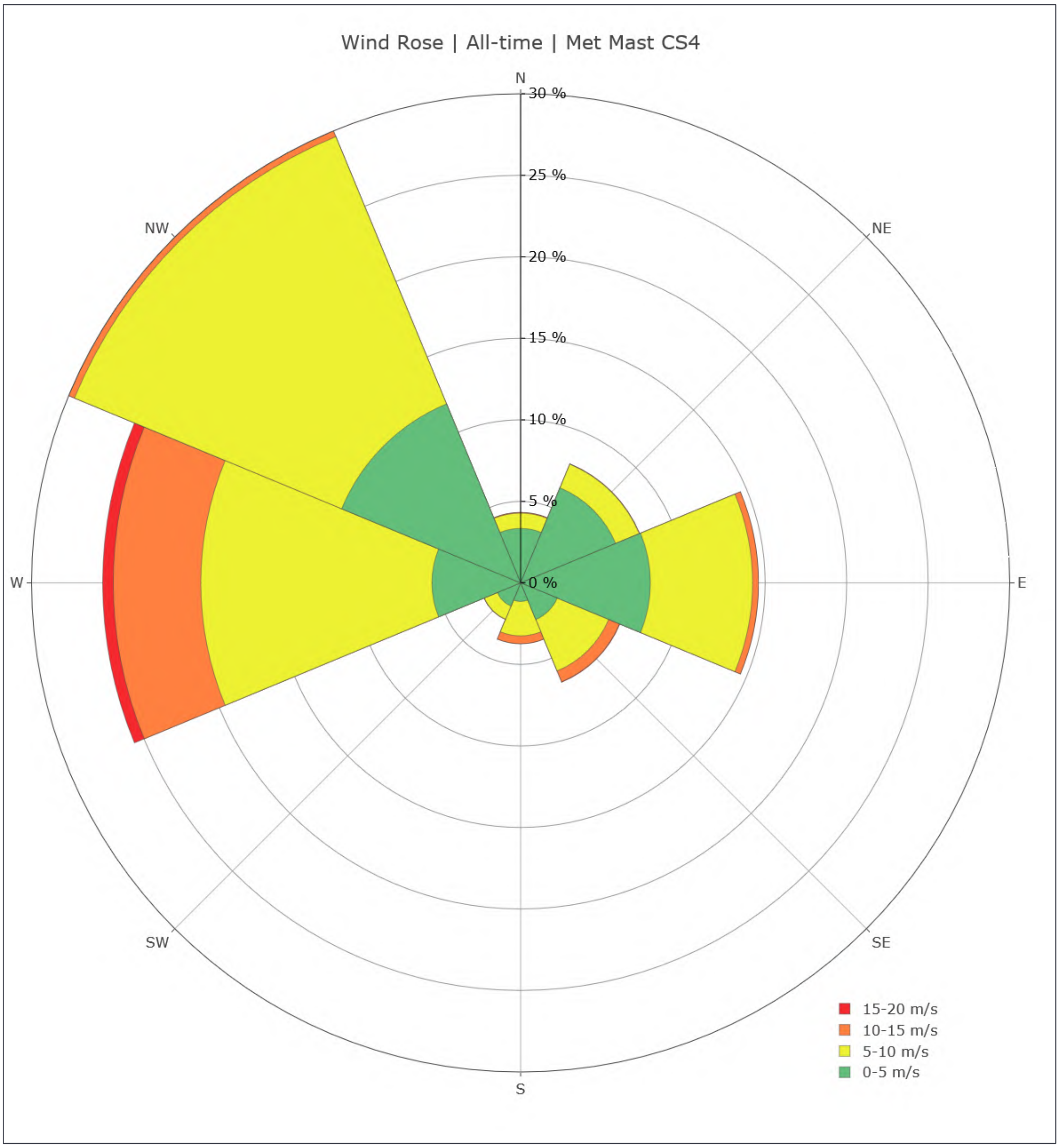
Given the distance between the Goulburn airport and the site of the wind farm, this data is indicative only.



G3.2 Collector 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 13: Collector Wind Farm noise monitoring period – CS4 wind rose



APPENDIX H DOWNWIND DIRECTIONS

Downwind conditions for each monitoring location were defined in the background noise report as directions that are equal to ±45° around a central downwind direction (other than Receiver AA which was not monitored previously). The same downwind conditions defined in the background noise report are the applicable downwind directions to consider in the compliance analysis.

The downwind direction ranges referenced in the analysis for each noise monitoring location are listed in Table 41.

Table 41: Downwind directions

Location	Central downwind direction, °	Downwind direction range, °
Receiver AA	255	205 - 295
Receiver FF	271	226 - 316
Receiver Z	78	33 - 123
Intermediate FF	255	210 - 300
Intermediate Z	79	34 - 124
Intermediate W	318	273 - 3
Intermediate DD	162	117 - 207
Intermediate GG	88	43 - 133
Intermediate J	350	305 - 35

APPENDIX I SUMMARY OF POST-CONSTRUCTION NOISE LEVELS

Table 42: 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**
Receiver AA	-0.00653	0.10807	1.20166	27.05374	0.44868	3 - 13
Receiver FF	-0.03209	0.56301	-0.77493	26.40543	0.67275	3 - 11
Receiver Z	0.02089	-0.44493	4.15758	19.85036	0.27156	3 - 10
Int DD	-0.01526	0.40712	-2.78506	46.98008	0.11177	3 - 13
Int FF	-0.03474	0.70531	-2.36661	33.87128	0.72775	3 - 11
Int GG	0.01156	-0.33604	4.00933	24.68032	0.27308	3 - 11
Int J	-0.01381	0.21674	1.09722	22.5903	0.69052	3 - 12
Int W	-0.01122	0.30319	-1.69484	34.82499	0.14089	3 - 12
Int Z	-0.01013	0.19259	0.64173	26.46685	0.40072	3 - 12

APPENDIX J INTERMEDIATE DD DATA

J1 Intermediate DD location data

Table 43: Intermediate DD noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Noise monitoring location	718,130	6,143,797

Figure 14: Intermediate DD aerial view – dwelling and noise monitor locations

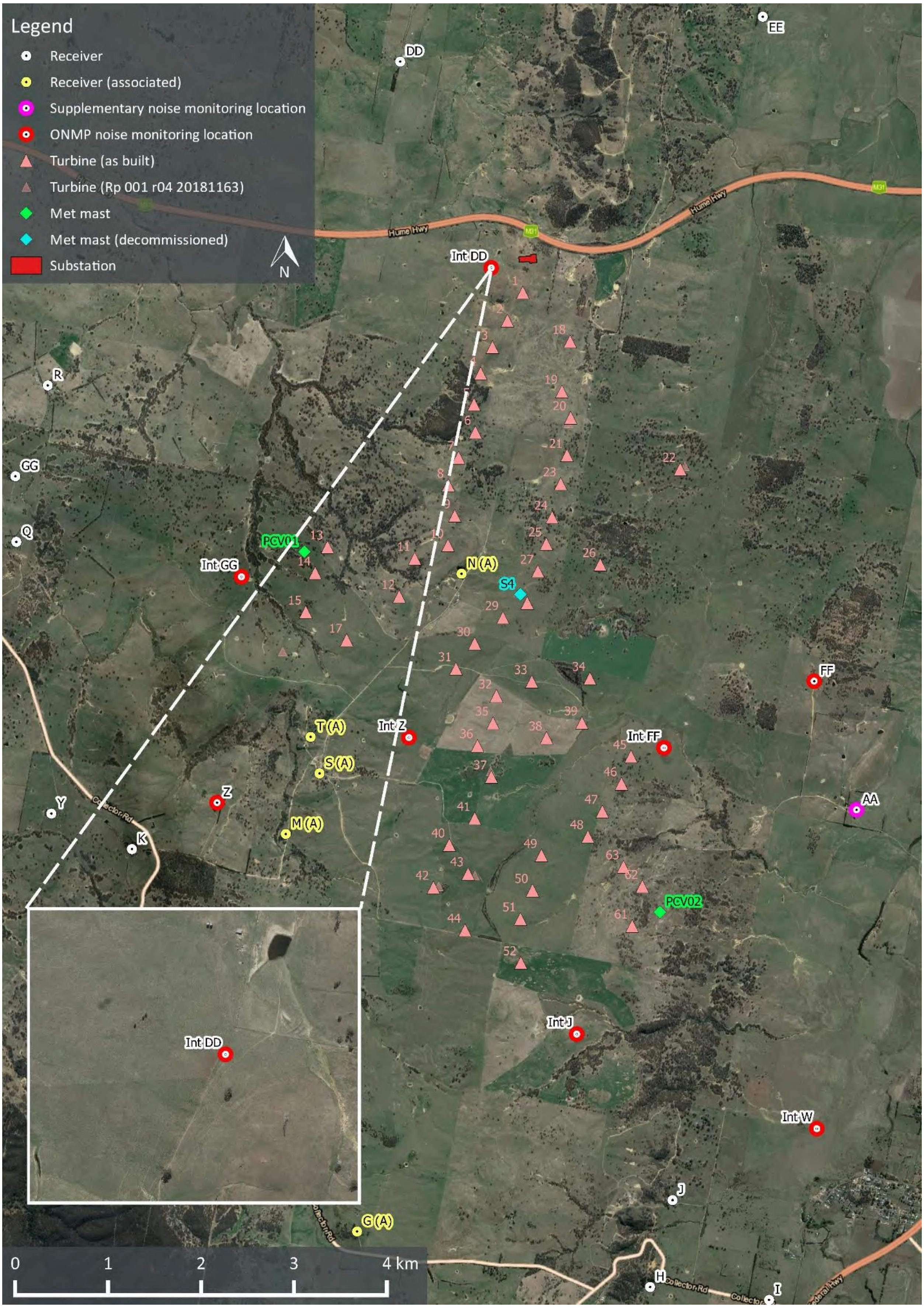


Table 44: Intermediate DD monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

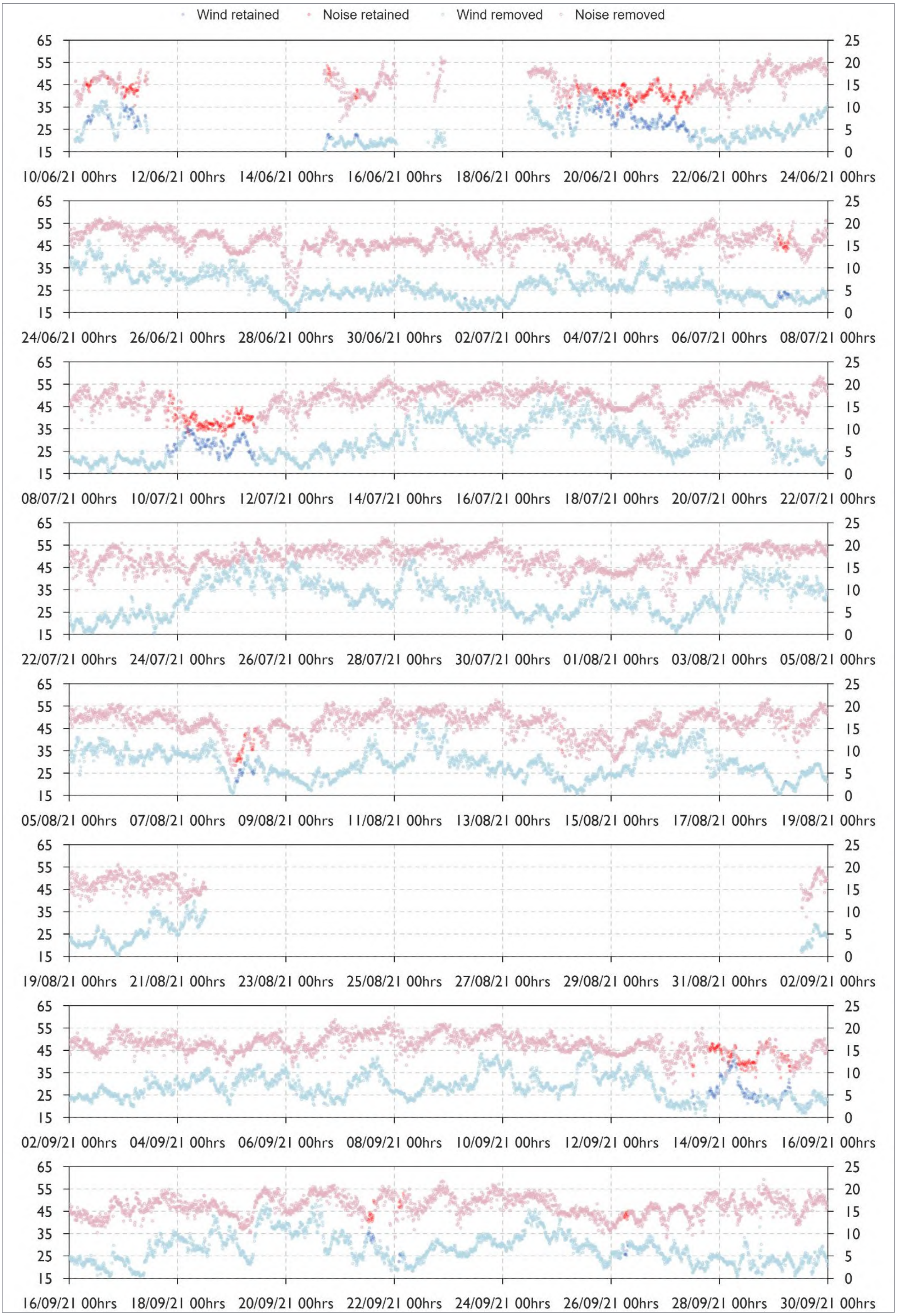
J2 Intermediate DD measurement data summary

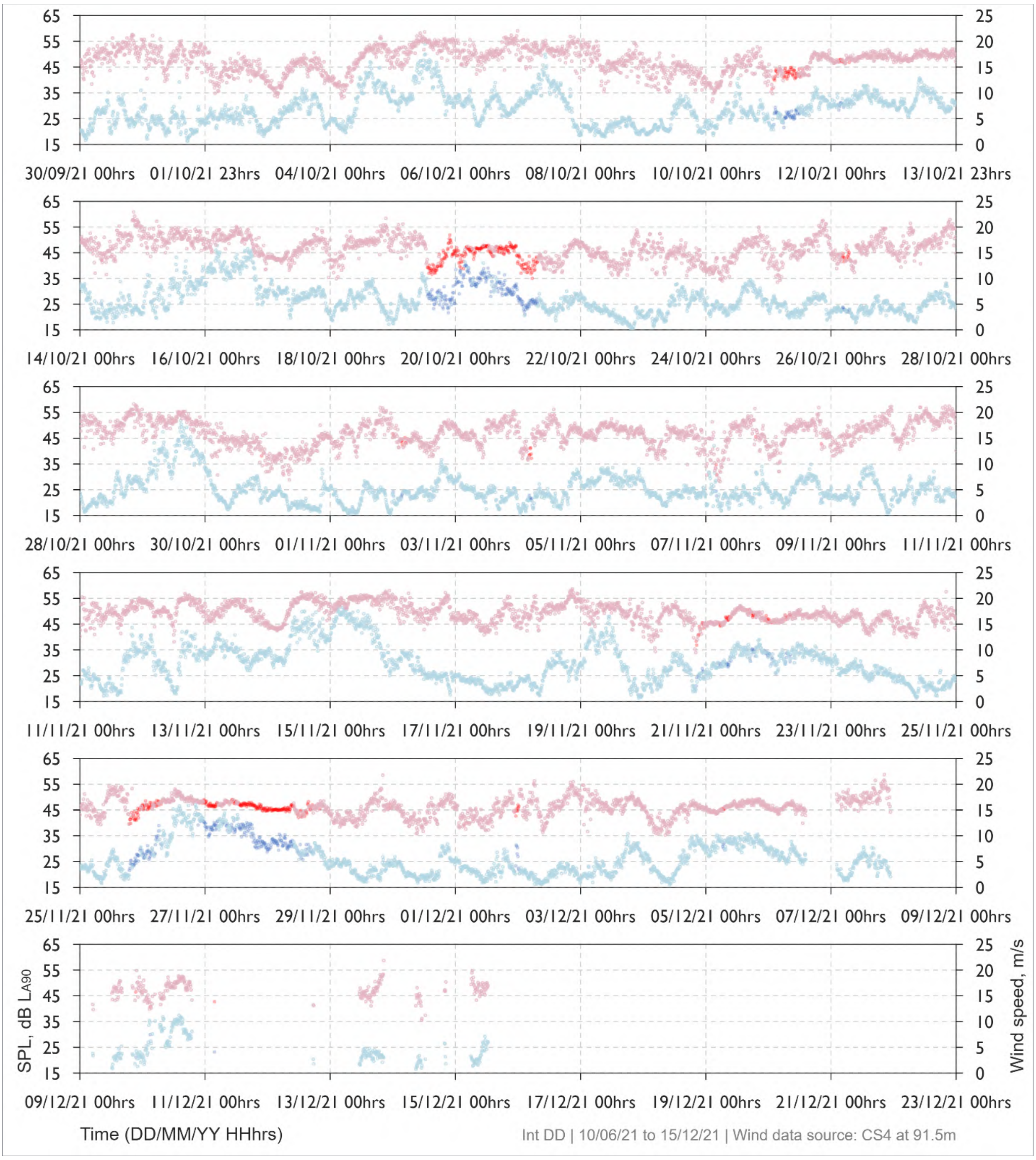
Table 45: Intermediate DD noise level analysis summary

Description	Data points
Collected	23,276
Removed [1]	21,734
Retained	1,542

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

Figure 15: Intermediate DD - post construction A-weighted noise level and wind speed time history





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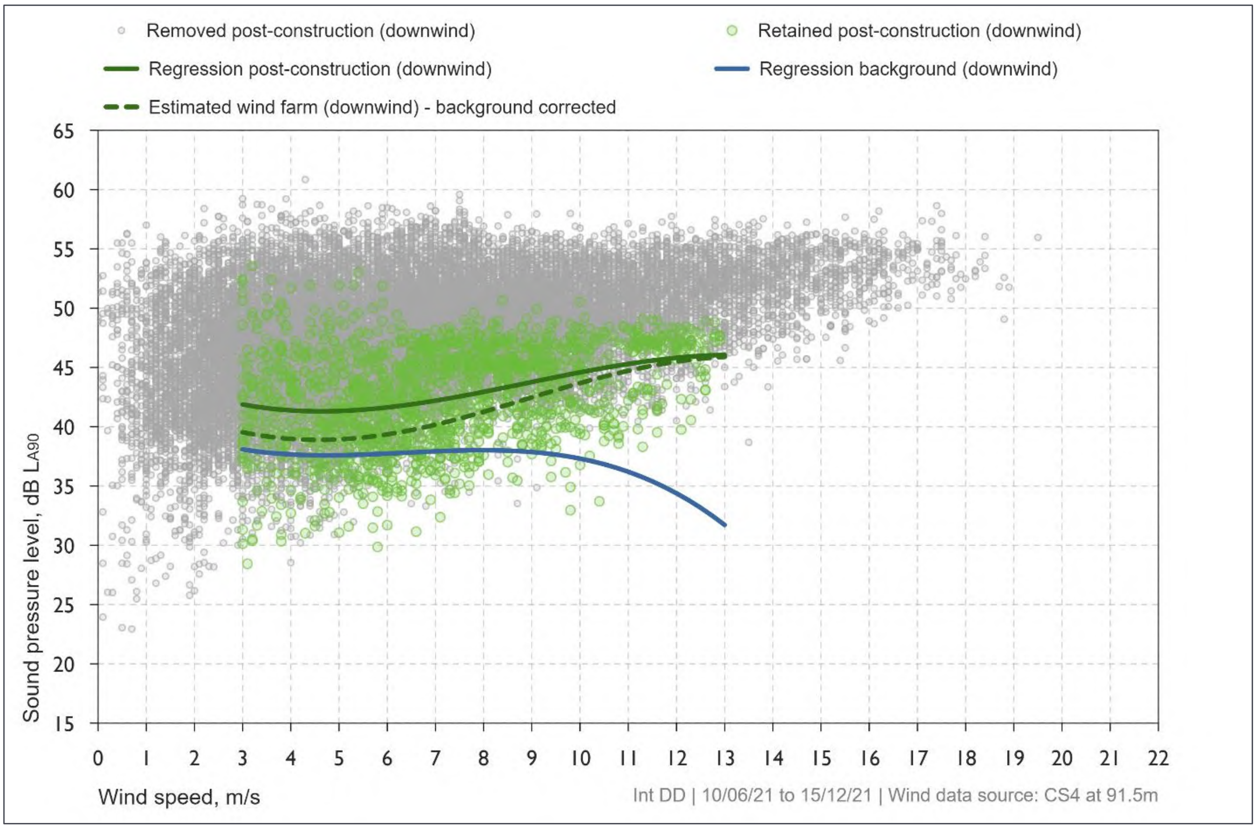
13/12/21 00hrs
15/12/21 00hrs
17/12/21 00hrs
19/12/21 00hrs
21/12/21 00hrs
23/12/21 00hrs
SPL, dB LA90
Wind speed, m/s
Time (DD/MM/YY HHhrs)
Int DD | 10/06/21 to 15/12/21 | Wind data source: CS4 at 91.5m

Figure 16: Intermediate DD - post-construction A-weighted noise levels versus site wind speed



APPENDIX K INTERMEDIATE FF DATA

K1 Intermediate FF location data

Table 46: Intermediate FF noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Noise monitoring location	719,989	6,138,626

Figure 17: Intermediate FF aerial view – dwelling and noise monitor locations

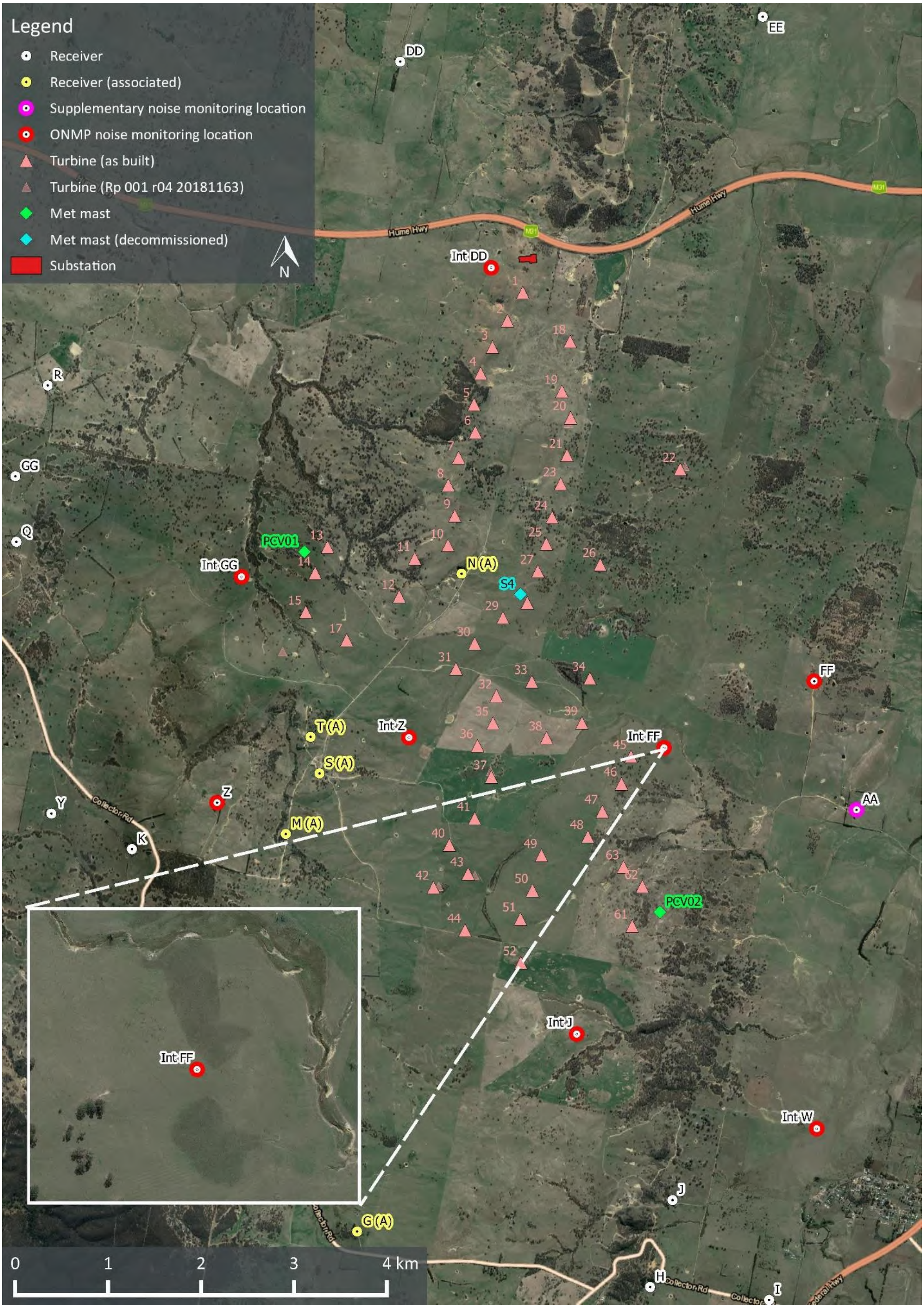


Table 47: Intermediate FF monitor installation photos

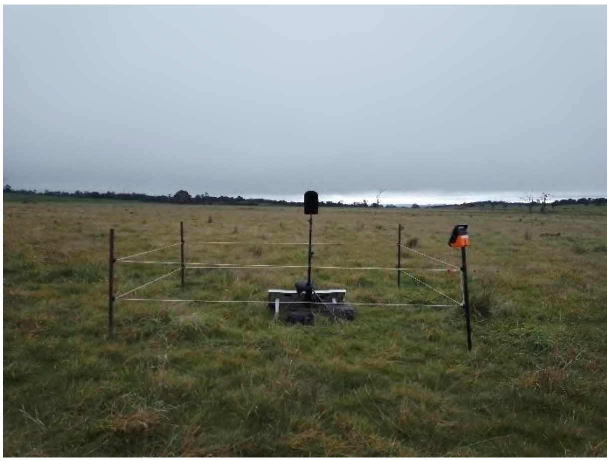
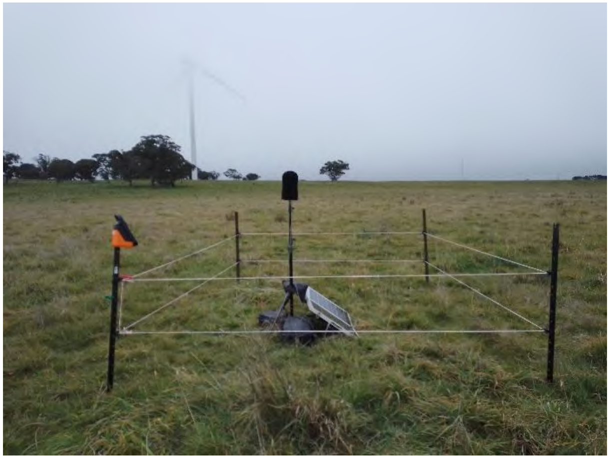
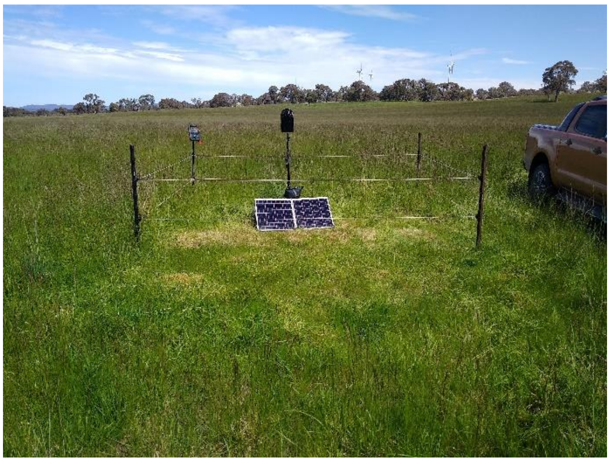
Looking North	Looking East
	
Looking South	Looking West
	

Table 48: Intermediate FF – grass management on 28 Oct. 2021

Before	After
	

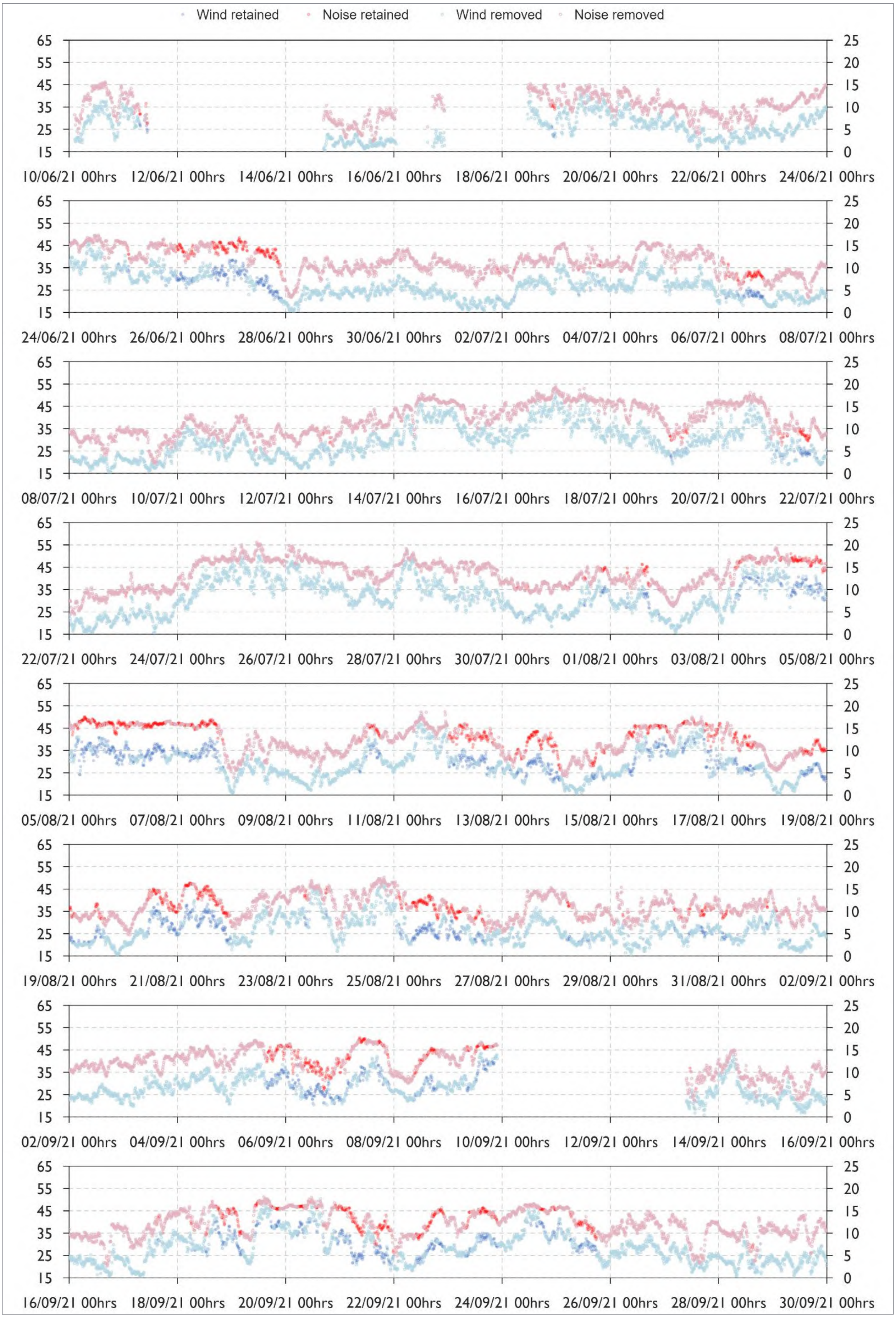
K2 Intermediate FF measurement data summary

Table 49: Intermediate FF noise level analysis summary

Description	Data points
Collected	22,542
Removed [1]	18,857
Retained	3,685

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

Figure 18: Intermediate FF - post construction A-weighted noise level and wind speed time history



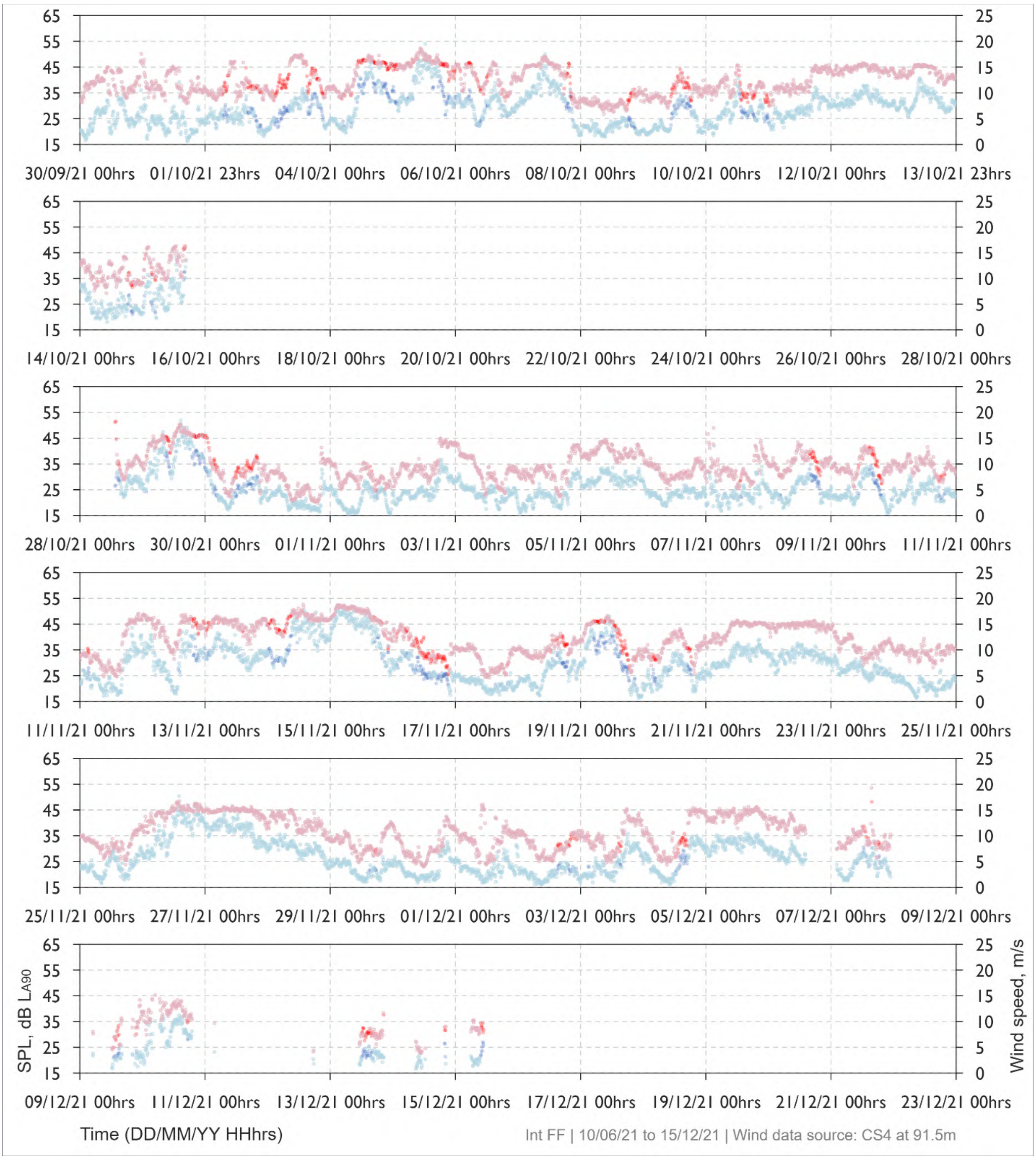
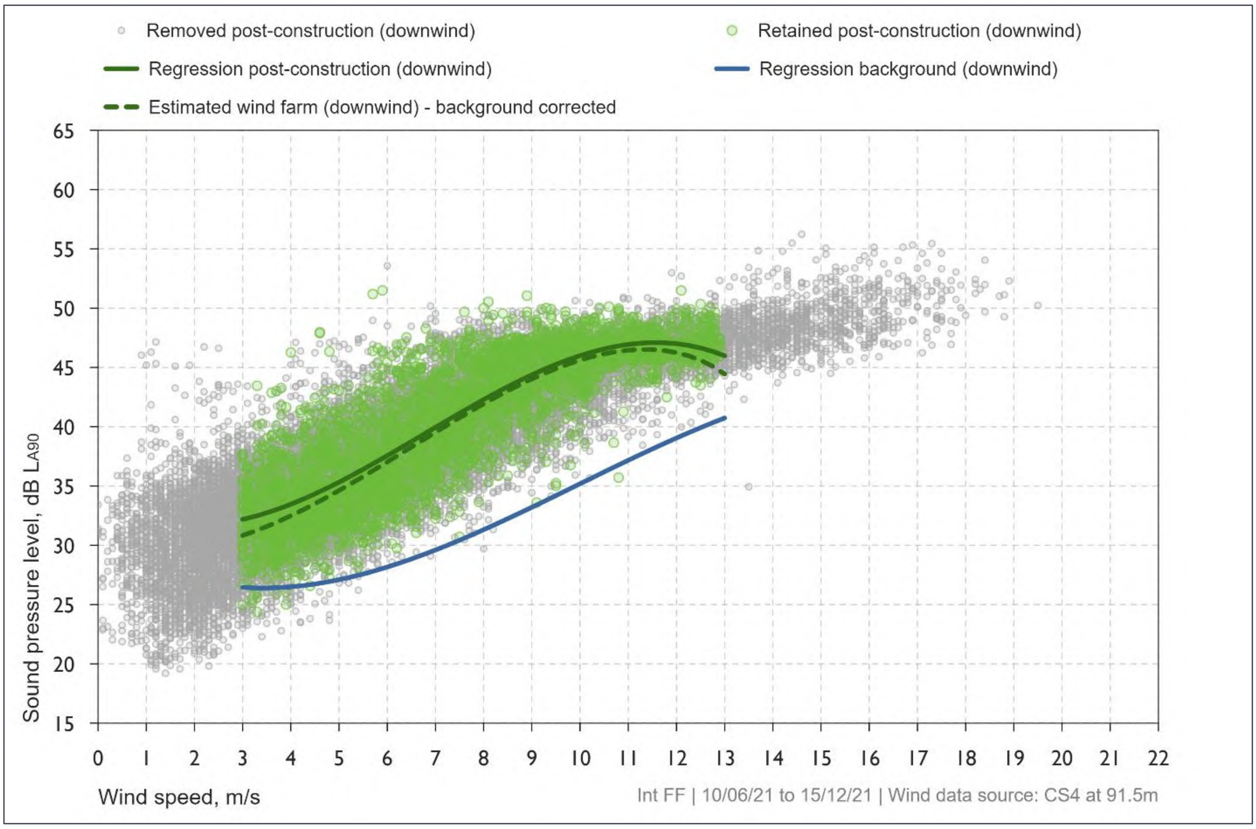

30/09/21 00hrs 01/10/21 23hrs 04/10/21 00hrs 06/10/21 00hrs 08/10/21 00hrs 10/10/21 00hrs 12/10/21 00hrs 13/10/21 23hrs
14/10/21 00hrs 16/10/21 00hrs 18/10/21 00hrs 20/10/21 00hrs 22/10/21 00hrs 24/10/21 00hrs 26/10/21 00hrs 28/10/21 00hrs
28/10/21 00hrs 30/10/21 00hrs 01/11/21 00hrs 03/11/21 00hrs 05/11/21 00hrs 07/11/21 00hrs 09/11/21 00hrs 11/11/21 00hrs
11/11/21 00hrs 13/11/21 00hrs 15/11/21 00hrs 17/11/21 00hrs 19/11/21 00hrs 21/11/21 00hrs 23/11/21 00hrs 25/11/21 00hrs
25/11/21 00hrs 27/11/21 00hrs 29/11/21 00hrs 01/12/21 00hrs 03/12/21 00hrs 05/12/21 00hrs 07/12/21 00hrs 09/12/21 00hrs
09/12/21 00hrs 11/12/21 00hrs 13/12/21 00hrs 15/12/21 00hrs 17/12/21 00hrs 19/12/21 00hrs 21/12/21 00hrs 23/12/21 00hrs
SPL, dB LA90
Wind speed, m/s
Time (DD/MM/YY HHhrs)
Int FF | 10/06/21 to 15/12/21 | Wind data source: CS4 at 91.5m

Figure 19: Intermediate FF - post-construction A-weighted noise levels versus site wind speed



APPENDIX L INTERMEDIATE GG DATA

L1 Intermediate GG location data

Table 50: Intermediate GG noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Noise monitoring location	715,442	6,140,469

Figure 20: Intermediate GG aerial view – dwelling and noise monitor locations

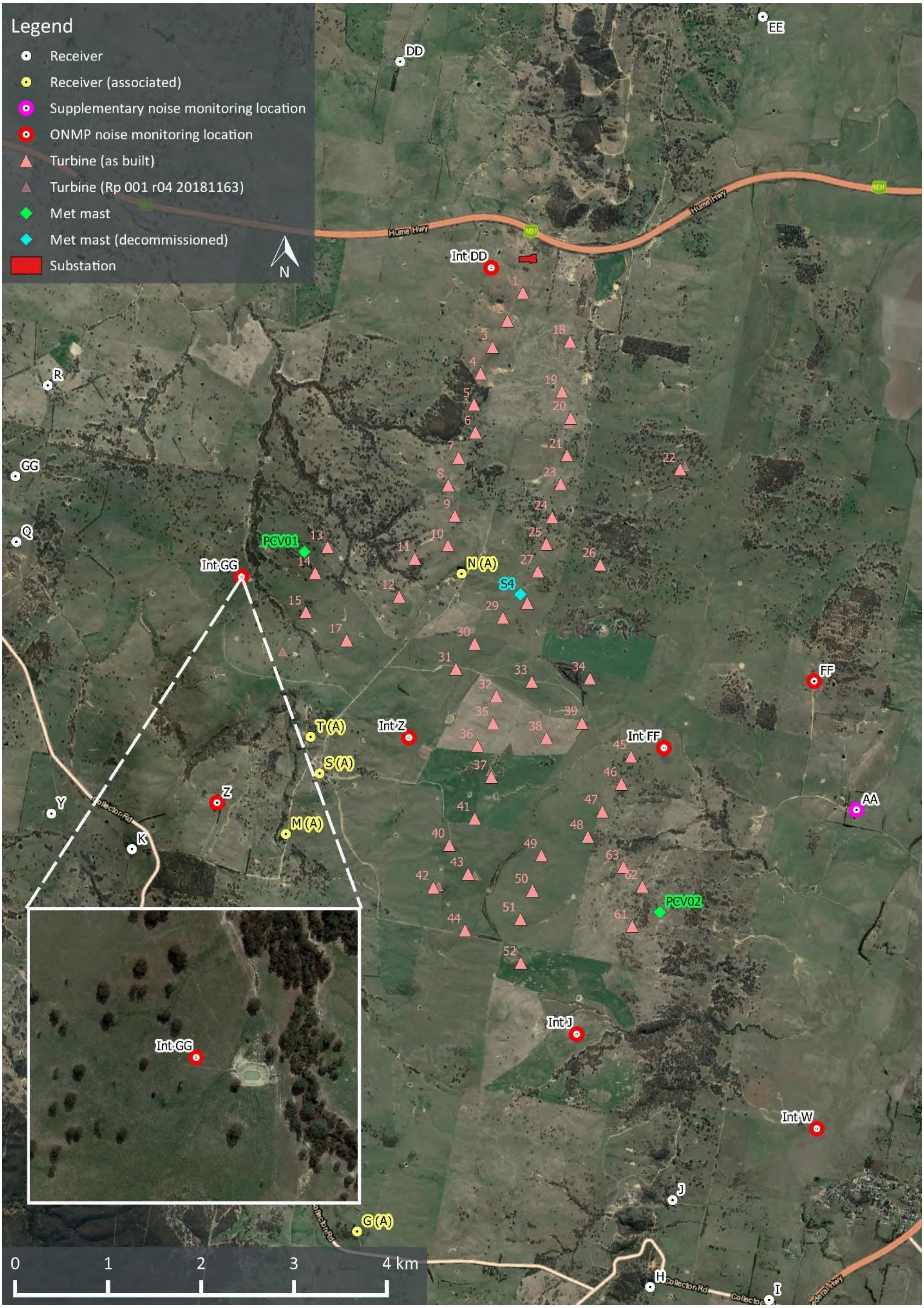


Table 51: Intermediate GG monitor installation photos

<table>
<tr><td>Looking North</td><td>Looking East</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Looking South</td><td>Looking West</td></tr>
<tr><td></td><td></td></tr>
</table>

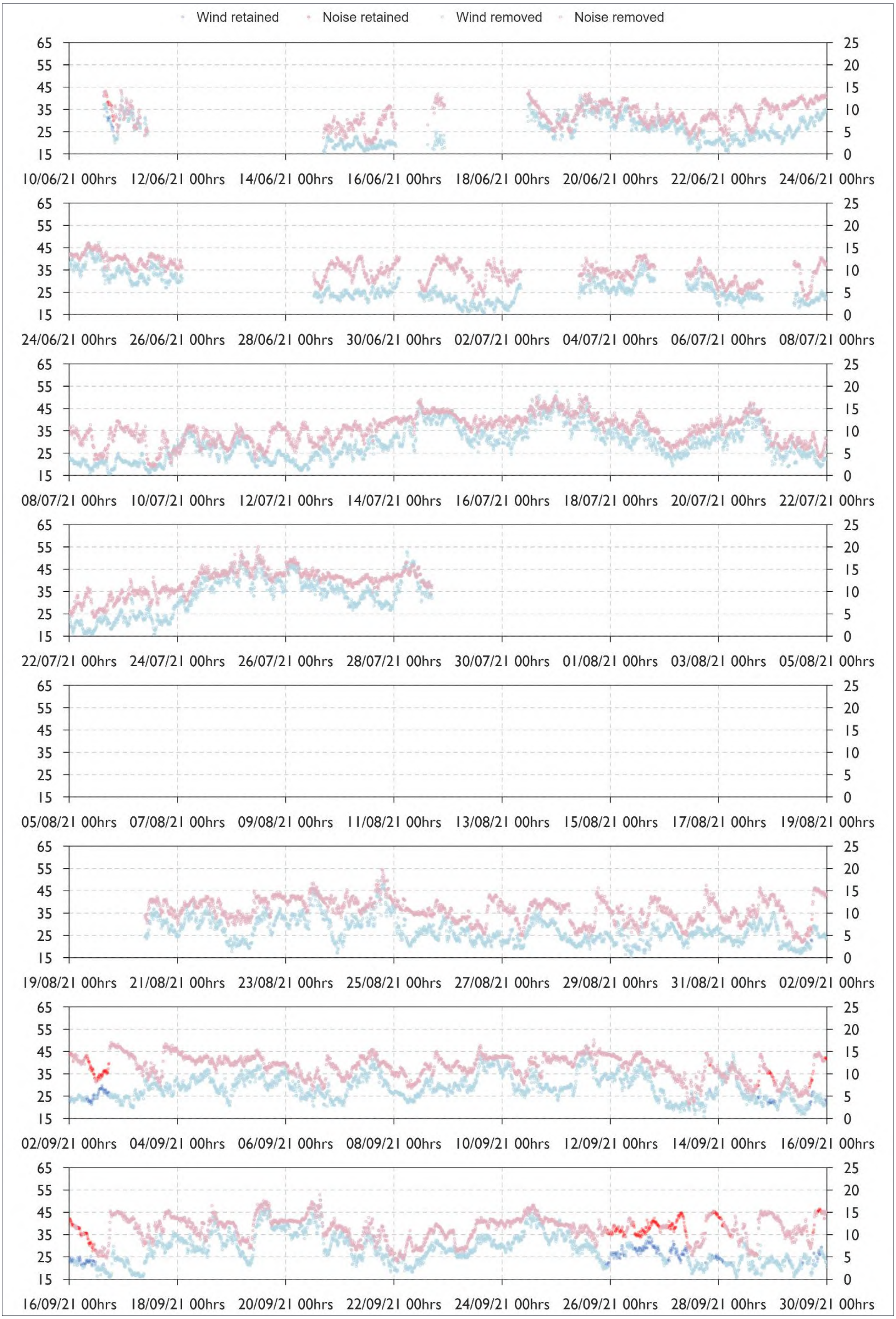
L2 Intermediate GG measurement data summary

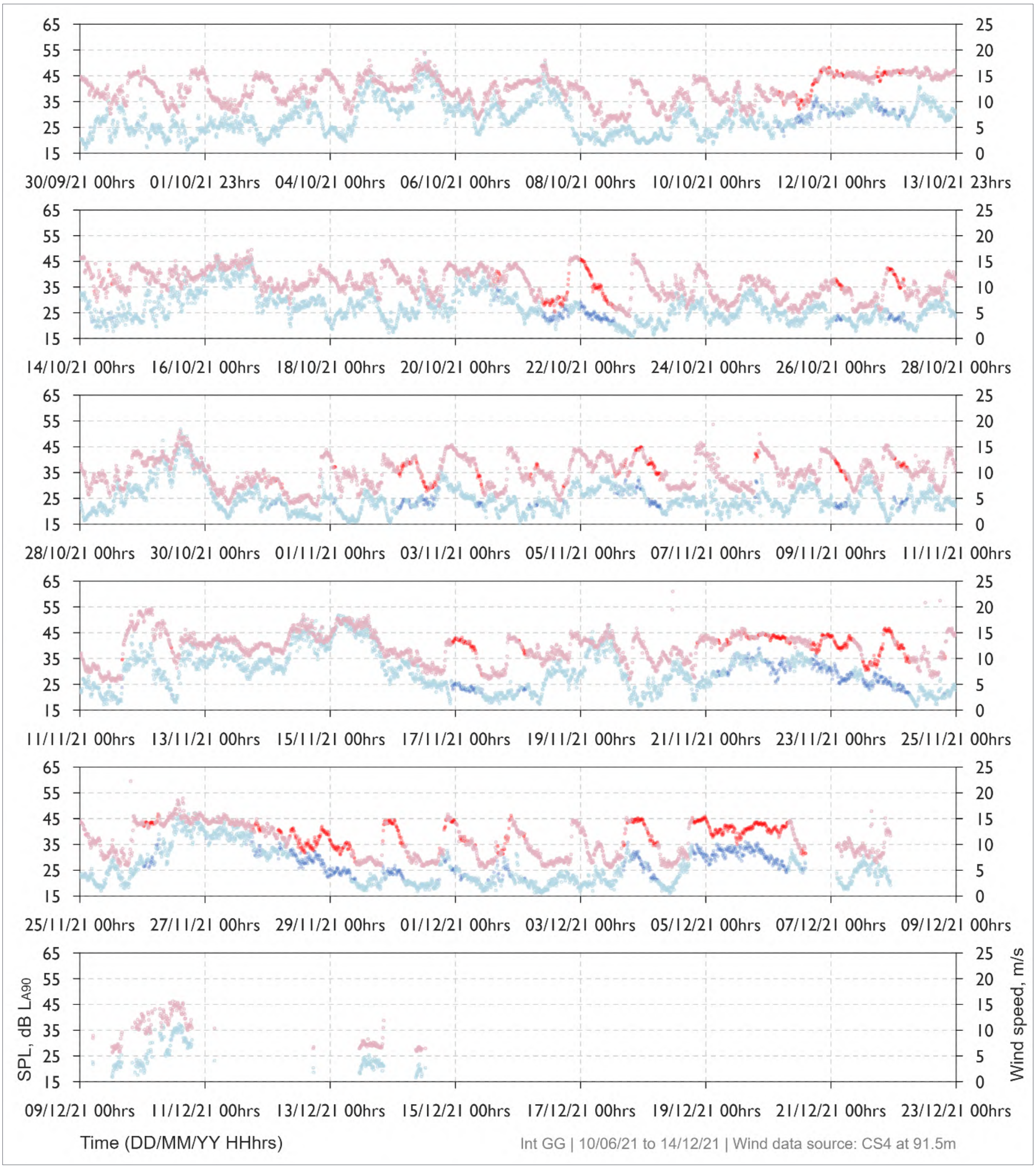
Table 52: Intermediate GG noise level analysis summary

Description	Data points
Collected	20,832
Removed [1]	18,820
Retained	2,012

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

Figure 21: Intermediate GG - post construction A-weighted noise level and wind speed time history




SPL, dB LA90
Wind speed, m/s
30/09/21 00hrs
01/10/21 23hrs
04/10/21 00hrs
06/10/21 00hrs
08/10/21 00hrs
10/10/21 00hrs
12/10/21 00hrs
13/10/21 23hrs
14/10/21 00hrs
16/10/21 00hrs
18/10/21 00hrs
20/10/21 00hrs
22/10/21 00hrs
24/10/21 00hrs
26/10/21 00hrs
28/10/21 00hrs
28/10/21 00hrs
30/10/21 00hrs
01/11/21 00hrs
03/11/21 00hrs
05/11/21 00hrs
07/11/21 00hrs
09/11/21 00hrs
11/11/21 00hrs
11/11/21 00hrs
13/11/21 00hrs
15/11/21 00hrs
17/11/21 00hrs
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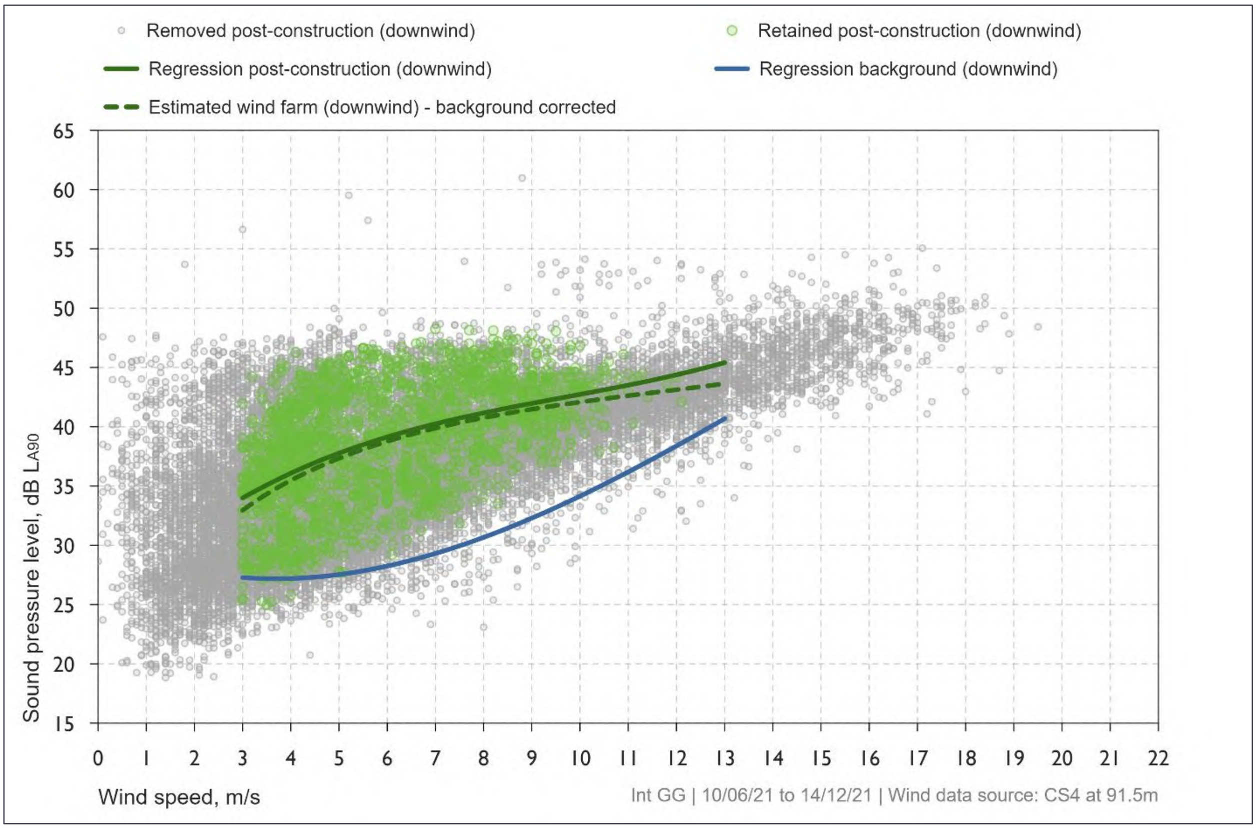
23/11/21 00hrs
25/11/21 00hrs
25/11/21 00hrs
27/11/21 00hrs
29/11/21 00hrs
01/12/21 00hrs
03/12/21 00hrs
05/12/21 00hrs
07/12/21 00hrs
09/12/21 00hrs
09/12/21 00hrs
11/12/21 00hrs
13/12/21 00hrs
15/12/21 00hrs
17/12/21 00hrs
19/12/21 00hrs
21/12/21 00hrs
23/12/21 00hrs
Time (DD/MM/YY HHhrs)
Int GG | 10/06/21 to 14/12/21 | Wind data source: CS4 at 91.5m

Figure 22: Intermediate GG - post-construction A-weighted noise levels versus site wind speed



APPENDIX M INTERMEDIATE J DATA

M1 Intermediate J location data

Table 53: Intermediate J noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Noise monitoring location	719,050	6,135,543

Figure 23: Intermediate J aerial view – dwelling and noise monitor locations

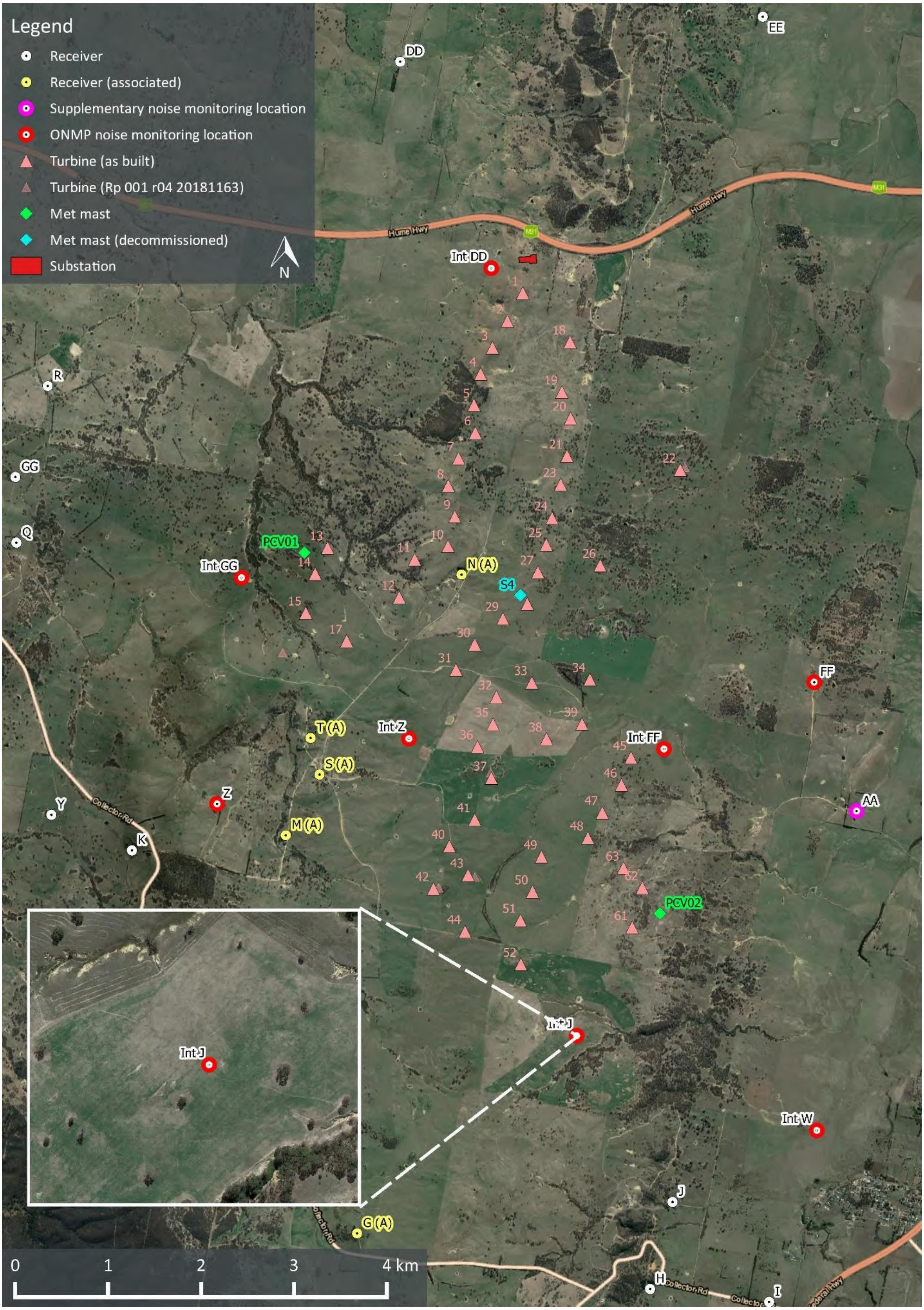


Table 54: Intermediate J monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

Table 55: Intermediate J – grass management 28 Oct. 2021

Post cutback


M2 Intermediate J measurement data summary

Table 56: Intermediate J noise level analysis summary

Description	Data points
Collected	22,194
Removed [1]	19,647
Retained	2,547

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

Figure 24: Intermediate J - post construction A-weighted noise level and wind speed time history

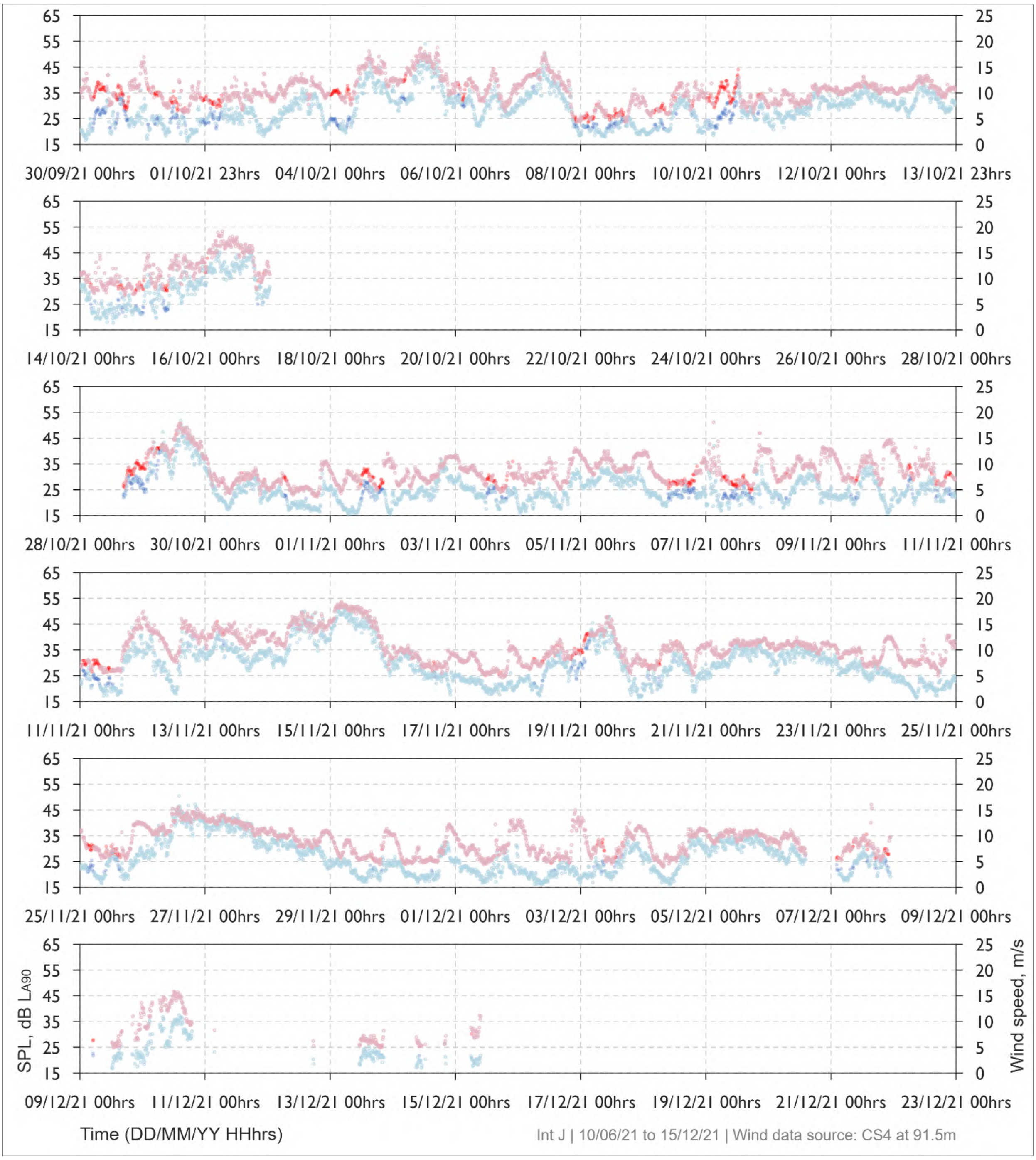
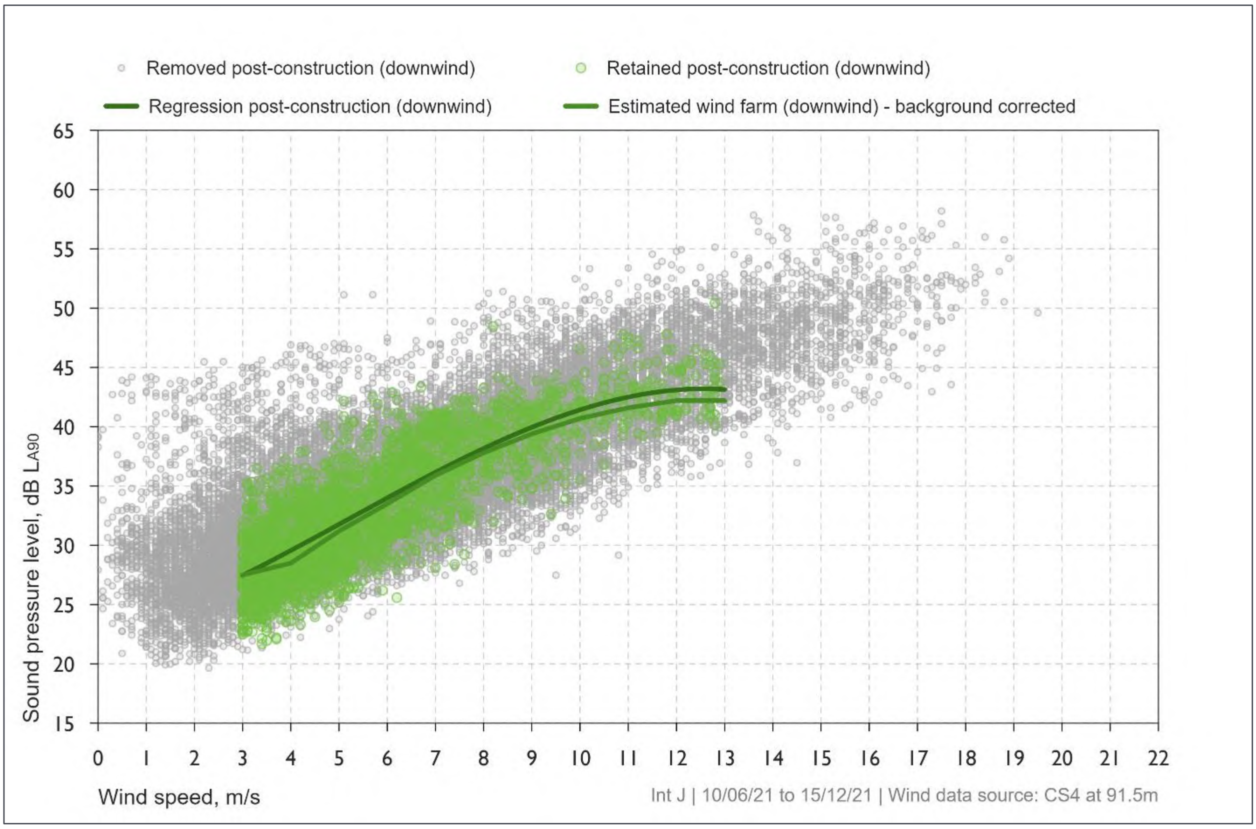

SPL, dB LA90
Wind speed, m/s
30/09/21 00hrs
01/10/21 23hrs
04/10/21 00hrs
06/10/21 00hrs
08/10/21 00hrs
10/10/21 00hrs
12/10/21 00hrs
13/10/21 23hrs
14/10/21 00hrs
16/10/21 00hrs
18/10/21 00hrs
20/10/21 00hrs
22/10/21 00hrs
24/10/21 00hrs
26/10/21 00hrs
28/10/21 00hrs
30/10/21 00hrs
01/11/21 00hrs
03/11/21 00hrs
05/11/21 00hrs
07/11/21 00hrs
09/11/21 00hrs
11/11/21 00hrs
13/11/21 00hrs
15/11/21 00hrs
17/11/21 00hrs
19/11/21 00hrs
21/11/21 00hrs
23/11/21 00hrs
25/11/21 00hrs
27/11/21 00hrs
29/11/21 00hrs
01/12/21 00hrs
03/12/21 00hrs
05/12/21 00hrs
07/12/21 00hrs
09/12/21 00hrs
11/12/21 00hrs
13/12/21 00hrs
15/12/21 00hrs
17/12/21 00hrs
19/12/21 00hrs
21/12/21 00hrs
23/12/21 00hrs
Time (DD/MM/YY HHhrs)
Int J | 10/06/21 to 15/12/21 | Wind data source: CS4 at 91.5m

Figure 25: Intermediate J - post-construction A-weighted noise levels versus site wind speed



APPENDIX N INTERMEDIATE W DATA

N1 Intermediate W location data

Table 57: Intermediate W noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Noise monitoring location	721,634	6,134,524

Figure 26: Intermediate W aerial view – dwelling and noise monitor locations

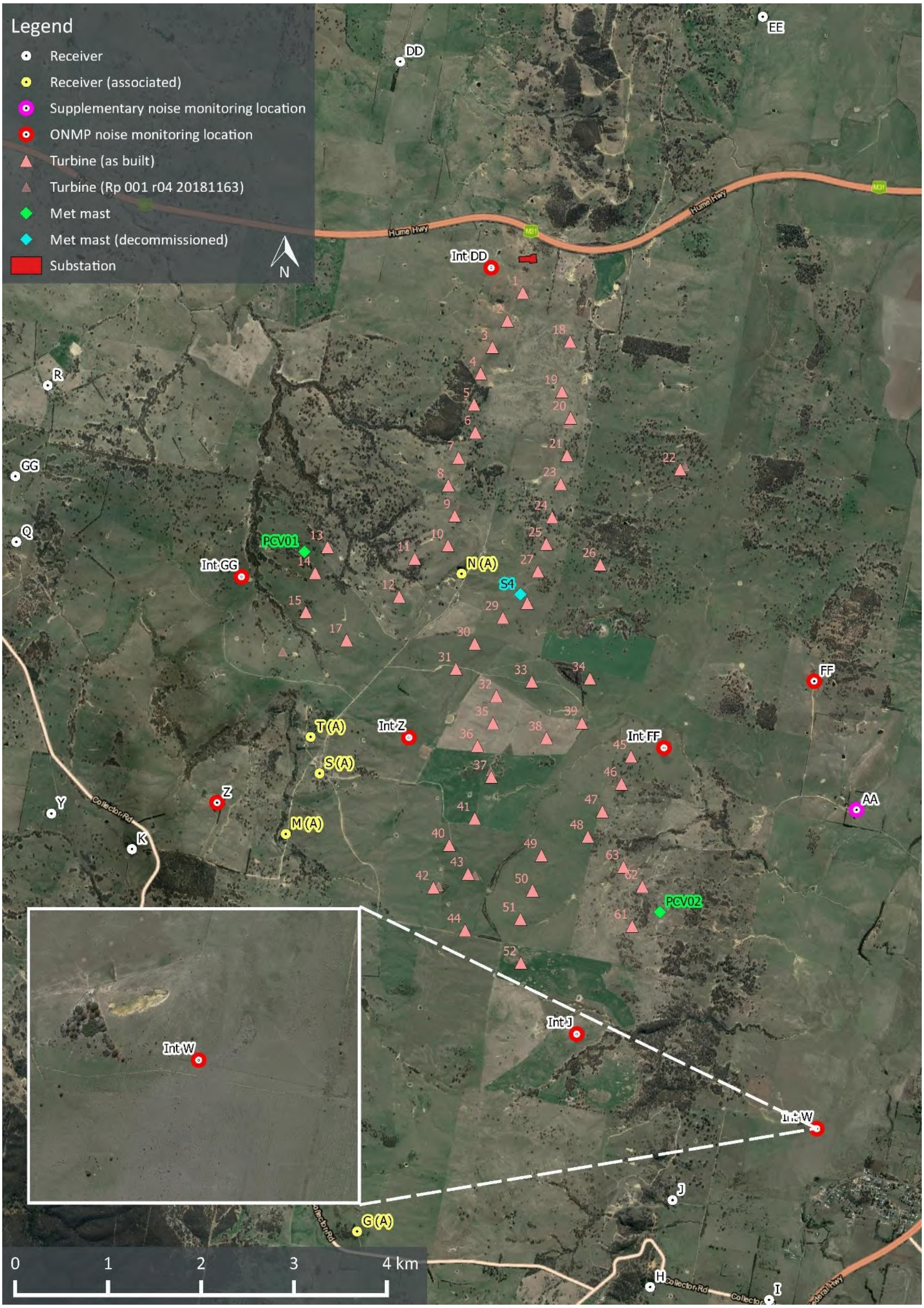


Table 58: Intermediate W monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

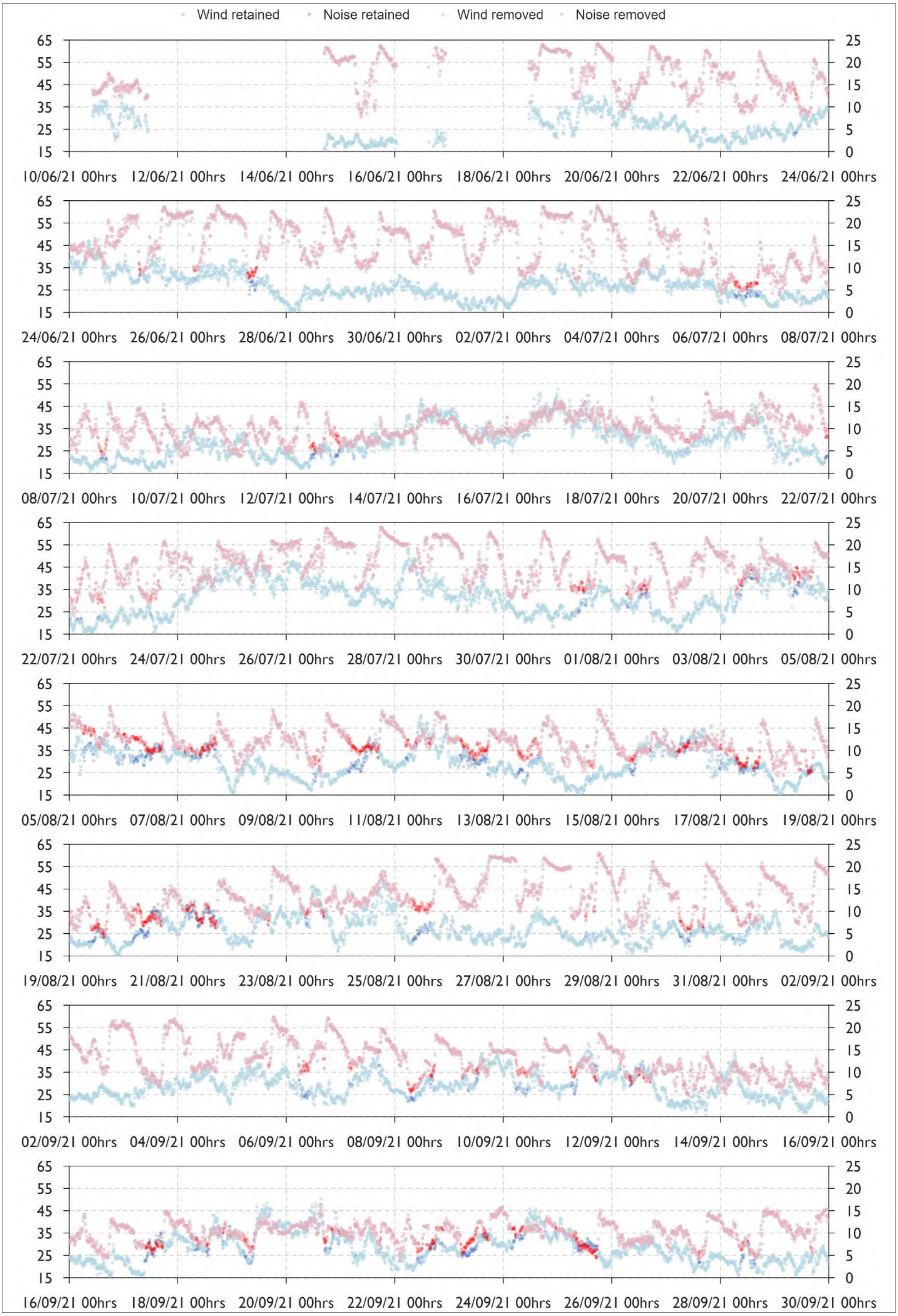
N2 Intermediate W measurement data summary

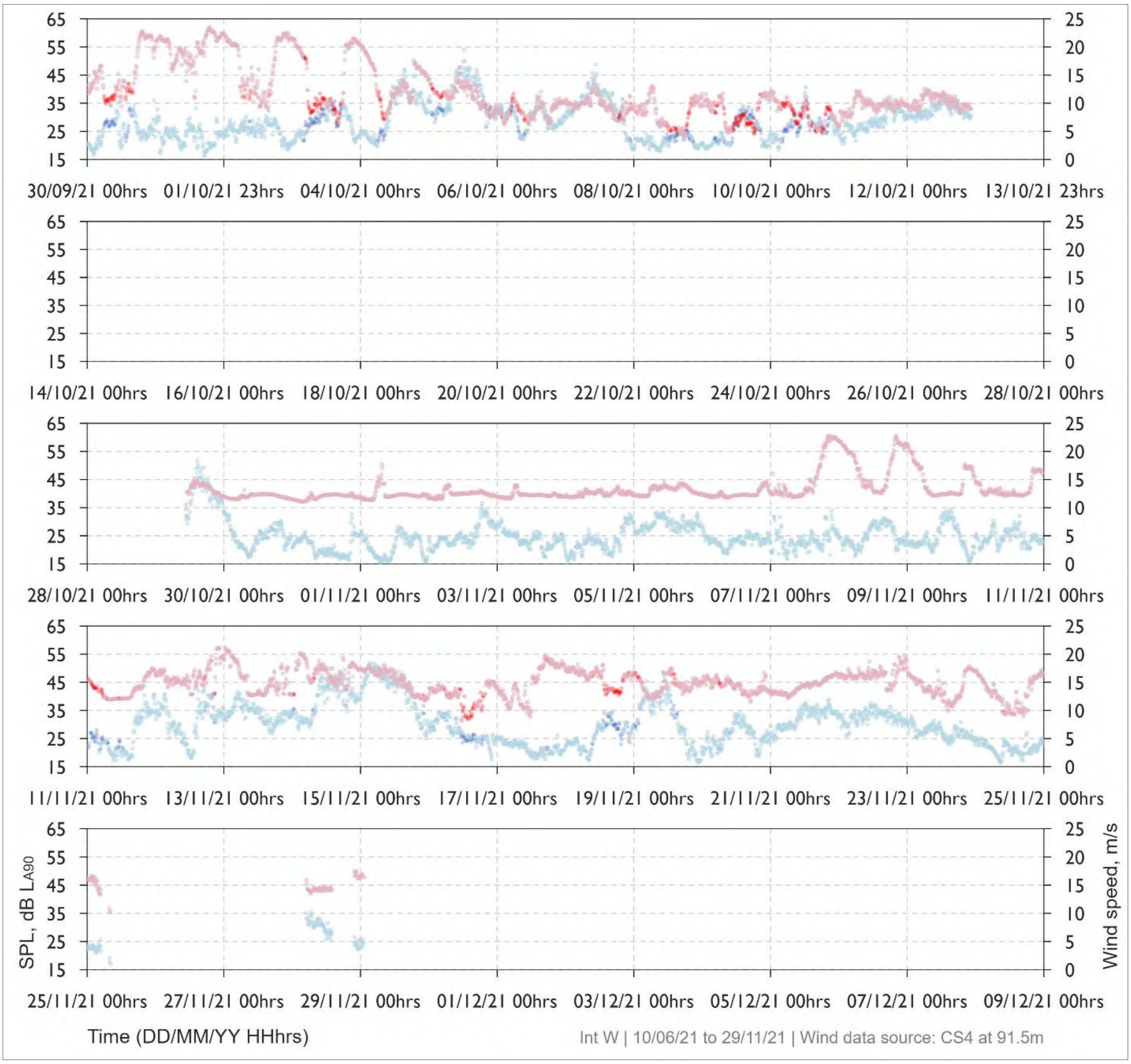
Table 59: Intermediate W noise level analysis summary

Description	Data points
Collected	20,585
Removed [1]	17,963
Retained	2,622

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

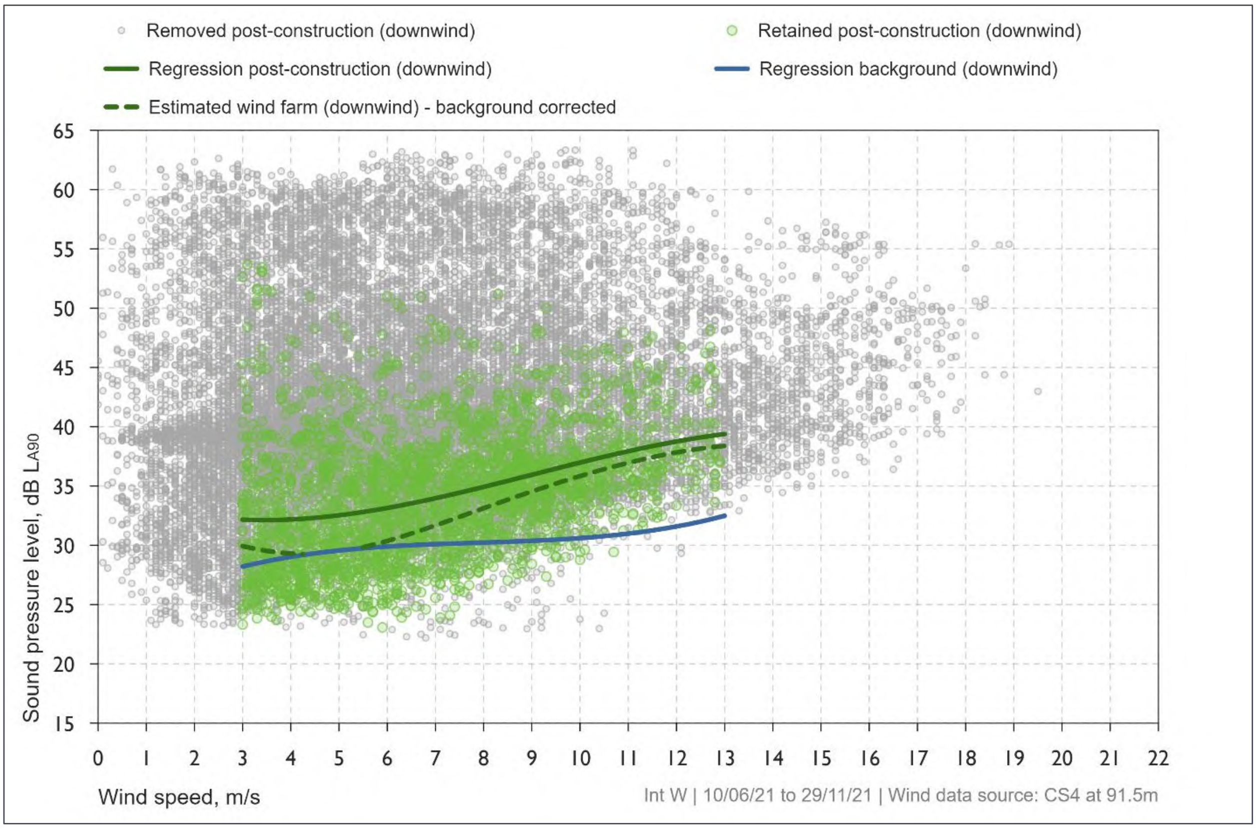
Figure 27: Intermediate W - post construction A-weighted noise level and wind speed time history





30/09/21 00hrs
01/10/21 23hrs
04/10/21 00hrs
06/10/21 00hrs
08/10/21 00hrs
10/10/21 00hrs
12/10/21 00hrs
13/10/21 23hrs
14/10/21 00hrs
16/10/21 00hrs
18/10/21 00hrs
20/10/21 00hrs
22/10/21 00hrs
24/10/21 00hrs
26/10/21 00hrs
28/10/21 00hrs
30/10/21 00hrs
01/11/21 00hrs
03/11/21 00hrs
05/11/21 00hrs
07/11/21 00hrs
09/11/21 00hrs
11/11/21 00hrs
13/11/21 00hrs
15/11/21 00hrs
17/11/21 00hrs
19/11/21 00hrs
21/11/21 00hrs
23/11/21 00hrs
25/11/21 00hrs
27/11/21 00hrs
29/11/21 00hrs
01/12/21 00hrs
03/12/21 00hrs
05/12/21 00hrs
07/12/21 00hrs
09/12/21 00hrs
SPL, dB LA90
Wind speed, m/s
Time (DD/MM/YY HHhrs)
Int W | 10/06/21 to 29/11/21 | Wind data source: CS4 at 91.5m

Figure 28: Intermediate W - post-construction A-weighted noise levels versus site wind speed



APPENDIX O INTERMEDIATE Z DATA

O1 Intermediate Z location data

Table 60: Intermediate Z noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Noise monitoring location	717,244	6,138,737

Figure 29: Intermediate Z aerial view – dwelling and noise monitor locations

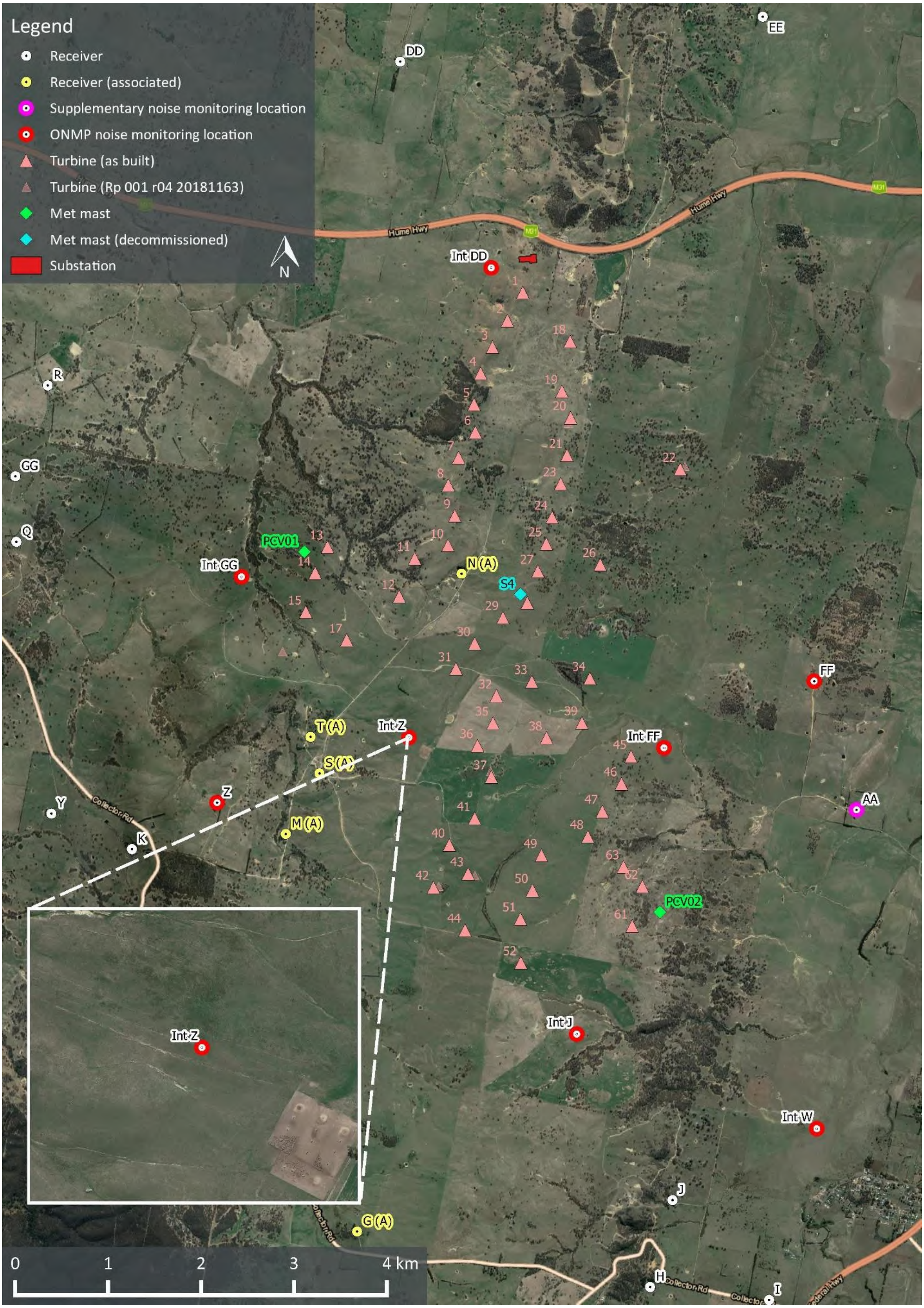


Table 61: Intermediate Z monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

Table 62: Intermediate Z – grass management 28 Oct. 2021

Before	After
	

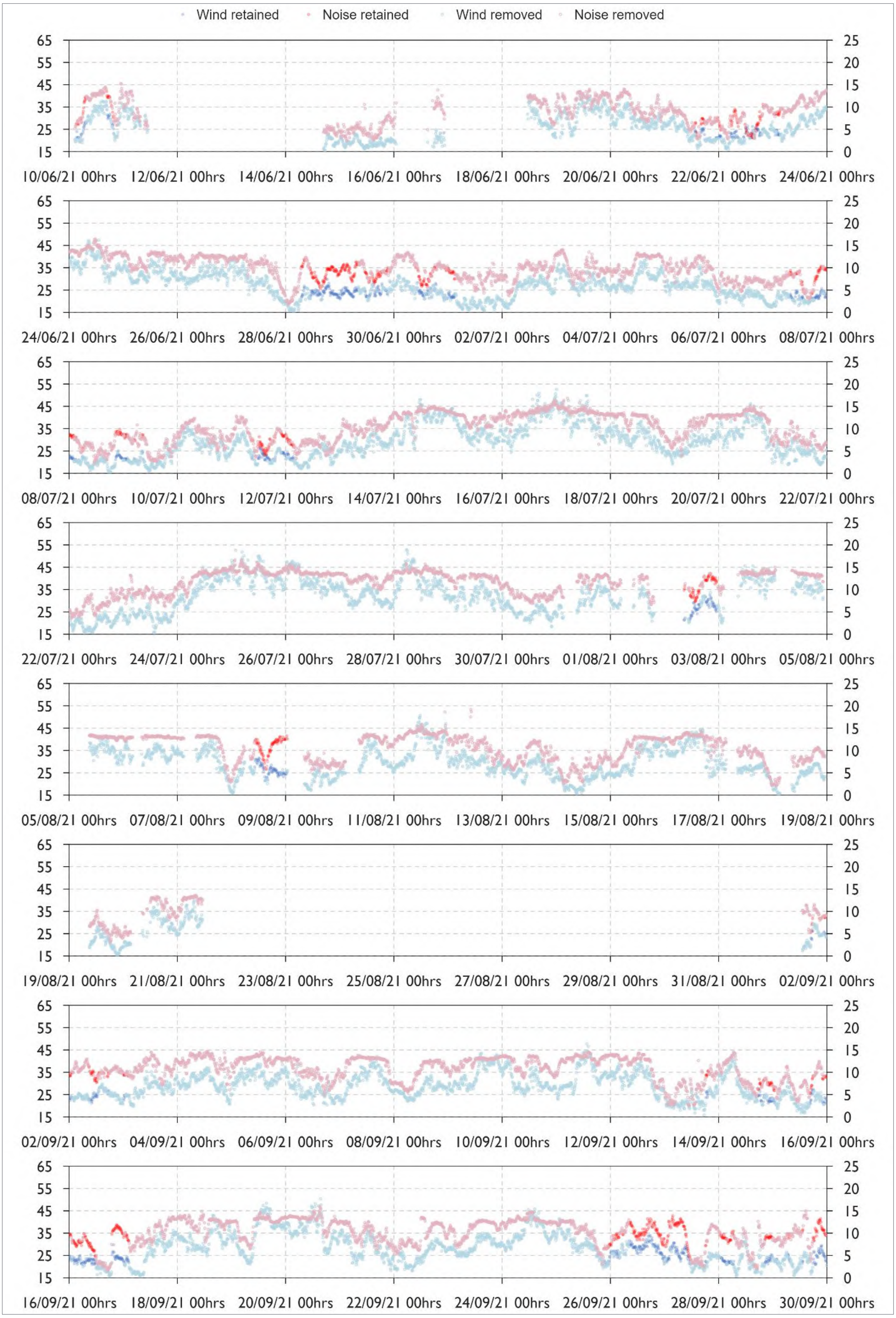
O2 Intermediate Z measurement data summary

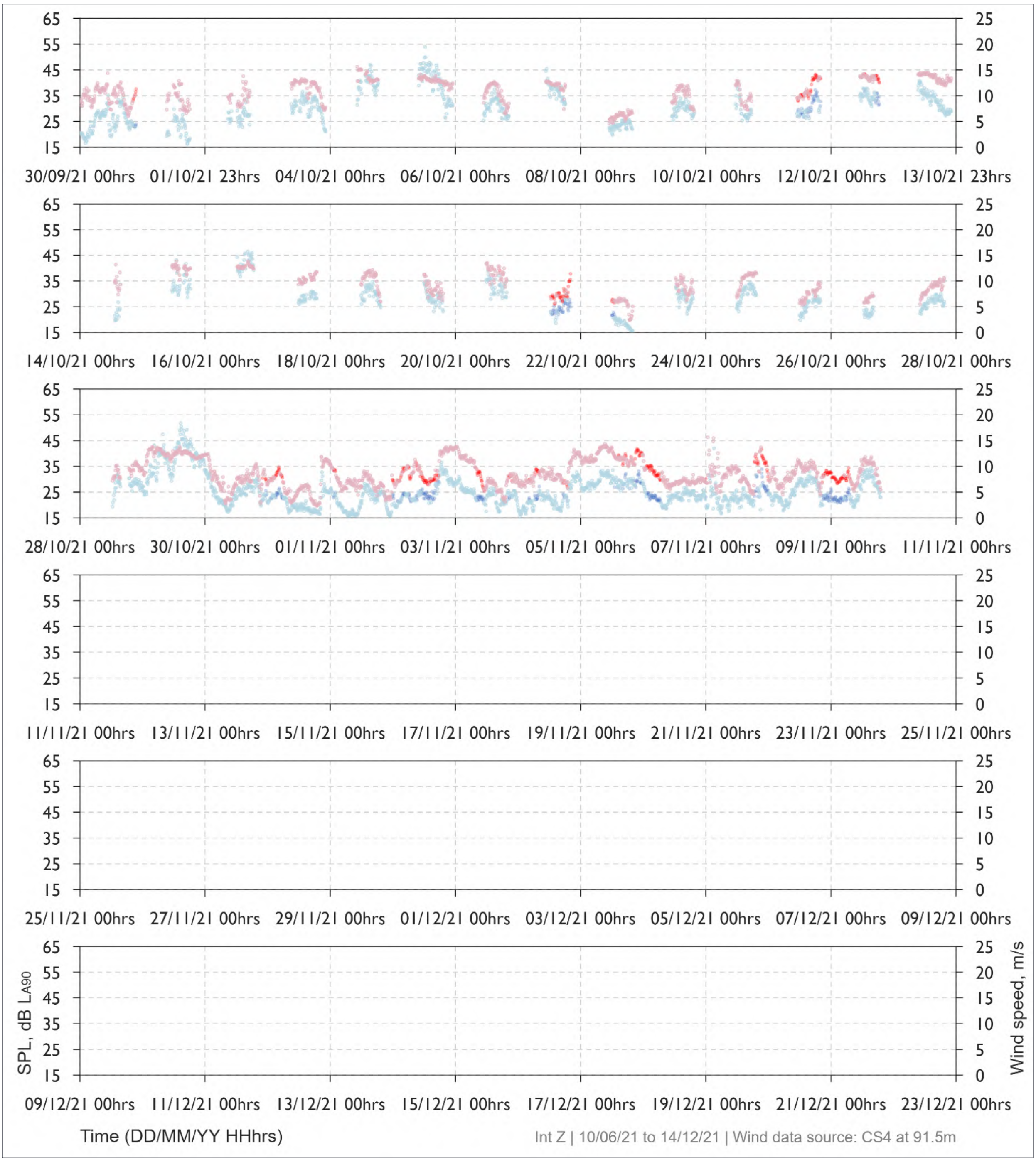
Table 63: Intermediate Z noise level analysis summary

Description	Data points
Collected	19,884
Removed [1]	18,306
Retained	1,578

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

Figure 30: Intermediate Z - post construction A-weighted noise level and wind speed time history




SPL, dB LA90
Wind speed, m/s
65
55
45
35
25
15
25
20
15
10
5
0
30/09/21 00hrs
01/10/21 23hrs
04/10/21 00hrs
06/10/21 00hrs
08/10/21 00hrs
10/10/21 00hrs
12/10/21 00hrs
13/10/21 23hrs
14/10/21 00hrs
16/10/21 00hrs
18/10/21 00hrs
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26/10/21 00hrs
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28/10/21 00hrs
30/10/21 00hrs
01/11/21 00hrs
03/11/21 00hrs
05/11/21 00hrs
07/11/21 00hrs
09/11/21 00hrs
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17/11/21 00hrs
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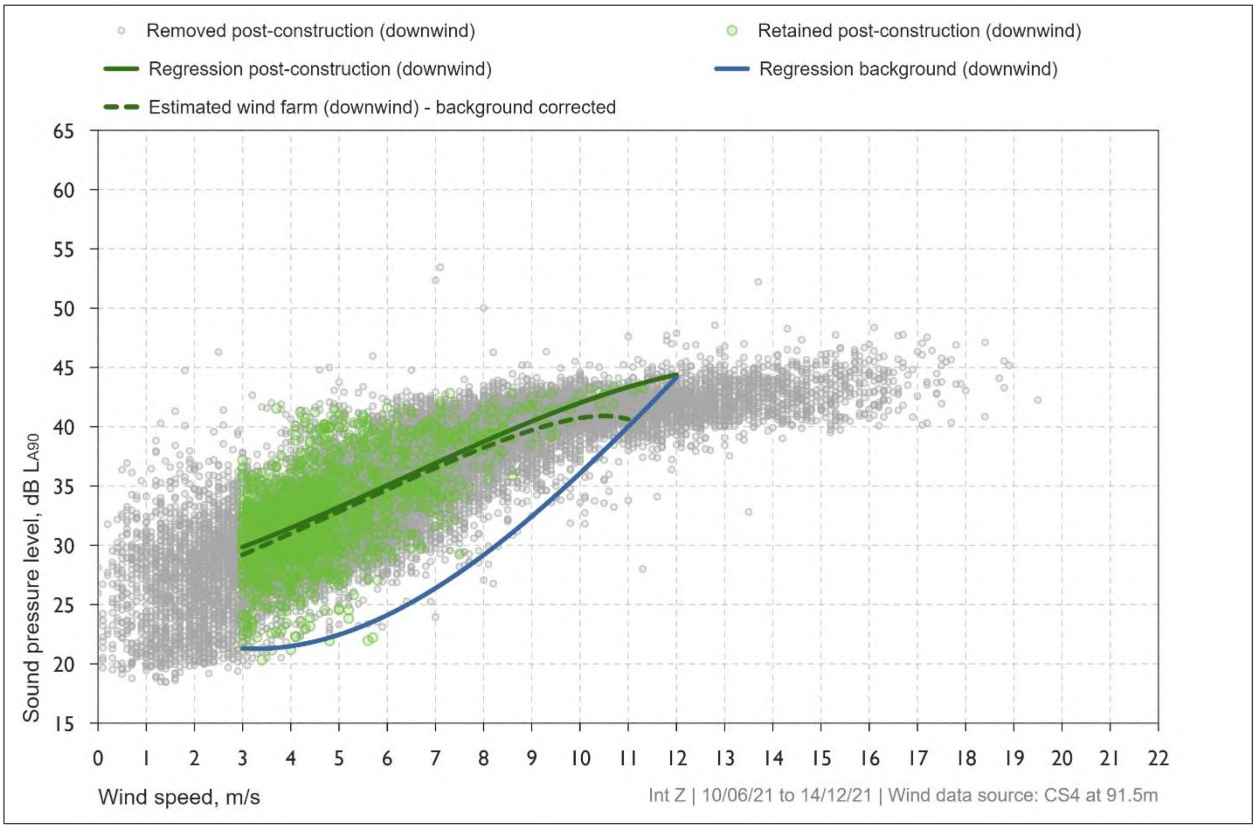
25/11/21 00hrs
27/11/21 00hrs
29/11/21 00hrs
01/12/21 00hrs
03/12/21 00hrs
05/12/21 00hrs
07/12/21 00hrs
09/12/21 00hrs
09/12/21 00hrs
11/12/21 00hrs
13/12/21 00hrs
15/12/21 00hrs
17/12/21 00hrs
19/12/21 00hrs
21/12/21 00hrs
23/12/21 00hrs
Time (DD/MM/YY HHhrs)
Int Z | 10/06/21 to 14/12/21 | Wind data source: CS4 at 91.5m

Figure 31: Intermediate Z - post-construction A-weighted noise levels versus site wind speed



APPENDIX P RECEIVER AA DATA

P1 Receiver AA location data

Table 64: Receiver AA dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Dwelling location	722,062	6,137,959
Noise monitoring location	722,032	6,137,946

Figure 32: Receiver AA aerial view – dwelling and noise monitor locations

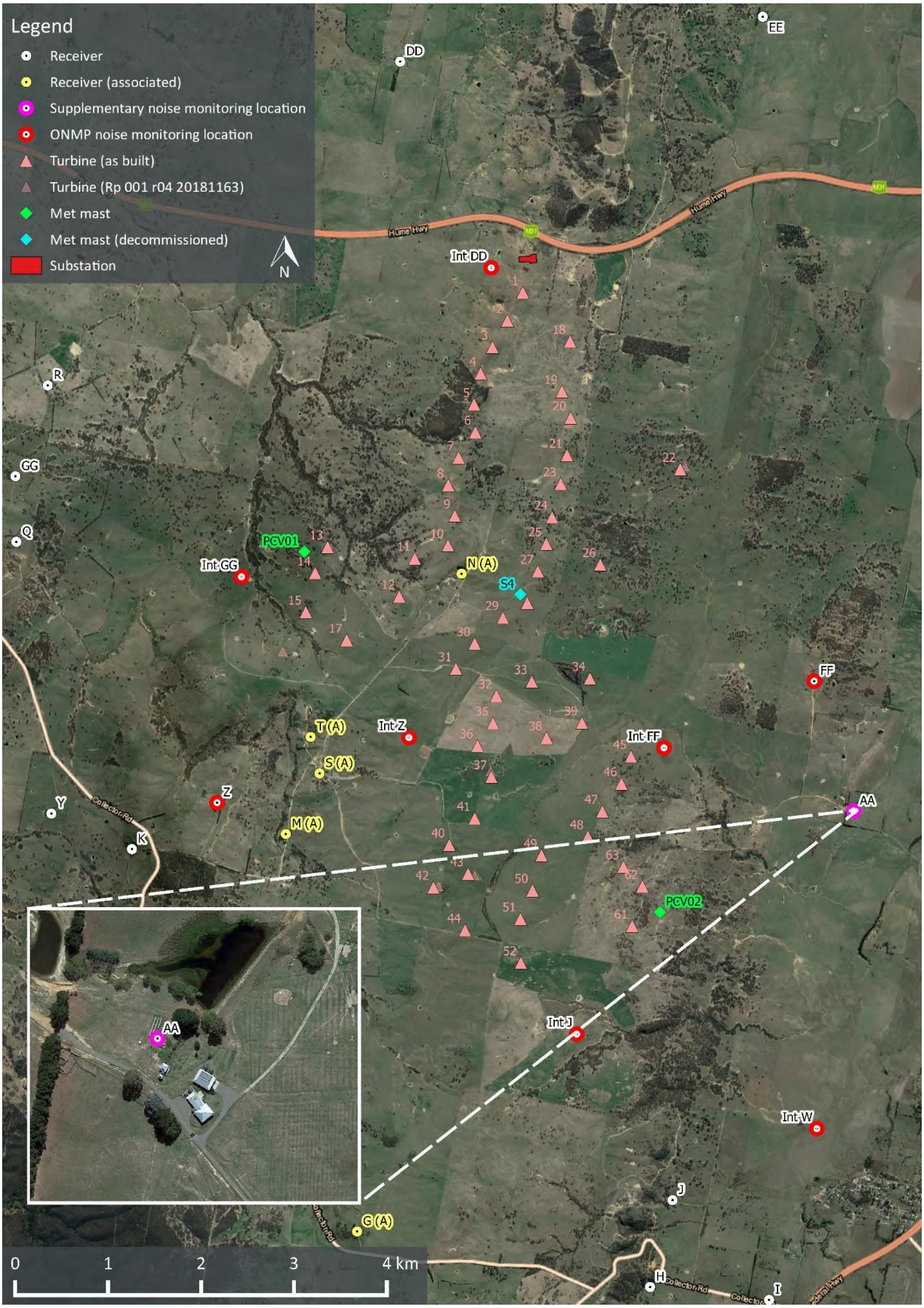


Table 65: Receiver AA monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

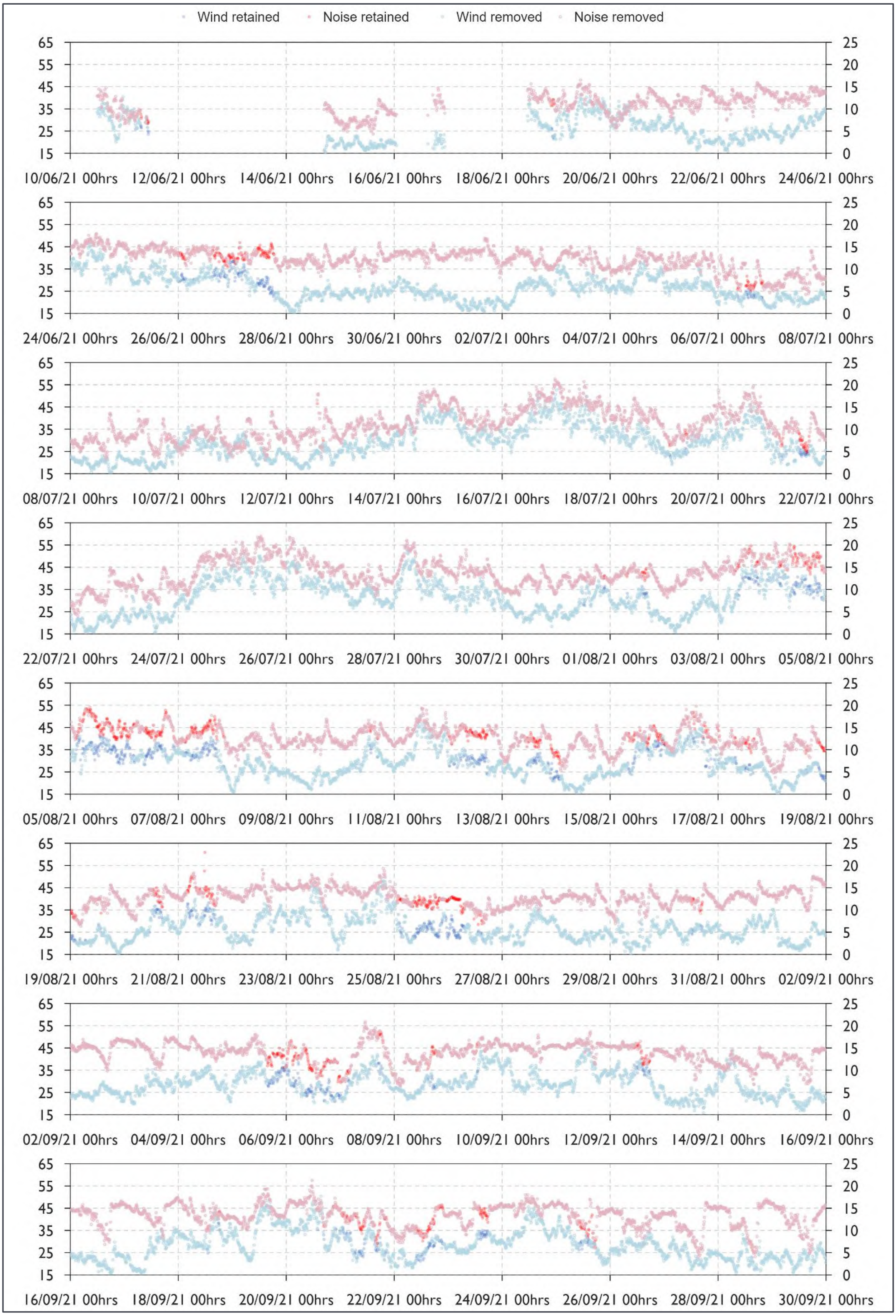
P2 Receiver AA measurement data summary

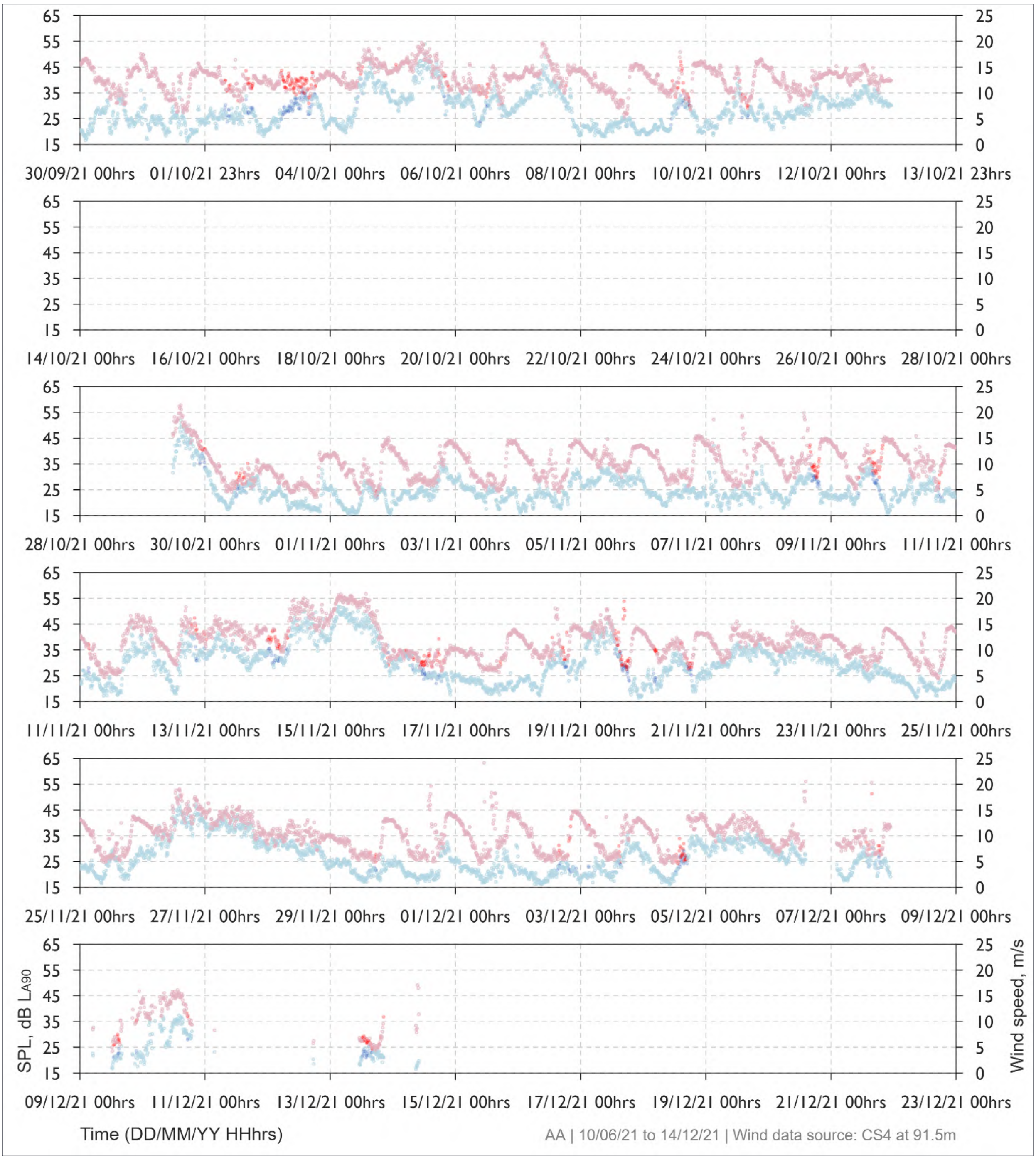
Table 66: Receiver AA noise level analysis summary

Description	Data points
Collected	22,407
Removed [1]	20,326
Retained	2,081

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

Figure 33: Receiver AA post construction A-weighted noise level and wind speed time history





30/09/21 00hrs
01/10/21 23hrs
04/10/21 00hrs
06/10/21 00hrs
08/10/21 00hrs
10/10/21 00hrs
12/10/21 00hrs
13/10/21 23hrs
14/10/21 00hrs
16/10/21 00hrs
18/10/21 00hrs
20/10/21 00hrs
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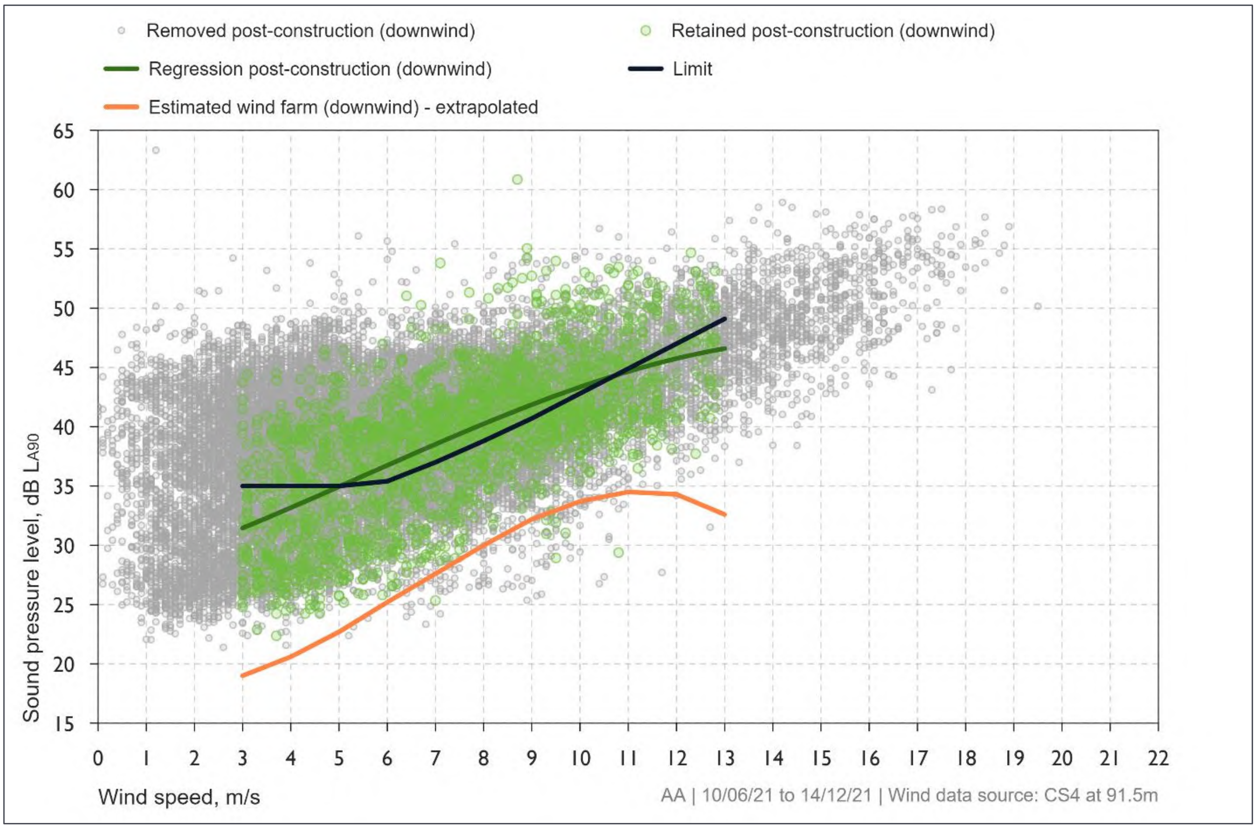
13/11/21 00hrs
15/11/21 00hrs
17/11/21 00hrs
19/11/21 00hrs
21/11/21 00hrs
23/11/21 00hrs
25/11/21 00hrs
25/11/21 00hrs
27/11/21 00hrs
29/11/21 00hrs
01/12/21 00hrs
03/12/21 00hrs
05/12/21 00hrs
07/12/21 00hrs
09/12/21 00hrs
09/12/21 00hrs
11/12/21 00hrs
13/12/21 00hrs
15/12/21 00hrs
17/12/21 00hrs
19/12/21 00hrs
21/12/21 00hrs
23/12/21 00hrs
SPL, dB LA90
Wind speed, m/s
Time (DD/MM/YY HHhrs)
AA | 10/06/21 to 14/12/21 | Wind data source: CS4 at 91.5m

Figure 34: Receiver AA - post-construction A-weighted noise levels and indicative noise limits versus site wind speed



APPENDIX Q RECEIVER FF DATA

Q1 Receiver FF location data

Table 67: Receiver FF dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Dwelling location	721,605	6,139,345
Noise monitoring location	721,631	6,139,344

Figure 35: Receiver FF aerial view – dwelling and noise monitor locations

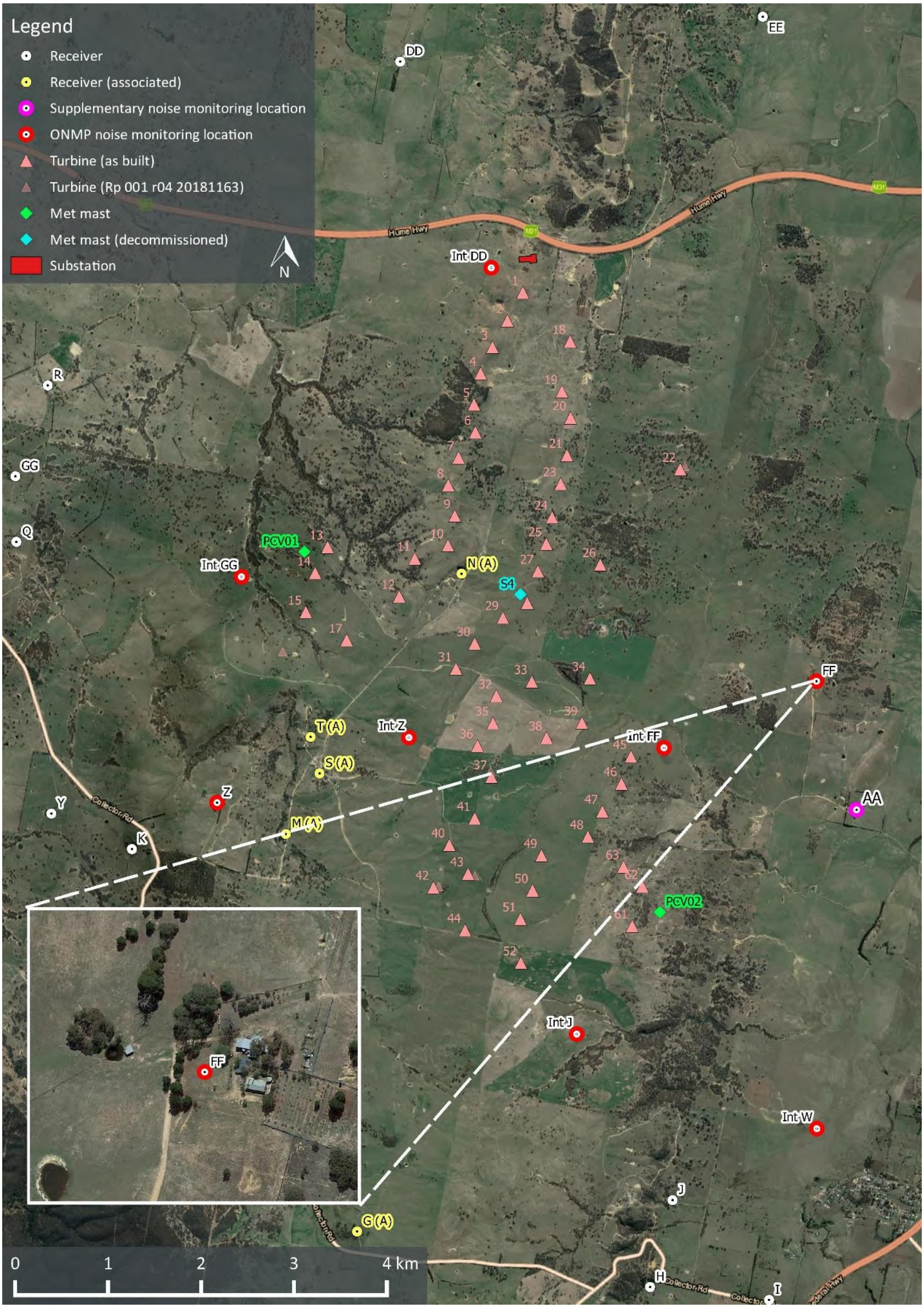


Table 68: Receiver FF monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

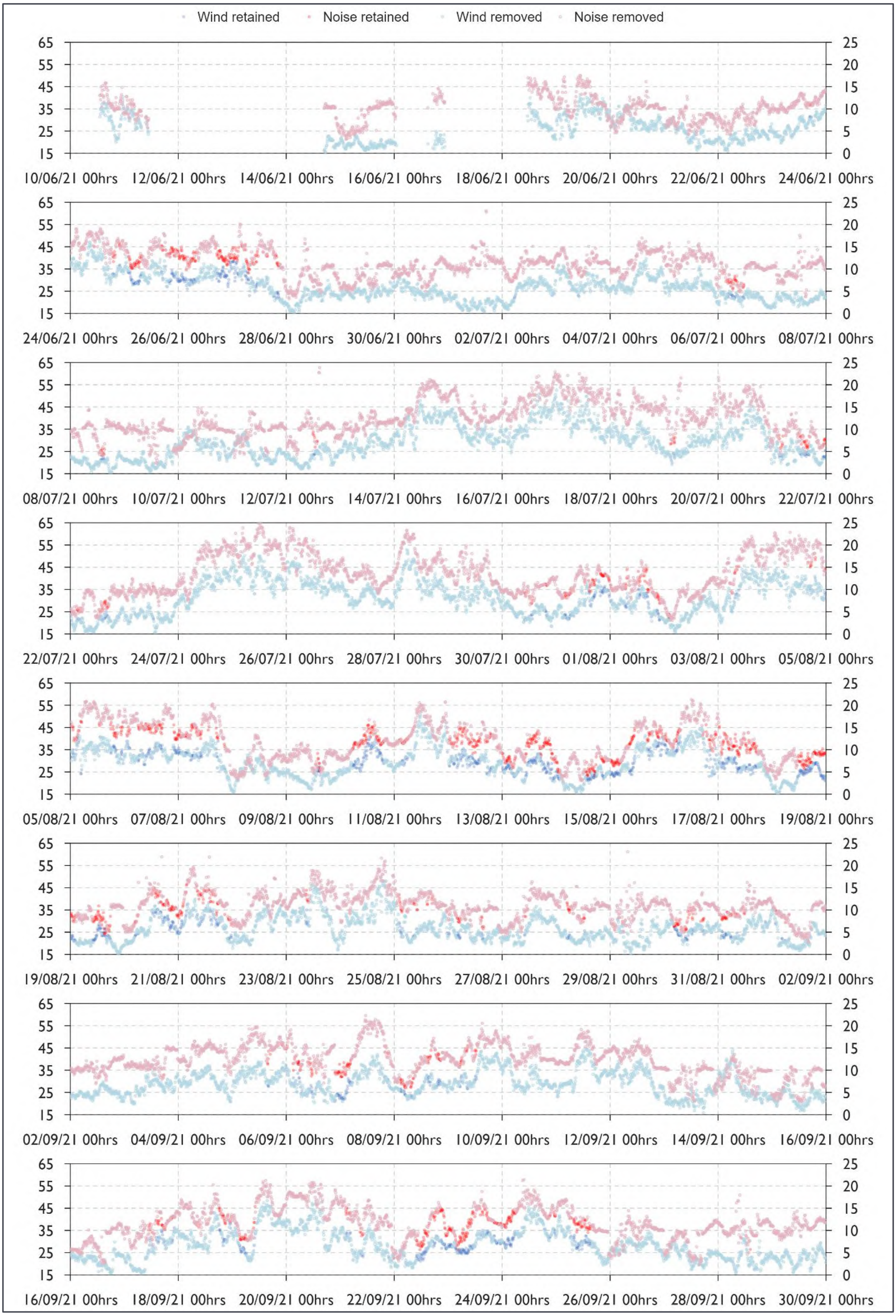
Q2 Receiver FF measurement data summary

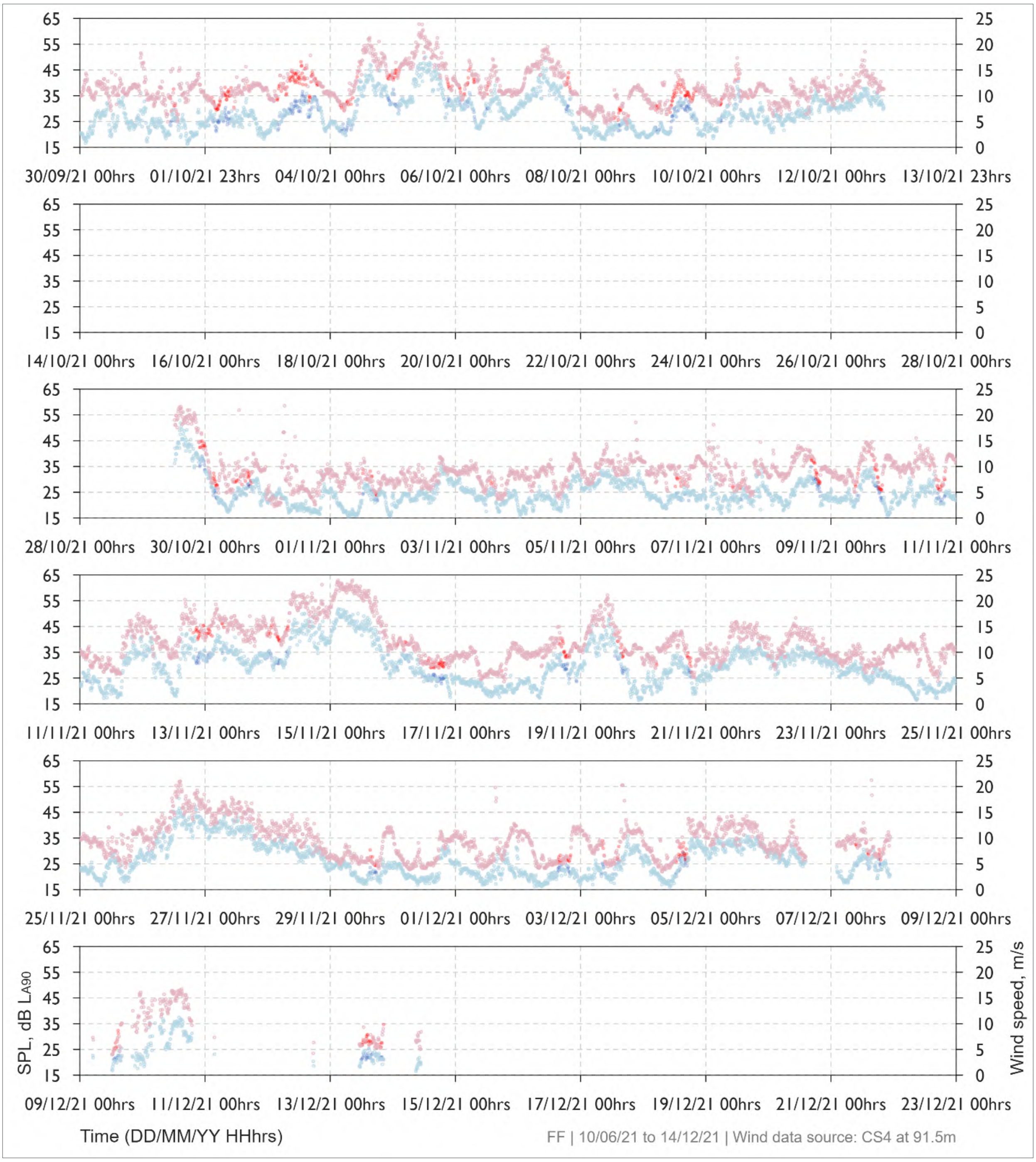
Table 69: Receiver FF noise level analysis summary

Description	Data points
Collected	22,512
Removed [1]	19,773
Retained	2,739

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

Figure 36: Receiver FF post construction A-weighted noise level and wind speed time history





65
55
45
35
25
15
25
20
15
10
5
0
30/09/21 00hrs
01/10/21 23hrs
04/10/21 00hrs
06/10/21 00hrs
08/10/21 00hrs
10/10/21 00hrs
12/10/21 00hrs
13/10/21 23hrs
14/10/21 00hrs
16/10/21 00hrs
18/10/21 00hrs
20/10/21 00hrs
22/10/21 00hrs
24/10/21 00hrs
26/10/21 00hrs
28/10/21 00hrs
30/10/21 00hrs
01/11/21 00hrs
03/11/21 00hrs
05/11/21 00hrs
07/11/21 00hrs
09/11/21 00hrs
11/11/21 00hrs
13/11/21 00hrs
15/11/21 00hrs
17/11/21 00hrs
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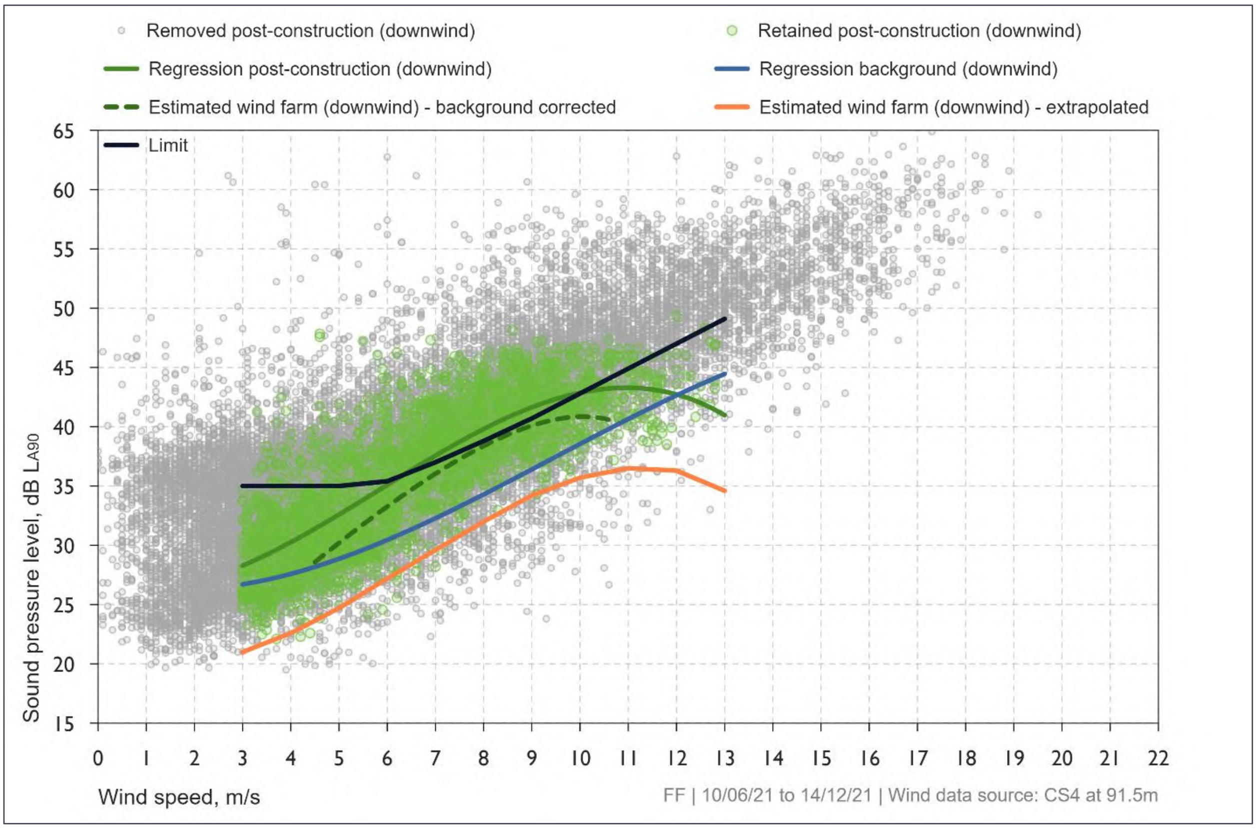
25/11/21 00hrs
27/11/21 00hrs
29/11/21 00hrs
01/12/21 00hrs
03/12/21 00hrs
05/12/21 00hrs
07/12/21 00hrs
09/12/21 00hrs
11/12/21 00hrs
13/12/21 00hrs
15/12/21 00hrs
17/12/21 00hrs
19/12/21 00hrs
21/12/21 00hrs
23/12/21 00hrs
SPL, dB LA90
Wind speed, m/s
Time (DD/MM/YY HHhrs)
FF | 10/06/21 to 14/12/21 | Wind data source: CS4 at 91.5m

Figure 37: Receiver FF - post-construction A-weighted noise levels and noise limits versus site wind speed



APPENDIX R RECEIVER Z DATA

R1 Receiver Z location data

Table 70: Receiver Z dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting, m	Northing, m
Dwelling location	715,180	6,138,036
Noise monitoring location	715,186	6,138,066

Figure 38: Receiver Z aerial view – dwelling and noise monitor locations

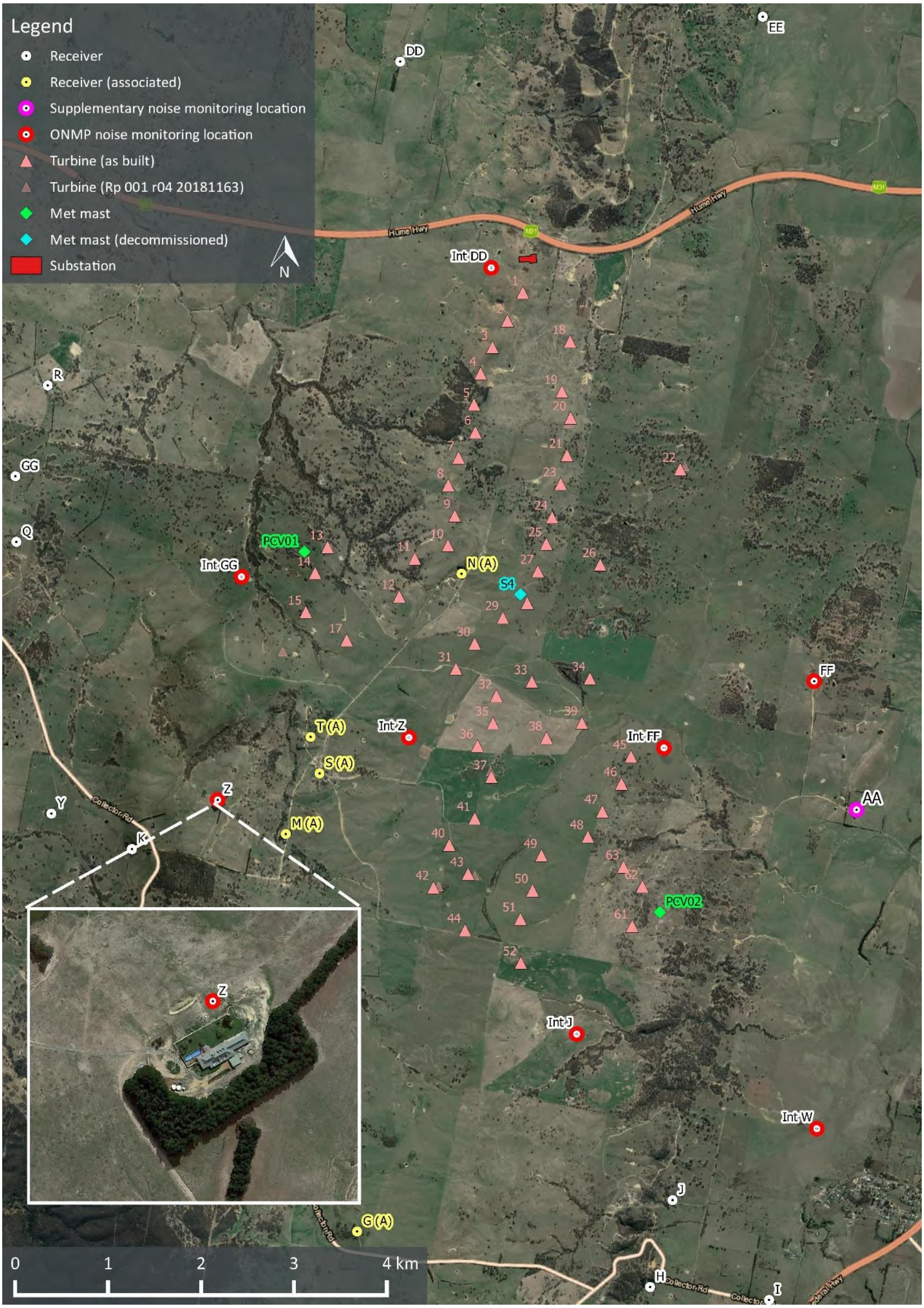


Table 71: Receiver Z monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

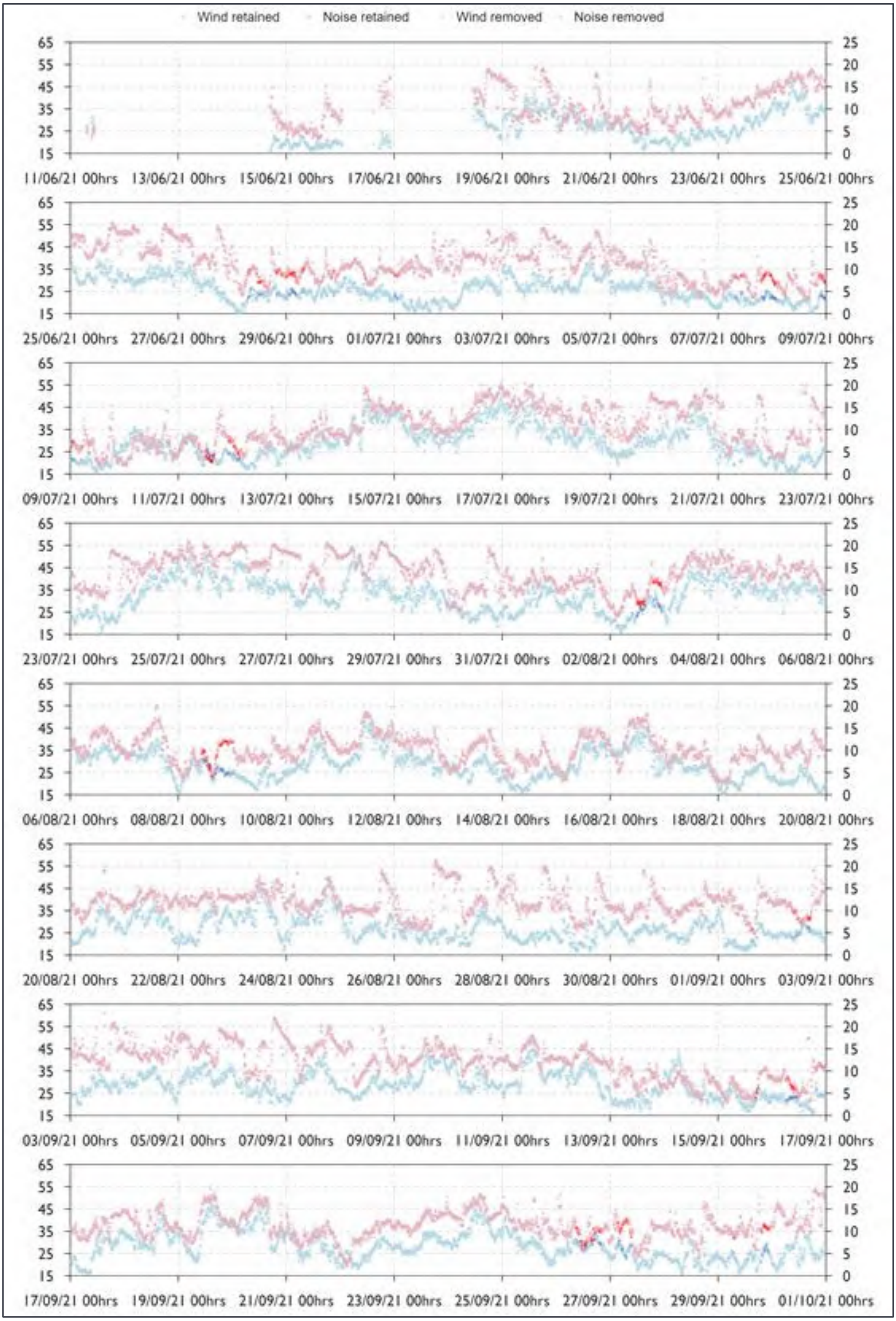
R2 Receiver Z measurement data summary

Table 72: Receiver Z noise level analysis summary

Description	Data points
Collected	22,331
Removed [1]	20,844
Retained	1,487

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

Figure 39: Receiver Z - post construction A-weighted noise level and wind speed time history



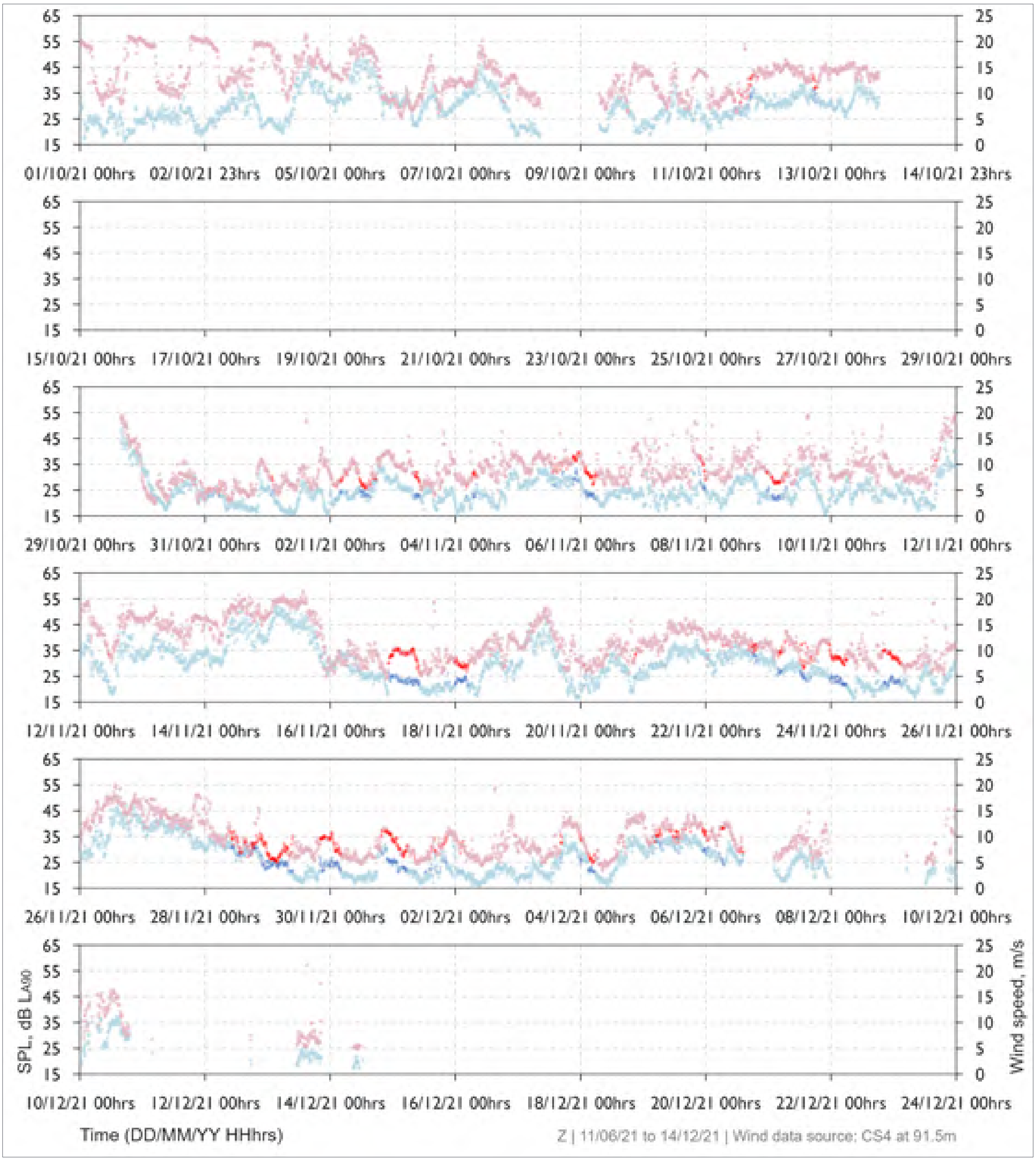

65
55
45
35
25
15
25
20
15
10
5
0
01/10/21 00hrs 02/10/21 23hrs 05/10/21 00hrs 07/10/21 00hrs 09/10/21 00hrs 11/10/21 00hrs 13/10/21 00hrs 14/10/21 23hrs
15/10/21 00hrs 17/10/21 00hrs 19/10/21 00hrs 21/10/21 00hrs 23/10/21 00hrs 25/10/21 00hrs 27/10/21 00hrs 29/10/21 00hrs
29/10/21 00hrs 31/10/21 00hrs 02/11/21 00hrs 04/11/21 00hrs 06/11/21 00hrs 08/11/21 00hrs 10/11/21 00hrs 12/11/21 00hrs
12/11/21 00hrs 14/11/21 00hrs 16/11/21 00hrs 18/11/21 00hrs 20/11/21 00hrs 22/11/21 00hrs 24/11/21 00hrs 26/11/21 00hrs
26/11/21 00hrs 28/11/21 00hrs 30/11/21 00hrs 02/12/21 00hrs 04/12/21 00hrs 06/12/21 00hrs 08/12/21 00hrs 10/12/21 00hrs
10/12/21 00hrs 12/12/21 00hrs 14/12/21 00hrs 16/12/21 00hrs 18/12/21 00hrs 20/12/21 00hrs 22/12/21 00hrs 24/12/21 00hrs
SPL, dB LA90
Wind speed, m/s
Time (DD/MM/YY HHhrs)
Z | 11/06/21 to 14/12/21 | Wind data source: CS4 at 91.5m

Figure 40: Receiver Z - post-construction A-weighted noise levels and noise limits versus site wind speed