



MARSHALL DAY
Acoustics 

BERRYBANK WIND FARM
ROUND 2 POST-CONSTRUCTION NOISE MONITORING

Rp 003 20200683 | 4 August 2023

Marshall Day Acoustics Pty Ltd
ABN: 53 470 077 191
10/50 Gipps Street
Collingwood VIC 3066
Australia
T: +613 9416 1855
www.marshallday.com

Project: **BERRYBANK WIND FARM**

Prepared for: **Berrybank Development Pty Ltd
c/- Global Power Generation Australia Pty Ltd
Suite 4, Level 3, 24 Marcus Clarke Street
Canberra ACT 2600**

Attention: **Gema Deus Vasquez**

Report No.: **Rp 003 20200683**

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EXECUTIVE SUMMARY

An initial post-construction noise compliance assessment for the Berrybank Wind Farm (wind farm) was completed in 2022, based on noise monitoring conducted between 21 June and 20 September 2021. The results were documented in the round 1 noise monitoring report¹ and demonstrated compliance with the performance requirements of the planning permits².

This report presents the results from the second round of post-construction noise monitoring and compliance assessment for the wind farm.

This assessment is based on noise monitoring carried out in the vicinity of the wind farm between 7 September 2022 and 29 March 2023. Stage 1 of the wind farm was fully operational during the monitoring period. However, operation of Stage 2 of the wind farm was significantly restricted due to Australian Energy Market Operator (AEMO) restrictions at the time. As a result, Stage 2 of the wind farm would not have significantly contributed to the measured noise levels during the monitoring period.

The monitoring was undertaken in accordance with the NZS 6808³ and the endorsed Noise Compliance Test Plan, as required by the planning permits.

The monitoring was conducted for twenty (20) of the twenty-one (21) receivers specified in the NCTP and comprised:

- unattended noise measurements at twelve (12) residential locations;
- unattended noise measurements at nine (9) intermediate locations positioned nearest to the wind farm; and
- attended observations to inform an assessment of whether the noise of the wind farm exhibited any special of the audible characteristics referred to in NZS 6808.

The location where compliance monitoring was not conducted was receiver 102. Noise measurements were previously conducted at this receiver during the background and round 1 post-construction noise monitoring periods. However, permission was not available for the round 2 monitoring.

Attended observations around the wind farm during the day and night did not indicate the presence of special audible characteristics at residential locations which would warrant objective assessment. However, in accordance with the NCTP, an objective assessment of tonality was conducted for all audio recordings obtained during the round 2 noise monitoring. Additional nearfield testing⁴ of turbine noise emissions (sound power levels) was also conducted, as recommended in the near-field compliance testing report⁵ prepared in accordance with the planning permits.

The results demonstrate that the noise levels of the Berrybank Wind Farm were below the noise limits determined in accordance with the planning permits and NZS 6808.

In accordance with the NCTP, further noise monitoring is to be conducted with both stages of the wind farm fully operational. The objective assessment of tonality will also be repeated, informed by the results of further near-field testing to focus the assessment on a narrower range of frequencies that are relevant to the turbines; the objective being to reduce the high rates of false positives (i.e. instances of tonality being detected for reasons not attributable to the wind farm) which were evident in the round 2 assessment.

¹ MDA report Rp 002 20200683 *Berrybank Wind Farm – Post-construction Noise Monitoring* dated 3 August 2022

² Planning Permits No. 20092821–A and 20092820-A for the Golden Plains Shire and Corangamite Shire sections of the project respectively, issued 4 February 2018 (the planning permits)

³ New Zealand Standard 6808:2010 *Acoustics – Wind turbine noise*

⁴ MDA document Rp 003 20210108 *Berrybank Wind Farm - Stage 2 Sound Power Test* dated 2 August 2023

⁵ MDA document Lt 002 20200683 *Berrybank Wind Farm – Near-field Compliance Testing Report* dated 3 August 2022

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1.0 INTRODUCTION

The Berrybank Wind Farm consists of two (2) stages of development:

- Stage 1 which is operational, and comprises forty-three (43) wind turbines; and
- Stage 2 which is constructed and was partly operational at the time, comprising twenty-six (26) wind turbines.

The planning permits⁶ for the Berrybank Wind Farm include conditions for the control of environmental noise from the development. Specifically, the planning permit requires noise from the wind farm to comply with the criteria detailed in NZS 6808⁷. The planning permit specifies that noise compliance monitoring is to be undertaken following the construction of the wind farm, and that the results must be submitted with a statement of compliance to the Minister for Planning.

In accordance with Condition 19 of the planning permits, the noise compliance monitoring procedures for the Berrybank Wind Farm are presented in the endorsed Noise Compliance Test Plan⁸ (NCTP) which forms part of the planning permits.

Berrybank Development Pty Ltd (BDPL), a subsidiary of Global Power Generation Australia Pty Ltd (GPG), engaged Marshall Day Acoustics Pty Ltd (MDA) to conduct noise compliance monitoring for the wind farm.

This report presents the results of the second round (round 2) of noise compliance monitoring for the Berrybank Wind Farm in accordance with the planning permits and NZS 6808.

The following key documents are referenced in this report:

- the background noise report⁹
- the NCTP
- the near-field compliance testing report¹⁰
- the round 1 noise monitoring report¹¹.

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

Site layout information is detailed in Appendix B.

⁶ Planning Permits No. 20092821–A and 20092820-A for the Golden Plains Shire and Corangamite Shire sections of the project respectively, issued 4 February 2018 (the planning permits)

⁷ New Zealand Standard 6808:2010 *Acoustics – Wind turbine noise*

⁸ MDA report Rp 001 R04 20180495 *Berrybank Wind Farm - Noise Compliance Test Plan* dated 15 April 2019

⁹ MDA report Rp 003 20180495 *Berrybank Wind Farm - Background Noise Monitoring* dated 1 July 2020

¹⁰ MDA document Lt 002 20200683 *Berrybank Wind Farm – Near-field Compliance Testing Report* dated 3 August 2022

¹¹ MDA report Rp 002 20200683 *Berrybank Wind Farm – Post-construction Noise Monitoring* dated 3 August 2022

2.0 WIND FARM DETAILS

2.1 Overview

The Berrybank Wind Farm consists of sixty-nine (69) Vestas V136 wind turbines.

The Vestas V136 is a variable speed wind turbine. The speed of rotation and the amount of power generated by the turbines being regulated by control systems which vary the pitch of the turbine blades (the angular orientation of the blade relative to its axis).

Details of the installed turbines are outlined in Table 1 below.

Table 1: Wind turbine details

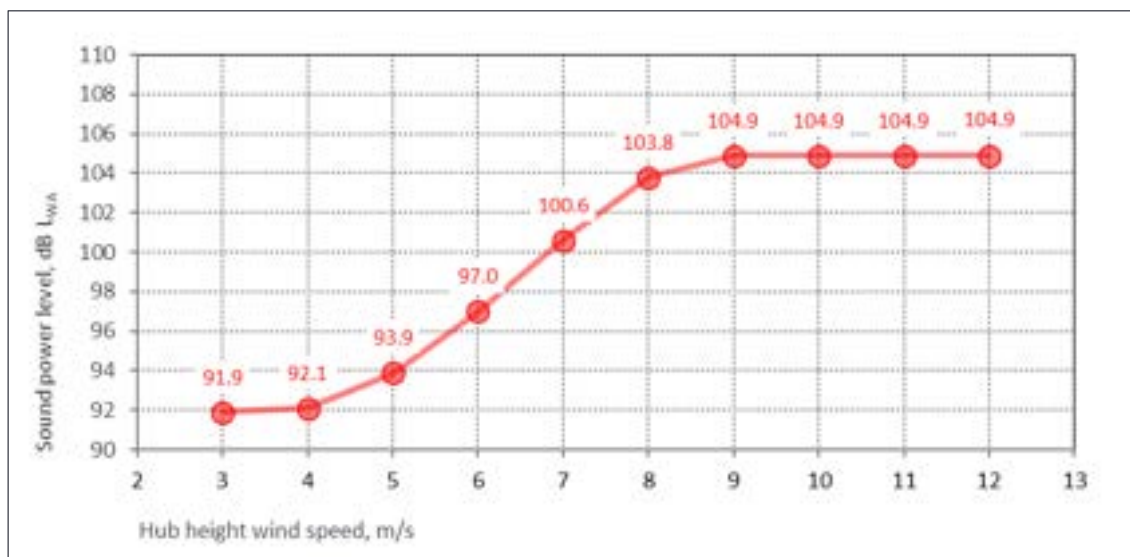
Detail	Turbine model
Make and model	Vestas V136
Rated power	4.2 MW
Rotor diameter	136 m
Hub height	112 m
Blade orientation	Upwind
Blade configuration	Serrated
Operating mode	Power optimised (P01) – sound management modes not utilised
Cut-in wind speed (hub height)	3.0 m/s
Rated power wind speed (hub height)	13.0 m/s
Cut-out wind speed (hub height)	25.0 m/s

For modern variable speed pitch regulated wind turbines, including the Vestas V136, the noise emissions typically increase with wind speed when the turbine is operating below rated power. At wind speeds approaching the speed of rated power, the noise emissions level off and remain relatively constant at higher wind speeds.

This trend is evident in the noise emission data¹² (sound power levels) for the Vestas V136 shown in Figure 1. In particular, the sound power reaches its highest value at a wind speed of around 9 m/s (at a height 112 m) and then no longer increases within increasing wind speed.

¹² Sourced from specification data detailed in Vestas document No. 0067-4732_02 V136-4.0/4.2 MW Third octave noise emission, dated 20 March 2018

Figure 1: Vestas V136-4.2MW sound power level versus hub height wind speed, dB L_{WA}



The total noise emissions of the Vestas V136 installed at the Berrybank Wind Farm were verified by the results of the sound power testing conducted in accordance with the requirements of the planning permit and the NCTP. The results were documented in the near-field compliance test report and confirmed A-weighted sound power levels below the values shown in Figure 1. The results also demonstrated that the sound power levels do not increase with increasing wind speed above the rated power of the turbines.

The sound power testing also involved an assessment of the sound frequency characteristics of the turbine. The assessment identified tonality as a characteristic of the test turbine at the test location. While the characteristic was identified close to the test turbine, it was not identified in the attended observations conducted near dwellings for the first round of compliance monitoring. However, in accordance with the NCTP, the identification of tonality in the sound power test establishes a requirement for an objective assessment of tonality as part of the noise compliance monitoring for the Berrybank Wind Farm.

As recommended in the near-field compliance test report, additional sound power level testing¹³ was undertaken at one of the Stage 2 turbines. Results of this additional test confirmed the presence of tonality close to the test turbine and overall sound power levels lower than the values shown in Figure 1.

¹³ MDA report Rp 003 20210108 *Berrybank Wind Farm - Stage 2 Sound Power Test* dated 2 August 2023

2.2 Operational status

Stage 1 of the Berrybank Wind Farm commenced full power operation prior to the round 2 noise monitoring. However, during the round 2 noise monitoring period which spanned from September 2022 to March 2023 (further details of the dates are provided subsequently in Section 4.2), operation of Stage 2 of the wind farm was significantly limited due to Australian Energy Market Operator (AEMO) power restrictions at the time. The following restrictions applied:

- Maximum Stage 2 power output limited to 5 MW until 17 February 2023, inclusive

This meant that only a single unconstrained Stage 2 turbine could operate at any given time while this restriction was in place. All other turbines were therefore not operating. The actual Stage 2 turbine selected to operate was varied during the round 2 noise monitoring period to meet other commissioning requirements for the development

- Maximum Stage 2 power output limited to 29.4 MW as of 18 February 2023

This meant that only seven (7) unconstrained Stage 2 turbines could operate at any given time with this restriction was in place. All other turbines were therefore not operating. Again, the actual Stage 2 turbines selected to operate was varied to meet other commissioning requirements for the development.

As a result, Stage 2 of the wind farm would not have significantly contributed to the measured noise levels during the monitoring period.

3.0 NOISE CRITERIA

3.1 Planning permits

Condition 17 of the planning permits specifies that operational noise levels of the wind energy facility must comply with NZS 6808 at any noise sensitive location (receiver) that existed as of 3 April 2017, to the satisfaction of the Minister for Planning. The condition also specifies that the noise limits do not apply if an agreement has been established with the relevant landowner to waive the noise limits.

The noise criteria detailed in NZS 6808 are defined using a combination of fixed values limits and background noise related limits. The fixed value component of the limit for the Berrybank Wind Farm is set at 40 dB L_{A90} (refer to Section 5.0 of the NCTP).

The applicable noise limits in accordance with NZS 6808 and the planning permits are therefore 40 dB L_{A90} or the background noise level $L_{A90} + 5$ dB, whichever is higher.

Background noise levels were previously measured at multiple receivers in the vicinity of the wind farm and have been referenced herein in order to:

- Determine operational noise limits in accordance with the planning permit; and
- Assist the analysis of noise data obtained from compliance monitoring after the wind farm commences operating.

3.2 Background noise levels

The NCTP nominates a total of seventeen (17) preferred receivers for conducting post-construction monitoring, subject to permission being granted by the landowners. The NCTP also notes that if permission is not able to be obtained for the monitoring, alternative locations shall be considered.

BDPL sought permission to measure background noise levels at all of the receivers nominated for post-constructing noise monitoring. However, permission was not able to be obtained at all locations, either as a result of the landowner declining to participate in the survey or the dwelling being uninhabited. In accordance with the NCTP, alternative locations were then selected for conducting background noise monitoring (referred to as substitute locations in the background noise report). The substitutes consisted of either a nearby receiver, where available, or an intermediate location positioned between the wind farm site and the original preferred noise compliance monitoring location.

Background noise monitoring was subsequently carried out at a total of sixteen (16) locations, comprising:

- Six (6) receivers; and
- Ten (10) intermediate locations between non-involved receivers and the wind farm.

Section 7.1.5 of NZS 6808 includes a provision to use a representative noise monitoring location for other nearby receivers:

When considering a group of noise sensitive locations it is acceptable to conduct background sound level measurements at a representative location. These measurements shall then be used to define noise limits that apply to every noise sensitive location in that group. The sound generating features at the representative location shall be similar in proximity and character to those at other noise sensitive locations represented by that location.

Two (2) of the six (6) receivers where background noise monitoring was conducted are used to represent other nearby receivers:

- Receiver 57: in lieu of access to receiver 57 to conduct background noise monitoring, the results of the monitoring at the nearby involved receiver 55 (S) were used to represent background noise levels at receiver 57 (noting that receiver 55 (S) is an involved location where the planning permits' noise limits do not apply).

Receiver 55 (S) is located across the road from receiver 57, and both locations are separated from the wind farm by a similar distance. Furthermore, the area around receiver 55 (S) was less vegetated than at receiver 57 and is therefore expected to provide a conservative basis for assessment (i.e. less vegetation around receiver 55 (S) is expected to have translated to lower background noise attributable to wind disturbed vegetation).

- Receiver 79: in lieu of access to receiver 79 to conduct background noise monitoring, the results of the monitoring conducted at the nearby receiver 80 were used to represent background noise levels at receiver 79.

Receiver 79 is approximately 350 m southeast of receiver 80, and both are located at comparable distances from the wind farm and the adjoining Hamilton Highway. The extent of vegetation around the two receivers is also similar.

The background noise data is defined for the following time periods:

- All-time (reduced): to exclude any potential residual effect of construction noise, the times when site records indicated construction activity was occurring were excluded from the analysis.

This generally involved the removal of all data between 0700 and 1700 hours for all days (and between 0530 and 1700 hours on the days when concrete pours were scheduled). The only exceptions to this were locations 83i and 103i where the background noise monitoring included some weekdays over the end of year holiday period when construction activity had stopped. Given the extent of data excluded, the period is subsequently referred to as "all-time (reduced)" in this report.

- Night-time (specific locations only): following removal of the daytime periods when construction activity was occurring (see discussion above relating to construction activity filtering), diurnal trends were not clearly evident in the data at receivers; they were also not evident in the data for the majority of intermediate locations.

Filtering for separate time periods was therefore generally not warranted, except for two of the intermediate locations (83i and 103i), where a separate analysis was warranted for the night period from 2200 to 0500 hours on account of a clearly distinct trend for these periods.

The round 2 compliance assessments included an investigation of the trends in the relationship between noise levels and wind speeds at the site. This has instigated a review of the wind data sources used for analysing noise measurement data, including the wind data used for previous and future noise monitoring.

As a result of this review to date, a revised hub height wind speed dataset for the background noise monitoring period was provided by GPG which more accurately reflects variations in wind shear at the site (the wind shear value describes the change in wind speed with height).

Details of the revised wind speed data resulting from the review, and reanalysed background noise levels will be documented in an updated version of the background noise report. In advance, the data presented in Table 2 and Table 3 summarises the updated background noise levels. The updated background noise level versus wind speed charts are also provided in Appendix L to Appendix DD (for the locations where background noise data is available).

The background noise data is provided for both receiver and intermediate locations. The data for receivers is used to determine operational noise limits in accordance with the planning permits and assist the analysis of the post-construction noise. The data from intermediate locations is only used to assist the analysis of the post-construction noise levels (i.e. intermediate location background noise levels are not used for setting noise limits). Tabulated values are only presented up to 13 m/s for ease of reporting, corresponding to the wind speed of rated power for the turbines. The full range of wind speeds at which background noise levels are available is presented in the respective background noise charts presented in the appendices.

Table 2: Derived background noise levels, dB LA90 - all-time (reduced)

Location	Hub height wind speed, m/s ^[1]										
	3	4	5	6	7	8	9	10	11	12	13
27	- ^[2]	28.4	28.4	28.9	29.6	30.7	32.1	33.6	35.3	37.1	39.0
69	- ^[2]	29.0	29.3	30.0	31.1	32.5	34.2	36.2	38.3	40.6	42.9
70	- ^[2]	26.7	27.0	27.9	29.3	31.1	33.2	35.6	38.1	40.8	43.5
80	- ^[2]	25.9	26.1	26.6	27.6	28.9	30.5	32.2	34.2	36.1	38.2
108	- ^[2]	30.3	30.6	31.4	32.6	34.3	36.2	38.3	40.6	42.9	45.1
55 (S)	- ^[2]	27.5	27.6	28.1	29.2	30.7	32.6	34.7	37.1	39.6	42.2
9i	21.2	21.8	22.4	23.1	23.8	24.5	25.2	26.0	26.9	27.9	28.9
10i	25.9	26.6	27.2	27.9	28.6	29.3	30.1	31.0	32.0	33.0	34.3
18i	21.8	22.1	22.5	23.1	23.7	24.5	25.4	26.4	27.5	28.7	30.0
56i	24.0	24.7	25.5	26.3	27.1	28.1	29.0	30.1	31.2	32.4	33.8
58i	19.6	20.1	20.6	21.2	21.9	22.7	23.6	24.6	25.7	27.0	28.4
63i	21.3	22.2	22.9	23.6	24.2	24.9	25.5	26.1	26.8	27.6	28.5
73i	21.4	21.6	22.0	22.8	23.8	25.0	26.4	27.8	29.2	30.5	31.7
83i	28.5	30.0	31.5	33.1	34.7	36.3	37.8	39.3	40.7	42.0	43.1
103i	23.5	24.9	26.2	27.4	28.4	29.4	30.3	31.1	32.0	32.8	33.6

1 112 m above ground level at 719773 E, 5800689 N (MGA 94 Zone 54)

2 Outside valid range of regression analysis

Table 3: Derived background noise levels, dB LA90 - night-time period (2200 to 0500 hours)

Location	Hub height wind speed, m/s ^[1]										
	3	4	5	6	7	8	9	10	11	12	13
83i	26.6	28.0	29.6	31.2	32.8	34.4	36.0	37.5	38.9	40.1	41.2
103i	18.3	18.9	20.0	21.3	22.8	24.3	25.7	26.8	27.6	27.9	- ^[2]

1 112 m above ground level at 719773 E, 5800689 N (MGA 94 Zone 54)

2 Outside valid range of regression analysis

3.3 Noise limits

The applicable noise limits summarised in Table 4 are based on measured background noise levels presented in Section 3.2 and the status of each receiver at the time of preparation of this report. The tabulated values are only presented up to 13 m/s for ease of reporting, corresponding to the wind speed of rated power for the turbines.

Table 4: All-time (reduced) operational wind farm noise limits, dB L_{A90}

Location	Hub height wind speed, m/s ^[1]										
	3	4	5	6	7	8	9	10	11	12	13
27	- ^[2]	- ^[2]	- ^[2]	- ^[2]	40.0	40.0	40.0	40.0	40.3	42.1	44.0
57 ^[3]	- ^[2]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	42.1	44.6	47.2
69	- ^[2]	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.3	45.6	47.9
70	- ^[2]	40.0	40.0	40.0	40.0	40.0	40.0	40.6	43.1	45.8	48.5
79 ^[4]	- ^[2]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.1	43.1
80	- ^[2]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.1	43.1
108	- ^[2]	40.0	40.0	40.0	40.0	40.0	41.2	43.4	45.6	47.9	50.1

1 112 m above ground level at 719773 E, 5800689 N (MGA 94 Zone 54)

2 Outside valid wind speed range of the regression analysis

3 Based on representative background noise levels measured at receiver 55 (S)

4 Based on representative background noise levels measured at receiver 80

At other non-involved receivers not listed in Table 4, a conservative assessment of compliance can be made by using the minimum applicable noise limit of 40 dB L_{A90}. For example, if the total measured noise levels are below 40 dB L_{A90}, then the noise contribution of the wind farm complies with the minimum noise limit. However, at higher wind speeds, near and above the rated power of the turbines, total measured noise levels are often higher than 40 dB L_{A90} due to the effect of increasing background noise with increasing wind speed. For this reason, compliance assessments based solely on post-construction measurements at receivers where background noise data are often inconclusive.

4.0 NOISE SURVEY & ANALYSIS METHOD

4.1 Noise monitoring locations

4.1.1 Preferred noise monitoring locations

The NCTP nominates a total of seventeen (17) preferred receivers for conducting post-construction monitoring, as detailed in Table 5, subject to permission being granted by the landowners. The NCTP also notes that if permission is not able to be obtained for the monitoring, alternative locations shall be considered.

As detailed in the background noise report, permission to undertake monitoring was not able to be obtained at all locations, either as a result of the landowner declining to participate in the survey or the dwelling being uninhabited. As such, consistent with the NCTP, substitute locations were selected for conducting background noise monitoring. The substitutes consisted of either a nearby receiver, where available, or an intermediate location positioned between the wind farm site and the original preferred noise compliance monitoring location.

Table 5: Preferred noise compliance monitoring locations nominated in the NCTP

Location	Direction from nearest turbine	Distance from nearest turbine, m
9	NNE	1,150
10	NW	1,141
18	NNW	1,071
27	NW	1,099
56 ^[1]	W	1,141
57	W	1,298
58	W	1,149
63	NE	1,416
69	SSW	1,114
70 ^[1]	SW	1,171
72	E	1,247
73	ESE	1,220
79*	SSW	1,093
80	SW	1,091
83	E	1,128
102	SSE	1,196
103	NNE	1,159

1 The inclusion of these noise sensitive receivers was requested by DELWP¹⁴

¹⁴ Department of Environment, Land, Water and Planning, now Department of Energy, Environment and Climate Action (DEECA)

The round 2 noise monitoring comprised noise measurements at a total of twenty-one (21) locations for the purposes of assessing noise levels at sixteen (16) of the seventeen (17) locations nominated in the NCTP. The measurements consisted of either:

- direct measurements at the receiver;
- measurements at a substitute monitoring location; or
- a combination of receiver and substitute location noise measurements for the locations where permission was previously not available, but subsequently became available during round 2.

The location where compliance monitoring was not conducted for was receiver 102. Background monitoring and round 1 post-construction noise compliance monitoring were conducted at this receiver previously, however permission for monitoring was not available for the round 2 monitoring.

4.1.2 Proximity of monitoring locations to wind farm operations

In light of the commencement of operation of Stage 2 of the Berrybank Wind Farm, the survey included locations relevant to both stages of the wind farm. However, AEMO restrictions on the power output of Stage 2 persisted throughout the round 2 noise monitoring. As a result, for the majority of the round 2 noise monitoring, only one of the Stage 2 turbines was permitted to operate at any given time, and no more than seven (7) turbines (less than 30 % of Stage 2) were able to operate during the later stages of the survey (see details in Section 2.2).

The power restrictions on Stage 2 meant that the noise emissions of Stage 2 were significantly limited; to the extent that the Stage 2 turbines would not have significantly contributed to the measured noise levels over the round 2 noise monitoring. Specifically, while brief periods within the overall survey period may have been influenced by Stage 2 turbine operations (for example, when the Stage 2 turbine(s) selected to operate were in the vicinity of receivers), these periods are unlikely to have been long enough to have materially influenced the overall analysis results for each location.

As a result, the round 2 noise monitoring was primarily relevant for assessing wind farm noise levels associated with Stage 1 turbines. This means that only eleven (11) of the sixteen (16) noise monitoring locations were suitable for the assessment of wind farm noise during the round 2 period.

At the remaining five (5) locations, the extent of wind farm operations, and the associated noise levels, were not sufficient to enable a meaningful assessment of wind farm noise levels during the round 2 noise monitoring period (i.e. on account of the measurements at these locations being too far from the Stage 1 turbines). Specifically, with only Stage 1 of the wind farm fully operational, the predictions for the site indicate that wind farm noise levels at these five (5) locations during the round 2 noise monitoring would have been less than 30 dB L_{A90} . In this respect, the following key items are noted:

- The predicted noise levels are more than 10 dB below the minimum noise limit; and
- The predicted noise levels are at least 5 dB below the total predicted noise level of the completed Berrybank Wind Farm. In accordance with Section 6.3 of the NCTP, measurements at these locations could have therefore been deferred, subject to the approval of the Minister for Planning.

4.1.3 Round 2 noise monitoring locations

Details of the noise monitoring conducted for the eleven (11) receivers which were suitable for wind farm noise monitoring during round 2 are summarised in Table 6. For consistency with the compliance assessment presented subsequently in this report (Section 5.4), the receivers are grouped in the table according to whether representative background noise monitoring data is available for each location.

Table 6: Noise monitoring for NCTP nominated receivers – receivers nearer to Stage 1 turbines

NCTP location	Round 2 measurements at receiver	Substitute location measurements	Reason for substitute location
<i>Receivers where representative background noise monitoring data is available</i>			
57	No	Yes (receiver 55(S))	Permission to monitor at the receiver was not available during the background noise survey (the background noise report notes there was no resident at the time, and the dwelling was abandoned). An alternative receiver for noise monitoring was selected across the road, at a similar distance from the wind farm.
69	Yes	No	No substitute required.
70 ^[1]	Yes	No	No substitute required.
79 ^[1]	Yes	No	Permission to monitor at the receiver was not available during the background noise survey (the background noise report notes there was no resident at the time, and the dwelling was abandoned). Receiver 80 was previously adopted as a substitute based on proximity. Permission for monitoring at receiver 79 was subsequently obtained for the second phase of the round 2 monitoring.
80	Yes	No	No substitute required.
72 (108) ^[2]	Yes	No	No substitute required
<i>Receivers where representative background noise monitoring data is not available</i>			
9	Yes	Yes (int. 9i)	Permission to monitor at the receiver was not available during the background noise survey. An intermediate location was selected for noise monitoring in lieu of an alternative nearby receiver. Permission was subsequently obtained for the second phase of the round 2 monitoring. Noise monitoring at the intermediate location was continued during the round 2 monitoring for supplementary analysis.
10	No	Yes (int. 10i)	Permission to monitor at the receiver was not available during the background noise survey (the NCTP notes the dwelling was uninhabitable). An intermediate location was selected for monitoring in lieu of an alternative nearby receiver.

NCTP location	Round 2 measurements at receiver	Substitute location measurements	Reason for substitute location
56 ^[1]	No	Yes (int. 56i)	Permission to monitor at the receiver was not available during the background noise survey (the NCTP notes the dwelling was uninhabitable). An intermediate location was selected for monitoring in lieu of an alternative nearby receiver.
63	Yes	Yes (int. 63i)	Permission to monitor at the receiver was not available during the background noise survey. An intermediate location was selected for background noise monitoring in lieu of an alternative nearby receiver. Permission was subsequently obtained for the second phase of the round 2 monitoring. Noise monitoring at the intermediate location was continued during the round 2 survey for supplementary analysis.
103	Yes	Yes (103i)	Permission to monitor at the receiver was not available during the background noise survey. An intermediate location was selected for background noise monitoring in lieu of an alternative nearby receiver. Permission was subsequently obtained for the second phase of the round 2 monitoring. Noise monitoring at the intermediate location was continued during the round 2 survey for supplementary analysis.

1 These locations were included in the NCTP at the request of DELWP

2 The coordinates of receivers 72 and 108 were rectified during the background noise monitoring. The dwelling location identified as 72 in the NCTP was subsequently identified as 108

Details of the noise monitoring conducted for the five (5) nominated receivers where the extent of wind farm operations were ultimately not sufficient to enable meaningful assessment of wind farm are summarised in Table 7. For consistency with the compliance assessment presented subsequently in this report (Section 5.4), the receivers are grouped in the table according to whether representative background noise monitoring data is available for each location.

As a further indication of the limitations of the monitoring conducted for the NCTP nominated receivers listed in Table 7, the four (4) intermediate locations which were used as substitutes for receiver monitoring were originally selected to be near the predicted 45 dB L_{A90} contour of the completed wind farm. The intent of the intermediates is that the contribution of the wind farm is more likely to be measurable at these positions, and provide a basis for then estimating wind farm noise levels at the corresponding receivers. However, with the AEMO restrictions in place on Stage 2, Figure 2 indicates all these intermediate locations were outside the predicted 35 dB L_{A90} noise contour for Stage 1 of the wind farm; three of them were also outside the 30 dB L_{A90} noise contour. This indicates that the measurements at these locations during round 2 would not provide a clear or meaningful indication of wind turbine noise that could be used to accurately estimate wind turbine noise levels at receivers.

Table 7: Noise monitoring for NCTP nominated locations – receivers nearer to Stage 2 turbines

NCTP location	Representative background noise data	Round 2 measurements at receiver	Substitute location measurements	Reason for substitution
<i>Locations with available representative background noise monitoring data</i>				
27	Yes	Yes	No	No substitution required
<i>Locations without available representative background noise monitoring data</i>				
18	No	Yes	Yes (int. 18i)	Permission to monitor at the receiver during the background survey was not available. An intermediate location was selected for background noise monitoring in lieu of an alternative nearby receiver. Permission was subsequently obtained for the second phase of the round 2 monitoring. Noise monitoring at the intermediate location was continued during the round 2 survey for supplementary analysis.
58	No	No	Yes (rec. 58i)	Permission to monitor at the receiver not available during any surveys conducted. An intermediate location was selected for background and round 2 monitoring in lieu of an alternative nearby receiver.
73	No	No	Yes (int. 73i)	Permission to monitor at the receiver not available during any surveys conducted. An intermediate location was selected for background and round 2 monitoring in lieu of an alternative nearby receiver.
83	No	Yes	Yes (int. 83i)	Permission to monitor at the receiver during the background survey was not available. An intermediate location was selected for background noise monitoring in lieu of an alternative nearby receiver. Permission was subsequently obtained for the second phase of the round 2 monitoring. Noise monitoring at the intermediate location was continued during the round 2 survey for supplementary analysis.

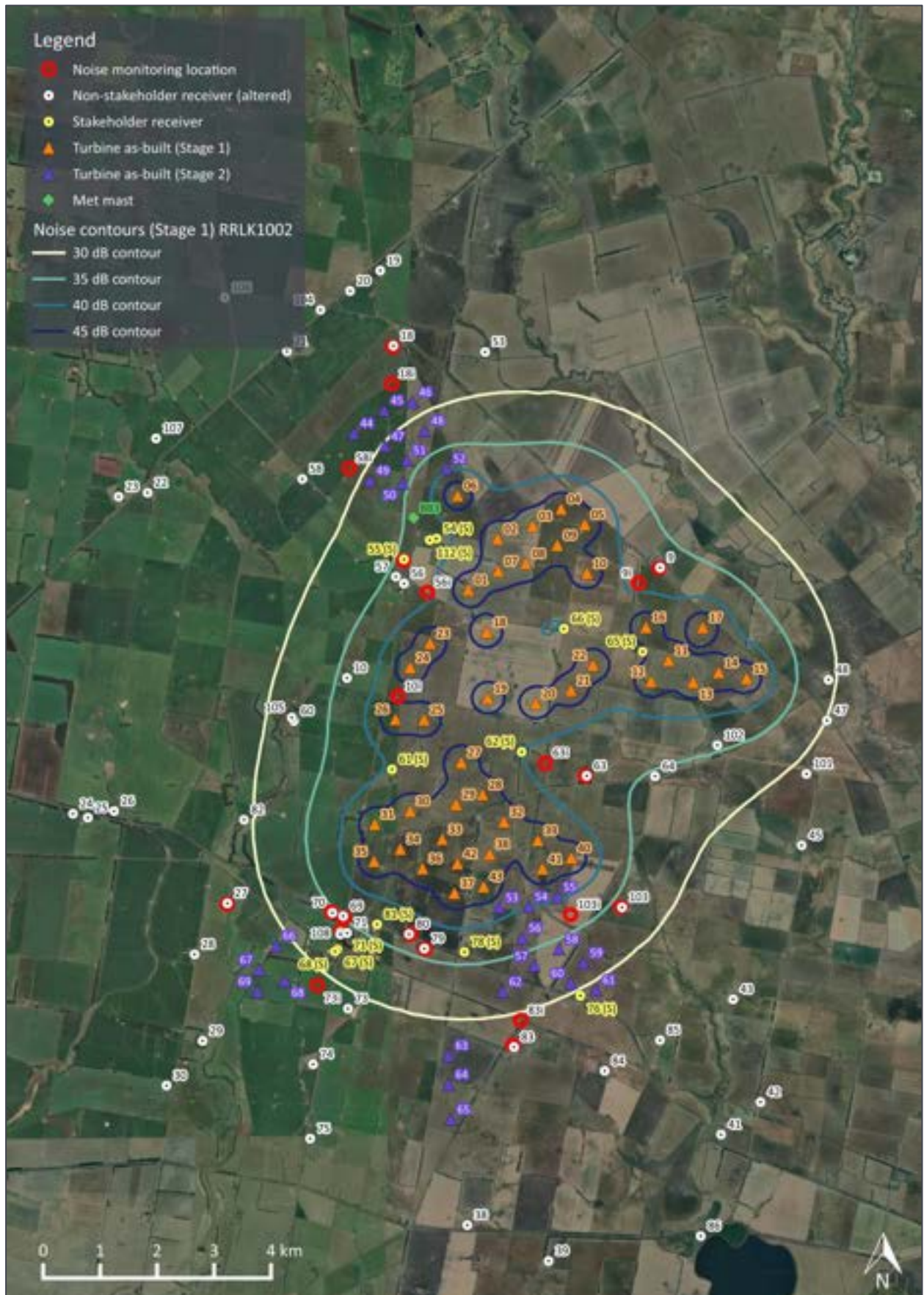
All noise monitoring equipment was positioned as follows:

- At the same location where the background noise monitoring was conducted (where relevant);
- Not less than 3.5 m from vertical reflecting surface;
- On the wind farm side of the dwelling and, as far as practically possible, within 20 m from the dwelling (where applicable) while avoiding reflecting surfaces and localised sources of background noise; and
- As far as practically possible from streams, watercourse and vegetation which may result in localised increases in background noise levels.

All of the noise monitoring locations are indicated on an aerial view of the site in Figure 2, along with the locations of the turbines of stages 1 and 2 and the predicted noise contours associated with Stage 1 of the wind farm. For reference, Appendix B3 provides the same layout view with the additional of the total predicted noise contours associated with operation of stages 1 and 2 turbines.

Coordinates and photographs for the twenty-one (21) monitoring locations are provided in Appendix J to Appendix DD.

Figure 2: Round 2 noise monitoring locations with Stage 1 predicted noise contours, dB L_{A90}



4.2 Survey description

The survey comprised noise measurements and attended observations. Key elements of the survey are summarised in Table 8.

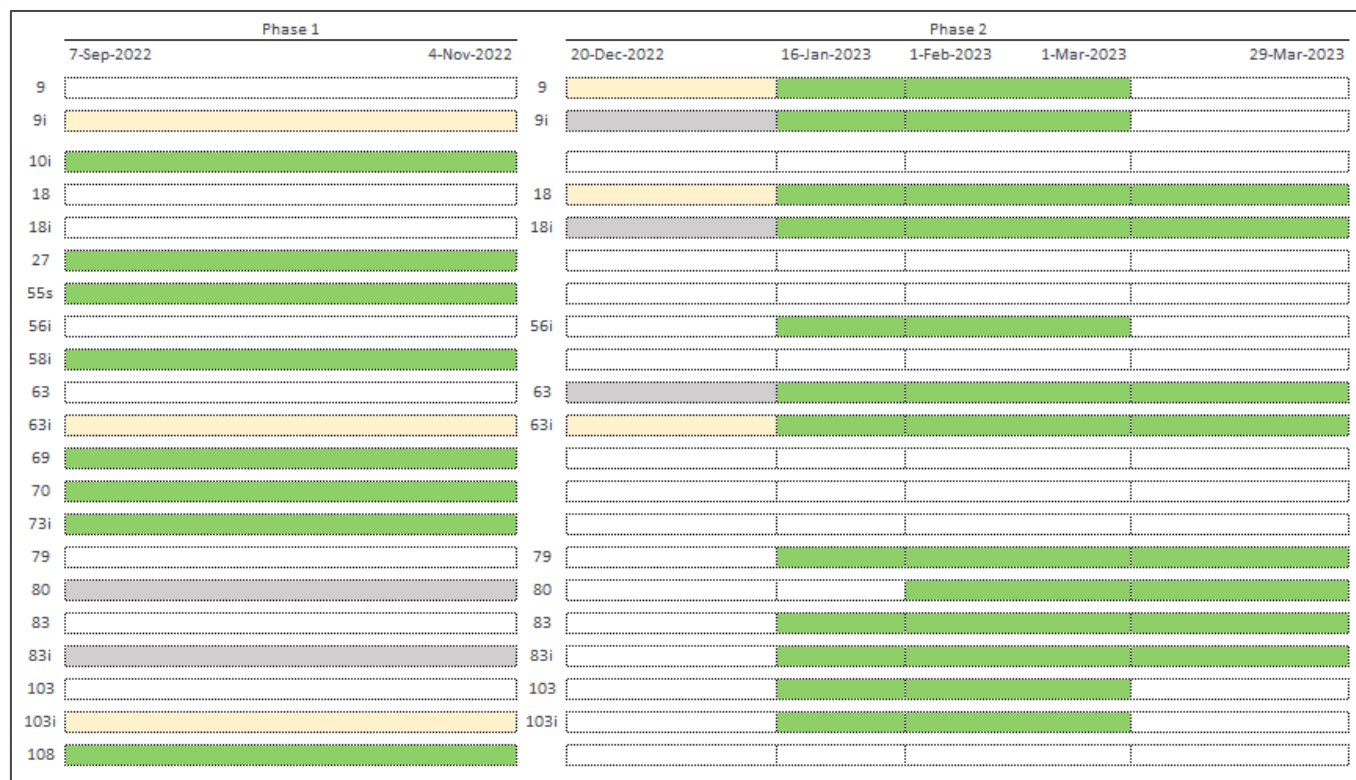
Table 8: Summary of key elements of the round 2 post construction noise survey

Item	Description
Monitoring locations	Twenty-one (21) locations as described in Section 4.1
Monitoring period	The monitoring was conducted in two phases: - Phase 1: 7 September to 4 November 2022 (comprising locations where monitoring had been conducted previously) - Phase 2: 20 December 2022 to 29 March 2023 (comprising locations where permission for monitoring had subsequently been obtained, plus two of the phase 1 monitoring locations where the equipment had failed). The dates of the monitoring for each location in Figure 3 below and documented in the appendices for each monitoring location. In accordance with the NCTP, the monitoring spanned a period of at least six (6) weeks at all locations (in excess of the 10-day survey period referred to in NZS 6808).
Attended observations	Six (6) visits for Phase 1 (including two (2) visits during the night period) and four (4) visits for Phase 2 (including one (1) visit during the night period) were undertaken by a qualified acoustic engineer with experience in the assessment of wind farm sound to conduct a subjective assessment of whether the sound contained special audible characteristics (SACs), comprising of identifying any clearly audible amplitude modulation, impulsiveness or tonality.
Sound level meters	Class 1 automated sound loggers (most accurate class rating for field usage). 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 guide¹⁵. See equipment specifications and calibration records in Appendix D. All noise monitoring equipment was independently laboratory calibrated; correct calibration was verified by reference checks at the start and end of the survey.
Noise measurement data	A-weighted and one-third octave band average and statistical sound pressure levels for consecutive 10-minute periods (time intervals commencing on the hour for alignment with site wind speed and operational records), based on instantaneous sound pressure levels (fast response) recorded in 100 ms resolution. The one-third octave band data was obtained to assist the identification of extraneous noise influences. Audio recordings were also made for the complete duration of every 10-minute interval; as an additional reference for the identification of extraneous noise influences, and to enable objective tonality analysis using the narrow-band method specified in the NCTP.

¹⁵ 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* dated May 2013

Item	Description
Local wind speed and rainfall data	A weather station was installed beside two (2) of the noise monitoring locations during the monitoring period 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). The data contains the average wind speed, direction and rainfall at the weather station for consecutive 10-minute periods with the time interval commencing on the hour.
Site wind speed data	Wake-free wind speed data at 112 m above ground level (the hub height of the turbines) was provided by GPG for the reference mast location BB3; the same mast location referenced for the background noise monitoring at the site. Based on the guidance of NZS 6808, and as discussed in Section 3.2, a wake-free data set was synthesised by GPG by analysing hub height wind speed data sourced from multiple turbine locations around the perimeter of the wind farm. Further details of the site wind speed data are provided in Appendix H.

Figure 3: Round 2 post-construction noise survey summary period



Legend:

dd-mmm-yyyy	site visit for deployment of noise monitoring equipment
dd-mmm-yyyy	site visit for collection of noise monitoring equipment
	noise monitoring was undertaken at location and data was assessed
	noise monitoring was undertaken at location, data was not assessed due to corresponding receiver or intermediate location not having available data
	equipment deployed but no valid data (due to factors such as equipment damage or fault)

4.3 Data analysis

4.3.1 Overview

Analysis procedures in accordance with the planning permits, NZS 6808 and the NCTP broadly involves the following:

- Collating the measured noise levels, site wind speeds and local weather data into a single dataset;
- Filtering the data set to remove measurement results that are clearly affected by extraneous or atypical noise (e.g. construction noise rainfall, agricultural machinery, atypically high insect noise in the vicinity of the microphone);
- Filtering the data where necessary to account for site wind directions;
- Plotting a chart of noise levels versus wind speeds and determining the line of best fit to the data; and
- Adjusting the line of best fit for the influence of background noise (where background noise data is available).

The wind speed range for the assessment is not explicitly defined in NZS 6808. Section 7.2.1 of the standard does however note the following with respect to the wind speed range of the measurements:

Sound level measurements should be made during a representative range of wind speeds and directions generally expected at the wind farm, and include the normal operating range of the turbines, that is, from cut-in to rated power. For dual-speed wind turbines the measurements should include the cut-in wind speed for the higher generating capacity.

The results of the noise measurements are presented for all wind speeds during the survey period. However, the assessment of compliance is based on wind speeds between the cut-in and rated power of the turbine (assessment wind speeds). The relevant considerations for this choice are:

- the change in the wind farm noise levels with increasing speeds;
- the change in the background noise levels with increasing speeds; and
- the NZS 6808 limits only applying to the noise levels attributable to the operation of the wind farm.

For modern variable speed pitch regulated wind turbines like the Vestas V136 installed at the wind farm, the noise level of the wind farm typically increases at wind speeds below speed of the turbine's rated power. At wind speeds approaching rated power, the noise emissions level off and remain relatively constant at higher wind speeds. This characteristic is evident in the noise emission data of the Vestas V136 presented earlier in Figure 1 of Section 2.1, and was verified by measurements conducted on-site for the near-field compliance testing report. Specifically, the turbine's noise emissions reach their highest value at approximately 9 m/s, around 4 m/s below the wind speed when the turbines have reached their rated power (13 m/s). This means that if compliance is demonstrated for wind speeds up to the rated power of the turbines, then compliance can be concluded for all higher wind speeds.

Further, at wind speeds above rated power, background noise levels are generally elevated, and increasing total noise levels above rated power primarily relate to sources other than the wind farm. This represents a significant source of uncertainty when attempting to quantify the noise contribution solely attributable to the wind farm at wind speeds above rated power.

The data analysis also involves an objective assessment of special audible characteristics (SACs) if their potential presence is indicated by:

- The attended observations conducted as part of the survey;
- Observations by site personnel at the wind farm; or
- Noise complaints recorded in the site's complaint handling and management system.

The NCTP for the Berrybank Wind Farm also specifies that an objective assessment of tonality is required if the results of the near-field testing identify tonality. As tonality was identified in the near-field testing, an objective assessment of tonality is required. However, for context, at the low to mid wind speeds which are usually most important for the assessment of tonality (on account wind farm noise being more likely to be audible at these wind speeds than at high wind speeds, due to the effects of background noise), the tonal audibility levels indicated by the near field testing were relatively low. Specifically, tonal audibility levels were below 1 dB at wind speeds below 10 m/s. The relationship between the tonality near a turbine and at distant receivers is complex. However, the level of tonality identified in the near-field testing does not provide a clear indication of tonality being a feature of the wind farm noise at the receivers.

A summary of the key steps in the analysis of the data is presented in Table 9.

Table 9: Noise data analysis summary

Process	Description
Data collation	Time stamps for each source of measurement data were reviewed to clarify start or end times and measurement time zone. Measured noise levels, site wind speeds and local weather conditions were then collated for each 10-minute measurement interval.
Local weather data filtering	10-minute intervals were 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 were used to identify periods that are likely to have been significantly affected by bird or insect sounds. 10-minute intervals were identified, and filtered from the analysis, when the following conditions¹⁶ were satisfied: • The highest A-weighted one-third octave band noise level was within 5 dB of the broadband A-weighted noise level for that interval; and • The identified one-third octave band A-weighted noise level was greater than a level of 20 dB L_{A90}.
Turbine shutdowns	In accordance with the NCTP, any periods significantly affected by turbine shutdowns were excluded from the regression analysis. Due to AEMO restrictions on the power output of Stage 2 of the wind farm, the noise monitoring was primarily relevant to the noise associated with the operation of Stage 1 turbines. The analysis to remove periods significantly affected by turbine shutdowns was therefore based solely on Stage 1 turbines (an analysis based on Stage 2 turbines would have resulted in the removal of significant quantities of data, due to the limited number of turbines which were operating, and the stringent operational analysis procedure specified in the NCTP). Wind farm operational records were supplied by BDPL for the duration of the monitoring. Any 10-minute period in which any relevant Stage 1 turbines¹⁷ were not operating, or producing atypically low power, were removed from the analysis. Further information is provided in Section 4.3.2.

¹⁶ Griffin, D., Delaire, C., & Pischedda, P. (2013). Methods of identifying extraneous noise during unattended noise measurements. *20th International Congress of Sound & Vibration*.

¹⁷ Relevant turbines are those which are most likely to contribute to the total wind farm noise level at a measurement location

Process	Description
Time periods	For consistency with the time periods used for the background analysis, the data was assessed for the all-time (reduced) period. This comprises all times other than 0700 to 1700 hours; the times which were excluded from the all-time analysis of the background noise data to exclude the potential effect of construction activities. The all-time (reduced) period is used for all locations for consistency, and to remove the influence of diurnally varying sources of background noise (unrelated to the operation of the wind farm) that are evident in the data trends. In relation to intermediate locations 83i and 103i, the all-time (reduced) filter differs slightly from the filter that was applied to the background noise monitoring at these locations. Specifically, the background noise monitoring at these locations included a brief period when weekday hours were included, corresponding to the end of year holiday period. However, the effect of this slight difference is inconsequential to the analysis of the intermediate locations (due to the limited length of the holiday period relative to the extended duration of the background noise survey, and the effect of broader background noise variations evident in the round 2 noise measurements for these locations). At some locations, separate consideration was given to noise levels measured during the night-period which is generally defined as 2200 – 0700 hrs (the night period is not specifically defined in NZS 6808, however 2200 – 0700 hrs is a commonly used definition for the night). Exceptions to this definition apply to intermediate locations 83i and 103i; the only locations in the background noise report where separate night trends were identified for the period 2200 – 0500 hours. The reduced night hours for 83i and 103i are also applied to the analysis of the round 2 noise monitoring data for these locations.
Objective tonality analysis	A narrow-band tonality analysis of the audio recording for each 10-minute period is conducted to calculate the tonal audibility and, where applicable, the associated tonal penalty for each 10-minute period of the survey. An important point of context is that the analysis is based on the recording of all sounds at the microphone and the procedure does not distinguish between tones originating from ambient noise sources and the wind farm. Further details of the tonality analysis are provided in Section 4.3.3 and Section 4.3.4.
Regression analysis	Two datasets were plotted on a chart of noise levels versus wind speeds: • All data points that were removed from the analysis using the above processes • The filtered dataset comprising all retained measurement data. The chart of filtered noise levels versus wind speed was reviewed to determine if there were any distinctive trends or gaps in the data which could warrant separation of the measurement results into subgroups (e.g., subgroups for time of day or wind direction). 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 was 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. Adjustments to the line of best fit were then applied, where applicable, for the influence of background noise (where data is available) and any identified tonality. The adjustment for identified tonality was based on repeat regression analysis of the data following the application of calculated penalties, where applicable, to the total measured noise level for each 10-minute period. Further details are provided in Section 4.3.4.

4.3.2 Operating configuration

The objective of the analysis is to assess whether the noise levels of the wind farm comply with the requirements of the planning permit 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 shut down or operating at reduced power levels (e.g. due to maintenance related issues or external energy market restrictions on the amount of power able to be generated by the site). As detailed in Section 4.3.1, the analysis of the round 2 noise monitoring data is based solely on the operating status of Stage 1 turbines (due to the limited operations of Stage 2 turbines during the noise monitoring).

To establish the profile of normal operations associated with the wind farm, a review of the data recorded by the site's supervisory control and data acquisition (SCADA) system was undertaken. 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 periods.

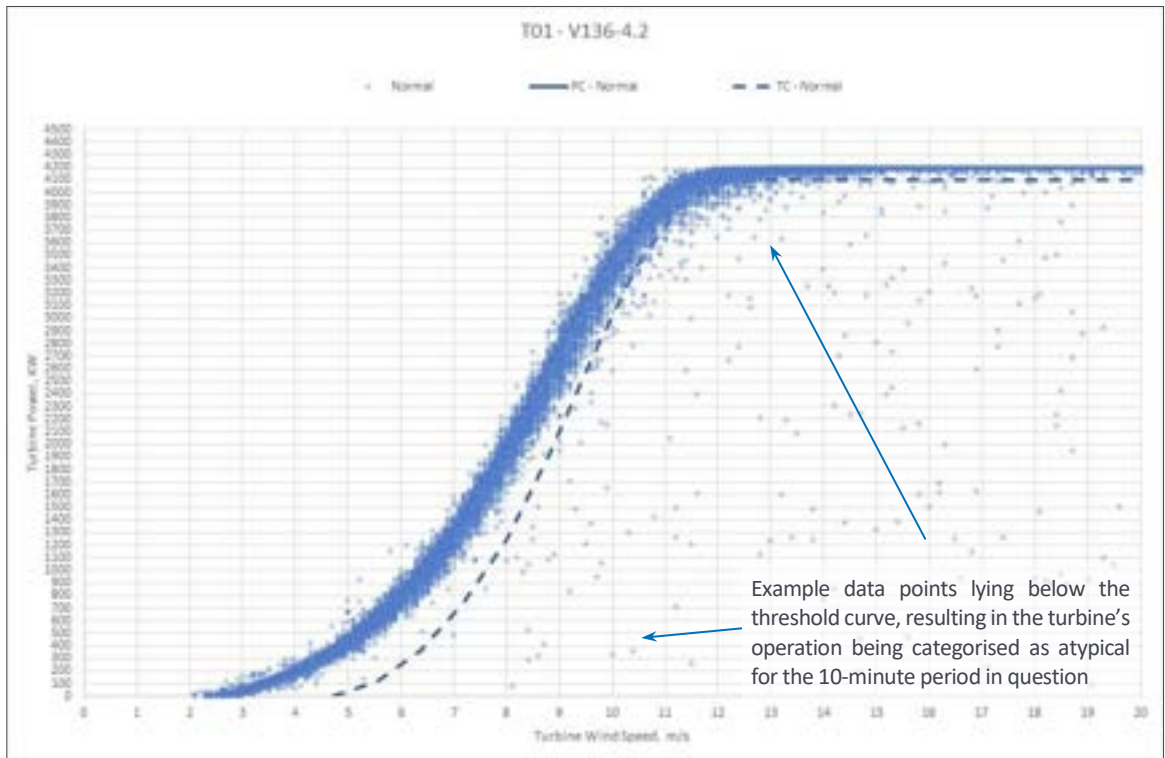
The review of the Stage 1 turbines' operational data involved generating average power versus nacelle wind speed plots for each turbine for the duration of the noise monitoring period. An example plot is provided below in Figure 4. The trends of these plots were reviewed to identify the typical range 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 power output was above or below the threshold curve. The power curve and threshold curve are illustrated on the chart in Figure 4. As an example of the analysis carried out for each turbine, Figure 4 also includes the 10-minute power data for turbine 01 during the monitoring period.

Figure 4: Example of a power versus nacelle wind speed plot (turbine 01)



To 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 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 NCTP, 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.

4.3.3 Special audible characteristics assessment methods

The procedures specified in the NCTP for conducting an objective assessment of SACs are detailed in Table 10.

Table 10: SAC objective assessment procedures

SAC	Objective assessment procedure
Amplitude modulation	UK Institute of Acoustics' Amplitude Modulation Working Group publication <i>Final Report - A Method for Rating Amplitude Modulation in Wind Turbine Noise Version 1</i> dated 9 Aug. 2016 (UK IOA AM procedure)
Impulsiveness	Australian Standard AS 1055:2018 <i>Description and measurement of environmental noise</i> (AS 1055:2018) The method defined in Appendix E (informative) <i>Objective method for application of an impulse adjustment to receiver noise</i>
Tonality	International Standard ISO 1996-2:2017 <i>Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels</i> 2017 (ISO 1996-2:2017) The narrow band method defined in Annex J <i>Objective method for assessing the audibility of tones in noise — Engineering method</i> (ISO 1996:2017 Annex J) is to be used

In relation to tonality, ISO 1996-2:2017 Annex J and the NCTP both refer to the procedure in ISO/PAS 20065:2016 *Acoustics - Objective method for assessing the audibility of tones in noise – Engineering Method* (ISO/PAS 20065) for the calculation of tonal audibility values for each 10-minute period. In the time since ISO 1996:2017 was released, and the NCTP was prepared, ISO/PAS 20065 was superseded by ISO/TS 20065:2022 *Acoustics — Objective method for assessing the audibility of tones in noise — Engineering method* (ISO/TS 20065).

ISO/TS 20065 states that the publication cancels and replaces ISO/PAS 20065. ISO/TS 20065 has therefore been used for the calculation of tonal audibility values. However, the changes introduced by ISO/TS 20065 are primarily editorial in nature, and the procedure for calculating tonal audibility remains unchanged.

4.3.4 Objective tonality analysis

Analysis of individual 10-minute periods

The tonality analysis for each 10-minute period of the survey comprises the following steps:

- Frequency analysis of the audio recording for each 10-minute period to determine the narrow band frequency spectrum with a resolution of 2 Hz for each consecutive 3-second step in the 10-minute period
- Analysis of the narrow band frequency spectra for each 3-second period of the 10-minute period using the procedure detailed in ISO/TS 20065 to calculate a tonal audibility value for each 3 second period. The 3-second values are then aggregated to produce an overall tonal audibility for the 10-minute period. The tonal audibility is a measure of the perceived audibility of a narrow group of frequencies which can be distinguished as a tonal sound.
- Calculation of a tonal penalty value in accordance with ISO 1996-2:2017 according to the value of the tonal audibility calculated in accordance with ISO/TS 20065. The calculated penalty value ranges between 0 and 6 dB inclusive.
- Addition of the tonal penalty values to the noise level of the wind farm in the 10-minute period where the tonal characteristic is identified, and then regression of these tonality adjusted wind farm noise levels.

NZS 6808 does not define requirements for the frequency range of a narrow band tonality analysis. However, the NCTP states:

In instances where an objective assessment of tonality is instigated on the basis of the results detailed in the Near Field Compliance Test Report, the objective assessment shall be restricted to the frequency of the range of the tones identified by the near field testing.

The following related guidance to limit the frequency range is also provided in ISO/TS 20065:

When unattended measurements are used, ancillary data such as audio recording or other methods of source identification are recommended. It is recommended that tones that are suspected of being caused by sources of residual sound are excluded from the analysis. In addition, it is recommended to consider limiting the frequency range over which tones are searched for.

A frequency range of 20 – 500 Hz was implemented for the tonality analysis. The lower bound of this frequency range reflects forthcoming guidance expected to be published by the International Electrotechnical Commission for the application of ISO/TS 20065 to wind farm noise assessment. The upper frequency range was selected to exclude higher frequency tonal sounds that would be related to the ambient environment, while still remaining well above the frequencies of the tones found during the nearfield testing of Turbine T04 of Stage 1 and Turbine T69 of Stage 2 (150 Hz and below). This frequency range will still identify multiple tone frequencies that are unrelated to the operation but provides a conservative basis for the assessment. It is envisaged that the results of further sound power level testing of other turbines at the site will enable a more targeted frequency range to be used for the analysis of subsequent rounds of monitoring.

Assessment of the overall dataset

In strict accordance with NZS 6808, an assessment of tonality is based on addition of the 10-minute penalty value to the noise level of the wind farm in each 10-minute period. The compliance assessment then involves a regression analysis of the tonality adjusted 10-minute data points. This presents two key considerations:

- The measured noise level in each 10-minute period does not represent the noise level of the wind farm. In particular, the 10-minute noise levels are highly variable and subject to considerable background noise influences; to the extent that the measured total noise level will frequently be much higher than the noise level attributable to the wind farm.
- The procedure specified in NZS 6808 to adjust for the influence of background noise comprises subtraction (logarithmically) of the regression line of the measured background noise levels from the regression line of the measured post-construction noise levels. Procedures for determining background noise adjustments for individual 10-minute periods are not defined in NZS 6808.

Given the above, it is not possible, using the procedures detailed in NZS 6808, to apply tonality adjustments to the noise levels solely attributable to the wind farm for each 10-minute period. However, to provide an assessment in strict accordance with NZS 6808¹⁸, penalties must be applied to the 10-minute periods in which they are identified, and background adjustments must only be applied to the regression of the post-construction measured noise levels. To fulfil these requirements of NZS 6808, the following approach has been adopted:

- Background and tonality related adjustments have been calculated and applied separately to the regression line of the measured post-construction noise levels
- Tonality adjustments have been determined by:
 - Conducting a regression analysis of the post-construction noise levels with and without calculated penalty values applied to the total measured noise levels in each 10-minute period
 - Calculating the arithmetic difference between the two regression curves with and without penalties applied to each 10-minute period. The difference at each wind speed represents the regression-based tonality adjustment to be applied to the estimated wind farm noise level. Consistent with the penalty values specified in NZS 6808, the regression-based tonality adjustment was capped at 6 dB.

A consequence of applying calculated penalty values to the total measured noise levels in each 10-minute period (as opposed to the noise level that is solely attributable to the wind farm) is that it includes applying penalties to 10-minute periods in which the measured noise levels are significantly elevated as a result of noise sources that are unrelated to the operation of the wind farm. As a result, the regression-based approach can lead to further overestimation of tonality related to the wind farm. This is in addition to the overestimate of tonality as a result of false positives which frequently occur in individual 10-minute periods (e.g. the calculation and application of penalty values caused by sources unrelated to the operation of the wind farm). However, the assessment approach is conservative.

¹⁸ Specifically, see Sections 7.5.3, 7.6.2 and Appendix B4 of NZS 6808

Receiver and intermediate monitoring locations

Tonal noise emissions from a wind farm will generally be more distinct at intermediate locations than at receivers. This is due to a combination of decreasing tone noise levels with increasing distance from the wind farm and the masking effect of higher background noise levels that typically occur near receivers. As a result, calculated tonal audibility values and penalties using data from intermediate locations would normally be higher than the corresponding value at the receiver, for tones solely related to the operation of the wind farm. The objective assessment of tonality is therefore always based on the audio recordings obtained at the receiver when monitoring was conducted at the receiver, even in situations where noise data measured at an intermediate location is used to estimate the noise level of the wind farm at a receiver. Objective assessment of tonality based on data obtained at an intermediate location is only used as a conservative indication of potential tonality at the receiver when monitoring was not able to be conducted at the receiver.

5.0 SURVEY & ANALYSIS RESULTS

This section presents the results of the measurements and attended observations, 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 could be significantly less than the total measured noise levels. However, the noise criteria only apply to the noise level that is solely attributable to the operation of the wind farm.

This is particularly relevant to the noise monitoring at receivers near Stage 2 of the wind farm. At these locations, the total measured noise levels mainly relate to background noise due to the limited operation of Stage 2 turbines during the noise monitoring.

5.1 Measured noise levels

The results of the unattended measurement data analysis for the twenty-one (21) locations are summarised for:

- the all-time (reduced) periods in Table 11 (all hours excluding 0700 – 1700 hrs); and
- the night periods for locations 83i and 103i in Table 12 (2200 – 0500 hrs).

The summary results correspond to the value of the line of best fit to the total noise level versus hub height wind speed chart for the assessment wind speeds (cut-in to rated power). 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 4.3.1 (i.e. for extraneous noise, rainfall, atypical operation of Stage 1 turbines and assessment wind speeds).

The detailed measurement and analysis results are presented in Appendix J to Appendix DD. This includes the noise level versus wind speed charts for the full range of wind speeds surveyed (charts provided separately for the full wind speed range and the assessment wind speed range), and 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. At some locations where supplementary analysis was warranted, the appendices also include data for the standard night period (2200 – 0700 hrs).

As per the requirements of NZS 6808, the analysis included a review of the relationship between measured noise levels and wind speeds to identify any distinctive trends which would warrant assessment of a subset of the measurement data. These types of trends are not evident; the variation that is evident in the measured noise levels at the receivers is indicative of background noise level variations rather than wind turbine noise.

The influence of background noise at the receivers is evident by comparing the measured noise levels at the locations where there was a pair of intermediate and receiver monitoring locations (e.g. receiver 9 and intermediate 9i). In almost all instances, the measured noise levels at the intermediate locations are lower than at the corresponding receiver. Given the relatively flat nature of the area, noise levels associated with operation of the wind farm will decrease with increasing distance from the wind farm. Therefore, the higher noise levels generally measured at the receivers indicates that the measurements were controlled by the influence of sources unrelated to the operation of the wind farm.

The notable exception to this was the intermediate and receiver pair for receiver 83, however both of these monitoring locations were located outside the predicted 30 dB L_{A90} contour of the Stage 1 turbines, and the measurements at both locations primarily represent background noise variations.

At two of the receivers, the regression line of the total measured noise levels is below the background noise level at high wind speeds. This was observed at receivers 55 (S) and 70 for wind speeds above 12 m/s and relates to variations in background noise levels. A review was conducted to assess if there were any factors which could indicate a systematic cause of the variation. The following observations are noted:

- The amount of vegetation evident in the monitor installation photos for the background and round 2 noise monitoring periods is similar and does not provide any indication of a systematic change in the level of background noise from wind disturbance of trees or other foliage (e.g. as can be the case when trees are removed or, conversely, have grown significantly).
- The wind farm site is relatively flat and background noise levels are not expected to vary with wind direction. Specifically, there are no indications of wind direction related causes of variation in background noise, whether as a result of changes in exposure to the wind (e.g. as can be the case at sites where terrain shelters a property from the wind in certain directions), distant background noise sources (e.g. as can be the case at sites where coastal or freeway noise is experienced in certain directions), or variations in wind shear with wind direction (wind shear does vary with wind direction, but the conditions of lower background noise do not coincide with the directions when wind shear tends to be higher).

Based on the above, the observed difference in noise levels at receivers 55 (S) and 70 is believed to be related to inherent variations in the background noise trends. As a further indication of the effect relating to background noise, the estimated noise contribution of the wind farm is well below the total measured noise levels at the wind speeds in question (below by more than 5 dB, based on the noise modelling and the verified sound power levels from the near-field testing).

While the variation in background noise at receivers 55 (S) and 70 was not able to be attributed a specific cause, the assessments presented subsequently for these locations demonstrate compliance by clear margins. The observed variation is therefore inconsequential to the assessment outcomes; particularly given that the estimated contribution of the wind farm at these locations is below the base (minimum) noise limit.

In terms of wind directions at the site during the noise monitoring period, wind roses are provided in Appendix H for the long-term trends of the site and the two separate phases of round 2 noise monitoring. The wind directions during phase 1 of the round 2 monitoring were broadly similar to annual average conditions at the site. Wind directions during phase 2 of the round 2 monitoring showed differences from average conditions, with winds from the southwest, west, northwest and north having occurred less frequently than annual average conditions.

The differences in wind direction trends in phase 2 of round 2 are not expected to have significantly affected the measurement results at most locations. Specifically, these conditions would have meant that direct downwind conditions from the wind farm at receivers to the northeast, east, southeast and south were experienced less frequently than occurs at other times. However, due to the extent of the wind farm, the wind direction ranges which are equivalent to downwind conditions (in terms of noise propagation) are relatively wide (see Appendix E for further information). Further, for receivers 9, 63 and 103 located to the north, east and southeast respectively, the analysis of downwind and upwind noise levels presented in the appendices do not show a systematic difference between noise levels measured under directly upwind and downwind conditions.

The exceptions are receivers 79 and 80 to the south, where the prevailing conditions during phase 2 of the round 2 monitoring are likely to have reduced the wind farm's contribution to the total measured noise level. However, given the absence of clear systematic differences between upwind and downwind noise levels at other receivers, more frequent winds from the north would not necessarily have altered the total measured noise levels. Notwithstanding this, an objective of further noise monitoring in future, as required by the planning permits, would be to obtain data for these locations for wind directions that are representative of typical conditions (or obtain additional data to understand the potential contribution of the wind farm, such as monitoring at additional intermediate locations).

Table 11: Total post-construction measured noise levels at receivers, dB LA90 – all-time (reduced)

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
9	- [1]	- [1]	27.6	29.2	31.8	34.9	37.9	40.5	42.0	42.1	- [1]
18	- [1]	25.2	25.3	26.9	29.6	32.8	36.3	39.5	42.1	43.5	- [1]
27	- [1]	- [1]	- [1]	- [1]	34.8	34.9	35.3	36.2	37.4	39.0	41.0
55s	- [1]	32.4	32.4	33.0	34.1	35.4	36.8	38.1	39.1	39.6	- [1]
63	- [1]	29.8	30.0	31.4	33.8	36.5	39.3	41.7	43.3	43.6	- [1]
69	- [1]	33.9	34.0	34.4	35.2	36.1	37.3	38.5	40.0	41.4	43.0
70	- [1]	30.3	30.3	31.0	32.3	34.0	35.9	37.7	39.4	40.6	41.2
79	- [1]	26.1	26.6	28.4	31.1	34.2	37.3	39.9	41.4	41.6	- [1]
80	- [1]	26.8	27.4	29.3	32.0	35.0	37.9	40.2	41.4	- [1]	- [1]
83	- [1]	- [1]	27.7	29.1	31.7	35.0	38.6	41.8	44.4	45.7	- [1]
103	- [1]	- [1]	27.9	28.8	30.8	33.5	36.5	39.3	41.5	42.7	- [1]
108	- [1]	32.4	32.3	32.8	33.8	35.3	37.0	38.9	40.8	42.7	44.4

1 Outside valid wind speed range of the regression analysis

Table 12: Total post-construction measured noise levels at intermediate locations, dB LA90 – all-time (reduced)

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
9i	26.6	26.8	27.7	29.2	31.0	33.0	34.9	36.4	37.4	37.7	- [1]
10i	36.2	36.7	37.5	38.5	39.7	41.0	42.3	43.5	44.6	45.4	46.0
18i	- [1]	24.3	24.3	25.4	27.3	29.7	32.6	35.5	38.3	40.8	42.6
56i	27.1	27.6	28.8	30.6	32.7	34.8	36.9	38.5	39.6	39.9	- [1]
58i	27.7	28.0	28.4	28.9	29.6	30.5	31.5	32.6	33.9	35.4	37.0
63i	24.8	26.1	27.4	28.9	30.5	32.2	33.8	35.5	37.0	38.5	39.9
73i	- [1]	- [1]	28.6	28.7	29.2	30.1	31.3	32.6	34.1	35.4	36.7
83i	- [1]	28.3	29.3	31.6	34.9	38.6	42.4	45.7	48.1	49.2	- [1]
103i	27.3	27.6	28.6	30.1	32.0	33.9	35.9	37.7	39.1	39.9	40.0

1 Outside valid wind speed range of the regression analysis

Table 13: Total post-construction measured noise levels, dB L_{A90} – night-time periods

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
83	- ^[1]	- ^[1]	26.0	26.5	28.4	31.1	34.4	38.0	41.4	44.3	46.3
83i	- ^[1]	- ^[1]	27.7	29.1	32.0	35.8	39.9	43.5	46.1	47.2	- ^[1]
103	- ^[1]	- ^[1]	26.8	26.8	27.7	29.5	32.0	35.0	38.4	42.2	46.0
103i	25.7	26.2	27.2	28.5	30.1	31.8	33.5	34.9	36.0	36.6	- ^[1]

1 Outside valid wind speed range of the regression analysis

5.2 Attended observations

The attended observations conducted during the round 2 monitoring comprised:

- Six (6) visits for Phase 1 (including two (2) visits during the night period); and
- Four (4) visits for Phase 2 (including one (1) visit during the night period).

Audibility of the wind farm near the receivers was highly variable according to:

- the operating conditions of the wind farm
- wind speed and direction; and
- background noise conditions.

Wind farm noise in the ranged from being inaudible during some visits, to clearly audible at other times. On the occasions when wind turbine noise was audible, the noise was typical of a correctly functioning wind farm in most instances, with audible sounds including broadband low to mid frequency sound and occasional blade swish. Out of the seventy-seven (77) observations completed near receivers during the round 2 monitoring, and documented in Appendix F1, special audible characteristics (SACs) were not evident during the majority of occasions. The only exceptions were the following two (2) instances when tonality was noted as a characteristic:

- 8 September 2022 near receiver 102: tonality was noted as just audible amid the background noise during conditions when the receiver was upwind of the wind farm
- 20 December 2022 near receiver 9: a tone was noted to be briefly audible during the attended observation, however it was unclear whether the tone was attributable to the wind farm.

On both occasions, the subjective ranking of the tones was that they were not sufficiently audible to automatically warrant an objective assessment of the data. However, irrespective of this ranking, and the broader absence of tonality during the majority of observations, an objective assessment of tonality is required in accordance with the NCTP as a result of the near-field compliance testing report indicating that tonality was a characteristic of the test turbine.

Amplitude modulation or impulsiveness were not observed as characteristics of the wind farm during any of the attended observations near the receivers. Objective assessment of these characteristics is therefore not warranted.

The characteristics of the wind farm noise are primarily relevant to locations near receivers. At intermediate locations, the character of the wind farm will differ from the character at the receivers. However, for information purposes, attended observations were also conducted at intermediate locations and are documented in Appendix F2. Similar to the observations at the receivers, tonality was not observed as a characteristic during the majority the observations at the intermediate locations. Tonality was however noted to be audible at low level during two (2) observations; once at intermediate 56i and once at intermediate 63i.

5.3 Tonality analysis results

This section summarises the results of the objective assessment of tonality conducted for all data obtained at the receiver and intermediate locations. In accordance with the NCTP, the assessment is based on the procedures of NZS 6808, ISO 1996:2017, and ISO/TS 20065 (see procedural description earlier in Section 4.3.4).

The data collected at the receivers is the primary consideration for the assessment. However, where data was not available at the receiver, the objective assessment data from the intermediate location is used as a conservative indication of potential tonality at the receiver (noting that tonality will generally be lower near receivers, due to increased distance and the masking effect of higher background noise levels near receivers).

As per the total measured noise levels discussed in Section 5.1, the results of an objective assessment of tonality relate to the total noise levels at each monitoring location. The objective assessment will therefore identify tones originating from a range of sources including domestic noise sources, agricultural machinery, road vehicles and aircraft movements. As a result, an objective assessment of unattended noise monitoring data will usually overestimate the potential tonality of the noise source under investigation.

In the case of the objective assessment of the round 2 monitoring, the results were affected by high rates of false positives which do not reflect the characteristics of the wind farm; the results mainly relate to background noise. The following key considerations and findings are noted:

- The ISO/TS 20065 procedure is intended for the analysis of ‘clean’ audio samples of the noise source in question. The standard notes that caution is required for the assessment of long-term unattended data. However, other than restricting the frequency range of the analysis, ISO/TS 20065 does not describe procedures to exclude tones arising from background noise sources.
- A conservative frequency range of 20 – 500 Hz was used for the analysis, resulting in the detection of numerous and widely varying tone frequencies. However, the available data from the nearfield testing indicates that the tones attributable to the turbines are characterised by a narrower range of frequencies. The wider range of frequencies detected in the results for the receivers is therefore indicative of background noise related sources of tones.
- The analysis indicated high tonal audibility levels at low wind speeds when either the wind farm would not have been operating, or would have been operating at reduced speeds and producing negligible noise at distances typical of receivers.
- If the wind farm was the primary contributor to identified tones, intermediate locations would be expected to have higher tonal audibility levels and rates of tone detection than the receivers. However, the results do not indicate a systematic pattern of higher tonal audibility levels, or tone detection rates, at the intermediate locations.

In light of the above, a series of further investigations were made to gauge the reliability of the ISO/TS 20065 procedure. The following investigations and findings are noted:

- The audio recordings of the attended observations were analysed and compared with the findings of the attending engineer. Despite tonality not being observed as a characteristic in seventy-five (75) of the seventy-seven (77) attended observations near receivers, the audio analysis using ISO/TS 20065 indicated tonality in most of the results, including the periods when the wind farm was noted to be inaudible.
- The audio recordings of the attended observations were also analysed using the superseded ISO 1996-2:2007 procedure which is directly referenced in NZS 6808. While ISO 1996-2:2007 also falsely indicated tones in many samples when tones were not present, the ISO/TS 20065 procedure had a significantly greater rate of detection of tones, and also indicated a higher level of tonal audibility.
- The ISO/TS 20065 procedure was used to analyse the unattended audio recordings obtained at three (3) or the receivers during the background noise monitoring. The results indicated high tonal audibility levels and rates of tone detection in the data measured prior to operation of the wind farm; the rates and levels were comparable to the results obtained from analysis of the data during the round 2 monitoring period.

Further details of the above investigations are provided in Appendix G.

The findings clearly indicate that the ISO/TS 20065 procedure is prone to indicating false positives when analysing unattended audio data with a conservative frequency range.

However, conversely, the results do not exclude the possibility of tonal noise at the receivers being attributable to the operation of the wind farm on some occasions. In recognition of this, and the detection of tonality in the near field testing, the calculated tonality adjustments for each receiver have been factored in the analysis to provide a conservative assessment of compliance.

Details of the overall tonality adjustment for each wind speed are provided in Appendix J to Appendix DD comprising:

- charts illustrating the regression analysis of the tonality adjusted data for each location; and
- tables summarising the calculation of the overall tonality adjustment.

The overall tonality adjustments calculated for each receiver monitoring location are summarised in Table 14 for the all-time (reduced) monitoring period. As part of the investigation of tonality, separate calculations were conducted for the night-time period and did not indicate any systematic difference in overall tonality adjustments. The assessment is therefore based solely on the overall tonality adjustments for the all-time (reduced) period.

Table 14: Overall tonality penalties at receivers, dB – all-time (reduced)

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
9	- [1]	- [1]	3.4	2.2	1.2	0.5	0.1	0.0	0.1	0.5	- [1]
18	- [1]	4.3	3.1	2.0	1.1	0.6	0.3	0.2	0.4	0.9	- [1]
27	- [1]	- [1]	- [1]	- [1]	1.6	1.1	0.9	0.5	0.4	0.3	0.2
55 (S)	- [1]	5.5	4.1	2.9	1.9	1.1	0.6	0.2	0.2	0.4	- [1]
63	- [1]	4.0	2.7	1.7	0.8	0.3	0.0	0.0	0.1	0.5	- [1]
69	- [1]	4.2	3.0	2.2	1.5	1.2	0.9	0.9	0.6	0.5	0.0
70	- [1]	4.0	2.8	2.0	1.4	1.0	0.8	0.7	0.5	0.4	0.2
79	- [1]	4.0	3.0	2.2	1.6	1.1	0.8	0.6	0.6	0.7	- [1]
80	- [1]	4.1	3.7	3.0	2.2	1.5	0.8	0.3	0.1	- [1]	- [1]
83	- [1]	- [1]	2.8	2.0	1.3	0.8	0.4	0.2	0.1	0.1	- [1]
103	- [1]	- [1]	3.2	1.9	1.0	0.4	0.0	0.0	0.0	0.4	- [1]
108	- [1]	4.4	3.1	2.1	1.5	0.9	0.7	0.5	0.5	0.4	0.4

1 Outside valid wind speed range of the regression analysis

The overall tonality adjustments calculated for each intermediate location are also summarised in Table 15 for the all-time (reduced) period. Note that only the tonality adjustments from intermediates 10i, 56i, 58i and 73i are referenced in the assessment in lieu of data obtained at the receivers. The data for the other intermediate locations is provided for information only as tonality adjustment data is available from the corresponding receiver.

Table 15: Aggregated tonality penalties at intermediates, dB – all-time (reduced)

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
9i [2]	- [1]	4.1	3.7	3.0	2.2	1.5	0.8	0.3	0.1	- [1]	- [1]
10i [3]	6.0 [4]	6.0 [4]	4.6	3.0	1.9	1.3	1.0	1.1	1.5	2.1	2.8
18i [2]	- [1]	4.7	4.0	2.9	1.8	0.8	0.0	0.0	0.0	0.6	2.5
56i [3]	6.0 [4]	5.6	4.4	3.1	1.9	1.0	0.3	0.2	0.4	1.3	- [1]
58i [3]	6.0 [4]	5.7	5.1	4.5	3.9	3.2	2.7	2.5	2.4	2.5	3.0
63i [2]	6.0 [4]	4.4	2.9	1.7	0.8	0.1	0.0	0.0	0.2	0.7	1.4
73i [3]	- [1]	- [1]	3.1	2.6	2.0	1.4	0.9	0.5	0.2	0.2	0.4
83i [2]	- [1]	5.4	3.5	2.2	1.1	0.5	0.1	0.1	0.2	0.5	- [1]
103i [2]	- [1]	5.1	3.6	2.3	1.2	0.6	0.1	0.0	0.0	0.6	1.5

1 Outside valid wind speed range of the regression analysis

2 Data provided for information only – tonality adjustments derived from data at the receivers

3 Data referenced in the compliance assessment

4 Tonality penalty values are capped at a maximum penalty of 6.0 dB

5.4 Compliance assessment

The following sections present an assessment of compliance for each location based on the measured noise levels and the calculated tonality adjustments documented in Section 5.3.

The nature of the compliance assessment for each receiver depended on whether representative background noise data was available. The extent of conclusions able to be reached from the noise monitoring data also depended on the proximity of the noise monitoring to operational turbines (i.e. Stage 1 turbines).

The compliance assessment results are therefore presented separately for the following:

- Receivers near Stage 1 turbines where background noise data is available;
- Receivers near Stage 1 turbines where background noise data is not available; and
- Receivers near Stage 2 turbines, where the noise level of Stage 1 turbines would have been too low to enable any meaningful separation of wind turbine noise from background noise.

The results presented in each section demonstrate that the noise levels of the Berrybank Wind Farm, accounting for the conservative tonality adjustments documented in Section 5.3, were below the noise limits determined in accordance with the planning permits and NZS 6808. In particular, at all locations where background noise data was available (for both adjusting post-construction noise levels and setting background-dependent noise limits), compliance was demonstrated based on the data directly measured at the receivers. At all other locations, compliance was supported by the supplementary assessments conducted in accordance with the requirements of the NCTP.

5.4.1 Receivers near Stage 1 turbines with representative background noise data

The following table summarises the assessment basis and findings for receivers near Stage 1 turbines where background noise data was available.

Table 16: Compliance summary for receivers near Stage 1 turbines with representative background noise

Receiver	Compliance
57	Compliance was directly demonstrated from the measurements at representative receiver 55 (S) (representative substitute location for receiver 57).
69	Compliance was directly demonstrated from the measurements at the receiver.
70	Compliance was directly demonstrated from the measurements at the receiver.
79	The data measured during the all-time (reduced) period was inconclusive due to the effect of elevated background noise. Compliance was however demonstrated from the total noise measurements during the night which provide a better representation of wind turbine noise in the absence of diurnal background noise sources during the round 2 monitoring period (see data and supplementary analysis in Appendix Q).
80	Data measured during the all-time (reduced) period was inconclusive due to the effect of elevated background noise. Compliance demonstrated from the total noise measurements during the night which provide a better representation of wind turbine noise in the absence of diurnal background noise sources during the round 2 monitoring period (see data and supplementary analysis in Appendix R)
108	Compliance was directly demonstrated from the measurements at the receiver.

The compliance margins determined from the assessments summarised above are presented in Table 17. The compliance margin is the difference between the estimated tonality adjusted wind farm noise level and the applicable noise limit. Negative compliance margin values indicate the estimated tonality adjusted wind farm noise level is below the noise limit.

Table 17: Compliance margin summary, dB L_{A90} – all-time period (reduced)

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
57	- ^[1]	-3.8	-5.2	-5.8	-5.7	-5.3	-4.7	-4.4	-2.8	-4.6	- ^[1]
69	- ^[1]	-3.6	-4.8	-5.4	-5.4	-5.2	-4.7	-1.8	-2.7	-3.7	-4.9
70	- ^[1]	-8.2	-9.6	-9.9	-9.3	-5.0	-3.3	-2.2	-3.2	-4.8	-7.1
79 ^[2]	- ^[1]	- ^[1]	-11.7	-11.6	-10.2	-8.2	-5.8	-5.7	-3.5	-4.1	- ^[1]
80 ^[2]	- ^[1]	- ^[1]	-10.1	-9.8	-8.6	-6.8	-7.1	-4.9	-3.7	- ^[1]	- ^[1]
108	- ^[1]	-3.2	-4.6	-5.1	-4.7	-3.8	-3.5	-4.0	-4.3	-4.8	-5.3

1 Outside valid wind speed range of the regression analysis

2 Indicates that compliance was assessed using noise levels measured during the night-time as an indication of potential wind farm noise levels at other times

5.4.2 Receivers near Stage 1 turbines without representative background noise data

The following table summarises the assessment basis and findings for receivers near Stage 1 turbines where background noise data was not available.

Table 18: Compliance summary for receivers near Stage 1 turbines without representative background noise

Receiver	Compliance
9	Data measured at the receiver during the all-time (reduced) period was inconclusive due to: - the effect of elevated background noise; and - the absence of background noise data for this receiver to establish the applicable limit at high wind speeds. However, separate analysis of the data for the night period indicated total measured noise levels below 40 dB L_{A90} at wind speeds up to 12 m/s inclusive. The night period data measured at the receiver was therefore consistent with the wind farm noise level being below 40 dB L_{A90}. Compliance was confirmed by extrapolation of the data obtained at intermediate location 9i which indicate that estimated tonality adjusted wind farm noise levels at receiver 9 were below the minimum noise limit value of 40 dB L_{A90}. Supplementary analysis of the data measured at the receiver also supported the compliance outcomes based on the intermediate location (see supplementary analysis in Appendix J).
10	This location was represented by measurements at an intermediate location only. Compliance was demonstrated at most wind speeds by extrapolation of the data obtained at intermediate location 10i. The extrapolation indicated estimated tonality adjusted wind farm noise levels below the minimum noise limit value of 40 dB L_{A90} at wind speeds up to 11 m/s inclusive. At wind speeds above 11 m/s, the data was inconclusive for the following reasons: - The effect of elevated background noise levels across the wind speed range. This was particularly evident from total measured noise levels of approximately 60 dB L_{A90} at low wind speeds when the noise emissions of the turbines would be negligible (data points which were able to be reliably filtered from the analysis at low wind speeds, but not at high wind speeds); and - The absence of background noise data for this receiver to establish the applicable limit at high wind speeds. However, given the turbines reach their highest noise emissions at a wind speed of approximately 9 m/s (see sound power level data presented in Section 2.1 and verified in the near-field compliance test report), the compliance outcomes at wind speeds up to 12 m/s are sufficient to conclude compliance at higher wind speeds.
56	This location was represented by measurements at an intermediate location only. Compliance was demonstrated at most winds speed by extrapolation of the data obtained at intermediate location 56i. This extrapolation indicated estimated tonality adjusted wind farm noise levels below the minimum noise limit value of 40 dB L_{A90} at wind speeds up to 12 m/s inclusive. Wind speeds above 12 m/s are outside of the valid range of the regression analysis (the regression curve sloped downwards above 12 m/s). However, the compliance outcomes at wind speeds up to 12 m/s are sufficient to conclude compliance at higher wind speeds.

Receiver	Compliance
63	This location was represented by measurements at an intermediate location only. Compliance was demonstrated at most winds speed by extrapolation of the data obtained at intermediate location 63i which indicated estimated tonality adjusted wind farm noise levels below the minimum noise limit value of 40 dB L_{A90} at wind speeds up to 13 m/s inclusive. Wind speeds above 13 m/s are outside of the valid range of the regression analysis (the regression curve sloped downwards above 13 m/s). However, the compliance outcomes at wind speeds up to 13 m/s are sufficient to conclude compliance at higher wind speeds.
103	Data measured at the receiver during the all-time (reduced) period was inconclusive due to: • the effect of elevated background noise; and • the absence of background noise data for this receiver to establish the applicable limit at high wind speeds. However, separate analysis of the data for the night period indicated total measured noise levels below 40 dB L_{A90} at wind speeds up to 11 m/s inclusive. The night period data is therefore consistent with the wind farm noise level being below 40 dB L_{A90}. Compliance was demonstrated by extrapolation of the data obtained at intermediate location 103i which indicate the estimated tonality adjusted wind farm noise levels at receiver 103 are below the minimum noise limit value of 40 dB L_{A90} at wind speeds up to 13 m/s inclusive. Supplementary analysis of the data measured at the receiver also supported the compliance outcomes based on the intermediate location (see supplementary analysis in Appendix T).

The compliance margins determined from the assessments summarised above are presented in Table 19. The compliance margin is the difference between the estimated tonality adjusted wind farm noise level and the applicable noise limit. Negative compliance margin values indicate the estimated tonality adjusted wind farm noise level is below the noise limit.

Table 19: Minimum compliance margin summary, dB L_{A90} – all periods (assessment relative to minimum noise limit of 40 dB L_{A90})

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
9 ^[3]	- ^[1]	- ^[1]	-11.4	-10.8	-9.7	-8.2	-6.5	-5.0	-3.9	-3.3	- ^[1]
10 ^[3]	-4.6	-4.1	-4.7	-5.3	-5.2	-4.4	-3.4	-2.1	-0.5	0.8 ^[4]	2.1 ^[4]
56	-11.7	-8.7	-11.4	-10.2	-8.7	-7.1	-5.5	-3.9	-2.6	-1.6	- ^[1]
63 ^[3]	- ^[1]	-12.7	-12.4	-11.5	-10.5	-9.1	-7.6	-5.8	-4.1	-2.2	- ^[1]
103 ^[3]	- ^[1]	- ^[1]	-10.0	-11.3	-11.3	-10.1	-8.0	-5.0	-1.6	2.6 ^[4]	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 Indicates that compliance was assessed using noise levels measured during the night-time as an indication of potential wind farm noise levels at other times

3 Indicates that compliance was assessed based on extrapolation of noise levels measured at an intermediate location

4 Result relates to background noise levels; actual wind turbine noise levels would be below the minimum noise limit of 40 dB L_{A90}

5.4.3 Receivers near Stage 2 wind turbines

The following table summarises the assessment basis and findings for receivers near Stage 2 turbines. These are the locations where wind turbine noise levels were low during the round 2 monitoring period (predictions indicate the levels would have been below 30 dB L_{A90}), due to the limited extent of Stage 2 turbine operations and the distance to Stage 1 turbines.

Table 20: Compliance summary for receivers near Stage 2

Receiver	Compliance
<i>Receivers where representative background noise monitoring data is available</i>	
27	Compliance was directly demonstrated from measurements at the receiver
<i>Receivers where representative background noise monitoring data is not available</i>	
18	The total measured noise levels at the receiver during the all-time (reduced) period was inconclusive due to: • the effect of elevated background noise; and • the absence of background noise data for this receiver to establish the applicable limit at high wind speeds. However, separate analysis of the data for the night period indicated total measured noise levels below 40 dB L_{A90} at wind speeds up to 11 m/s inclusive. The night period data is therefore consistent with the wind farm noise level being below the minimum noise limit of 40 dB L_{A90}. Given the distance of receiver 18 from the Stage 1 turbines, and the low predicted noise level of the wind farm during the monitoring period, limited information was able to be determined from the supplementary analysis. However, the data trends are consistent with background noise rather than wind farm noise. Intermediate location 18i was also well outside the predicted 30 dB L_{A90} contour of Stage 1 operations. As a result, total measured noise levels at this location primarily related to background noise and therefore do not provide a suitable basis for estimating wind farm noise using extrapolation. However, the extrapolated data demonstrated tonality adjusted noise levels below 40 dB L_{A90} at wind speeds up to 12 m/s inclusive. The compliance outcomes at wind speeds up to 12 m/s are sufficient to conclude compliance at higher wind speeds. Given that the intermediate location data was primarily related to background noise, the extrapolated data supports that tonality adjusted wind farm noise levels at receiver 18 were well below the minimum noise limit of 40 dB L_{A90}.
58	This location was represented by measurements at an intermediate location only. Intermediate location 58i was outside the predicted 30 dB L_{A90} contour of Stage 1 operations. Total measured noise levels at this location primarily related to background noise and therefore does not provide a suitable basis for estimating wind farm noise using extrapolation. Notwithstanding the above, extrapolation of the data obtained at intermediate location 58i indicates the estimated tonality adjusted total noise levels below 40 dB L_{A90} at all assessment wind speeds. The actual noise level attributable to the wind farm would have been significantly lower and therefore compliant with the minimum limit.

Receiver	Compliance
73	This location was represented by measurements at an intermediate location only. Intermediate location 73i was outside the predicted 30 dB L_{A90} contour of Stage 1 operations. Total measured noise levels at this location primarily related to background noise and therefore does not provide a suitable basis for estimating wind farm noise using extrapolation. Notwithstanding the above, extrapolation of the data obtained at 73i indicates the estimated tonality adjusted total noise levels below 40 dB L_{A90} across the assessment wind speed range. The actual noise level attributable to the wind farm would have been significantly lower and therefore compliant with the minimum limit.
83	The data measured at both the receiver and intermediate location were inconclusive due to: • the effect of elevated background noise, which was clearly evident across the wind speed range, including low wind speeds when the wind farm would not have been operating or producing negligible noise emissions; and • the absence of background noise data for this receiver to establish the applicable limit at high wind speeds. Given the elevated background noise levels, the large separating distance between the monitoring locations and operational turbines, the supplementary analysis did not reveal any meaningful indication of wind turbine noise. However, comparison of the data measured at intermediate location 83i with the data measured intermediate location 103i provides context and a clear indication that the measured noise levels at 83i were background related. Both are located to the south of Stage 1 turbines, however 103i is located much nearer to the turbines. Estimated tonality adjusted wind farm noise levels at 103i were below 40 dB L_{A90}; in contrast, noise levels at 83i were well above 40 dB L_{A90} despite being much further from the wind farm. This demonstrates the measured noise levels at 83i were controlled by sources that are unrelated to the wind farm. It also supports that wind farm noise levels at receiver 83 would have been well below the minimum noise limit of 40 dB L_{A90}.

Table 21: Minimum compliance margin summary for receivers near Stage 2 wind turbines, dB L_{A90}

Location	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
<i>Receivers where representative background noise monitoring data is available</i>											
27	- [1]	- [1]	- [1]	- [1]	-5.2	-6.1	-6.6	-3.3	-2.5	-2.8	-2.8
<i>Receivers where representative background noise monitoring data is not available</i>											
18 [2]	- [1]	-12.0	-13.2	-13.2	-14.7	-11.9	-8.6	-5.5	-2.3	0.8 [4]	- [1]
58 [2]	-7.8	-7.9	-8.1	-8.2	-8.1	-7.9	-7.4	-6.4	-5.2	-3.6	-1.4
73 [2]	- [1]	- [1]	-9.4	-10.0	-10.3	-10.1	-9.5	-8.6	-7.4	-6.1	-4.6
83 [3]	- [1]	- [1]	-11.2	-11.5	-10.3	-8.1	-5.2	-1.8	1.5 [4]	4.4 [4]	- [1]

1 Outside valid wind speed range of the regression analysis

2 Indicates that compliance was assessed based on extrapolation of noise levels measured at an intermediate location

3 Indicates that compliance was assessed using noise levels measured during the night-time as an indication of potential wind farm noise levels at other times

4 Result relates to background noise levels; actual wind turbine noise levels would be below the minimum limit of 40 dB L_{A90}

6.0 SUMMARY

A second round of operational wind farm noise monitoring has been carried out in the vicinity of the Berrybank Wind Farm to assess compliance with the operational noise requirements specified in the planning permits.

The noise monitoring was carried out in accordance with the planning permits, NZS 6808 and the endorsed NCTP.

Stage 2 turbine operations during the round 2 noise monitoring were limited as a result of ongoing AEMO power restrictions. The results are therefore primarily relevant to the Stage 1 turbines which were operational during the noise monitoring.

In accordance with the NCTP, the assessment included an objective assessment of tonality to account for the detection of tonality during the nearfield testing. This is despite extensive attended observations not indicating tonality to be a recurring characteristic near the receivers.

The results demonstrate that the noise levels of the Berrybank Wind Farm were below the noise limits determined in accordance with the planning permits and NZS 6808. This finding accounts for conservative tonality adjustments which were found to be heavily affected by false positives.

In accordance with the NCTP, further noise monitoring is to be conducted and will account for operations of the Stage 2 turbines when AEMO power restrictions are lifted.

Given the extent of the background noise effects on the round 2 measurement results, further noise monitoring in accordance with the NCTP is likely to involve the use of additional intermediate monitoring points to assist the identification of noise contributions solely related to the wind farm.

Further noise monitoring will also account for:

- the findings of the review of the wind data analysis methodologies instigated by GPG; and
- a refined objective assessment of tonality focussed on a narrower range of frequencies, informed by the results of further nearfield testing to verify the relevant frequencies of interest.

APPENDIX A GLOSSARY OF TERMINOLOGY

Ambient noise	The total, encompassing sound.
Frequency	Sound can occur over a range of frequencies extending from the very low, such as the rumble of thunder, up to the very high such as the crash of cymbals. Sound is generally described over the frequency range from 63Hz to 4000Hz (4kHz). This is roughly equal to the range of frequencies on a piano.
Hertz (Hz)	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).
Octave band	A range of frequencies where the highest frequency included is twice the lowest frequency. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.
Residual noise	The total, encompassing sound without the sound of interest.
Sound pressure level (L_p)	A logarithmic ratio of a sound pressure measured at distance, relative to the threshold of hearing (20 μ Pa RMS) and expressed in decibels.
dB	Decibel. The unit of sound level.
A-weighting	The A-weighting approximates the response of the human ear
L_{Aeq}	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.
Noise is often not steady. Traffic noise, music noise and the barking of dogs are all examples of noises that vary over time. When such noises are measured, the noise level can be expressed as an average level, or as a statistical measure, such as the level exceeded for 90 % of the time.	
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.

APPENDIX B SITE LAYOUT AND NOISE CONTOURS

B1 Turbine coordinates

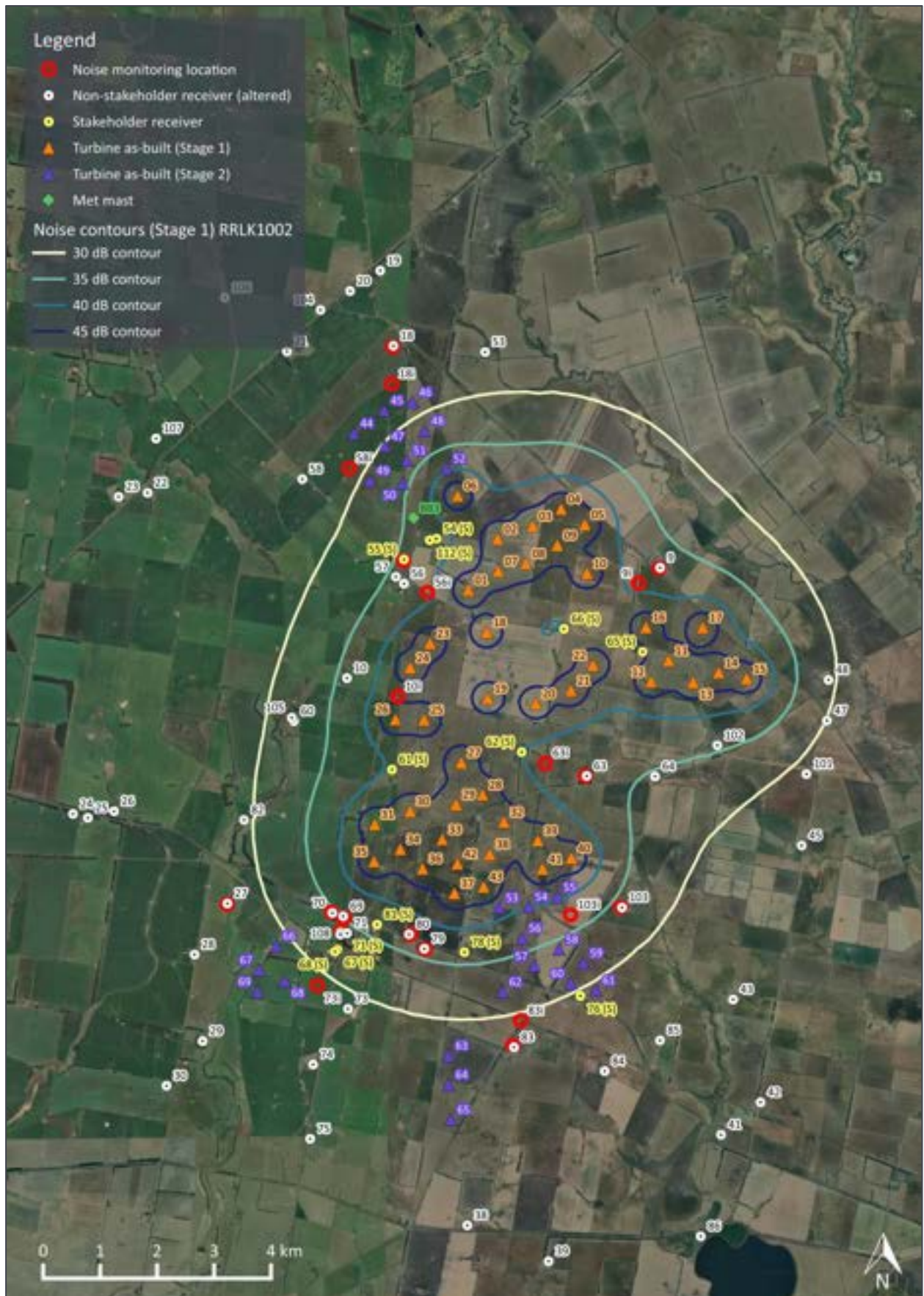
Table 22: Turbine coordinates (as-built) Stage 1 – MGA 94 Zone 54

WTG ID	Easting, m	Northing, m	WTG ID	Easting, m	Northing, m
1	720733	5799429	31	719092	5795312
2	721251	5800323	32	721359	5795356
3	721859	5800552	33	720275	5795050
4	722364	5800847	34	719538	5794878
5	722780	5800575	35	719076	5794661
6	720545	5801081	36	719929	5794535
7	721258	5799760	37	720489	5794103
8	721740	5799891	38	721109	5794788
9	722296	5800211	39	721955	5795028
10	722817	5799718	40	722543	5794720
11	724250	5799189	41	722034	5794531
12	723942	5797816	42	720541	5794620
13	724683	5797804	43	721000	5794218
14	725133	5797978			
15	725624	5797870			
16	723854	5798772			
17	724851	5798766			
18	721057	5798686			
19	721076	5797527			
20	721921	5797435			
21	722535	5797663			
22	722922	5798109			
23	720062	5798490			
24	719710	5798063			
25	719954	5797147			
26	719453	5797154			
27	720611	5796396			
28	720985	5795834			
29	720518	5795662			
30	719710	5795545			

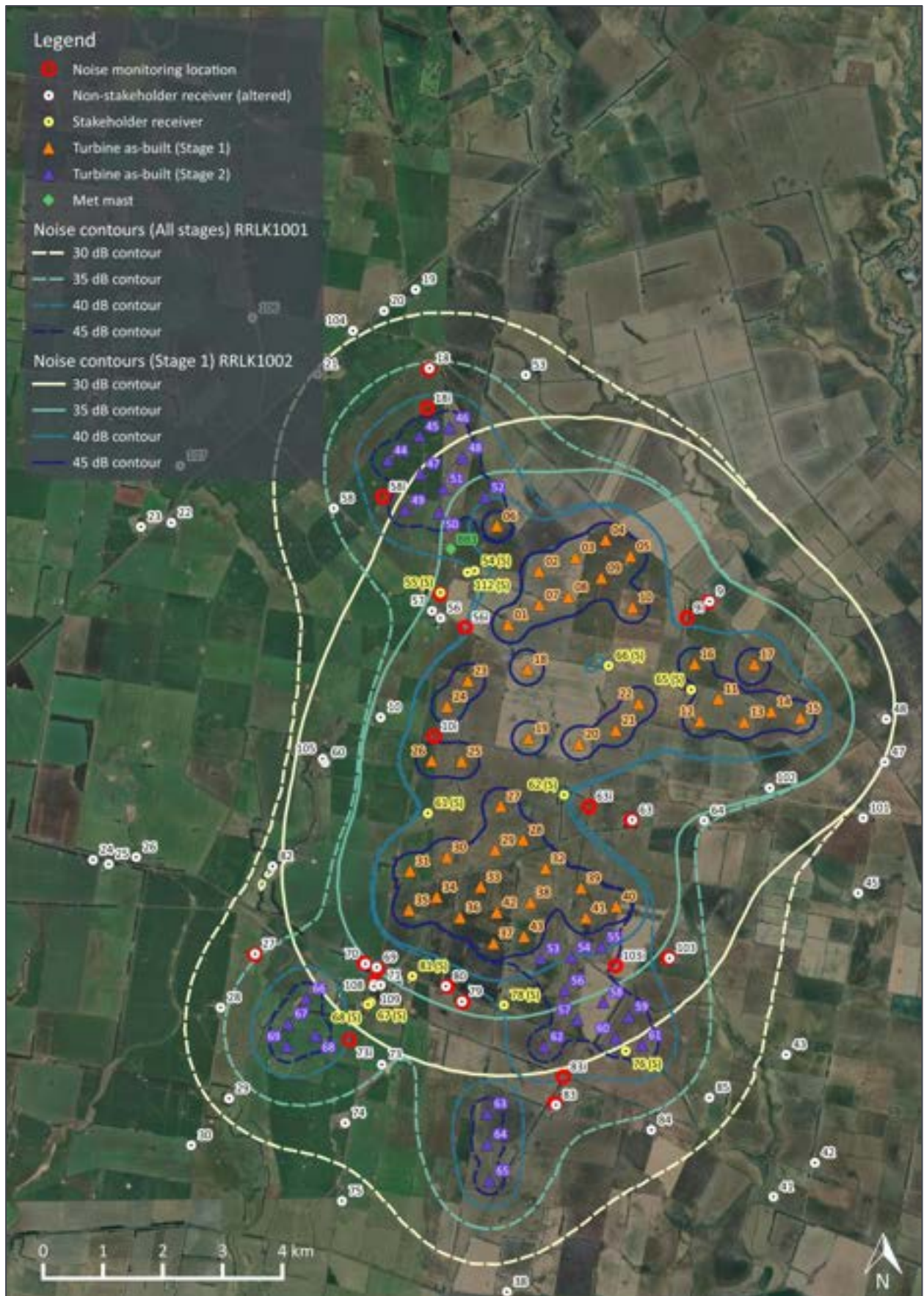
Table 23: Turbine coordinates (as-built) Stage 2 – MGA 94 Zone 54

WTG ID	Easting, m	Northing, m
44	718723	5802175
45	719252	5802579
46	719750	5802720
47	719265	5801951
48	719966	5802220
49	719008	5801345
50	719579	5801301
51	719651	5801704
52	720348	5801558
53	721277	5793850
54	721789	5793868
55	722289	5794038
56	721681	5793315
57	721892	5792826
58	722325	5793118
59	722753	5792880
60	722532	5792518
61	722975	5792401
62	721336	5792373
63	720387	5791254
64	720387	5790742
65	720423	5790131
66	717353	5793180
67	717057	5792756
68	717508	5792560
69	717031	5792378

B2 Site layout map with the predicted Stage 1 noise contours



B3 Site layout map with predicted noise contours for Stage 1 and the complete development



APPENDIX C PREDICTED WIND TURBINE NOISE LEVELS

Table 24: Predicted stage and total wind turbine farm noise levels, dB LA90

Monitoring location	Stage 1 only	Stage 2 only	Cumulative
9	37.3	23.4	37.4
9i	39.3	23.9	39.4
10i	43.6	26.4	43.7
18	26.5	35.5	36.0
18i	28.1	42.7	42.9
27	28.3	33.8	34.9
55 (S)	35.9	33.4	37.9
56i	39.7	30.2	40.2
58i	29.8	42.6	42.8
63	37.1	28.9	37.7
63i	38.9	28.7	39.3
69	35.3	33.3	37.4
70	34.8	33.9	37.4
73i	29.6	39.4	39.8
79	36.3	34.4	38.4
80	37.2	33.3	38.7
83	28.7	37.2	37.8
83i	30.2	39.9	40.4
103	33.9	36.3	38.3
103i	37.4	44.2	45.0
108	33.9	34.4	37.1

APPENDIX D SURVEY INSTRUMENTATION

Table 25: 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 ¹⁹
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 IOA good practice guide. The system comprises an inner solid primary wind shield and an outer secondary large diameter hollow wind shield.

Table 26: Sound level meter installation records

Location	System	Unit serial number	Microphone serial number	Independent calibration date ^[1]	Calibration drift ^[2,3]
9	01dB CUBE	10521	207208	29/05/2021	-0.17
18	01dB CUBE	10655	2004035	23/06/2021	-0.53
27	01dB CUBE	11276	207223	5/04/2022	-0.06
55 (S)	01dB CUBE	11876	331776	10/02/2022	+0.30
63	01dB DUO	10778	162059	28/09/2021	-0.12
69	01dB CUBE	10656	217460	27/04/2022	+0.11
70	01dB DUO	10496	141230	29/07/2022	0.00
79	01dB CUBE	10518	207205	24/05/2021	+0.30
80	01dB CUBE	11276	207223	5/04/2022	-0.77
83	01dB CUBE	10419	161864	1/07/2022	-0.41
103	01dB CUBE	10197	141100	24/05/2021	-0.22
108	01dB CUBE	11296	292451	10/02/2022	-0.34
9i	01dB CUBE	10422	224301	17/06/2021	-0.34
10i	01dB CUBE	11289	292400	22/02/2022	+0.78
18i	01dB CUBE	10421	260714	13/05/2022	-0.16
56i	01dB CUBE	10517	161870	1/07/2021	+0.07
58i	01dB CUBE	11877	331800	9/02/2022	+0.24
63i	01dB CUBE	10523	207224	23/06/2021	-0.60
73i	01dB CUBE	10657	161822	25/05/2021	-0.23

¹⁹ AS/IEC 61672.1-2019 *Electroacoustics - Sound level meters Specifications*

Location	System	Unit serial number	Microphone serial number	Independent calibration date ^[1]	Calibration drift ^[2,3]
83i	01dB CUBE	11877	331800	9/02/2022	0.00
103i	01dB CUBE	10511	255808	18/11/2022	+0.37

1 Independent (laboratory) calibration date to be within 2 years of measurement period as per AS 1055:2018²⁰

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

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

Table 27: Local meteorological measurement instrumentation

Data	Description
Local wind speeds and rainfall	Vaisala WXT 520 (Serial No. K3630005) weather station positioned at receiver 9 Vaisala WXT 520 (Serial No. K1850005) weather station positioned at intermediate location 58i Vaisala WXT 520 (Serial No. K4150004) weather station positioned at intermediate location 103i Vaisala WXT 520 (Serial No. H5010003) weather station positioned at intermediate location 103i
Site wind speeds	See Appendix H

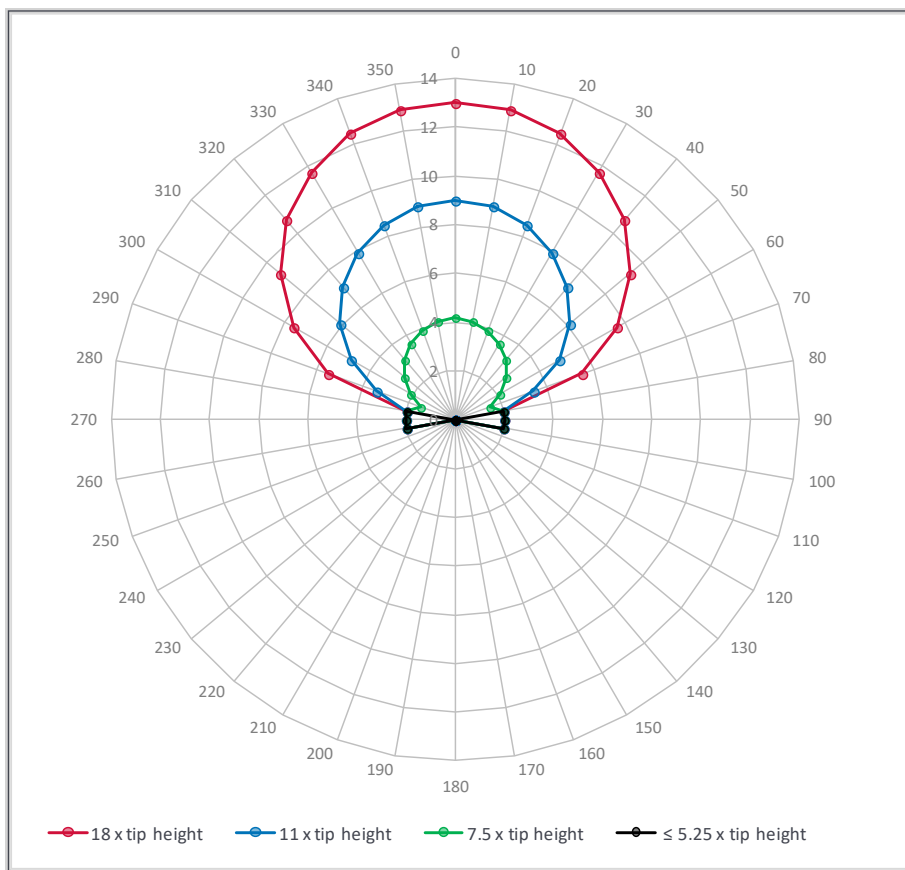
²⁰ AS 1055:2018 *Acoustics – Description and measurement of environmental noise*

APPENDIX E DOWNWIND AND UPWIND DIRECTIONS

The wind direction ranges in which each noise monitoring location was considered to be downwind of the wind farm were determined based on the following:

- The configuration of the wind farm layout relative to each noise monitoring location; and
- The range of wind directions in which noise propagation corresponds to downwind conditions for the majority of wind turbines associated with the wind farm, based on the recommendations of the UK Institute of Acoustics guide with respect to changes in sound propagation with wind direction (see Figure 5 below). This guidance indicates that wind directions approaching cross winds are still likely to result in propagation equivalent to direct downwind conditions, on account of the increased wind speeds involved when assessing wind turbine noise.

Figure 5: UK IOA good practice guide – propagation directivity profile – flat landscape directional attenuation (dB) versus angle relative to upwind conditions (degrees)



The downwind and upwind direction ranges referenced in the analysis for each noise monitoring location are listed in Table 28.

Table 28: Downwind direction ranges – lower and upper bounds

Location	Lower bound		Upper bound	
	Degrees	Direction	Degrees	Direction
9	101	ESE	349	NNW
18	101	E	191	SSW
63	169	S	56	NE
79	304	NW	79	ENE
80	304	NW	79	ENE
83	281	WNW	56	NE
103	236	WSW	11	N

Table 29: Upwind direction ranges – lower and upper bounds

Location	Lower bound		Upper bound	
	Degrees	Direction	Degrees	Direction
9	281	WNW	169	SSE
18	281	W	11	NNE
63	349	N	236	SW
79	124	SE	259	WSW
80	124	SE	259	WSW
83	101	ESE	236	SW
103	56	ENE	191	S

APPENDIX F ATTENDED OBSERVATION RECORDS

This section presents the findings of the attended observations which were carried out to subjectively assess whether special audible characteristics (SACs) were evident in the noise of the wind farm (and therefore whether objective assessments were warranted).

F1 Receiver observations

The findings of the attended observations and subjective assessments at receivers are summarised in Table 30, along with the number of operational turbines and the site wind speeds at the times when the observations were made.

Table 30: Attended observations and site measurements, phase 1 – receiver locations

Date and local time	Location	Number of turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 1</i>					
7/09/2022 1340 hrs	27	14 turbines operating	3 – 6	Downwind	Wind farm inaudible – no turbines running in close proximity (i.e. Stage 2 turbines)
7/09/2022 1610 hrs	55 (S)	All visible turbines operating	< 3	Downwind	Wind farm clearly audible – swoosh from blades not characteristic of SACs, general broadband low frequency just audible
7/09/2022 1430 hrs	69	45 turbines operating, 4 turbines near field	3 – 6	Downwind	Wind farm inaudible
7/09/2022 1105 hrs	80	22 turbines operating, 7 turbines near field	3 – 6	Downwind	Wind farm inaudible – animals in backyard prominent
7/09/2022 1145 hrs	108	14 turbines operating	3 – 6	Downwind	Wind farm inaudible
8/09/2022 1040 hrs	70	-	3 – 6	Downwind	Wind farm inaudible due to nearby farming equipment

Date and local time	Location	Number of turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 2 (night)</i>					
8/09/2022 0030 hrs	18	2 turbines visible and running	< 3	Crosswind	Just audible blade pass, no SACs present
7/09/2022 2310 hrs	27 proxy (Hamilton Hwy)	One turbine visible	< 3	Downwind	Just audible normal aerodynamic blade swish, no SACs observed
7/09/2022 2340 hrs	56	6 turbines visible and running	3 – 6	Downwind	Typical wind farm noise, mostly barely audible – broadband low frequency and some blade pass without SACs
8/09/2022 0004 hrs	58	3 turbines can be seen operating	< 3	Crosswind / downwind	Very infrequent broadband low-mid frequency noise from turbines
7/09/2022 2340 hrs	69	3 turbines visible	< 3	Downwind	Aerodynamic blade swish just audible, no SACs present
8/09/2022 0040 hrs	80	-	-	-	Assessment not conducted due to continuous noise from dog barking
7/09/2022 2345 hrs	102	3 turbines visible and running, 15 total visible	< 3	Upwind	Turbine noise clearly audible, just audible low frequency noise noted with tonality just audible and intermittent
8/09/2022 0001 hrs	108	1 turbine visible	< 3	Downwind	Turbine noise just audible as non-SAC aerodynamic blade swish and broadband low frequency noise

Date and local time	Location	Number of turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 3</i>					
30/09/2022 1153 hrs	18	22 turbines operating	> 8	Crosswind / downwind	Wind farm just audible – swoosh from blades without SACs
30/09/2022 1652 hrs	27	-	3 – 6	Downwind	Wind farm inaudible – no turbines running in close proximity (i.e. Stage 2 turbines)
30/09/2022 1108 hrs	55 (S)	22 turbines operating	3 – 6	Downwind	Wind farm just audible – mainly swoosh from turbines without SACs
30/09/2022 1132 hrs	58	32 turbines operating	6 – 8	Downwind	Wind farm inaudible – ambient noise dominant
30/09/2022 1610 hrs	69	29 turbines operating	3 – 6	Crosswind / downwind	Road traffic dominant but intermittent – turbine swoosh just audible between traffic movements. No SACs present
30/09/2022 1600 hrs	70	20 turbines operating	3 – 6	Crosswind / downwind	Wind farm inaudible
30/09/2022 1545 hrs	80	3 turbines operating	6 – 8	Crosswind	Wind farm inaudible
30/09/2022 1535 hrs	83	11 turbines operating	6 – 8	Crosswind	Wind farm inaudible – ambient noise dominant (trees)
30/09/2022 1257 hrs	102	7 turbines operating	6 – 8	Upwind / crosswind	Broadband low frequency just audible between intermittent traffic, high frequency masked by ambient noise
30/09/2022 1624 hrs	108	15 turbines operating	6 – 8	Crosswind / downwind	Wind farm inaudible

Date and local time	Location	Number of turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 4</i>					
11/10/2022 1805 hrs	27	27 turbines operating	3 – 6	Crosswind / downwind	Wind farm inaudible over road traffic
11/10/2022 1340 hrs	102	11 turbines operating	6 - 8	Downwind	Wind farm just audible - swoosh audible. No SACs present
11/10/2022 1142 hrs	55 (S)	11 turbines operating	< 3	Downwind	Wind farm just audible – ambient noise dominant
11/10/2022 1722 hrs	69	40 turbines operating	3 - 6	Downwind	Wind farm just audible when no intermittent traffic present
11/10/2022 1715 hrs	70	38 turbines operating	3 - 6	Downwind	Wind farm inaudible
11/10/2022 1655 hrs	80	-	< 3	Downwind	Wind farm just audible – intermittent traffic dominant
11/10/2022 1738 hrs	108	6 turbines visible	3 - 6	Downwind	Wind farm just audible, broadband low to mid frequency
<i>Visit 5 – night</i>					
12/10/2022 0055 hrs	27	-	< 3	Downwind	General wind farm operational noise very distant and just audible
12/10/2022 0020 hrs	69	-	< 3	Downwind	General wind farm operation just audible
12/10/2022 0035 hrs	70	-	< 3	Downwind	General wind farm operation just audible but masked by wind in trees
11/10/2022 2330 hrs	80	-	< 3	Downwind	General wind farm operation audible in low ambient environment, constant but not unusual broadband low frequency
11/10/2022 0020 hrs	102	4 nearby turbines visible and running	< 3	Crosswind	Just audible noise from nearest turbines, general wind farm operation distant

Date and local time	Location	Number of turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
12/10/2022 0005 hrs	108	-	< 3	Downwind	Just audible turbine noise at similar level to distant road traffic
11/10/2022 2255 hrs	83	-	< 3	Downwind	General wind farm operation just audible and distant
<i>Visit 6</i>					
4/11/2022 1024 hrs	27	No nearby turbines running	< 3	Downwind	Wind farm inaudible
3/11/2022 1622 hrs	55(s)	13 turbines visible and running, more hidden by trees	<3/3 – 6	Crosswind	Typical rumble and blade swoosh audible intermittently. No SACs present
4/11/2022 1143 hrs	69	19 turbines running, some slowly	< 3	Upwind	Turbines inaudible even when road traffic not present
4/11/2022 1100 hrs	70	-	< 3	Upwind	Just discernible broadband low frequency noise between road traffic passing, but unclear if related to wind farm
4/11/2022 1453 hrs	80	6 turbines visible and running, more hidden by trees	< 3	Upwind / crosswind	Turbines not audible
4/11/2022 1538 hrs	102	-	< 3	Upwind	Turbines not audible
4/11/2022 1207 hrs	108	Most turbines hidden from sight	< 3	Upwind / crosswind	Turbines not audible

Table 31: Attended observations and site measurements, phase 2 – receiver locations

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 1</i>					
20/12/2022 1158 hrs	9	38 turbines running	3 – 6	Upwind / crosswind	Wind farm just audible as typical blade swoosh and some broadband low frequency noise. Brief tonal noise unable to be linked to wind turbines, no wind farm SACs observed
20/12/2022 1352 hrs	18	No nearby turbines running	3 – 6	Downwind	Wind farm not audible
20/12/2022 1727 hrs	63	Turbines running but obscured by trees	6	Upwind / crosswind	Broadband blade swoosh just audible, no SACs present
<i>Visit 2</i>					
16/01/2023 1713 hrs	9	-	< 3	Crosswind	Distant turbine blade swoosh, no SACs
16/01/2023 1622 hrs	18	No nearby turbines operating (all are Stage 2)	< 3	Downwind	Wind turbines not audible
17/01/2023 1127 hrs	63	1 turbine visible and operating	3 – 6	Downwind	Turbine noise inaudible above ambient noise of trees and plants in wind
16/01/2023 1547 hrs	103	2 turbines nearby but not operational, others in distance running	< 3	Crosswind	Faint turbine blade movement just audible, not observed as a SAC
16/01/2023 1410 hrs	79	-	< 3	Downwind	Turbine noise not noted, nearby road traffic present
16/01/2023 1317 hrs	83	No nearby turbines running, Stage 1 in distance operating	< 3	Upwind	No wind turbine noise audible

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 3 – night</i>					
17/01/2023 0023 hrs	9	Turbines running at high power	< 3	Downwind	Turbines clearly audible in good assessment conditions, just audible broadband low frequency noise noted but no SACs
17/01/2023 0000 hrs	18	-	3 – 6	Upwind / crosswind	Turbines not audible
16/01/2023 2317 hrs	63	Nearby turbines operating	3 – 6	Crosswind	Typical wind farm blade swoosh audible, clearly audible during strong wind gusts. No SACs noted
17/01/2023 0044 hrs	79	Wind farm operational but not visible	3 – 6	Crosswind	Wind farm not audible due to construction noise
17/01/2023 0043 hrs	83	Distant from any operating turbines	3 – 6	Crosswind	Wind farm noise potentially just audible when background noise decreases
16/01/2023 2359 hrs	103	Nearby turbines operational	3 – 6	Upwind	Constantly audible blade swoosh from multiple turbines constituting typical operational noise, no SACs
<i>Visit 4</i>					
1/02/2023 1718 hrs	80	-	< 3	Upwind	Ambient domestic noise masking any wind turbine noise

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 5</i>					
16/02/2023 1034 hrs	9	40 turbines visible and running	6 – 8	Upwind / crosswind	Wind farm inaudible
16/02/2023 0953 hrs	18	1 nearby turbine running	6 – 8	Upwind	Wind farm inaudible
15/02/2023 1630 hrs	63	Nearest turbines running	< 3	Crosswind / downwind	Just audible non-SAC blade swoosh audible intermittently between birds
16/02/2023 1159 hrs	79	All nearby turbines operating	6 – 8	Downwind	Blade pass audible between traffic passing, no SACs present
16/02/2023 1238 hrs	80	All nearby turbines operating	3 – 6	Crosswind / downwind	Blade pass just audible when ambient noise decreases, no SACs present
16/02/2023 1451 hrs	83	No nearby turbines running, wind farm in distance operational	6 – 8	Downwind	Wind farm not audible
16/02/2023 1308 hrs	103	Nearest turbines not running, 30 turbines operational in distance	6 – 8	Crosswind / downwind	Blade swoosh noise alternates between just audible and audible, no SACs observed
<i>Visit 6</i>					
1/03/2023 1445 hrs	9	42 turbines visible and running	6 – 8	DW	Typical broadband blade noise just audible intermittently, no SACs
1/02/2023 1552 hrs	103	Turbines not visible due to trees but operating	6 – 8	Crosswind / downwind	Typical blade pass noise only, no SACs observed

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 7 (night)</i>					
1/03/2023 2323 hrs	79	Most visible turbines running at low power	< 3	Upwind	Non-SAC blade pass and some broadband low frequency rumble, not tonal in nature
1/03/2023 2343 hrs	80	-	< 3	Upwind	Measurement contaminated by dog barking. Notes at location 79 valid here
<i>Visit 8</i>					
29/03/2023 1232 hrs	18	Nearest turbines not running	6 – 8/> 8	Crosswind / downwind	Turbines inaudible
29/03/2023 1126 hrs	63	Most of wind farm not visible but operating at moderate power	3 – 6	Downwind	Broadband blade pass just audible, no SACs
29/03/2023 1427 hrs	79	Nearby turbines running	3 – 6	Upwind	Wind farm not audible
29/03/2023 1456 hrs	80	Not all nearby turbines running	6 – 8	Upwind	Wind farm not audible over ambient domestic noise
29/03/2023 1525 hrs	83	Distant visible turbines running	6 – 8	Upwind	Wind farm not audible

F2 Intermediate observations

Intermediate locations are, by definition, located closer to the wind turbines than their corresponding receivers. As a result, the character of the wind farm at the intermediates will differ from the character at the receivers. The findings of the attended observations and subjective assessments at intermediate locations are therefore summarised in Table 32 for information only.

Table 32: Attended observations and site measurements, phase 1 – intermediate locations

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 1</i>					
7/09/2022 1455 hrs	9i	Most turbines in close proximity operating	3 – 6	Upwind	Non-SAC blade swooshes audible, broadband low frequency audible Ambient environment prominent (cows, sheep, birds)
7/09/2022 1634 hrs	10i	43 turbines operating, 5 turbines near field	3 – 6	Crosswind	Barely audible, intermittent mechanical noise/low frequency from turbine – tonal component just audible. High frequency blade swoosh just audible during gaps in traffic, no SACs identified
7/09/2022 1725 hrs	58i	Most visible turbines operating, close proximity turbines not operating	3	Downwind	Wind farm clearly audible – constant broadband low frequency and blade swoosh, no SACs present One turbine prominent with the above comment
7/09/2022 1030 hrs	63i	39 turbines operating	< 3	Crosswind / downwind	Low frequency just audible – tone audible at low level – plane flyover noted during the duration of the 10-minute assessment
7/09/2022 1535 hrs	73i	10 turbines operating	3 – 6	Downwind	Wind farm inaudible – traffic and aircraft intermittent
7/09/2022 1205 hrs	83i	37 turbines operating	3 – 6	Crosswind	Wind farm inaudible – road traffic, aircraft and train

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
7/09/2022 1010 hrs	103i	28 turbines operating	3 – 6	Crosswind	Wind farm just audible – ambient environment prominent (insects and birds) Mechanical hum just audible from nearest turbine, but subjectively classified as non-tonal
<i>Visit 2 (night)</i>					
7/09/2022 2315 hrs	9i	-	<3 / 3 – 6	-	Difficult to see turbine operation in dark Non-SAC blade movement and broadband low frequency noise audible
7/09/2022 2310 hrs	10i	18 visible, likely 40 total	3 – 6	Crosswind / downwind	Turbine noise clearly audible, some broadband low frequency noise and potential tonal characteristics just audible
8/09/2022 0005 hrs	63i	16 turbines visible, operation status unclear during night	< 3	-	Low frequency noise from turbine movement just audible, noted as broadband low-mid frequency
8/09/2022 0017 hrs	73i	-	< 3/3 – 6	Downwind	Turbine noise just audible as aerodynamic blade swish, not SAC related
8/09/2022 0047 hrs	83i	-	-	-	Turbine noise inaudible due to wind in trees, formal assessment not conducted
8/09/2022 0035 hrs	103i	More than 30 turbines visible, operation unclear	< 3	Upwind / crosswind	One turbine clearly audible at close proximity without SACs, more distant broadband low frequency noise audible at low level

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 3</i>					
30/09/2022 1223 hrs	9i	42 turbines operating	6 – 8	Crosswind	Broadband low frequency faintly audible
30/09/2022 1354 hrs	10i	42 turbines operating	6 – 8	Crosswind	Wind farm just audible – non-SAC blade swoosh from south-east turbine
30/09/2022 1326 hrs	63i	41 turbines operating	6 – 8	Crosswind	Clearly audible turbine operation from south-west, no SACs noted
30/09/2022 1638 hrs	73i	15 turbines operating	-	Crosswind	Wind farm inaudible
30/09/2022 1516 hrs	103i	31 turbines operating	6 – 8	Upwind / crosswind	Wind farm just audible – mainly swoosh from north-west, no SACs present
<i>Visit 4</i>					
11/10/2022 1318 hrs	9i	40 turbines operating	3 - 6	Upwind / crosswind	Wind farm just audible – ambient noise dominant
11/10/2022 1432 hrs	10i	42 turbines operating	3 - 6	Turbines operating upwind and downwind of observation point	Wind farm just audible, mainly swoosh, not modulating
11/10/2022 1253 hrs	18i	19 turbines operating	3 - 6	Downwind	Wind farm inaudible
11/10/2022 1224 hrs	58i	38 turbines operating	3 – 6	Crosswind	Wind farm just audible – ambient noise dominant
11/10/2022 1403 hrs	63i	33 turbines operating	6 – 8	Upwind from nearest turbine	Broadband low frequency faintly audible
11/10/2022 1755 hrs	73i	14 turbines operating	3 – 6	Downwind	Wind farm inaudible over road traffic
11/10/2022 1608 hrs	83i	42 turbines operating	3 – 6	Downwind	Distant infrequent mechanical/gearbox noises but subjectively characterised as not tonal

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
11/10/2022 1548 hrs	103i	39 turbines operating	3 – 6	Crosswind	Wind farm just audible, mainly swoosh, not modulating
<i>Visit 5 (night)</i>					
11/10/2022 0107 hrs	10i	44 turbines visible	< 3	Downwind	Wind farm noise clearly audible at close proximity
11/10/2022 0000 hrs	9i	30 turbines running	< 3	Downwind	General wind farm operation just audible
10/10/2022 2337 hrs	18i	20 turbines running	< 3	Downwind	General turbine movement just audible but very distant
10/10/2022 2245 hrs	56i	7 turbines running	< 3	Downwind	General turbine movement just audible
10/10/2022 2310 hrs	58i	13 turbines running	< 3	Downwind	Faintly audible and distant turbine movement
11/10/2022 0040 hrs	63i	24 turbines running	< 3	Upwind	General wind farm operation clearly audible
10/10/2022 2350 hrs	73i	-	< 3	Downwind	Wind turbine noise masked by intermittent traffic, just audible
11/10/2022 2236 hrs	103i	Nearest turbine visible and operating	< 3	Crosswind / downwind	Some high frequency aerodynamic blade noise without SACs and masked by insects, constant typical broadband low frequency wind farm noise

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 6</i>					
4/11/2022 1150 hrs	9i	-	< 3	Downwind	Just audible mid-frequency mechanical noise observed, not tonal in nature
4/11/2022 1455 hrs	10i	-	< 3	Downwind	Wind farm inaudible, distant intermittent alarm confirmed to be from substation
3/11/2022 1822 hrs	18i	18 turbines visible and running, none close-by	< 3	Downwind	Wind farm inaudible
3/11/2022 1748 hrs	58i	Closest turbines not running	< 3/3 – 6	Crosswind	Intermittent just audible mechanical noise from nearby non-operational turbine nacelle. Tonality not identified as a characteristic.
4/11/2022 1035 hrs	63i	-	< 3	Downwind	Broadband low frequency noise present
4/11/2022 1248 hrs	73i	9 turbines visible and running slowly	< 3	Upwind / crosswind	Turbine noise inaudible other than infrequent mechanical noises from non-operational nacelles.
4/11/2022 1530 hrs	83i	8 turbines operational	< 3	Upwind	Just audible mechanical noises from nearby nacelle when hunting wind. Tonality not identified as a characteristic.
4/11/2022 1615 hrs	103i	Nearby turbines not running, distant turbines operational	< 3	Upwind / crosswind	Just audible broadband low frequency noise from distant turbines. Tonality not identified as a characteristic.

Table 33: Attended observations and site measurements, phase 2 – intermediate locations

Date and Local Time	Location	Turbines operating	Estimated wind speed at observation point, m/s	Wind direction (observation point relative to wind farm)	Subjective assessment and comments
<i>Visit 1</i>					
20/12/2022 1308 hrs	9i	33 turbines visible and running	3 – 6	-	Typical broadband blade swoosh clearly audible from nearest turbine, some broadband low frequency noise heard. No SACs identified
20/12/2022 1451 hrs	18i	43 turbines visible and operating, none nearby	3 – 6	Downwind	Wind farm not audible
20/12/2022 1634 hrs	63i	31 turbines operating including nearest	3 – 6	Crosswind to closest turbine	Typical blade swoosh from nearby turbines just audible, no SACs
<i>Visit 2</i>					
16/01/2023 1645 hrs	9i	-	< 3	Downwind	Just audible low and mid frequency (broadband) noise from closest turbine
16/01/2023 1648 hrs	18i	No nearby turbines running, 28 operating in distance	< 3	Crosswind / downwind	No turbines noise audible
16/01/2023 1257 hrs	56i	4-6 turbines nearby and operational	< 3	Crosswind	Faint turbine movement audible but difficult to hear over ambient noise, no SACs identified
17/01/2023 1044 hrs	63i	30 turbines operating	6 – 8	Downwind	Turbine noise not audible
16/01/2023 1418 hrs	83i	No nearby turbines operating, 13 total visible	< 3	Crosswind / downwind	Wind turbine noise inaudible
16/01/2023 1506 hrs	103i	7 distant turbines turning slowly, none nearby	< 3	Upwind	Wind turbine noise not audible

Visit 3 (night)					
16/01/2023 2311 hrs	56i	-	3 – 6	Downwind	Tone present but not from wind farm noise – likely substation
Visit 4					
16/02/2023 1431 hrs	83i	No nearby turbines running, 37 running in distance	-	Downwind	Wind farm not audible
16/02/2023 1114 hrs	9i	41 turbines visible and running	6 – 8	Upwind / crosswind	Just audible blade swoosh when masking noise from trees decreases, no SACs present
16/02/2023 0921 hrs	18i	1 nearby turbine running	6 – 8	Upwind	Typical blade swoosh noise only, no SACs
16/02/2023 0824 hrs	56i	41 turbines running at or near rated power	6 – 8	Crosswind of nearest turbine	Audible broadband blade swoosh from near turbines, broadband low frequency rumble may be due to power lines rather than wind farm. No SACs identified
15/02/2023 1830 hrs	63i	36 turbines visible and running, some slowly	< 3	Crosswind / downwind	Just audible broad low frequency noise from nearby turbines
16/02/2023 1431 hrs	83i	No nearby turbines running, 37 operating in distance at rated power	-	Downwind	Wind farm not audible
16/02/2023 1308 hrs	103i	Nearest turbines not running, 30 turbines at rated power in distance	6 – 8	Crosswind / downwind	Clear blade swoosh noise alternated between just audible and audible, not identified as a SAC
Visit 5					
1/03/2023 1515 hrs	9i	46 turbines visible and running	6 – 8	Crosswind / downwind	Typical non-SAC broadband blade pass audible from near turbines between wind gusts

1/03/2023 1312 hrs	56i	46 turbines visible and running	3 – 6/6 – 8	Upwind / crosswind	Just audible tonality from nearest turbine when wind gusts decrease Broadband low frequency noise intermittent, may be caused by power lines rather than wind farm
1/03/2023 1612 hrs	103i	30 turbines visible and running, more hidden by trees	6 – 8/> 8	Crosswind / downwind	Wind turbine noise audible to clearly audible, broadband blade pass only. Not SAC related
<i>Visit 6</i>					
29/03/2023 1254 hrs	18i	Nearby turbines not running	3 – 6, gusts 6 – 8	Crosswind / downwind	Turbines nearby not running
29/03/2023 1155 hrs	63i	44 turbines visible and running	3 – 6	Turbines running in all directions nearby	Just audible distant broadband wind farm noise, mainly in DW direction
29/03/2023 1550 hrs	83i	Most nearby turbines running	3 – 6, gusts 6 – 8	Upwind / crosswind	Turbines just audible during low ambient noise periods, no SACs noted

APPENDIX G FURTHER DISCUSSION OF OBJECTIVE TONALITY ANALYSIS

The following sections contain discussion and charts which expand on the discussion of false positive tone identification in Section 4.3.4.

G1 Comparison of ISO/TS 20065 and ISO 1996-2:2007

The following two charts compare the results of analysing attended audio samples with ISO/TS 20065 and ISO 1996-2:2007.

Samples were split into 2-minute periods for analysis and presentation. Each 2-minute period was coloured to indicate whether the sample was subjectively noted to contain tonality which may have been attributed to the wind farm, and that ranking's magnitude. The subjective ranking scale for tonality used by attending engineers is contained in Table 34.

Table 34: Subjective ranking scale for the evaluation of SACs by an attending engineer

Ranking	Description	Persistence	Objective assessment
0	Not perceptible	-	Not required
1	Just audible/discernible	Intermittent	Not required
2	Just audible/discernible	Constant	Not required
3	Audible at low level	Intermittent	Not required
4	Audible at low level	Constant	Not required
5	Clearly audible at moderate level	Intermittent	Probably required
6	Clearly audible at moderate level	Constant	Probably required
7	Clearly audible and prominent	Intermittent	Probably required
8	Clearly audible and prominent	Constant	Objective assessment needed
9	Clearly audible and quite likely penalisable	Intermittent	Objective assessment needed
10	Clearly audible and quite likely penalisable	Constant	Objective assessment needed

It is noted that:

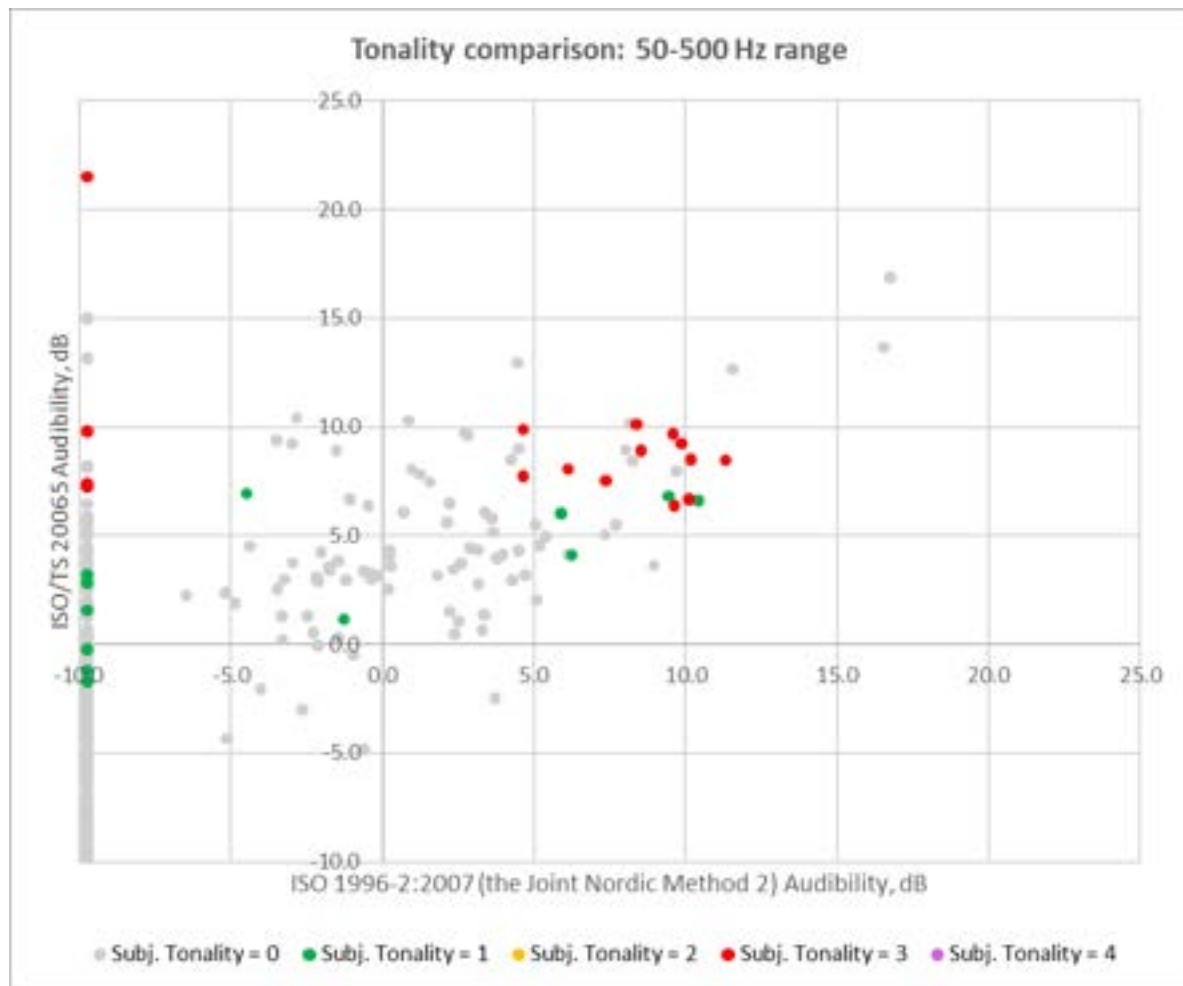
- ISO/TS 20065 was used for the identification of tonal audibilities for unattended data in this report as required by the NCTP;
- ISO 1996-2:2007 has been used previously objective tonality analyses for unattended data from wind farms;
- All unattended audio samples from the first phase of round 2 monitoring were used for the comparison. This included both receiver and intermediate monitoring locations;
- All coloured samples, i.e. those where wind farm tonality was subjectively identified, were observed at intermediate locations; and
- A somewhat reduced frequency range of 50-500 Hz has been used, compared to the 20 – 500 Hz range of the post-construction analysis. Similar results were found for a much broader 20 – 5,000 Hz frequency range.

In general, the tonal audibilities of attended samples found by ISO/TS 20065 are higher than those found by ISO 1996-2:2007, shown by most points having a higher tonal audibility on the y axis than the x axis in Figure 6. In addition, the points clustered along the left-hand side of the chart are those for which ISO/TS 20065 found an audibility above -10 dB for while ISO 1996-2:2007 did not find any tone with an audibility above -10 dB.

These results demonstrate that the sensitivity of the standard used for tonality in this post-construction analysis is likely higher than previously used standards such as ISO 1996-2:2007. This would lead to likely higher tonal audibilities, and tonal penalties, found an unattended tonality analysis using ISO/TS 20065, such as this project.

In addition, most samples where either standard identified a tonal audibility above 0 dB were not identified subjectively as containing a tone. This indicates a high likelihood that unattended samples with tonal penalties applied likely have these penalties arising from tonal background, rather than wind farm, noise.

Figure 6: ISO/TS 20065, ISO 1996-2:2007, and attended tonality ranking comparison for first phase attended observations



G2 Objective analysis of background survey audio recordings

ISO/TS 20065 was also used to process audio recordings made during the background noise survey as described in Section 3.2.

A representative selection of receivers from the first phase of noise monitoring were considered, being 55 (S), 70, and 18. These locations were distributed around the subject site to ensure that background causes of tonality would likely be different across the sites.

It is noted that this analysis of the background audio recordings includes the following factors:

- The mean penalty approach as briefly described in Section 5.3 and used in tonality analyses for other wind farm projects was used for this analysis, as NZS 6808 does not specify a method for analysis of background noise data for tonality and therefore a regression-based approach was not required. In any case, identification of tonality penalties through the mean wind-speed method was very likely to be associated with tonal penalties which would be identified through a regression-based approach.
- Audio recordings were made on a 2-in-10-minute basis during the background survey, rather than on a continuous basis as during the round 2 monitoring. For many samples, this difference in recording length should not preclude a comparison of results between the surveys.

Table 35: Results of objective tonality analysis of background survey – tonal audibility, dB

Item	Hub height wind speed, m/s													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Location 55 (S)</i>														
Mean Penalty	3.4	3.8	3.9	3.8	3.6	3.4	2.9	2.6	1.8	1.3	0.9	0.5	0.3	0.0
Number of samples analysed	57	31	95	176	300	349	411	407	420	343	326	299	242	203
<i>Location 70</i>														
Mean Penalty	2.6	2.8	3.0	2.7	2.6	2.6	2.2	2.2	1.6	1.5	1.3	1.1	0.8	0.6
Number of samples analysed	57	31	95	176	300	349	411	408	440	372	349	302	243	203
<i>Location 108</i>														
Mean Penalty	2.5	3.3	3.3	3.0	2.8	2.8	2.5	2.2	1.8	1.5	1.4	1.0	0.7	0.6
Number of samples analysed	57	31	95	178	305	357	432	418	451	383	349	291	237	188

The results in Table 35 indicate that ISO/TS 20065 analysis finds audible and penalisable tones from background monitoring audio where wind farm operation is not occurring. All these tonal penalty results would be a false positive result if also found during post-construction monitoring. This suggests that the results obtained from objective analysis of post-construction data will contain a similar rate of false positives which would lead to non-negligible tonal penalties caused entirely due to background noise.

Finally, the following charts indicate that background and post-construction tonality penalty levels at the three representative locations have a similar trend and magnitude. This comparison has been conducted on a mean penalty basis also for the post-construction monitoring data to enable an equal comparison. The results of this strongly suggest that false positive results make up a significant portion of the penalties applied on a regression basis leading to tonal penalties found at all receiver and intermediate locations.

Figure 7: Mean penalty comparison between background and post-construction monitoring – Location 55 (S)

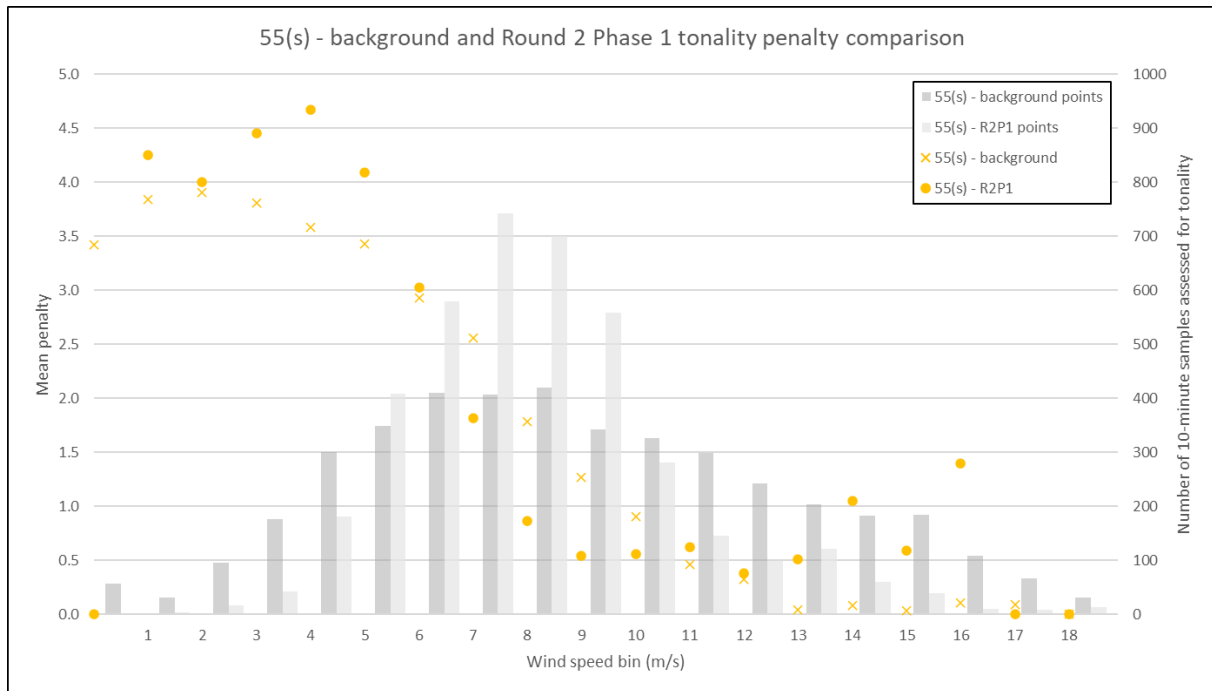


Figure 8: Mean penalty comparison between background and post-construction monitoring – Location 70

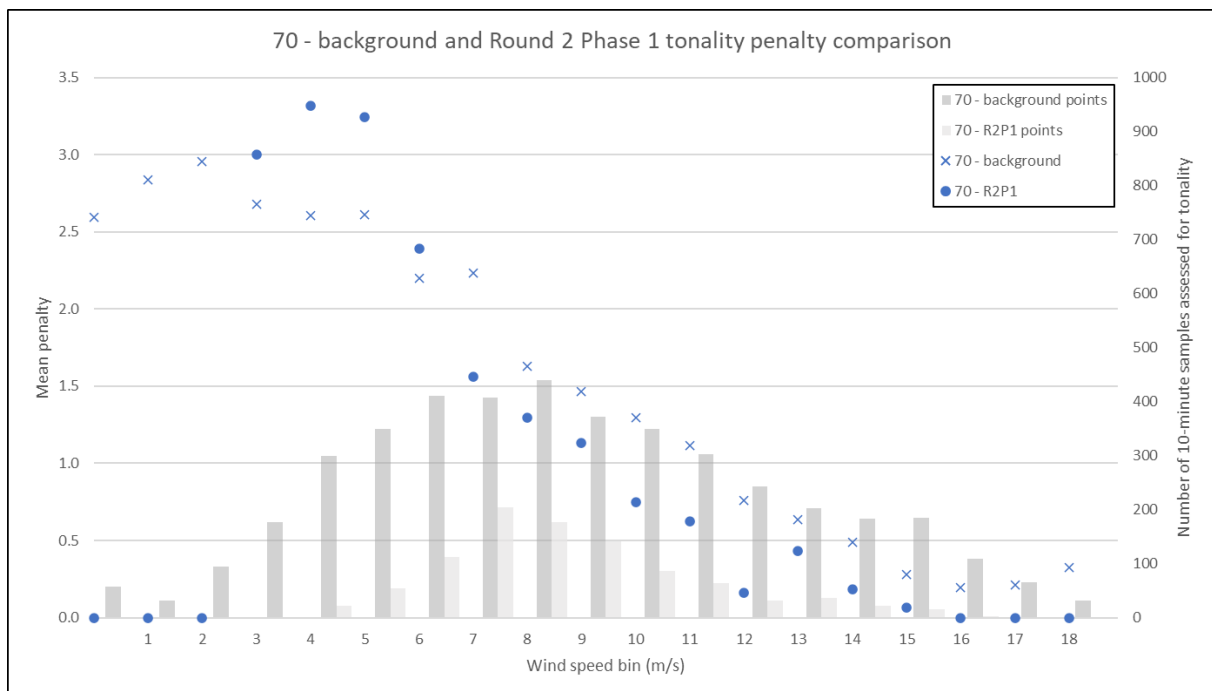
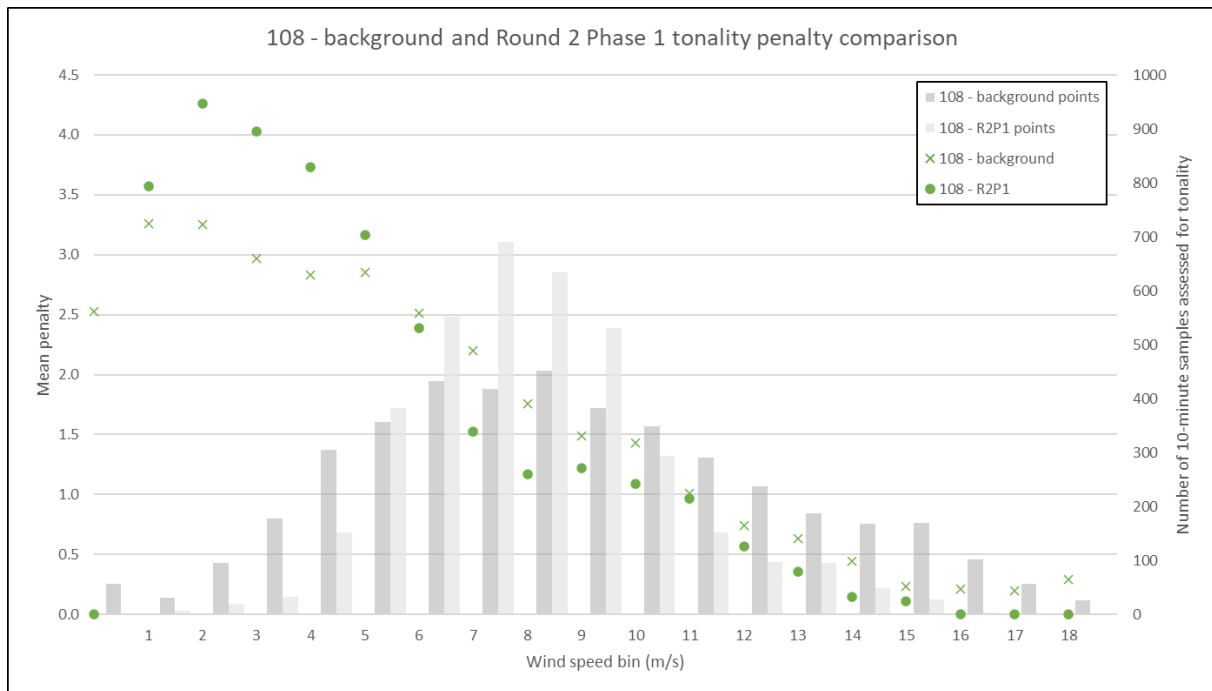


Figure 9: Mean penalty comparison between background and post-construction monitoring – Location 108



G3 Identification of tonality penalties at low wind speeds

Tonality penalties were regularly found using the ISO/TS 20065 process for 10-minute samples at wind speeds where the wind farm was not expected to be operational, i.e. below the turbines' cut-in wind speed of 3 m/s. This result indicates that the sources of penalised tones were from background noise sources as well as wind farm noise, as only background noise should cause tones to arise at these wind speeds.

Results of tonality analysis at low wind speeds are presented in Table 36. These penalties are presented on a mean wind speed basis for all assessable analysis samples, being all samples recorded at all wind speeds rather than those filtered for use in the regression analysis for compliance. This is because the regression analysis process, as set out in NZS 6808, is designed to exclude points where the wind farm would not be operating.

Penalties found using the mean wind speed method, in this case, are based on arithmetically averaging 10 minute tonal audibility results from ISO/TS 20065 and therefore indicate false positive detection using that standard.

Table 36: Tonality penalties for all wind speeds and all recorded samples, mean wind speed basis, dB

Location	Hub height wind speed, m/s													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
9	1.0	3.1	3.2	3.2	3.6	3.4	2.2	0.9	0.5	0.4	0.3	0.3	0.4	0.3
18	0.8	3.3	3.4	3.4	3.1	2.6	1.8	0.8	0.5	0.4	0.4	0.3	0.2	0.2
27	3.6	3.4	3.3	3.1	2.8	2.5	2.0	1.3	1.0	0.7	0.5	0.5	0.3	0.3
55 (S)	4.0	3.9	3.9	4.4	4.4	4.0	3.0	1.8	0.9	0.5	0.5	0.6	0.5	0.5
63	0.5	3.1	3.0	3.2	3.4	2.9	1.6	0.6	0.3	0.2	0.2	0.2	0.4	0.3
69	3.6	4.5	4.3	4.2	3.8	3.5	2.6	1.7	1.6	1.4	1.0	0.9	0.8	0.6
70	3.4	3.8	3.5	3.7	3.7	3.2	2.2	1.6	1.3	1.1	0.9	0.8	0.9	0.5
79	1.4	3.4	3.5	3.6	3.5	3.1	2.3	1.5	1.2	0.9	0.6	0.8	0.5	0.5
80	1.3	4.2	4.2	4.0	3.7	3.1	2.7	2.0	1.3	0.7	0.5	0.5	0.3	0.3
83	0.8	3.9	3.8	3.9	3.9	3.3	2.2	1.4	1.0	0.6	0.4	0.3	0.2	0.2
103	0.5	2.8	2.7	3.3	3.4	3.2	1.9	0.8	0.3	0.2	0.1	0.0	0.1	0.1
108	3.4	3.9	4.0	4.0	3.8	3.4	2.5	1.6	1.3	1.2	1.0	0.9	0.6	0.4

The shaded results at hub height wind speeds of 0, 1, and 2 m/s are tonality penalties found at wind speeds when the wind farm should not be operational and therefore are very likely arising from background noise. These penalties are similar in magnitude to, or larger, than penalties found at wind speeds above 3 m/s when the wind farm may be operational.

G4 Future points of investigation for ISO/TS 20065 tonality analysis

For future rounds of monitoring which may require objective tonality analysis using ISO/TS 20065, or general investigation into wind farm tonality analysis methods, future points of investigation are described.

Results of the attended observations during the second phase of this round of post-construction monitoring were not processed with the procedure described in Section G1 due to the volume of additional work required. A similar sensitivity comparison of ISO/TS 20065 and other established wind farm tonality analysis methods, including third-octave analysis, may be useful for future context. Linking such analyses with results of attended observation, such as those from the second phase of monitoring which were not included in Section G1, should give a clear qualitative indication of the false positive and negative identification rate of different standards.

Further restriction of the frequency range used with ISO/TS 20065 in wind farm tonality analysis, as informed by near field tests of subject turbines, would also likely assist in rejection of false positive results at frequencies not associated with turbine emissions. MDA note that frequency range restriction using ISO/TS 20065 has as-yet had little investigation or best practises established. Tones from wind turbines generally present within narrow and well-defined ranges of frequency such as 100 – 200 Hz. The methodology for isolating such a narrow range using ISO/TS 20065 is unclear, especially with consideration of the standard's process of considering tone critical bands and groups of frequencies contributing to an averaged audibility value.

Finally, a detailed comparison of the results and considerations of using a regression-based approach as in the compliance section of this report, and a mean wind speed method as used in this appendix and other wind farm noise surveys, for tonality analysis may be considered. Above comparisons of background and post-construction tonality data could be completed with a regression-based approach for a more direct comparison to the results found in this report.

APPENDIX H SITE WIND DATA

H1 Derivation of reference mast wind speeds

This appendix reproduces correspondence prepared by GPG documenting the methodology used to prepare a de-waked time series of wind speed data for the round 2 noise monitoring period.

Report



Wind Data for Far Field Noise Test

Berrybank Wind Farm

November 2022



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List of Acronyms

AGD94: Geocentric Datum Of Australia 1994.

AGL: Above Ground Level.

ASL: Above Sea Level.

CF: Correction Factor.

BB1WF: Berrybank 1 Wind Farm.

BB2WF: Berrybank 2 Wind Farm.

BB3: Berrybank 3 Meteorological Station.

DTU: Technical University of Denmark.

HH: Hub Height.

UTM: Universal Transverse Mercator.

WASP: Wind Atlas and Application Program.

WTG: Wind Turbine Generator.



1. Aim

The purpose of this report is to provide the necessary wind data to MARSHALL DAY ACOUSTICS to perform the Far Field Test according to the Noise and Vibration MP for Berrybank 1 Wind Farm.

The previous rounds of testing were done using the wind data from BB3 met mast, but it was decommissioned in December 2020.

Berrybank 1 Wind Farm commercial operations commenced in July 2021. The Wind Farm has 43 turbines and each one has an anemometer and a windvane that record its wind speed and direction respectively. Since BB3 meteorological mast data is not available, wind data from the turbines that best represent BB3 will be used to estimate its wind data.

To the north and south of the Berrybank 1 wind farm is the Berrybank 2 wind farm, with 26 wind turbines. This wind farm has been recently constructed and has been in operation since November 2022.

The main objectives of this report are:

- Decide which wind turbine generators from BB1WF should be selected to represent the wind resource in BB3 meteorological mast. The wind data needs to be wake-free for all directions.
- Provide a data set (wind speed and direction) at BB3 with adjusted measurement data from the selected wind turbines.

2. Site description

Berrybank 1 y 2 Wind Farms site is located in South-Western Victoria approximately 14km east of Lismore and 16km west of Cressy. It is approximately 130km west of Melbourne within the Victorian district known as the Western Plains, located within the Corangamite and Golden Plains Local Government Areas.

This wind farm has been designed to contain 43 turbines in Stage 1 and 26 wind turbines in Stage 2. There are 4 meteorological masts situated in different positions of the site: BB2, BB3, BB4 and BB5.

A map with the site location of Berrybank 1 & 2 wind farm is shown below.



Figure 1. Location of the wind farm site in the state of Victoria



Figure 2. Location of the wind farm site



Figure 3. Location of the wind turbines

The site locations of the wind turbines are as follows:

Berrybank 1 Wind Farm		
Datum AGD94		
Zone 54		
43 Wind Turbine Locations		
WTG	X UTM	Y UTM
WTG-1.1	720,733	5,799,429
WTG-2.1	721,251	5,800,323
WTG-3.1	721,859	5,800,552
WTG-4.1	722,364	5,800,847
WTG-5.1	722,780	5,800,575
WTG-6.1	720,545	5,801,081
WTG-7.2	721,258	5,799,760
WTG-8.2	721,740	5,799,891
WTG-9.2	722,296	5,800,211
WTG-10.2	722,817	5,799,718
WTG-11.3	724,250	5,798,189



Berrybank 1 Wind Farm		
Datum AGD94		
Zone 54		
43 Wind Turbine Locations		
WTG	X UTM	Y UTM
WTG-12.3	723,942	5,797,816
WTG-13.3	724,683	5,797,804
WTG-14.3	725,133	5,797,978
WTG-15.3	725,624	5,797,870
WTG-16.3	723,854	5,798,772
WTG-17.3	724,851	5,798,766
WTG-18.4	721,057	5,798,686
WTG-19.4	721,076	5,797,527
WTG-20.4	721,921	5,797,435
WTG-21.4	722,535	5,797,663
WTG-22.4	722,922	5,798,109
WTG-23.5	720062	5,798,490
WTG-24.4	719,710	5,798,063
WTG-25.5	719,954	5,797,147
WTG-26.5	719,453	5,797,155
WTG-27.6	720,611	5,796,396
WTG-28.6	720,985	5,795,834
WTG-29.6	720,518	5,795,662
WTG-30.6	719,710	5,795,545
WTG-31.6	719092	5,795,312
WTG-32.7	721,359	5,795,356
WTG-33.7	720,275	5,795,050
WTG-34.7	719,538	5,794,878
WTG-35.7	719,076	5,794,661
WTG-36.7	719,929	5,794,535
WTG-37.7	720489	5,794,103
WTG-38.8	721,109	5,794,788
WTG-39.8	721,955	5,795,028
WTG-40.8	722543	5,794,720
WTG-41.8	722,034	5,794,531
WTG-42.8	720,541	5,794,620
WTG-43.8	721,000	5,794,218

Table 1. Location of the wind turbines of Berrybank 1 wind farm



Berrybank 2 Wind Farm		
Datum AGD94		
Zone 54		
26 Wind Turbine Locations		
WTG	X UTM	Y UTM
1	718,723	5,802,176
2	719,252	5,802,580
3	719,751	5,802,721
6	719,967	5,802,221
7	719,58	5,801,302
9	719,652	5,801,705
12	719,008	5,801,346
13	720,348	5,801,559
34	719,266	5,801,952
31	720,387	5,791,255
33	717,508	5,792,561
40	722,753	5,792,881
42	721,336	5,792,374
43	722,532	5,792,519
48	717,354	5,793,181
55	720,424	5,790,132
62	717,031	5,792,379
63	720,387	5,790,743
74	717,057	5,792,757
80	722,289	5,794,039
84	721,277	5,793,851
86	722,325	5,793,119
96	721,79	5,793,869
97	721,893	5,792,827
98	721,681	5,793,316
99	722,975	5,792,402

Table 2. Location of the wind turbines of Berrybank 2 wind farm

The location of the BB3 meteorological mast is UTM (719,773 m; 5,800,689 m), Datum AGD94, Zone 54.



3. Methodology

In order to obtain the adjusted wind data set that would have occurred at BB3 meteorological station location if the wind farms (Berrybank 1 and 2) were not present, the following methodology will be applied:

3.1. Selection of the wind turbine generators representative of BB3 meteorological stations wind data

The selection of the turbines used to represent wind data at BB3 meteorological mast location, has been done using WAsP software, developed by DTU Denmark Technical University. This software is used for the surface extrapolation of the wind resource at a site. Based on the wind resource recorded by the BB3 meteorological mast (from June 2010 until January 2020), WAsP simulates the wind speed and energy production at all wind turbine positions of both Berrybank stage 1 and 2 wind farms.

The WAsP simulation estimates the wake loss and wind speed of each turbine and wind rose sector from the BB1WF and BB2WF.

The wake effect of a turbine quantifies the decrease in energy production of the wind farm, which results from the changes in wind speed caused by the impact of the turbines on each other.

The selection of the WTG locations that best represent the wind speed and direction from BB3 has been done choosing the direction sectors that are wake free and close to BB3 meteorological mast.

The table in Annex I shows the wake losses in each turbine from BB1WF according to the different sectors from the direction wind rose.

The following WTG have been chosen to cover all wind direction so that no sector is wake affected:

- WTG-15.3 will be used to cover from sector 1 to sector 9.
- WTG-31.6 will be used to cover from sector 12 to sector 16.
- WTG-37.7 will be used to cover from sector 10 to sector 11.

The next table shows the wake losses results for Wind Turbine Generators 15.3, 31.6 and 37.7:



Sector	Direction [°]		Wake losses [%]		
	From	To	WTG-15.3	WTG-31.6	WTG-37.7
Sector 1 (0°)	348.75	11.25	0.00%	2.61%	19.35%
Sector 2 (22,5°)	11.25	33.75	0.00%	10.27%	15.16%
Sector 3 (45°)	33.75	56.25	0.00%	13.11%	28.34%
Sector 4 (67,5°)	56.25	78.75	0.00%	41.73%	38.43%
Sector 5 (90°)	78.75	101.25	0.00%	15.84%	26.55%
Sector 6 (112,5°)	101.25	123.75	0.00%	20.82%	23.71%
Sector 7 (135°)	123.75	146.25	0.00%	46.82%	11.08%
Sector 8 (157,5°)	146.25	168.75	0.00%	5.70%	7.99%
Sector 9 (180°)	168.75	191.25	0.00%	33.21%	6.85%
Sector 10 (202,5°)	191.25	213.75	2.42%	4.66%	0.00%
Sector 11 (225°)	213.75	236.25	5.75%	4.35%	0.00%
Sector 12 (247,5°)	236.25	258.75	5.08%	0.00%	5.34%
Sector 13 (270°)	258.75	281.25	26.49%	0.00%	0.00%
Sector 14 (292,5°)	281.25	303.75	21.14%	0.00%	10.07%
Sector 15 (315°)	303.75	326.25	9.03%	0.00%	17.07%
Sector 16 (337,5°)	326.25	348.75	0.28%	0.00%	8.07%

Table 3. Wake losses [%] from turbines WTG-15.3, WTG-31.6 and WTG-37.7

The location of these three chosen turbines on the Berrybank Wind Farm is shown in the following figure:



Figure 4. Location of the chosen wind turbines WTG-15.3, WTG-31.6 and WTG-37.7, in the Berrybank WF

3.2. Synthesised data set

For the current Noise Test, as BB3 is already decommissioned, BB1WF turbines wind data will be used to estimate data for BB3. The period of data available goes from 06/09/2022 until 05/11/2022.

The windvane from WTG-15.3 will be used to for the wind direction of the wind farm.

The wind speed dataset from the turbines selected for each sector needs to be corrected in order to neutralise the wake effect.

The correction factor will be calculated as follows:



- With WAsP software entering the data from BB3 mast, the wind speed at the selected wind turbines, WTG-15.3, WTG-31.6, and WTG-37.7 is obtained for each sector of the wind rose. The results are shown in the table below.
- The wind speed distribution in each of the BB3 met station sectors is also available in the WAsP simulation. The results are shown in the table below.
- The correction factor will be calculated using the differences between the wind speed from BB3 met mast and the one from the turbine chosen for each sector. The wind speed and correction factor from all the turbines of BB1WF is shown in Annex II and III.
- Therefore, to correct the wind speed at the turbine location to BB3 met mast location, the wind speed needs to be multiplied by the following correction factors (CF):

Sector	Direction [°]		Wind speed [m/s]				Correction factor Wind Speed (CF)		
	From	To	BB3 mast	WTG-15.3	WTG-31.6	WTG-37.7	WTG-15.3	WTG-31.6	WTG-37.7
Sector 1 (0°)	348.75	11.25	10.61	10.54	10.59	10.58	1.0066	1.0019	1.0028
Sector 2 (22,5°)	11.25	33.75	7.77	7.75	7.66	7.71	1.0026	1.0144	1.0078
Sector 3 (45°)	33.75	56.25	5.34	5.26	5.27	5.31	1.0152	1.0133	1.0056
Sector 4 (67,5°)	56.25	78.75	5.98	5.95	5.94	5.96	1.0050	1.0067	1.0034
Sector 5 (90°)	78.75	101.25	7.66	7.53	7.61	7.64	1.0173	1.0066	1.0026
Sector 6 (112,5°)	101.25	123.75	7.67	7.53	7.65	7.66	1.0186	1.0026	1.0013
Sector 7 (135°)	123.75	146.25	6.06	5.97	6.09	6.09	1.0151	0.9951	0.9951
Sector 8 (157,5°)	146.25	168.75	5.77	5.70	5.77	5.78	1.0123	1.0000	0.9983
Sector 9 (180°)	168.75	191.25	5.99	5.95	5.98	5.99	1.0067	1.0017	1.0000
Sector 10 (202,5°)	191.25	213.75	6.67	6.63	6.65	6.65	1.0060	1.0030	1.0030
Sector 11 (225°)	213.75	236.25	7.36	7.28	7.32	7.34	1.0110	1.0055	1.0027
Sector 12 (247,5°)	236.25	258.75	7.69	7.61	7.64	7.67	1.0105	1.0065	1.0026
Sector 13 (270°)	258.75	281.25	8.34	8.19	8.28	8.31	1.0183	1.0072	1.0036
Sector 14 (292,5°)	281.25	303.75	8.87	8.69	8.83	8.85	1.0207	1.0045	1.0023
Sector 15 (315°)	303.75	326.25	9.52	9.36	9.51	9.51	1.0171	1.0011	1.0011
Sector 16 (337,5°)	326.25	348.75	10.37	10.25	10.37	10.35	1.0117	1.0000	1.0019

Table 4. Correction factor for the Wind Speed from turbines WTG-15.3, WTG-31.6 and WTG-37.7

The generation of the synthesised dataset of wind speed and direction has been obtained from the data recorded by the wind turbines by applying the correction factor obtained in each sector.

The corrected wind data is wake-free for all directions that occurred during the noise survey, including the directions when these turbines would be wake affected.

The final result is to provide the synthesised wind speed and direction dataset that goes from 25/05/2021 to 24/11/2022 that represent the wind resource at BB3 meteorological station (file Synthesized dataset in BB3 at 112m_20210525-20221124.txt).



Annex I. Wake losses (WAsP simulation)



- Wake losses (%) simulated with WAsP with BB3 wind data from June 2010 until January 2020.

Wake losses [%] (Simulated with BB3 wind data June 2010 - January 2020)																
Wind Turbine Generator BB1WF	Sector 1 (0°)	Sector 2 (22,5°)	Sector 3 (45°)	Sector 4 (67,5°)	Sector 5 (90°)	Sector 6 (112,5°)	Sector 7 (135°)	Sector 8 (157,5°)	Sector 9 (180°)	Sector 10 (202,5°)	Sector 11 (225°)	Sector 12 (247,5°)	Sector 13 (270°)	Sector 14 (292,5°)	Sector 15 (315°)	Sector 16 (337,5°)
WTG-1.1	3.14%	8.42%	29.33%	37.49%	6.28%	8.79%	8.33%	34.61%	15.62%	14.33%	9.27%	0.00%	0.00%	0.00%	2.97%	6.02%
WTG-2.1	0.00%	0.00%	0.35%	42.71%	18.65%	14.00%	33.07%	11.41%	45.89%	18.53%	4.76%	0.00%	0.00%	4.12%	13.40%	2.40%
WTG-3.1	0.00%	0.00%	14.72%	28.58%	18.38%	11.50%	39.86%	9.09%	25.64%	23.25%	15.23%	19.01%	1.46%	11.68%	4.47%	0.00%
WTG-4.1	0.00%	0.00%	0.00%	0.00%	0.00%	20.26%	29.92%	22.06%	32.86%	19.68%	20.63%	21.06%	4.83%	8.77%	1.14%	0.00%
WTG-5.1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.70%	13.44%	28.75%	9.41%	22.70%	16.15%	14.20%	19.16%	11.24%	0.00%
WTG-6.1	1.18%	0.00%	0.00%	0.00%	5.65%	15.44%	25.86%	18.28%	17.06%	5.46%	0.00%	0.00%	6.18%	13.21%	9.98%	20.53%
WTG-7.2	13.55%	4.78%	21.33%	45.58%	19.35%	8.50%	9.56%	11.29%	20.23%	13.56%	16.77%	12.76%	0.00%	0.77%	6.05%	7.99%
WTG-8.2	6.60%	15.24%	24.25%	30.71%	9.54%	12.22%	8.91%	9.91%	12.95%	15.46%	8.92%	24.74%	8.89%	3.79%	19.72%	0.49%
WTG-9.2	9.66%	5.65%	27.33%	14.69%	0.00%	3.43%	34.14%	8.77%	12.36%	9.31%	14.20%	22.57%	7.99%	13.30%	15.52%	0.00%
WTG-10.2	8.00%	0.00%	0.00%	0.00%	0.00%	5.12%	18.71%	5.40%	16.64%	10.90%	6.81%	6.02%	10.89%	10.26%	18.98%	5.49%
WTG-11.3	0.00%	0.00%	26.61%	0.55%	10.10%	20.26%	34.09%	0.29%	0.63%	15.58%	28.54%	9.68%	9.02%	4.26%	13.06%	6.43%
WTG-12.3	6.33%	8.70%	47.29%	4.70%	32.07%	0.78%	0.00%	0.00%	0.91%	9.09%	7.80%	6.08%	10.15%	9.81%	6.25%	4.48%
WTG-13.3	4.17%	5.32%	3.39%	45.40%	18.56%	0.00%	0.00%	0.00%	0.00%	5.38%	7.08%	4.70%	19.95%	7.04%	22.63%	0.59%
WTG-14.3	0.53%	0.00%	0.00%	0.00%	19.23%	21.31%	0.00%	0.00%	0.00%	3.63%	7.62%	28.07%	15.64%	12.68%	5.91%	8.78%
WTG-15.3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.42%	5.75%	5.08%	26.49%	21.14%	9.03%	0.28%
WTG-16.3	0.00%	0.00%	0.00%	0.00%	17.04%	8.45%	26.09%	20.60%	19.61%	8.03%	14.63%	7.88%	4.19%	6.43%	10.26%	1.89%
WTG-17.3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.69%	27.71%	13.98%	11.22%	23.88%	8.82%	12.12%	7.77%	3.49%	0.00%
WTG-18.4	5.88%	13.98%	12.19%	5.42%	7.91%	10.22%	10.43%	12.40%	25.61%	10.76%	6.65%	10.66%	5.00%	0.00%	1.44%	12.48%
WTG-19.4	8.57%	7.86%	4.17%	12.18%	25.24%	3.84%	0.00%	15.65%	20.21%	20.20%	5.03%	9.85%	1.75%	5.41%	5.06%	3.79%
WTG-20.4	4.60%	4.95%	9.60%	41.48%	7.06%	0.00%	0.00%	4.29%	16.19%	15.06%	12.65%	2.11%	13.73%	6.20%	3.32%	6.32%
WTG-21.4	4.86%	5.41%	40.24%	13.13%	13.93%	0.00%	0.00%	0.00%	12.34%	12.40%	11.11%	20.36%	8.79%	4.35%	5.51%	5.46%
WTG-22.4	4.58%	0.00%	10.80%	14.45%	18.72%	11.55%	0.00%	0.00%	6.76%	14.35%	29.13%	10.53%	3.62%	5.53%	6.75%	4.50%
WTG-23.5	4.06%	6.49%	26.17%	14.24%	14.90%	7.93%	12.71%	18.35%	22.34%	17.38%	22.21%	0.00%	0.00%	0.00%	0.00%	2.67%
WTG-24.4	3.85%	10.92%	43.69%	14.10%	9.47%	10.13%	4.74%	33.64%	20.58%	15.72%	0.00%	0.00%	0.00%	0.00%	0.00%	1.06%

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Wake losses [%] (Simulated with B83 wind data June 2010 - January 2020)																
Wind Turbine Generator BB1WF	Sector 1 (0°)	Sector 2 (22,5°)	Sector 3 (45°)	Sector 4 (67,5°)	Sector 5 (90°)	Sector 6 (112,5°)	Sector 7 (135°)	Sector 8 (157,5°)	Sector 9 (180°)	Sector 10 (202,5°)	Sector 11 (225°)	Sector 12 (247,5°)	Sector 13 (270°)	Sector 14 (292,5°)	Sector 15 (315°)	Sector 16 (337,5°)
WTG-25.5	7.62%	8.87%	10.59%	20.06%	6.46%	0.00%	26.08%	24.22%	18.65%	11.59%	0.93%	1.74%	22.58%	2.56%	0.00%	5.90%
WTG-26.5	4.23%	17.53%	13.30%	10.58%	38.57%	8.74%	21.39%	22.77%	17.70%	6.80%	0.00%	0.00%	0.00%	0.00%	0.00%	0.07%
WTG-27.6	3.91%	13.48%	12.41%	11.23%	0.00%	0.00%	28.84%	36.98%	32.25%	15.93%	14.90%	1.56%	0.00%	3.18%	9.95%	4.79%
WTG-28.6	5.65%	7.10%	13.85%	5.66%	0.00%	2.30%	39.81%	29.64%	25.16%	14.21%	18.38%	29.74%	5.68%	0.00%	11.79%	8.99%
WTG-29.6	10.05%	10.74%	14.13%	44.94%	6.71%	23.80%	20.01%	28.96%	27.00%	31.85%	11.52%	10.47%	9.99%	0.00%	2.24%	5.99%
WTG-30.6	6.83%	7.88%	21.31%	18.88%	22.53%	14.36%	40.12%	22.83%	21.06%	22.65%	10.00%	18.72%	1.31%	0.00%	0.00%	1.15%
WTG-31.6	2.61%	10.27%	13.11%	41.73%	15.84%	20.82%	46.82%	5.70%	33.21%	4.66%	4.35%	0.00%	0.00%	0.00%	0.00%	0.00%
WTG-32.7	4.46%	8.48%	9.35%	2.57%	0.00%	25.41%	25.71%	23.62%	17.89%	35.12%	15.06%	15.57%	8.43%	10.99%	17.04%	8.15%
WTG-33.7	5.36%	25.88%	23.38%	16.33%	14.06%	21.67%	38.78%	43.38%	11.89%	14.98%	14.84%	16.06%	9.67%	5.82%	11.47%	3.19%
WTG-34.7	7.34%	19.06%	21.77%	28.36%	24.08%	25.11%	45.55%	5.02%	2.08%	0.00%	9.36%	23.59%	0.77%	1.06%	15.34%	0.39%
WTG-35.7	12.87%	11.14%	27.05%	52.43%	25.95%	20.84%	5.37%	5.51%	0.00%	0.89%	8.12%	0.00%	0.00%	0.00%	0.00%	0.16%
WTG-36.7	6.22%	21.36%	28.76%	27.78%	30.56%	25.32%	26.56%	3.62%	5.39%	0.00%	3.10%	2.97%	8.53%	8.67%	23.30%	4.46%
WTG-37.7	19.35%	15.16%	28.34%	38.43%	26.55%	23.71%	11.08%	7.99%	6.85%	0.00%	0.00%	5.34%	0.00%	10.07%	17.07%	8.07%
WTG-38.8	7.58%	25.45%	10.08%	20.13%	15.55%	16.65%	19.33%	27.80%	34.55%	17.62%	13.98%	21.87%	14.42%	14.43%	4.98%	8.51%
WTG-39.8	4.05%	5.73%	9.56%	0.00%	0.00%	21.56%	6.56%	35.69%	43.02%	14.69%	11.14%	19.36%	11.49%	16.95%	10.86%	3.80%
WTG-40.8	3.71%	5.10%	5.15%	0.00%	0.00%	0.00%	0.00%	2.55%	17.11%	28.79%	13.54%	29.31%	13.61%	21.73%	7.53%	4.09%
WTG-41.8	12.95%	5.19%	7.21%	40.85%	4.64%	0.00%	8.54%	46.33%	16.37%	30.56%	11.36%	13.55%	12.70%	13.28%	13.51%	10.68%
WTG-42.8	10.00%	11.62%	21.61%	37.32%	19.13%	13.45%	46.97%	7.18%	38.13%	10.01%	1.14%	10.33%	18.23%	10.02%	12.27%	12.93%
WTG-43.8	11.91%	20.47%	18.37%	22.84%	10.05%	18.73%	44.19%	29.27%	8.36%	1.99%	0.00%	17.42%	13.13%	13.67%	20.29%	6.28%

Table 5. Wake losses simulated with WASP



Annex II. Wind speed (WAsP simulation)



- Wind speed at hub height 112 m (m/s) simulated with WAsP with BB3 wind data from June 2010 until January 2020.

Wind Speed (Simulated with BB3 wind data June 2010 - January 2020)																
Wind Turbine Generator BB1WF	Sector 1 (0°)	Sector 2 (22,5°)	Sector 3 (45°)	Sector 4 (67,5°)	Sector 5 (90°)	Sector 6 (112,5°)	Sector 7 (135°)	Sector 8 (157,5°)	Sector 9 (180°)	Sector 10 (202,5°)	Sector 11 (225°)	Sector 12 (247,5°)	Sector 13 (270°)	Sector 14 (292,5°)	Sector 15 (315°)	Sector 16 (337,5°)
WTG-1.1	10.60	7.81	5.36	5.99	7.67	7.67	6.05	5.76	5.98	6.66	7.36	7.71	8.35	8.87	9.51	10.36
WTG-2.1	10.59	7.79	5.33	5.97	7.63	7.63	6.04	5.75	5.98	6.66	7.34	7.68	8.31	8.82	9.48	10.34
WTG-3.1	10.60	7.78	5.30	5.97	7.60	7.61	6.02	5.74	5.99	6.66	7.34	7.66	8.27	8.79	9.45	10.33
WTG-4.1	10.59	7.72	5.27	5.94	7.59	7.61	6.03	5.74	5.98	6.65	7.31	7.63	8.26	8.79	9.46	10.33
WTG-5.1	10.65	7.69	5.25	5.92	7.58	7.62	6.06	5.78	6.01	6.68	7.32	7.62	8.24	8.78	9.48	10.39
WTG-6.1	10.64	7.80	5.35	6.00	7.68	7.68	6.07	5.78	6.01	6.69	7.38	7.71	8.35	8.88	9.54	10.40
WTG-7.2	10.59	7.74	5.32	5.97	7.64	7.66	6.05	5.76	5.98	6.65	7.33	7.67	8.32	8.85	9.51	10.36
WTG-8.2	10.62	7.67	5.24	5.92	7.60	7.65	6.06	5.78	6.00	6.65	7.30	7.62	8.26	8.82	9.52	10.40
WTG-9.2	10.62	7.68	5.25	5.93	7.60	7.65	6.06	5.78	6.00	6.66	7.31	7.63	8.27	8.82	9.52	10.39
WTG-10.2	10.61	7.67	5.24	5.92	7.58	7.63	6.05	5.77	6.00	6.65	7.30	7.62	8.25	8.80	9.49	10.38
WTG-11.3	10.55	7.74	5.28	5.94	7.57	7.58	6.00	5.72	5.96	6.63	7.30	7.63	8.24	8.76	9.41	10.29
WTG-12.3	10.56	7.67	5.25	5.91	7.56	7.59	6.01	5.73	5.96	6.62	7.28	7.61	8.23	8.76	9.43	10.31
WTG-13.3	10.55	7.73	5.26	5.94	7.55	7.56	5.99	5.72	5.96	6.63	7.29	7.61	8.21	8.73	9.39	10.28
WTG-14.3	10.56	7.75	5.27	5.95	7.55	7.56	5.99	5.72	5.96	6.64	7.29	7.62	8.22	8.73	9.39	10.28
WTG-15.3	10.54	7.75	5.26	5.95	7.53	7.53	5.97	5.70	5.95	6.63	7.28	7.61	8.19	8.69	9.36	10.25
WTG-16.3	10.65	7.70	5.26	5.94	7.61	7.65	6.07	5.79	6.02	6.68	7.33	7.64	8.27	8.82	9.51	10.41
WTG-17.3	10.60	7.77	5.26	5.97	7.55	7.56	5.99	5.73	5.98	6.66	7.32	7.62	8.21	8.72	9.40	10.31
WTG-18.4	10.59	7.79	5.37	6.00	7.69	7.68	6.06	5.76	5.97	6.65	7.35	7.71	8.37	8.89	9.53	10.36
WTG-19.4	10.58	7.76	5.35	5.98	7.67	7.68	6.06	5.76	5.97	6.64	7.34	7.70	8.35	8.88	9.53	10.35
WTG-20.4	10.56	7.63	5.30	5.95	7.66	7.71	6.09	5.78	5.97	6.61	7.29	7.66	8.33	8.91	9.58	10.39
WTG-21.4	10.56	7.63	5.21	5.89	7.55	7.60	6.03	5.75	5.97	6.61	7.26	7.58	8.21	8.76	9.46	10.34
WTG-22.4	10.62	7.68	5.26	5.94	7.61	7.64	6.05	5.77	6.00	6.66	7.32	7.64	8.27	8.82	9.50	10.38
WTG-23.5	10.54	7.64	5.31	5.95	7.66	7.68	6.06	5.76	5.95	6.61	7.29	7.66	8.33	8.89	9.54	10.35
WTG-24.4	10.53	7.62	5.27	5.93	7.62	7.65	6.06	5.75	5.94	6.60	7.27	7.62	8.28	8.84	9.51	10.33

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Wind Speed (Simulated with BB3 wind data June 2010 - January 2020)																
Wind Turbine Generator BB1WF	Sector 1 (0°)	Sector 2 (22,5°)	Sector 3 (45°)	Sector 4 (67,5°)	Sector 5 (90°)	Sector 6 (112,5°)	Sector 7 (135°)	Sector 8 (157,5°)	Sector 9 (180°)	Sector 10 (202,5°)	Sector 11 (225°)	Sector 12 (247,5°)	Sector 13 (270°)	Sector 14 (292,5°)	Sector 15 (315°)	Sector 16 (337,5°)
WTG-25.5	10.60	7.69	5.28	5.95	7.62	7.65	6.07	5.77	5.98	6.65	7.32	7.65	8.29	8.83	9.51	10.37
WTG-26.5	10.62	7.70	5.29	5.96	7.63	7.66	6.09	5.78	5.99	6.66	7.34	7.66	8.30	8.85	9.53	10.39
WTG-27.6	10.57	7.66	5.30	5.95	7.64	7.67	6.07	5.77	5.97	6.62	7.31	7.65	8.31	8.86	9.52	10.36
WTG-28.6	10.54	7.65	5.31	5.95	7.65	7.67	6.07	5.76	5.95	6.61	7.30	7.66	8.32	8.88	9.53	10.34
WTG-29.6	10.55	7.69	5.32	5.96	7.65	7.67	6.08	5.76	5.96	6.62	7.32	7.67	8.32	8.87	9.52	10.34
WTG-30.6	10.57	7.71	5.31	5.96	7.64	7.65	6.07	5.76	5.97	6.64	7.33	7.66	8.31	8.85	9.50	10.34
WTG-31.6	10.59	7.66	5.27	5.94	7.61	7.65	6.09	5.77	5.98	6.65	7.32	7.64	8.28	8.83	9.51	10.37
WTG-32.7	10.54	7.65	5.30	5.94	7.63	7.65	6.06	5.76	5.95	6.61	7.29	7.65	8.30	8.85	9.51	10.33
WTG-33.7	10.56	7.72	5.33	5.97	7.66	7.67	6.08	5.76	5.96	6.63	7.33	7.69	8.33	8.87	9.52	10.34
WTG-34.7	10.55	7.69	5.30	5.94	7.62	7.64	6.07	5.75	5.96	6.63	7.32	7.65	8.29	8.83	9.49	10.33
WTG-35.7	10.60	7.75	5.30	5.95	7.62	7.63	6.08	5.76	5.99	6.67	7.35	7.66	8.29	8.82	9.48	10.35
WTG-36.7	10.56	7.71	5.32	5.96	7.65	7.66	6.09	5.76	5.97	6.64	7.33	7.68	8.32	8.86	9.51	10.34
WTG-37.7	10.58	7.71	5.31	5.96	7.64	7.66	6.09	5.78	5.99	6.65	7.34	7.67	8.31	8.85	9.51	10.35
WTG-38.8	10.55	7.67	5.31	5.96	7.65	7.67	6.09	5.77	5.96	6.62	7.31	7.66	8.32	8.87	9.53	10.35
WTG-39.8	10.56	7.65	5.26	5.92	7.59	7.62	6.05	5.77	5.97	6.62	7.29	7.62	8.26	8.80	9.48	10.34
WTG-40.8	10.57	7.69	5.27	5.93	7.58	7.60	6.02	5.77	5.98	6.63	7.30	7.62	8.25	8.78	9.45	10.32
WTG-41.8	10.58	7.67	5.25	5.92	7.57	7.60	6.04	5.77	5.98	6.64	7.30	7.61	8.24	8.77	9.45	10.33
WTG-42.8	10.56	7.73	5.33	5.96	7.65	7.66	6.07	5.77	5.97	6.63	7.33	7.67	8.32	8.85	9.50	10.34
WTG-43.8	10.57	7.65	5.30	5.95	7.65	7.68	6.09	5.79	5.98	6.63	7.32	7.66	8.32	8.88	9.54	10.36
BB3	10.61	7.77	5.34	5.98	7.66	7.67	6.06	5.77	5.99	6.67	7.36	7.69	8.34	8.87	9.52	10.37

Table 6. Wind Speed simulated with WAsP



Annex III. Correction Factor



- Correction Factor for Wind Speed, simulated with WAsP with BB3 wind data from June 2010 until January 2020.

Correction Factor for Wind Speed (Simulated with BB3 wind data June 2010 - January 2020)																
Wind Turbine Generator BB1WF	Sector 1 (0°)	Sector 2 (22,5°)	Sector 3 (45°)	Sector 4 (67,5°)	Sector 5 (90°)	Sector 6 (112,5°)	Sector 7 (135°)	Sector 8 (157,5°)	Sector 9 (180°)	Sector 10 (202,5°)	Sector 11 (225°)	Sector 12 (247,5°)	Sector 13 (270°)	Sector 14 (292,5°)	Sector 15 (315°)	Sector 16 (337,5°)
WTG-1.1	1.0009	0.9949	0.9963	0.9983	0.9987	1.0000	1.0017	1.0017	1.0017	1.0015	1.0000	0.9974	0.9988	1.0000	1.0011	1.0010
WTG-2.1	1.0019	0.9974	1.0019	1.0017	1.0039	1.0052	1.0033	1.0035	1.0017	1.0015	1.0027	1.0013	1.0036	1.0057	1.0042	1.0029
WTG-3.1	1.0009	0.9987	1.0075	1.0017	1.0079	1.0079	1.0066	1.0052	1.0000	1.0015	1.0027	1.0039	1.0085	1.0091	1.0074	1.0039
WTG-4.1	1.0019	1.0065	1.0133	1.0067	1.0092	1.0079	1.0050	1.0052	1.0017	1.0030	1.0068	1.0079	1.0097	1.0091	1.0063	1.0039
WTG-5.1	0.9962	1.0104	1.0171	1.0101	1.0106	1.0066	1.0000	0.9983	0.9967	0.9985	1.0055	1.0092	1.0121	1.0103	1.0042	0.9981
WTG-6.1	0.9972	0.9962	0.9981	0.9967	0.9974	0.9987	0.9984	0.9983	0.9967	0.9970	0.9973	0.9974	0.9988	0.9989	0.9979	0.9971
WTG-7.2	1.0019	1.0039	1.0038	1.0017	1.0026	1.0013	1.0017	1.0017	1.0017	1.0030	1.0041	1.0026	1.0024	1.0023	1.0011	1.0010
WTG-8.2	0.9991	1.0130	1.0191	1.0101	1.0079	1.0026	1.0000	0.9983	0.9983	1.0030	1.0082	1.0092	1.0097	1.0057	1.0000	0.9971
WTG-9.2	0.9991	1.0117	1.0171	1.0084	1.0079	1.0026	1.0000	0.9983	0.9983	1.0015	1.0068	1.0079	1.0085	1.0057	1.0000	0.9981
WTG-10.2	1.0000	1.0130	1.0191	1.0101	1.0106	1.0052	1.0017	1.0000	0.9983	1.0030	1.0082	1.0092	1.0109	1.0080	1.0032	0.9990
WTG-11.3	1.0057	1.0039	1.0114	1.0067	1.0119	1.0119	1.0100	1.0087	1.0050	1.0060	1.0082	1.0079	1.0121	1.0126	1.0117	1.0078
WTG-12.3	1.0047	1.0130	1.0171	1.0118	1.0132	1.0105	1.0083	1.0070	1.0050	1.0076	1.0110	1.0105	1.0134	1.0126	1.0095	1.0058
WTG-13.3	1.0057	1.0052	1.0152	1.0067	1.0146	1.0146	1.0117	1.0087	1.0050	1.0060	1.0096	1.0105	1.0158	1.0160	1.0138	1.0088
WTG-14.3	1.0047	1.0026	1.0133	1.0050	1.0146	1.0146	1.0117	1.0087	1.0050	1.0045	1.0096	1.0092	1.0146	1.0160	1.0138	1.0088
WTG-15.3	1.0066	1.0026	1.0152	1.0050	1.0173	1.0186	1.0151	1.0123	1.0067	1.0060	1.0110	1.0105	1.0183	1.0207	1.0171	1.0117
WTG-16.3	0.9962	1.0091	1.0152	1.0067	1.0066	1.0026	0.9984	0.9965	0.9950	0.9985	1.0041	1.0065	1.0085	1.0057	1.0011	0.9962
WTG-17.3	1.0009	1.0000	1.0152	1.0017	1.0146	1.0146	1.0117	1.0070	1.0017	1.0015	1.0055	1.0092	1.0158	1.0172	1.0128	1.0058
WTG-18.4	1.0019	0.9974	0.9944	0.9967	0.9961	0.9987	1.0000	1.0017	1.0034	1.0030	1.0014	0.9974	0.9964	0.9978	0.9990	1.0010
WTG-19.4	1.0028	1.0013	0.9981	1.0000	0.9987	0.9987	1.0000	1.0017	1.0034	1.0045	1.0027	0.9987	0.9988	0.9989	0.9990	1.0019
WTG-20.4	1.0047	1.0183	1.0075	1.0050	1.0000	0.9948	0.9951	0.9983	1.0034	1.0091	1.0096	1.0039	1.0012	0.9955	0.9937	0.9981
WTG-21.4	1.0047	1.0183	1.0250	1.0153	1.0146	1.0092	1.0050	1.0035	1.0034	1.0091	1.0138	1.0145	1.0158	1.0126	1.0063	1.0029
WTG-22.4	0.9991	1.0117	1.0152	1.0067	1.0066	1.0039	1.0017	1.0000	0.9983	1.0015	1.0055	1.0065	1.0085	1.0057	1.0021	0.9990
WTG-23.5	1.0066	1.0170	1.0056	1.0050	1.0000	0.9987	1.0000	1.0017	1.0067	1.0091	1.0096	1.0039	1.0012	0.9978	0.9979	1.0019
WTG-24.4	1.0076	1.0197	1.0133	1.0084	1.0052	1.0026	1.0000	1.0035	1.0084	1.0106	1.0124	1.0092	1.0072	1.0034	1.0011	1.0039

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Correction Factor for Wind Speed (Simulated with BB3 wind data June 2010 - January 2020)																
Wind Turbine Generator BB1WF	Sector 1 (0°)	Sector 2 (22,5°)	Sector 3 (45°)	Sector 4 (67,5°)	Sector 5 (90°)	Sector 6 (112,5°)	Sector 7 (135°)	Sector 8 (157,5°)	Sector 9 (180°)	Sector 10 (202,5°)	Sector 11 (225°)	Sector 12 (247,5°)	Sector 13 (270°)	Sector 14 (292,5°)	Sector 15 (315°)	Sector 16 (337,5°)
WTG-25.5	1.0009	1.0104	1.0114	1.0050	1.0052	1.0026	0.9984	1.0000	1.0017	1.0030	1.0055	1.0052	1.0060	1.0045	1.0011	1.0000
WTG-26.5	0.9991	1.0091	1.0095	1.0034	1.0039	1.0013	0.9951	0.9983	1.0000	1.0015	1.0027	1.0039	1.0048	1.0023	0.9990	0.9981
WTG-27.6	1.0038	1.0144	1.0075	1.0050	1.0026	1.0000	0.9984	1.0000	1.0034	1.0076	1.0068	1.0052	1.0036	1.0011	1.0000	1.0010
WTG-28.6	1.0066	1.0157	1.0056	1.0050	1.0013	1.0000	0.9984	1.0017	1.0067	1.0091	1.0082	1.0039	1.0024	0.9989	0.9990	1.0029
WTG-29.6	1.0057	1.0104	1.0038	1.0034	1.0013	1.0000	0.9967	1.0017	1.0050	1.0076	1.0055	1.0026	1.0024	1.0000	1.0000	1.0029
WTG-30.6	1.0038	1.0078	1.0056	1.0034	1.0026	1.0026	0.9984	1.0017	1.0034	1.0045	1.0041	1.0039	1.0036	1.0023	1.0021	1.0029
WTG-31.6	1.0019	1.0144	1.0133	1.0067	1.0066	1.0026	0.9951	1.0000	1.0017	1.0030	1.0055	1.0065	1.0072	1.0045	1.0011	1.0000
WTG-32.7	1.0066	1.0157	1.0075	1.0067	1.0039	1.0026	1.0000	1.0017	1.0067	1.0091	1.0096	1.0052	1.0048	1.0023	1.0011	1.0039
WTG-33.7	1.0047	1.0065	1.0019	1.0017	1.0000	1.0000	0.9967	1.0017	1.0050	1.0060	1.0041	1.0000	1.0012	1.0000	1.0000	1.0029
WTG-34.7	1.0057	1.0104	1.0075	1.0067	1.0052	1.0039	0.9984	1.0035	1.0050	1.0060	1.0055	1.0052	1.0060	1.0045	1.0032	1.0039
WTG-35.7	1.0009	1.0026	1.0075	1.0050	1.0052	1.0052	0.9967	1.0017	1.0000	1.0000	1.0014	1.0039	1.0060	1.0057	1.0042	1.0019
WTG-36.7	1.0047	1.0078	1.0038	1.0034	1.0013	1.0013	0.9951	1.0017	1.0034	1.0045	1.0041	1.0013	1.0024	1.0011	1.0011	1.0029
WTG-37.7	1.0028	1.0078	1.0056	1.0034	1.0026	1.0013	0.9951	0.9983	1.0000	1.0030	1.0027	1.0026	1.0036	1.0023	1.0011	1.0019
WTG-38.8	1.0057	1.0130	1.0056	1.0034	1.0013	1.0000	0.9951	1.0000	1.0050	1.0076	1.0068	1.0039	1.0024	1.0000	0.9990	1.0019
WTG-39.8	1.0047	1.0157	1.0152	1.0101	1.0092	1.0066	1.0017	1.0000	1.0034	1.0076	1.0096	1.0092	1.0097	1.0080	1.0042	1.0029
WTG-40.8	1.0038	1.0104	1.0133	1.0084	1.0106	1.0092	1.0066	1.0000	1.0017	1.0060	1.0082	1.0092	1.0109	1.0103	1.0074	1.0048
WTG-41.8	1.0028	1.0130	1.0171	1.0101	1.0119	1.0092	1.0033	1.0000	1.0017	1.0045	1.0082	1.0105	1.0121	1.0114	1.0074	1.0039
WTG-42.8	1.0047	1.0052	1.0019	1.0034	1.0013	1.0013	0.9984	1.0000	1.0034	1.0060	1.0041	1.0026	1.0024	1.0023	1.0021	1.0029
WTG-43.8	1.0038	1.0157	1.0075	1.0050	1.0013	0.9987	0.9951	0.9965	1.0017	1.0060	1.0055	1.0039	1.0024	0.9989	0.9979	1.0010

Table 7. Correction of the Wind Speed simulated with WAsP. Multiplier applied to the synthesised dataset.

H2 Site wind speed and direction trends

H2.1 Historic data

An updated wind rose illustrating the wind direction trends at the reference mast BB3 was provided by GPG for the period 1 June 2010 to 15 January 2020, and is reproduced in Figure 10. As an additional reference, an online wind rose based on data from the nearest Australian Bureau of Meteorology (BoM) mast is reproduced in Figure 11.

Figure 10: Historic wind rose for reference mast BB3, 2010 to 2020

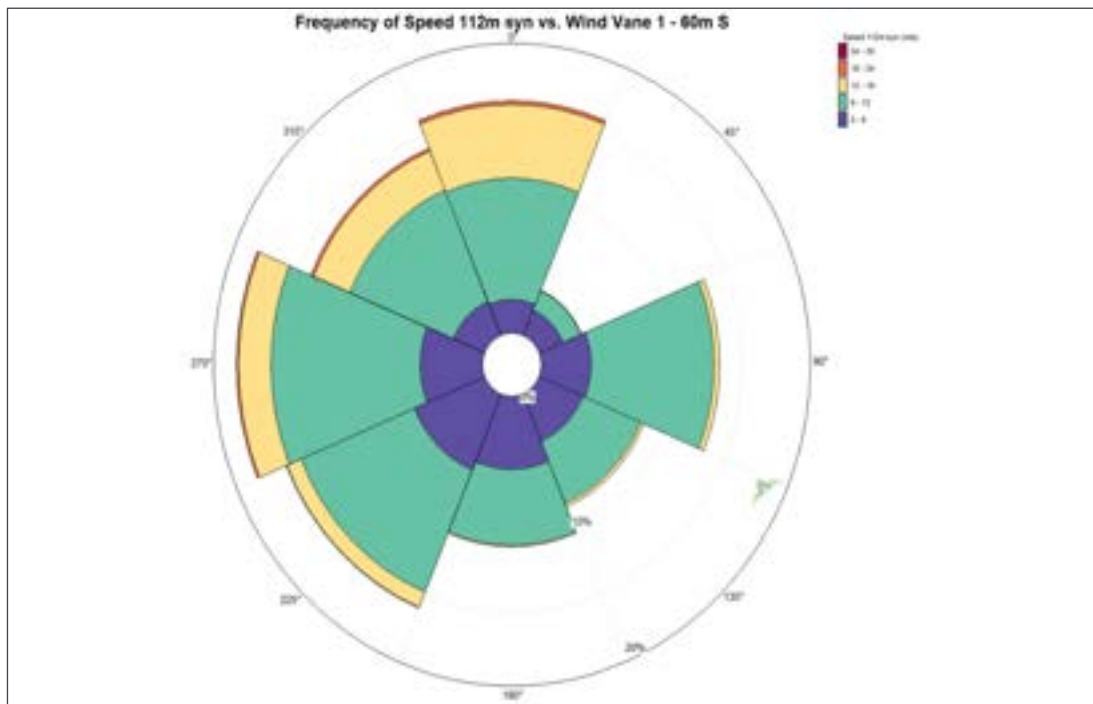
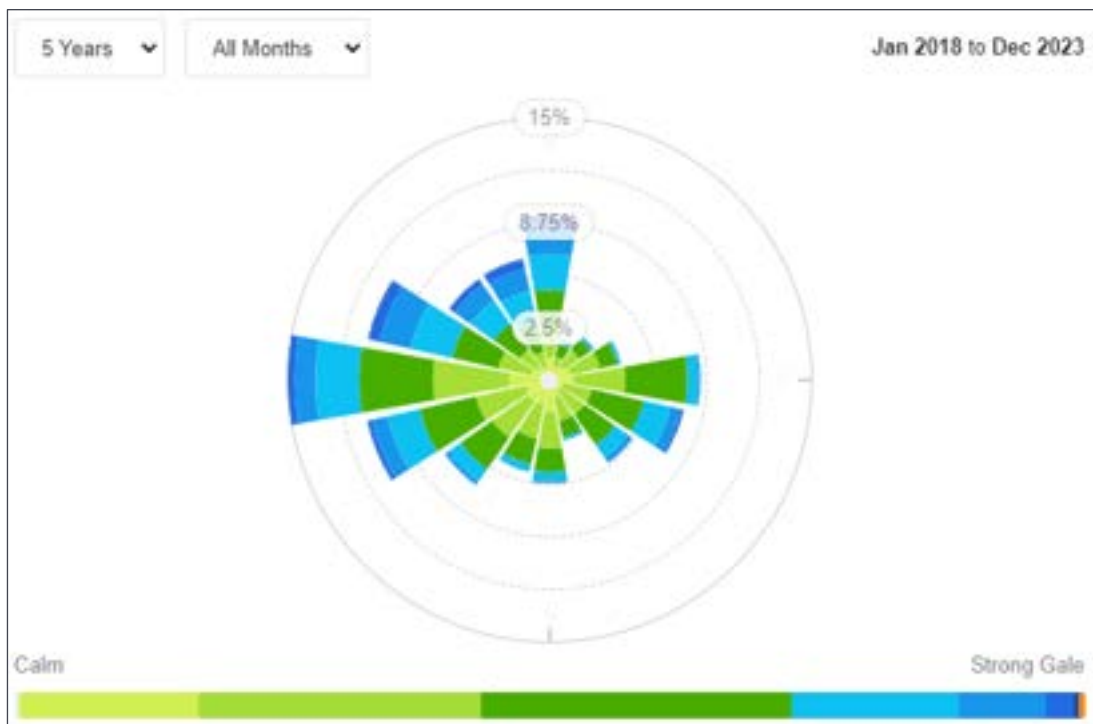


Figure 11: 5-year annual average from online data (image courtesy of <https://wind.willyweather.com.au/>)
Data based on the nearest BoM mast at Mt Gellibrand



H2.2 Round 2 phase 1 post-construction survey period

The trend of the wind directions and wind speeds at the site during the first phase of the round 2 noise monitoring are illustrated for all-time (reduced) and night-time periods in Figure 12 and Figure 13 respectively.

Figure 12: Round 2 phase 1 monitoring period wind rose - all-time (reduced)

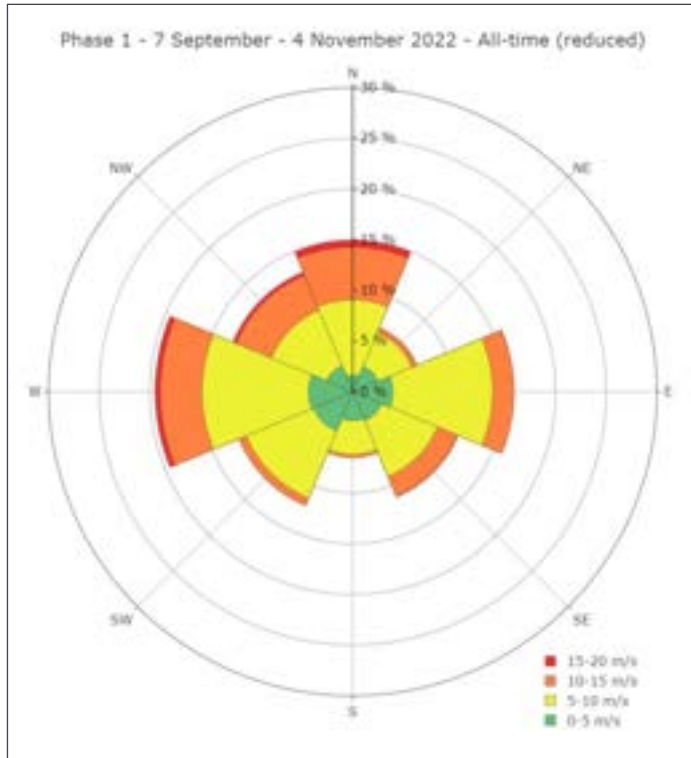
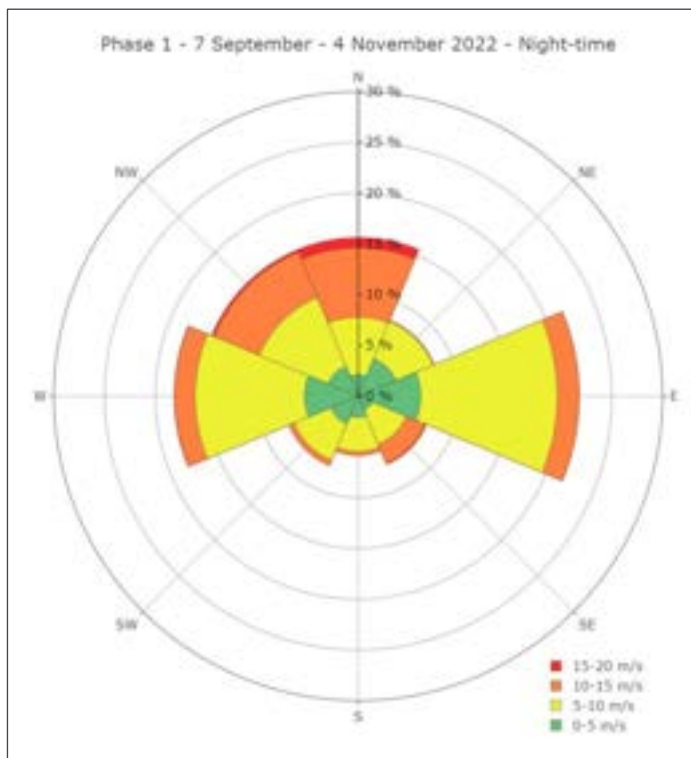


Figure 13: Round 2 phase 1 monitoring period wind rose – night-time



H2.3 Round 2 phase 2 post-construction survey period

The trend of the wind directions and wind speeds at the site during the second phase of the round 2 noise monitoring are illustrated for all-time (reduced) and night-time periods in Figure 14 and Figure 15 respectively.

Figure 14: Round 2 phase 2 monitoring period wind rose - all-time (reduced)

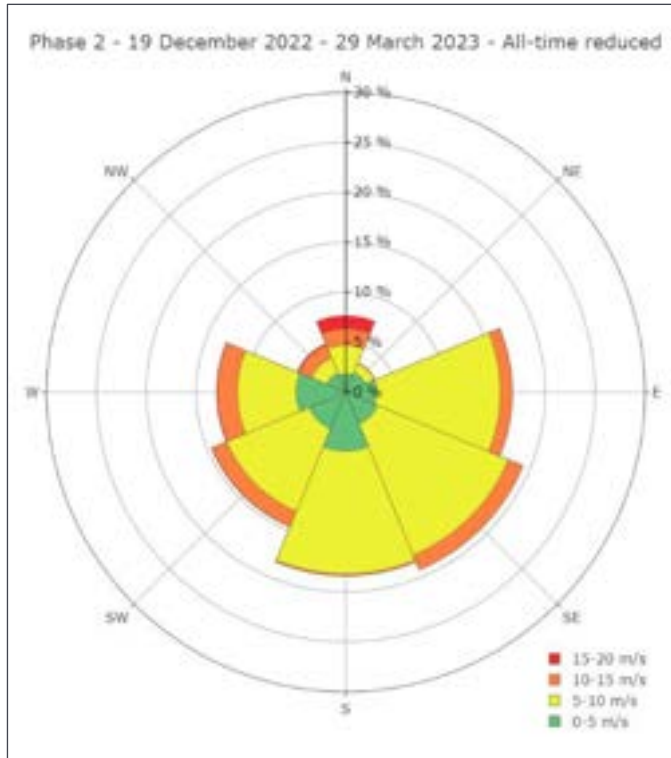
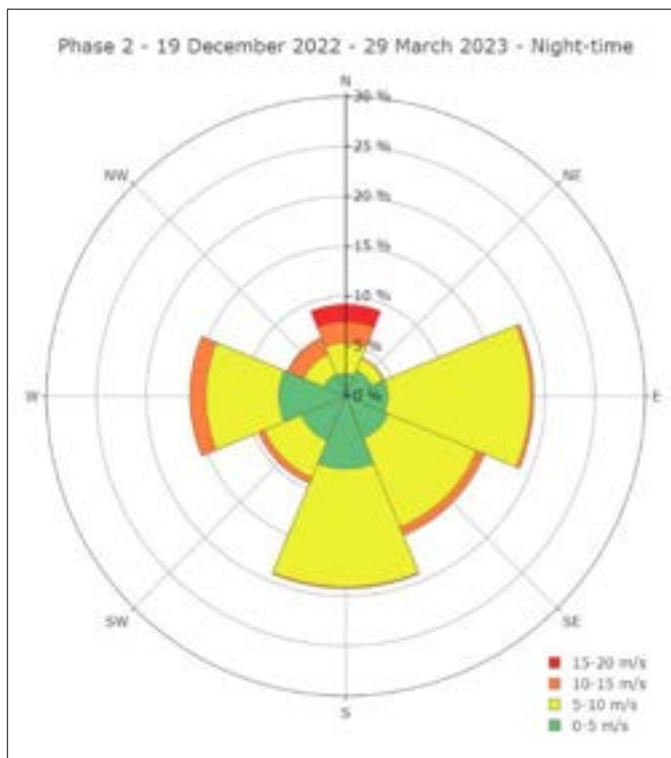


Figure 15: Round 2 phase 2 monitoring period wind rose – night-time



APPENDIX I SUMMARY OF POST CONSTRUCTION NOISE LEVELS

Table 37: Regression equation coefficients – all-time (reduced)

Location	Regression equation coefficients for background noise equation of best fit $L_{A90} = a x^3 + b x^2 + c x + d$, where x = windspeed in m/s					Valid wind speed range, m/s
	a	b	c	d	R ²	
9	-0.08118	1.94055	-12.32755	50.87653	0.48	5 – 12
18	-0.0718	1.8191	-11.88676	48.27781	0.34	4 – 12
27	-0.00163	0.14561	-2.38631	43.84001	0.10	7 – 13
55 (S)	-0.03074	0.77261	-5.07444	42.31272	0.44	4 – 12
63	-0.06911	1.66899	-10.59728	49.87486	0.30	4 – 12
69	-0.00647	0.25131	-1.72811	37.1664	0.33	4 – 13
70	-0.03299	0.88366	-5.99177	42.26524	0.33	4 – 13
79	-0.07779	1.8461	-11.42517	47.28448	0.40	4 – 12
80	-0.07674	1.77866	-10.70119	46.07908	0.36	4 – 11
83	-0.08108	2.06182	-13.90583	55.80522	0.42	5 – 12
103	-0.07395	1.90935	-13.4147	56.48725	0.39	5 – 12
108	-0.01933	0.60602	-4.39122	41.49669	0.39	4 – 13

APPENDIX J RECEIVER 9

J1 Receiver 9 location data

Table 38: Receiver 9 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	724103	5799811
Noise monitoring location	724086	5799802

Figure 16: Receiver 9 aerial view – dwelling and noise monitor locations

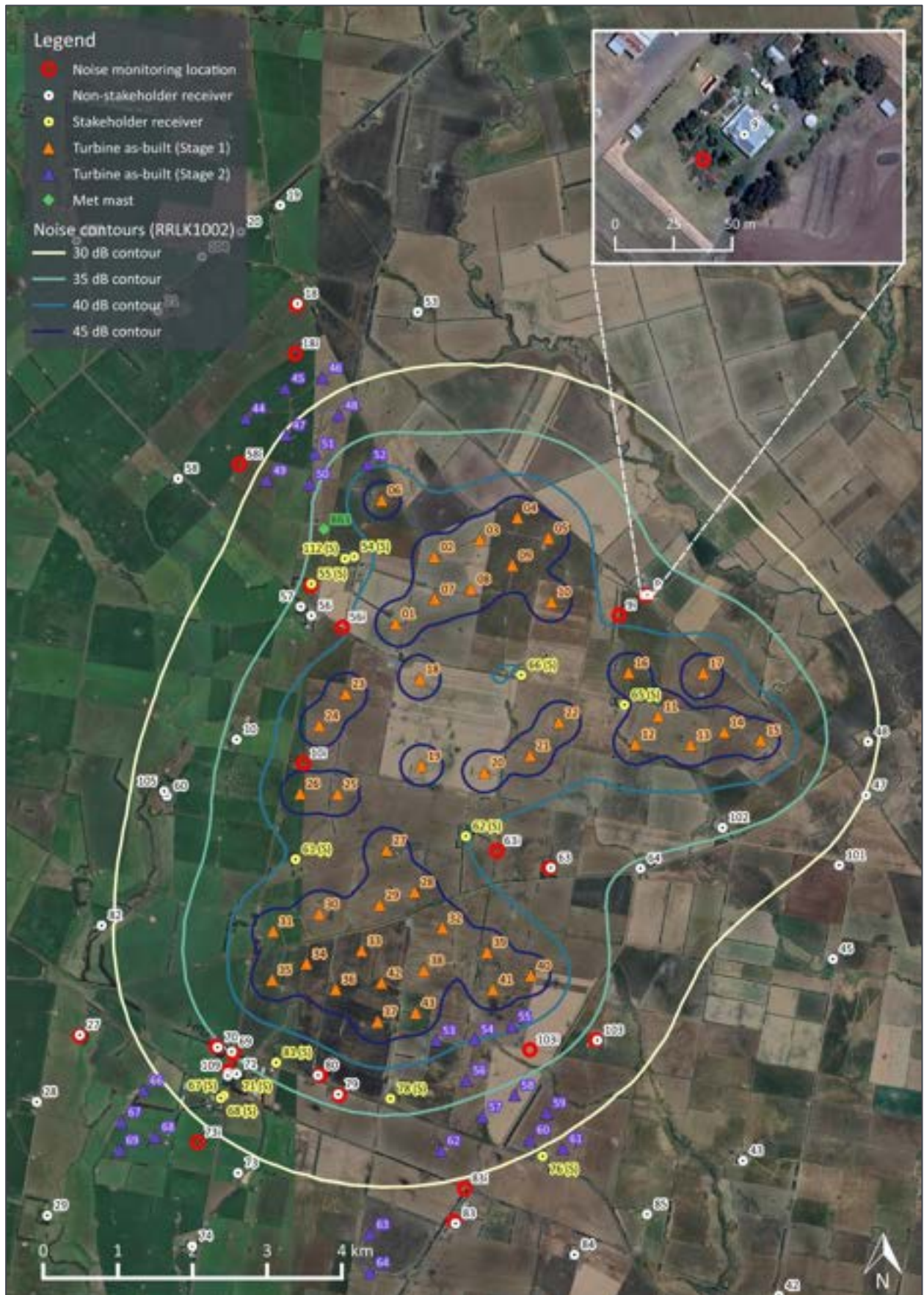
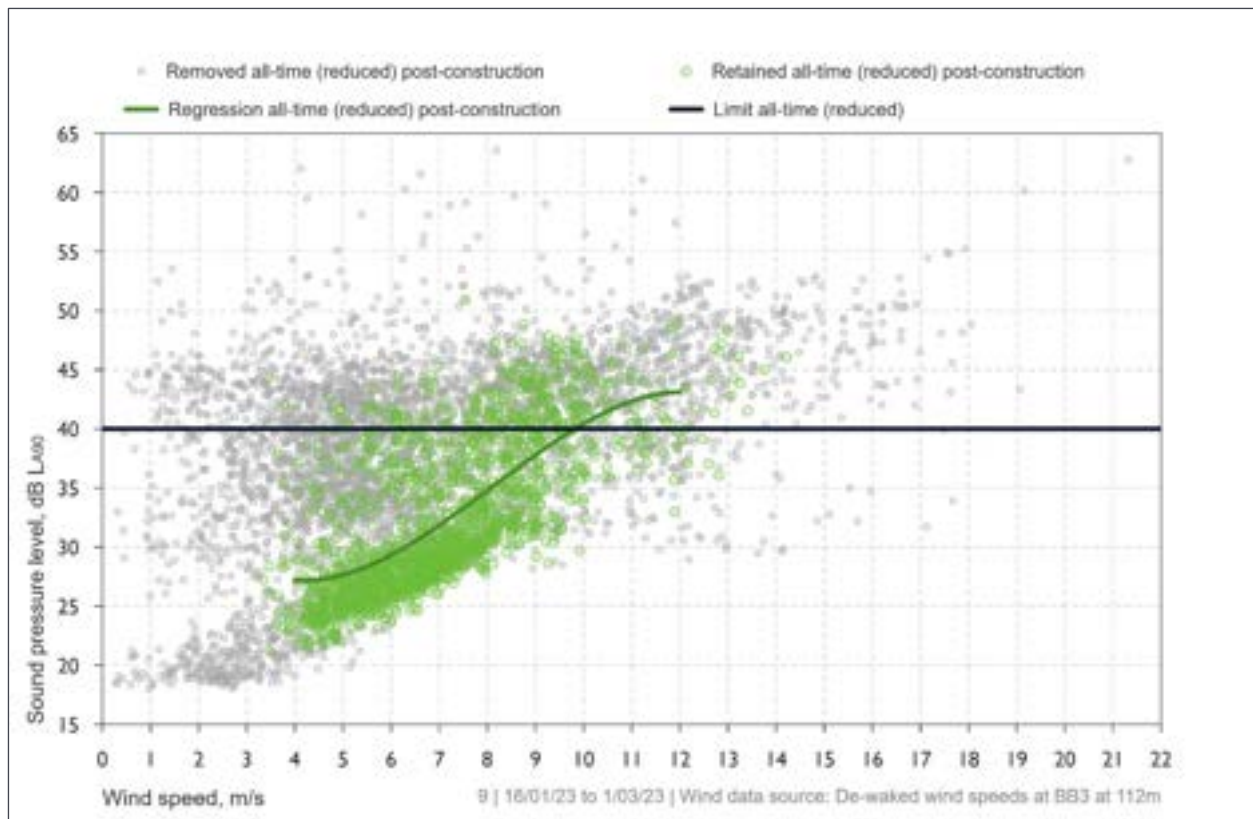


Figure 17: Receiver 9 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

J2 Receiver 9 post-construction measurement data – all wind speeds

Figure 18: Receiver 9 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



J3 Receiver 9 post-construction measurement data summary – assessment wind speeds

Table 39: Receiver 9 assessment data summary – number of data points

Data description	All-time (reduced)
Collected	5703
Removed	4099
Retained	1604

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 40.

Table 40: Receiver 9 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	2358
Rainfall	437
Extraneous noise	960
Wind farm operations curtailed	2902
Wind speeds outside assessment range	674

Figure 19: Receiver 9 – post-construction noise levels and wind speed time history

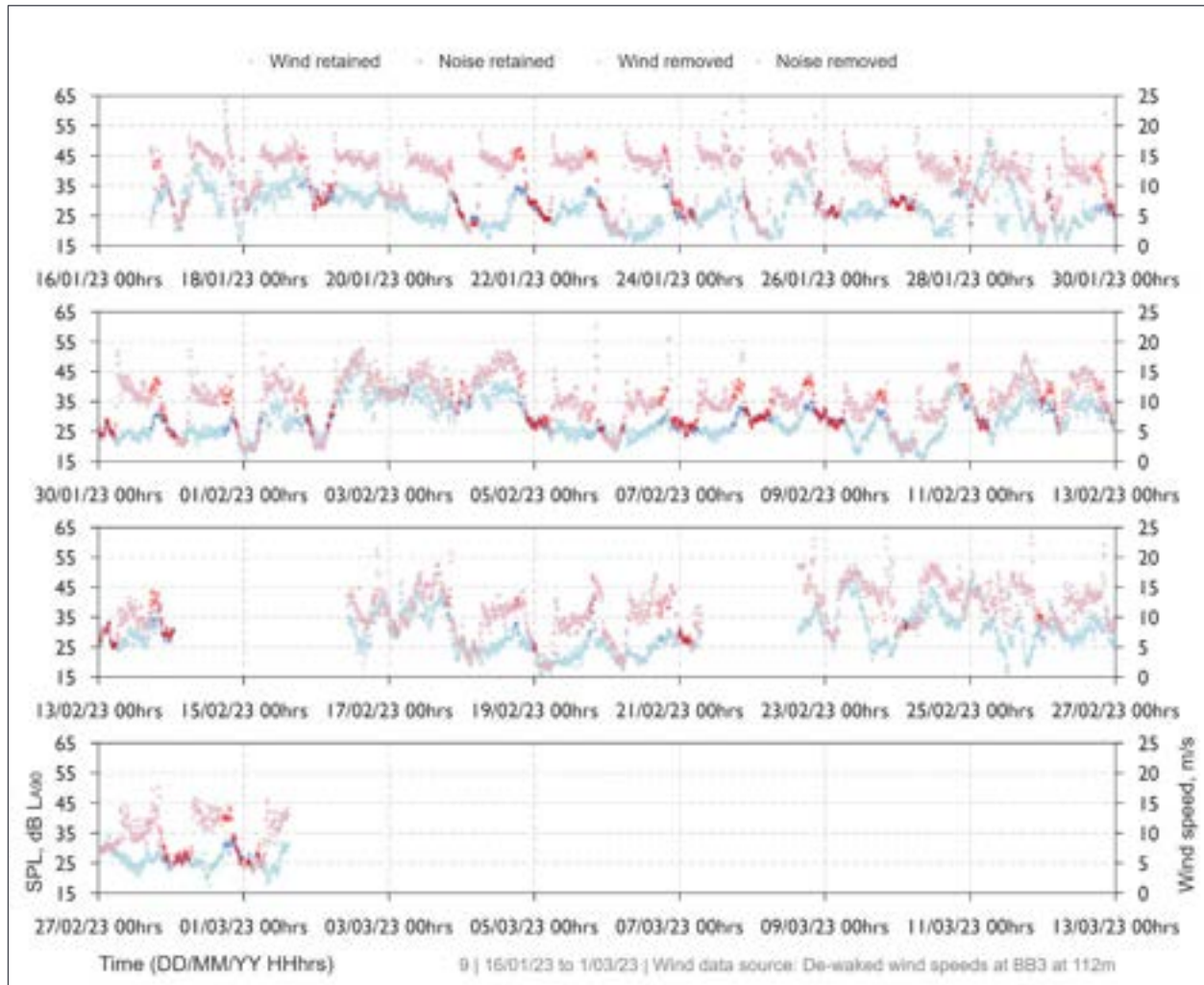


Figure 20: Receiver 9 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

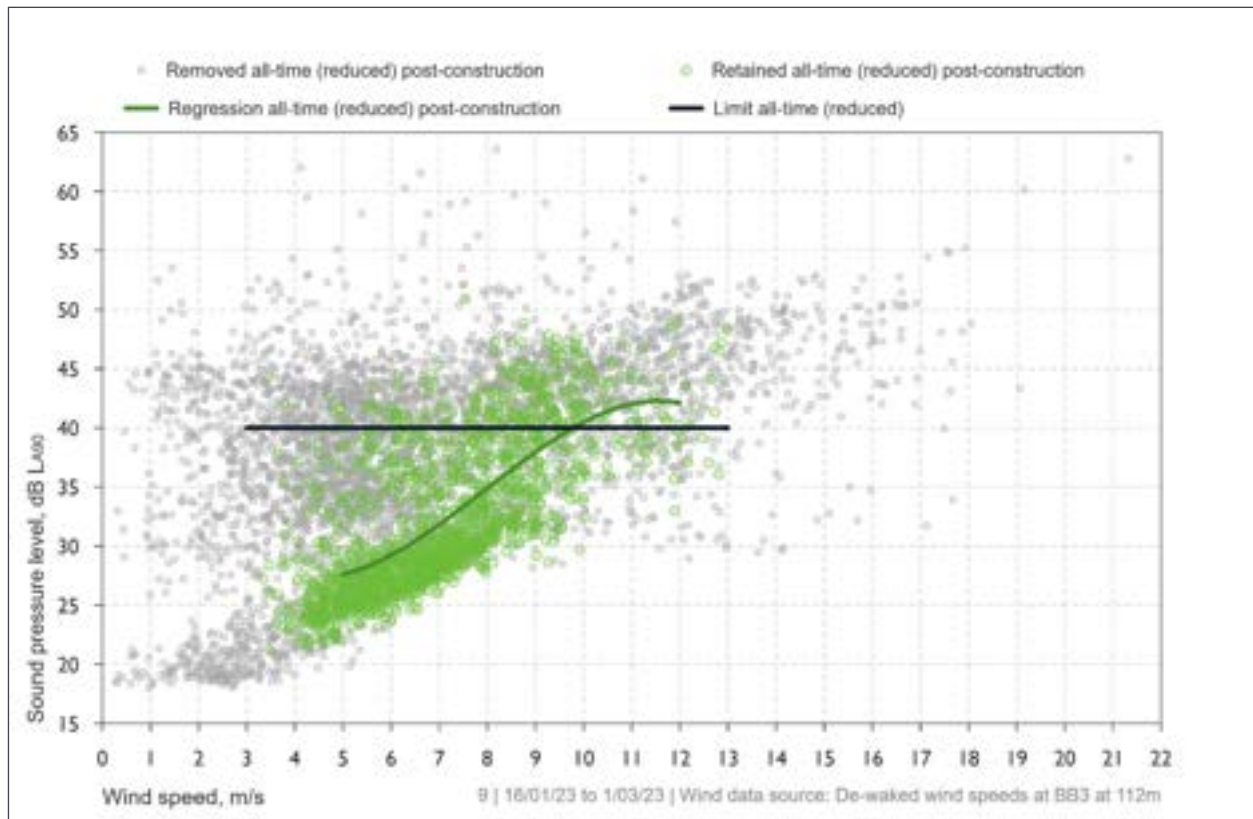
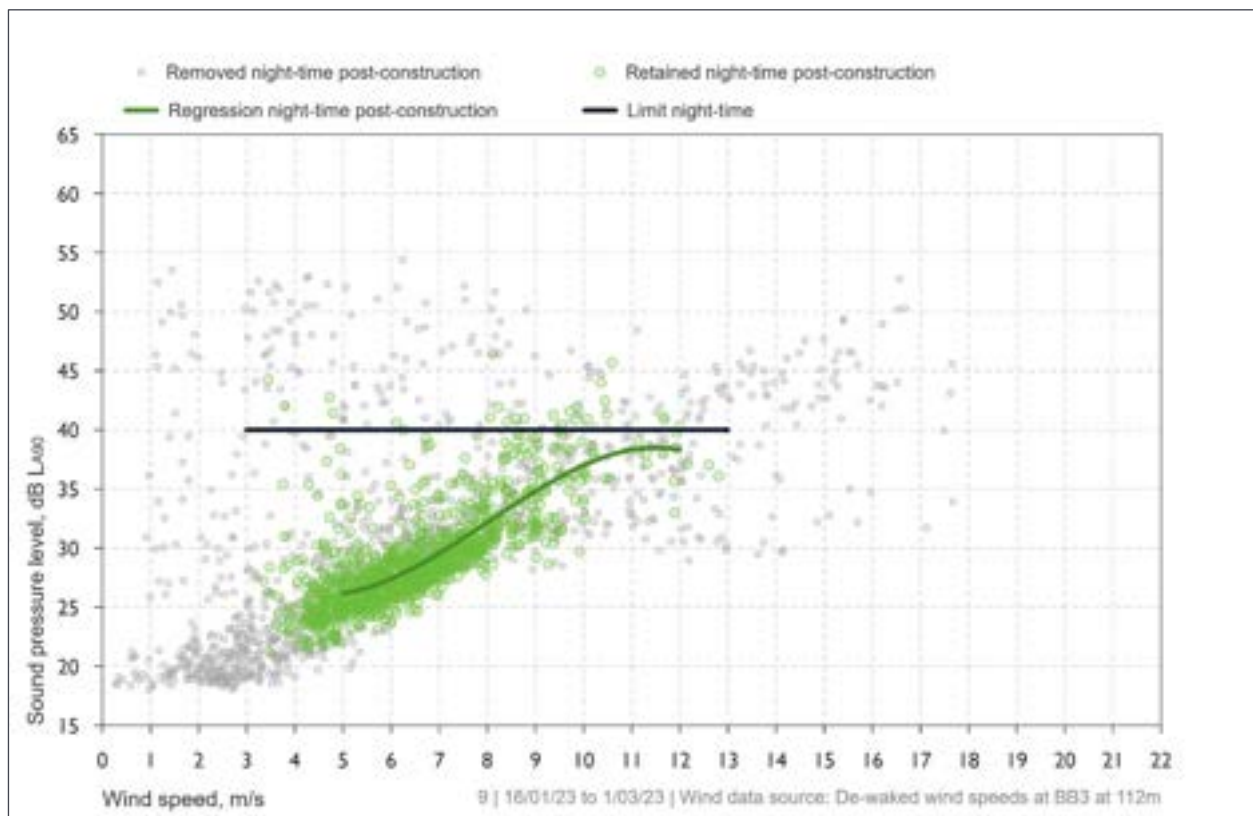


Figure 21: Receiver 9 – post-construction noise levels and minimum noise limits versus site wind speed – night-time



J4 Receiver 9 supplementary analysis

The night-period measurement data presented in Figure 21 indicates that the regression line of the total A-weighted noise level is below 40 dB L_{A90} for the relevant range of wind speeds. While the noise level attributable to the operation of the wind farm cannot be estimated from this data, the results are sufficient to conclude that the contribution of the wind farm at receiver 9 was below the base (minimum) noise limit of 40 dB L_{A90} during the night period.

The results for the all-time period indicate significant background noise influence during the day. This is also evident from the time-history in Figure 19 which indicates a clear pattern of diurnal variation in noise levels which is not related to the operation of the wind farm. However, data for the night period is also sufficient to conclude that the noise level of the wind farm during the all-time period was also below the 40 dB L_{A90} base noise limit, on account of the wind farm noise contribution during the all-time and night-time periods being similar for the following reasons:

- The wind direction trends for the all-time and night periods of the survey were equivalent for noise assessment purposes (i.e. the differences between the direction trends of the all-time (reduced) and night period were not sufficient to cause material changes in wind farm noise levels between the periods)
- The assessment is referenced to hub height wind speeds, meaning that variations in wind shear between the day and night period do not translate to material changes in wind farm noise levels for a given wind speed (i.e. for an assessment referenced to hub height wind speeds, changes in wind shear will mainly cause a change in the wind speed occurring around the dwelling and, in turn, the background noise associated with wind disturbance of vegetation).

Notwithstanding the above, in accordance with the NCTP, supplementary analysis procedures as specified in the NCTP were used to investigate the wind farm's contribution to the total measured noise levels. The relevant supplementary procedures and observations are summarised in Table 41.

Table 41: Receiver 9 – supplementary analysis summary

Procedure	Findings
Comparison of data trends for upwind and downwind conditions	See Figure 22 and Figure 23 for the comparisons for all-time (reduced) and night-time respectively. No indication of a distinct difference between the noise levels measured under downwind and upwind conditions.
Noise level versus wind speed profile review	See Figure 24. The profile indicates a greater rate of increase in noise levels above 9 m/s than occurs at locations nearer to the wind farm. This indicates background noise influences rather than wind farm noise at high wind speeds.
Data filtering using intermediate measurement data	See Figure 25 and Figure 26 for data subject to additional filtering for the all-time (reduced) and night-time respectively. This additional filter removes a data point if the measured noise level at the receiver was higher than at the intermediate location positioned nearer to the wind farm. The figures demonstrate a significant number of points are removed by this filter, and the retained data points for the all-time (reduced) period are: • below the 40 dB L_{A90} minimum noise limit; and • consistent with the predicted noise levels for this location.
Extrapolation of intermediate data	See Table 45 in Appendix J6. The extrapolation indicates estimated tonality adjusted wind farm noise levels below 40 dB L_{A90}

Figure 22: Receiver 9 – upwind and downwind post-construction noise levels and noise limits versus site wind speed – all-time (reduced) period

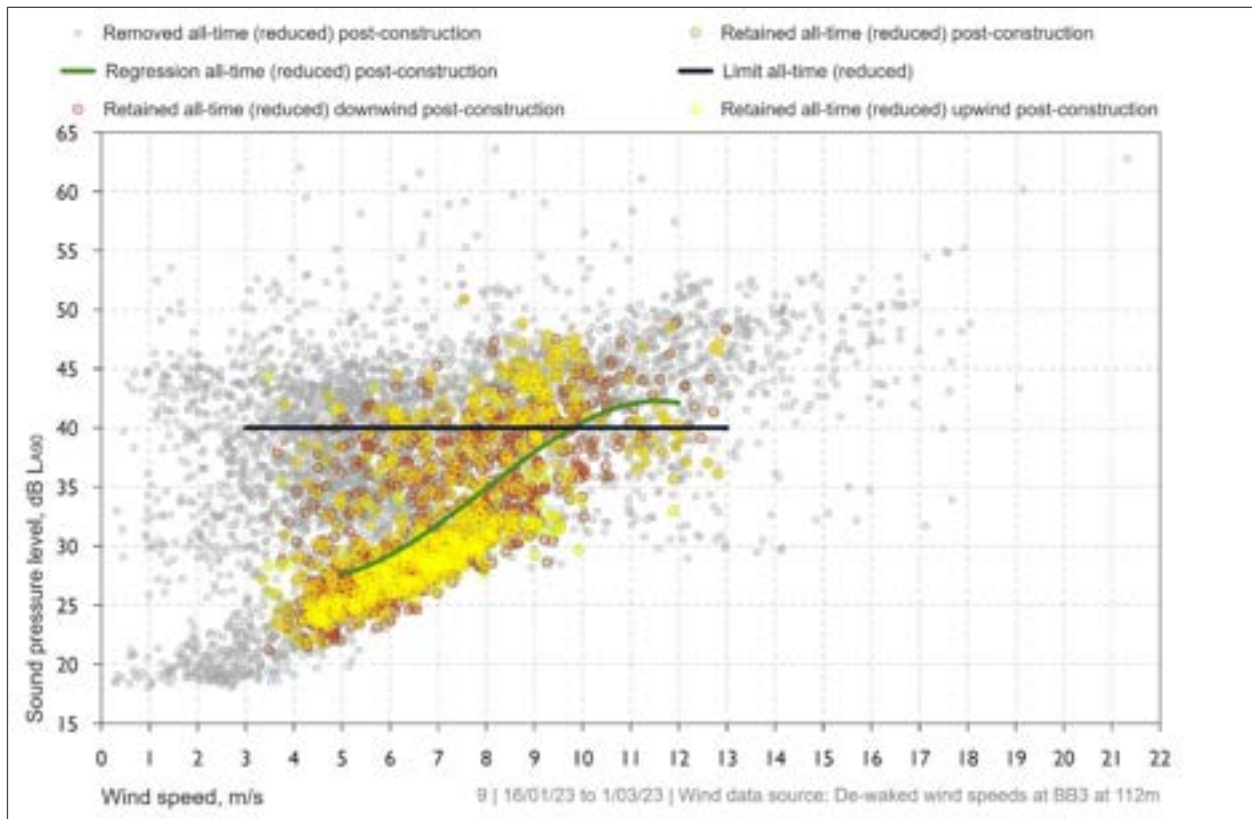


Figure 23: Receiver 9 – upwind and downwind post-construction noise levels and noise limits versus site wind speed – night-time

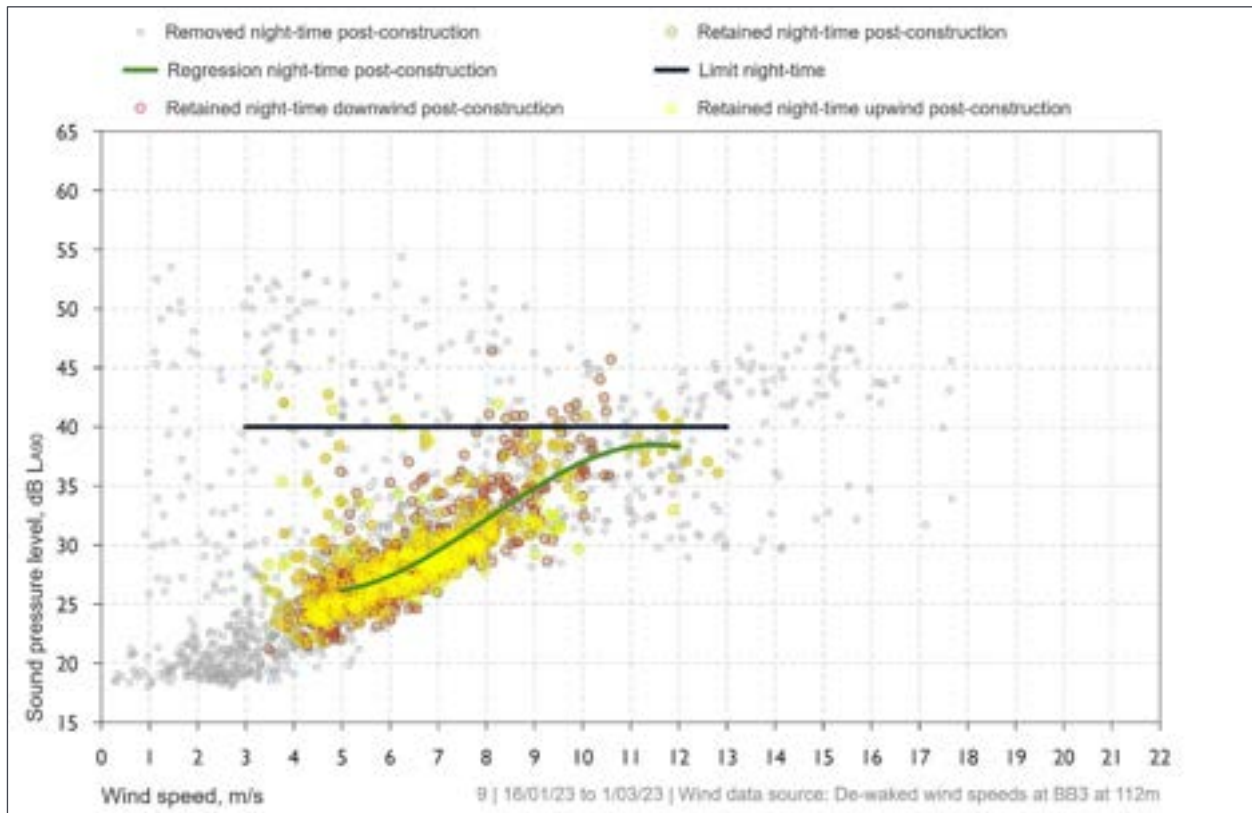


Figure 24: Receiver 9 and intermediate locations comparison - change in noise level with wind speed – all-time (reduced)

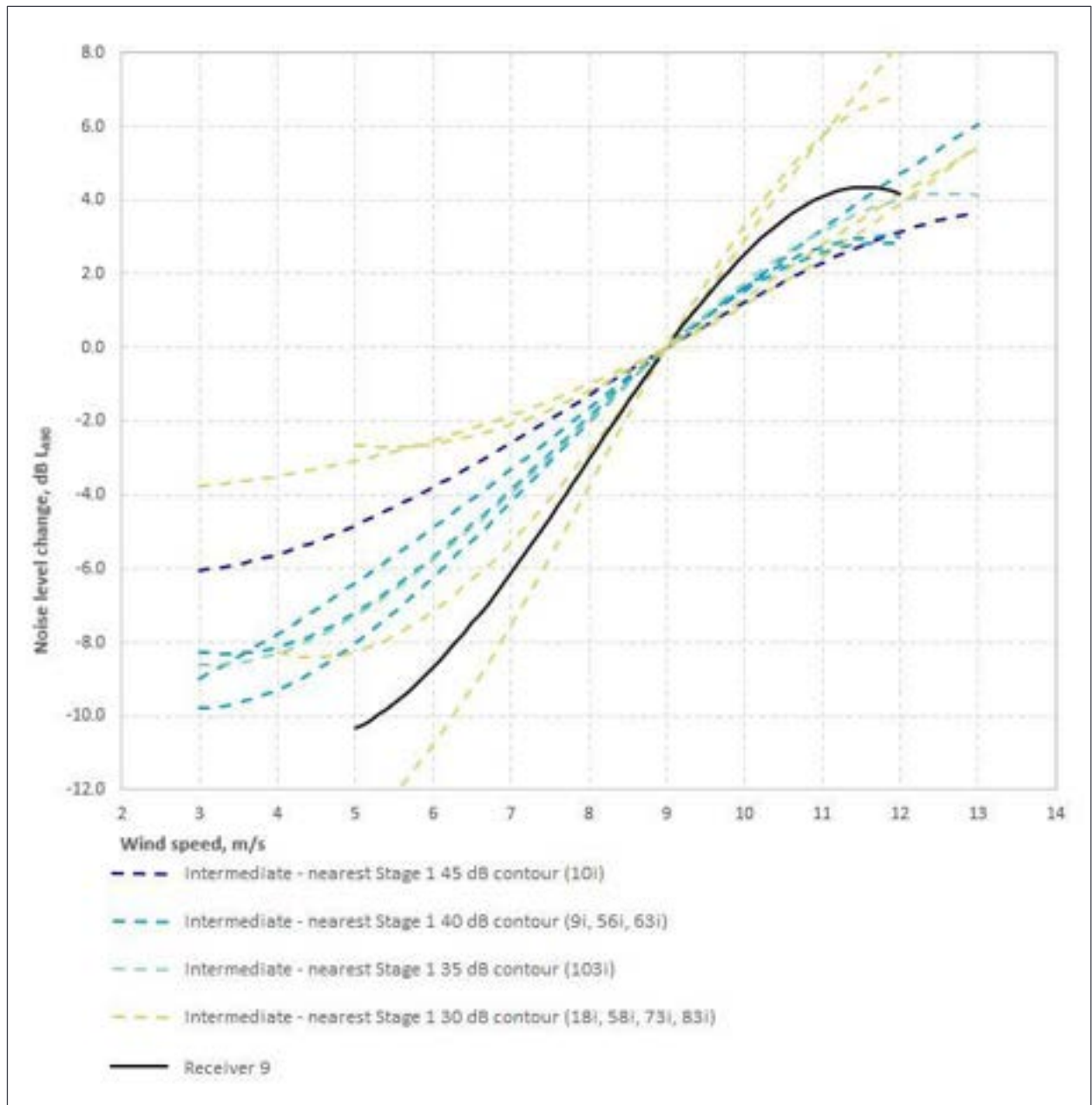


Figure 25: Receiver 9 using intermediate 9i as an additional filter – post-construction noise levels and noise limits versus site wind speed – all-time (reduced)

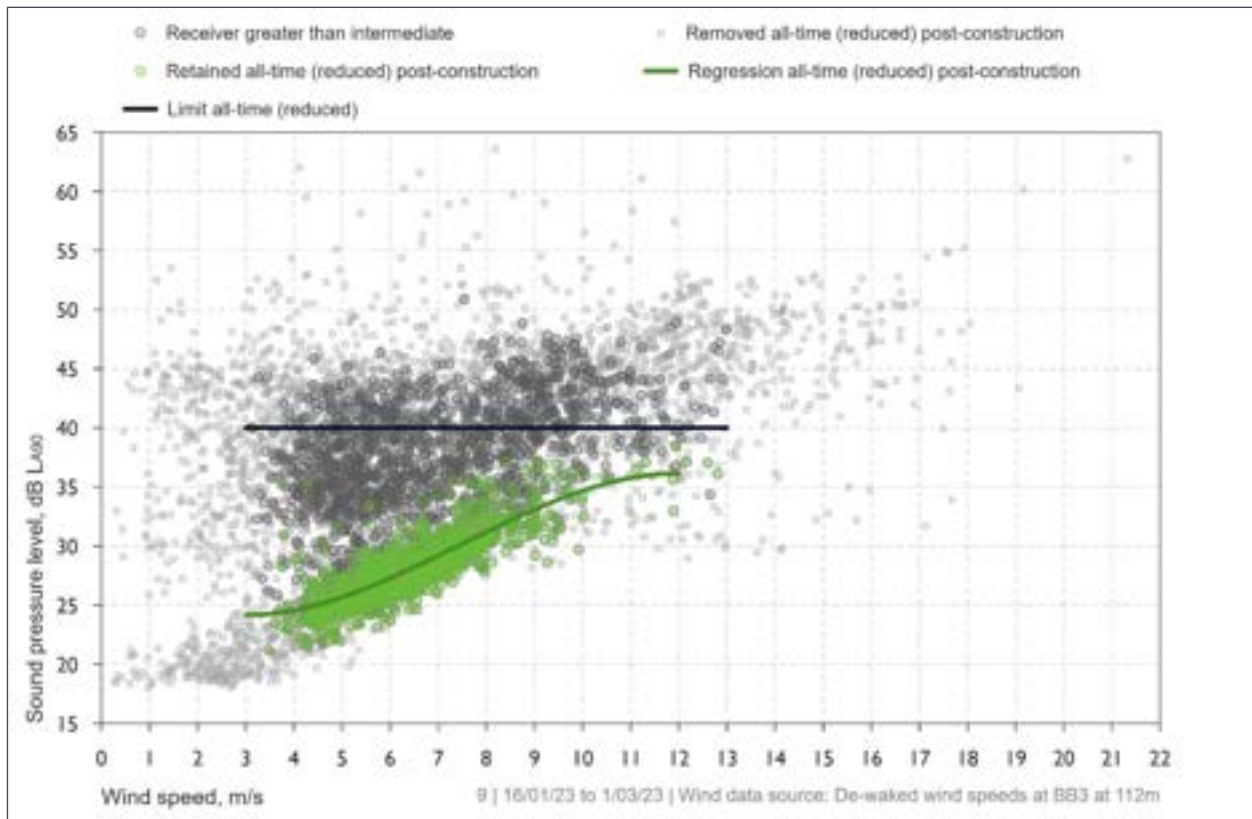
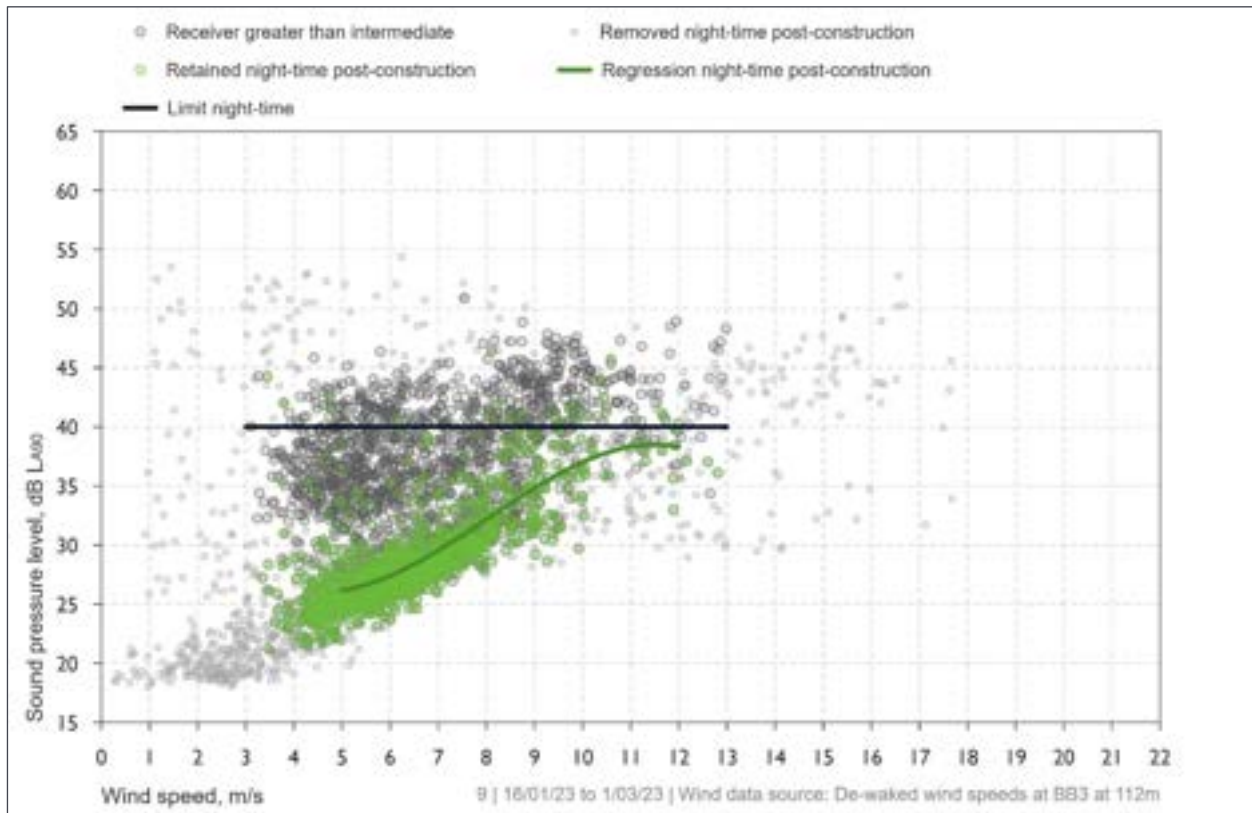


Figure 26: Receiver 9 using intermediate 9i as an additional filter – post-construction noise levels and noise limits versus site wind speed – night-time



J5 Receiver 9 tonality assessment

Figure 27: Receiver 9 tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

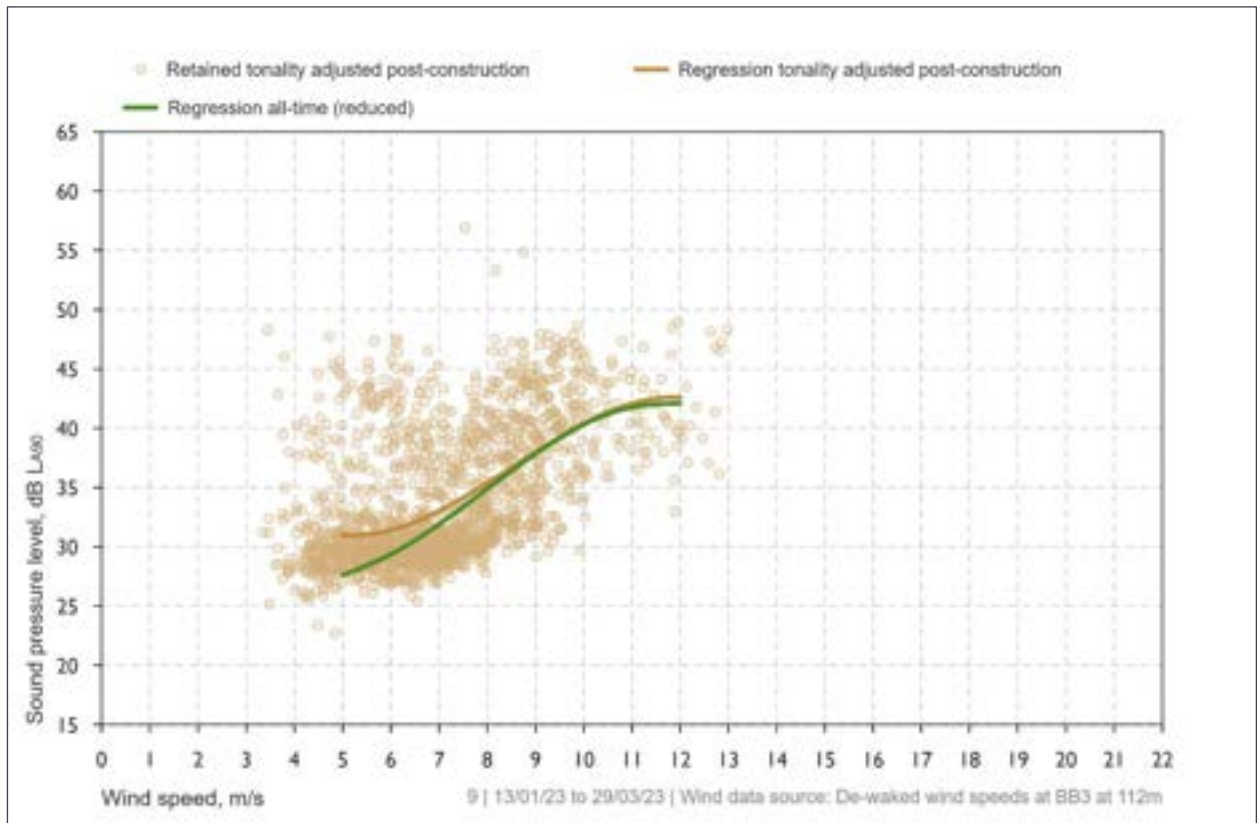


Table 42: Receiver 9 tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	- ^[1]	31.0	31.4	33.0	35.4	38.0	40.4	42.1	42.6	- ^[1]
Post-construction regression - no penalties	- ^[1]	- ^[1]	27.6	29.2	31.8	34.9	37.9	40.5	42.0	42.1	- ^[1]
Penalty adjustment	- ^[1]	- ^[1]	3.4	2.2	1.2	0.5	0.1	0.0	0.1	0.5	- ^[1]

1 Outside valid wind speed range of the regression analysis

J6 Receiver 9 compliance assessment

Table 43: Receiver 9 compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- [1]	- [1]	27.6	29.2	31.8	34.9	37.9	40.5	42.0	42.1	- [1]
Background noise level	- [1]	- [1]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [1]
Background adjustment	- [1]	- [1]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [1]
Tonality adjustment	- [1]	- [1]	3.4	2.2	1.2	0.5	0.1	0.0	0.1	0.5	- [1]
Estimated tonality adjusted wind farm noise level ^[3]	- [1]	- [1]	< 31.0	< 31.4	< 33.0	< 35.4	< 38.0	< 40.5	< 42.1	< 42.6	- [1]
Noise limit	- [1]	- [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- [1]
Compliance margin	- [1]	- [1]	-9.0	-8.6	-7.0	-4.6	-2.0	0.5 ^[4]	2.1 ^[4]	2.6 ^[4]	- [1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location - the background adjustment is therefore not available for this location

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB L_{A90} minimum limit

Table 44: Receiver 9 compliance assessment, dB L_{A90} – night-time

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- [1]	- [1]	26.2	27.4	29.5	32.2	34.8	37.0	38.3	38.3	- [1]
Background noise level	- [1]	- [1]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [1]
Background adjustment	- [1]	- [1]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [1]
Tonality adjustment	- [1]	- [1]	3.4	2.2	1.2	0.5	0.1	0.0	0.1	0.5	- [1]
Estimated tonality adjusted wind farm noise level ^[3]	- [1]	- [1]	< 29.6	< 29.6	< 30.7	< 32.7	< 34.9	< 37.0	< 38.4	< 38.8	- [1]
Noise limit	- [1]	- [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- [1]
Compliance margin	- [1]	- [1]	-10.4	-10.4	-9.3	-7.3	-5.1	-3.0	-1.6	-1.2	- [1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location - the background adjustment is therefore not available for this location

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

Table 45: Receiver 9 compliance assessment based on extrapolation of intermediate 9i, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 9i	26.6	26.8	27.7	29.2	31.0	33.0	34.9	36.4	37.4	37.7	- ^[1]
Background noise level intermediate 9i	21.2	21.8	22.4	23.1	23.8	24.5	25.2	26.0	26.9	27.9	- ^[1]
Background adjustment intermediate 9i	-1.5	-1.7	-1.5	-1.2	-0.9	-0.7	-0.5	-0.4	-0.4	-0.5	- ^[1]
Extrapolation correction	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	- ^[1]
Tonality adjustment receiver 9	- ^[1]	- ^[1]	3.4	2.2	1.2	0.5	0.1	0.0	0.1	0.5	- ^[1]
Estimated tonality adjusted wind farm noise level receiver 9	- ^[1]	- ^[1]	28.6	29.2	30.3	31.8	33.5	35.0	36.1	36.7	- ^[1]
Noise limit receiver 9 ^[2]	- ^[1]	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]
Compliance margin	- ^[1]	- ^[1]	-11.4	-10.8	-9.7	-8.2	-6.5	-5.0	-3.9	-3.3	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

APPENDIX K RECEIVER 18

K1 Receiver 18 location data

Table 46: Receiver 18 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	719416	5803707
Noise monitoring location	719409	5803690

Figure 28: Receiver 18 aerial view – dwelling and noise monitor locations

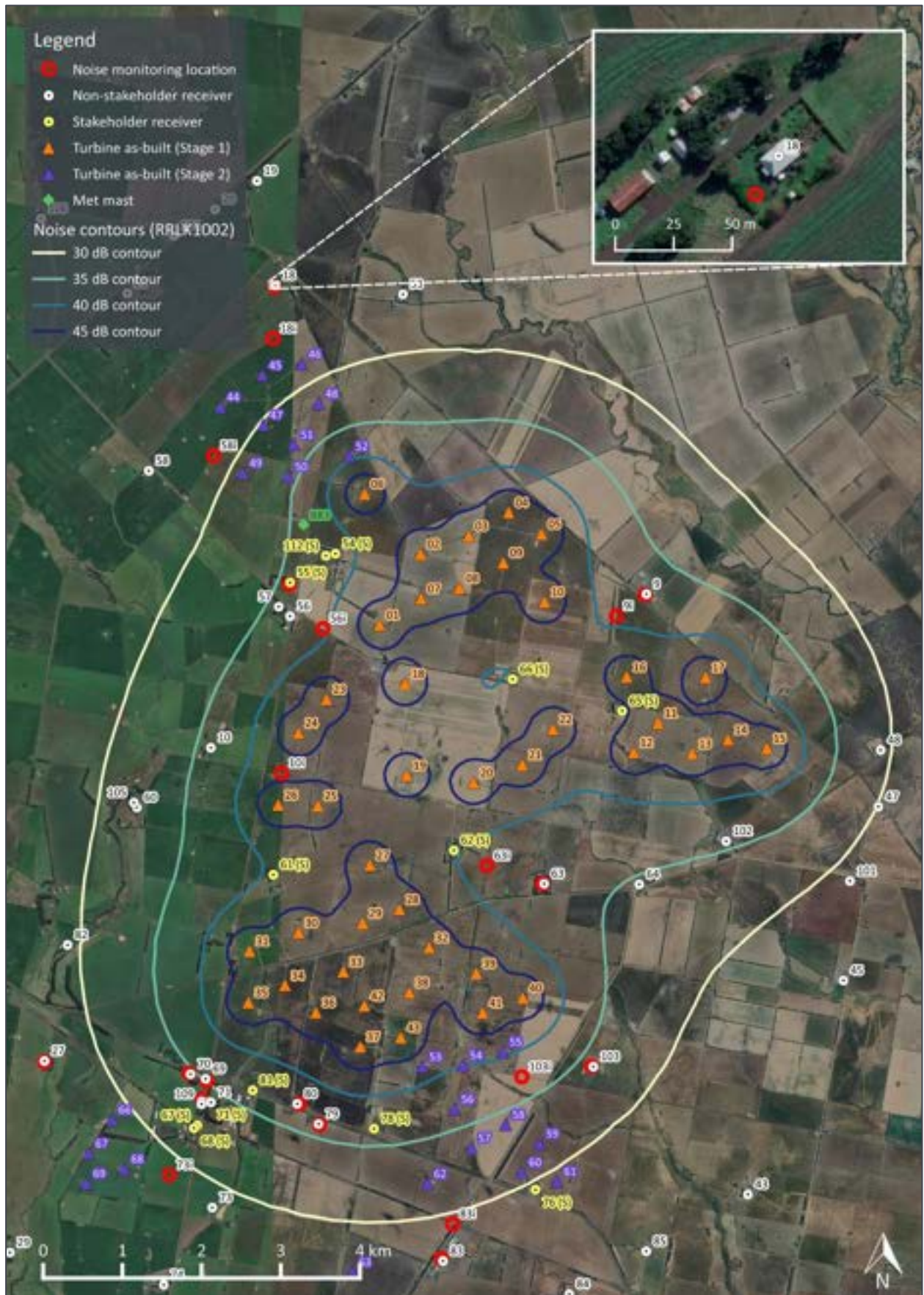
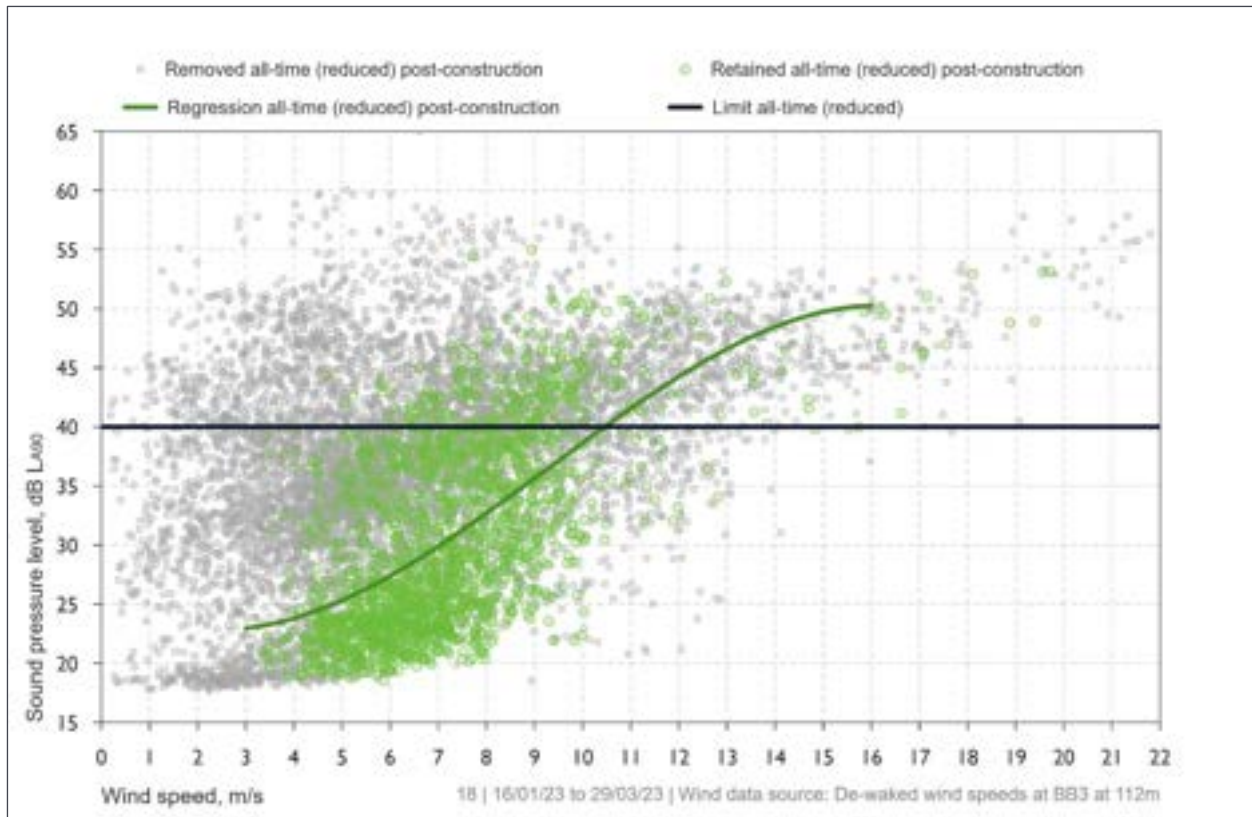


Table 47: Receiver 18 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

K2 Receiver 18 post-construction measurement data – all wind speeds

Figure 29: Receiver 18 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



K3 Receiver 18 post-construction measurement data summary – assessment wind speeds

Table 48: Receiver 18 assessment data summary – number of data points

Data points	All-time (reduced)
Collected	9158
Removed	7304
Retained	1854

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 49.

Table 49: Receiver 18 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3851
Rainfall	366
Extraneous noise	2642
Wind farm operations curtailed	5050
Wind speeds outside assessment range	1232

Figure 30: Receiver 18 – post-construction noise levels and wind speed time history

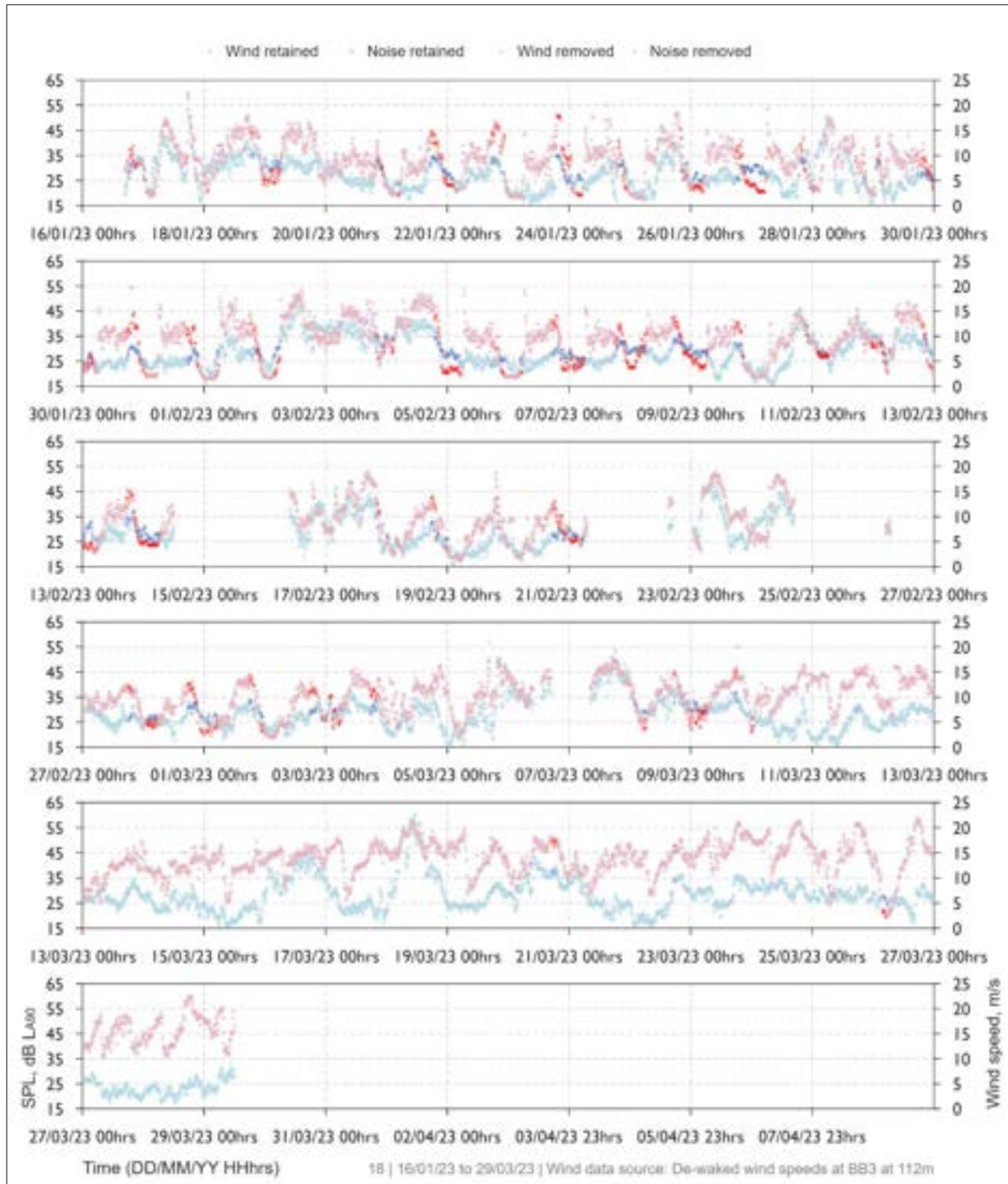


Figure 31: Receiver 18 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

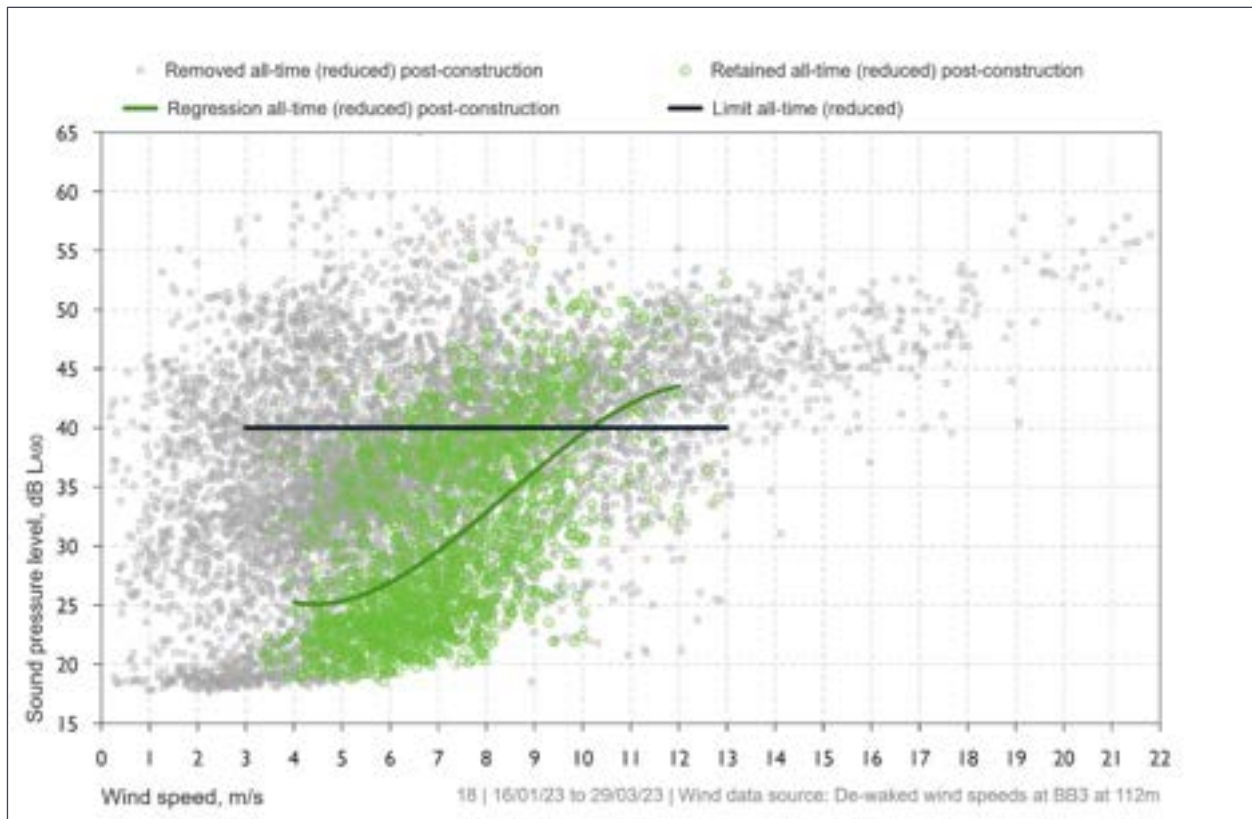
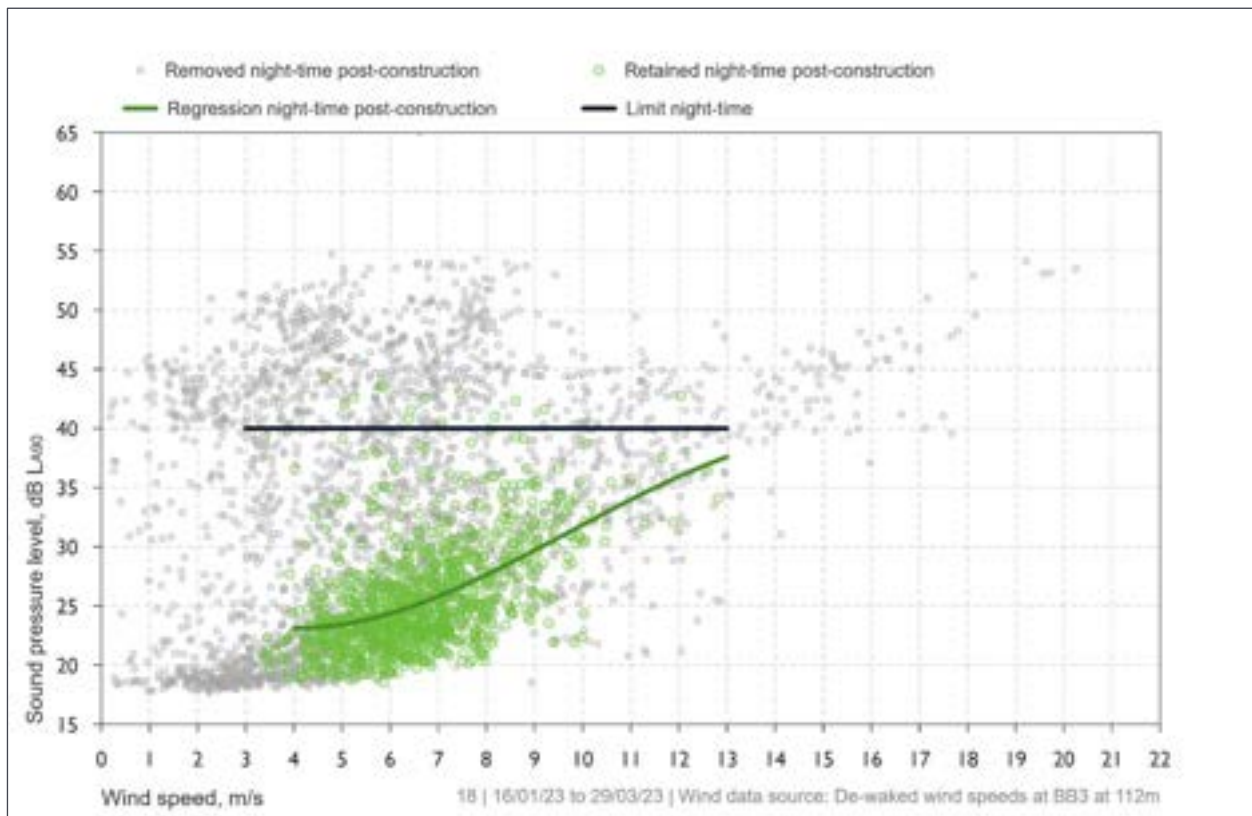


Figure 32: Receiver 18 – post-construction noise levels and minimum noise limits versus site wind speed – night-time



K4 Receiver 18 supplementary analysis

The night period measurement data presented in Figure 32 indicates that the regression line of the total A-weighted noise level is below 40 dB L_{A90} for the assessment wind speed range. While the noise level attributable to the operation of the wind farm cannot be estimated from this data, the results are sufficient to conclude that the contribution of the wind farm at receiver 18 was below the base (minimum) noise limit of 40 dB L_{A90} during the night period.

The results for the all-time period indicate significant background noise influence during the day. This is also evident from the time-history in Figure 30 which indicates a clear pattern of diurnal variation in noise levels which is not related to the operation of the wind farm. However, the data for the night period is sufficient to conclude that the noise levels of the wind farm during the all-time (reduced) period were also below the 40 dB L_{A90} base noise limit. This is because the wind farm noise contribution during the all-time and night-time periods would be similar for the following reasons:

- The wind direction trends for the all-time and night periods of the survey were equivalent for noise assessment purposes (i.e. the differences between the wind direction trends of the all-time (reduced) and night-time were not sufficient to cause material changes in wind farm noise levels between the periods)
- The assessment is referenced to hub height wind speeds, meaning that variations in wind shear between the day and night period do not translate to material changes in wind turbine noise levels for a given wind speed (i.e. for an assessment referenced to hub height wind speeds, changes in wind shear will mainly cause a change in the wind speed occurring around the dwelling and, in turn, the background noise associated with wind disturbance of vegetation).

Notwithstanding the above, in accordance with the NCTP, supplementary analysis procedures as specified in the NCTP were used to investigate the wind farm's contribution to the total measured noise levels. The relevant supplementary procedures and observations are summarised in Table 50.

Table 50: Receiver 18 – supplementary analysis summary

Procedure	Findings
Comparison of data trends for upwind and downwind conditions	See Figure 33 and Figure 34 for the comparisons for all-time (reduced) and night-time respectively. No indication of distinct difference between the noise levels measured under downwind and upwind conditions. The all-time (reduced) chart initially suggests higher points under downwind conditions. However, this location is subject to comparable elevated noise levels across the wind speed range. This indicates a source other than wind farm noise rather than a distinct downwind direction trend (noting this location was too far from Stage 1 turbine operations to enable a meaningful assessment of wind farm noise).
Noise level versus wind speed profile review	See Figure 35. The profile clearly indicates a greater rate of increase in noise levels above 9 m/s than occurs at locations nearer to the wind farm. This indicates background noise influences rather than wind farm noise at high wind speeds.
Data filtering using intermediate measurement data	See Figure 36 and Figure 37 for data subject to additional filtering for the all-time (reduced) and night-time respectively. This additional filter removes a data point if the measured noise level at the receiver was higher than at the intermediate location positioned nearer to the wind farm. Given that both the intermediate and receiver monitoring locations were remote from Stage 1 operations, the additional filtering does not provide any further insight into the potential noise levels related to the operation of the wind farm.

Procedure	Findings
Extrapolation of intermediate data	See Table 54 in Appendix K6. Intermediate location 18i was too far from Stage 1 turbine operations to provide any further insight about wind farm noise levels at receiver 18. However, the extrapolation indicates estimated tonality adjusted wind farm noise levels below 40 dB L_{A90} at wind speeds up to 10 m/s inclusive.

Figure 33: Receiver 18 – upwind and downwind post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

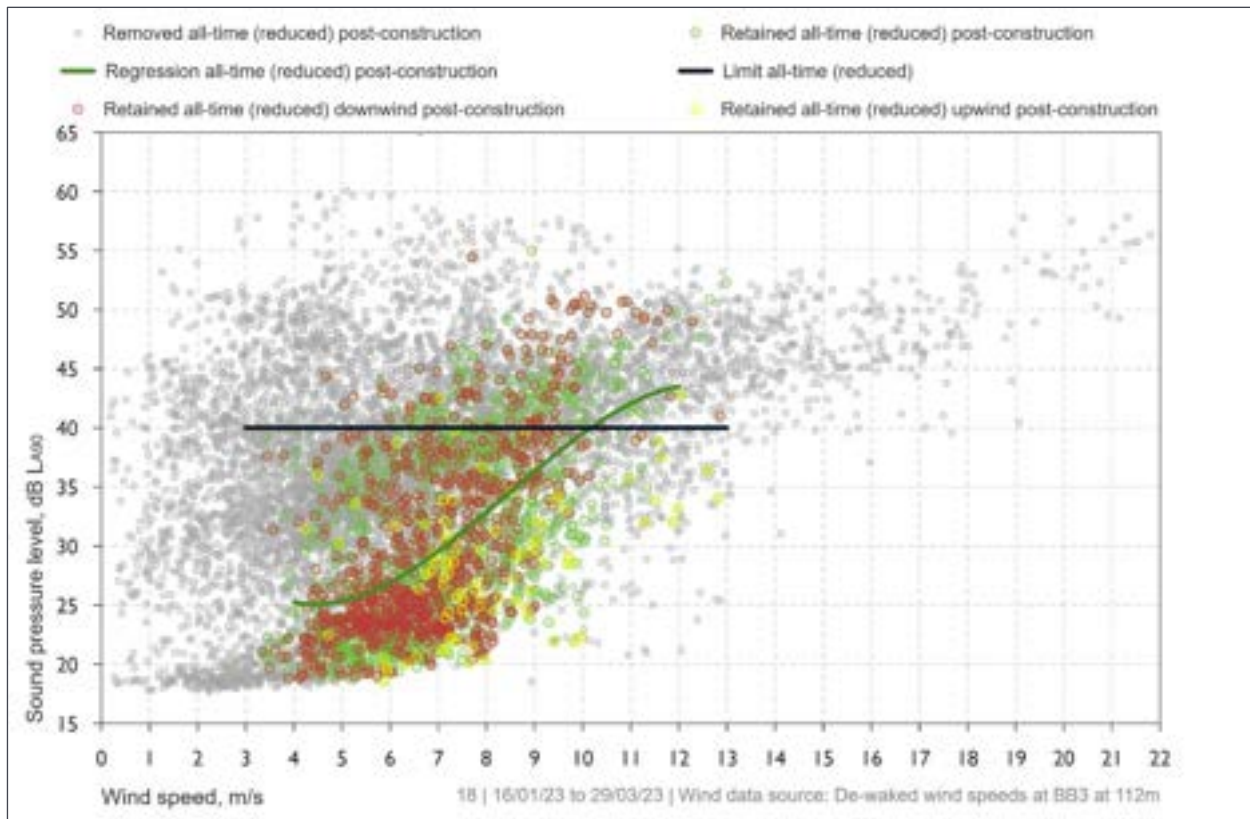


Figure 34: Receiver 18 – upwind and downwind post-construction noise levels and minimum noise limits versus site wind speed – night-time

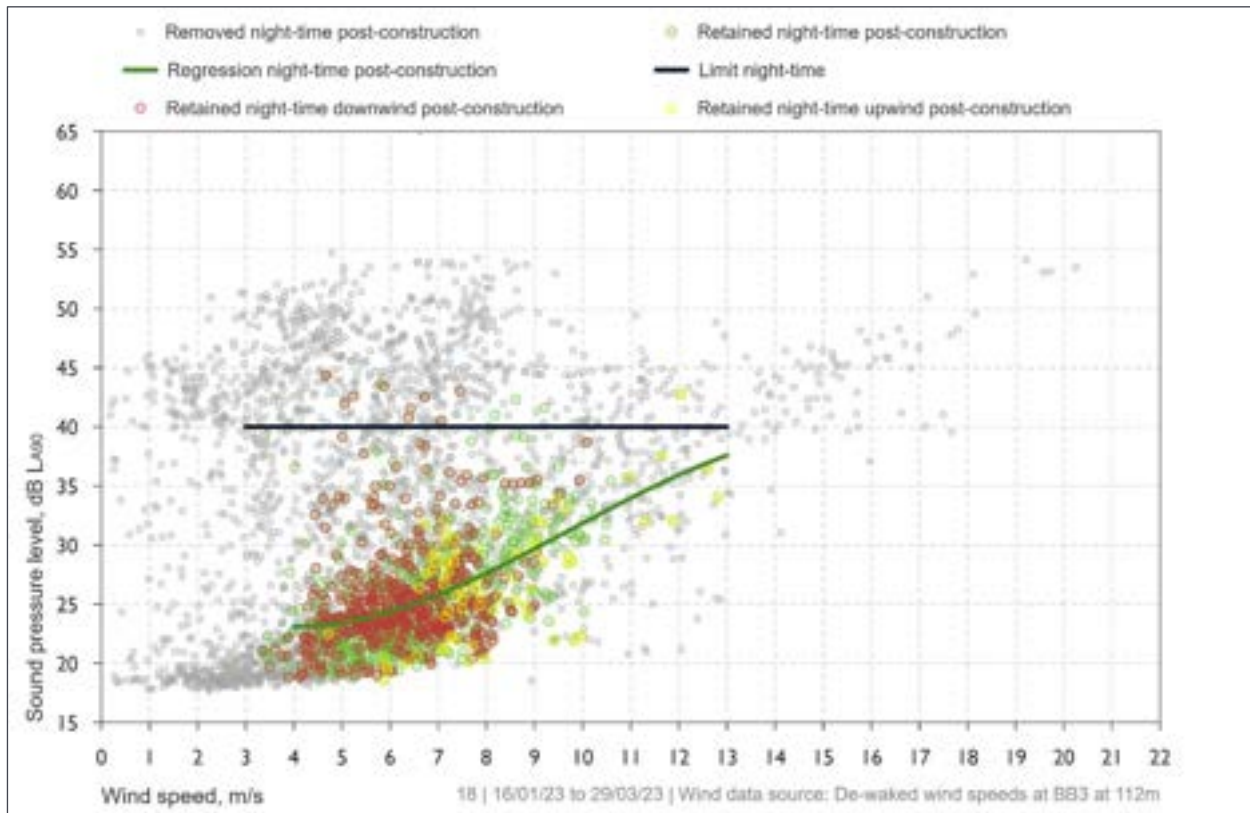


Figure 35: Receiver 18 and intermediate locations comparison - change in noise level with wind speed – all-time (reduced)

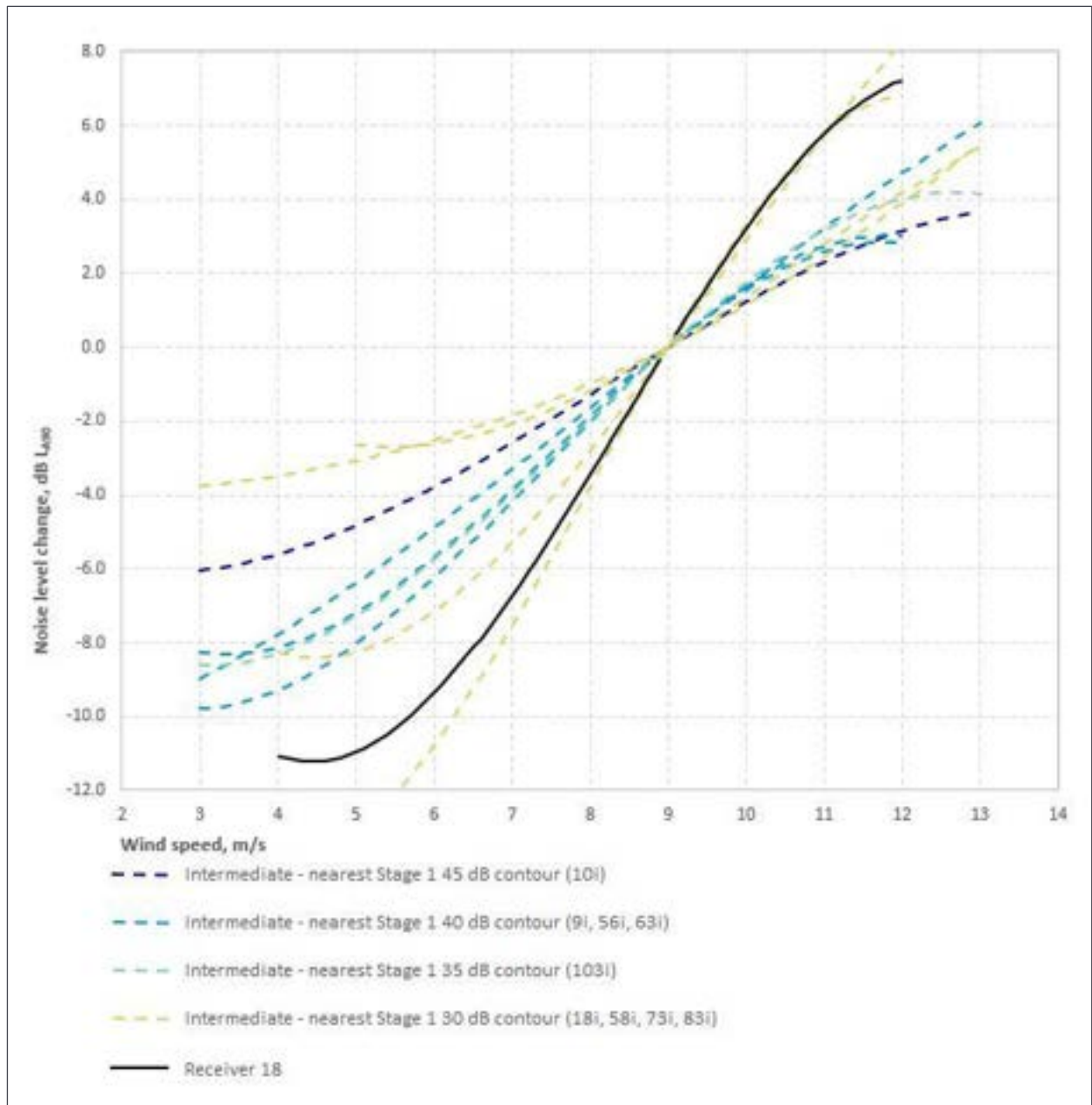


Figure 36: Receiver 18 using intermediate 18i as an additional filter – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

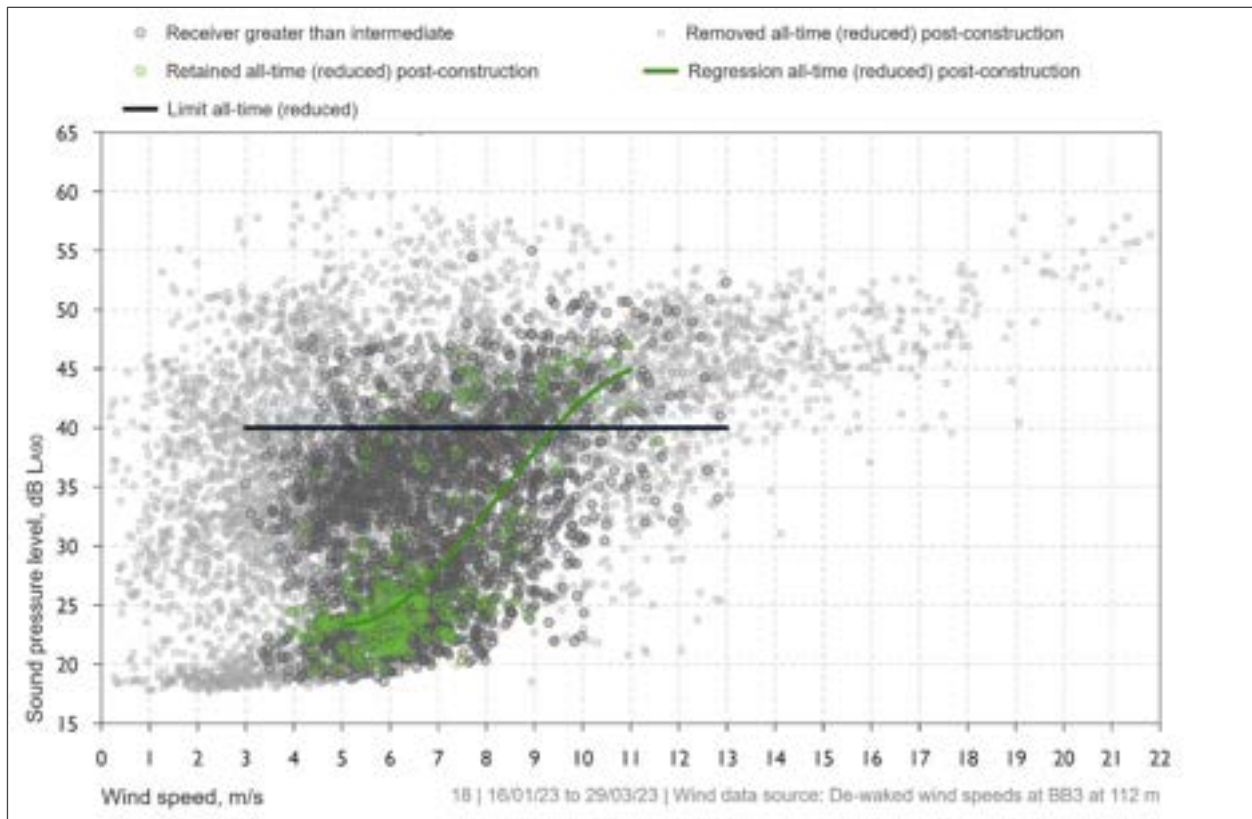
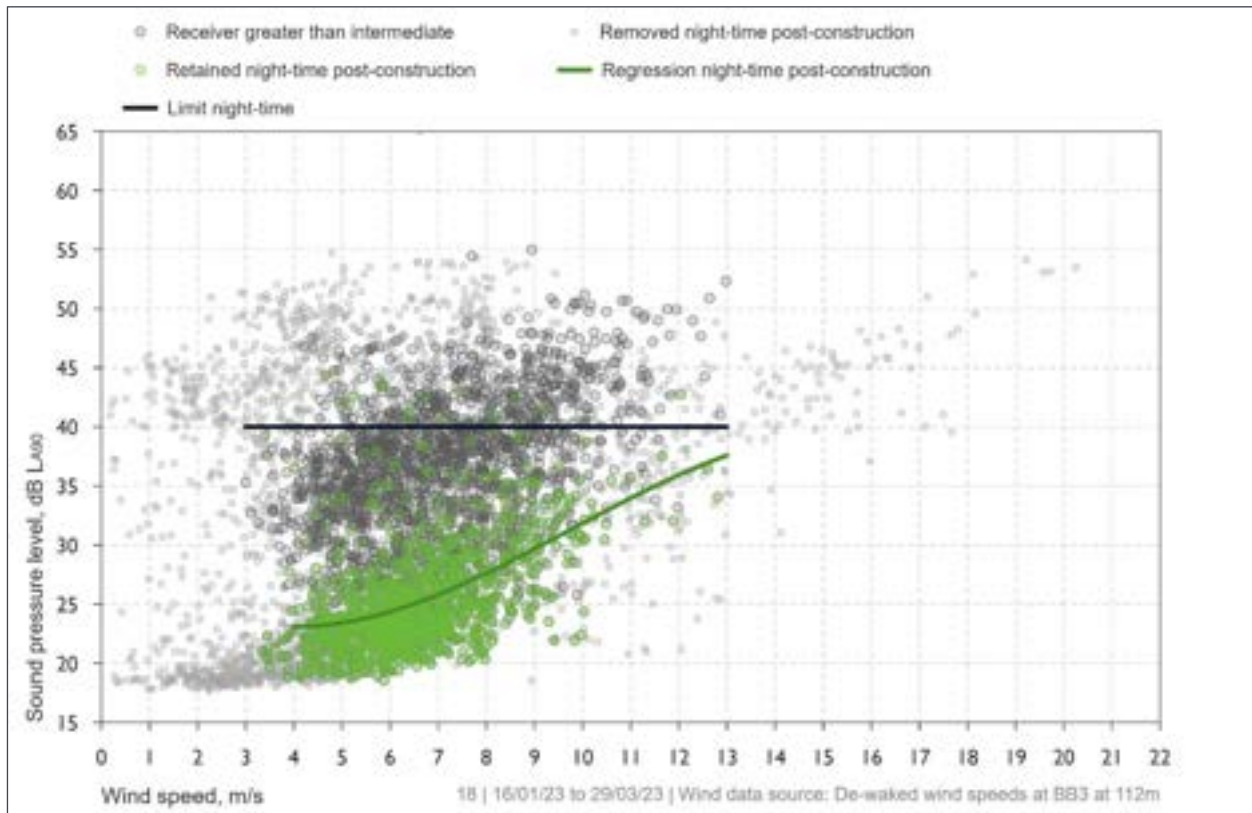


Figure 37: Receiver 18 using intermediate 18i as an additional filter – post-construction noise levels and minimum noise limits versus site wind speed – night-time



K5 Receiver 18 tonality assessment

Figure 38: Receiver 18 – tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

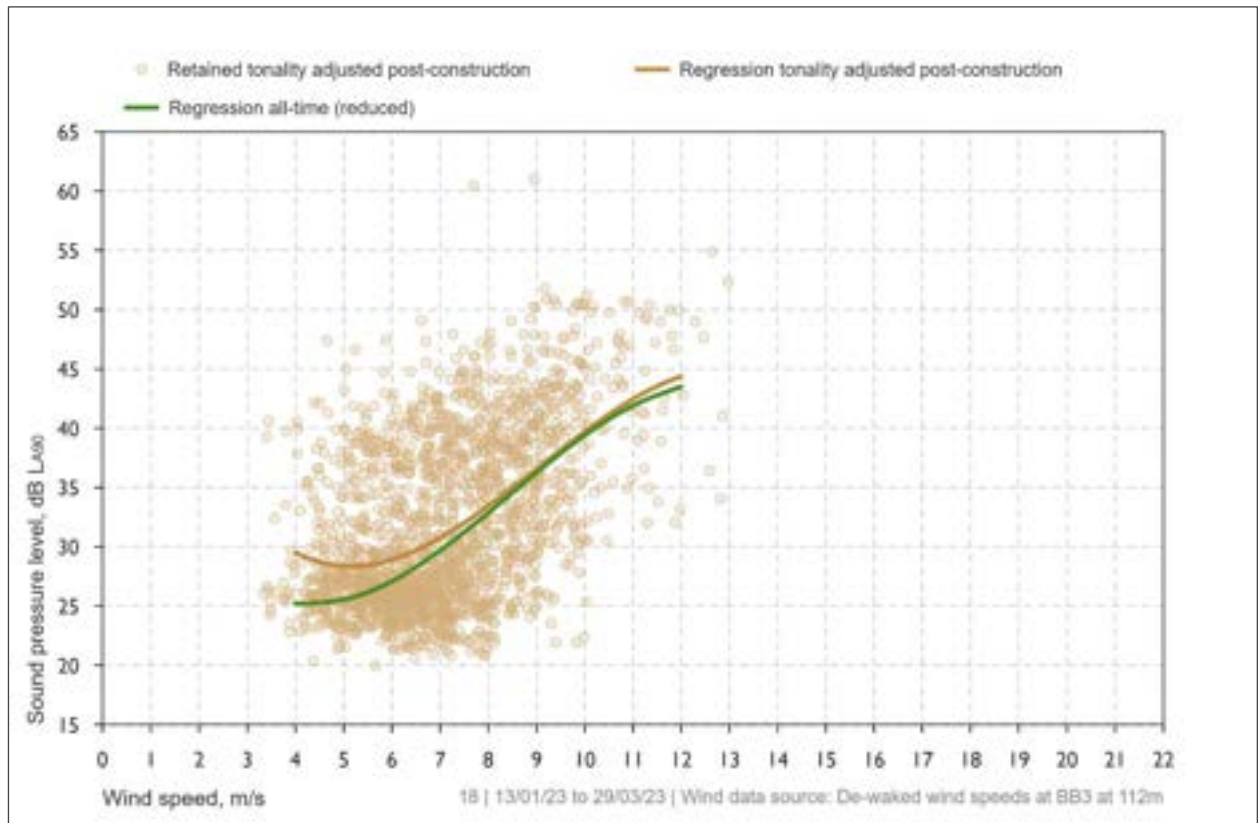


Table 51: Receiver 18 – tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	29.5	28.4	28.9	30.7	33.4	36.6	39.7	42.5	44.4	- ^[1]
Post-construction regression - no penalties	- ^[1]	25.2	25.3	26.9	29.6	32.8	36.3	39.5	42.1	43.5	- ^[1]
Penalty adjustment	- ^[1]	4.3	3.1	2.0	1.1	0.6	0.3	0.2	0.4	0.9	- ^[1]

1 Outside valid wind speed range of the regression analysis

K6 Receiver 18 compliance assessment

Table 52: Receiver 18 – compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	25.2	25.3	26.9	29.6	32.8	36.3	39.5	42.1	43.5	- ^[1]
Background noise level	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[1]
Background adjustment	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[1]
Tonality adjustment	- ^[1]	4.3	3.1	2.0	1.1	0.6	0.3	0.2	0.4	0.9	- ^[1]
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	< 29.5	< 28.4	< 28.9	< 30.7	< 33.4	< 36.6	< 39.7	< 42.5	< 44.4	- ^[1]
Noise limit	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]
Compliance margin	- ^[1]	-10.5	-11.6	-11.1	-9.3	-6.6	-3.4	-0.3	2.5 ^[4]	4.4 ^[4]	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver - the background adjustment is therefore not available for this receiver

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB L_{A90} minimum limit

Table 53: Receiver 18 – compliance assessment, dB LA90 – night-time

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	23.1	23.4	24.4	25.8	27.6	29.7	31.8	34.0	35.9	37.6
Background noise level ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]
Background adjustment ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]
Tonality adjustment	- ^[1]	4.3	3.1	2.0	1.1	0.6	0.3	0.2	0.4	0.9	- ^[1]
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	< 27.4	< 26.5	< 26.4	< 26.9	< 28.2	< 30.0	< 32.0	< 34.4	< 36.8	- ^[1]
Noise limit	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Compliance margin	- ^[1]	-12.6	-13.5	-13.6	-13.1	-11.8	-10.0	-8.0	-5.6	-3.2	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver - the background adjustment is therefore not available for this receiver

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

Table 54: Receiver 18 compliance assessment based on extrapolation of intermediate 18i, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 18i	- ^[1]	24.3	24.3	25.4	27.3	29.7	32.6	35.5	38.3	40.8	42.6
Background noise level intermediate 18i	- ^[1]	22.1	22.5	23.1	23.7	24.5	25.4	26.4	27.5	28.7	30.0
Background adjustment intermediate 18i	- ^[1]	- ^[2]	- ^[2]	- ^[2]	-2.5	-1.6	-0.9	-0.6	-0.4	-0.3	-0.2
Extrapolation correction	- ^[1]	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
Tonality adjustment receiver 18	- ^[1]	4.3	3.1	2.0	1.1	0.6	0.3	0.2	0.4	0.9	- ^[1]
Estimated tonality adjusted wind farm noise level receiver 18 ^[3]	- ^[1]	< 28	< 26.8	< 26.8	25.3	28.1	31.4	34.5	37.7	40.8	- ^[1]
Noise limit receiver 18 ^[4]	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]
Compliance margin	- ^[1]	-12.0	-13.2	-13.2	-14.7	-11.9	-8.6	-5.5	-2.3	0.8 ^[5]	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

5 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB L_{A90} minimum limit

APPENDIX L RECEIVER 27

L1 Receiver 27 location data

Table 55: Location 27 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	716500	5793918
Noise monitoring location	716500	5793907

Figure 39: Receiver 27 aerial view – dwelling and noise monitor locations

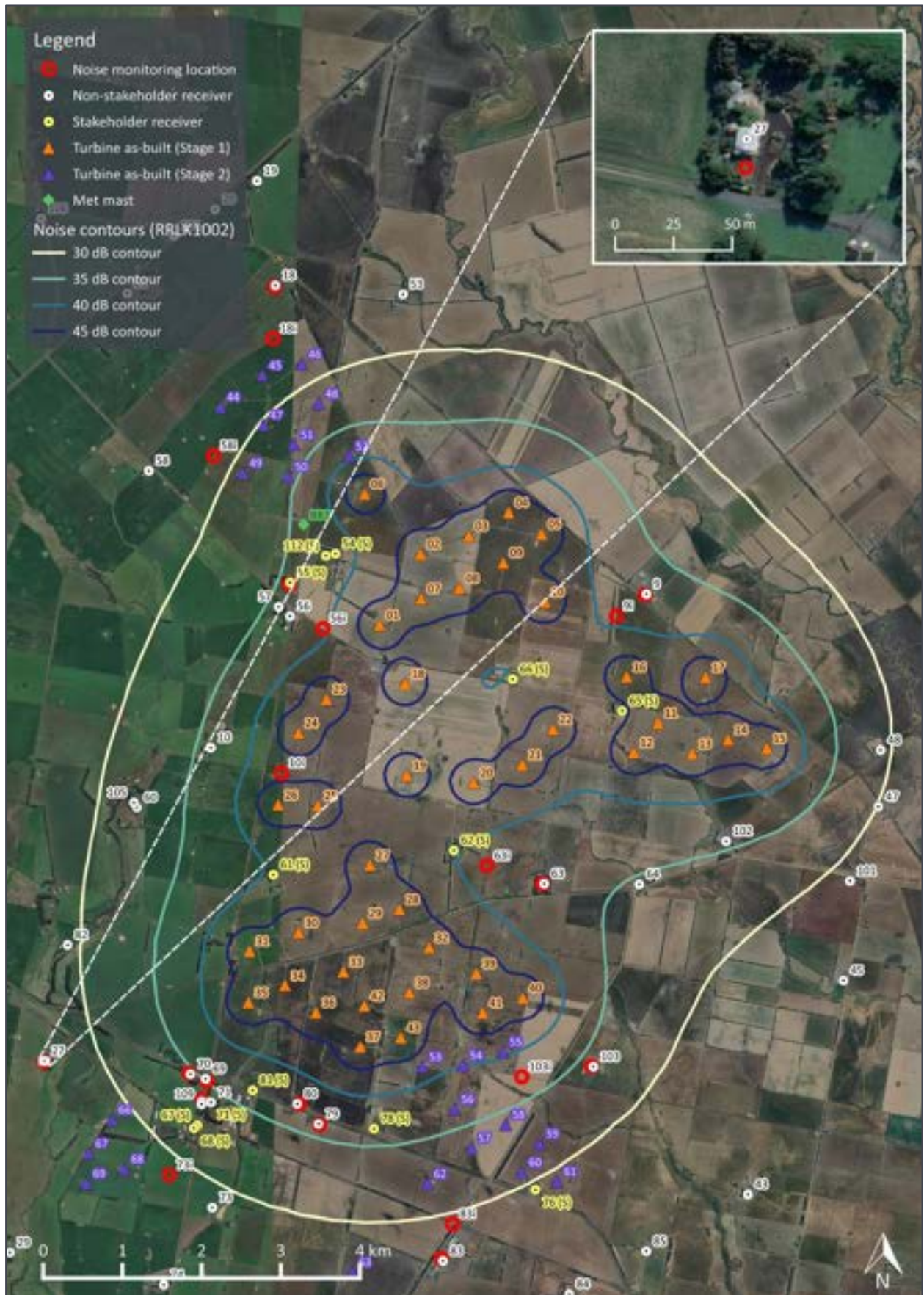
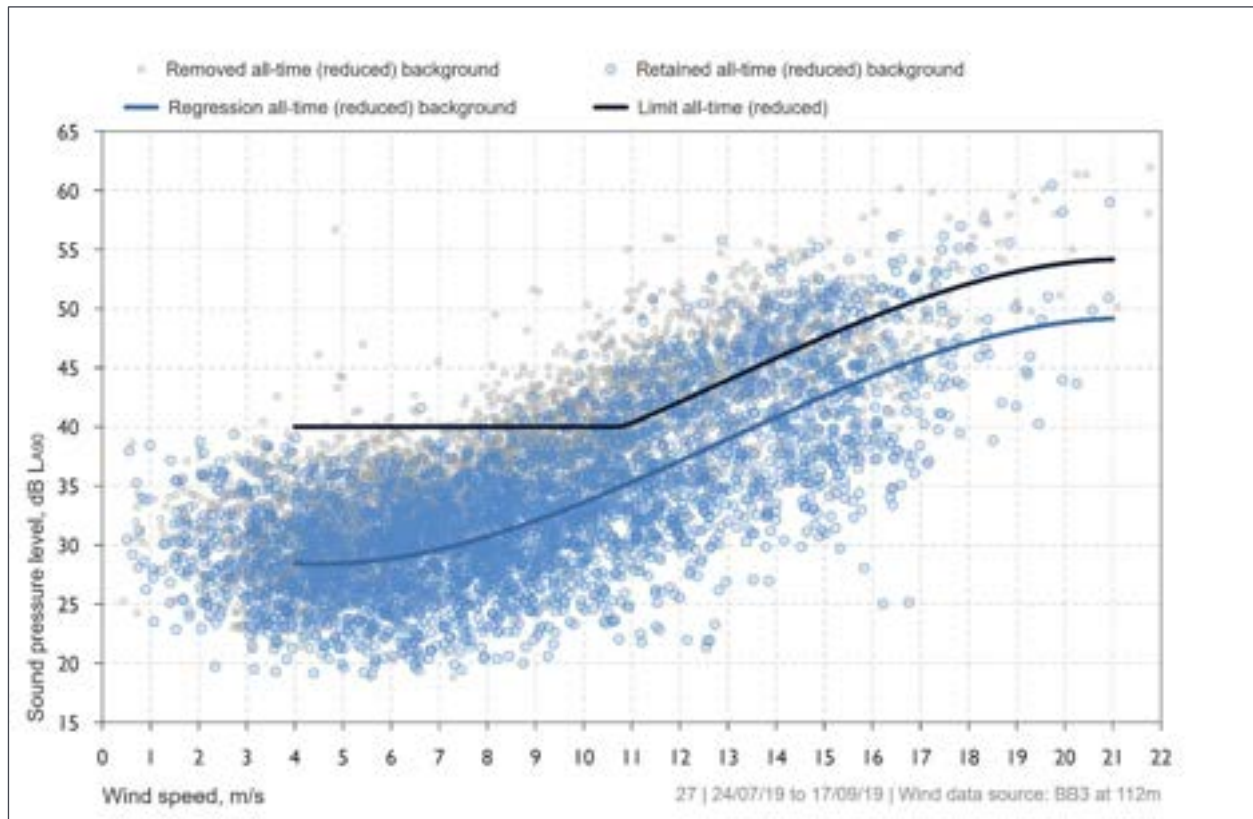


Figure 40: Receiver 27 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

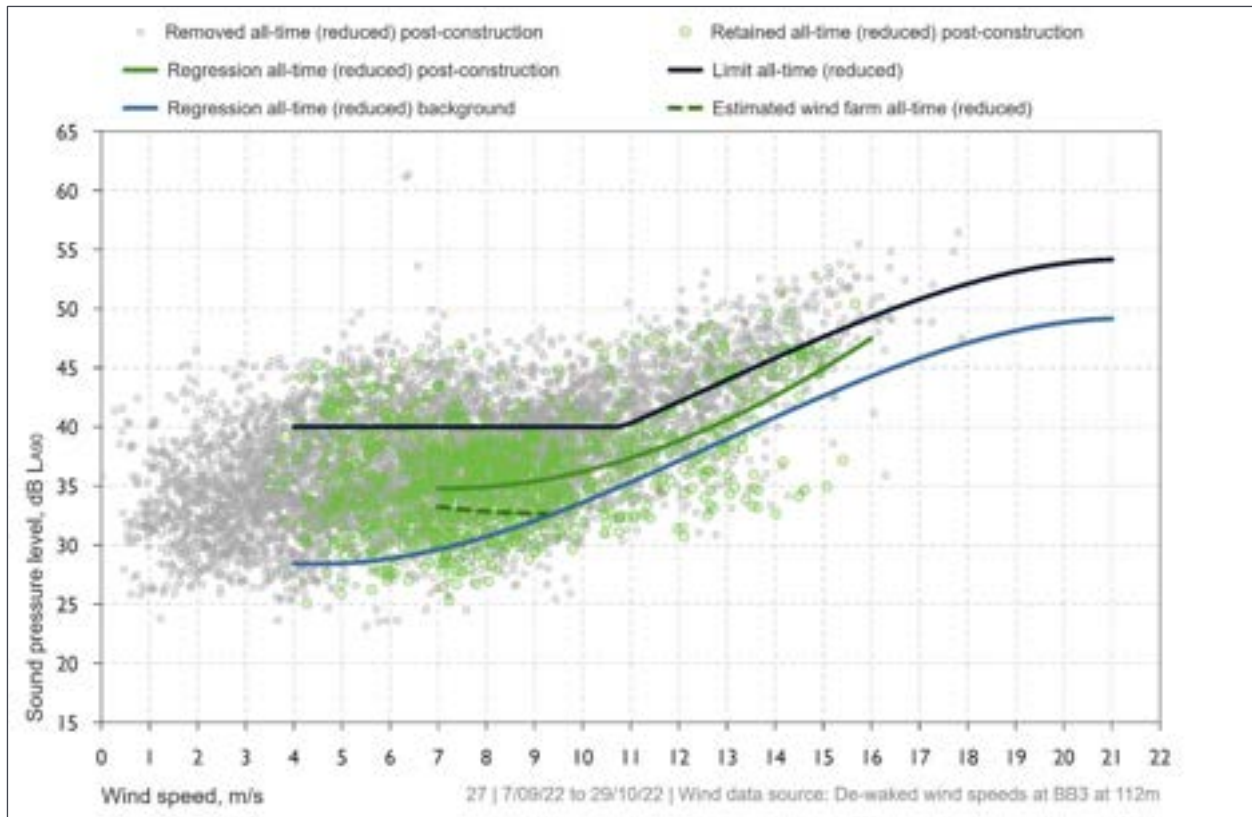
L2 Receiver 27 background noise data

Figure 41: Receiver 27 – derived background noise levels and noise limit – all-time (reduced)



L3 Receiver 27 post-construction measurement data – all wind speeds

Figure 42: Receiver 27 - post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



L4 Receiver 27 post-construction measurement data summary – assessment wind speeds

Table 56: Receiver 27 assessment data summary – number of data points

Data points	All-time (reduced)
Collected	7264
Removed	6230
Retained	1034

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 57.

Table 57: Receiver 27 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3050
Rainfall	2228
Extraneous noise	1179
Wind farm operations curtailed	3898
Wind speeds outside assessment range	1089

Figure 43: Receiver 27 post-construction noise levels and wind speed time history

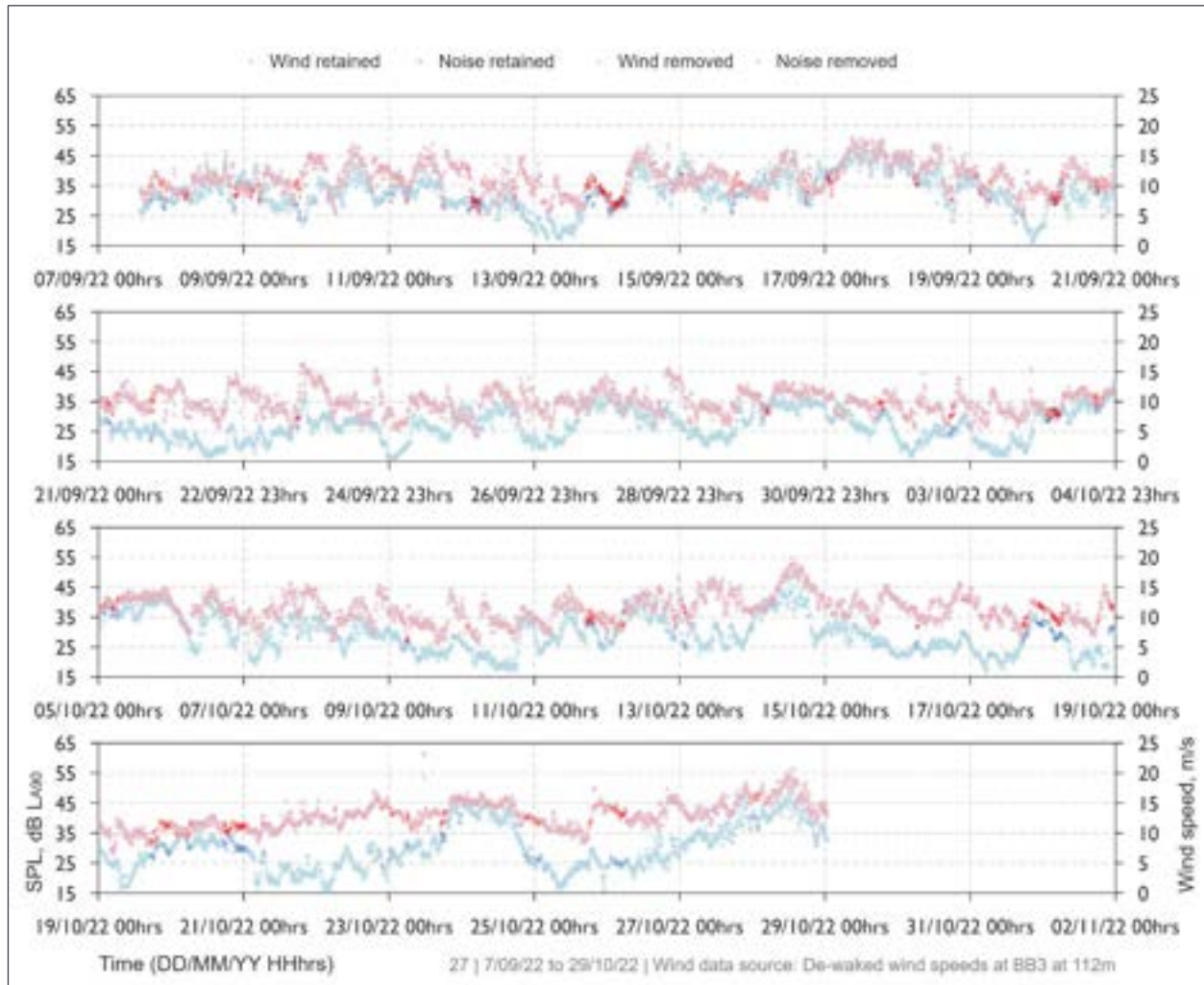
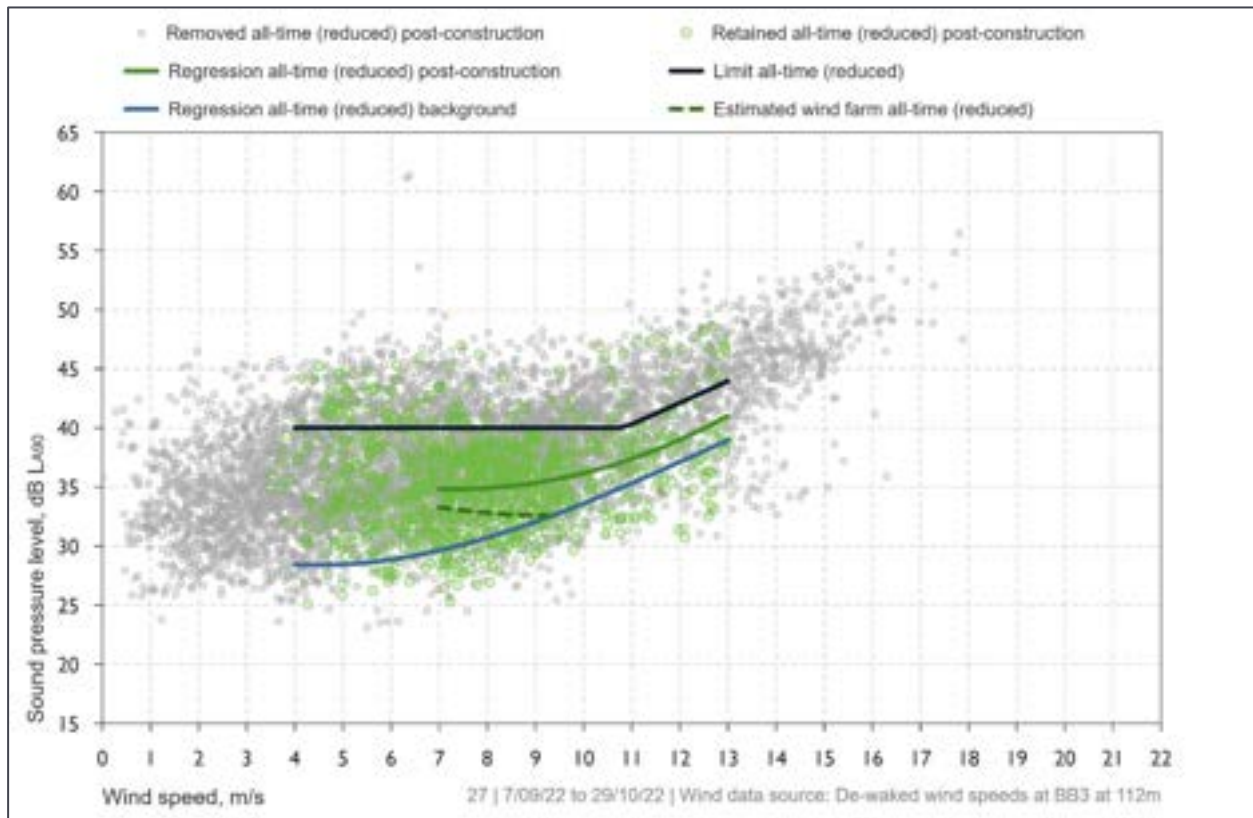


Figure 44: Receiver 27 – post-construction noise levels and noise limits versus site wind speed – all-time (reduced)



L5 Receiver 27 tonality assessment

Figure 45: Receiver 27 – tonality adjusted total-construction noise levels versus site wind speed – all-time (reduced)

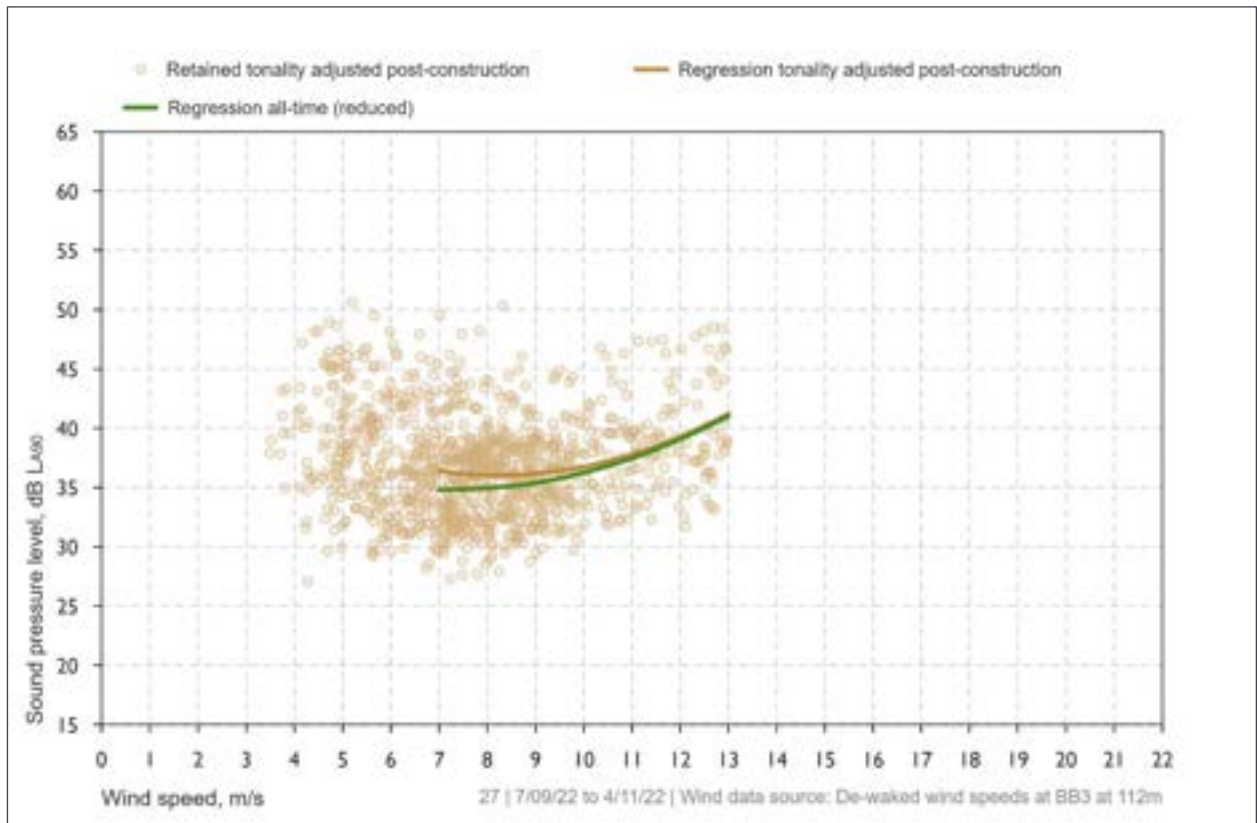


Table 58: Receiver 27 – tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- [1]	- [1]	- [1]	- [1]	36.4	36.0	36.2	36.7	37.8	39.3	41.2
Post-construction regression - no penalties	- [1]	- [1]	- [1]	- [1]	34.8	34.9	35.3	36.2	37.4	39.0	41.0
Penalty adjustment	- [1]	- [1]	- [1]	- [1]	1.6	1.1	0.9	0.5	0.4	0.3	0.2

1 Outside valid wind speed range of the regression analysis

L6 Receiver 27 compliance assessment

Table 59: Receiver 27 – compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	– [1]	– [1]	– [1]	– [1]	34.8	34.9	35.3	36.2	37.4	39.0	41.0
Background noise level	– [1]	– [1]	– [1]	– [1]	29.6	30.7	32.1	33.6	35.3	37.1	39.0
Background adjustment	– [1]	– [1]	– [1]	– [1]	-1.6	-2.1	-2.8	– [2]	– [2]	– [2]	– [2]
Tonality adjustment	– [1]	– [1]	– [1]	– [1]	1.6	1.1	0.9	0.5	0.4	0.3	0.2
Estimated tonality adjusted wind farm noise level [3]	– [1]	– [1]	– [1]	– [1]	34.8	33.9	33.4	< 36.7	< 37.8	< 39.3	< 41.2
Noise limit	– [1]	– [1]	– [1]	– [1]	40.0	40.0	40.0	40.0	40.3	42.1	44.0
Compliance margin	– [1]	– [1]	– [1]	– [1]	-5.2	-6.1	-6.6	-3.3	-2.5	-2.8	-2.8

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

APPENDIX M RECEIVER 55 (S)

M1 Receiver 55 (S) location data

Table 60: Receiver 55 (S) dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	719613	5799970
Noise monitoring location	719594	5799934

Figure 46: Receiver 55 (S) aerial view – dwelling and noise monitor locations

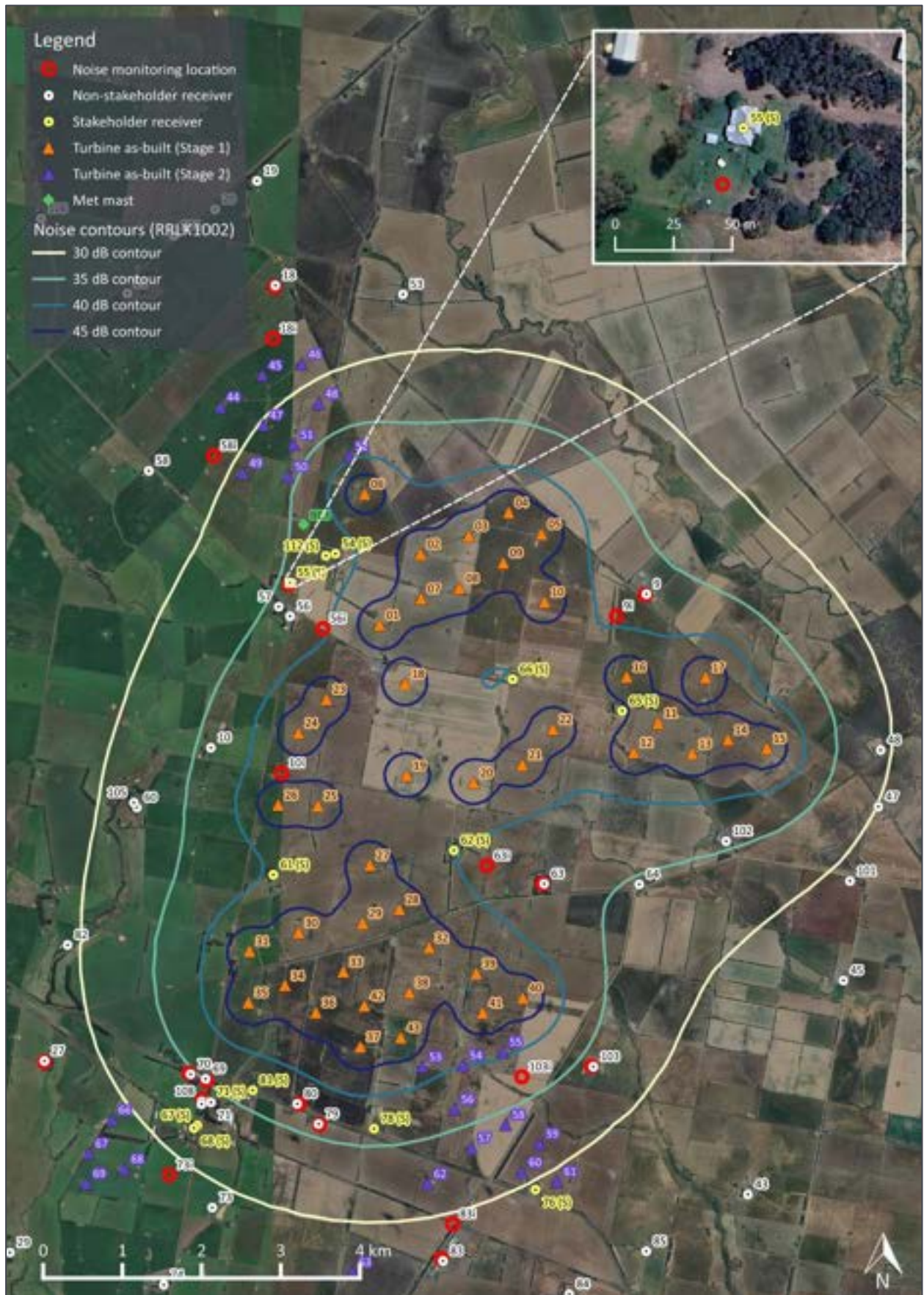
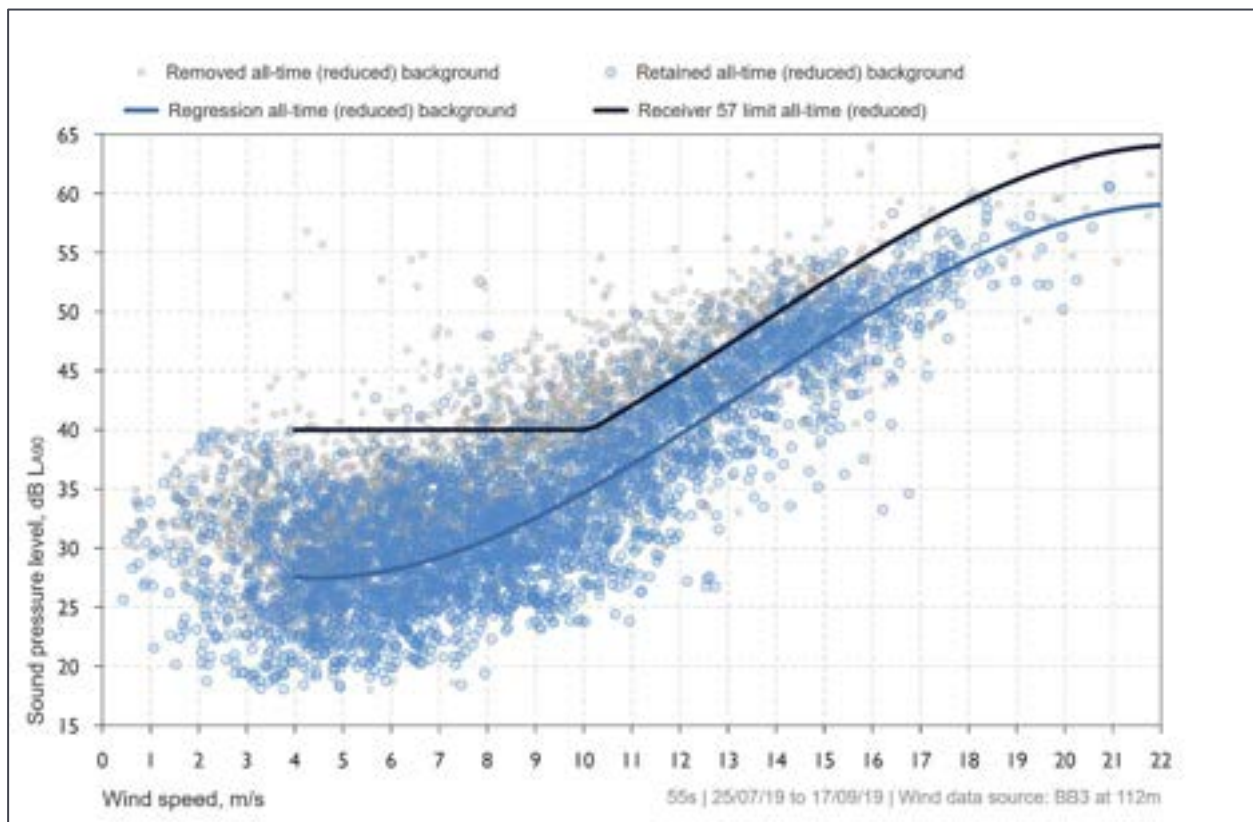


Table 61: Receiver 55 (S) monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

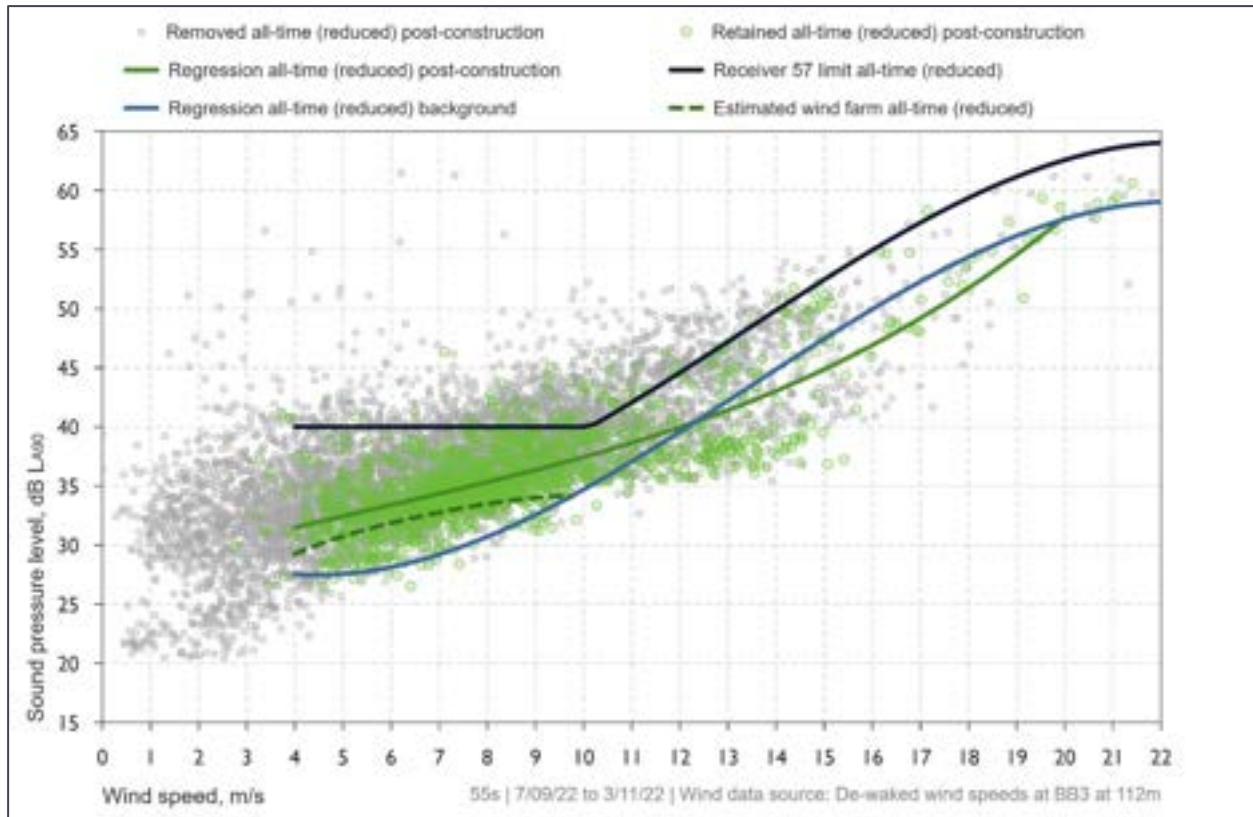
M2 Receiver 55 (S) background noise data

Figure 47: Receiver 55 (S) - derived background noise levels and noise limit – all-time (reduced)



M3 Receiver 55 (S) post-construction measurement data – all wind speeds

Figure 48: Receiver 55 (S) - post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



M4 Receiver 55 (S) post-construction measurement data summary – assessment wind speeds

Table 62: Receiver 55 (S) assessment data summary – number of data points

Data points	All-time (reduced)
Collected	8077
Removed	6653
Retained	1424

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 63.

Table 63: Receiver 55 (S) assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3395
Rainfall	2387
Extraneous noise	846
Wind farm operations curtailed	4072
Wind speeds outside assessment range	1219

Figure 49: Receiver 55 (S) post-construction noise levels and wind speed time history

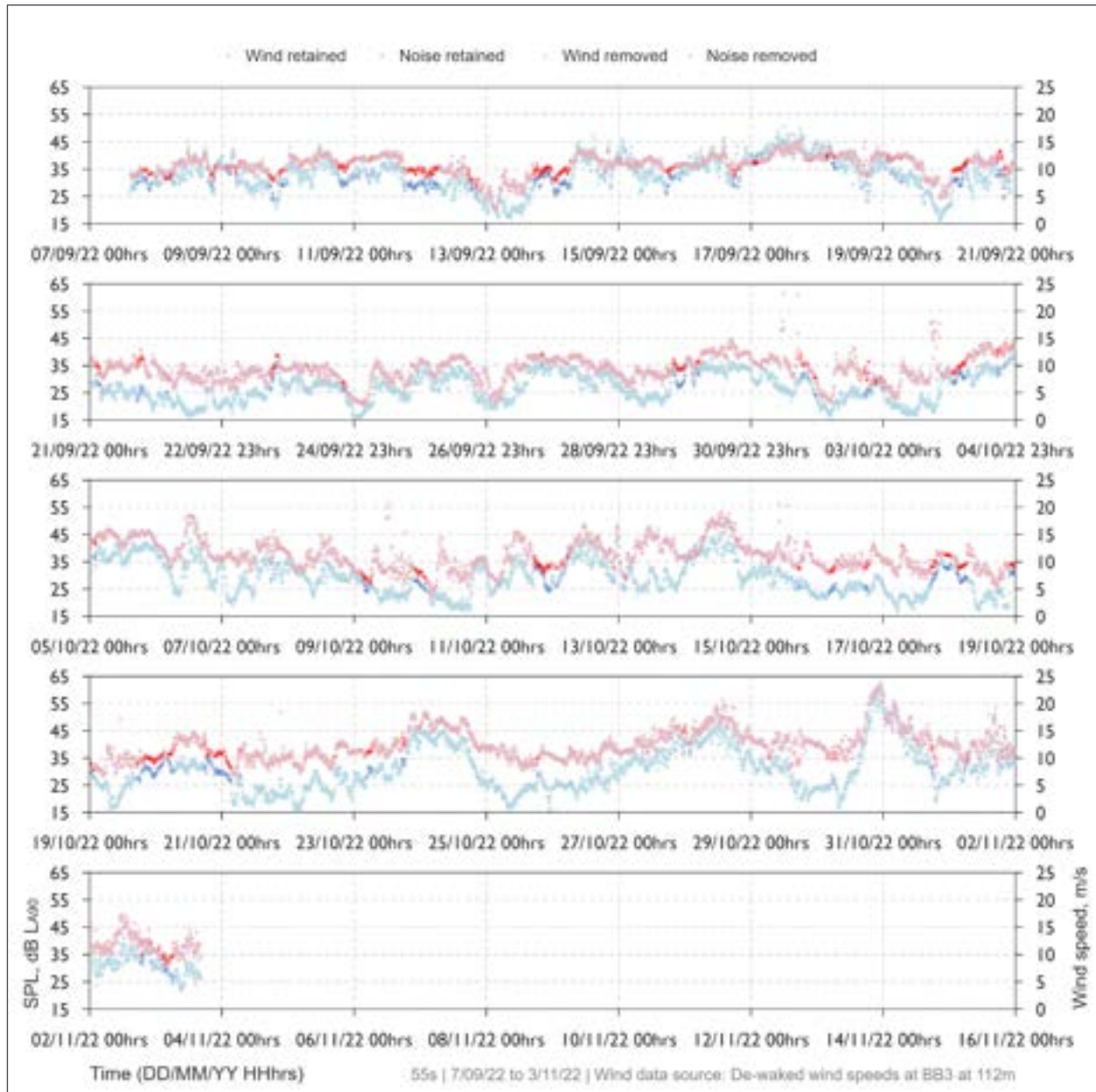
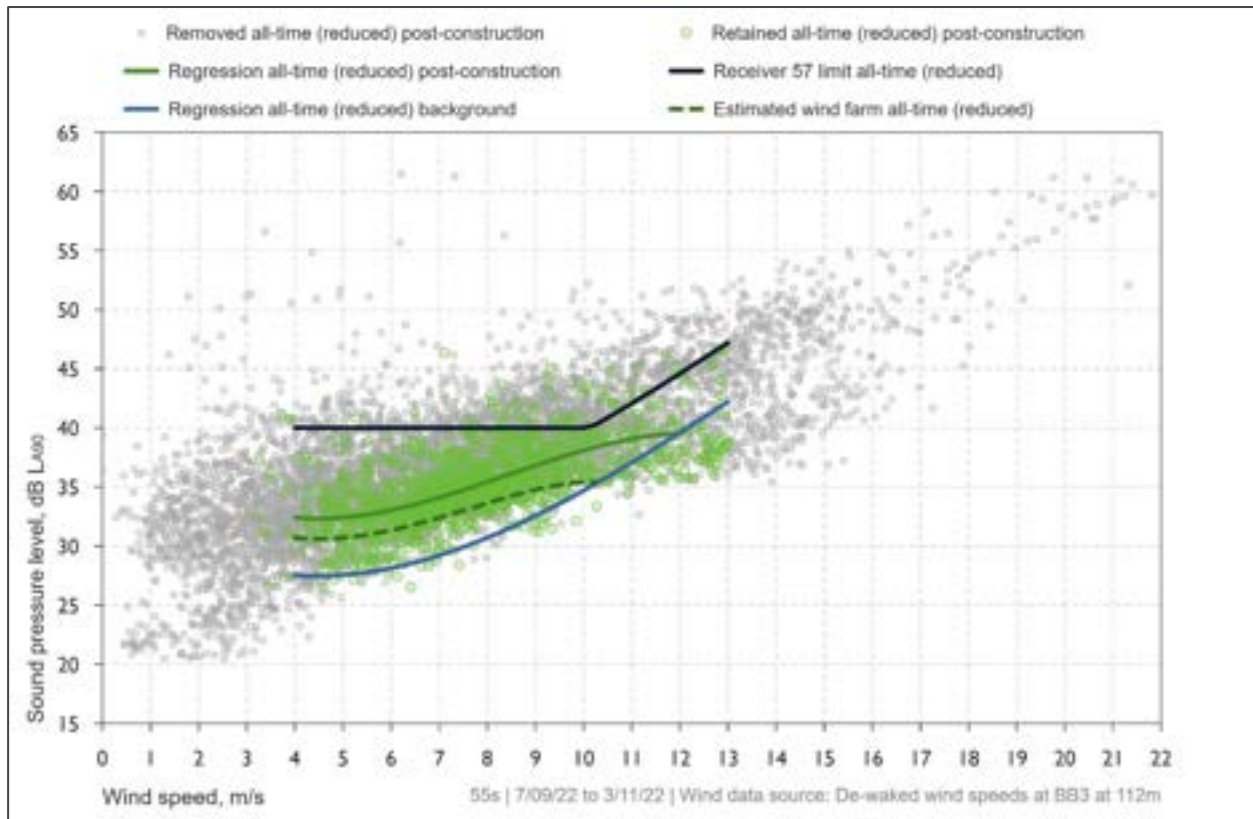


Figure 50: Receiver 55 (S) – post-construction noise levels and receiver 57 noise limits versus site wind speed – all-time (reduced)



M5 Receiver 55 (S) tonality assessment

Figure 51: Receiver 55 (S) – tonality adjusted total-construction noise levels versus site wind speed – all-time (reduced)

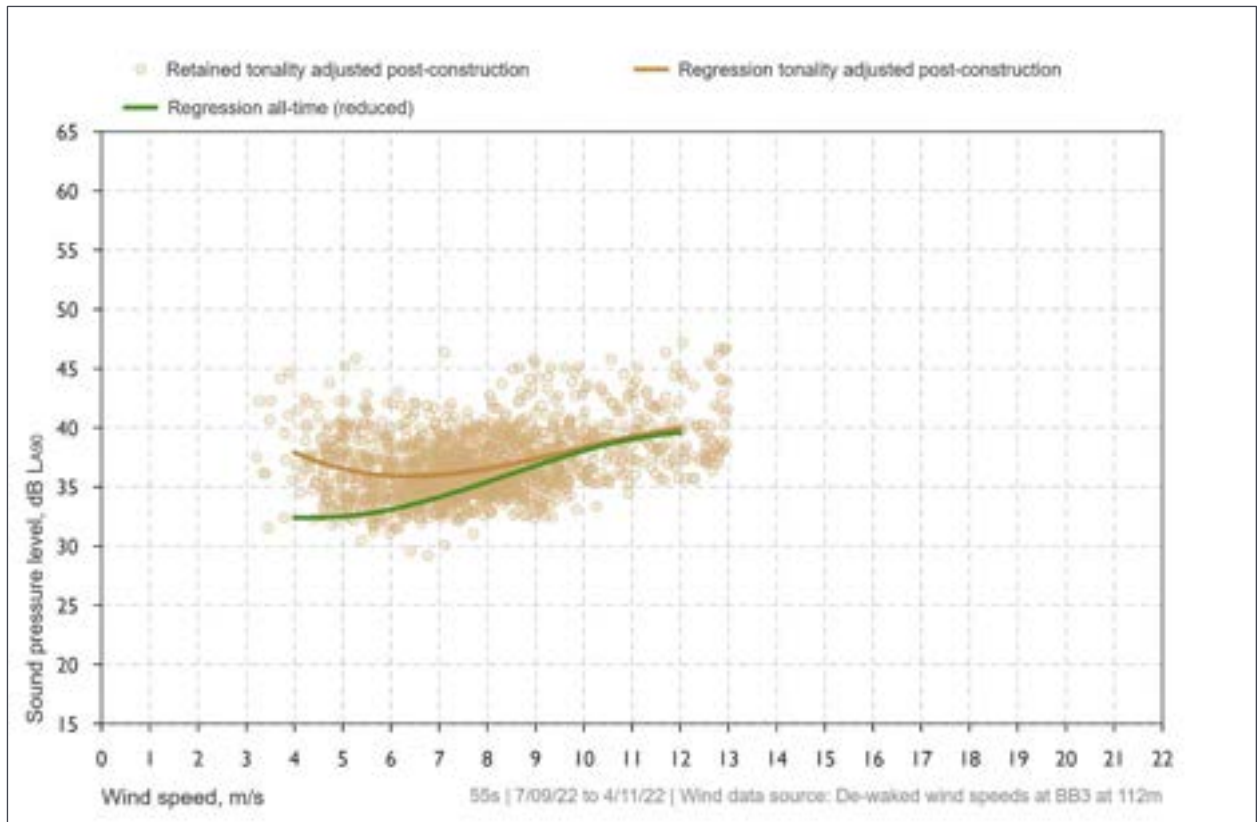


Table 64: Receiver 55 (S) – tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	37.9	36.5	35.9	36.0	36.5	37.4	38.3	39.3	40.0	- ^[1]
Post-construction regression - no penalties	- ^[1]	32.4	32.4	33.0	34.1	35.4	36.8	38.1	39.1	39.6	- ^[1]
Penalty adjustment	- ^[1]	5.5	4.1	2.9	1.9	1.1	0.6	0.2	0.2	0.4	- ^[1]

1 Outside valid wind speed range of the regression analysis

M6 Receiver 57 compliance assessment

Table 65: Receiver 57 – compliance assessment based on measurements at stakeholder 55(S), dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	32.4	32.4	33.0	34.1	35.4	36.8	38.1	39.1	39.6	- ^[1]
Background noise level	- ^[1]	27.5	27.6	28.1	29.2	30.7	32.6	34.7	37.1	39.6	- ^[1]
Background adjustment	- ^[1]	-1.7	-1.7	-1.7	-1.7	-1.8	-2.1	-2.7	- ^[2]	- ^[2]	- ^[1]
Tonality adjustment	- ^[1]	5.5	4.1	2.9	1.9	1.1	0.6	0.2	0.2	0.4	- ^[1]
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	36.2	34.8	34.2	34.3	34.7	35.3	35.6	< 39.3	< 40.0	- ^[1]
Noise limit	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	42.1	44.6	- ^[1]
Compliance margin	- ^[1]	-3.8	-5.2	-5.8	-5.7	-5.3	-4.7	-4.4	-2.8	-4.6	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

APPENDIX N RECEIVER 63

N1 Receiver 63 location data

Table 66: Receiver 63 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	722811	5796156
Noise monitoring location	722791	5796150

Figure 52: Receiver 63 aerial view – dwelling and noise monitor locations

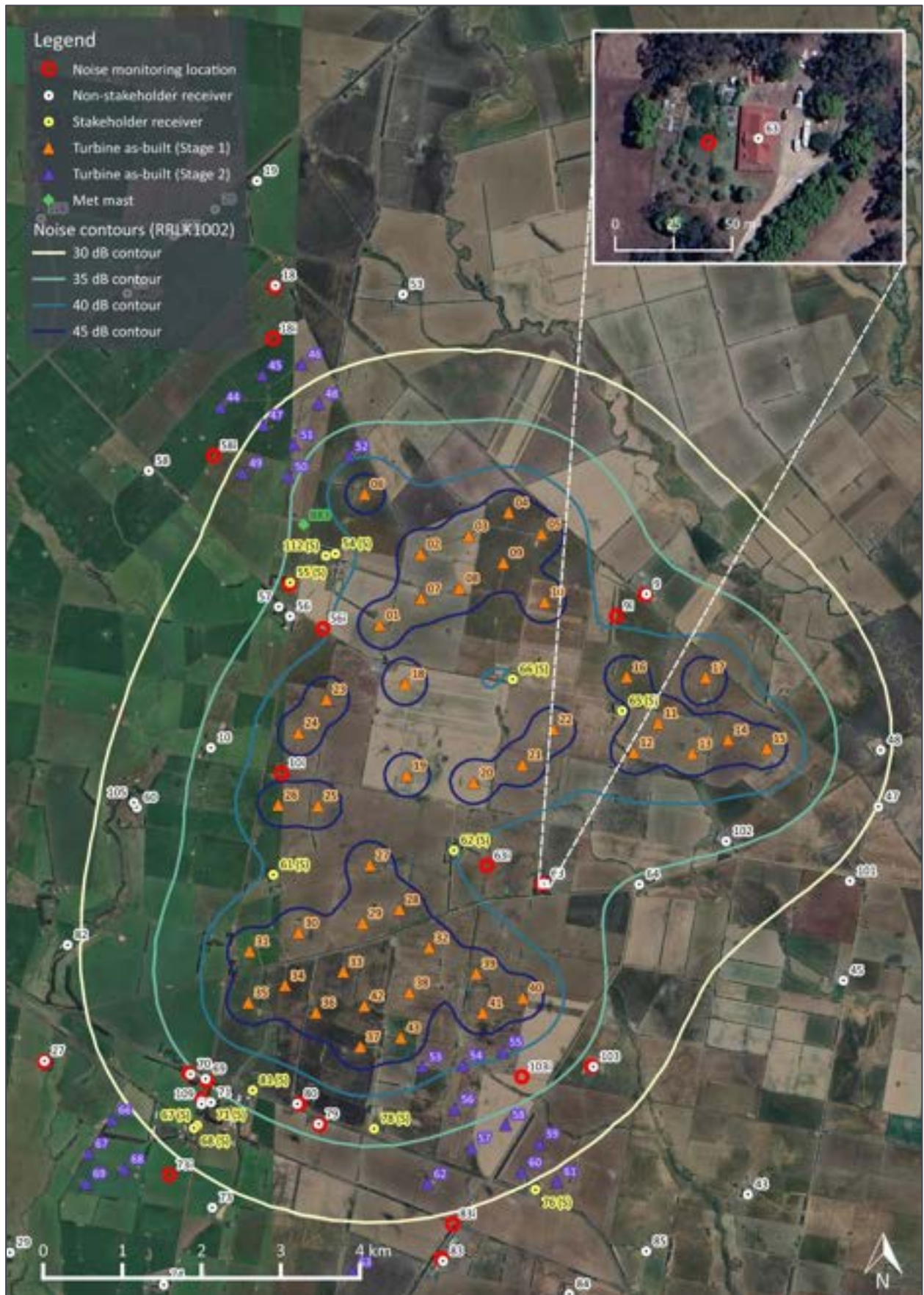
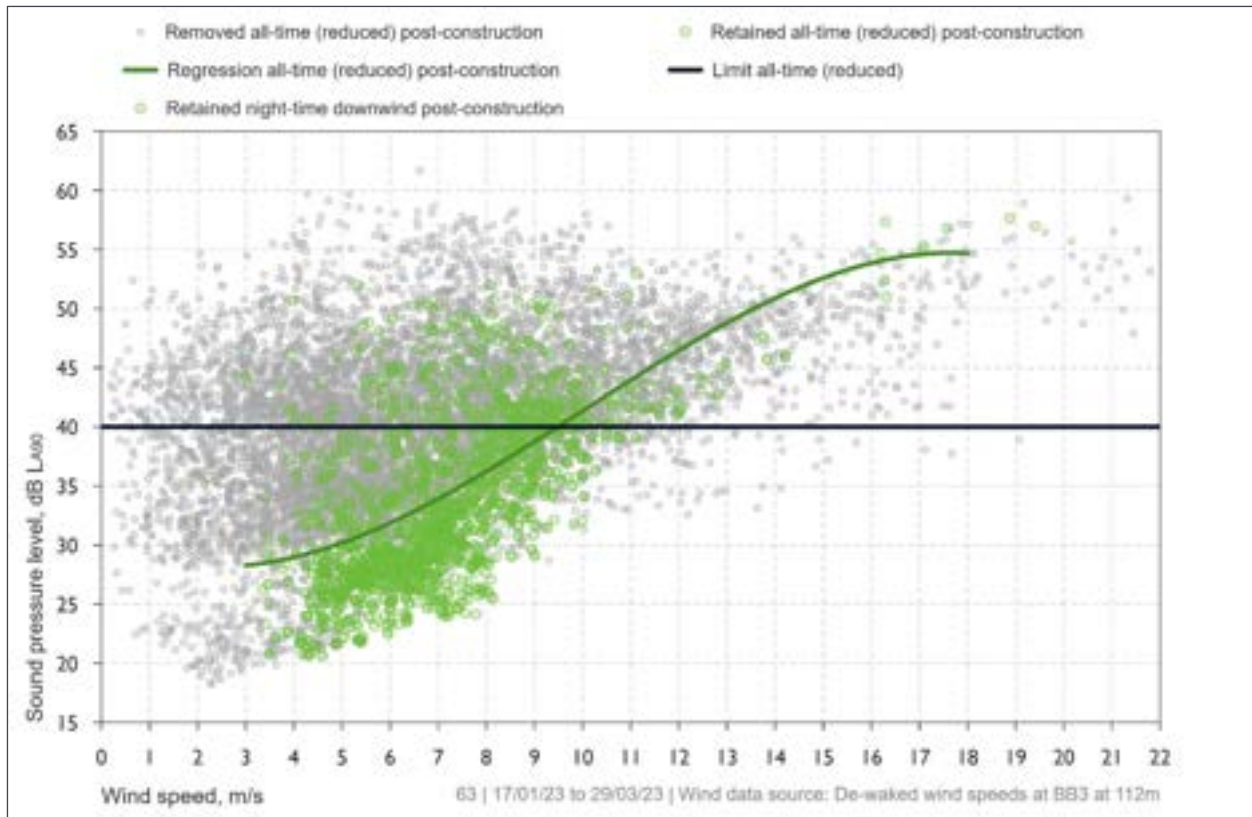


Table 67: Receiver 63 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

N2 Receiver 63 post-construction measurement data – all wind speeds

Figure 53: Receiver 63 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



N3 Receiver 63 post-construction measurement data summary – assessment wind speeds

Table 68: Receiver 63 assessment data summary – number of data points

Data points	All-time (reduced)
Collected	9543
Removed	8125
Retained	1418

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 69.

Table 69: Receiver 63 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3979
Rainfall	434
Extraneous noise	3477
Wind farm operations curtailed	5289
Wind speeds outside assessment range	1273

Figure 54: Receiver 63 – post-construction noise levels and wind speed time history

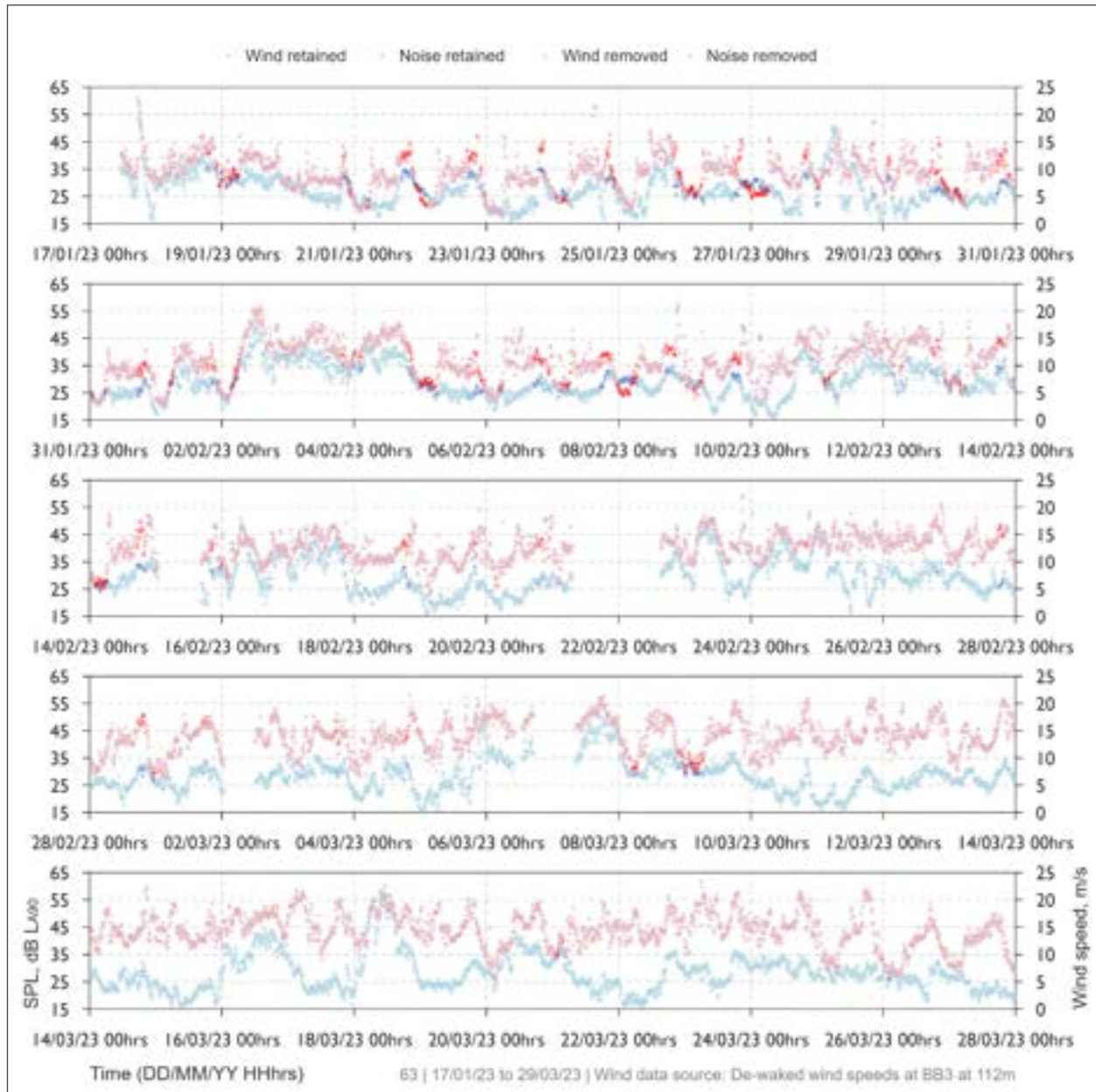


Figure 55: Receiver 63 – post-construction noise levels and minimum noise limits versus site wind speed - all-time (reduced)

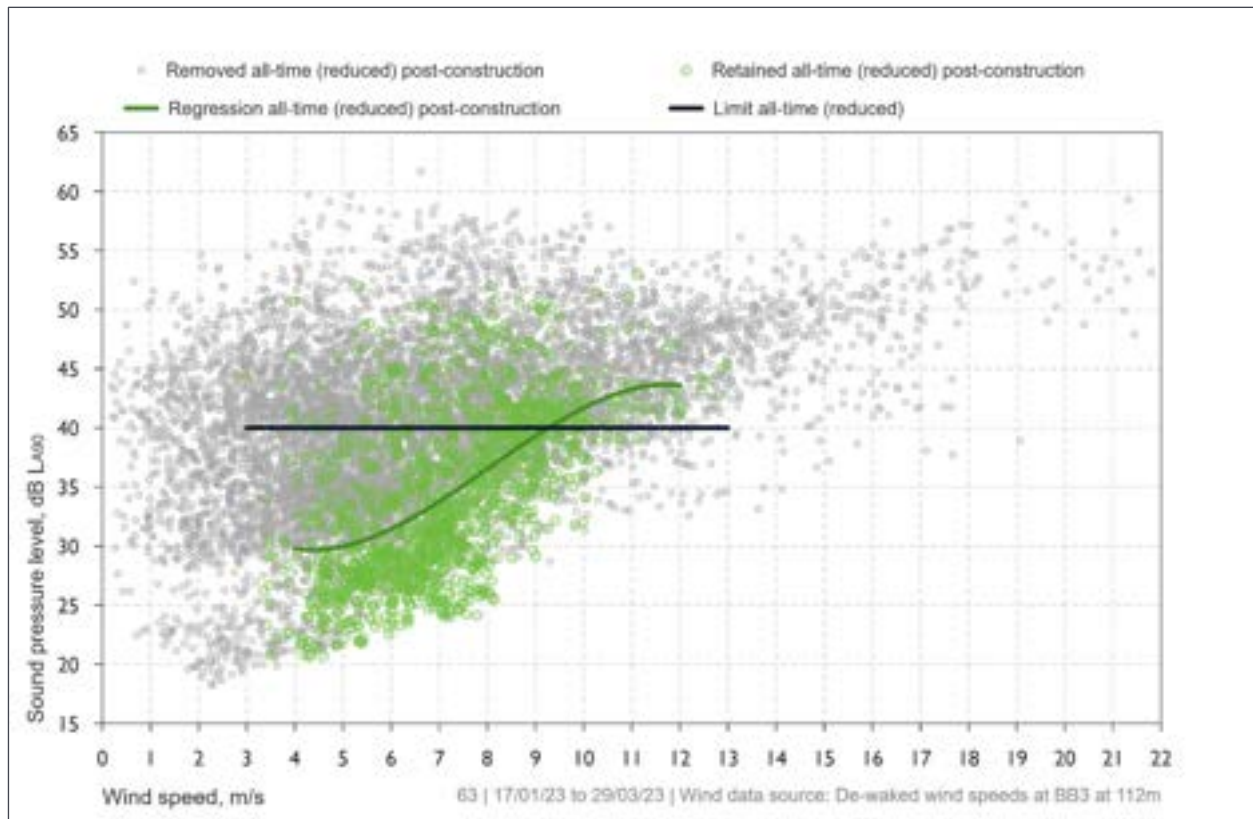
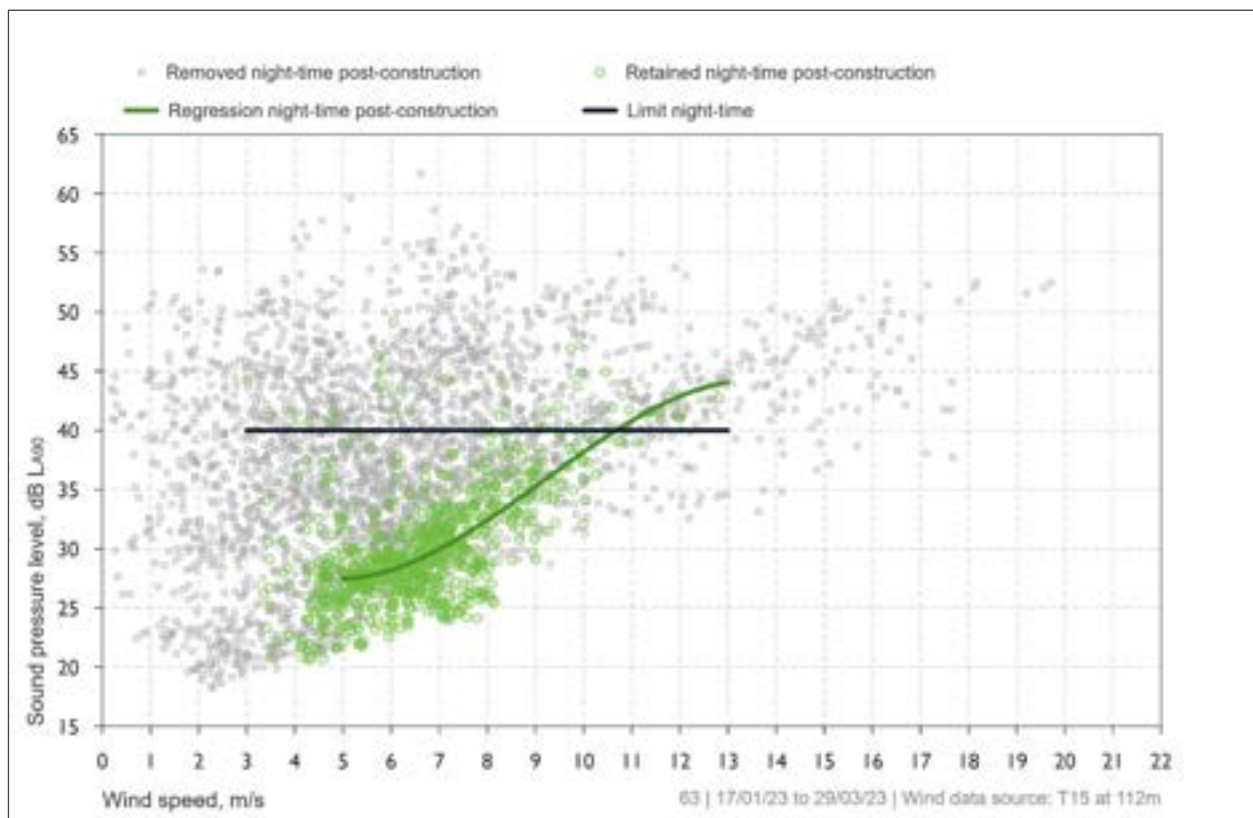


Figure 56: Receiver 63 - post-construction noise levels and minimum noise limits versus site wind speed – night-time



N4 Receiver 63 supplementary analysis

The total measured noise levels at receiver 63 are greater than 40 dB L_{A90} above 9 m/s and 10 m/s for the all-time (reduced) and night-time respectively. These results are consistent with the influence of background noise levels. In particular, the results indicated background noise levels well above 40 dB L_{A90} at low wind speeds when the wind turbines would either not be operating or would be operating at low speeds and producing negligible noise emissions. However, in the absence of background noise data for receiver 63, the total measured noise levels at this receiver are inconclusive with respect to compliance (i.e. on account of the absence of background noise related limits and the absence of data to estimate the likely contribution of background noise levels to the measurements).

in accordance with the NCTP, supplementary analysis procedures as specified in the NCTP were used to investigate the wind farm's contribution to the total measured noise levels. The relevant supplementary procedures and observations are summarised in Table 70.

Table 70: Receiver 63 – supplementary analysis summary

Procedure	Findings
Comparison of data trends for upwind and downwind conditions	See Figure 57 and Figure 58 for the comparisons for all-time (reduced) and night-time respectively. No indication of distinct difference between the noise levels measured under downwind and upwind conditions.
Noise level versus wind speed profile review	See Figure 59. The profile indicates a greater rate of increase in noise levels above 9 m/s than occurs at locations nearer to the wind farm. This indicates background noise influences rather than wind farm noise at high wind speeds.
Data filtering using intermediate measurement data	See Figure 60 and Figure 61 for data subject to additional filtering for the all-time (reduced) and night-time respectively. This additional filter removes a data point if the measured noise level at the receiver was higher than at the intermediate location positioned nearer to the wind farm. The additional filter removes a significant quantity of additional points where noise levels would have been unrelated to the operation of the wind farm. However, the additional filtering does not provide any further insight into the potential noise levels related to the operation of the wind farm.
Extrapolation of intermediate data	See Table 74 in Appendix N6. The extrapolation indicates estimated tonality adjusted wind farm noise levels below 40 dB L_{A90} across the assessable range of wind speeds.

Figure 57: Receiver 63 – upwind and downwind post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

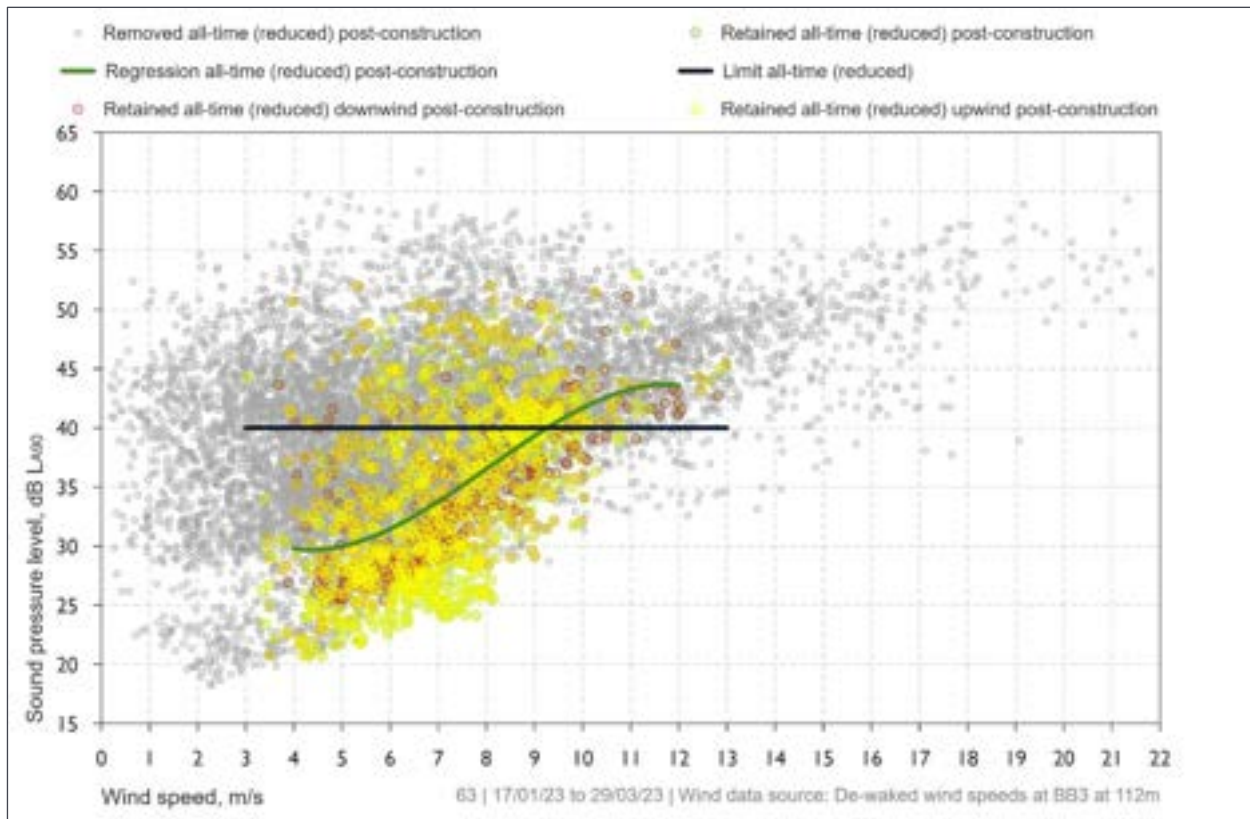


Figure 58: Receiver 63 – upwind and downwind post-construction noise levels and minimum noise limits versus site wind speed – night-time

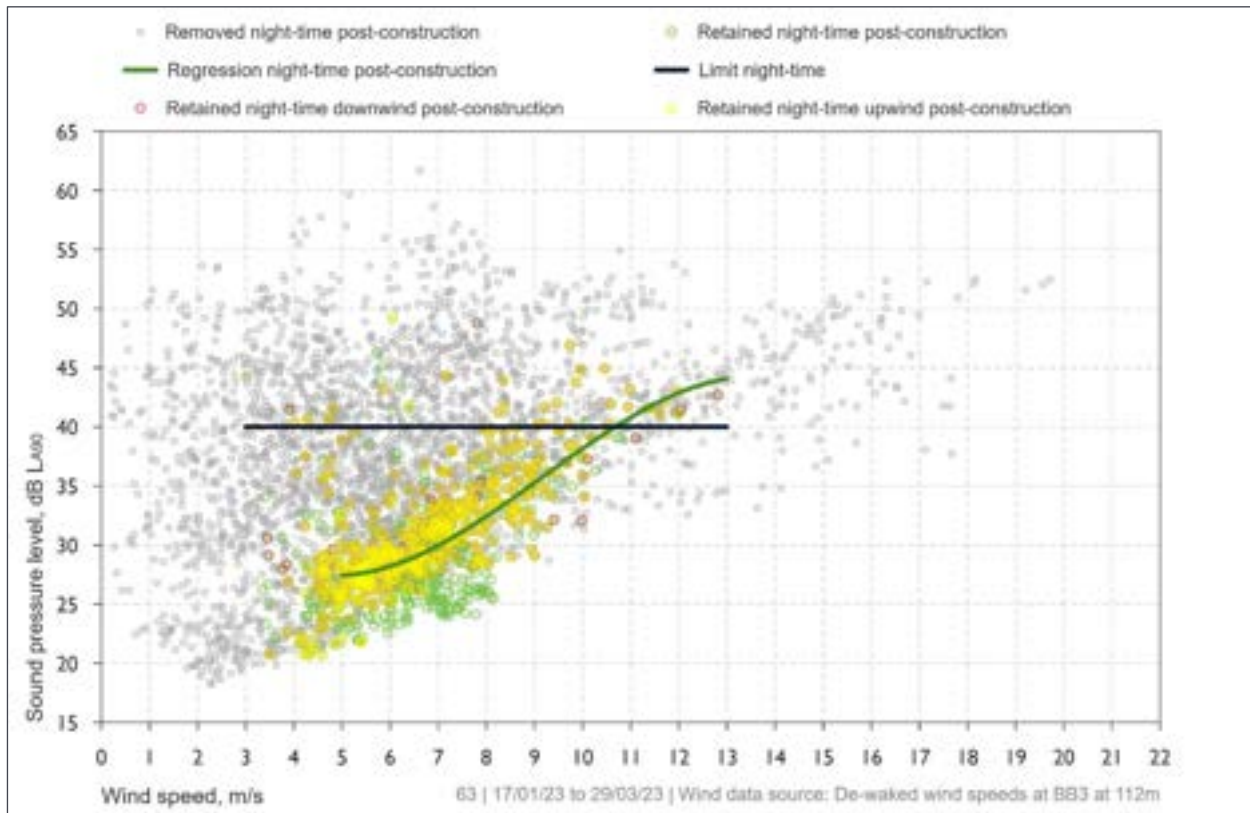


Figure 59: Change in noise level with wind speed, receiver 63 compared to intermediate locations – all-time (reduced)

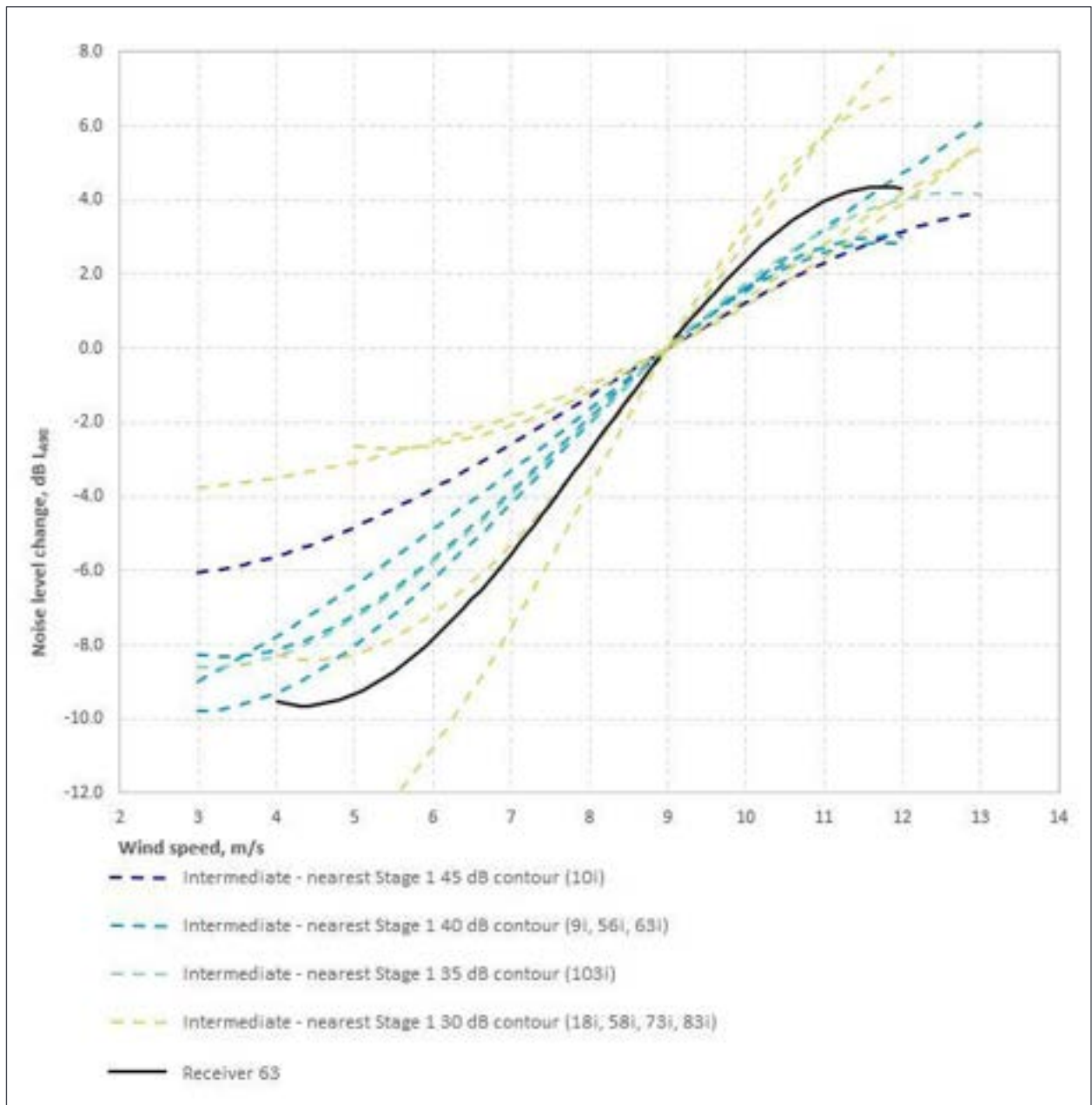


Figure 60: Receiver 63 using intermediate 63i as an additional filter – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

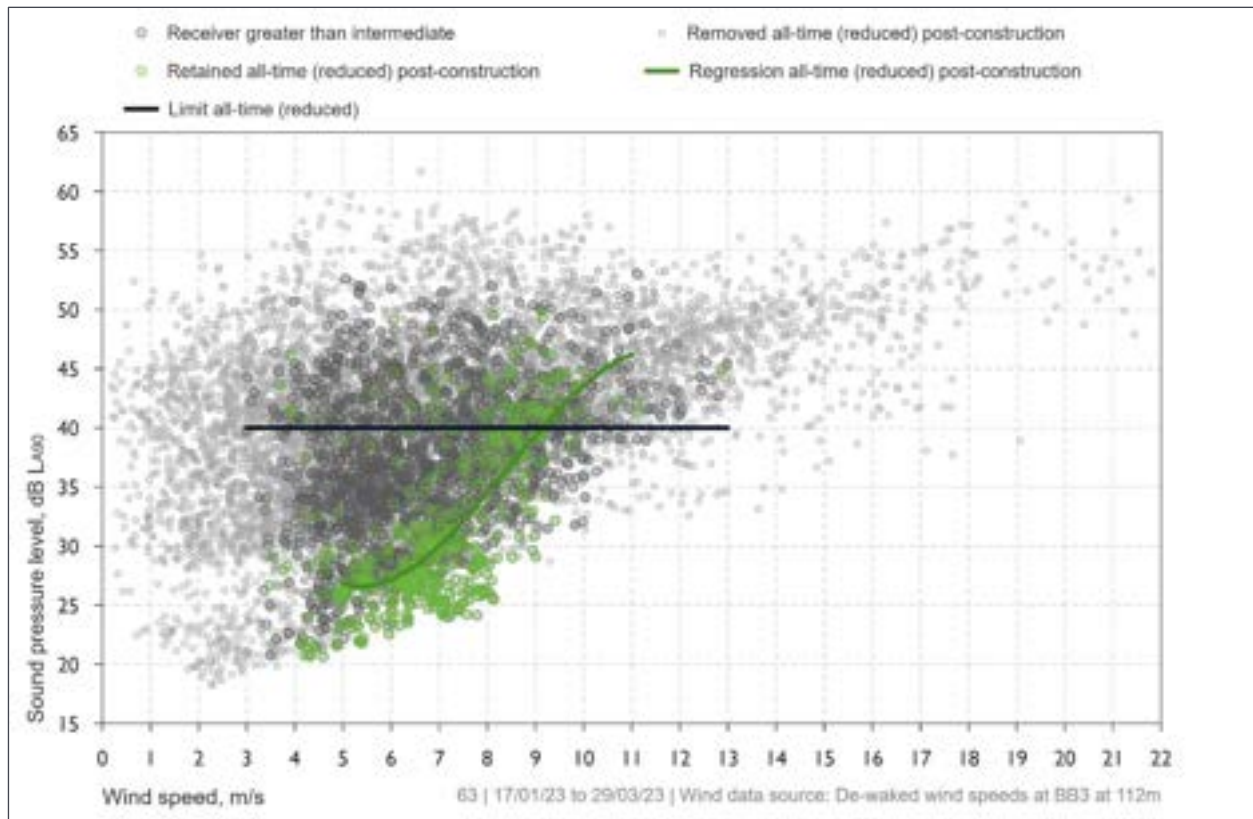
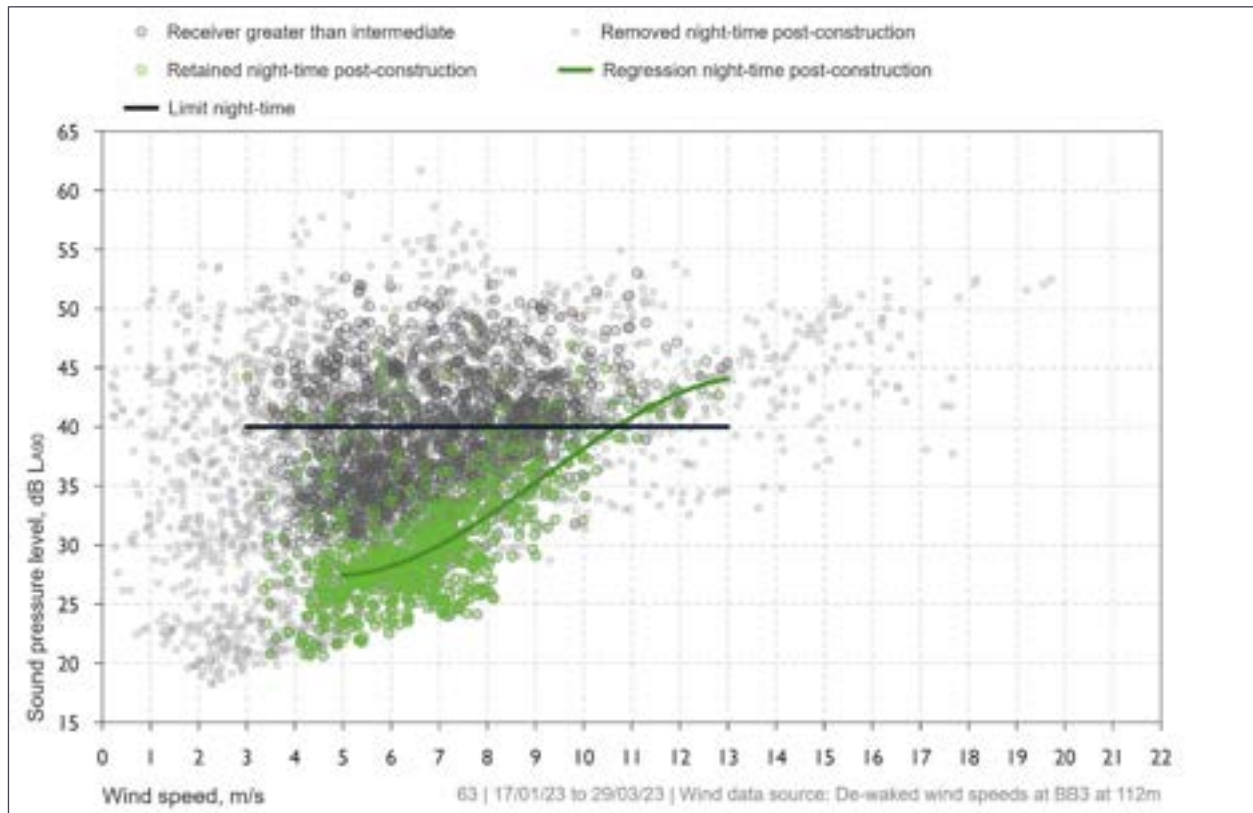


Figure 61: Receiver 63 using intermediate 63i as an additional filter – post-construction noise levels and noise limits versus site wind speed – night-time



N5 Receiver 63 tonality assessment

Figure 62: Receiver 63 tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

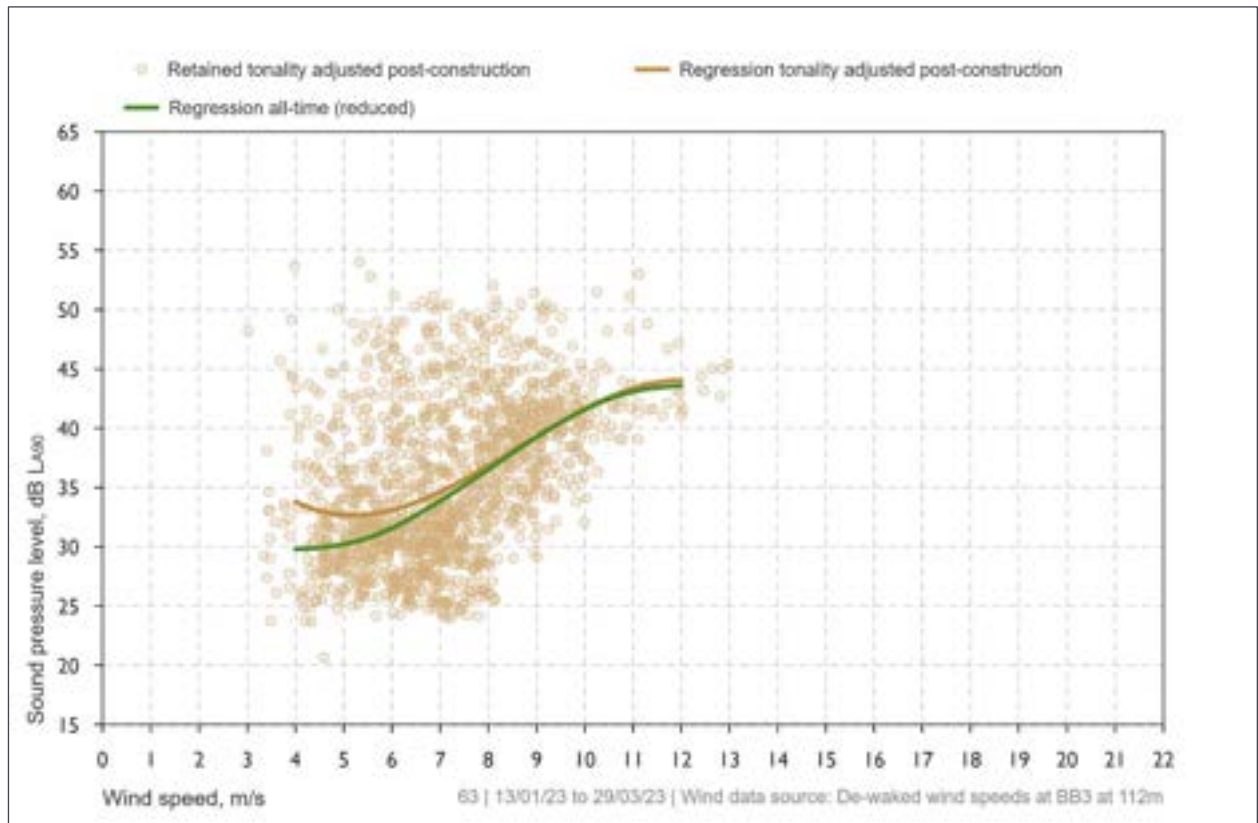


Table 71: Receiver 63 tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	33.8	32.7	33.1	34.6	36.8	39.3	41.6	43.4	44.1	- ^[1]
Post-construction regression - no penalties	- ^[1]	29.8	30.0	31.4	33.8	36.5	39.3	41.7	43.3	43.6	- ^[1]
Penalty adjustment	- ^[1]	4.0	2.7	1.7	0.8	0.3	0.0	0.0	0.1	0.5	- ^[1]

1 Outside valid wind speed range of the regression analysis

N6 Receiver 63 compliance assessment

Table 72: Receiver 63 – compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	29.8	30.0	31.4	33.8	36.5	39.3	41.7	43.3	43.6	- ^[1]
Background noise level	- ^[1]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[1]
Background adjustment	- ^[1]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[1]
Tonality adjustment	- ^[1]	4.0	2.7	1.7	0.8	0.3	0.0	0.0	0.1	0.5	- ^[1]
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	< 33.8	< 32.7	< 33.1	< 34.6	< 36.8	< 39.3	< 41.7	< 43.4	< 44.1	- ^[1]
Noise limit	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]
Compliance margin	- ^[1]	-6.2	-7.3	-6.9	-5.4	-3.2	-0.7	1.7 ^{4}	3.4 ^{4}	4.1 ^{4}	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location - the background adjustment is therefore not available for this location

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Inconclusive outcomes due to background noise variation – see supplementary assessment and assessment of night-time data

Table 73: Receiver 63 – compliance assessment, dB LA90 – night-time

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- [1]	- [1]	27.4	28.2	30.0	32.4	35.3	38.2	40.8	42.9	44.1
Background noise level	- [1]	- [1]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]
Background adjustment	- [1]	- [1]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]	- [2]
Tonality adjustment	- [1]	4.0	2.7	1.7	0.8	0.3	0.0	0.0	0.1	0.5	- [1]
Estimated tonality adjusted wind farm noise level [3]	- [1]	- [1]	< 30.1	< 29.9	< 30.8	< 32.7	< 35.3	< 38.2	< 40.9	< 43.4	- [1]
Noise limit	- [1]	- [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Compliance margin	- [1]	- [1]	-9.9	-10.1	-9.2	-7.3	-4.7	-1.8	0.9 [4]	3.4 [4]	- [1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location - the background adjustment is therefore not available for this location

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Inconclusive outcomes due to background noise variation – see supplementary assessment and assessment of night-time data

Table 74: Receiver 63 – compliance assessment based on extrapolation of intermediate 63i, dB LA90 – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 63i	24.8	26.1	27.4	28.9	30.5	32.2	33.8	35.5	37.0	38.5	39.9
Background noise level intermediate 63i	21.2	21.8	22.4	23.1	23.8	24.5	25.2	26.0	26.9	27.9	28.9
Background adjustment intermediate 63i	-2.5	-2.0	-1.7	-1.3	-1.0	-0.8	-0.6	-0.5	-0.4	-0.4	-0.4
Extrapolation correction	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Tonality adjustment receiver 63	- ^[1]	4.0	2.7	1.7	0.8	0.3	0.0	0.0	0.1	0.5	- ^[1]
Estimated tonality adjusted wind farm noise level receiver 63	- ^[1]	27.3	27.6	28.5	29.5	30.9	32.4	34.2	35.9	37.8	- ^[1]
Noise limit receiver 63 ^[2]	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]
Compliance margin	- ^[1]	-12.7	-12.4	-11.5	-10.5	-9.1	-7.6	-5.8	-4.1	-2.2	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location – the background dependent component of the noise limits for this receiver are therefore not defined

APPENDIX O RECEIVER 69

O1 Receiver 69 location data

Table 75: Receiver 69 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	718535	5793693
Noise monitoring location	718552	5793664

Figure 63: Receiver 69 aerial view – dwelling and noise monitor locations

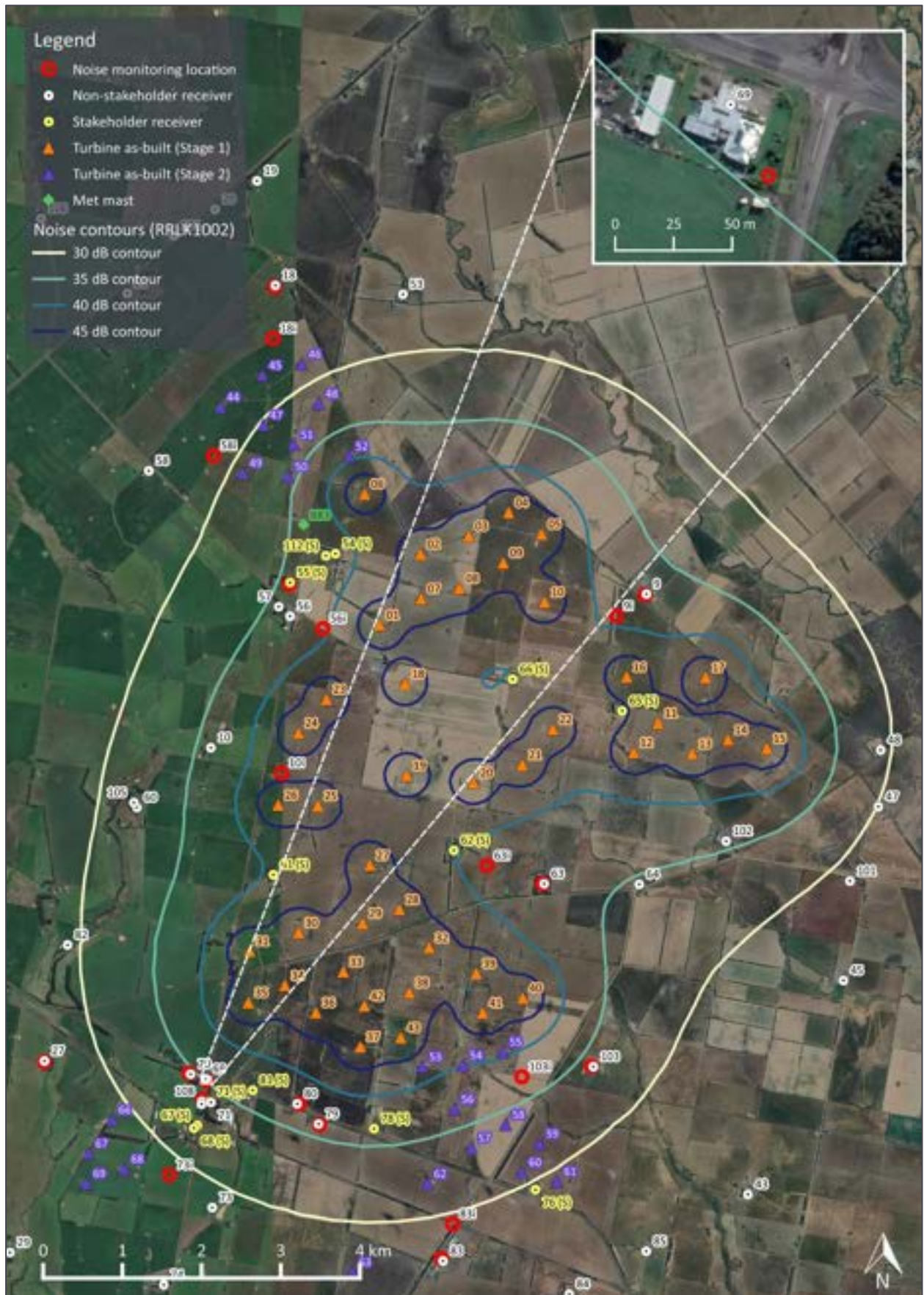
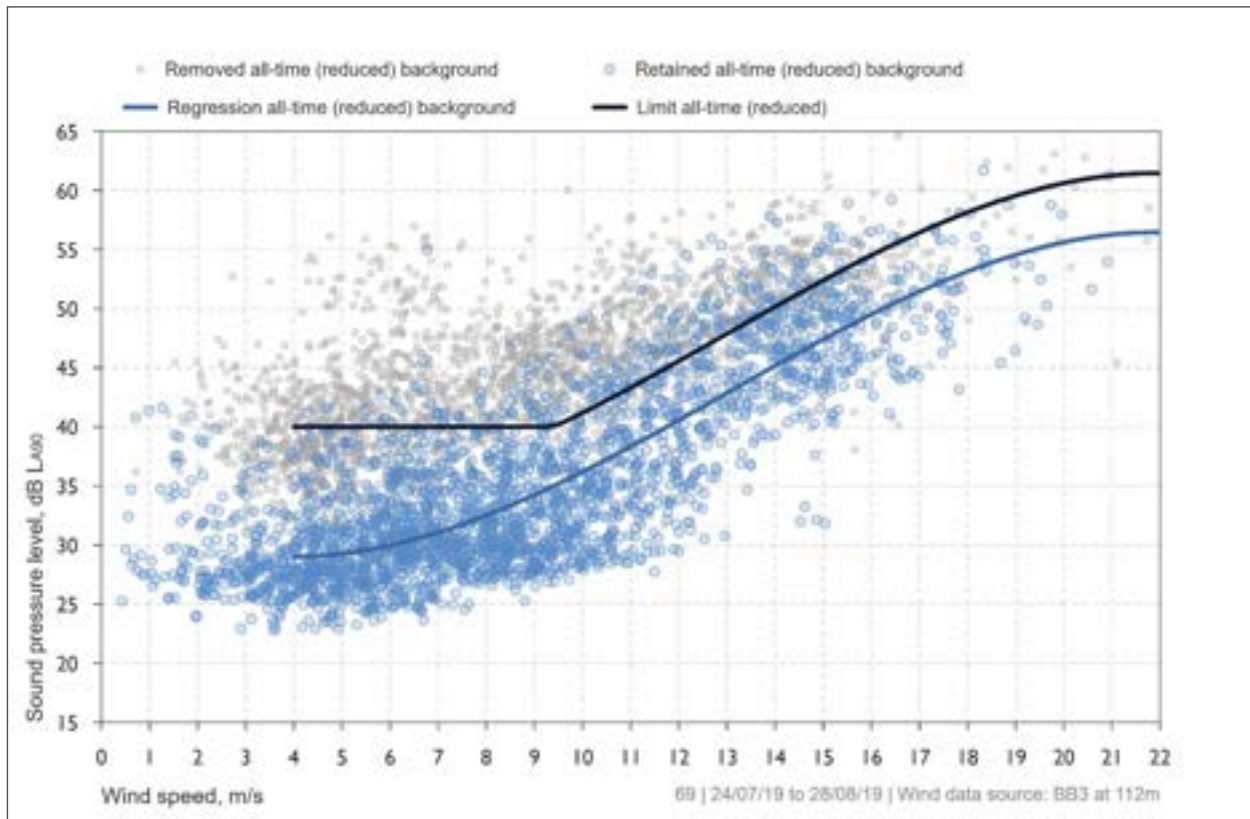


Table 76: Receiver 69 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

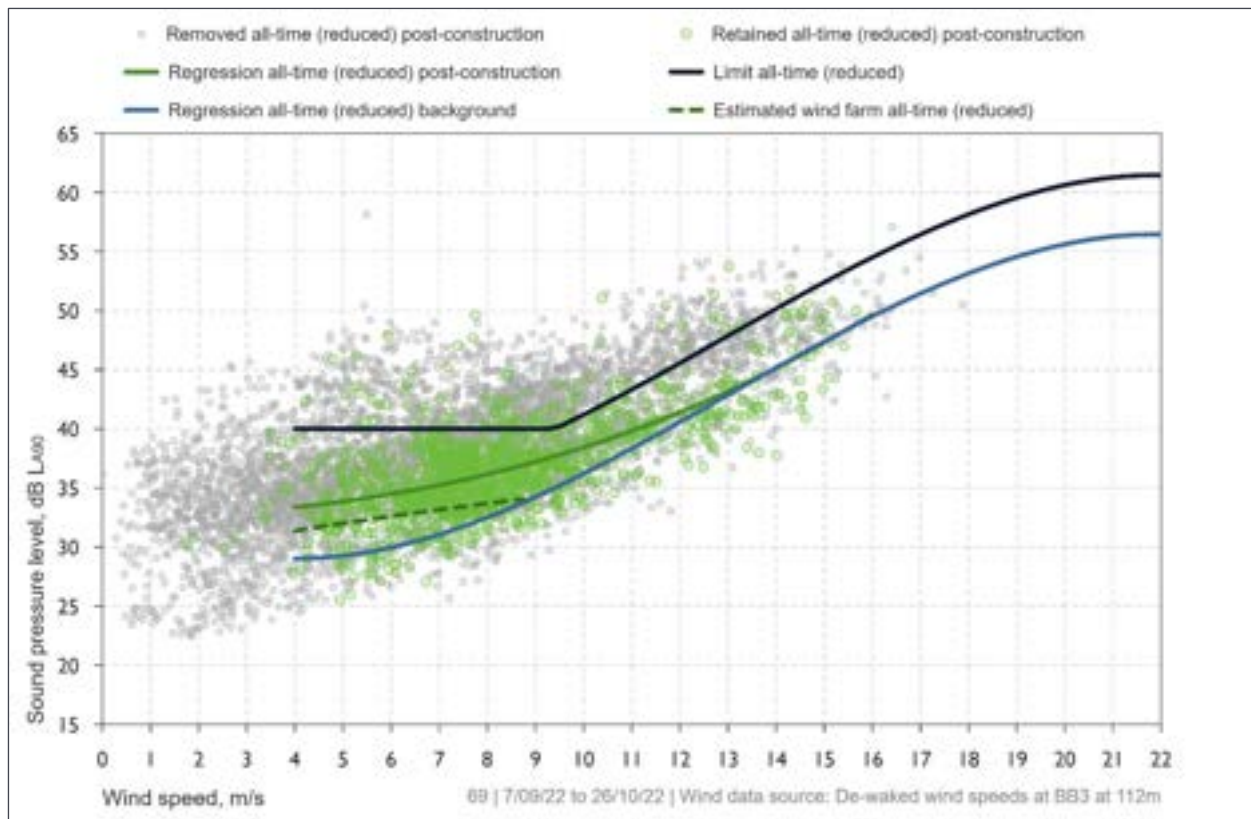
O2 Receiver 69 background noise data

Figure 64: Receiver 69 - derived background noise levels and noise limit – all-time (reduced)



O3 Receiver 69 post-construction measurement data – all wind speeds

Figure 65: Receiver 69 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



O4 Receiver 69 post-construction measurement data summary – assessment wind speeds

Table 77: Receiver 69 assessment data summary – number of data points

Data points	All-time (reduced)
Collected	6016
Removed	4795
Retained	1221

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 78.

Table 78: Receiver 69 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	2502
Rainfall	1689
Extraneous noise	555
Wind farm operations curtailed	2948
Wind speeds outside assessment range	922

Figure 66: Receiver 69 – post-construction noise levels and wind speed time history

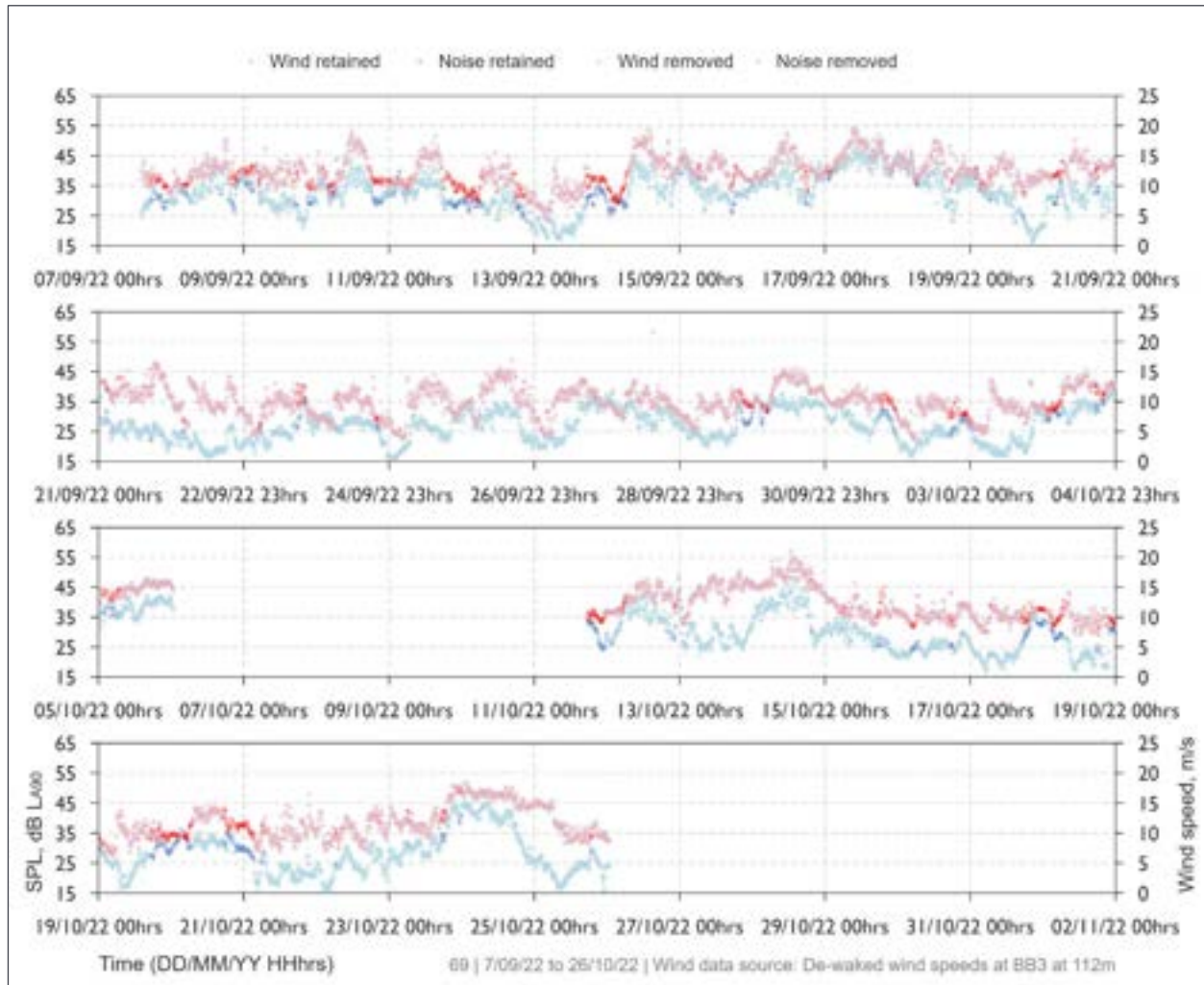
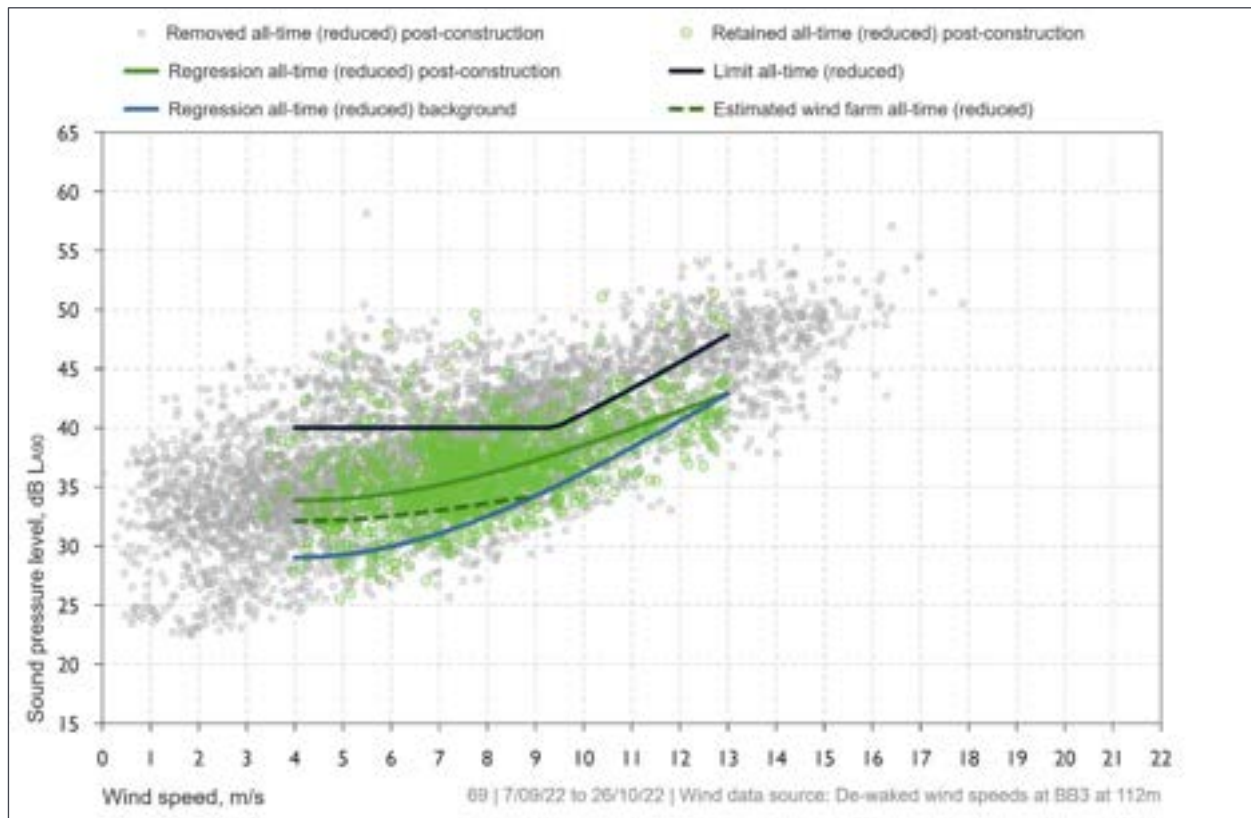


Figure 67: Receiver 69 – post-construction noise levels and noise limits versus site wind – all-time (reduced)



O5 Receiver 69 tonality assessment

Figure 68: Receiver 69 – tonality-adjusted total-construction noise levels versus site wind speed – all-time (reduced)

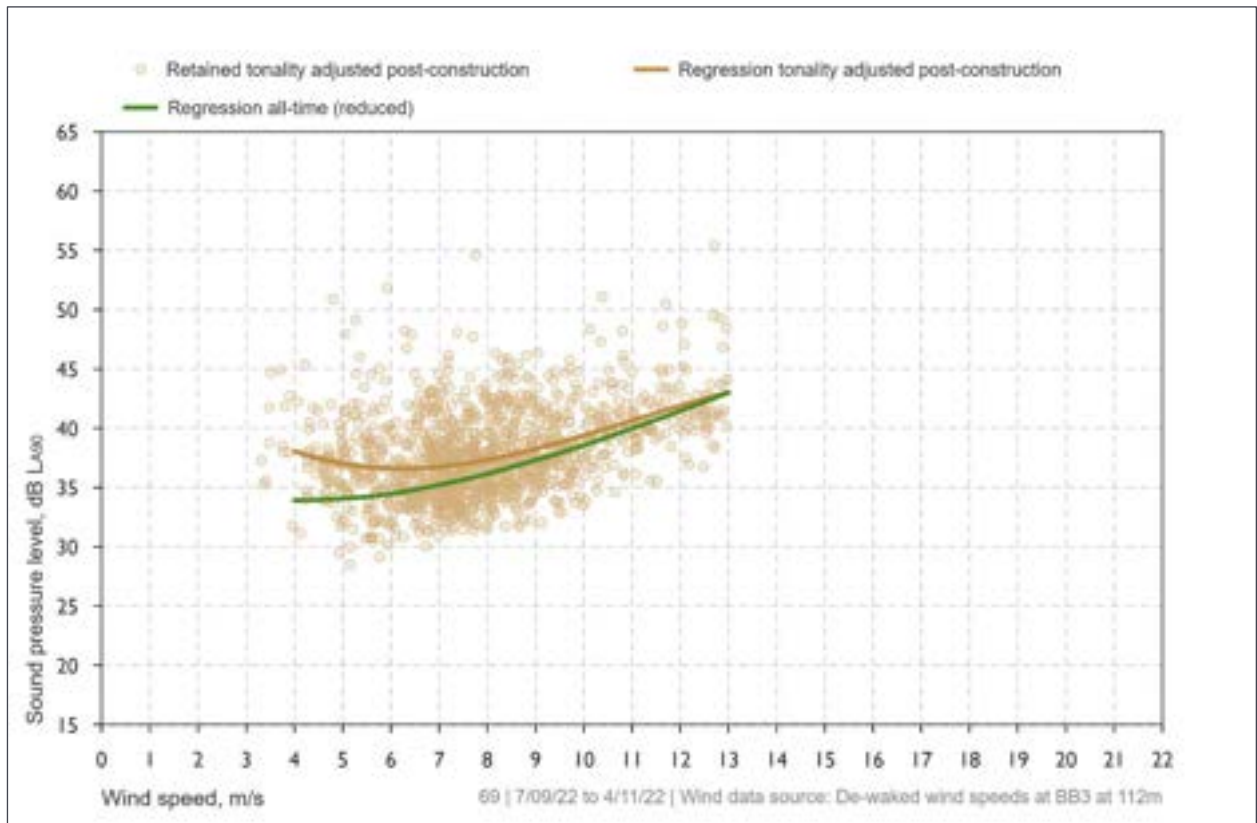


Table 79: Receiver 69 – tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	38.1	37.0	36.6	36.7	37.3	38.2	39.4	40.6	41.9	43.0
Post-construction regression - no penalties	- ^[1]	33.9	34.0	34.4	35.2	36.1	37.3	38.5	40.0	41.4	43.0
Penalty adjustment	- ^[1]	4.2	3.0	2.2	1.5	1.2	0.9	0.9	0.6	0.5	0.0

1 Outside valid wind speed range of the regression analysis

O6 Receiver 69 compliance assessment

Table 80: Receiver 69 – compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	33.9	34.0	34.4	35.2	36.1	37.3	38.5	40.0	41.4	43.0
Background noise level	- ^[1]	29.0	29.3	30.0	31.1	32.5	34.2	36.2	38.3	40.6	42.9
Background adjustment	- ^[1]	-1.7	-1.8	-2.0	-2.1	-2.5	-2.9	- ^[2]	- ^[2]	- ^[2]	- ^[2]
Tonality adjustment	- ^[1]	4.2	3.0	2.2	1.5	1.2	0.9	0.9	0.6	0.5	0.0
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	36.4	35.2	34.6	34.6	34.8	35.3	< 39.4	< 40.6	< 41.9	< 43
Noise limit	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	41.2	43.3	45.6	47.9
Compliance margin	- ^[1]	-3.6	-4.8	-5.4	-5.4	-5.2	-4.7	-1.8	-2.7	-3.7	-4.9

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

APPENDIX P RECEIVER 70

P1 Receiver 70 location data

Table 81: Receiver 70 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	718346	5793752
Noise monitoring location	718327	5793766

Figure 69: Receiver 70 aerial view – dwelling and noise monitor locations

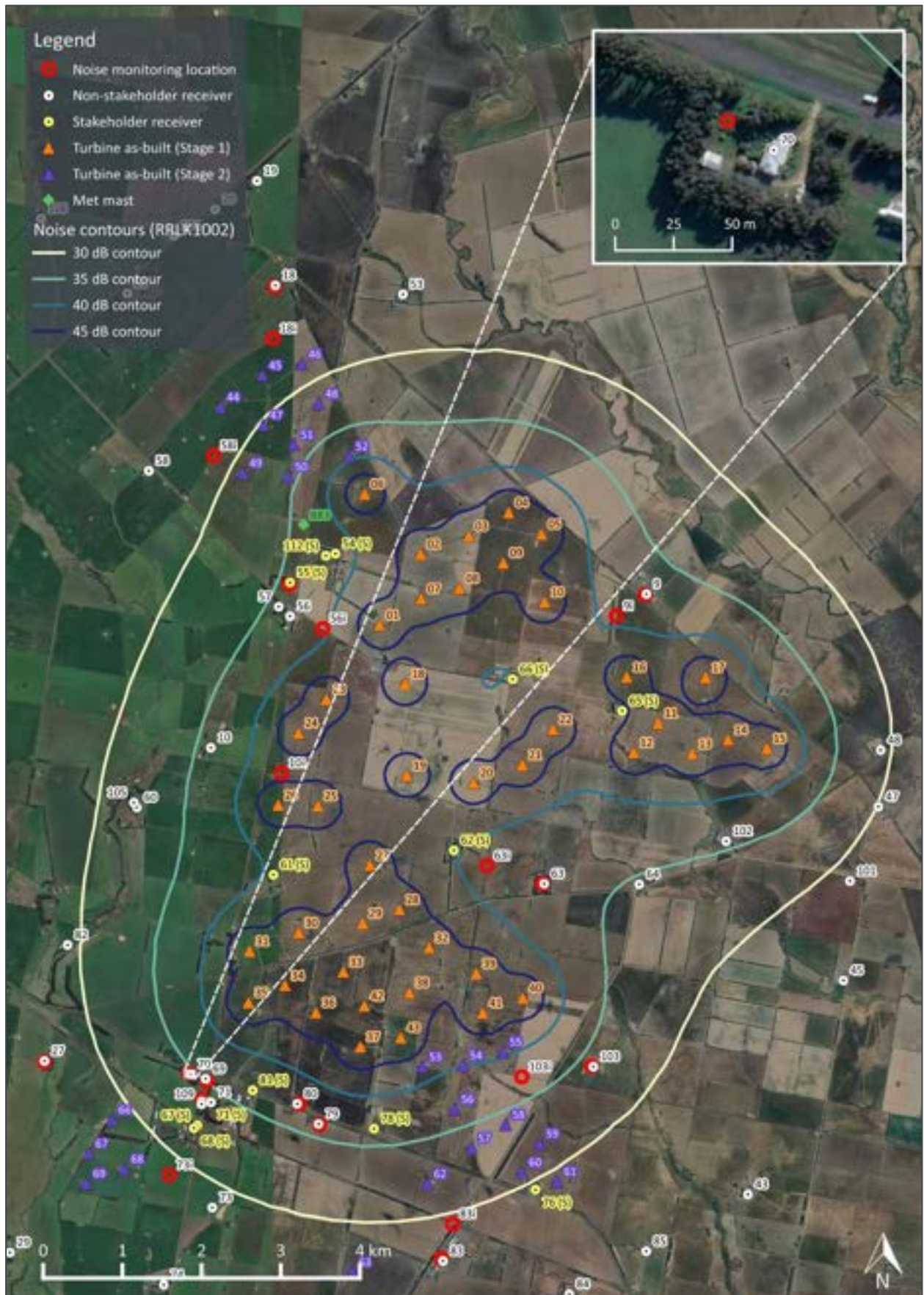
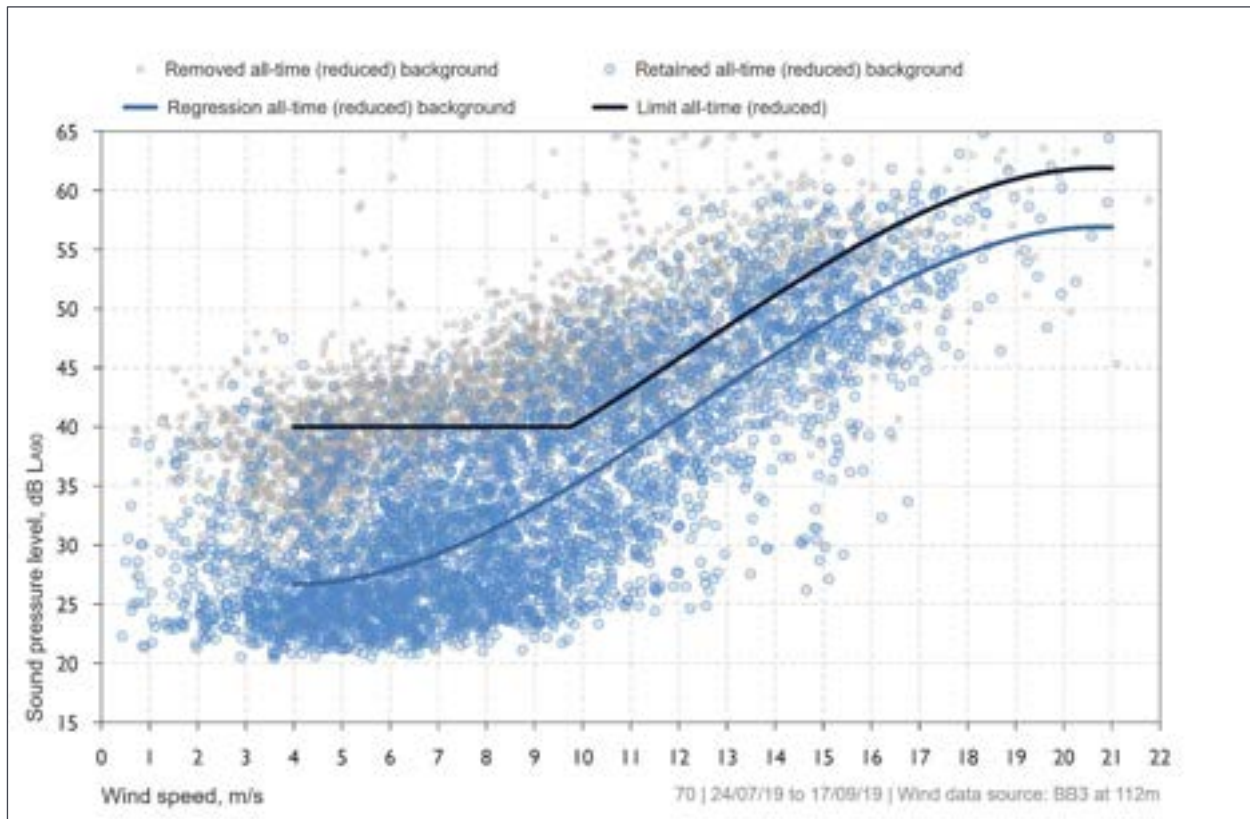


Table 82: Receiver 70 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

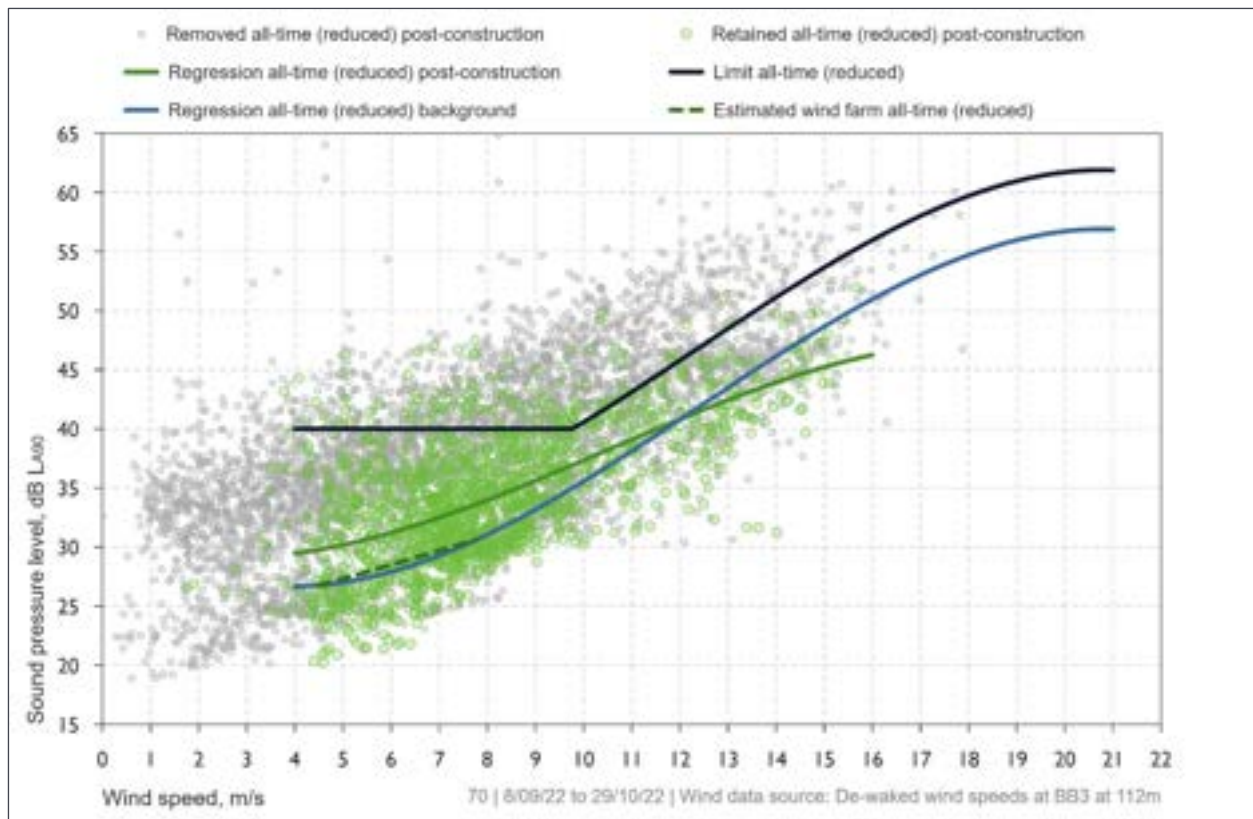
P2 Receiver 70 background noise data

Figure 70: Receiver 70 - derived background noise levels and noise limit – all-time (reduced)



P3 Receiver 70 post-construction measurement data – all wind speeds

Figure 71: Receiver 70 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



P4 Receiver 70 post-construction measurement data summary – assessment wind speeds

Table 83: Receiver 70 assessment data summary – number of data points

Data points	All-time (reduced)
Collected	6102
Removed	4609
Retained	1493

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 84.

Table 84: Receiver 9 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	2551
Rainfall	1512
Extraneous noise	118
Wind farm operations curtailed	2968
Wind speeds outside assessment range	997

Figure 72: Receiver 70 post-construction noise levels and wind speed time history

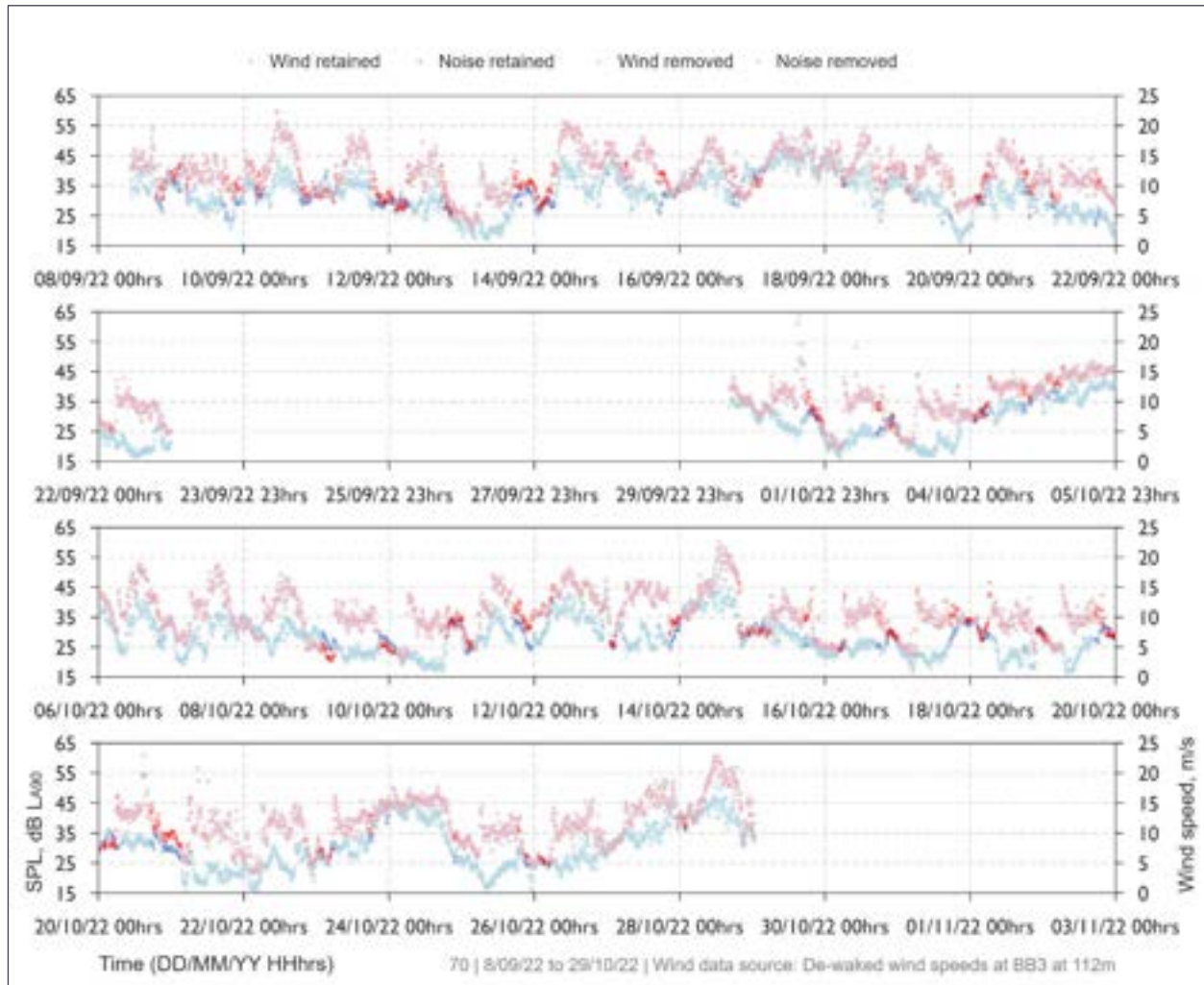
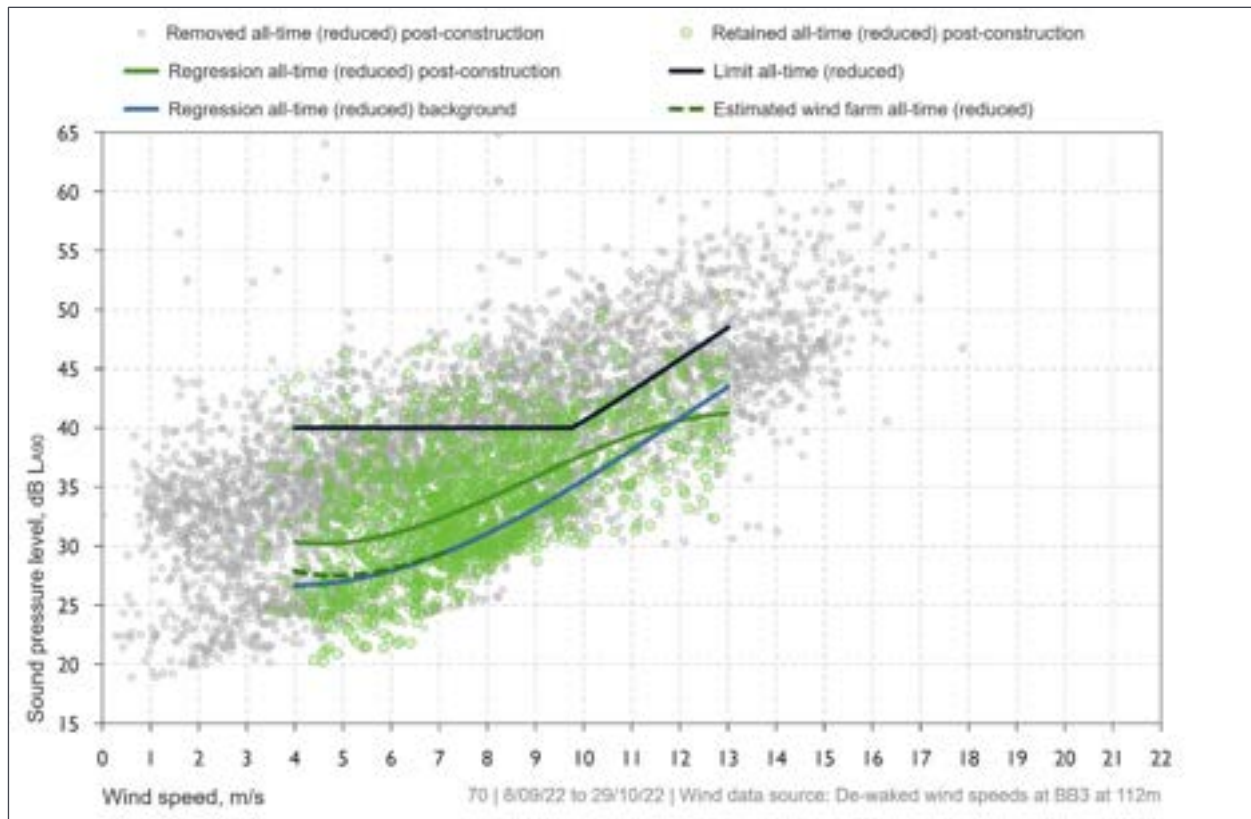


Figure 73: Receiver 70 – post-construction noise levels and noise limits versus site wind speed, dB L_{A90} – all-time (reduced)



P5 Receiver 70 tonality assessment

Figure 74: Receiver 70 – tonality adjusted total-construction noise levels versus site wind speed, dB LA90

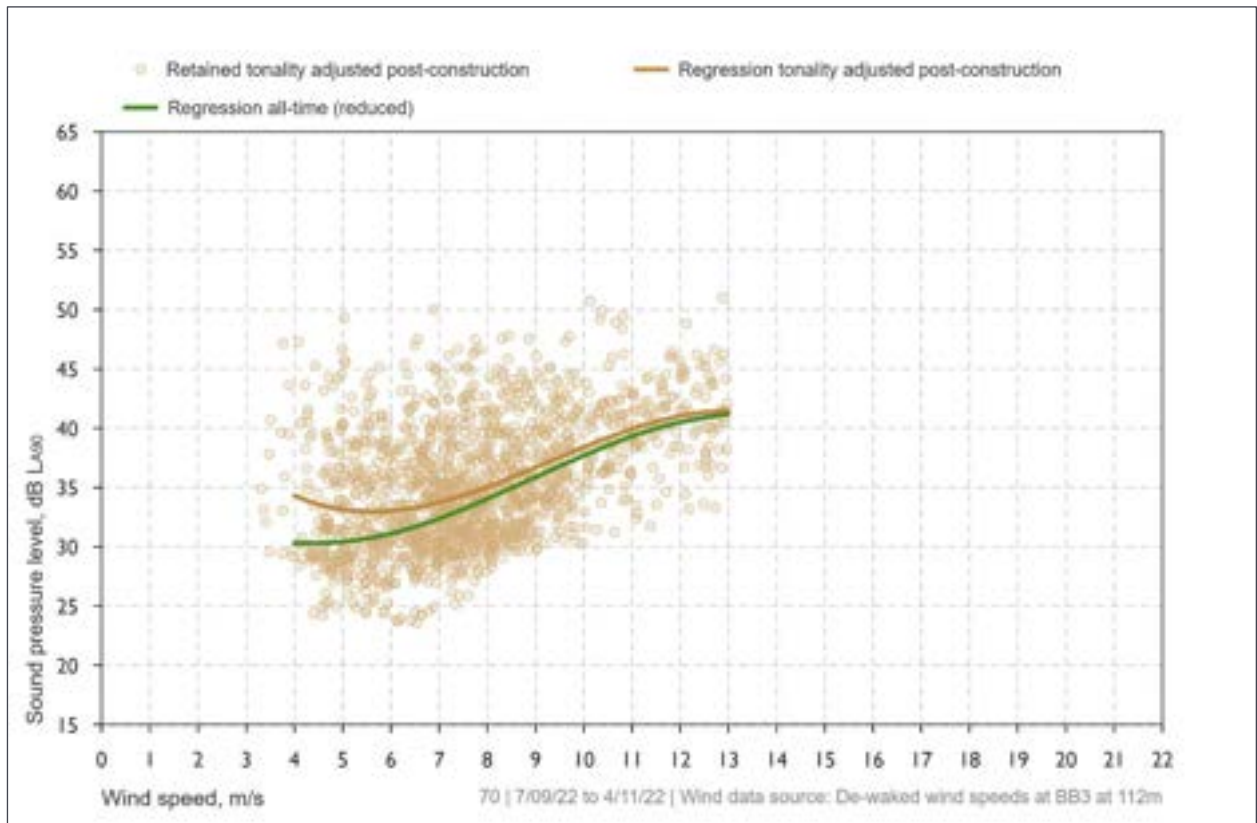


Table 85: Receiver 70 tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	34.3	33.1	33.0	33.7	35.0	36.7	38.4	39.9	41.0	41.4
Post-construction regression - no penalties	- ^[1]	30.3	30.3	31.0	32.3	34.0	35.9	37.7	39.4	40.6	41.2
Penalty adjustment	- ^[1]	4.0	2.8	2.0	1.4	1.0	0.8	0.7	0.5	0.4	0.2

1 Outside valid wind speed range of the regression analysis

P6 Receiver 70 compliance assessment

Table 86: Receiver 70 – compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	30.3	30.3	31.0	32.3	34.0	35.9	37.7	39.4	40.6	41.2
Background noise level	- ^[1]	26.7	27.0	27.9	29.3	31.1	33.2	35.6	38.1	40.8	43.5
Background adjustment	- ^[1]	-2.5	-2.7	-2.9	-3.0	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]
Tonality adjustment	- ^[1]	4.0	2.8	2.0	1.4	1.0	0.8	0.7	0.5	0.4	0.2
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	31.8	30.4	30.1	30.7	< 35	< 36.7	< 38.4	< 39.9	< 41.0	< 41.4
Noise limit	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.6	43.1	45.8	48.5
Compliance margin	- ^[1]	-8.2	-9.6	-9.9	-9.3	-5.0	-3.3	-2.2	-3.2	-4.8	-7.1

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

APPENDIX Q RECEIVER 79

Q1 Receiver 79 location data

Table 87: Receiver 79 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	719983	5793140
Noise monitoring location	719976	5793114

Figure 75: Receiver 79 aerial view – dwelling and noise monitor locations

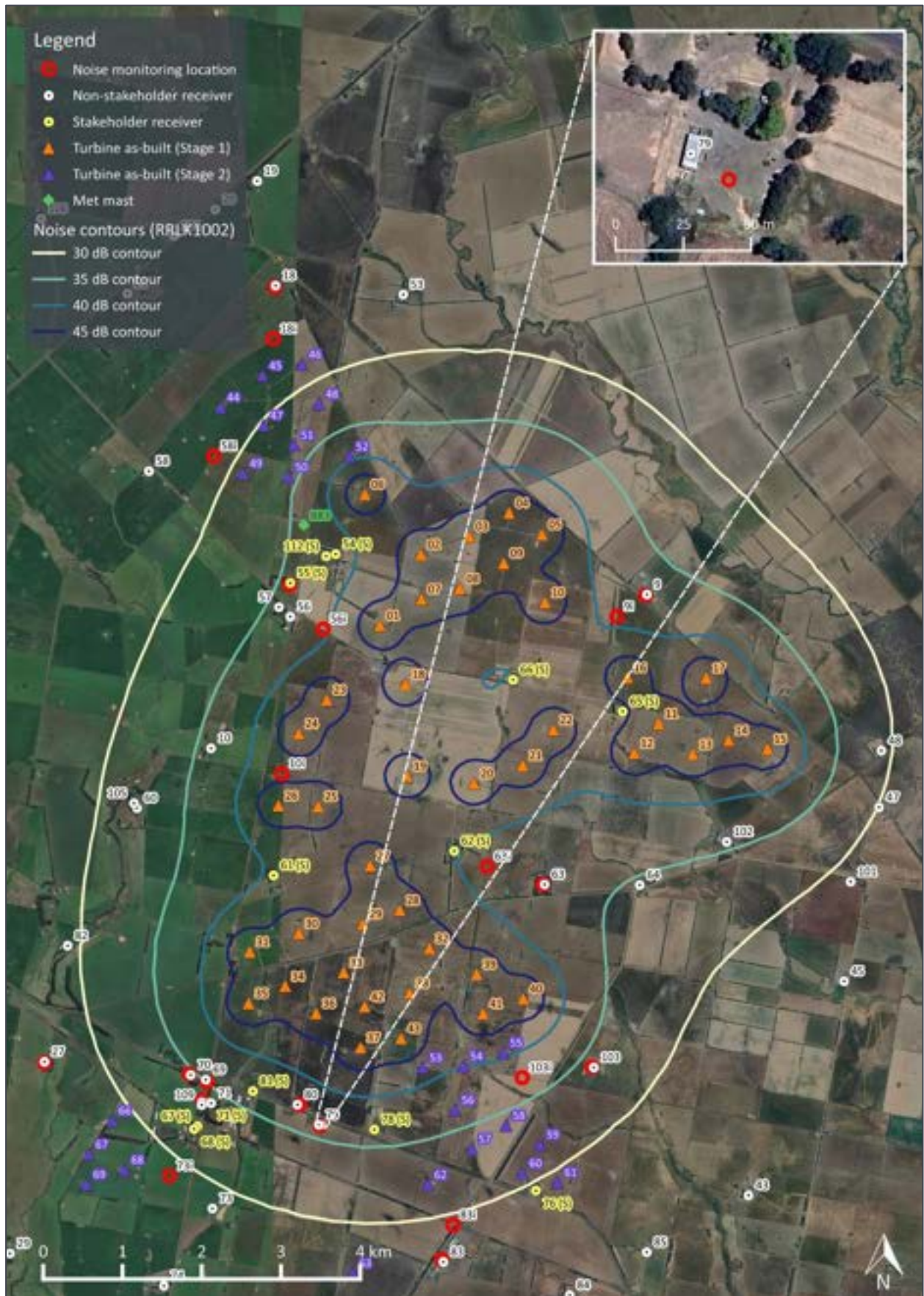


Table 88: Receiver 79 monitor installation photos

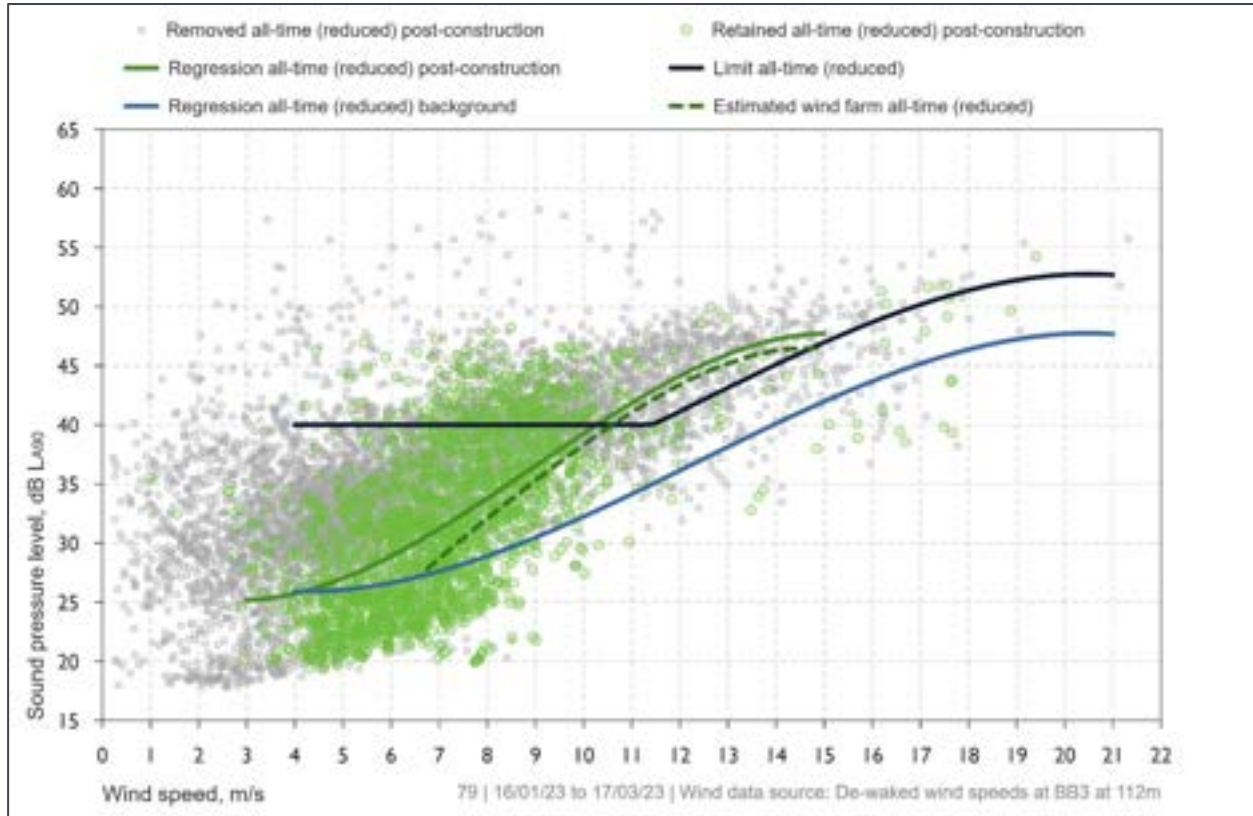
Looking North	Looking East
	
Looking South	Looking West
	

Q2 Receiver 79 background noise data

Representative background data sourced from nearby receiver 80. See Section R2.

Q3 Receiver 79 post-construction measurement data – all wind speeds

Figure 76: Receiver 79 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



Q4 Receiver 79 post-construction measurement data summary – assessment wind speeds

Table 89: Receiver 79 assessment data summary – number of data points

Data points	All-time (reduced)
Collected	7830
Removed	5701
Retained	2129

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 90.

Table 90: Receiver 79 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3263
Rainfall	440
Extraneous noise	954
Wind farm operations curtailed	3937
Wind speeds outside assessment range	1024

Figure 77: Receiver 79 post-construction noise levels and wind speed time history

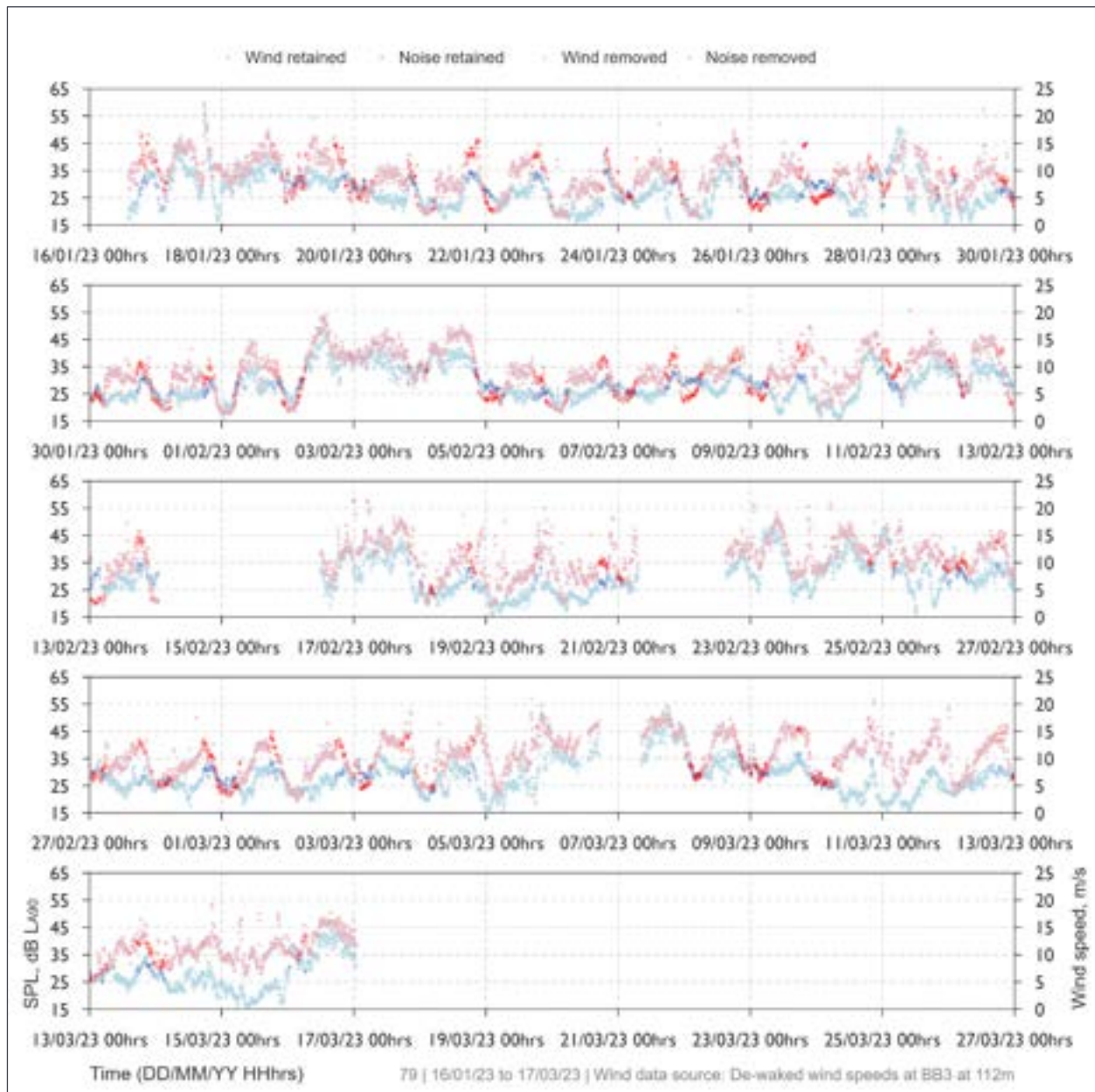


Figure 78: Receiver 79 – post-construction noise levels and noise limits versus site wind speed – all-time (reduced)

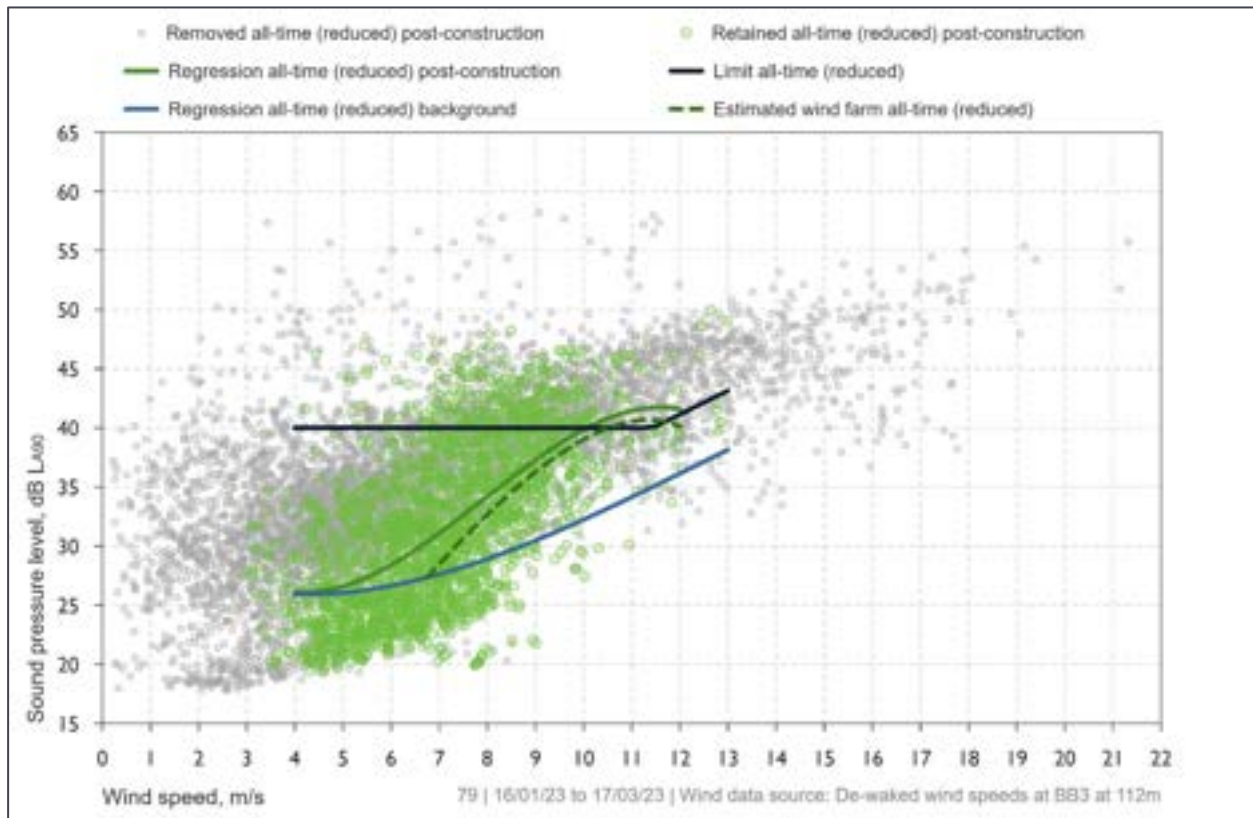
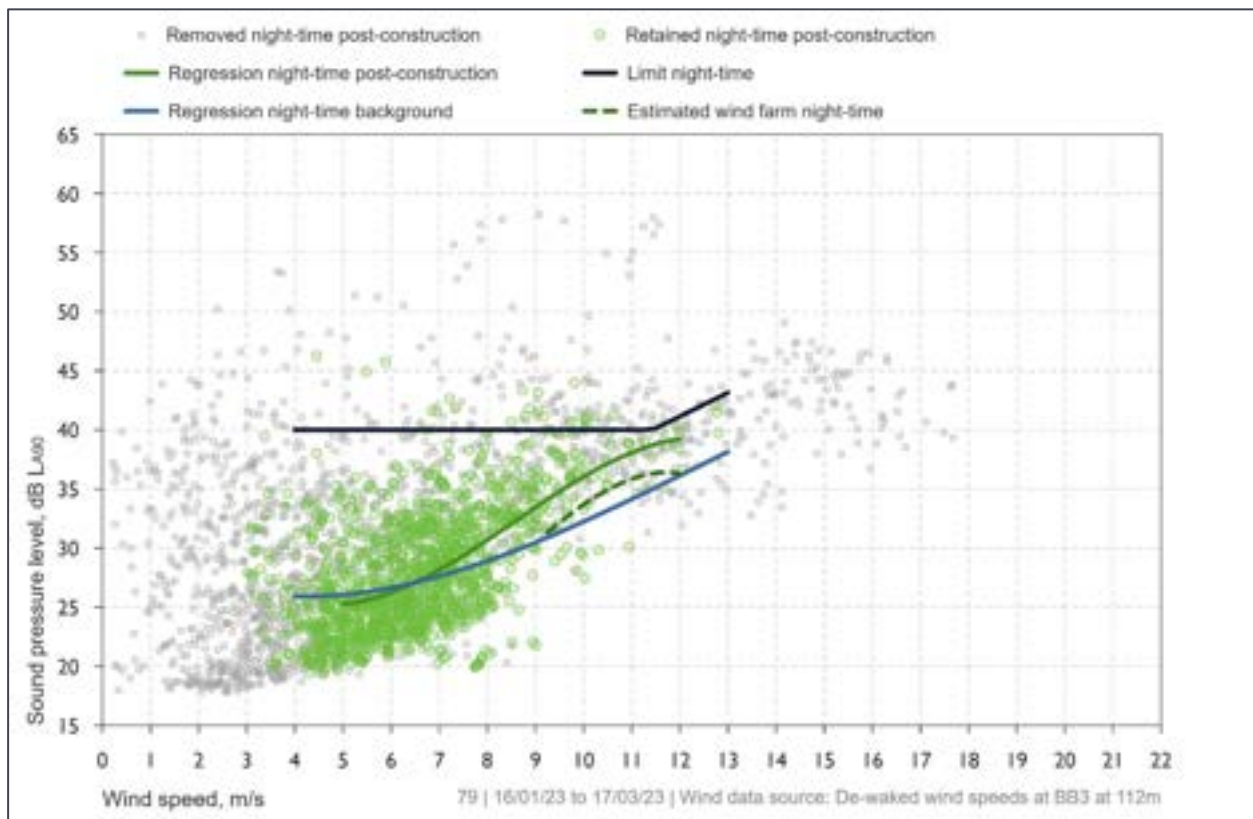


Figure 79: Receiver 79 – post-construction noise levels and noise limits versus site wind speed – night period data



Q5 Receiver 79 supplementary analysis

The night-period measurement data presented in Figure 79 indicates that the regression line of the total A-weighted noise level is below the noise limit line for the assessment wind speeds. While the noise level attributable to the operation of the wind farm cannot be estimated from this data, the results are sufficient to conclude that the contribution of the wind farm at receiver 79 was below the base (minimum) noise limit of 40 dB L_{A90} during the night period.

The data for the night period is sufficient to conclude that the noise levels of the wind farm during the all-time (reduced) period were also below the 40 dB L_{A90} base noise limit. This is because the wind farm noise contribution during the all-time and night-time periods would be similar for the following reasons:

- The wind direction trends for the all-time and night periods of the survey were equivalent for noise assessment purposes (i.e. the differences between the wind direction trends of the all-time (reduced) and night-time were not sufficient to cause material changes in wind farm noise levels between the periods)
- The assessment is referenced to hub height wind speeds, meaning that variations in wind shear between the day and night period do not translate to material changes in wind turbine noise levels for a given wind speed (i.e. for an assessment referenced to hub height wind speeds, changes in wind shear will mainly cause a change in the wind speed occurring around the dwelling and, in turn, the background noise associated with wind disturbance of vegetation).

Notwithstanding the above, in accordance with the NCTP, supplementary analysis procedures as specified in the NCTP were used to investigate the wind farm's contribution to the total measured noise levels. The relevant supplementary procedures and observations are summarised in Table 91.

Table 91: Receiver 79 – supplementary analysis summary

Procedure	Findings
Comparison of data trends for upwind and downwind conditions	See Figure 80 and Figure 81 for the comparisons for all-time (reduced) and night-time respectively. No indication of distinct difference between the noise levels measured under downwind and upwind conditions.
Noise level versus wind speed profile review	See Figure 82. The profile indicates a greater rate of increase in noise levels above 9 m/s than occurs at locations nearer to the wind farm. This indicates background noise influences rather than wind farm noise at high wind speeds.
Data filtering using intermediate measurement data	No intermediate noise monitoring location associated with this receiver
Extrapolation of intermediate data	No intermediate noise monitoring location associated with this receiver

Figure 80: Receiver 79 – upwind and downwind post-construction noise levels and noise limits versus site wind speed – all-time (reduced) period

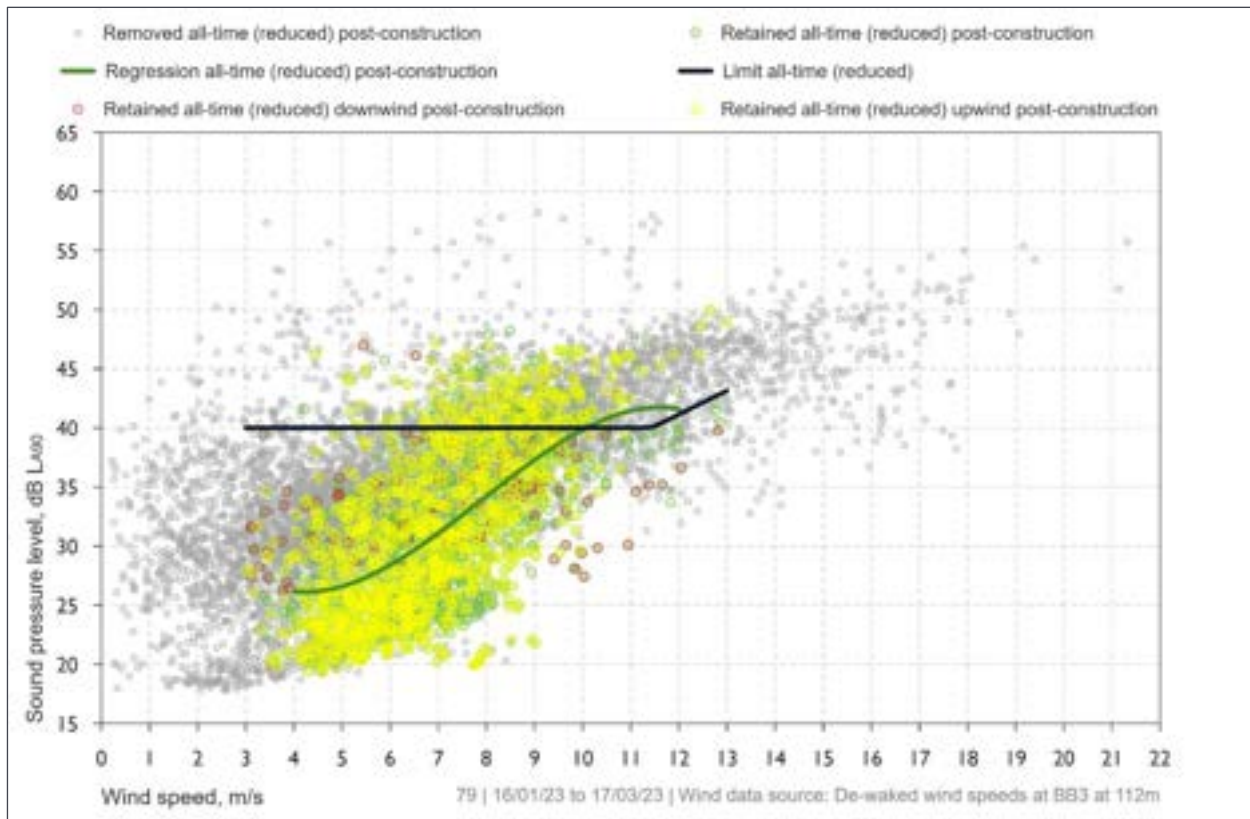


Figure 81: Receiver 79 – upwind and downwind post-construction noise levels and noise limits versus site wind speed – night-time period

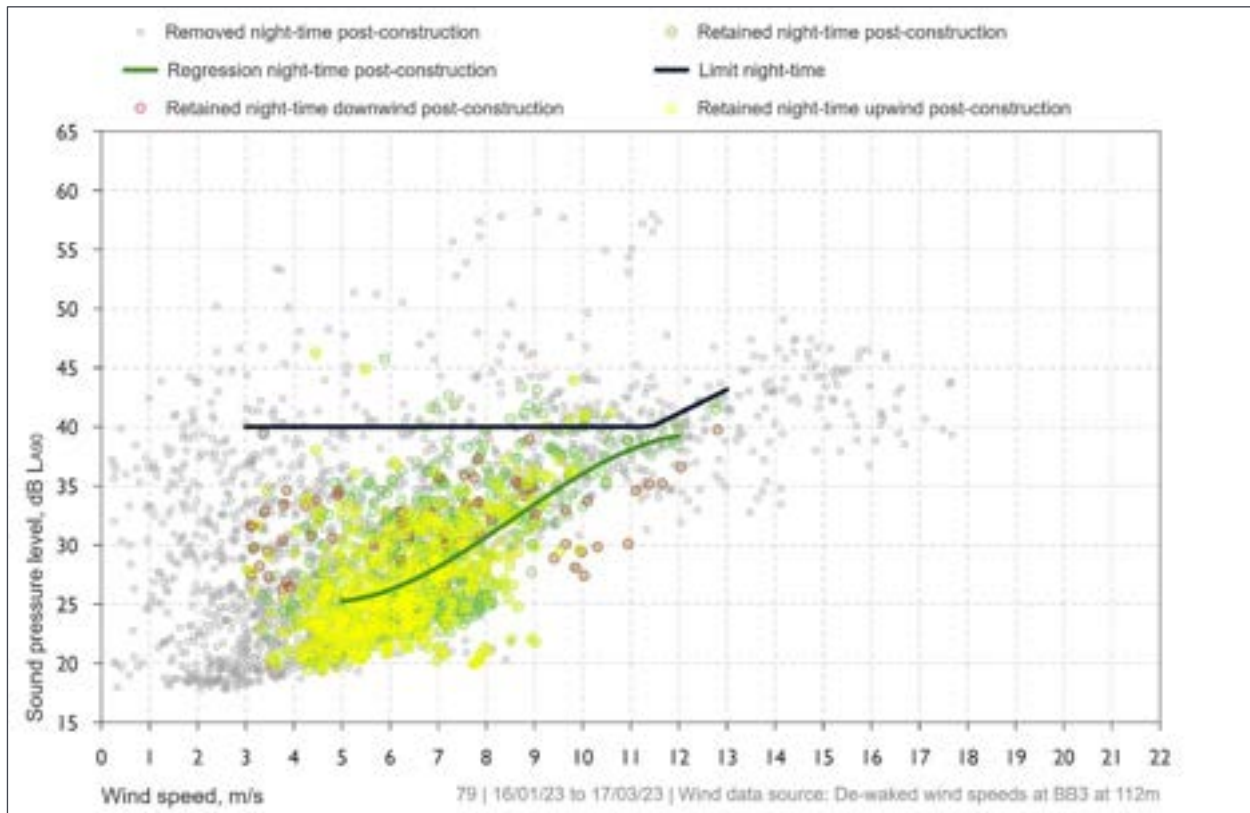
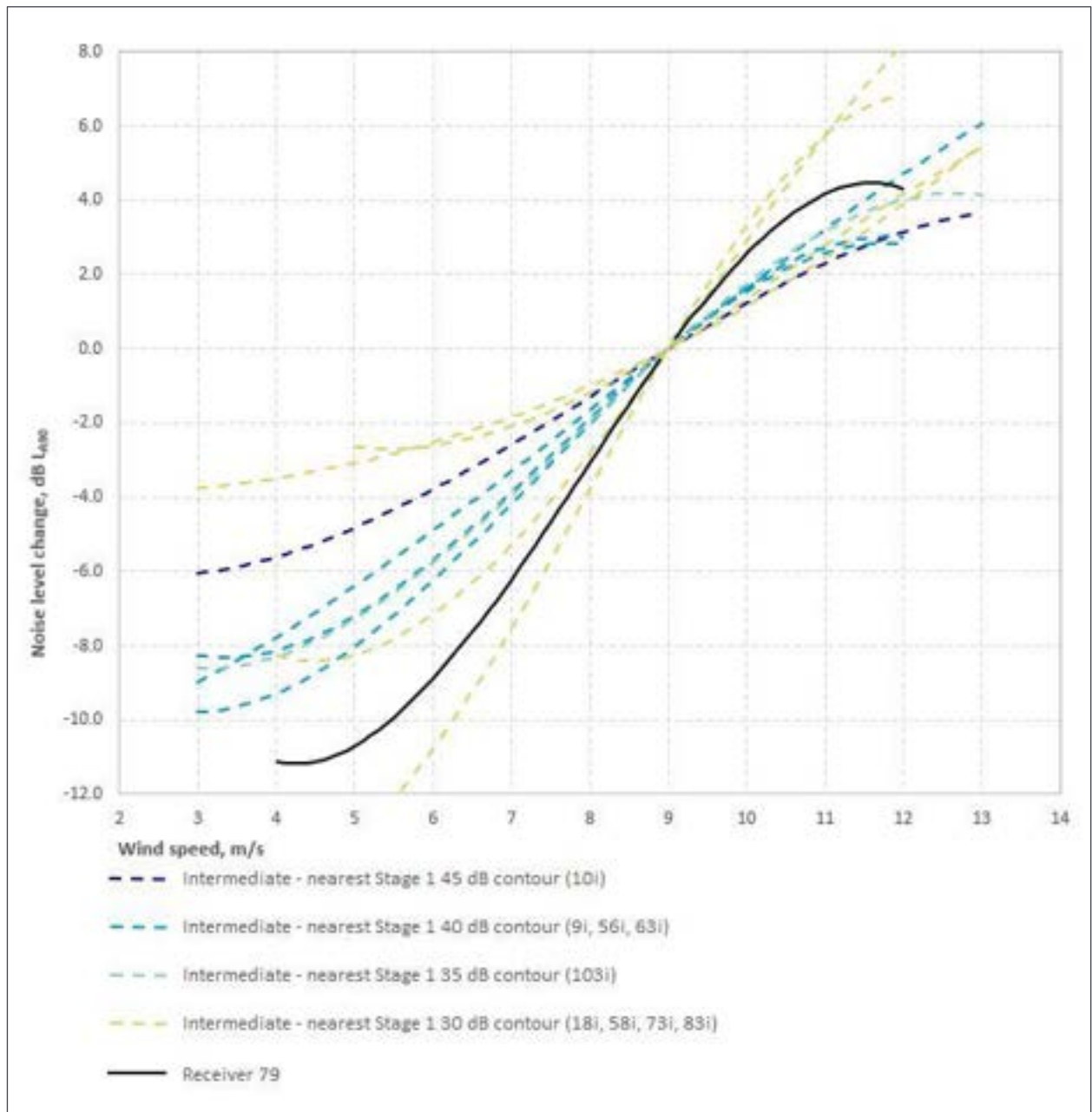


Figure 82: Change in noise level with wind speed, receiver 79 compared to intermediate locations – all-time (reduced)



Q6 Receiver 79 tonality assessment

Figure 83: Receiver 79 – tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

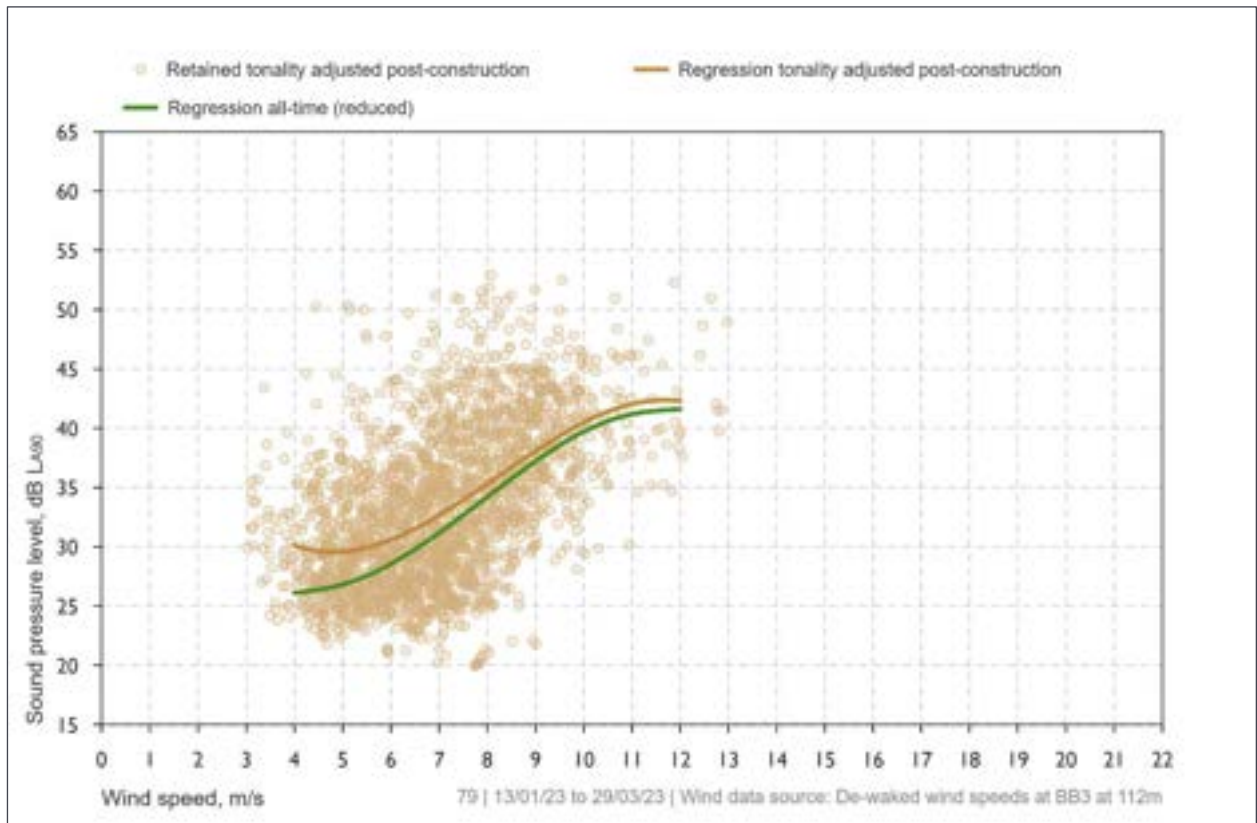


Table 92: Receiver 79 tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	30.1	29.6	30.6	32.7	35.3	38.1	40.5	42.0	42.3	- ^[1]
Post-construction regression - no penalties	- ^[1]	26.1	26.6	28.4	31.1	34.2	37.3	39.9	41.4	41.6	- ^[1]
Penalty adjustment	- ^[1]	4.0	3.0	2.2	1.6	1.1	0.8	0.6	0.6	0.7	- ^[1]

1 Outside valid wind speed range of the regression analysis

Q7 Receiver 79 compliance assessment

Table 93: Receiver 79 – compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	26.1	26.6	28.4	31.1	34.2	37.3	39.9	41.4	41.6	- ^[1]
Background noise level receiver 80	- ^[1]	25.9	26.1	26.6	27.6	28.9	30.5	32.2	34.1	36.1	- ^[1]
Background adjustment	- ^[1]	- ^[2]	- ^[2]	- ^[2]	-2.6	-1.5	-1.0	-0.8	-0.9	-1.4	- ^[1]
Tonality adjustment	- ^[1]	4.0	3.0	2.2	1.6	1.1	0.8	0.6	0.6	0.7	- ^[1]
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	< 30.1	< 29.6	< 30.6	30.1	33.8	37.1	39.7	41.1	40.9	- ^[1]
Noise limit receiver 80	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.1	- ^[1]
Compliance margin	- ^[1]	-9.9	-10.4	-9.4	-9.9	-6.2	-2.9	-0.3	1.1 ^[4]	-0.2	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Inconclusive outcomes due to background noise variation – see supplementary assessment and assessment of night-time data

Table 94: Receiver 79 – compliance assessment, dB L_{A90} – assessment against all-time limit using wind turbine noise representation from night-time data

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	- ^[1]	25.3	26.2	28.2	30.7	33.4	36.0	38.1	39.2	- ^[1]
Background noise level receiver 80	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]
Background adjustment	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]
Tonality adjustment	- ^[1]	4.0	3.0	2.2	1.6	1.1	0.8	0.6	0.6	0.7	- ^[1]
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	- ^[1]	< 28.3	< 28.4	< 29.8	< 31.8	< 34.2	34.3	36.5	37.0	- ^[1]
Noise limit receiver 80	- ^[1]	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.1	- ^[1]
Compliance margin	- ^[1]	- ^[1]	-11.7	-11.6	-10.2	-8.2	-5.8	-5.7	-3.5	-4.1	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 The background noise data was not separately analysed for the night period and a background adjustment therefore cannot be calculated

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

APPENDIX R RECEIVER 80

R1 Receiver 80 location data

Table 95: Receiver 80 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	719692	5793377
Noise monitoring location	719720	5793376

Figure 84: Receiver 80 aerial view – dwelling and noise monitor locations

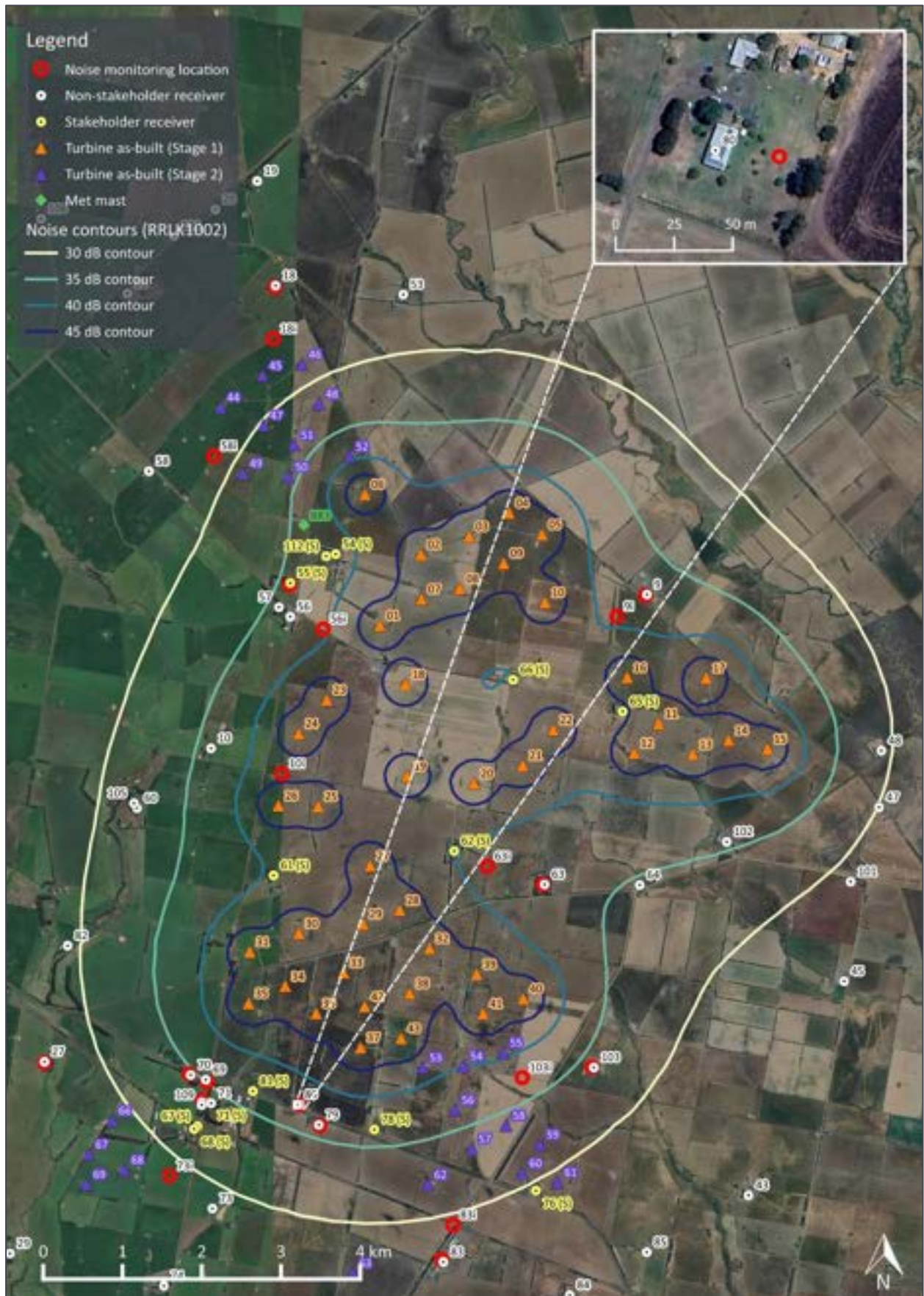
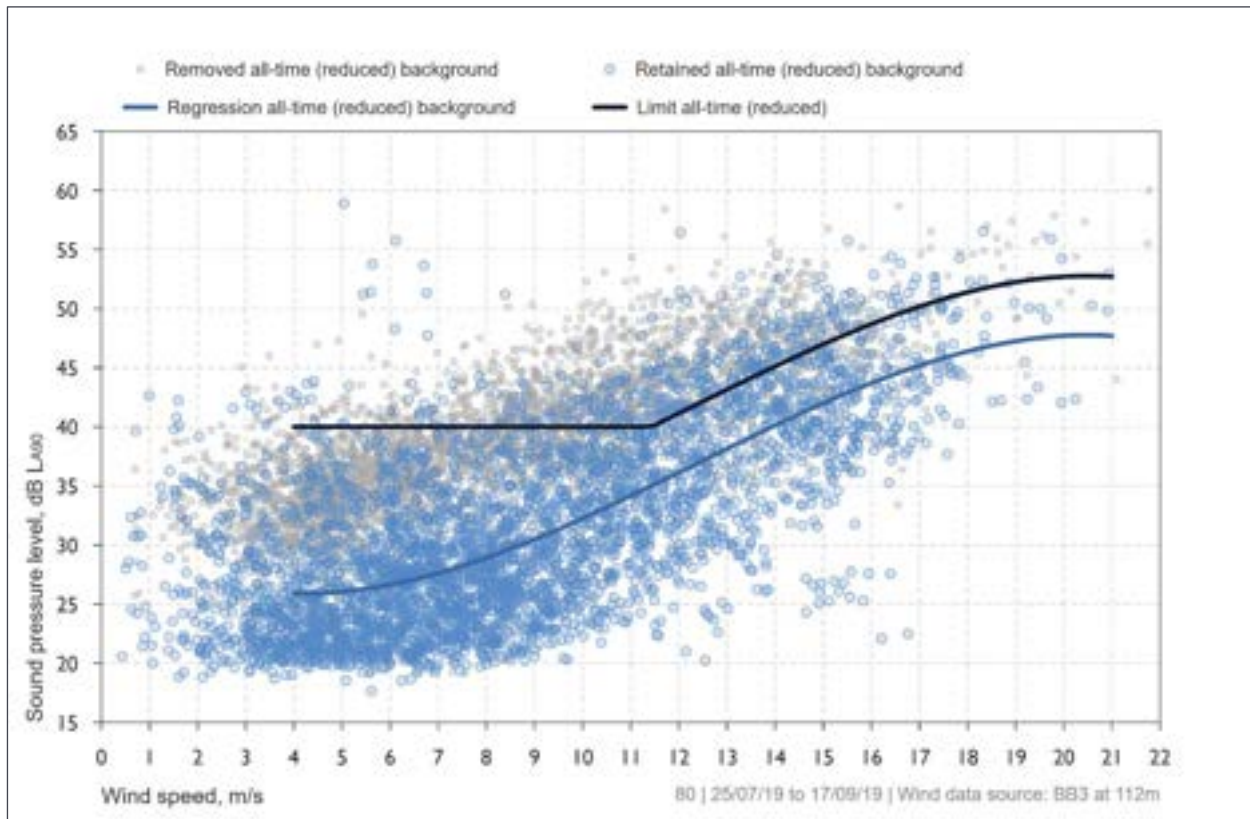


Table 96: Receiver 80 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

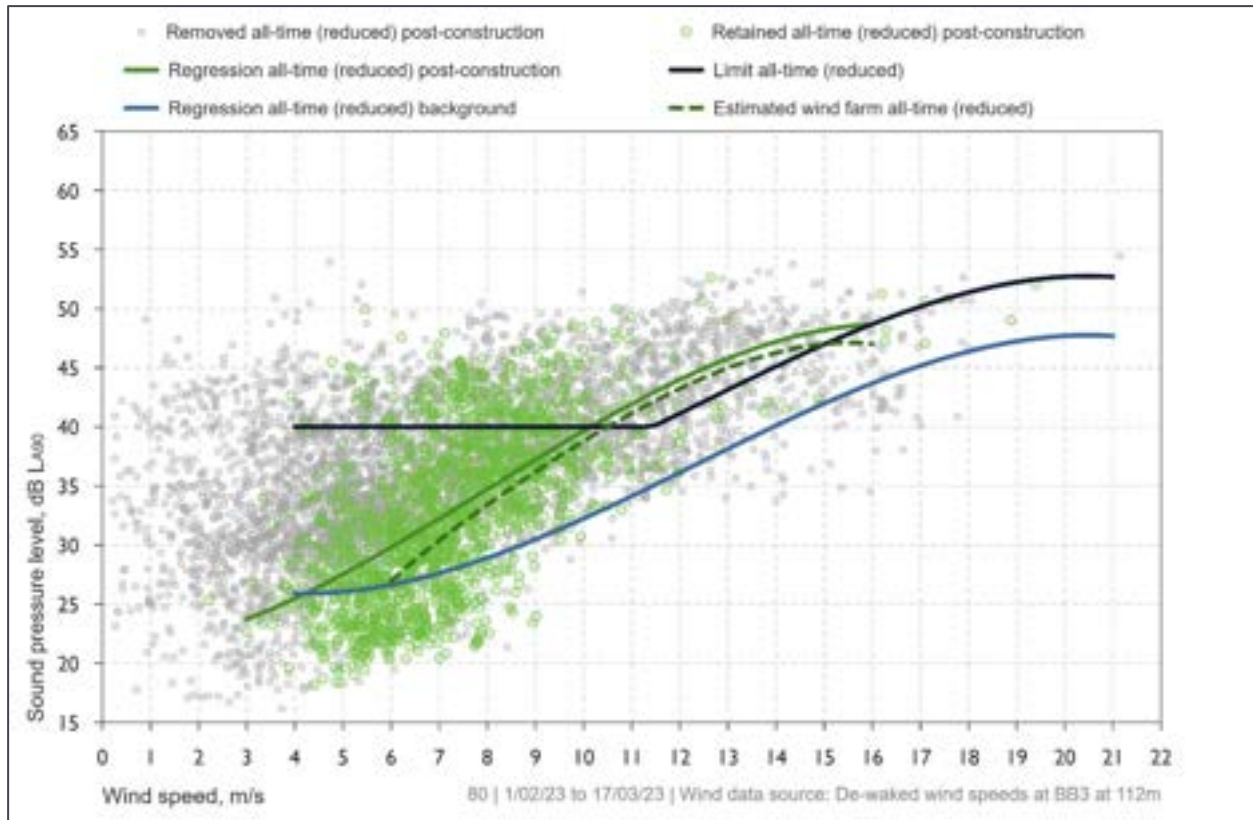
R2 Receiver 80 background noise data

Figure 85: Receiver 80 - derived background noise levels and noise limit – all-time (reduced)



R3 Receiver 80 post-construction measurement data – all wind speeds

Figure 86: Receiver 80 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



R4 Receiver 80 post-construction measurement data summary – assessment wind speeds

Table 97: Receiver 80 assessment data summary – number of data points

Data points	All-time (reduced)
Collected	5795
Removed	4170
Retained	1625

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 98.

Table 98: Receiver 80 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	2401
Rainfall	279
Extraneous noise	709
Wind farm operations curtailed	3063
Wind speeds outside assessment range	717

Figure 87: Receiver 80 post-construction noise levels and wind speed time history

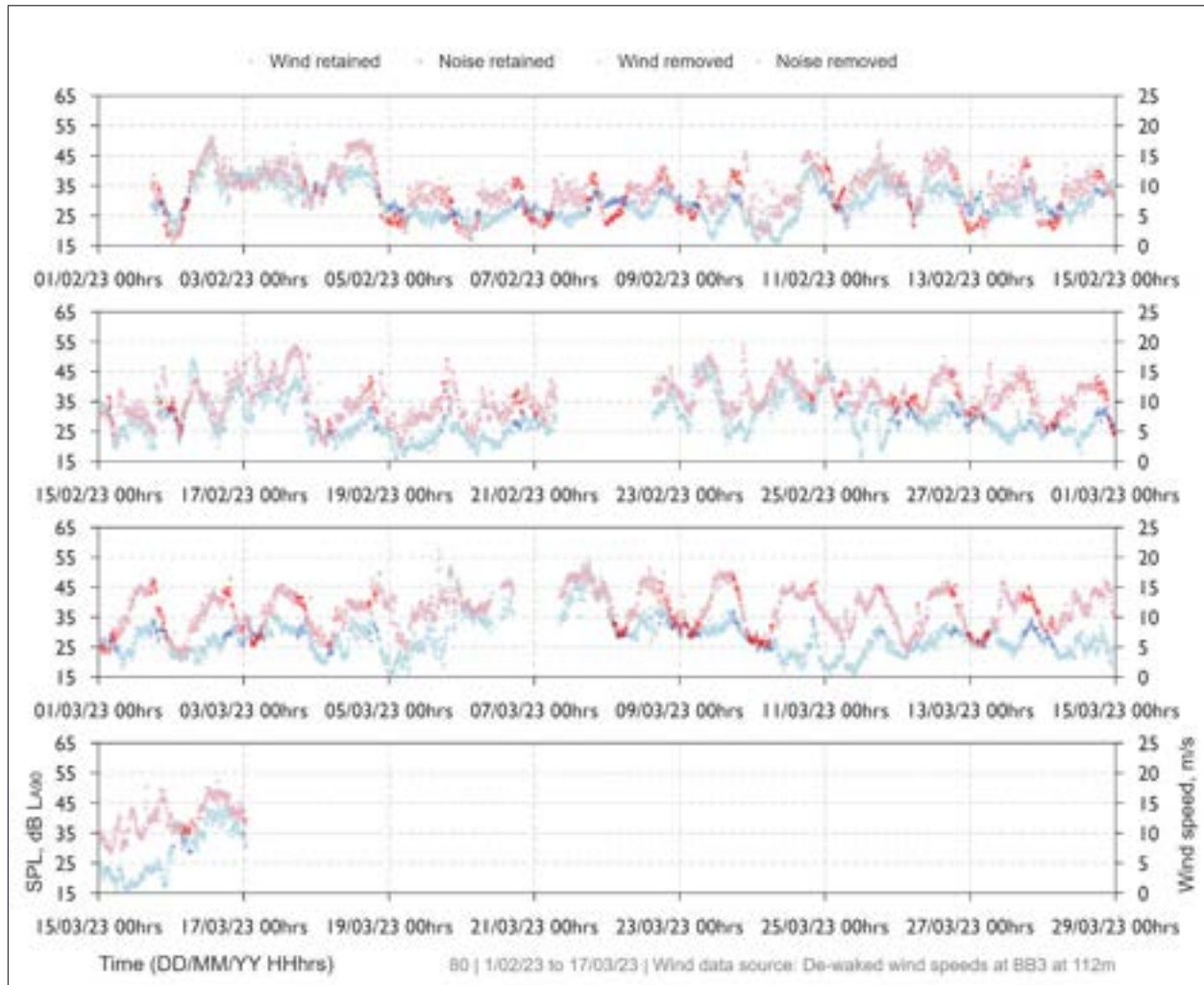


Figure 88: Receiver 80 – post-construction noise levels and noise limits versus site wind speed - all-time (reduced)

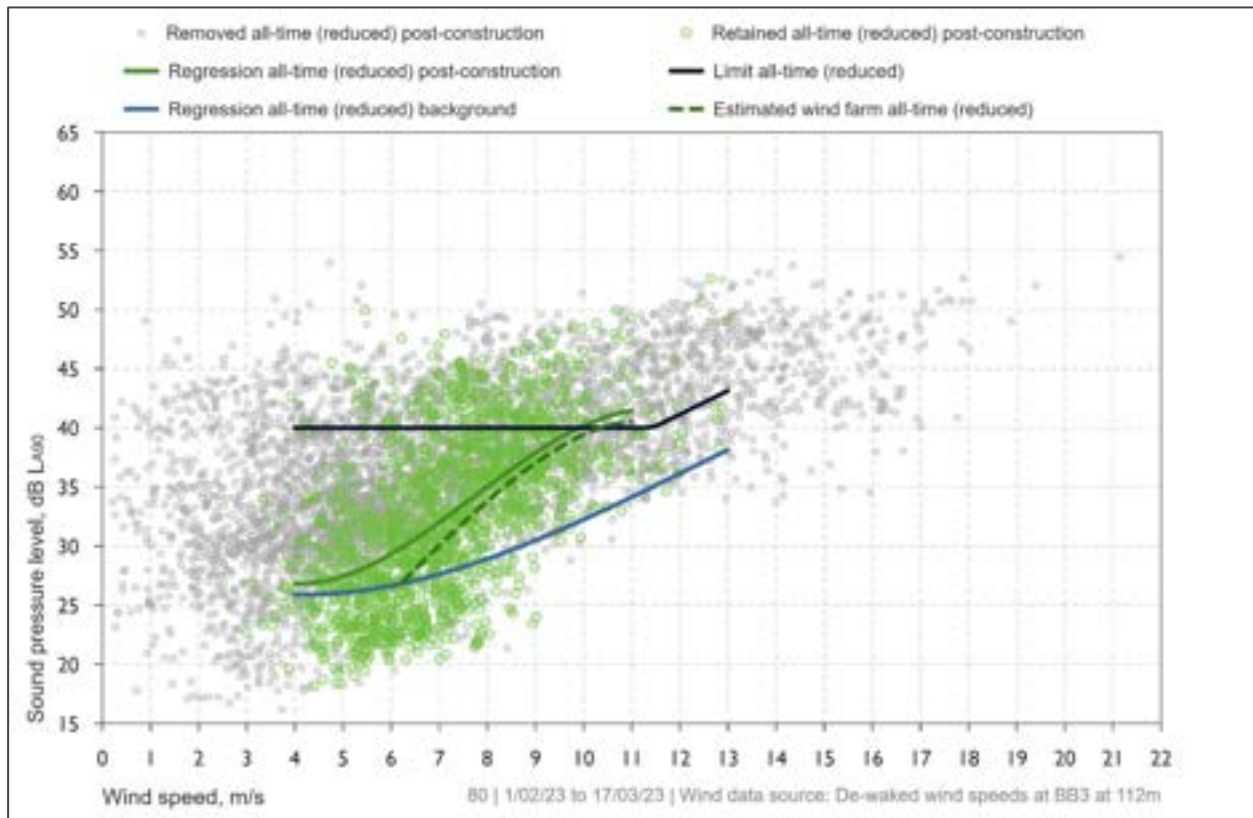
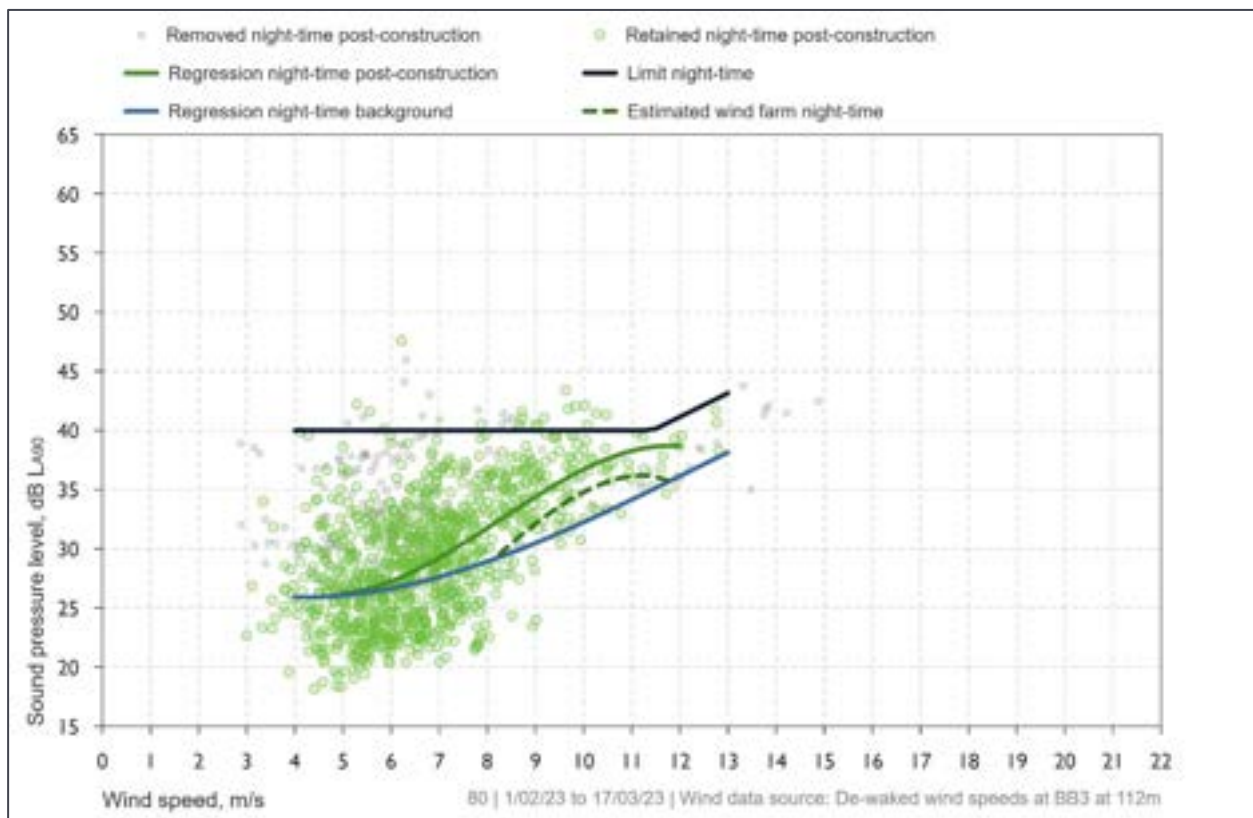


Figure 89: Receiver 80 – post-construction noise levels and noise limits versus site wind speed – night-time



R5 Receiver 80 supplementary analysis

The night-period measurement data presented in Figure 89 indicates that the regression line of the total A-weighted noise level is below 40 dB L_{A90} for the relevant range of wind speeds. While the noise level attributable to the operation of the wind farm cannot be estimated from this data, the results are sufficient to conclude that the contribution of the wind farm at receiver 80 was below the base (minimum) noise limit of 40 dB L_{A90} during the night period.

Data for the night period is sufficient to conclude that the noise level of the wind farm during the all-time period were also below the 40 dB L_{A90} base noise limit, on account of the wind farm noise contribution during the all-time and night-time periods being similar for the following reasons:

- The wind direction trends for the all-time and night periods of the survey were equivalent for noise assessment purposes (i.e. there were no distinctive changes to the wind direction trends between the all-time and night period to cause changes in wind farm noise levels between the periods)
- The assessment is referenced to hub height wind speeds, meaning that variations in wind shear between the day and night period do not translate to material changes in wind turbine noise levels for a given wind speed (i.e. for an assessment referenced to hub height wind speeds, changes in wind shear will mainly cause a change in the wind speed occurring around the dwelling and, in turn, the background noise associated with wind disturbance of vegetation).

Notwithstanding the above, in accordance with the NCTP, supplementary analysis procedures as specified in the NCTP were used to investigate the wind farm's contribution to the total measured noise levels. The relevant supplementary procedures and observations are summarised in Table 99.

Table 99: Receiver 80 – supplementary analysis summary

Procedure	Findings
Comparison of data trends for upwind and downwind conditions	See Figure 90 and Figure 91 for the comparisons for all-time (reduced) and night-time respectively. Insufficient downwind data points for any meaningful conclusion from this dataset.
Noise level versus wind speed profile review	See Figure 92. The profile indicates a greater rate of increase in noise levels above 9 m/s than occurs at locations nearer to the wind farm. This is indicative of background noise influences at high wind speeds.
Data filtering using intermediate measurement data	No intermediate noise monitoring location associated with this receiver
Extrapolation of intermediate data	No intermediate noise monitoring location associated with this receiver

Figure 90: Receiver 80 – upwind and downwind post-construction noise levels and noise limits versus site wind speed – all-time (reduced)

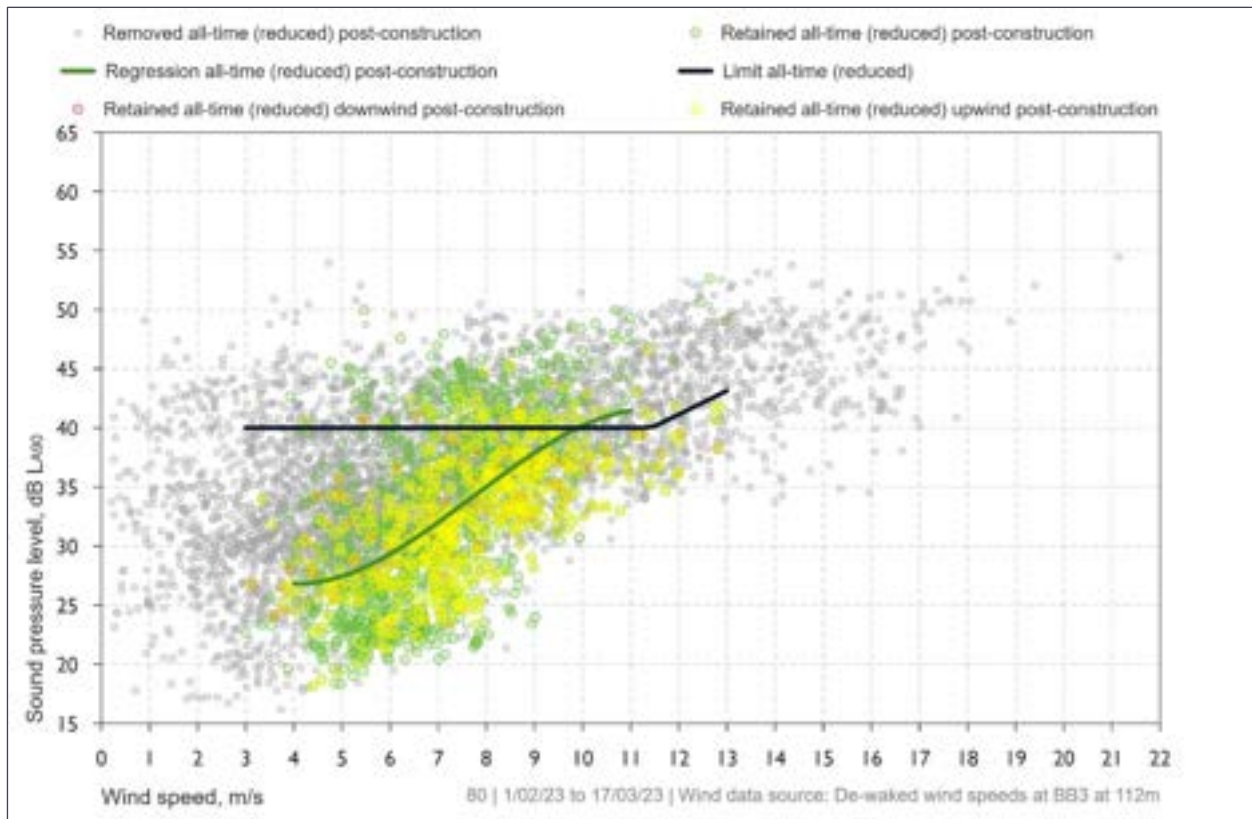


Figure 91: Receiver 80 – upwind and downwind post-construction noise levels and noise limits versus site wind speed – night-time

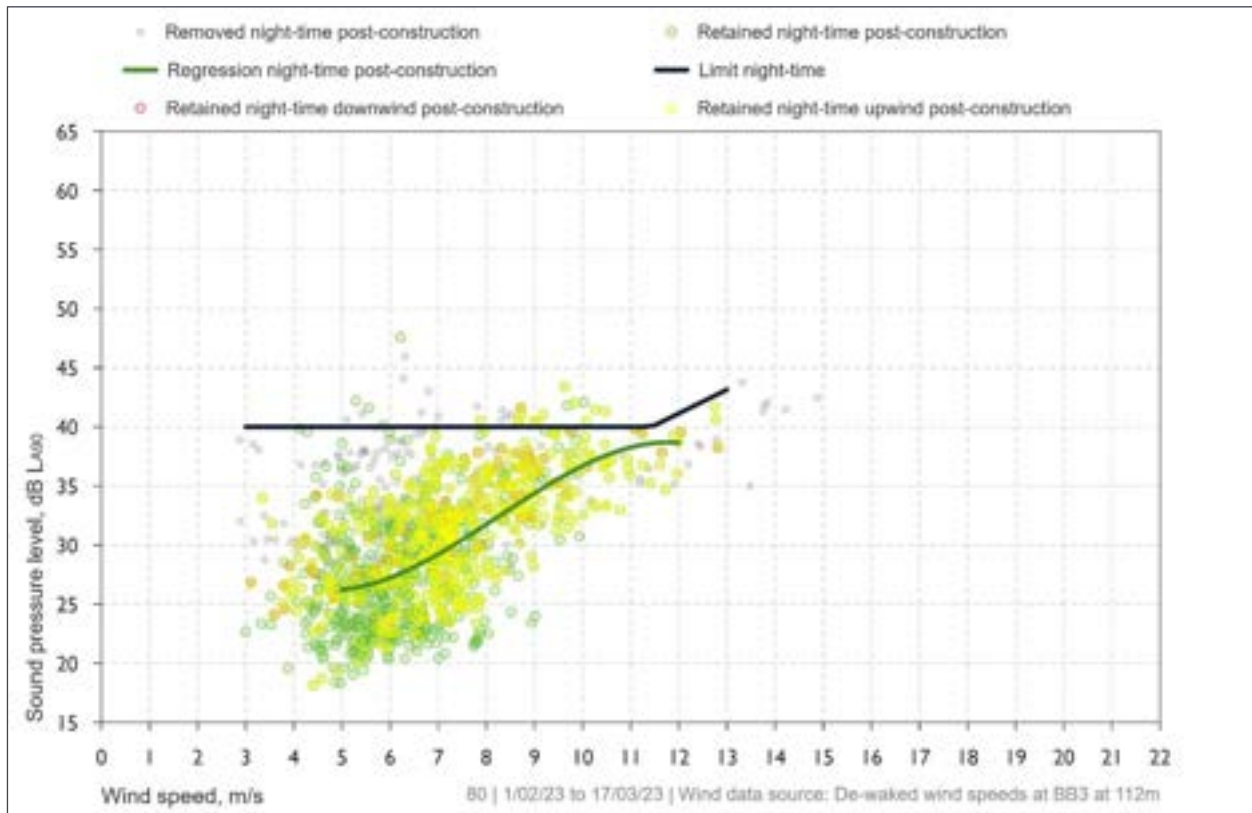
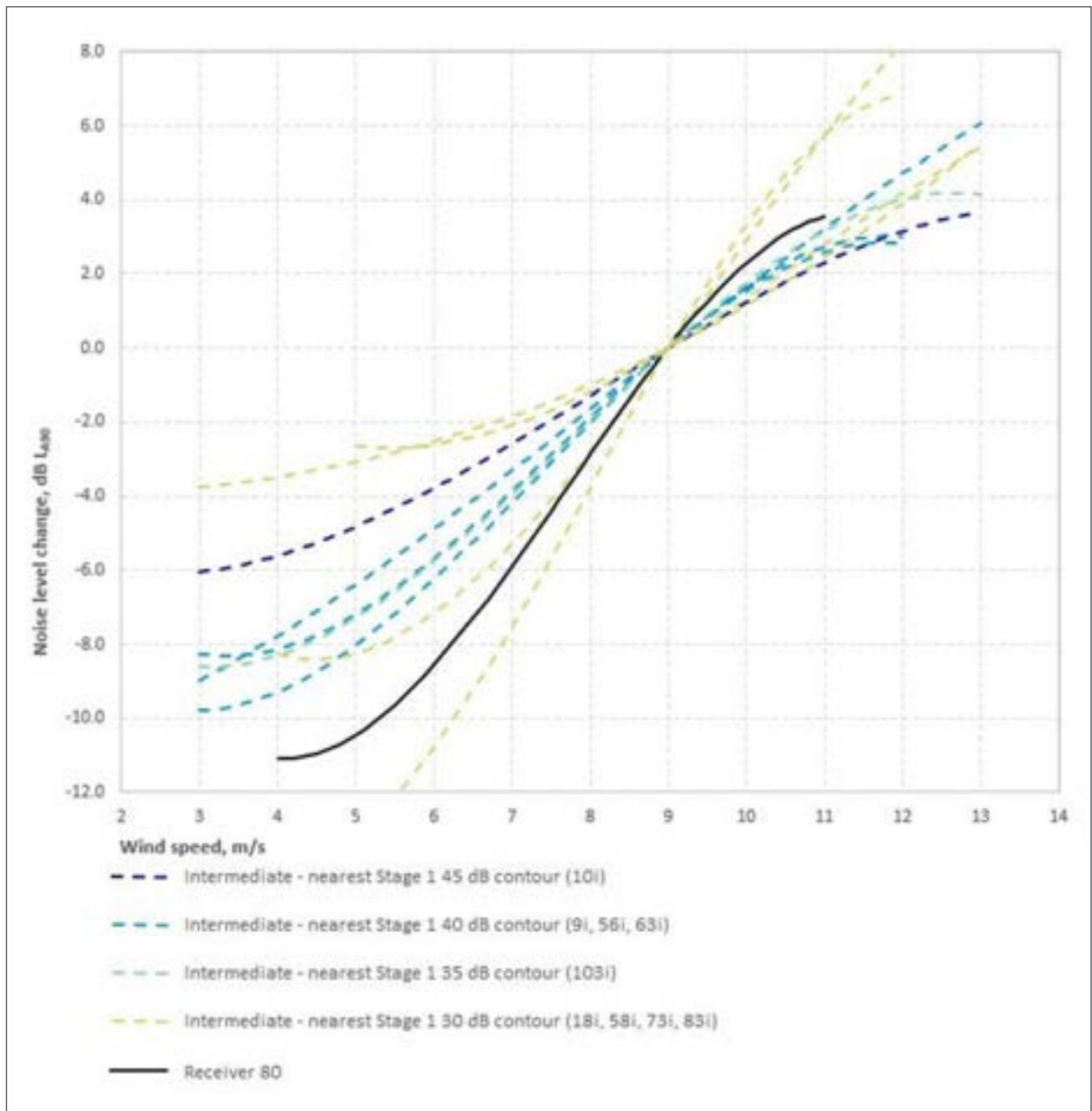


Figure 92: Change in noise level with wind speed, receiver 80 compared to intermediate locations – all-time (reduced)



R6 Receiver 80 tonality assessment

Figure 93: Receiver 80 tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

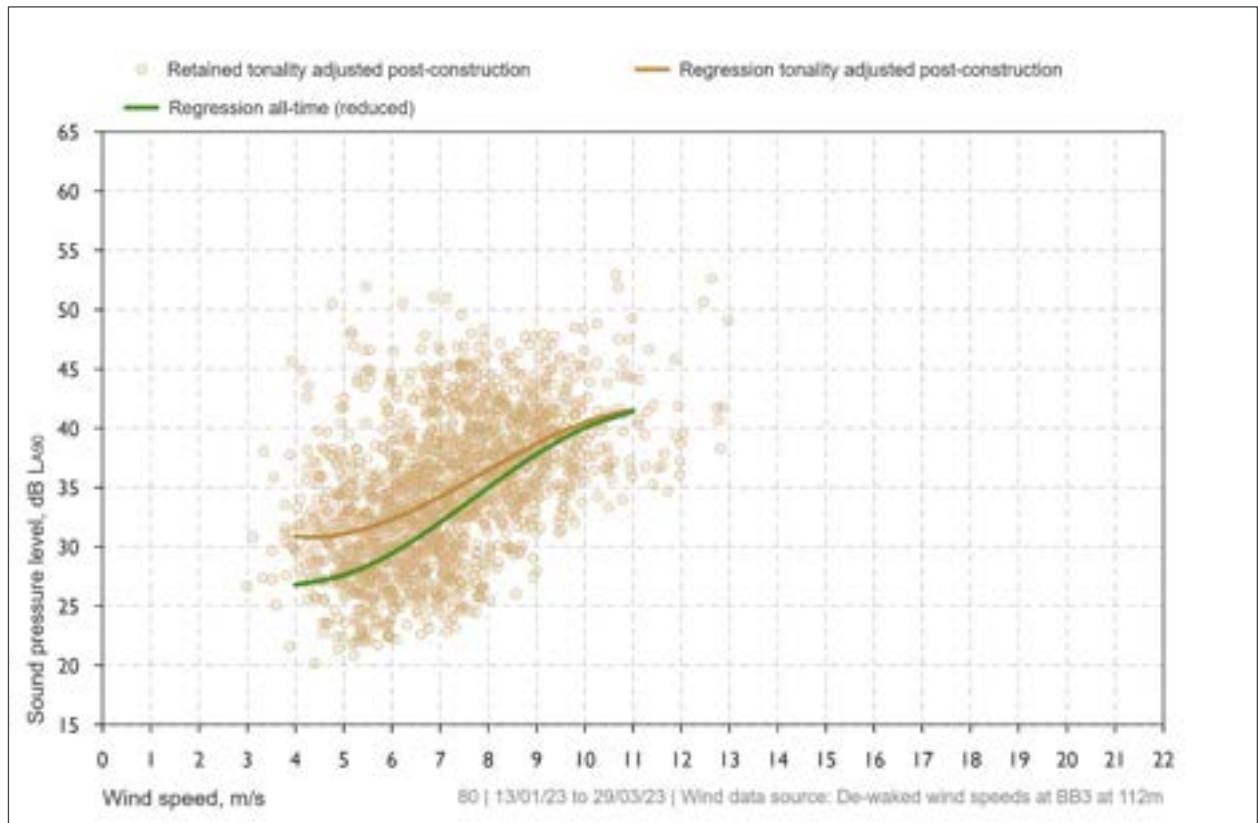


Table 100: Receiver 80 tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	30.9	31.1	32.3	34.2	36.5	38.7	40.5	41.5	- ^[1]	- ^[1]
Post-construction regression - no penalties	- ^[1]	26.8	27.4	29.3	32.0	35.0	37.9	40.2	41.4	- ^[1]	- ^[1]
Penalty adjustment	- ^[1]	4.1	3.7	3.0	2.2	1.5	0.8	0.3	0.1	- ^[1]	- ^[1]

1 Outside valid wind speed range of the regression analysis

R7 Receiver 80 compliance assessment

Table 101: Receiver 80 – compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	26.8	27.4	29.3	32.0	35.0	37.9	40.2	41.4	- ^[1]	- ^[1]
Background noise level	- ^[1]	25.9	26.1	26.6	27.6	28.9	30.5	32.2	34.1	- ^[1]	- ^[1]
Background adjustment	- ^[1]	- ^[2]	- ^[2]	- ^[2]	-2.0	-1.2	-0.9	-0.7	-0.9	- ^[1]	- ^[1]
Tonality adjustment	- ^[1]	4.1	3.7	3.0	2.2	1.5	0.8	0.3	0.1	- ^[1]	- ^[1]
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	< 30.9	< 31.1	< 32.3	32.2	35.3	37.8	39.8	40.6	- ^[1]	- ^[1]
Noise limit	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]	- ^[1]
Compliance margin	- ^[1]	-9.1	-8.9	-7.7	-7.8	-4.7	-2.2	-0.2	0.6 ^[4]	- ^[1]	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Inconclusive outcomes due to background noise variation – see supplementary assessment and assessment of night-time data

Table 102: Receiver 80 – compliance assessment, dB LA90 – assessment against all-time limit using wind turbine noise representation from night-time data

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- [1]	- [1]	26.2	27.2	29.2	31.7	34.4	36.7	38.3	38.7	- [1]
Background noise level	- [1]	- [1]	26.1	26.6	27.6	28.9	30.5	32.2	34.1	36.1	- [1]
Background adjustment	- [1]	- [1]	- [2]	- [2]	- [2]	- [2]	-2.3	-1.9	-2.1	- [2]	- [1]
Tonality adjustment	- [1]	4.1	3.7	3.0	2.2	1.5	0.8	0.3	0.1	- [1]	- [1]
Estimated tonality adjusted wind farm noise level [3]	- [1]	- [1]	< 29.9	< 30.2	< 31.4	< 33.2	32.9	35.1	36.3	- [1]	- [1]
Noise limit	- [1]	- [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.1	- [1]
Compliance margin	- [1]	- [1]	-10.1	-9.8	-8.6	-6.8	-7.1	-4.9	-3.7	- [1]	- [1]

1 Outside valid wind speed range of the regression analysis

2 The background noise data was not separately analysed for the night period and a background adjustment therefore cannot be calculated

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

APPENDIX S RECEIVER 83

S1 Receiver 83 location data

Table 103: Receiver 83 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	721534	5791392
Noise monitoring location	721518	5791415

Figure 94: Receiver 83 aerial view – dwelling and noise monitor locations

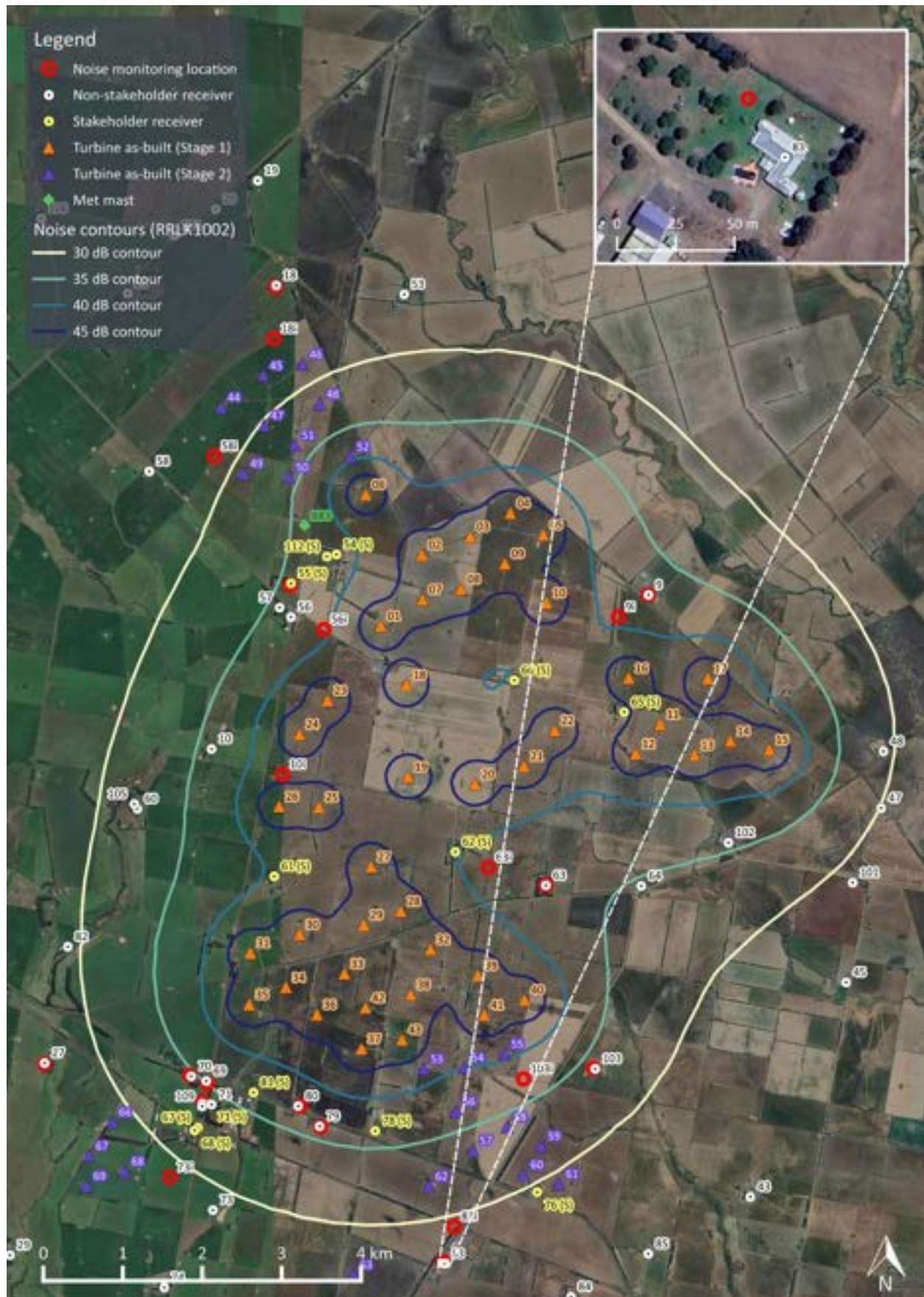
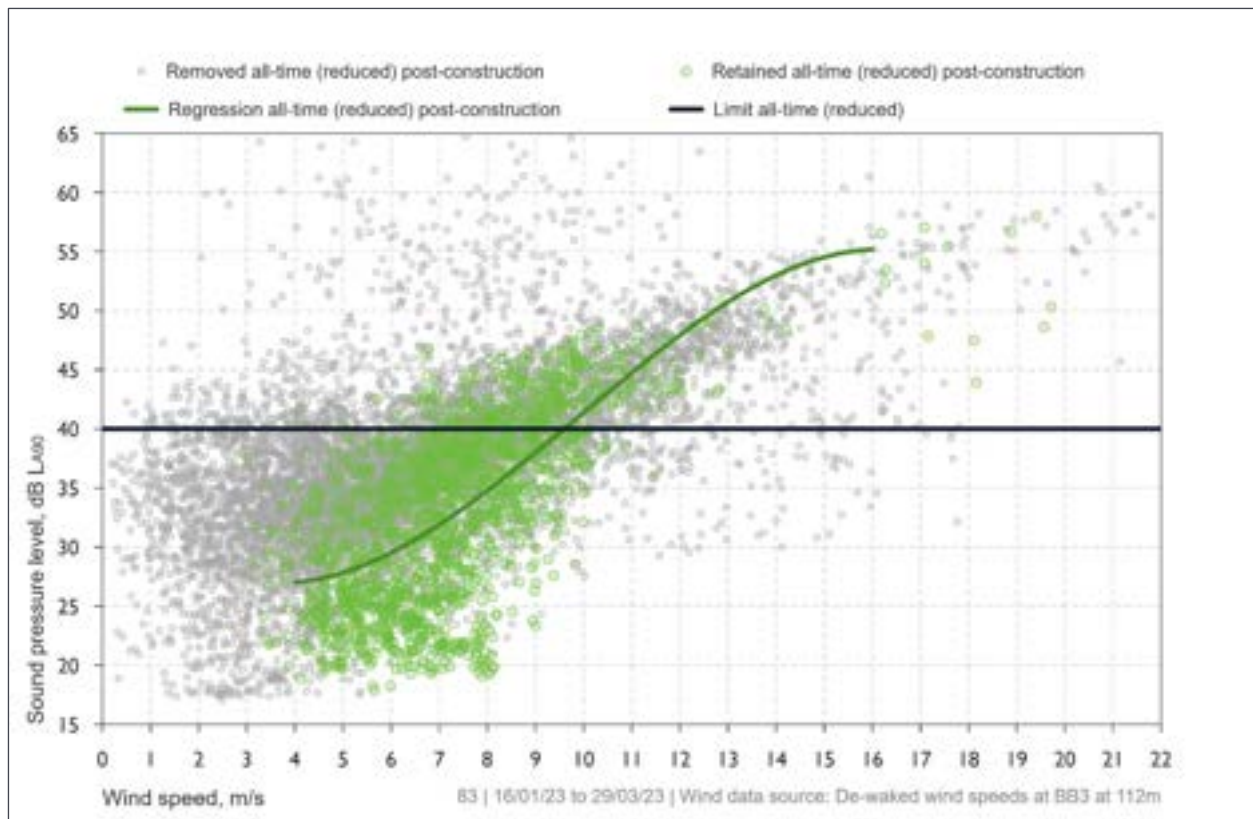


Table 104: Receiver 83 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

S2 Receiver 83 post-construction measurement data – all wind speeds

Figure 95: Receiver 83 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



S3 Receiver 83 post-construction measurement data summary – assessment wind speeds

Table 105: Receiver 83 assessment data summary – number of data points

Data points	All-time (reduced)	Night-time (2200 – 0500 hrs)
Collected	9487	3502
Removed	7829	2576
Retained	1658	926

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 106.

Table 106: Receiver 83 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)	Night-time (2200 – 0500 hrs)
Periods from 0700 – 1700 hrs	3960	-
Rainfall	434	110
Extraneous noise	2223	1417
Wind farm operations curtailed	5314	1754
Wind speeds outside assessment range	1301	514

Figure 96: Receiver 83 post-construction noise levels and wind speed time history

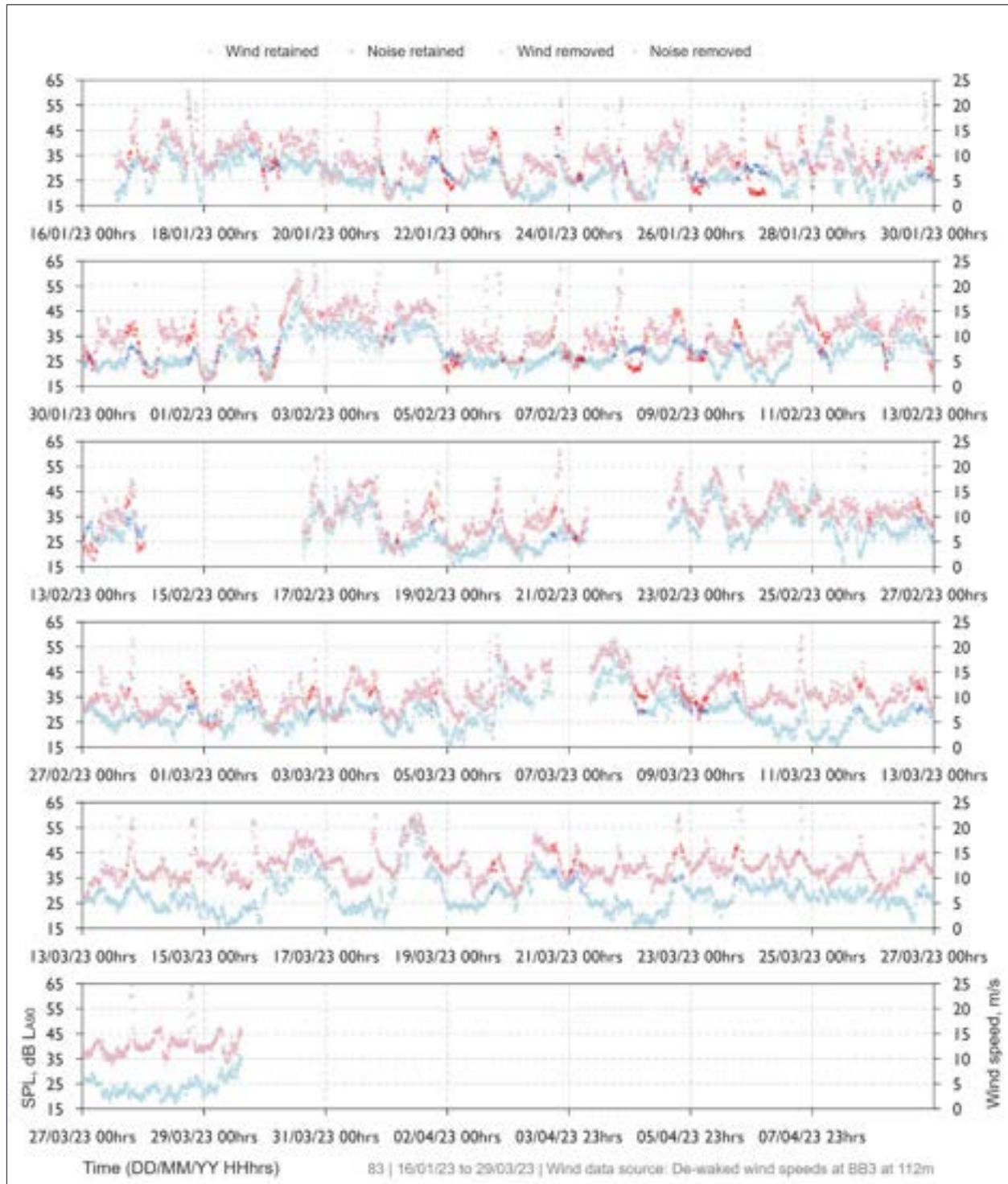


Figure 97: Receiver 83 post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

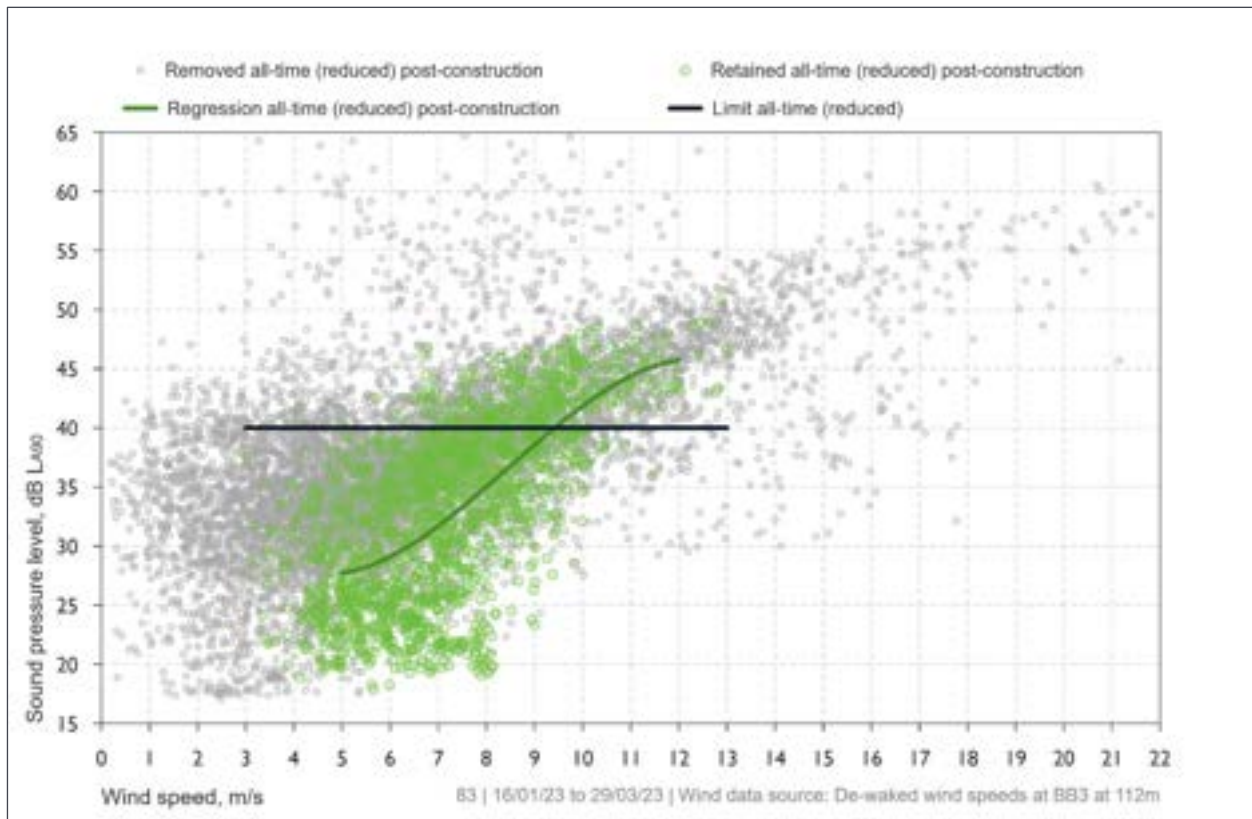
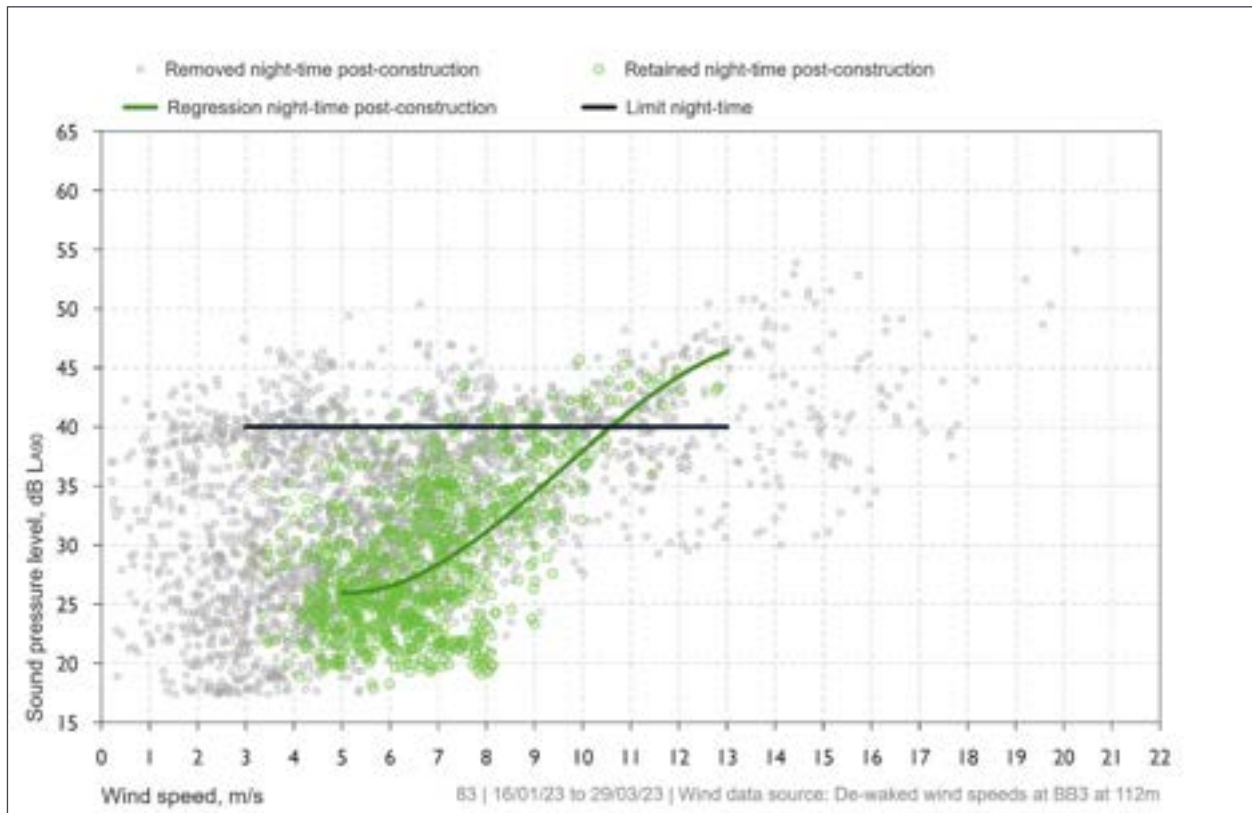


Figure 98: Receiver 83 - post-construction noise levels and minimum noise limits versus site wind speed – night-time (2200 – 0500 hrs)



S4 Receiver 83 supplementary analysis

The total measured noise levels at receiver 83 are greater than 40 dB L_{A90} above 9 m/s and 10 m/s for the all-time (reduced) and night-time respectively. These results are consistent with the influence of background noise levels. In particular, the results indicated background noise levels well above 40 dB L_{A90} at low wind speeds when the wind turbines would either not be operating or would be operating at low speeds and producing negligible noise emissions. However, in the absence of background noise data for receiver 83, the total measured noise levels at this receiver are inconclusive with respect to compliance (i.e. on account of the absence of background noise related limits and the absence of data to estimate the likely contribution of background noise levels to the measurements).

In accordance with the NCTP, supplementary analysis procedures as specified in the NCTP were used to investigate the wind farm's contribution to the total measured noise levels. The relevant supplementary procedures and observations are summarised in Table 107.

Table 107: Receiver 83 – supplementary analysis summary

Procedure	Findings
Comparison of data trends for upwind and downwind conditions	See Figure 99 and Figure 100 for the comparisons for all-time (reduced) and night-time respectively. No indication of distinct difference between the noise levels measured under downwind and upwind conditions.
Noise level versus wind speed profile review	See Figure 101. The profile indicates a greater rate of increase in noise levels above 9 m/s than occurs at locations nearer to the wind farm. This indicates background noise influences rather than wind farm noise at high wind speeds.
Data filtering using intermediate measurement data	See Figure 102 and Figure 103 for data subject to additional filtering for the all-time (reduced) and night-time respectively. This additional filter removes a data point if the measured noise level at the receiver was higher than at the intermediate location positioned nearer to the wind farm. The additional filter removes a significant quantity of additional points where noise levels would have been unrelated to the operation of the wind farm. However, the additional filtering does not provide any further insight into the potential noise levels related to the operation of the wind farm.
Extrapolation of intermediate data	See Table 111 and Table 112 in Appendix S6. The extrapolation indicates estimated tonality adjusted wind farm noise levels below 40 dB L_{A90} across the assessable range of wind speeds.

Figure 99: Receiver 83 – upwind and downwind post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

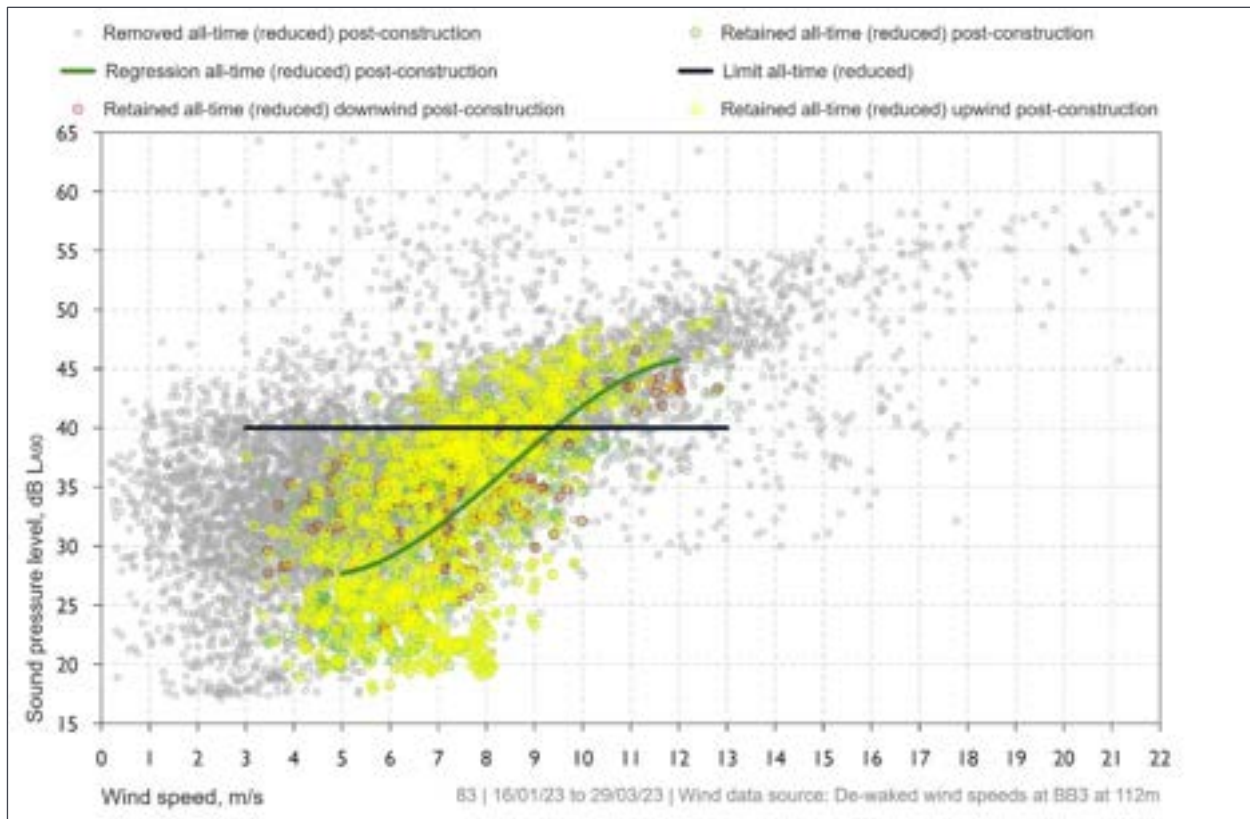


Figure 100: Receiver 83 – upwind and downwind post-construction noise levels and noise limits versus site wind speed – night-time (2200 – 0500 hrs)

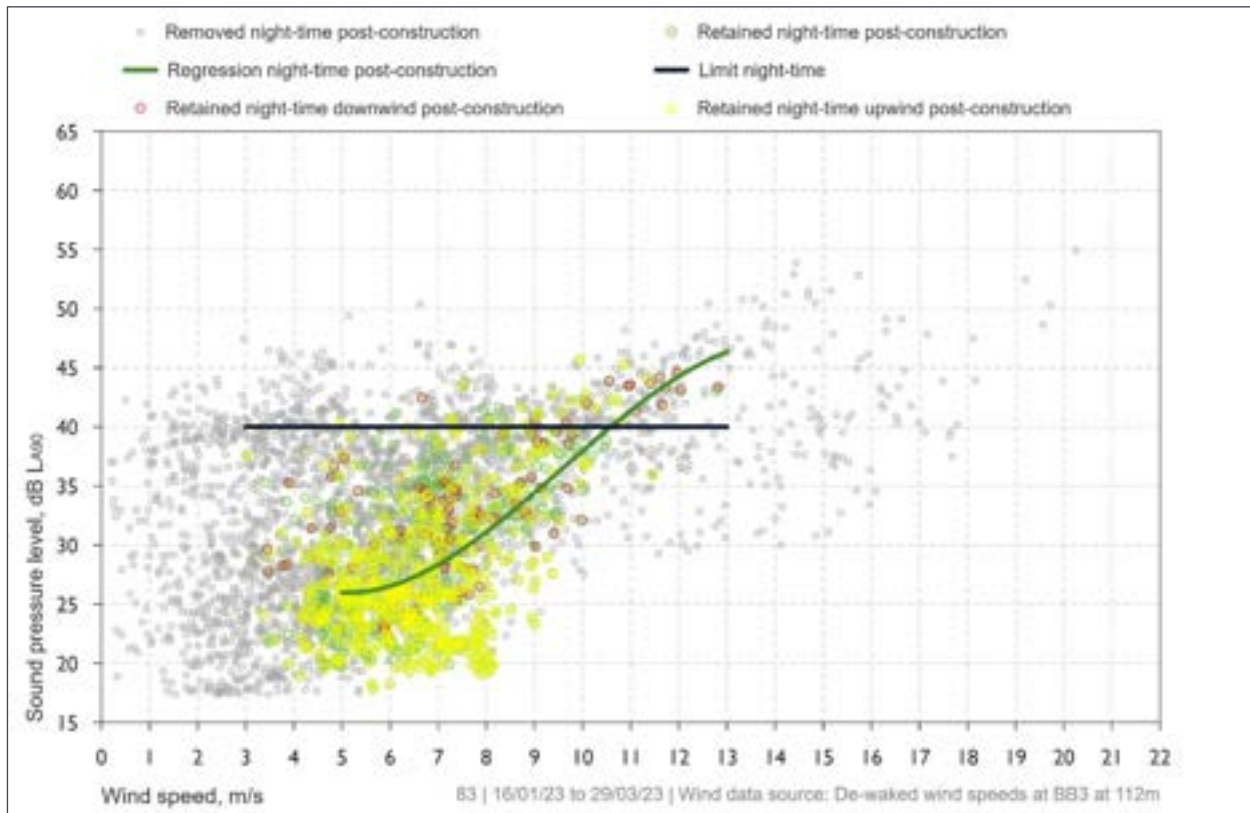


Figure 101: Change in noise level with wind speed, receiver 83 compared to intermediate locations – all-time (reduced)

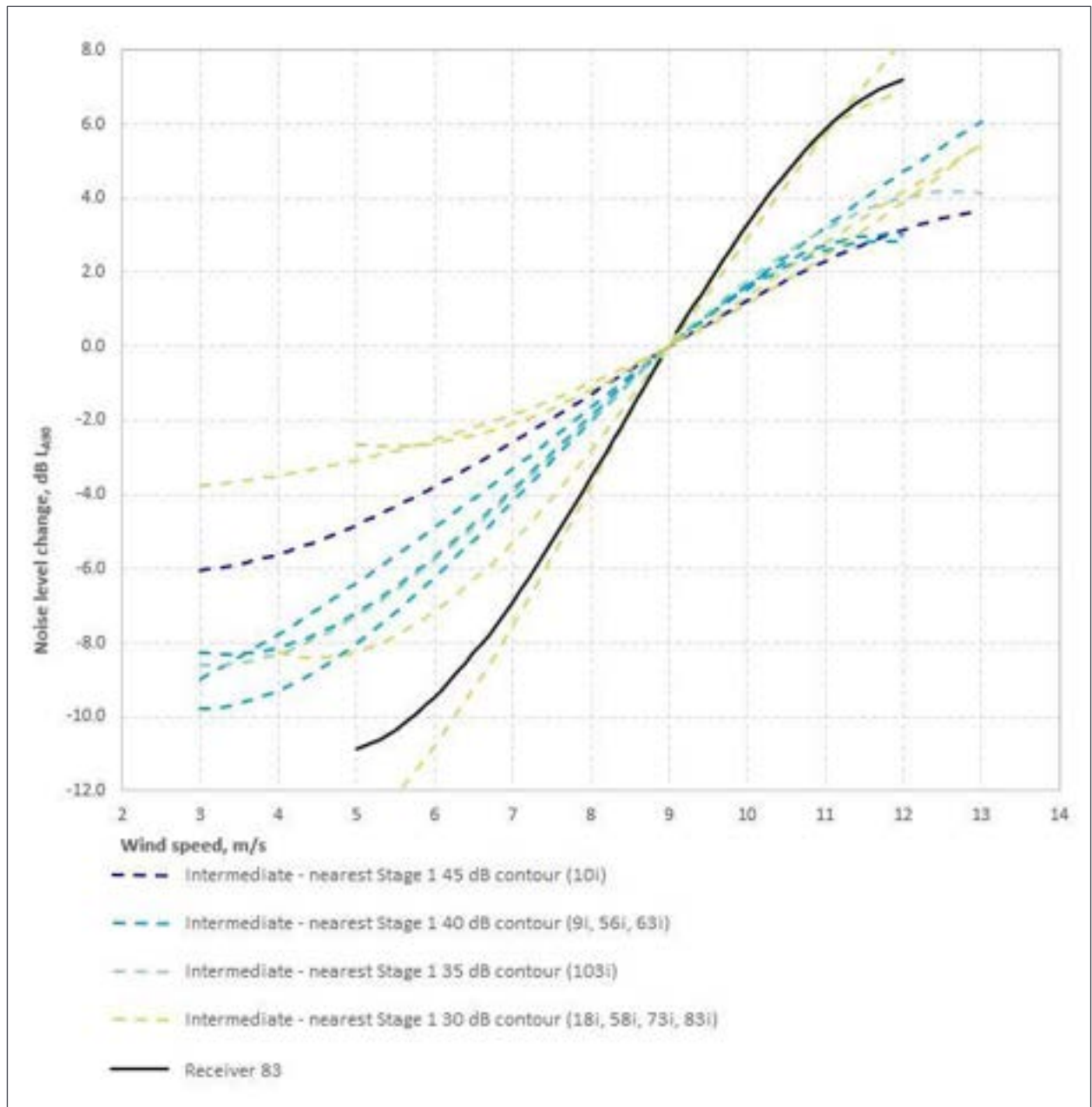


Figure 102: Receiver 83 using intermediate 83i as an additional filter – post-construction noise levels and noise limits versus site wind speed – all-time (reduced)

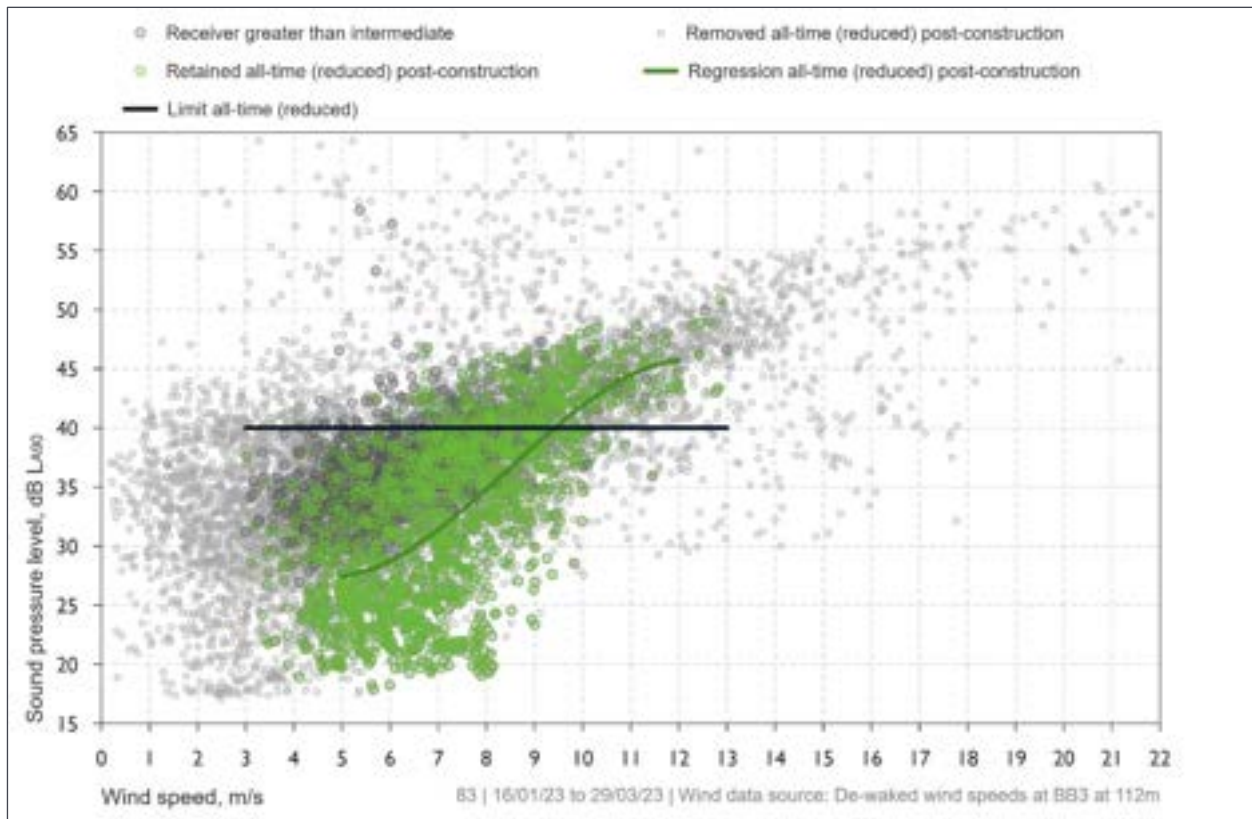
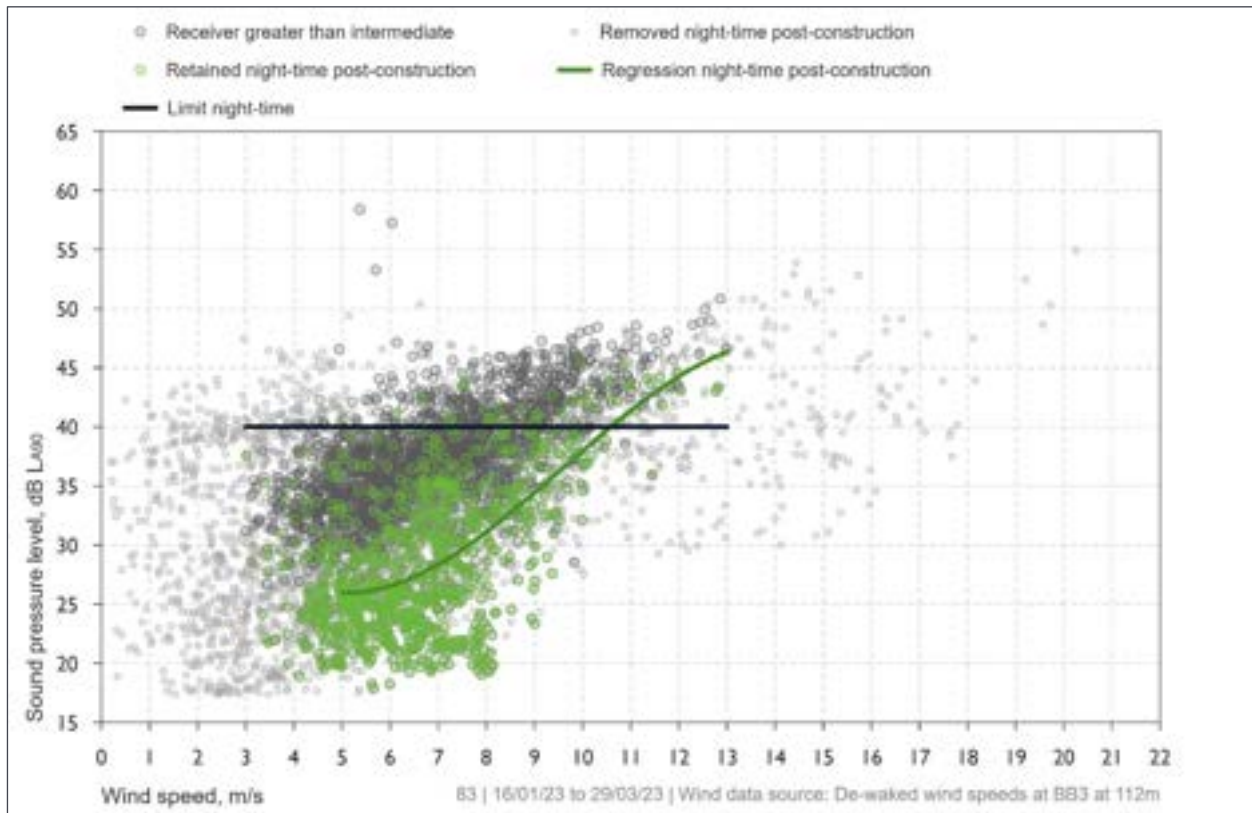


Figure 103: Receiver 83 using intermediate 83i as an additional filter – post-construction noise levels and noise limits versus site wind speed – night-time (2200 – 0500 hrs)



S5 Receiver 83 tonality assessment

Figure 104: Receiver 83 tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

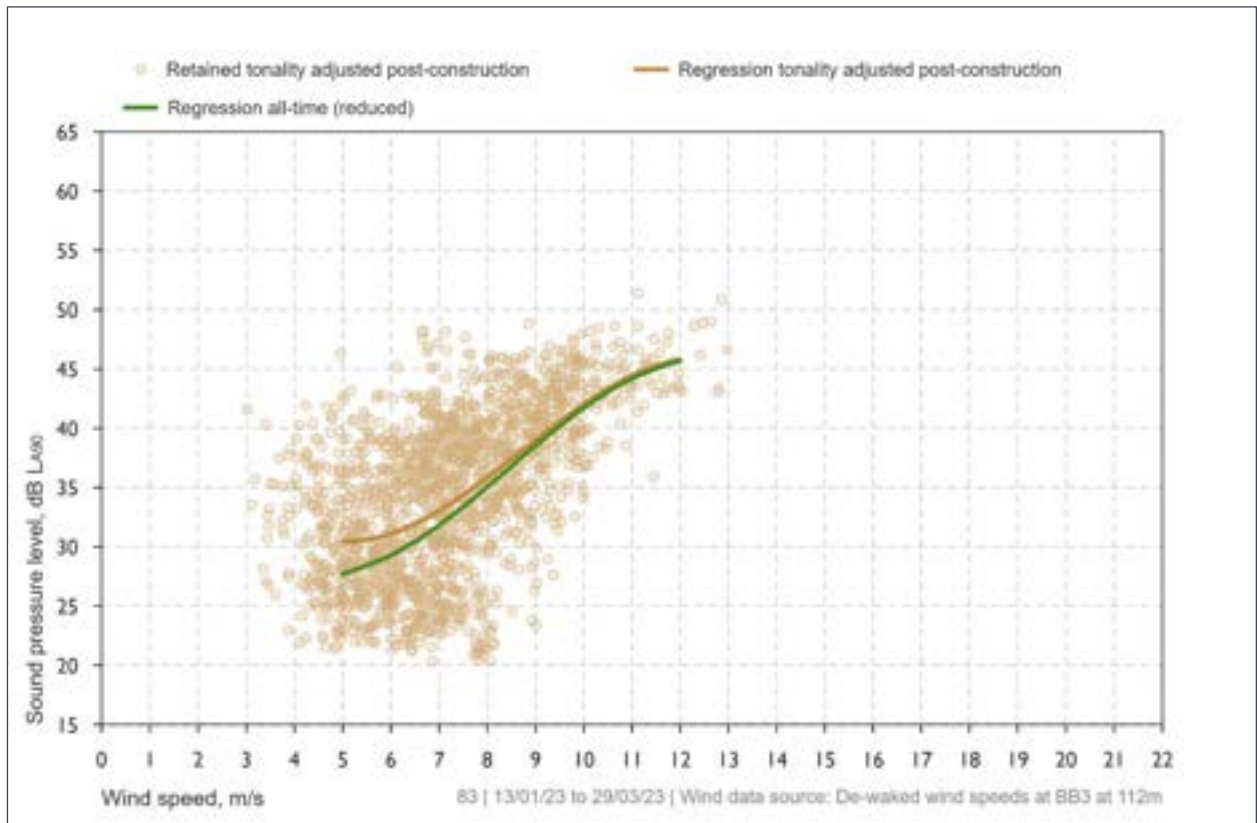


Table 108: Receiver 83 tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	- ^[1]	30.5	31.1	33.0	35.8	39.0	42.0	44.5	45.8	- ^[1]
Post-construction regression - no penalties	- ^[1]	- ^[1]	27.7	29.1	31.7	35.0	38.6	41.8	44.4	45.7	- ^[1]
Penalty adjustment	- ^[1]	- ^[1]	2.8	2.0	1.3	0.8	0.4	0.2	0.1	0.1	- ^[1]

1 Outside valid wind speed range of the regression analysis

S6 Receiver 83 compliance assessment

Table 109: Receiver 83 compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	– [1]	– [1]	27.7	29.1	31.7	35.0	38.6	41.8	44.4	45.7	– [1]
Background noise level	– [1]	– [1]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [1]
Background adjustment	– [1]	– [1]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [1]
Tonality adjustment	– [1]	– [1]	2.8	2.0	1.3	0.8	0.4	0.2	0.1	0.1	– [1]
Estimated tonality adjusted wind farm noise level [3]	– [1]	– [1]	< 30.5	< 31.1	< 33	< 35.8	< 39.0	< 42.0	< 44.5	< 45.8	– [1]
Noise limit	– [1]	– [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	– [1]
Compliance margin	– [1]	– [1]	-9.5	-8.9	-7.0	-4.2	-1.0	2.0 [4]	4.5 [4]	5.8 [4]	– [1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location - the background adjustment is therefore not available for this location

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB L_{A90} minimum limit

Table 110: Receiver 83 compliance assessment, dB L_{A90} – night-time

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	– [1]	– [1]	26.0	26.5	28.4	31.1	34.4	38.0	41.4	44.3	46.3
Background noise level	– [1]	– [1]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]
Background adjustment	– [1]	– [1]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]
Tonality adjustment	– [1]	– [1]	2.8	2.0	1.3	0.8	0.4	0.2	0.1	0.1	– [1]
Estimated tonality adjusted wind farm noise level [3]	– [1]	– [1]	< 28.8	< 28.5	< 29.7	< 31.9	< 34.8	< 38.2	< 41.5	< 44.4	– [1]
Noise limit	– [1]	– [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Compliance margin	– [1]	– [1]	-11.2	-11.5	-10.3	-8.1	-5.2	-1.8	1.5 [4]	4.4 [4]	– [1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location - the background adjustment is therefore not available for this location

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB L_{A90} minimum limit

Table 111: Receiver 83 compliance assessment based on extrapolation of intermediate 83i, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 83i	- ^[1]	28.3	29.3	31.6	34.9	38.6	42.4	45.7	48.1	49.2	- ^[1]
Background noise level intermediate 83i	- ^[1]	30.0	31.5	33.1	34.7	36.3	37.8	39.3	40.7	42.0	- ^[1]
Background adjustment intermediate 83i	- ^[1]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	-1.8	-1.1	-0.9	-0.9	- ^[1]
Extrapolation correction	- ^[1]	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	- ^[1]
Tonality adjustment receiver 83	- ^[1]	- ^[1]	2.8	2.0	1.3	0.8	0.4	0.2	0.1	0.1	- ^[1]
Estimated tonality adjusted wind farm noise level receiver 83 ^[3]	- ^[1]	- ^[1]	< 31.6	< 33.1	< 35.7	< 38.9	40.5	44.3	46.8	47.9	- ^[1]
Noise limit receiver 83 ^[4]	- ^[1]	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]
Compliance margin	- ^[1]	- ^[1]	-8.4	-6.9	-4.3	-1.1	0.5 ^[5]	4.3 ^[5]	6.8 ^[5]	7.9 ^[5]	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

5 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB L_{A90} minimum limit

Table 112: Receiver 83 compliance assessment based on extrapolation of intermediate 83i, dB LA90 – night-time (2200–0500hrs)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 83i	- [1]	- [1]	27.7	29.1	32.0	35.8	39.9	43.5	46.1	47.2	- [1]
Background noise level intermediate 83i	- [1]	- [1]	31.5	33.1	34.7	36.3	37.8	39.3	40.7	42.0	- [1]
Background adjustment intermediate 83i	- [1]	- [1]	- [3]	- [3]	- [3]	- [3]	- [3]	-2.1	-1.5	-1.6	- [1]
Extrapolation correction	- [1]	- [1]	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	- [1]
Tonality adjustment receiver 83	- [1]	- [1]	2.8	2.0	1.3	0.8	0.4	0.2	0.1	0.1	- [1]
Estimated tonality adjusted wind farm noise level receiver 83 [4]	- [1]	- [1]	< 30.0	< 30.6	< 32.8	< 36.1	< 39.8	41.1	44.2	45.2	- [1]
Noise limit receiver 83 [5]	- [1]	- [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- [1]
Compliance margin	- [1]	- [1]	-10.0	-9.4	-7.2	-3.9	-0.2	1.1 [5]	4.2 [5]	5.2 [5]	- [1]

- 1 Outside valid wind speed range of the regression analysis
- 2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3dB
- 3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available
- 4 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver
- 5 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB LA90 minimum limit

APPENDIX T RECEIVER 103

T1 Receiver 103 location data

Table 113: Receiver 103 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	723433	5793846
Noise monitoring location	723409	5793854

Figure 105: Receiver 103 aerial view – dwelling and noise monitor locations

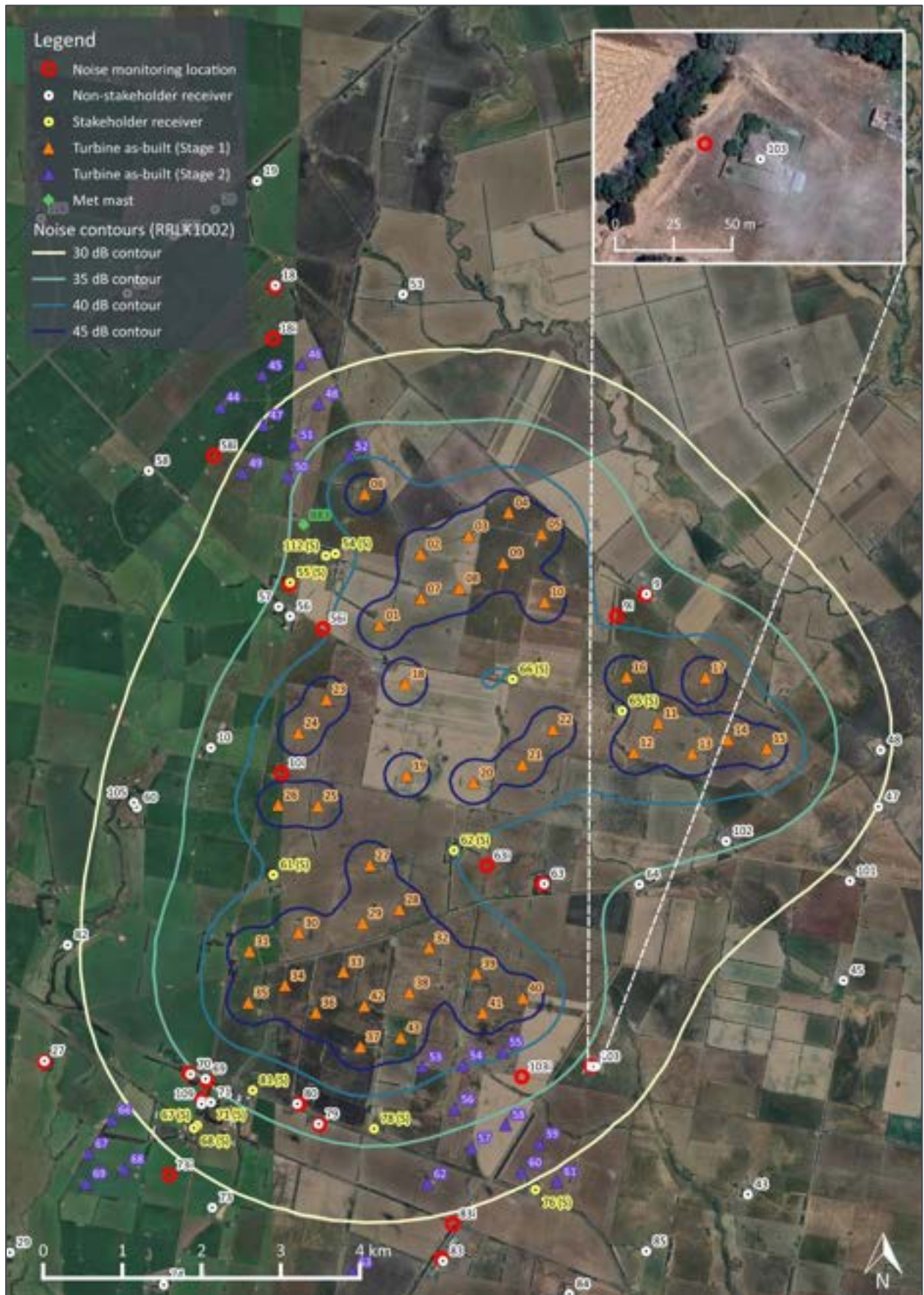
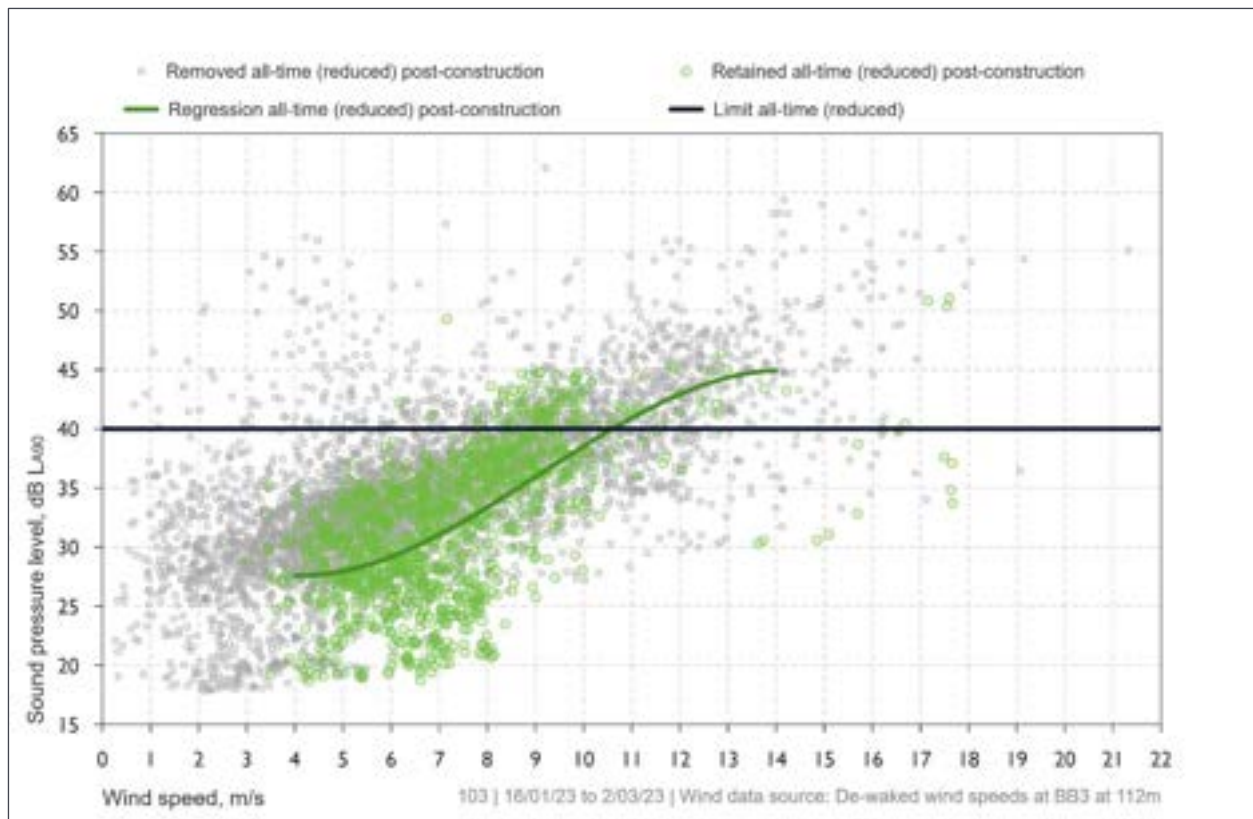


Table 114: Receiver 103 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

T2 Receiver 103 post-construction measurement data – all wind speeds

Figure 106: Receiver 103 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



T3 Receiver 103 post-construction measurement data summary – assessment wind speeds

Table 115: Receiver 103 assessment data summary – number of data points

Data points	All-time (reduced)	Night-time (2200 – 0500 hrs)
Collected	5702	2107
Removed	4528	1473
Retained	1174	634

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 116.

Table 116: Receiver 103 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)	Night-time (2200 – 0500 hrs)
Periods from 0700 – 1700 hrs	2361	-
Rainfall	437	110
Extraneous noise	1049	694
Wind farm operations curtailed	3294	1091
Wind speeds outside assessment range	674	302

Figure 107: Receiver 103 post-construction noise levels and wind speed time history

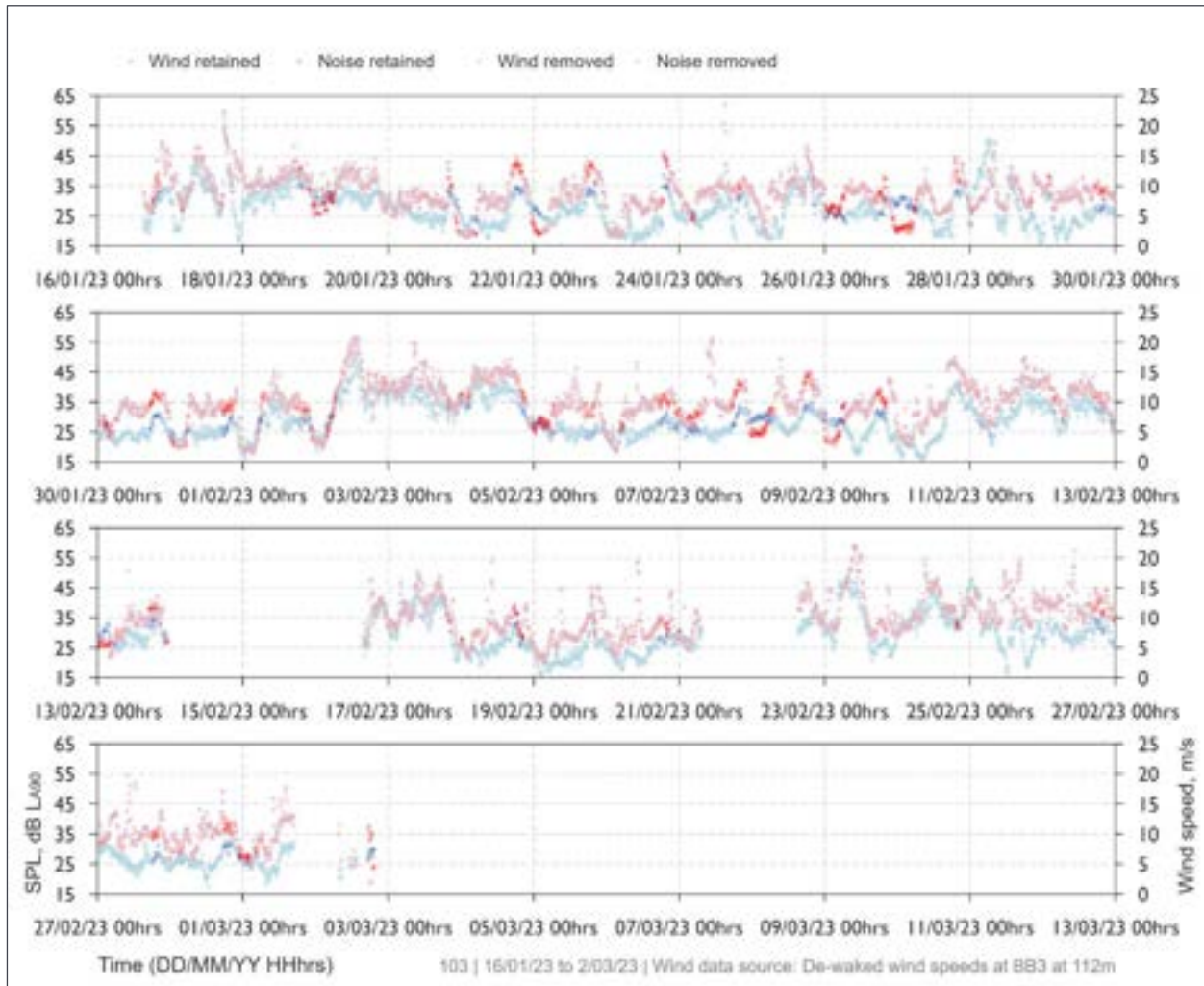


Figure 108: Receiver 103 post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

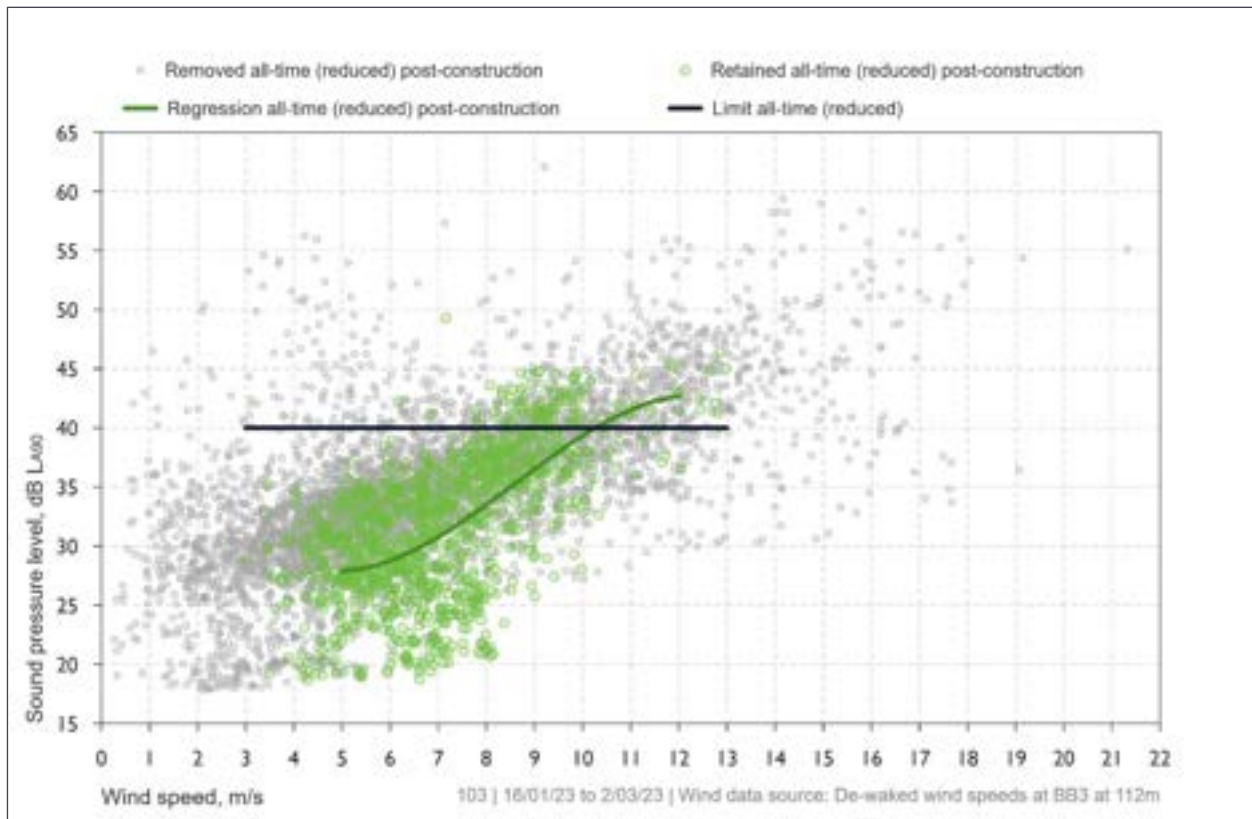
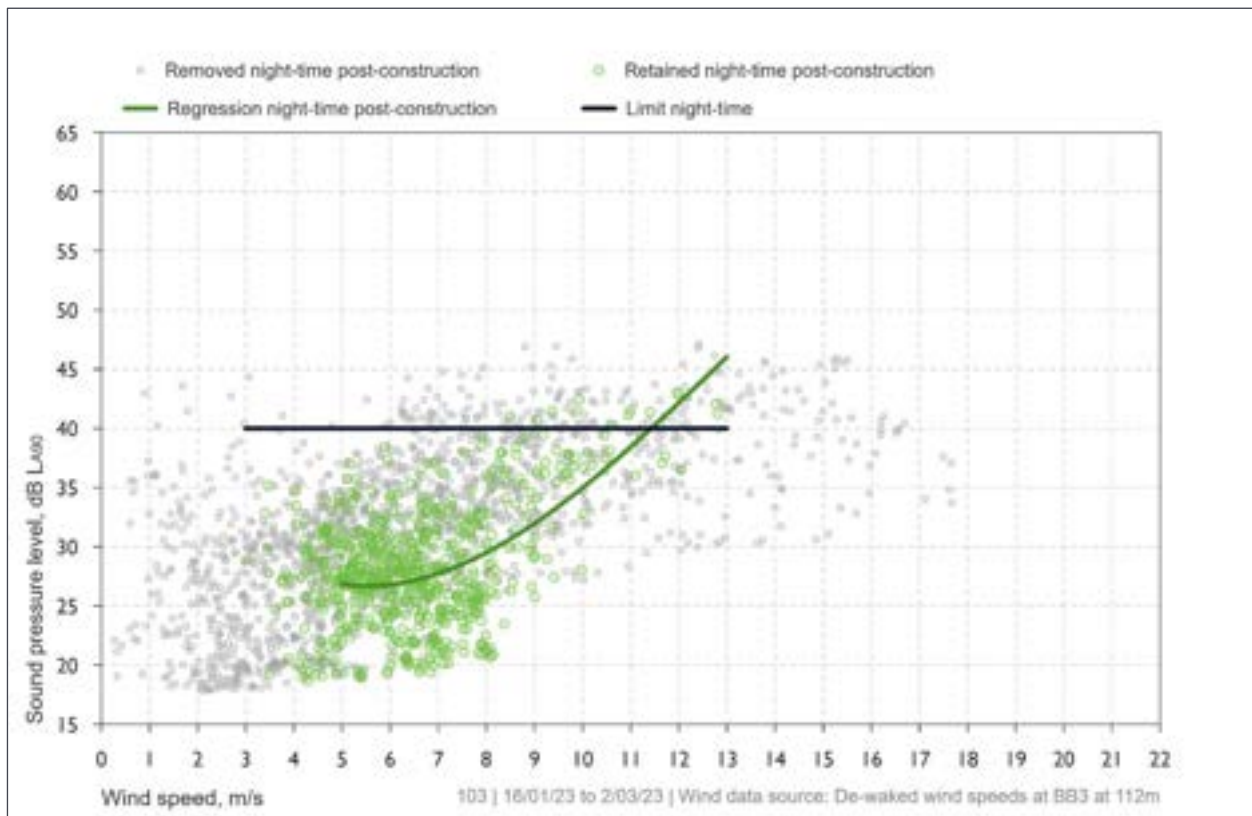


Figure 109: Receiver 103 post-construction noise levels and minimum noise limits versus site wind speed – night-time



T4 Receiver 103 supplementary analysis

The total measured noise levels at receiver 103 are greater than 40 dB L_{A90} above 10 m/s and 11 m/s for the all-time (reduced) and night-time respectively. These results are consistent with the influence of background noise levels. In particular, the results indicated background noise levels well above 40 dB L_{A90} at low wind speeds when the wind turbines would either not be operating or would be operating at low speeds and producing negligible noise emissions. However, in the absence of background noise data for receiver 103, the total measured noise levels at this receiver are inconclusive with respect to compliance (i.e. on account of the absence of background noise related limits and the absence of data to estimate the likely contribution of background noise levels to the measurements).

In accordance with the NCTP, supplementary analysis procedures as specified in the NCTP were used to investigate the wind farm's contribution to the total measured noise levels. The relevant supplementary procedures and observations are summarised in Table 117.

Table 117: Receiver 83 – supplementary analysis summary

Procedure	Findings
Comparison of data trends for upwind and downwind conditions	See Figure 110 and Figure 111 for the comparisons for all-time (reduced) and night-time respectively. No indication of distinct difference between the noise levels measured under downwind and upwind conditions.
Noise level versus wind speed profile review	See Figure 112. The profile indicates greater increases in noise levels above 9 m/s than occurs at locations nearer to the wind farm. This indicates background noise influences rather than wind farm noise at high wind speeds.
Data filtering using intermediate measurement data	See Figure 113 and Figure 114 for data subject to additional filtering for the all-time (reduced) and night-time respectively. This additional filter removes a data point if the measured noise level at the receiver was higher than at the intermediate location positioned nearer to the wind farm. The additional removes a significant quantity of additional points where noise levels would have been unrelated to the operation of the wind farm. Application of the additional filter to the all-time (reduced) data indicates the trend line of the data is below 40 dB L_{A90} for wind speeds up to 11 m/s inclusive.
Extrapolation of intermediate data	See Table 121 and Table 122 in Appendix T6. The extrapolation indicates estimated tonality adjusted wind farm noise levels below 40 dB L_{A90} across the assessable range of wind speeds.

Figure 110: Receiver 103 – upwind and downwind post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

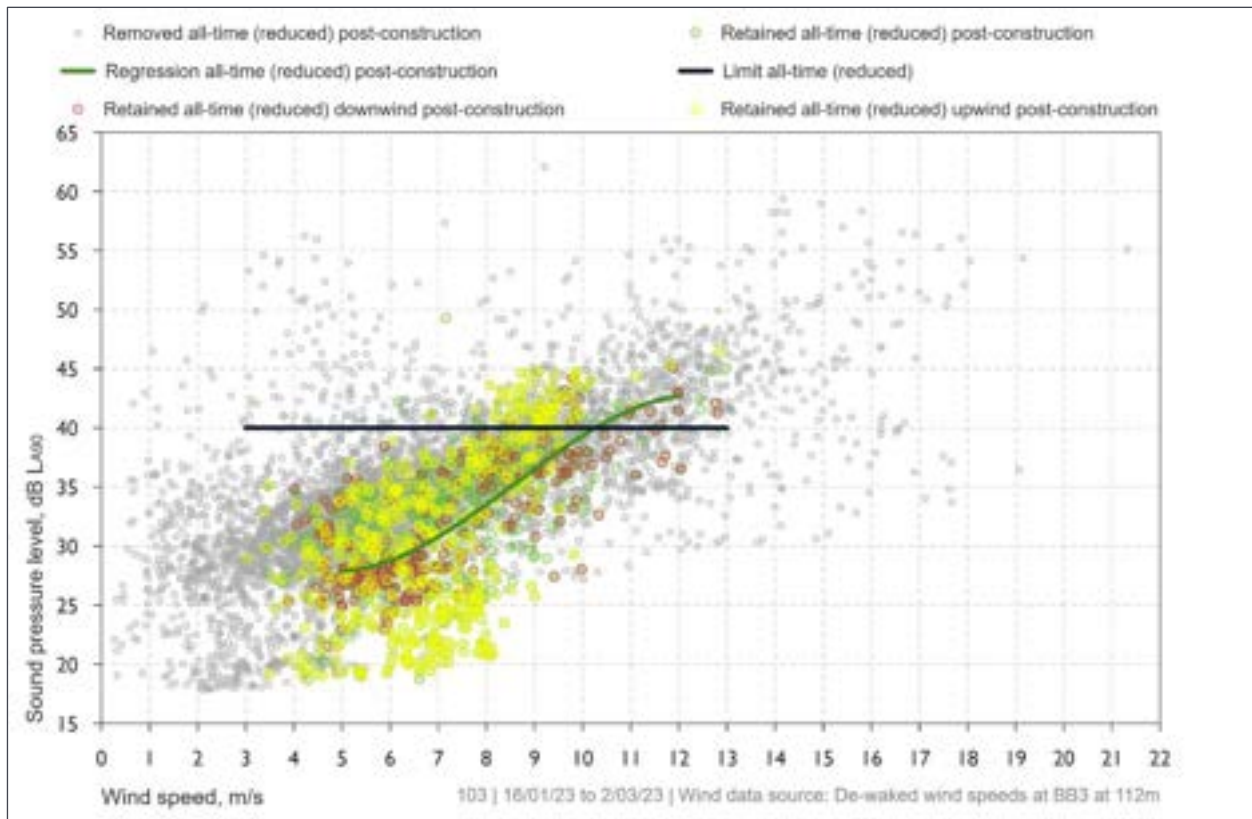


Figure 111: Receiver 103 – upwind and downwind post-construction noise levels and minimum noise limits versus site wind speed – night-time

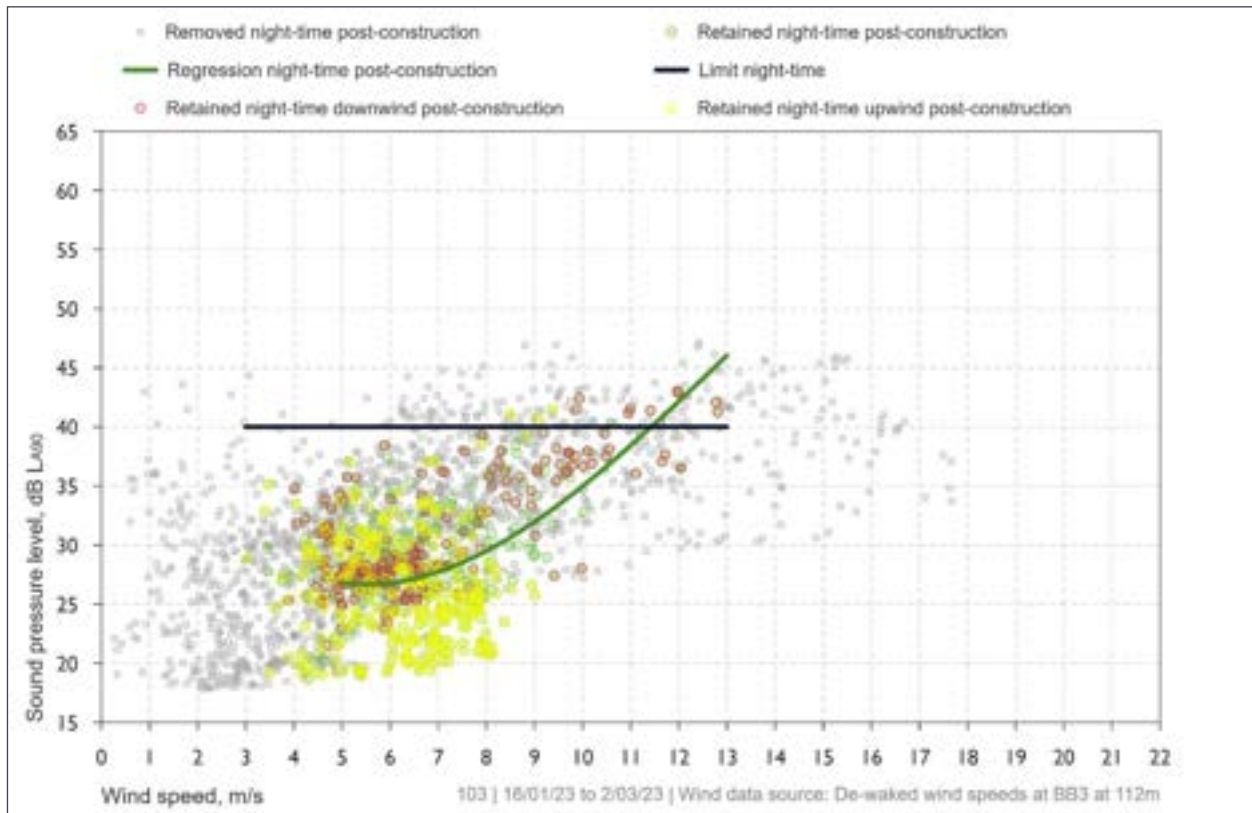


Figure 112: Change in noise level with wind speed, receiver 103 compared to intermediate locations – all-time (reduced)

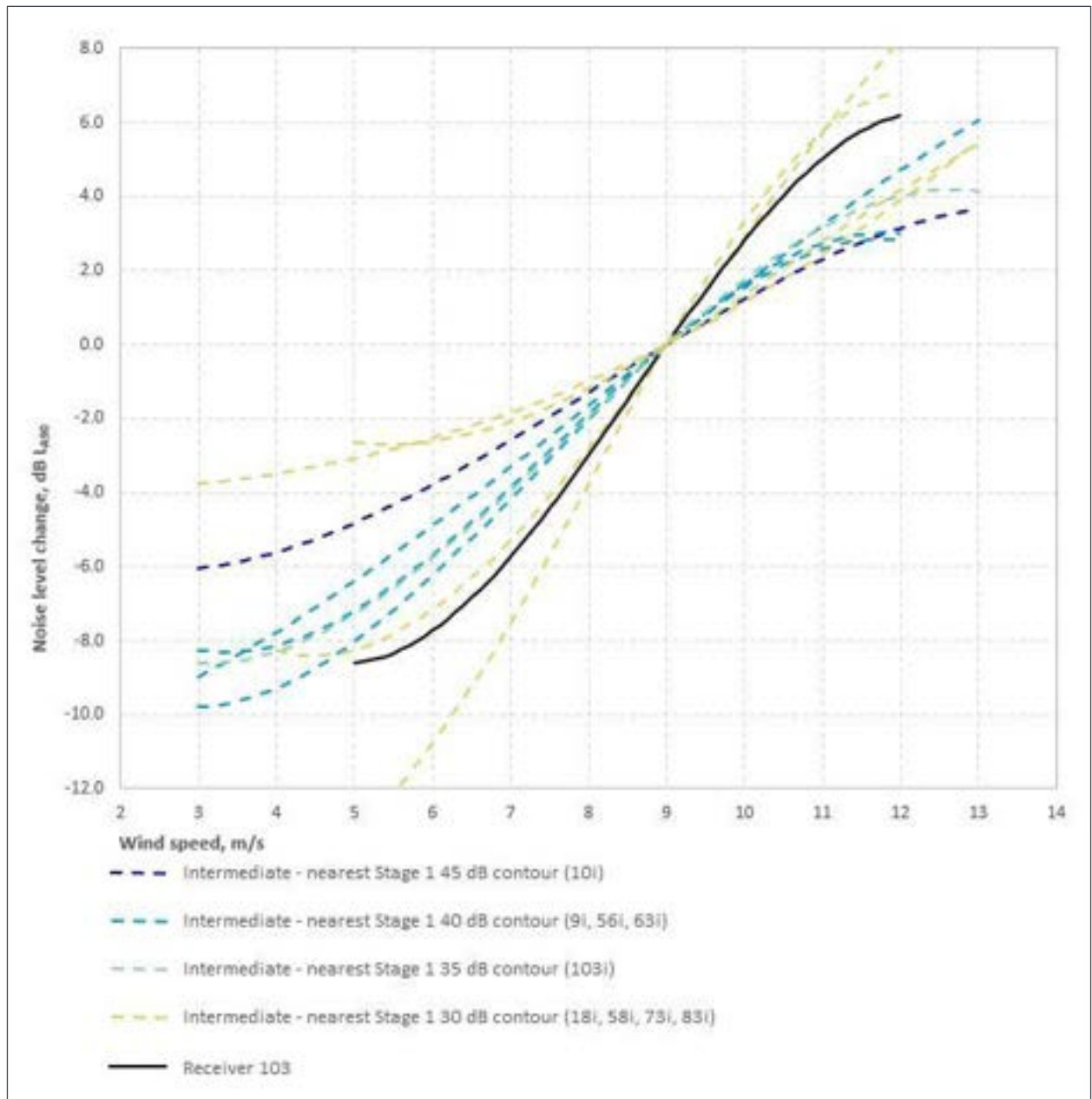


Figure 113: Receiver 103 using intermediate 103i as an additional filter – post-construction noise levels and noise limits versus site wind speed – all-time (reduced)

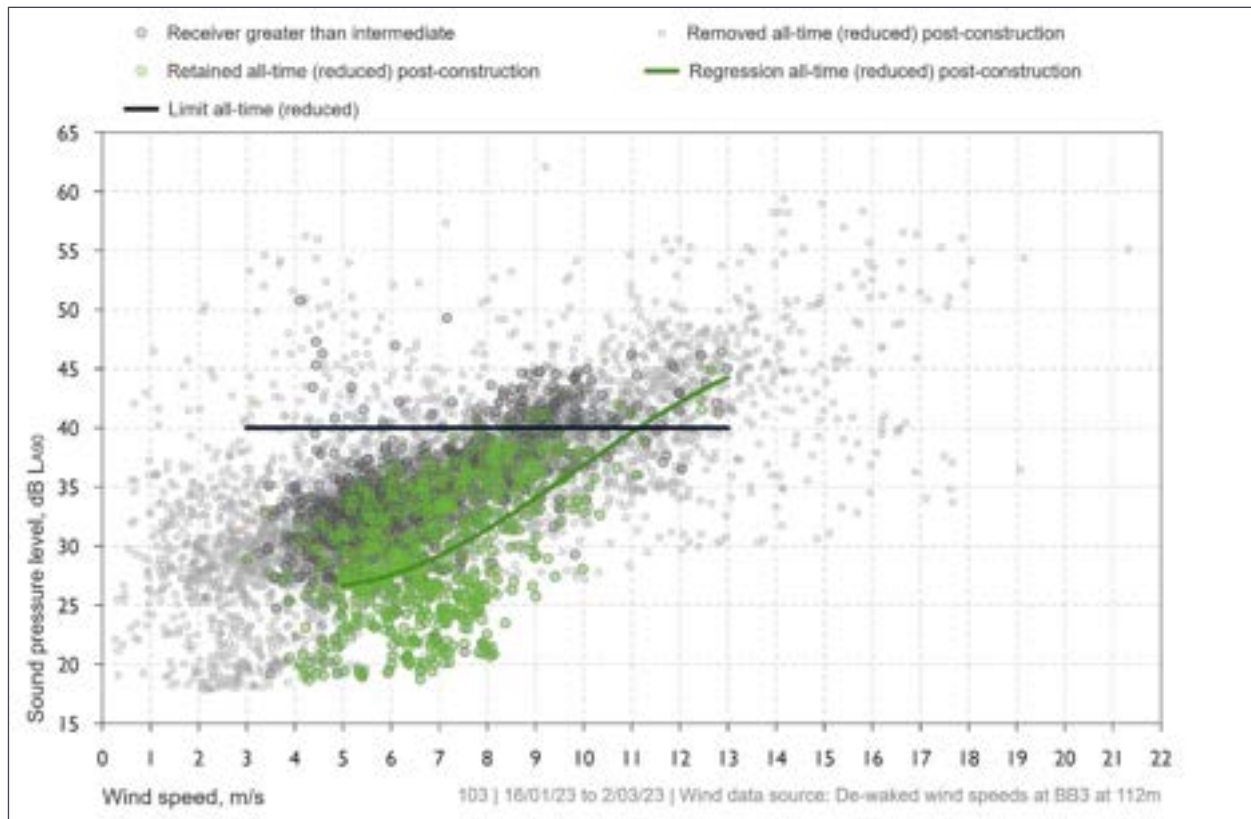
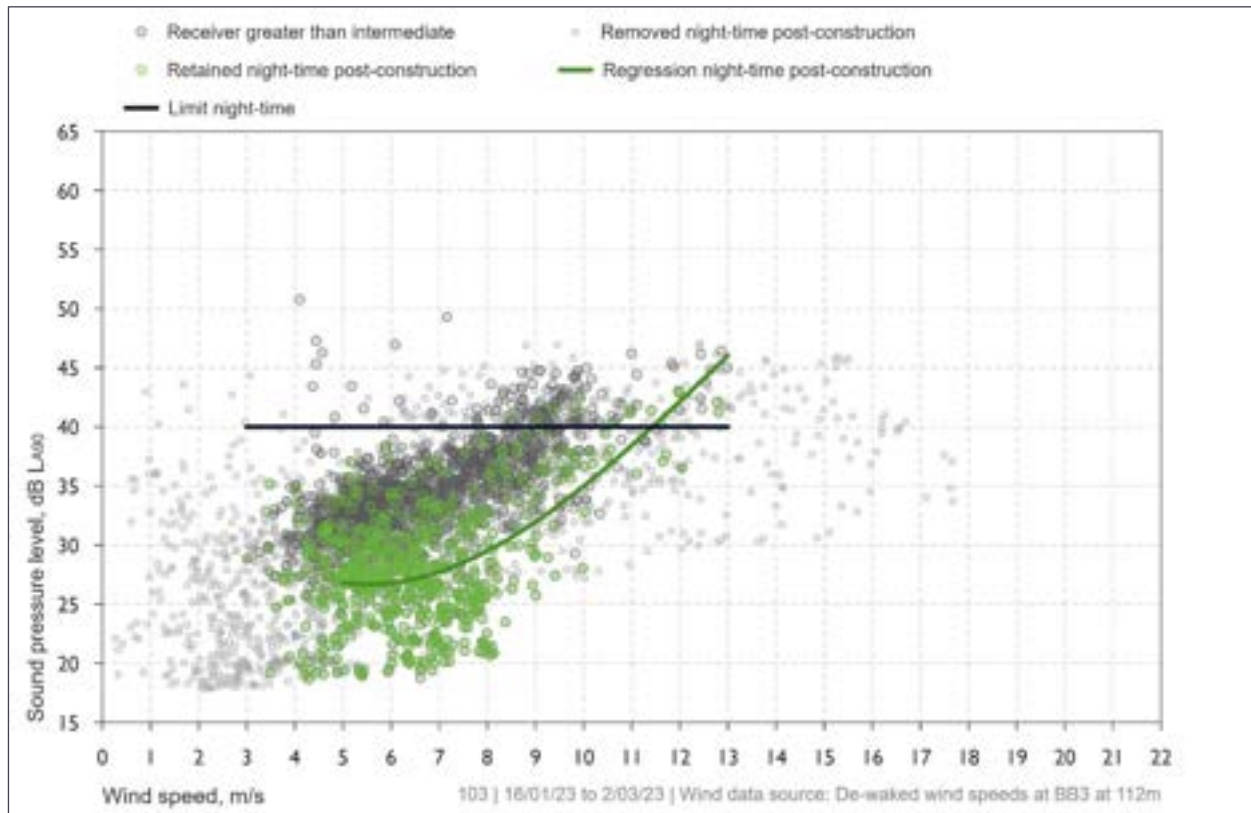


Figure 114: Receiver 103 using intermediate 103i as an additional filter – post-construction noise levels and noise limits versus site wind speed – night-time



T5 Receiver 103 tonality assessment

Figure 115: Receiver 103 tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

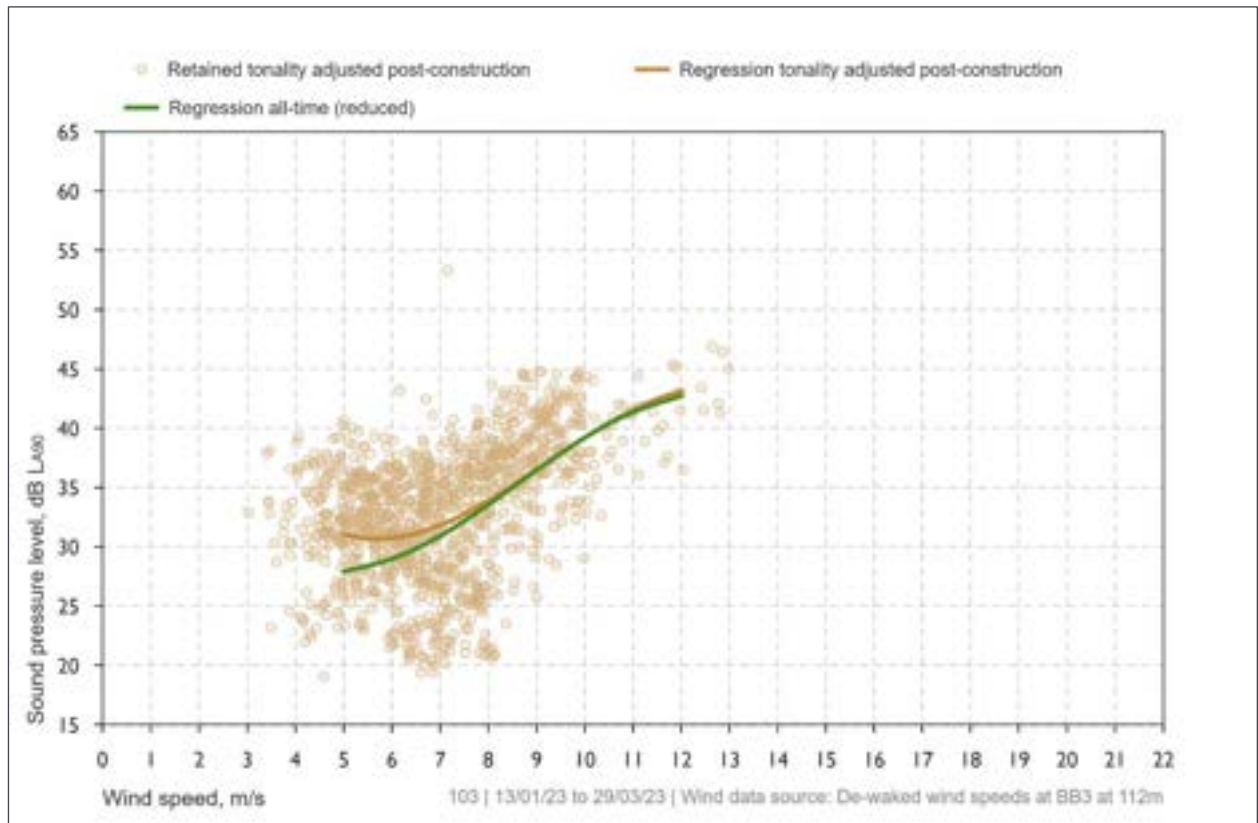


Table 118: Receiver 103 tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	- ^[1]	31.1	30.7	31.8	33.9	36.5	39.2	41.5	43.1	- ^[1]
Post-construction regression - no penalties	- ^[1]	- ^[1]	27.9	28.8	30.8	33.5	36.5	39.3	41.5	42.7	- ^[1]
Penalty adjustment	- ^[1]	- ^[1]	3.2	1.9	1.0	0.4	0.0	0.0	0.0	0.4	- ^[1]

1 Outside valid wind speed range of the regression analysis

T6 Receiver 103 compliance assessment

Table 119: Receiver 103 compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	– [1]	– [1]	27.9	28.8	30.8	33.5	36.5	39.3	41.5	42.7	– [1]
Background noise level	– [1]	– [1]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [1]
Background adjustment	– [1]	– [1]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [2]	– [1]
Tonality adjustment	– [1]	– [1]	3.2	1.9	1.0	0.4	0.0	0.0	0.0	0.4	– [1]
Estimated tonality adjusted wind farm noise level [3]	– [1]	– [1]	< 31.1	< 30.7	< 31.8	< 33.9	< 36.5	< 39.3	< 41.5	< 43.1	– [1]
Noise limit	– [1]	– [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	– [1]
Compliance margin	– [1]	– [1]	-8.9	-9.3	-8.2	-6.1	-3.5	-0.7	1.5 [4]	3.1 [4]	– [1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location - the background adjustment is therefore not available for this location

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB L_{A90} minimum limit

Table 120: Receiver 103 compliance assessment, dB L_{A90} – night-time (2200 – 0500 hrs)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	– ^[1]	– ^[1]	26.8	26.8	27.7	29.5	32.0	35.0	38.4	42.2	46.0
Background noise level	– ^[1]	– ^[1]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]
Background adjustment	– ^[1]	– ^[1]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]	– ^[2]
Tonality adjustment	– ^[1]	– ^[1]	3.2	1.9	1.0	0.4	0.0	0.0	0.0	0.4	– ^[1]
Estimated tonality adjusted wind farm noise level ^[3]	– ^[1]	– ^[1]	< 30.0	< 28.7	< 28.7	< 29.9	< 32.0	< 35	< 38.4	< 42.6	– ^[1]
Noise limit	– ^[1]	– ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Compliance margin	– ^[1]	– ^[1]	-10.0	-11.3	-11.3	-10.1	-8.0	-5.0	-1.6	2.6 ^[4]	– ^[1]

1 Outside valid wind speed range of the regression analysis

2 Background monitoring was not undertaken at this receiver location - the background adjustment is therefore not available for this location

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Result relates to background noise levels; actual wind turbine noise levels would be below the 40 dB L_{A90} minimum limit

Table 121: Receiver 103 compliance assessment based on extrapolation of intermediate 103i, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 103i	27.3	27.6	28.6	30.1	32.0	33.9	35.9	37.7	39.1	39.9	40.0
Background noise level intermediate 103i	23.5	24.9	26.2	27.4	28.4	29.4	30.3	31.1	32.0	32.8	33.6
Background adjustment intermediate 103i	-2.3	- [2]	- [2]	- [2]	-2.5	-1.9	-1.4	-1.1	-0.9	-0.9	-1.1
Extrapolation correction	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5
Tonality adjustment receiver 103	- [1]	- [1]	3.2	1.9	1.0	0.4	0.0	0.0	0.0	0.4	- [1]
Estimated tonality adjusted wind farm noise level receiver 103 [3]	- [1]	- [1]	< 29.3	< 29.5	28.0	29.9	32.0	34.1	35.7	36.9	- [1]
Noise limit receiver 103 [4]	- [1]	- [1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- [1]
Compliance margin	- [1]	- [1]	-10.7	-10.5	-12.0	-10.1	-8.0	-5.9	-4.3	-3.1	- [1]

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

Table 122: Receiver 103 compliance assessment based on extrapolation of intermediate 103i, dB L_{A90} – night-time (2200 – 0500 hrs)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 103i	25.7	26.2	27.2	28.5	30.1	31.8	33.5	34.9	36.0	36.6	- ^[1]
Background noise level intermediate 103i	18.3	24.9	26.2	27.4	28.4	29.4	30.3	31.1	32.0	32.8	- ^[1]
Background adjustment intermediate 103i	-0.9	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	-2.8	-2.3	-2.2	-2.3	- ^[1]
Extrapolation correction	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	- ^[1]
Tonality adjustment receiver 103	- ^[1]	- ^[1]	3.2	1.9	1.0	0.4	0.0	0.0	0.0	0.4	- ^[1]
Estimated tonality adjusted wind farm noise level receiver 103 ^[3]	- ^[1]	- ^[1]	< 27.9	< 27.9	< 28.6	< 29.7	28.2	30.1	31.3	32.2	- ^[1]
Noise limit receiver 103 ^[4]	- ^[1]	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]
Compliance margin	- ^[1]	- ^[1]	-12.1	-12.1	-11.4	-10.3	-11.8	-9.9	-8.7	-7.8	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

APPENDIX U RECEIVER 108

U1 Receiver 108 location data

Table 123: Receiver 108 dwelling and noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Dwelling location	718486	5793409
Noise monitoring location	718500	5793433

Figure 116: Receiver 108 aerial view – dwelling and noise monitor locations

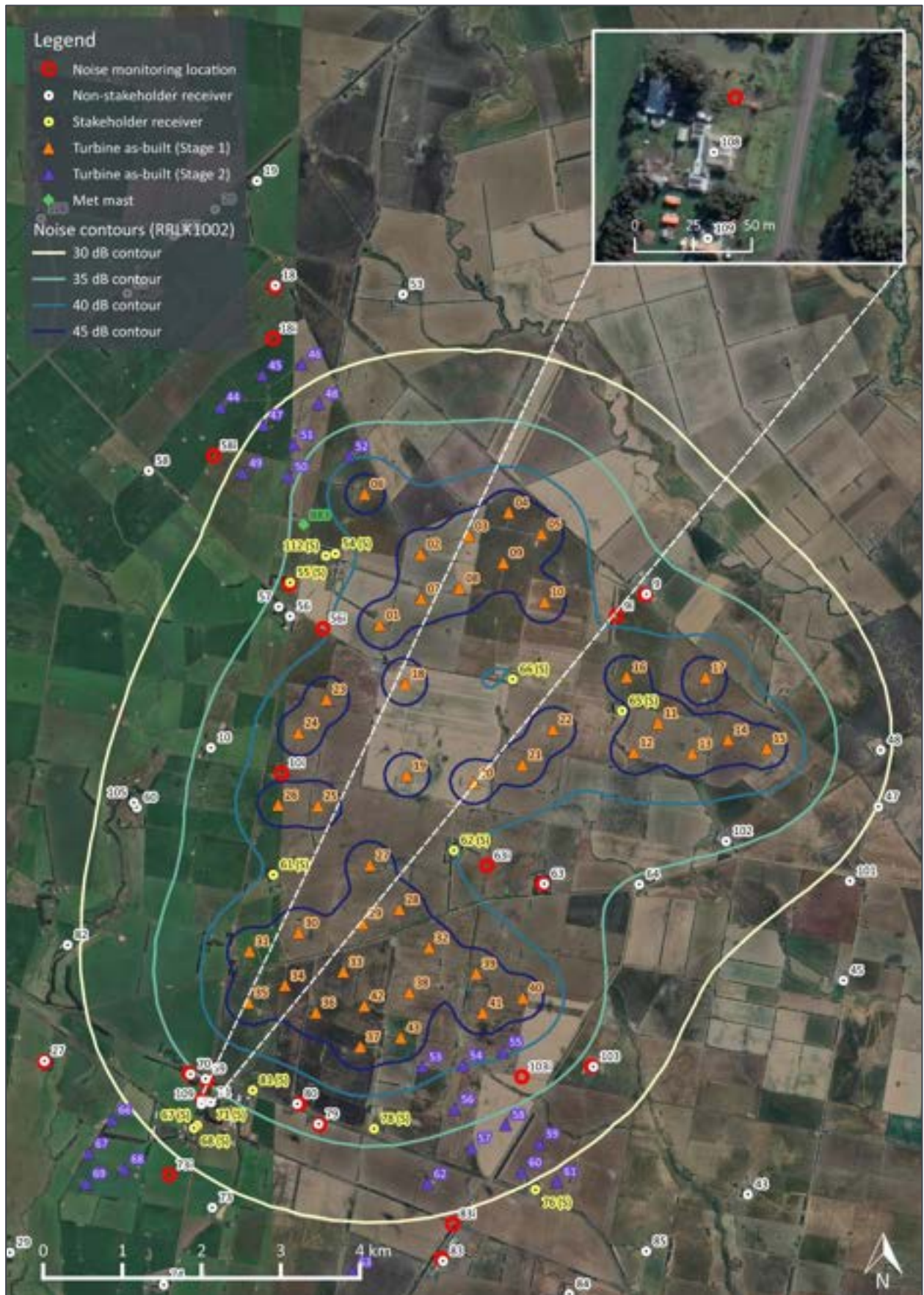
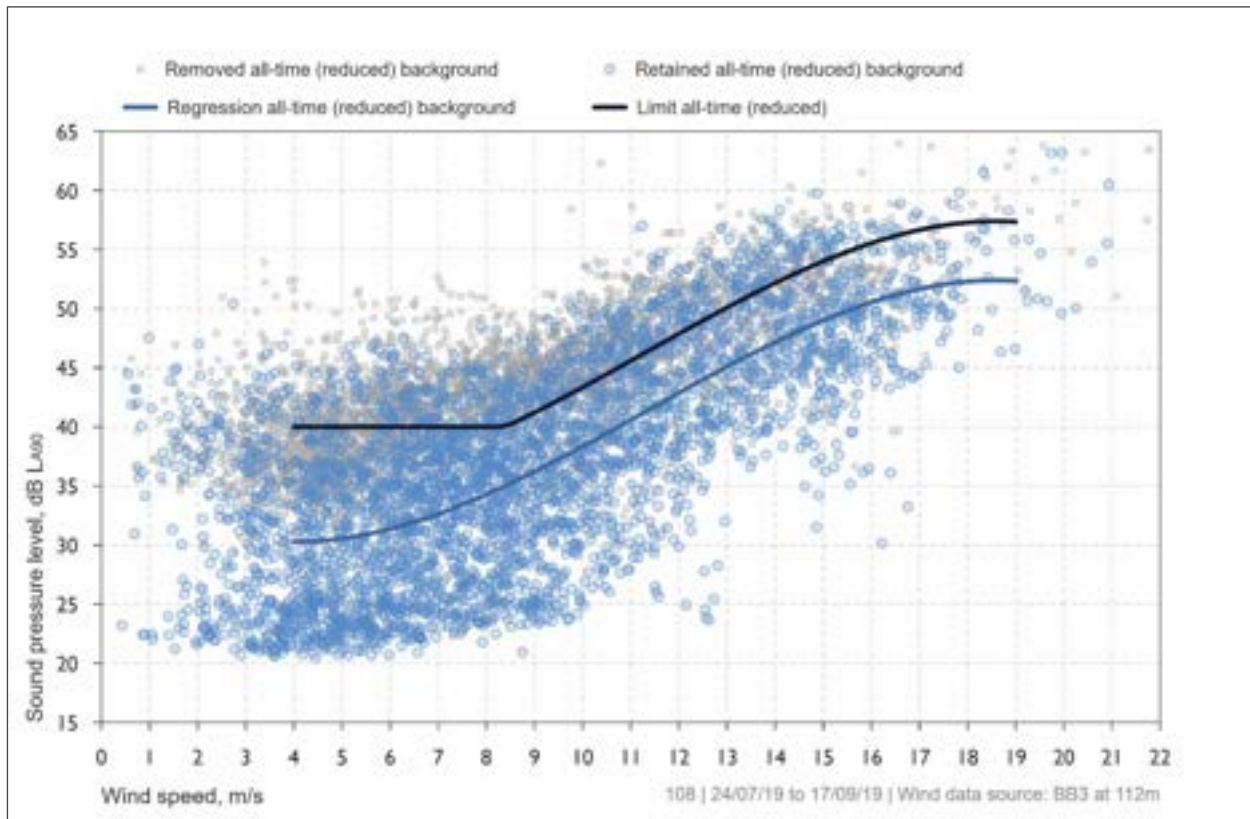


Table 124: Receiver 108 monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

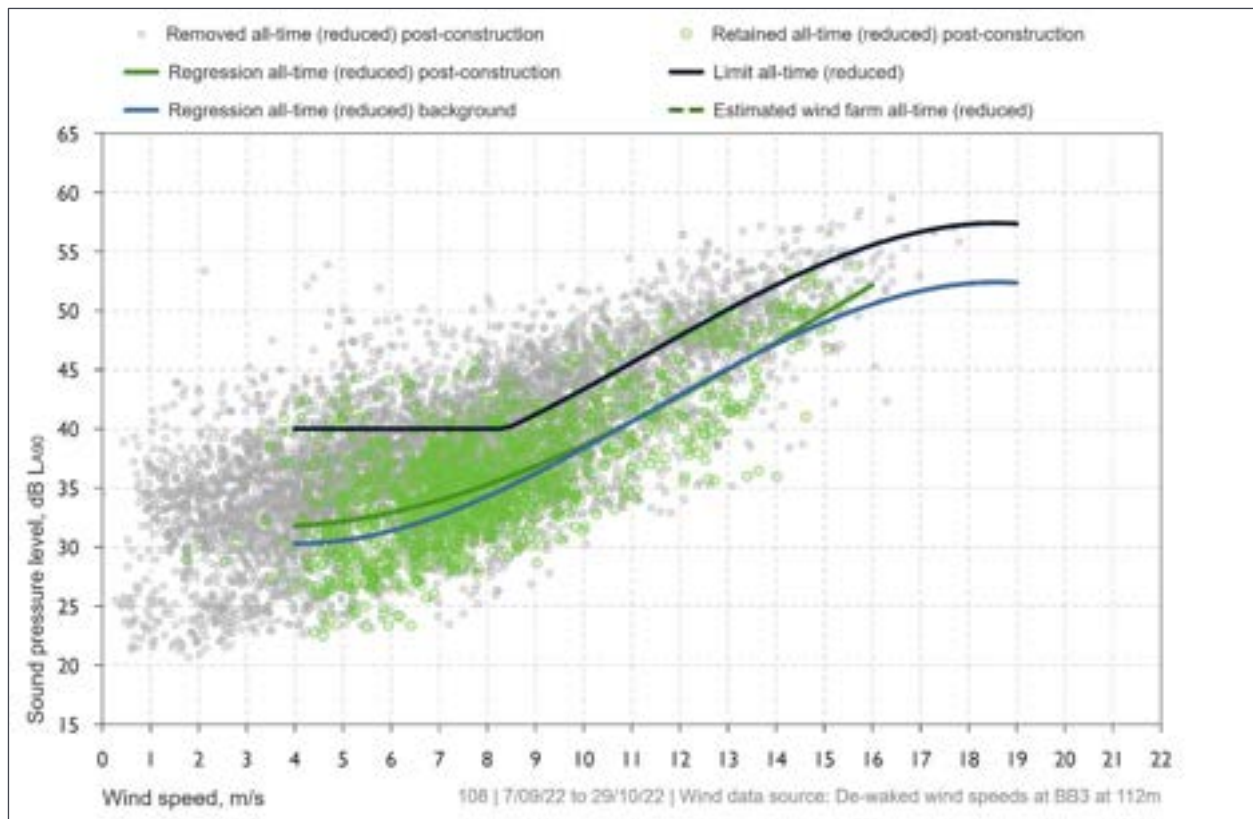
U2 Receiver 108 background noise data

Figure 117: Receiver 108 - derived background noise levels and noise limit – all-time (reduced)



U3 Receiver 108 post-construction measurement data – all wind speeds

Figure 118: Receiver 108 – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



U4 Receiver 108 post-construction measurement data summary – assessment wind speeds

Table 125: Receiver 108 assessment data summary – number of data points

Data points	All-time (reduced)
Collected	7257
Removed	5797
Retained	1460

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 126.

Table 126: Receiver 108 assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3045
Rainfall	2222
Extraneous noise	524
Wind farm operations curtailed	3574
Wind speeds outside assessment range	1088

Figure 119: Receiver 108 post-construction noise levels and wind speed time history

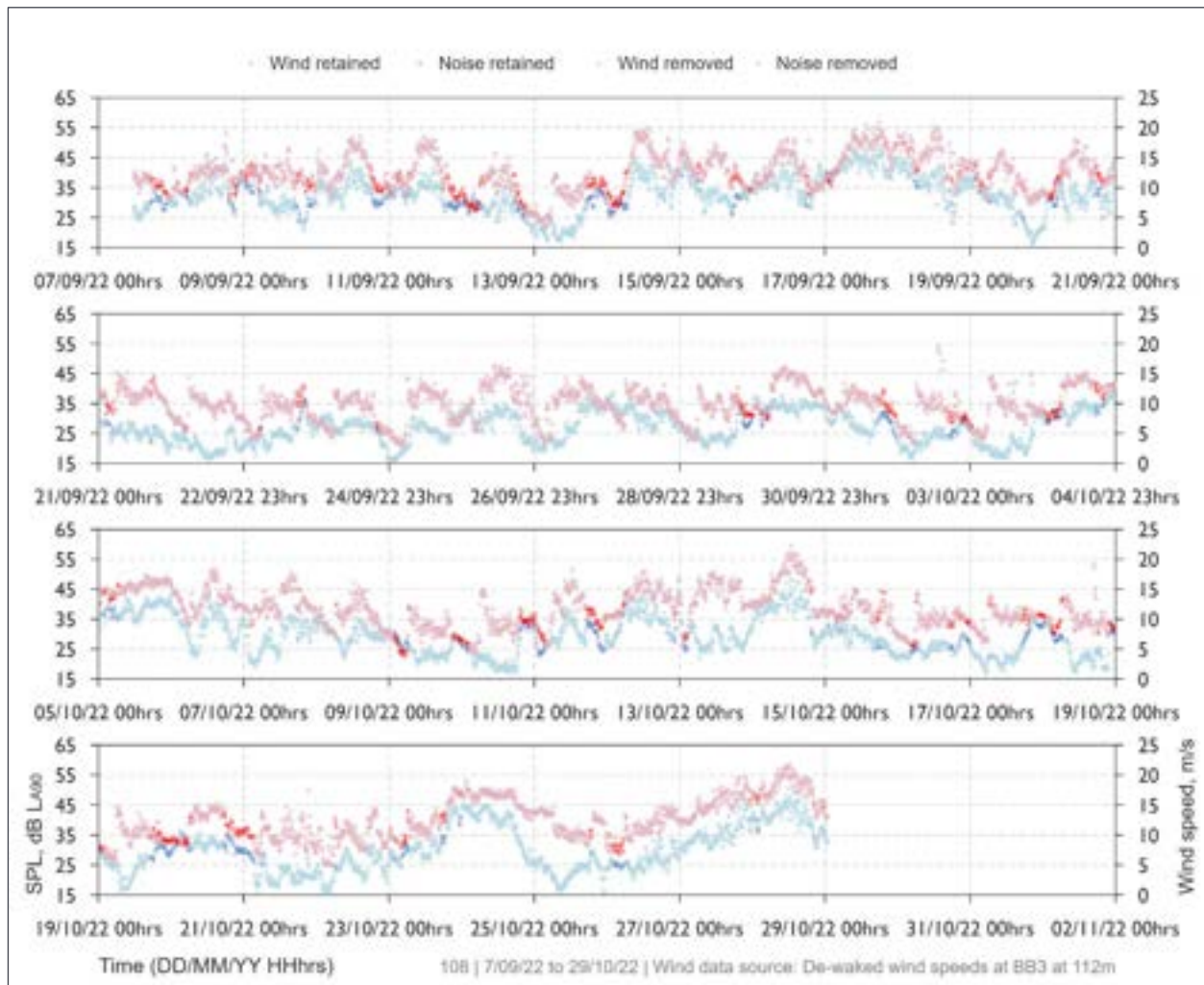
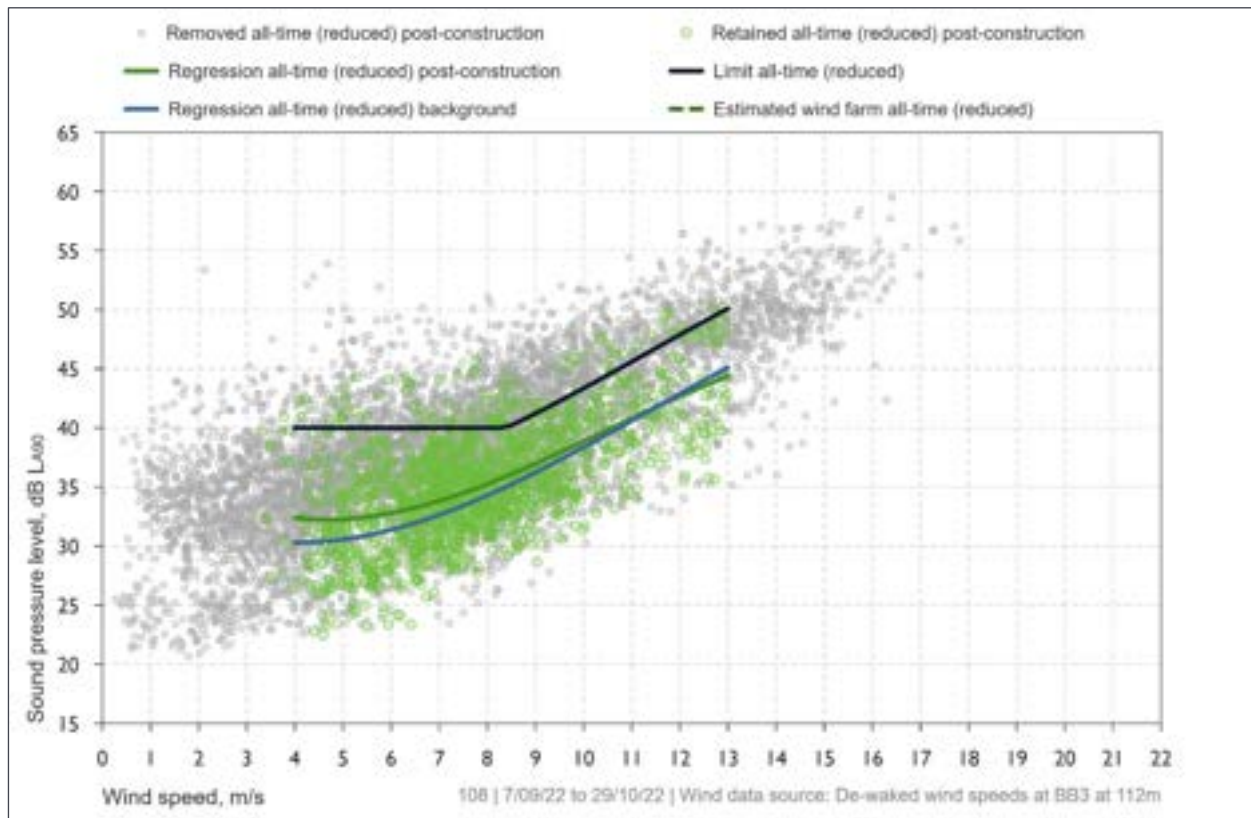


Figure 120: Receiver 108 post-construction noise levels and noise limits versus site wind speed – all-time (reduced)



U5 Receiver 108 tonality assessment

Figure 121: Receiver 108 tonality adjusted total-construction noise levels versus site wind speed – all-time (reduced)

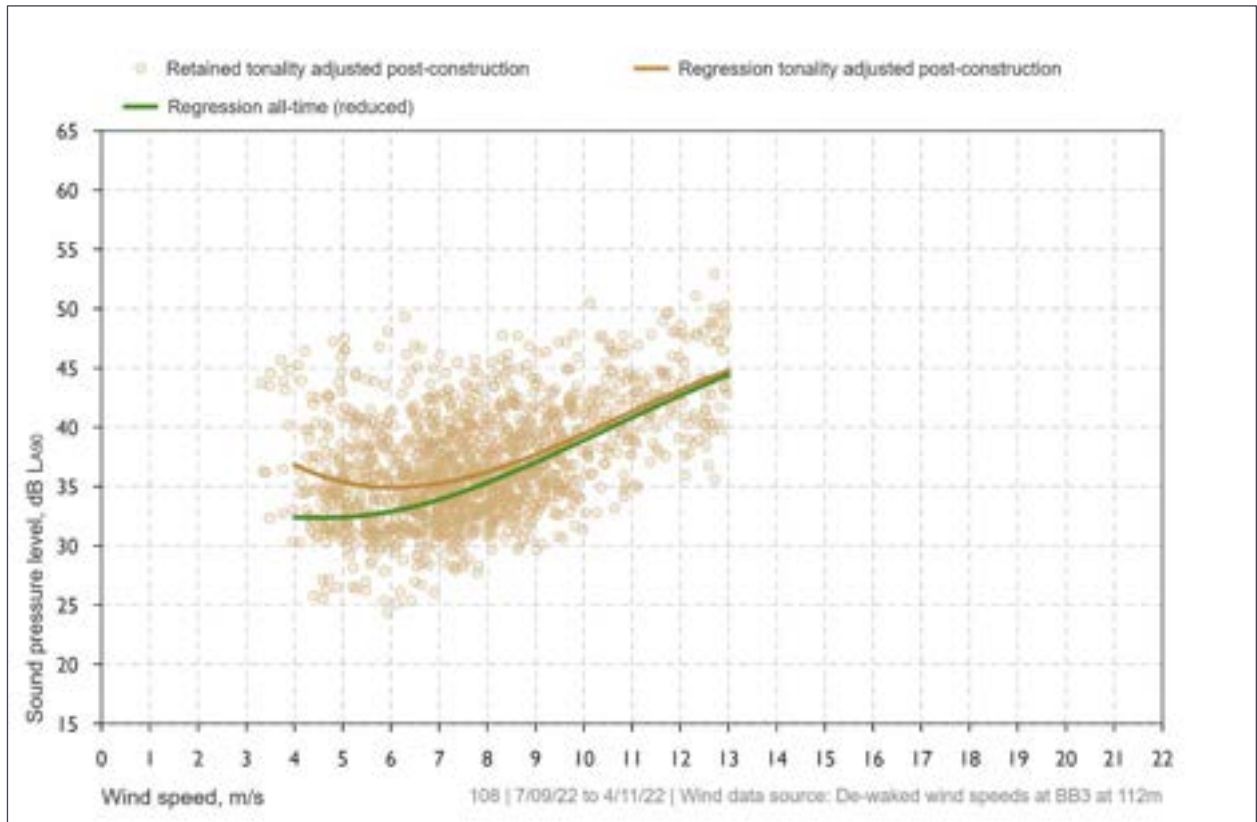


Table 127: Receiver 108 tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	36.8	35.4	34.9	35.3	36.2	37.7	39.4	41.3	43.1	44.8
Post-construction regression - no penalties	- ^[1]	32.4	32.3	32.8	33.8	35.3	37.0	38.9	40.8	42.7	44.4
Penalty adjustment	- ^[1]	4.4	3.1	2.1	1.5	0.9	0.7	0.5	0.5	0.4	0.4

1 Outside valid wind speed range of the regression analysis

U6 Receiver 108 compliance assessment

Table 128: Receiver 108 compliance assessment, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level	- ^[1]	32.4	32.3	32.8	33.8	35.3	37.0	38.9	40.8	42.7	44.4
Background noise level	- ^[1]	30.3	30.6	31.4	32.6	34.3	36.2	38.4	40.6	42.9	45.1
Background adjustment	- ^[1]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]	- ^[2]
Tonality adjustment	- ^[1]	4.4	3.1	2.1	1.5	0.9	0.7	0.5	0.5	0.4	0.4
Estimated tonality adjusted wind farm noise level ^[3]	- ^[1]	< 36.8	< 35.4	< 34.9	< 35.3	< 36.2	< 37.7	< 39.4	< 41.3	< 43.1	< 44.8
Noise limit	- ^[1]	40.0	40.0	40.0	40.0	40.0	41.2	43.4	45.6	47.9	50.1
Compliance margin	- ^[1]	-3.2	-4.6	-5.1	-4.7	-3.8	-3.5	-4.0	-4.3	-4.8	-5.3

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

APPENDIX V INTERMEDIATE 9i

V1 Intermediate 9i location data

Table 129: Intermediate 9i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	723725	5799537

Figure 122: Intermediate 9i aerial view – noise monitor location

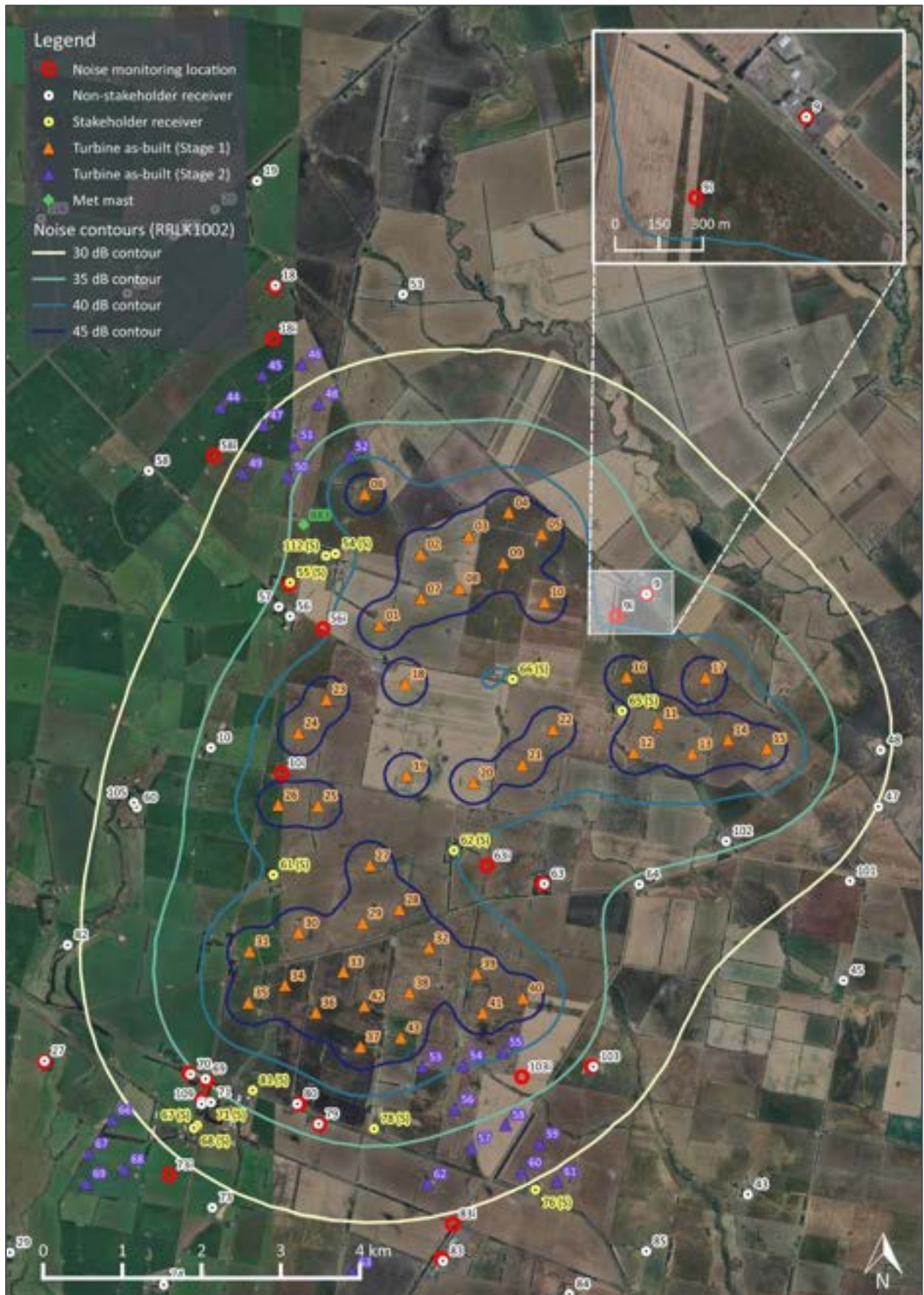
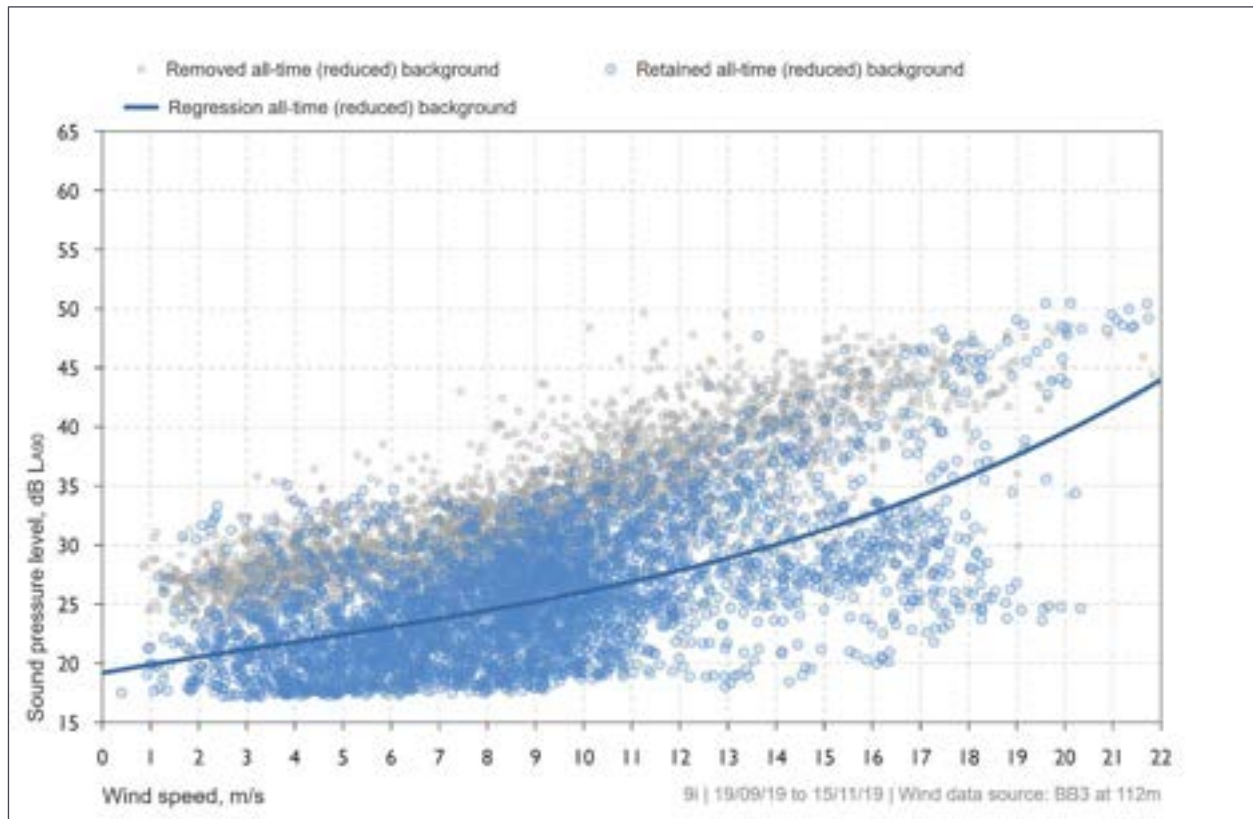


Table 130: Intermediate 9i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

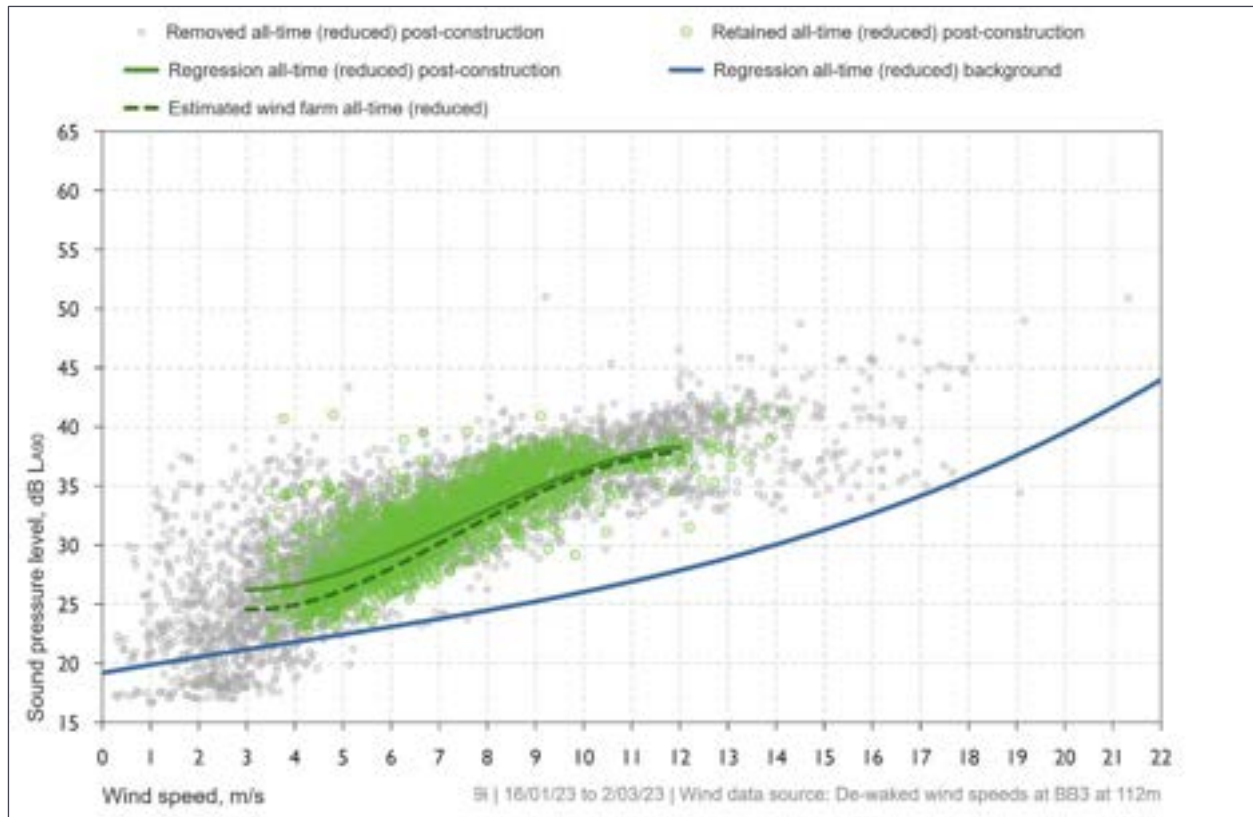
V2 Intermediate 9i background noise data

Figure 123: Intermediate 9i - derived background noise levels and noise limit – all-time (reduced)



V3 Intermediate 9i post-construction measurement data – all wind speeds

Figure 124: Intermediate 9i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



V4 Intermediate 9i post-construction measurement data summary – assessment wind speeds

Table 131: Intermediate 9i assessment data summary – number of data points

Data points	All-time (reduced)
Collected	5802
Removed	3861
Retained	1941

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 132.

Table 132: Intermedia 9i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	2401
Rainfall	433
Extraneous noise	58
Wind farm operations curtailed	2689
Wind speeds outside assessment range	676

Figure 125: Intermediate 9i post-construction noise levels and wind speed time history

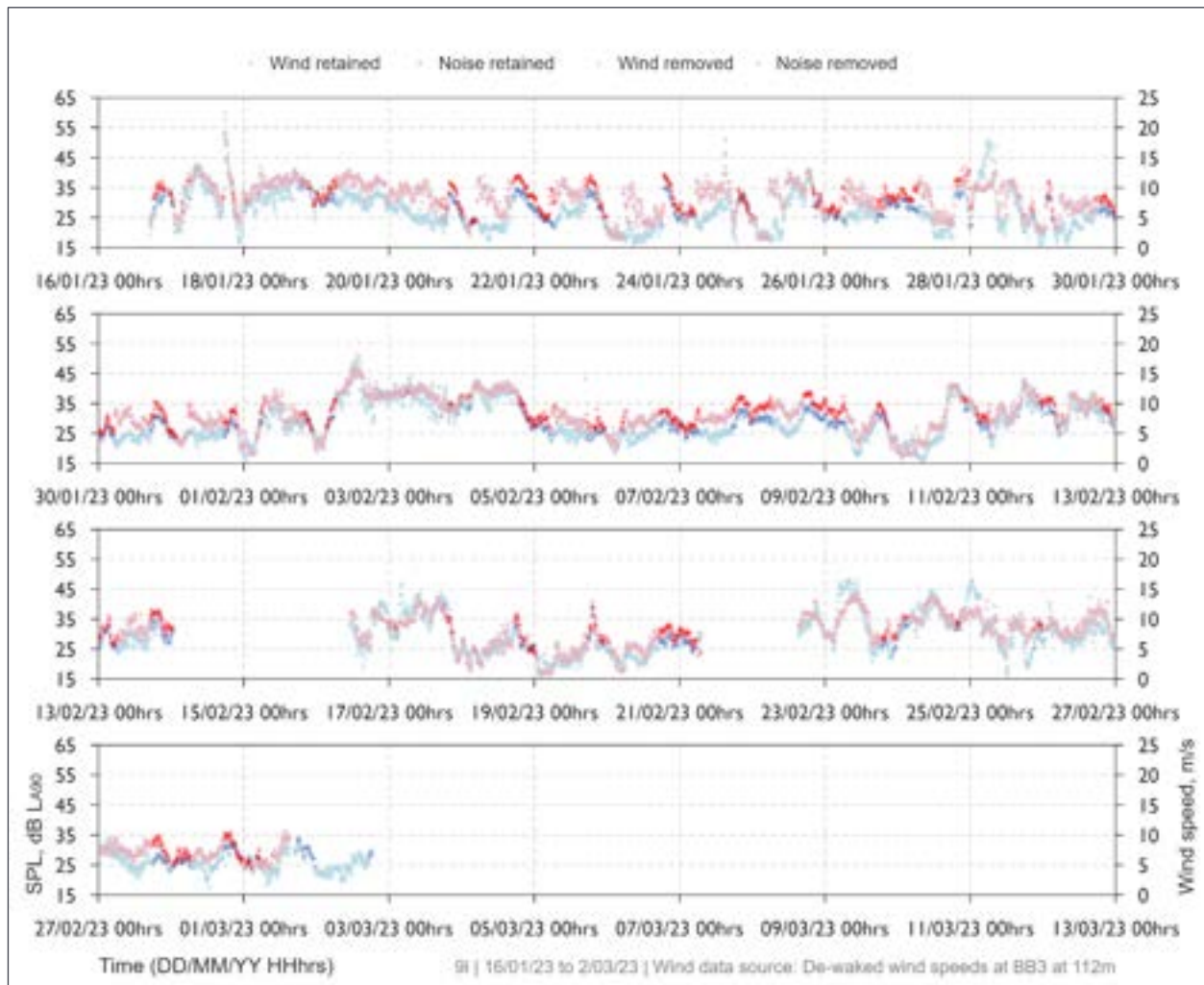
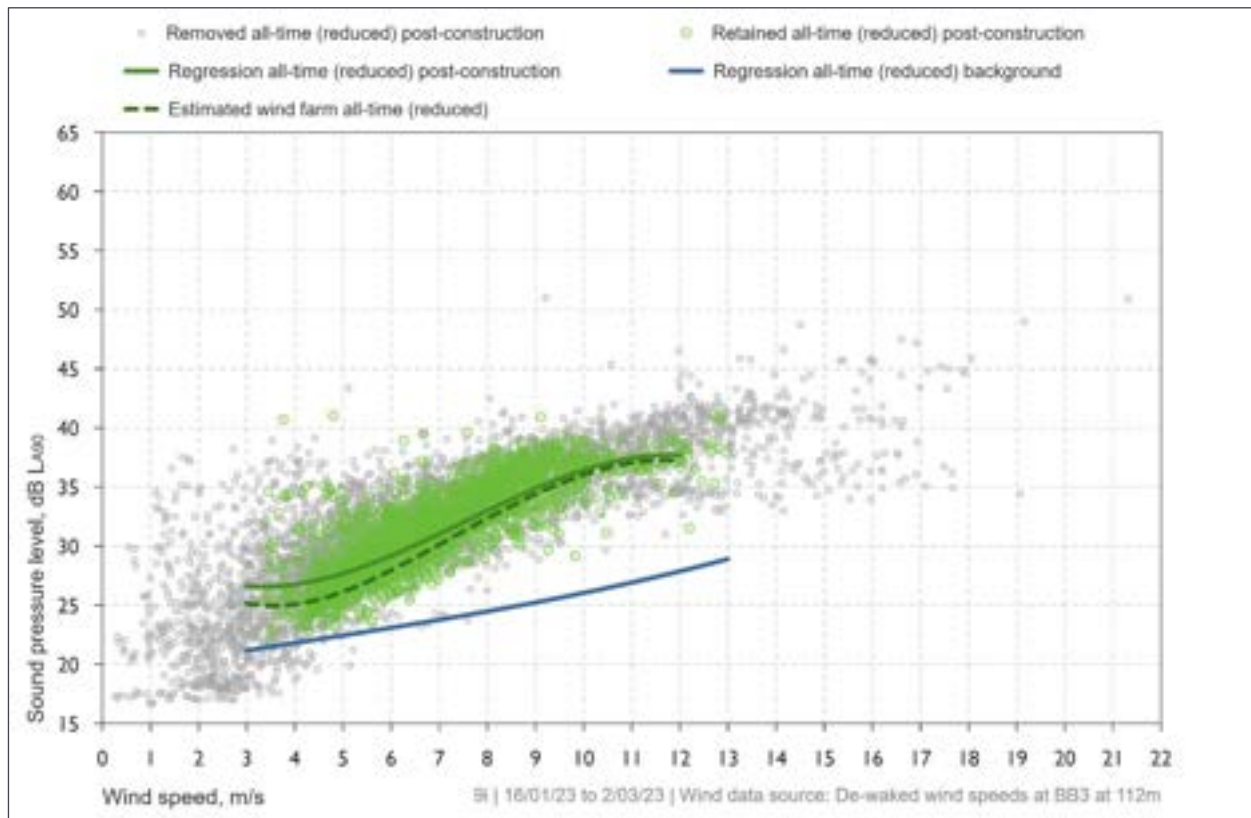


Figure 126: Intermediate 9i – post-construction noise levels versus site wind speed – all-time (reduced)



V5 Intermediate 9i tonality data

Tonality data for intermediate 9i is provided as reference information only. The tonality assessment for receiver 9 is based on data obtained at receiver 9.

Figure 127: Intermediate 9i – tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

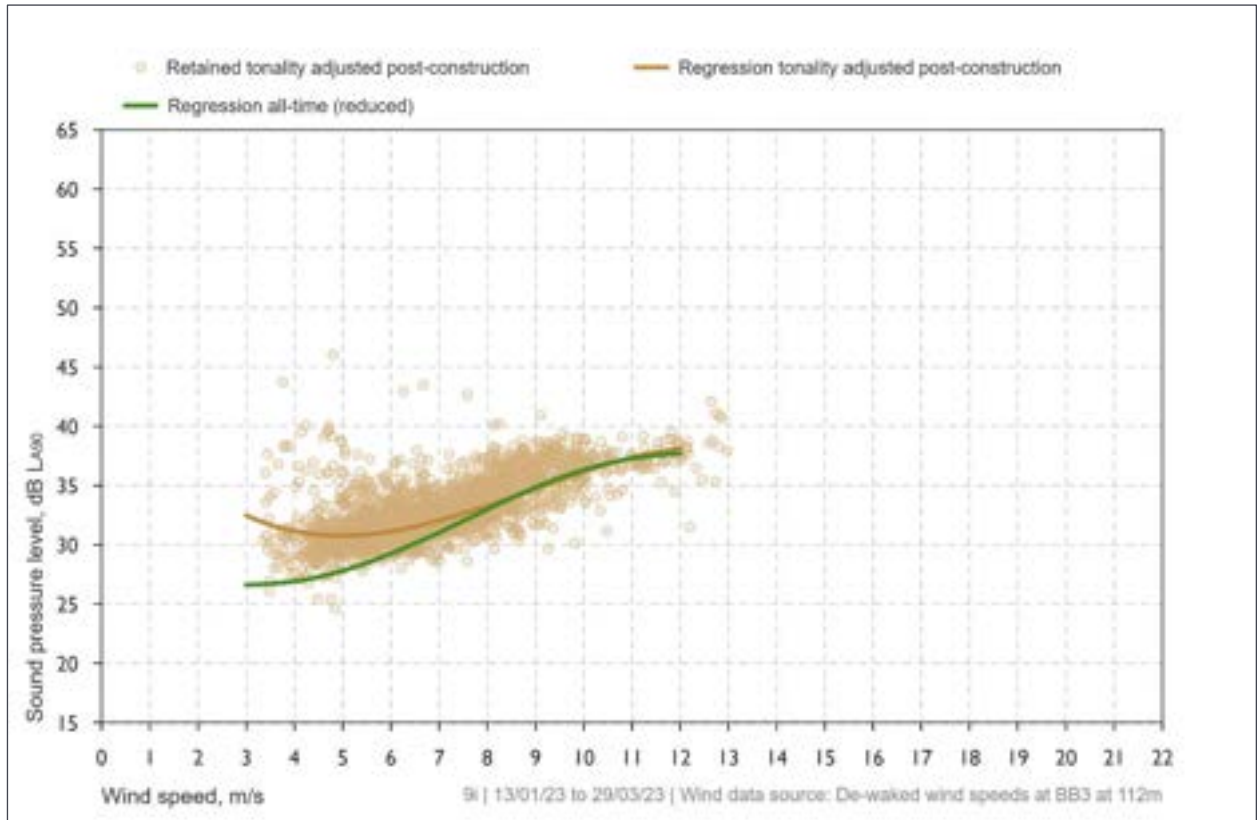


Table 133: Intermediate 9i tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	32.5	31.1	30.8	31.1	32.0	33.3	34.7	36.1	37.3	38.1	- ^[1]
Post-construction regression - no penalties	26.6	26.8	27.7	29.2	31.0	33.0	34.9	36.4	37.4	37.7	- ^[1]
Penalty adjustment	5.9	4.3	3.1	1.9	1.0	0.3	0.0	0.0	0.0	0.4	- ^[1]

1 Outside valid wind speed range of the regression analysis

V6 Receiver 9 compliance assessment

Refer to Appendix J6.

APPENDIX W INTERMEDIATE 10i

W1 Intermediate 10i location data

Table 134: Intermediate 10i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	719496	5797554

Figure 128: Intermediate 10i aerial view – noise monitor location

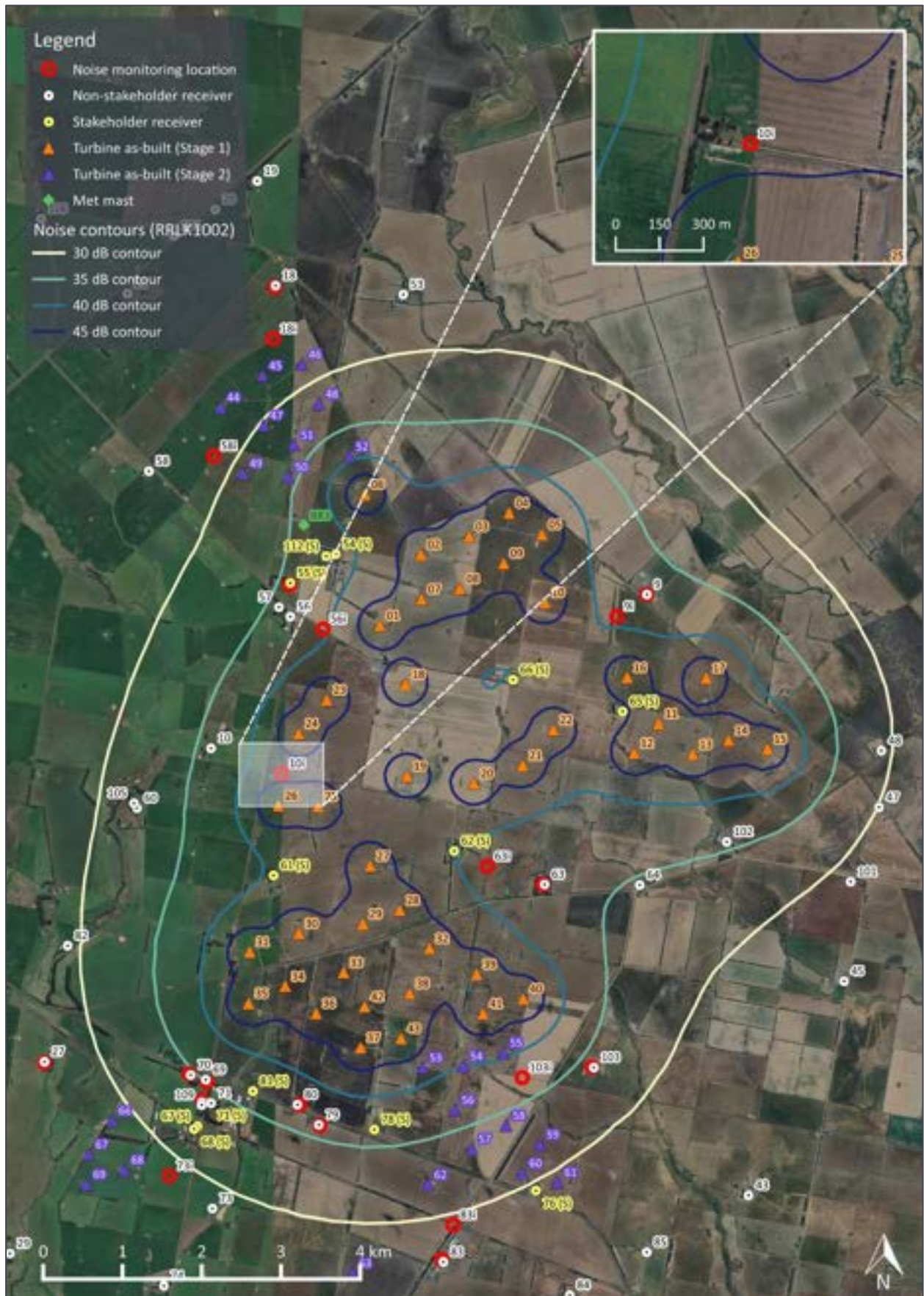
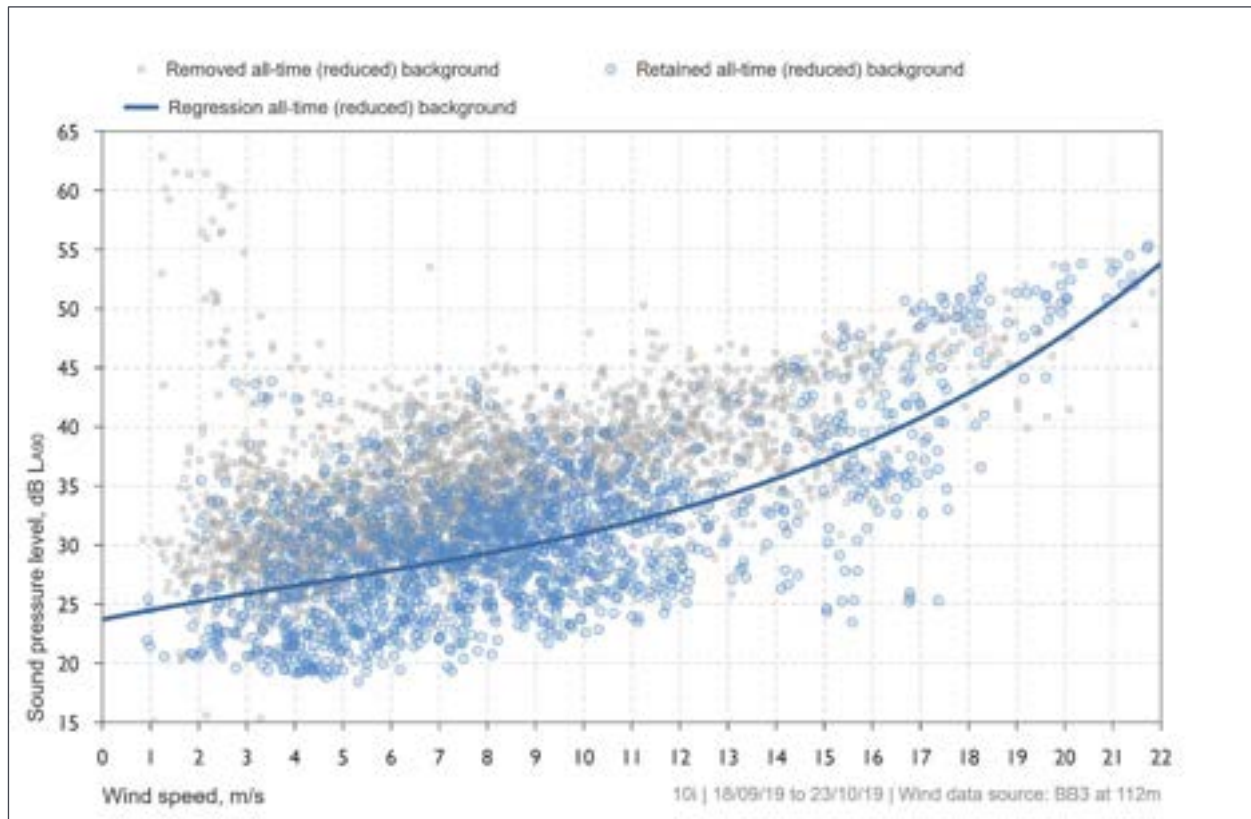


Table 135: Intermediate 10i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

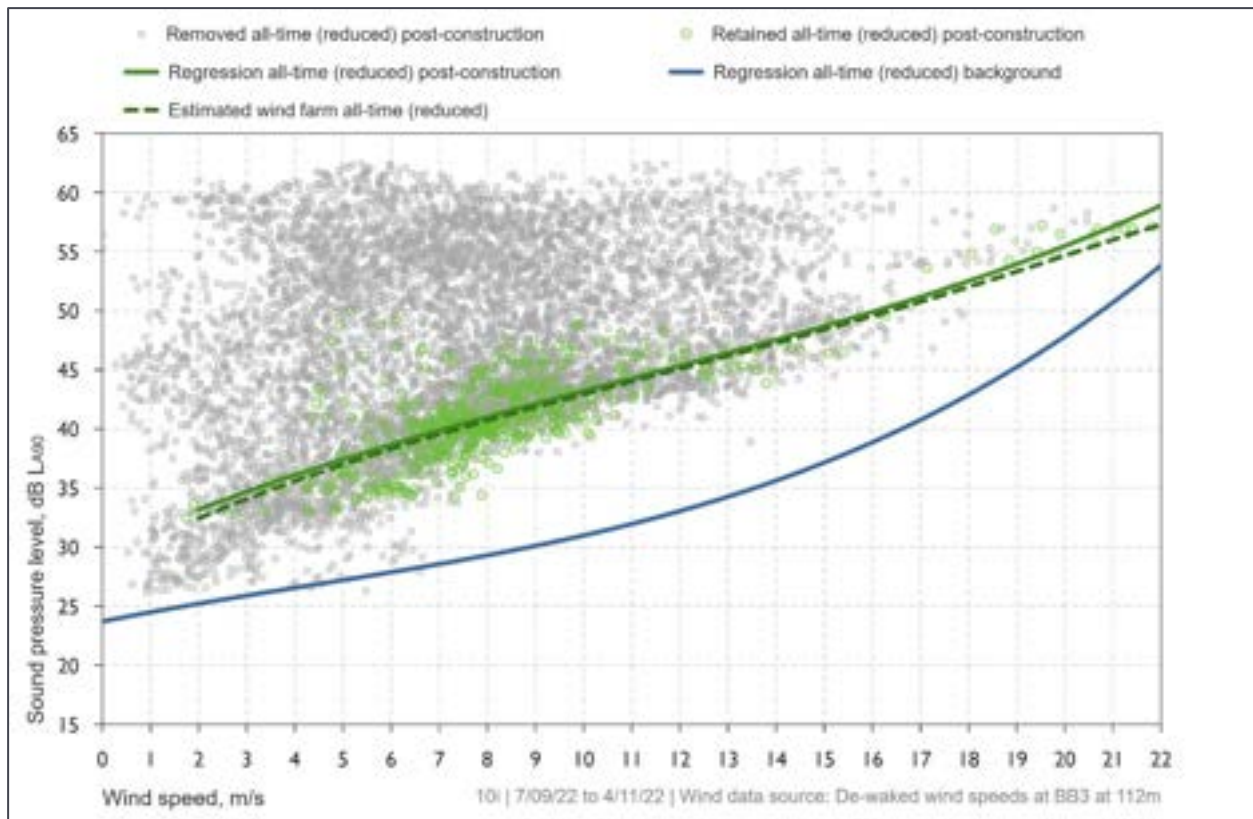
W2 Intermediate 10i background noise data

Figure 129: Intermediate 10i - derived background noise levels and noise limit – all-time (reduced)



W3 Intermediate 10i post-construction measurements data – all wind speeds

Figure 130: Intermediate 10i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



W4 Intermediate 10i post-construction measurement data summary – assessment wind speeds

Table 136: Intermediate 10i assessment data summary – number of data points

Data points	All-time (reduced)
Collected	7385
Removed	6870
Retained	515

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 137.

Table 137: Intermedia 10i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3088
Rainfall	2187
Extraneous noise	3796
Wind farm operations curtailed	3289
Wind speeds outside assessment range	1160

Figure 131: Intermediate 10i post-construction noise levels and wind speed time history

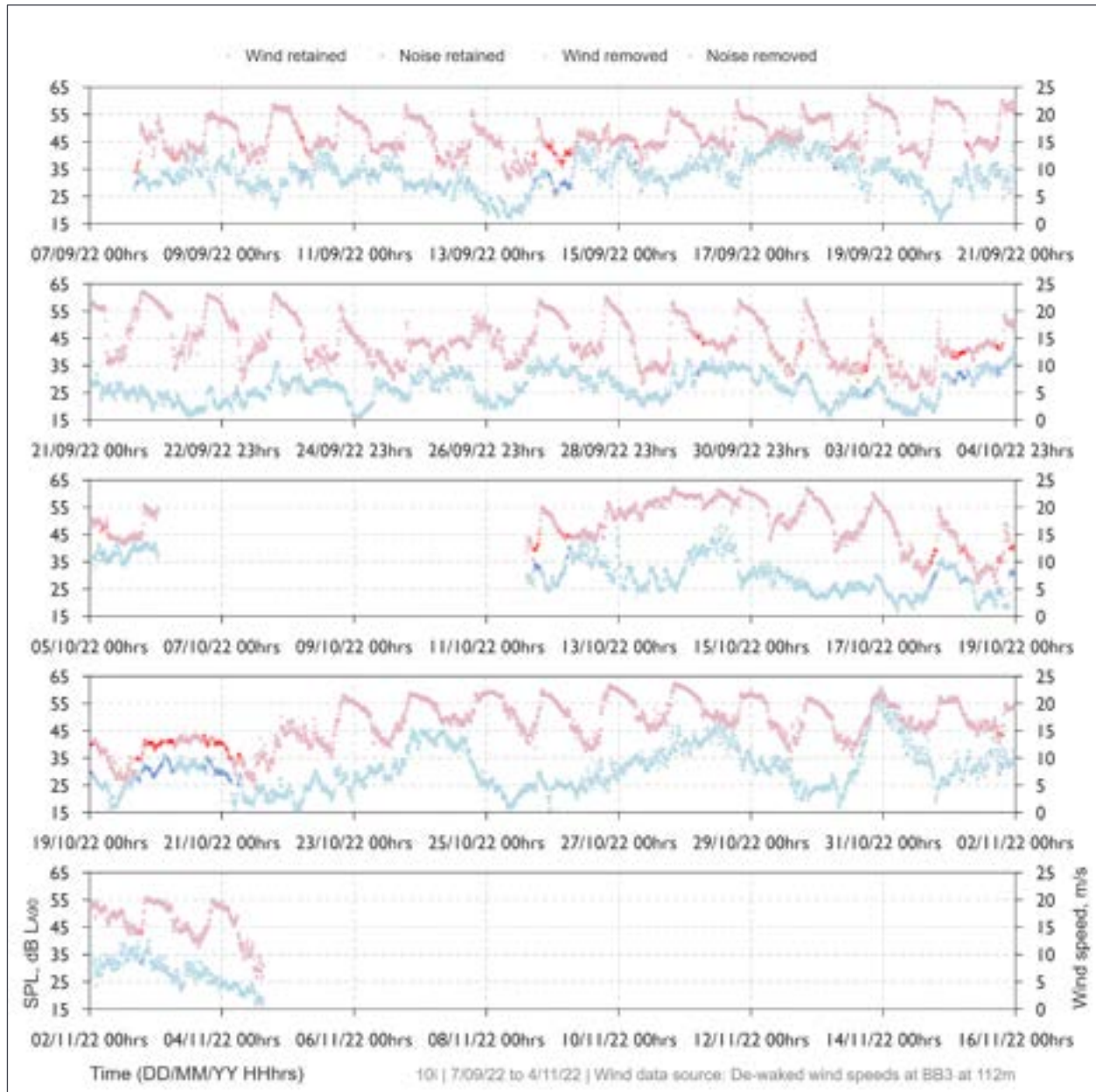
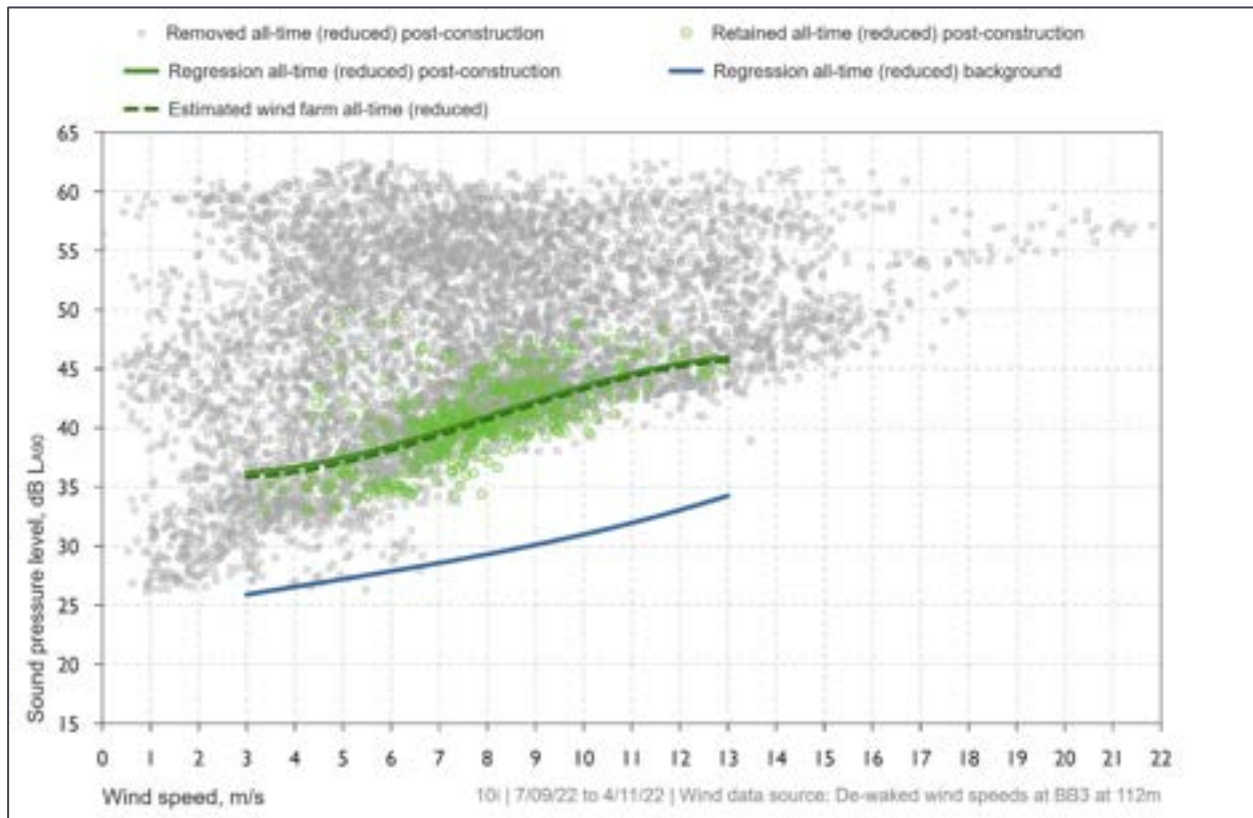


Figure 132: Intermediate 10i post-construction noise levels versus site wind speed – all-time (reduced)



W5 Intermediate 10i tonality assessment

Figure 133: Intermediate 10i tonality adjusted total-construction noise levels versus site wind speed – all-time (reduced)

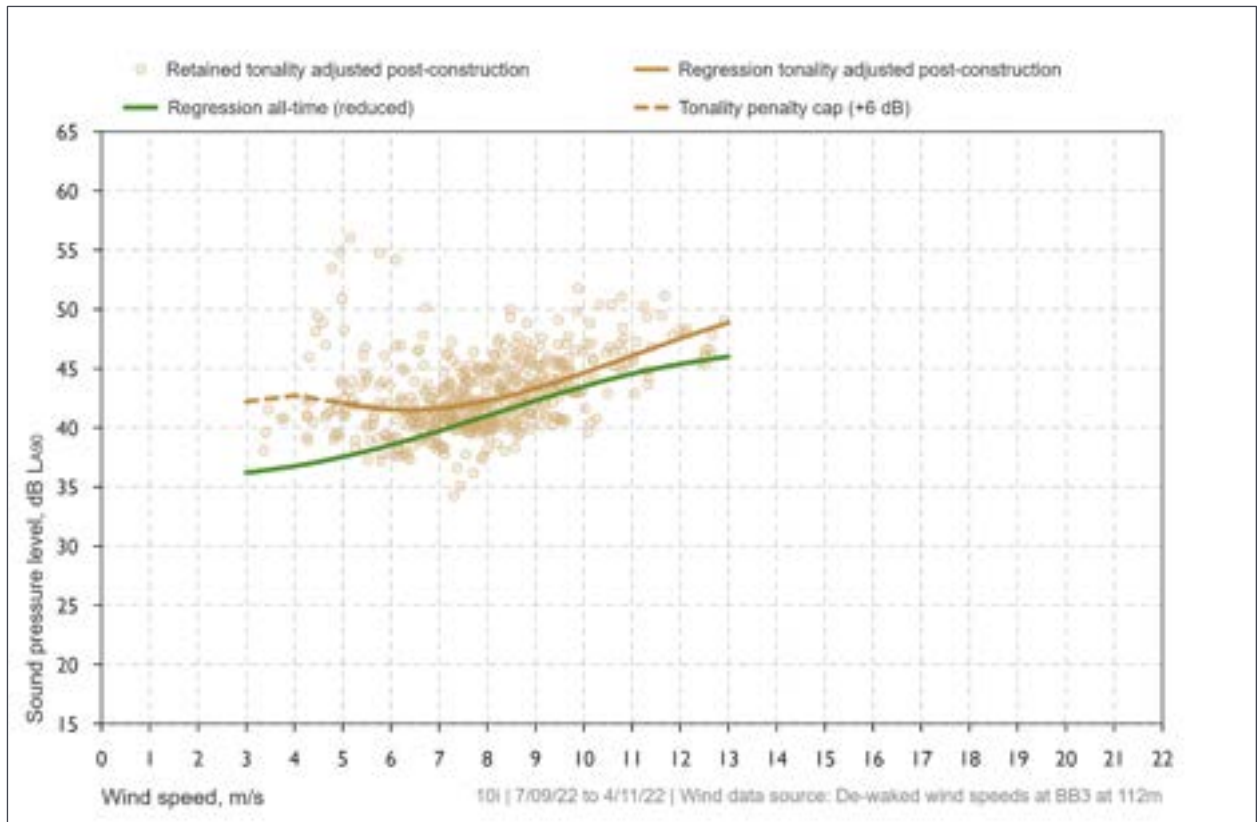


Table 138: Intermediate 10i tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	43.4	42.1	41.5	41.6	42.3	43.3	44.6	46.1	47.5	48.8
Post-construction regression - no penalties	36.2	36.7	37.5	38.5	39.7	41.0	42.3	43.5	44.6	45.4	46.0
Penalty adjustment	6.0 ^[1]	6.0 ^[1]	4.6	3.0	1.9	1.3	1.0	1.1	1.5	2.1	2.8

1 Tonality penalty values are capped at a maximum penalty of 6.0 dB

W6 Receiver 10 compliance assessment

Table 139: Receiver 10 compliance assessment based on extrapolation of intermediate 10i, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 10i	36.2	36.7	37.5	38.5	39.7	41.0	42.3	43.5	44.6	45.4	46.0
Background noise level intermediate 10i	25.9	26.6	27.2	27.9	28.6	29.3	30.1	31.0	32.0	33.0	34.3
Background adjustment intermediate 10i	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3
Extrapolation correction	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4
Tonality adjustment intermediate 10i ^[1]	6.0	6.0	4.6	3.0	1.9	1.3	1.0	1.1	1.5	2.1	2.8
Estimated tonality adjusted wind farm noise level receiver 10	35.4	35.9	35.3	34.7	34.8	35.6	36.6	37.9	39.5	40.8	42.1
Noise limit receiver 10 ^[2]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Compliance margin	-4.6	-4.1	-4.7	-5.3	-5.2	-4.4	-3.4	-2.1	-0.5	0.8 ^[4]	2.1 ^[4]

1 Noise monitoring was not conducted at the receiver – the tonality adjustment from the intermediate location is therefore provided as a conservative indication of tonality

2 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

4 Result relates to background noise levels; actual wind turbine noise levels would be below the minimum noise limit of 40 dB L_{A90}

APPENDIX X INTERMEDIATE 18i

X1 Intermediate 18i location data

Table 140: Intermediate 18i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	719388	5803039

Figure 134: Intermediate 18i aerial view –noise monitor location

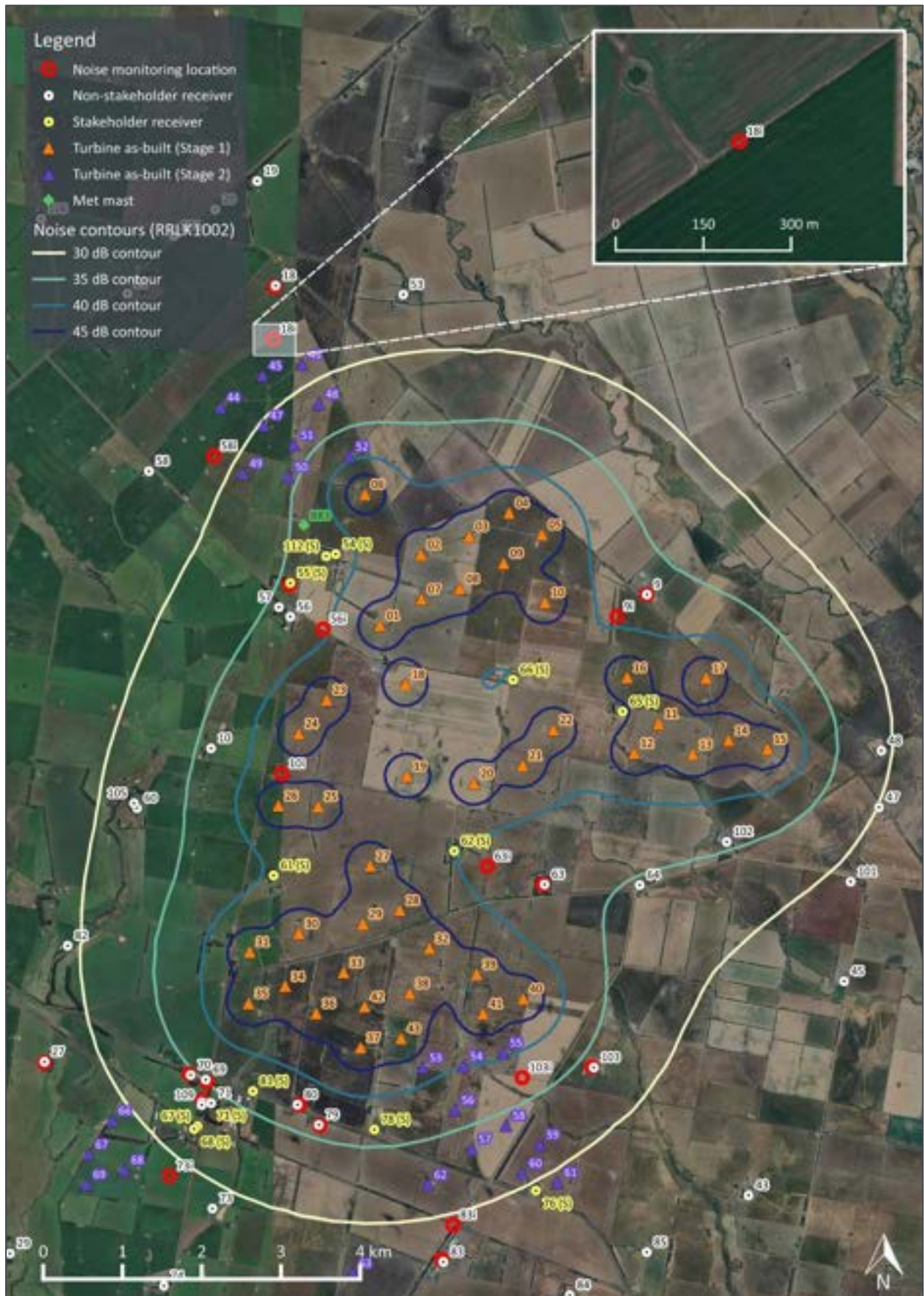
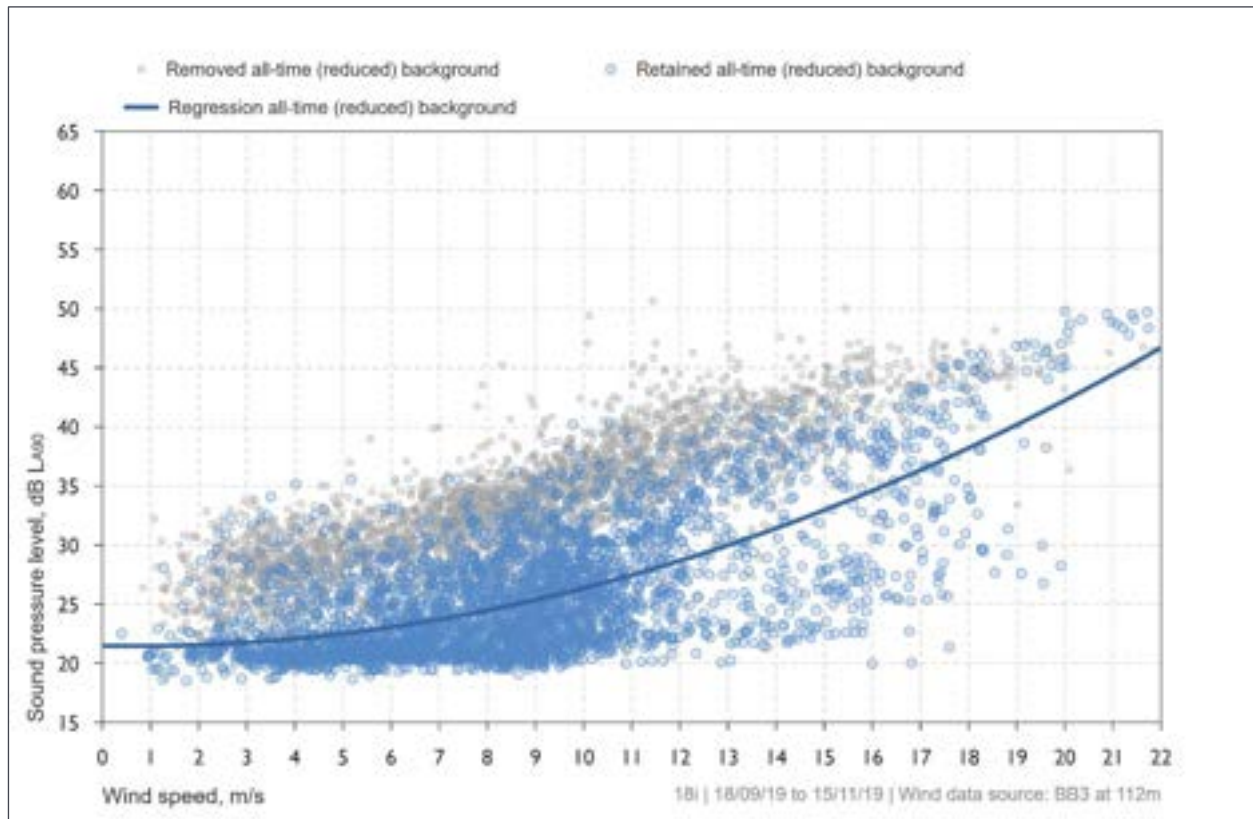


Table 141: Intermediate 18i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

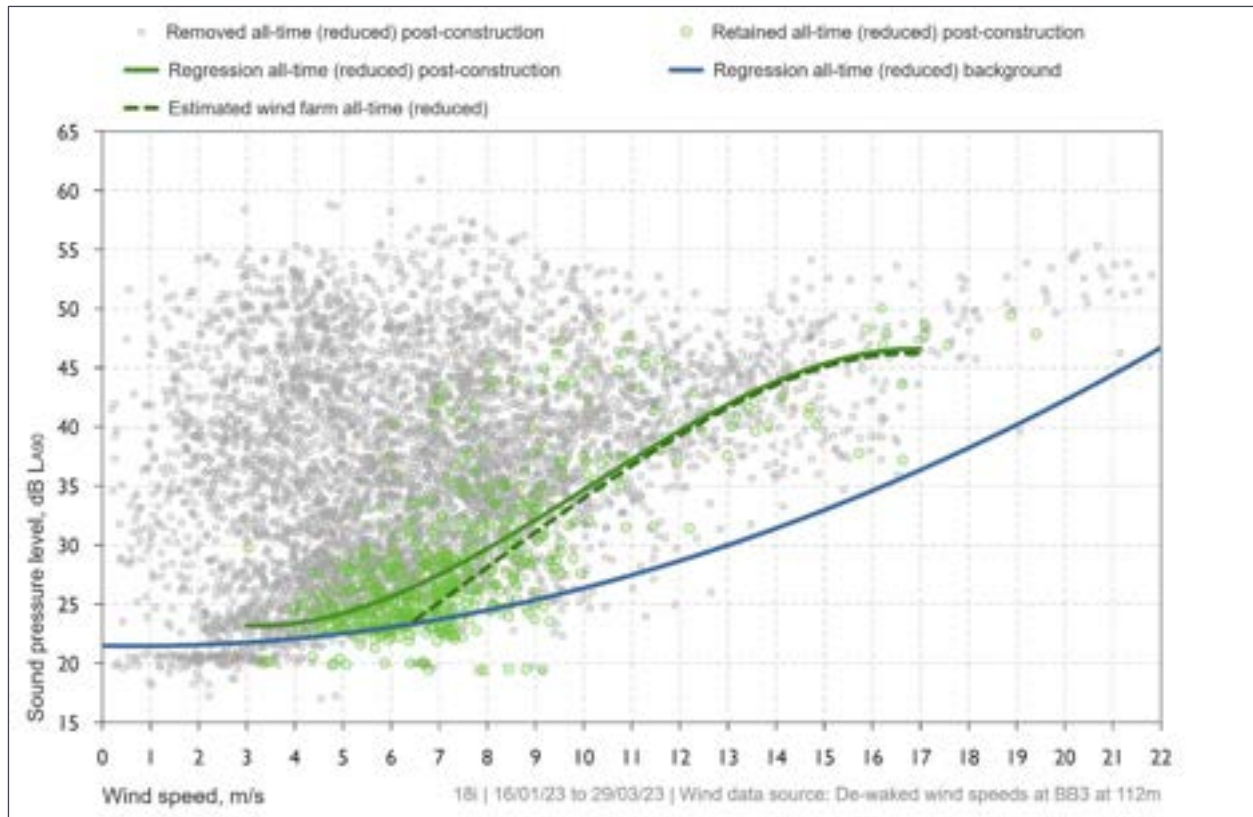
X2 Intermediate 18i background noise data

Figure 135: Intermediate 18i - derived background noise levels and noise limit – all-time (reduced)



X3 Intermediate 18i post-construction measurement data – all wind speeds

Figure 136: Intermediate 18i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



X4 Intermediate 18i post-construction measurement data summary – assessment wind speeds

Table 142: Intermediate 18i assessment data summary – number of data points

Data points	All-time (reduced)
Collected	5713
Removed	5134
Retained	579

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 143.

Table 143: Intermedia 18i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	2381
Rainfall	110
Extraneous noise	2594
Wind farm operations curtailed	3394
Wind speeds outside assessment range	909

Figure 137: Intermediate 18i post-construction noise levels and wind speed time history

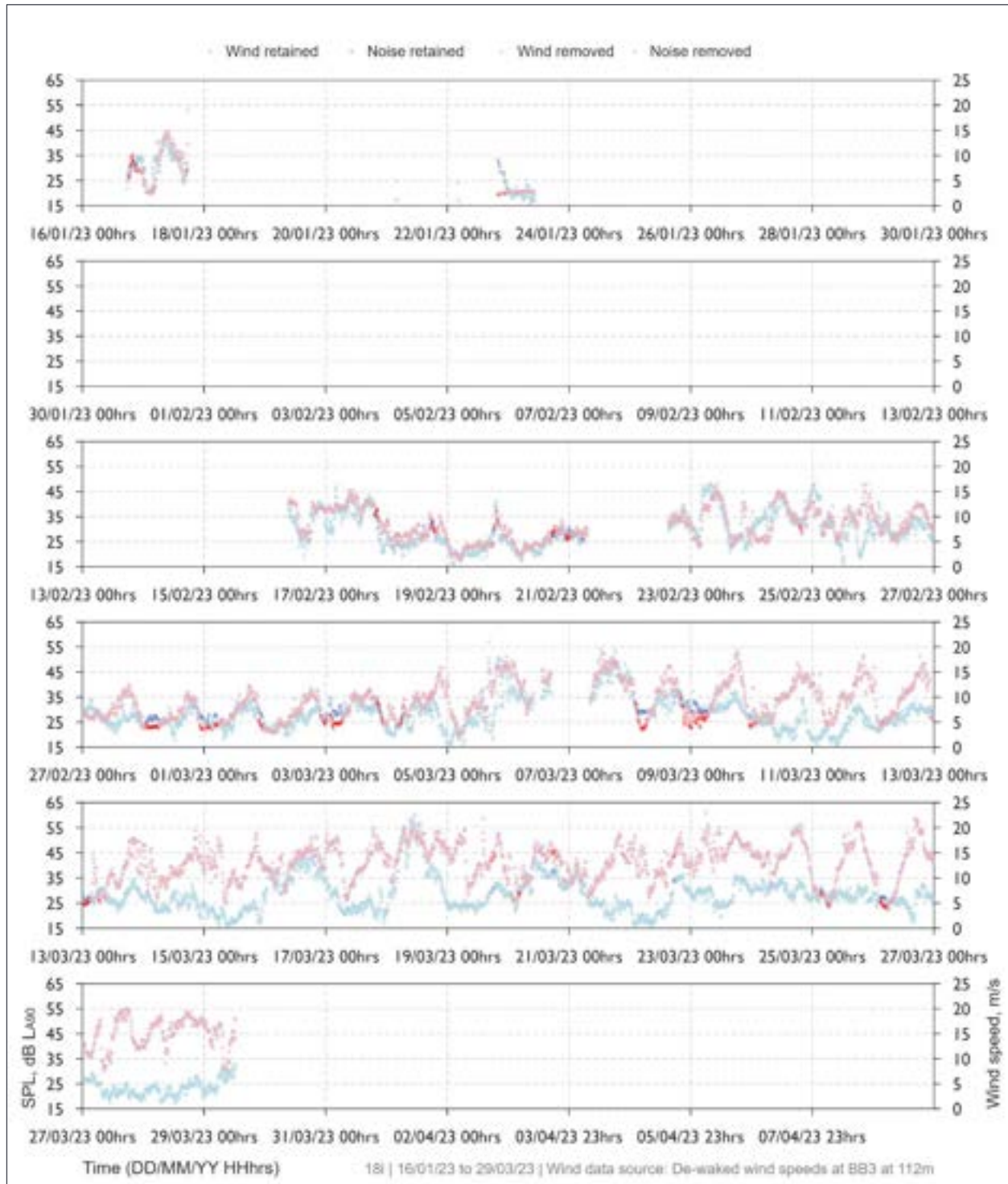
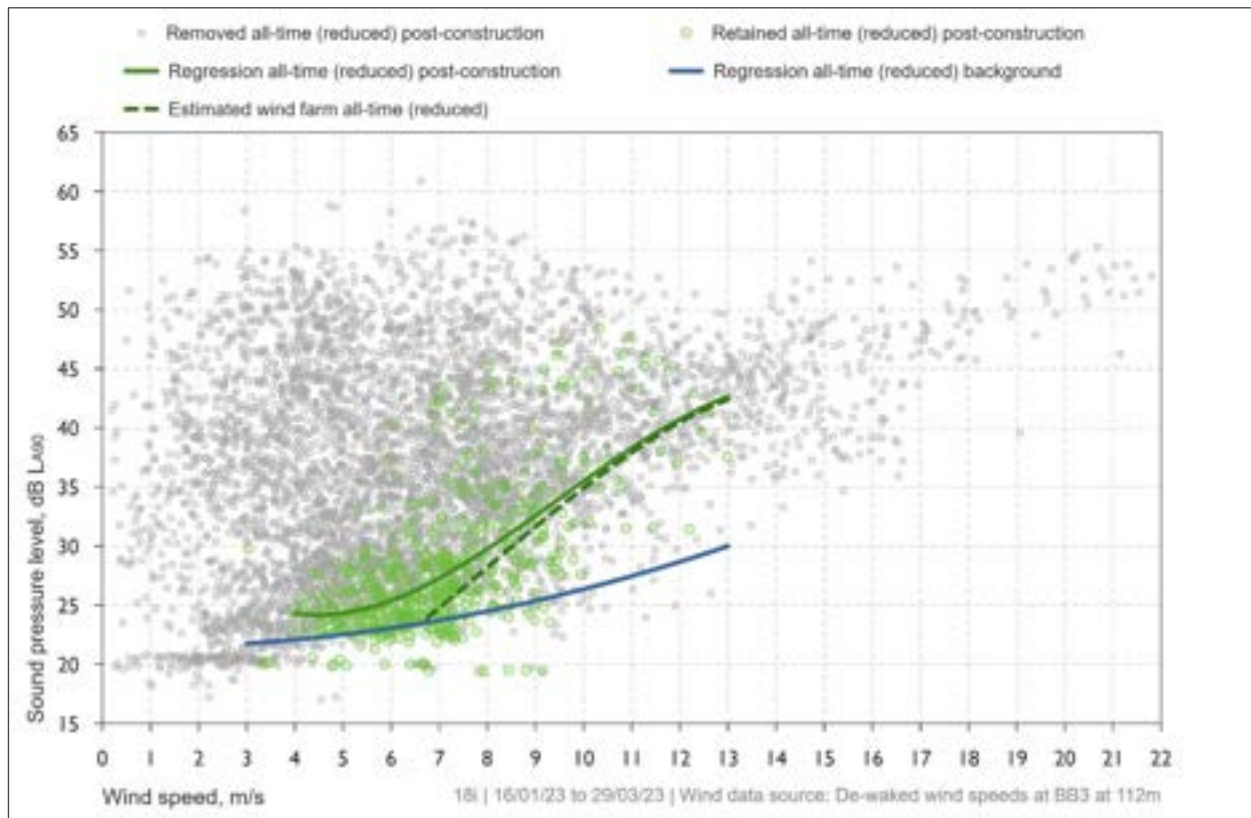


Figure 138: Intermediate 18i – post-construction noise levels versus site wind speed – all-time (reduced)



X5 Intermediate 18i tonality data

Tonality data for intermediate 18i are provided as reference information only. The tonality assessment for receiver 18 is based on data obtained at receiver 18.

Figure 139: Intermediate 18i – tonality adjusted post-construction noise levels versus site wind speed

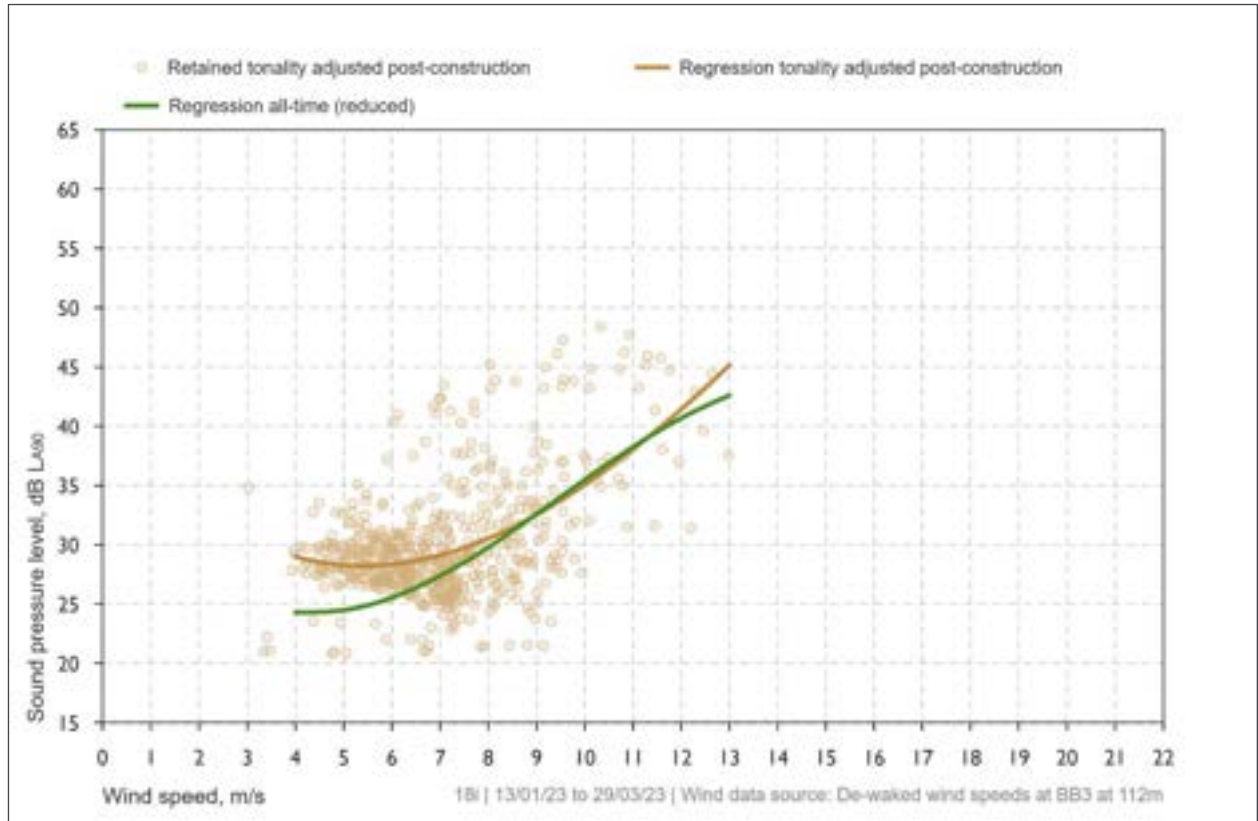


Table 144: Intermediate 18i tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	29.0	28.3	28.3	29.1	30.5	32.5	35.1	38.0	41.4	45.1
Post-construction regression - no penalties	- ^[1]	24.3	24.3	25.4	27.3	29.7	32.6	35.5	38.3	40.8	42.6
Penalty adjustment	- ^[1]	4.7	4.0	2.9	1.8	0.8	0.0	0.0	0.0	0.6	2.5

1 Outside valid wind speed range of the regression analysis

X6 Receiver 18 compliance assessment

Refer to Appendix K6.

APPENDIX Y INTERMEDIATE 56i

Y1 Intermediate 56i location data

Table 145: Intermediate 56i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	720018	5799377

Figure 140: Intermediate 56i aerial view – noise monitor location

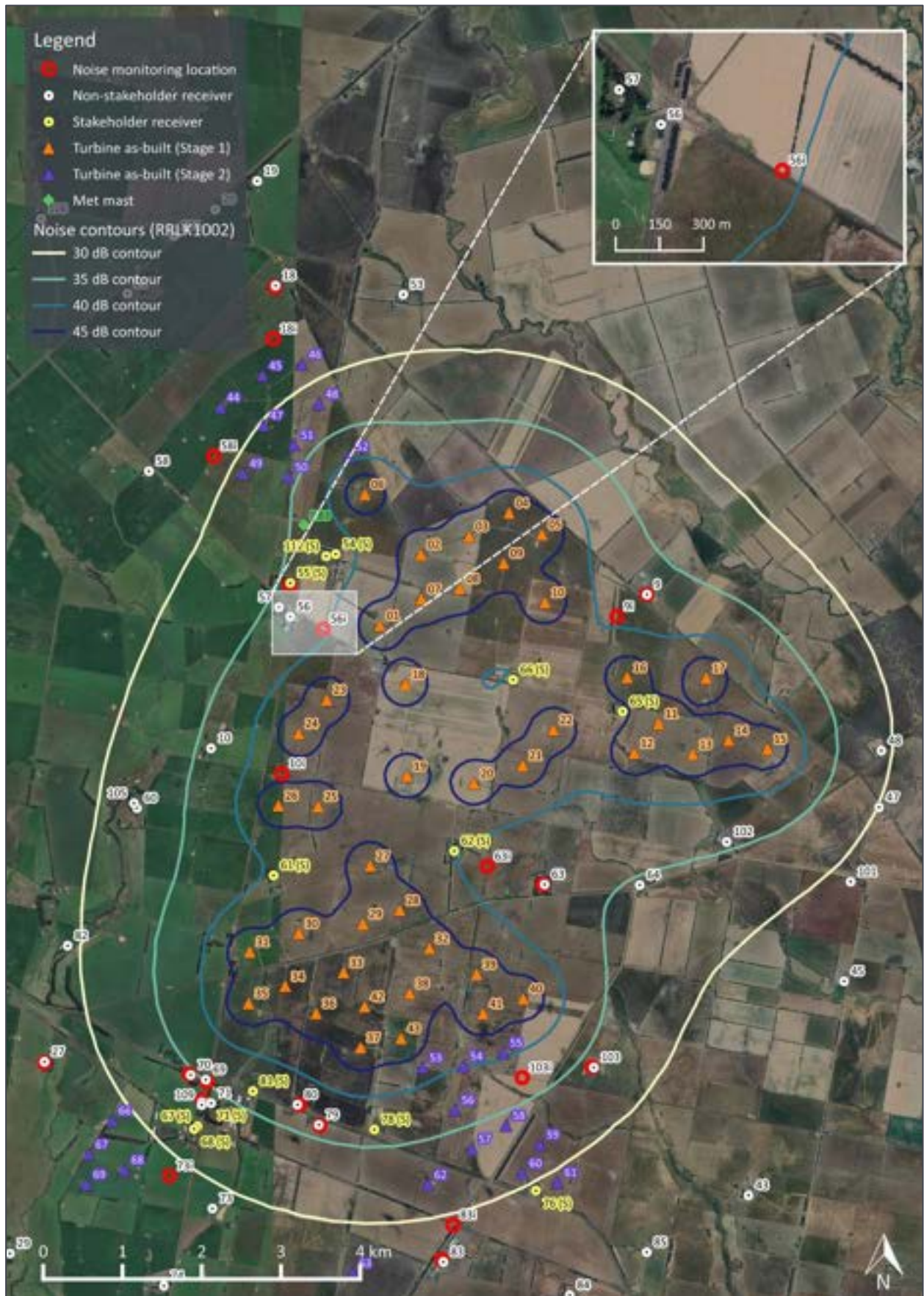
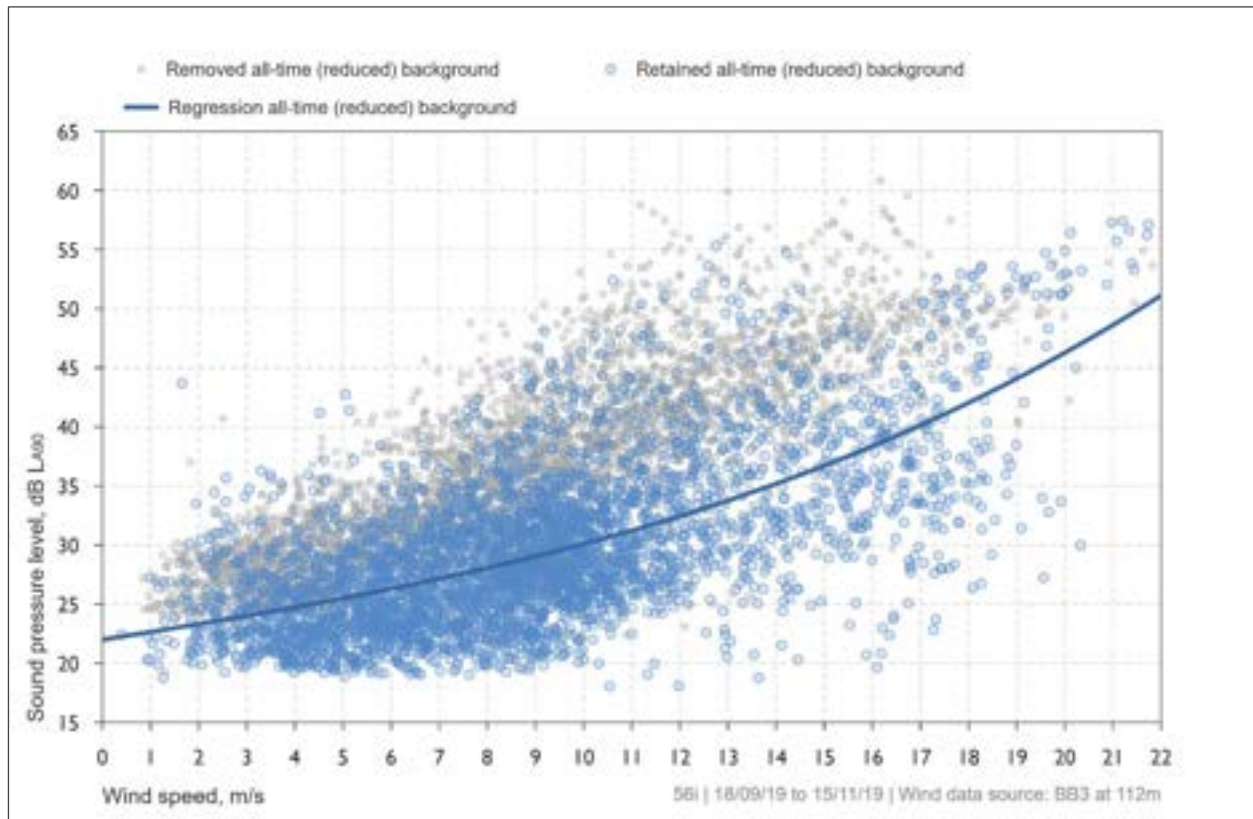


Table 146: Intermediate 56i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

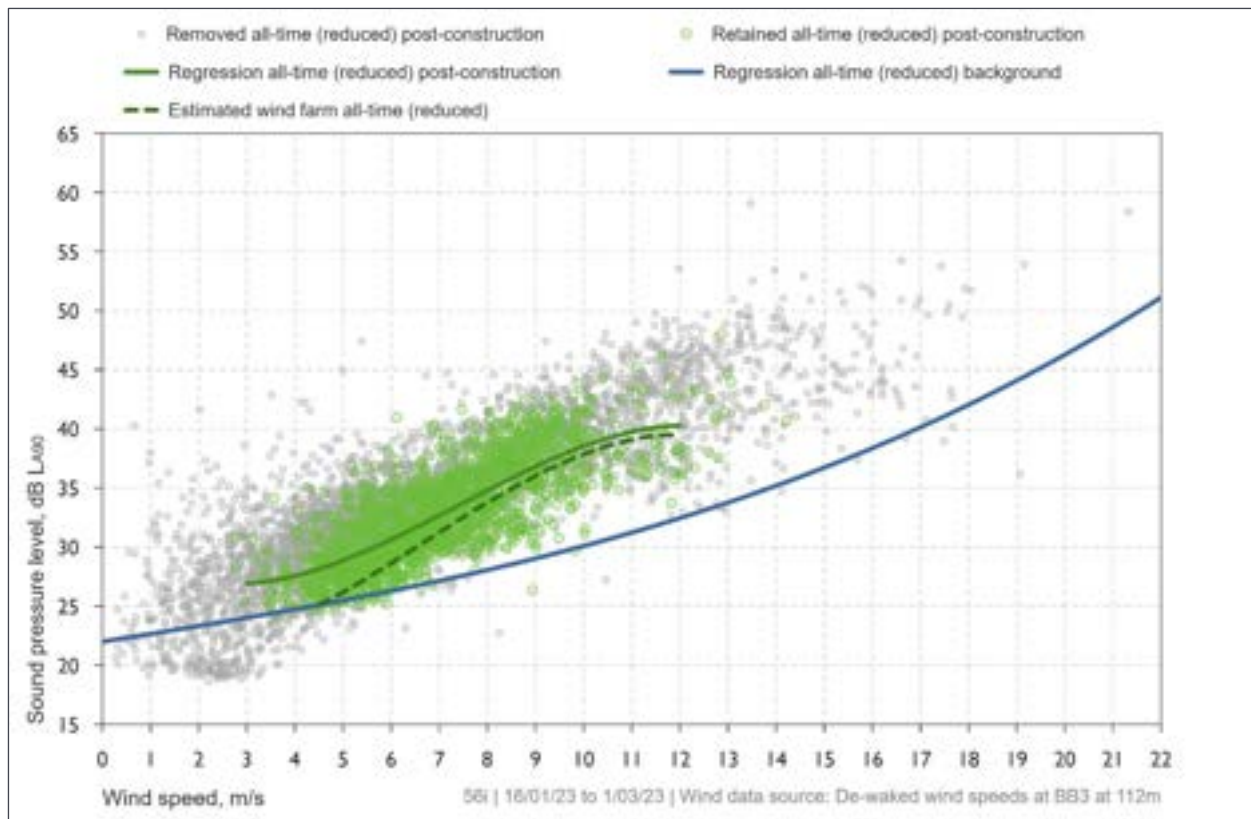
Y2 Intermediate 56i background noise data

Figure 141: Intermediate 56i - derived background noise levels and noise limit – all-time (reduced)



Y3 Intermediate 56i post-construction measurement data – all wind speeds

Figure 142: Intermediate 56i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



Y4 Intermediate 56i post-construction measurement data summary – assessment wind speeds

Table 147: Intermediate assessment data summary – number of data points

Data points	All-time (reduced)
Collected	5690
Removed	3858
Retained	1832

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 148.

Table 148: Intermedia 56i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	2373
Rainfall	436
Extraneous noise	96
Wind farm operations curtailed	3022
Wind speeds outside assessment range	693

Figure 143: Intermediate 56i post-construction noise levels and wind speed time history

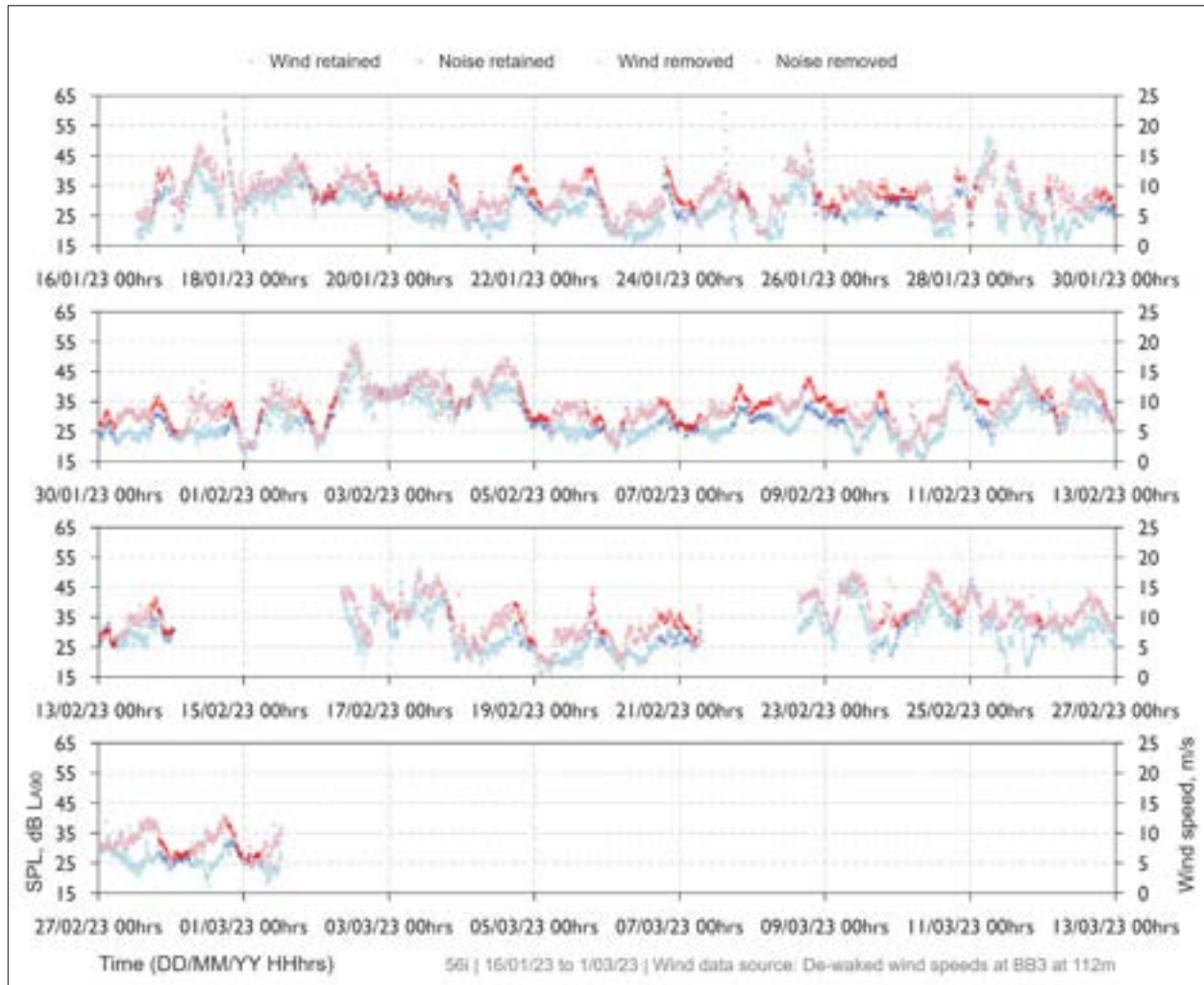
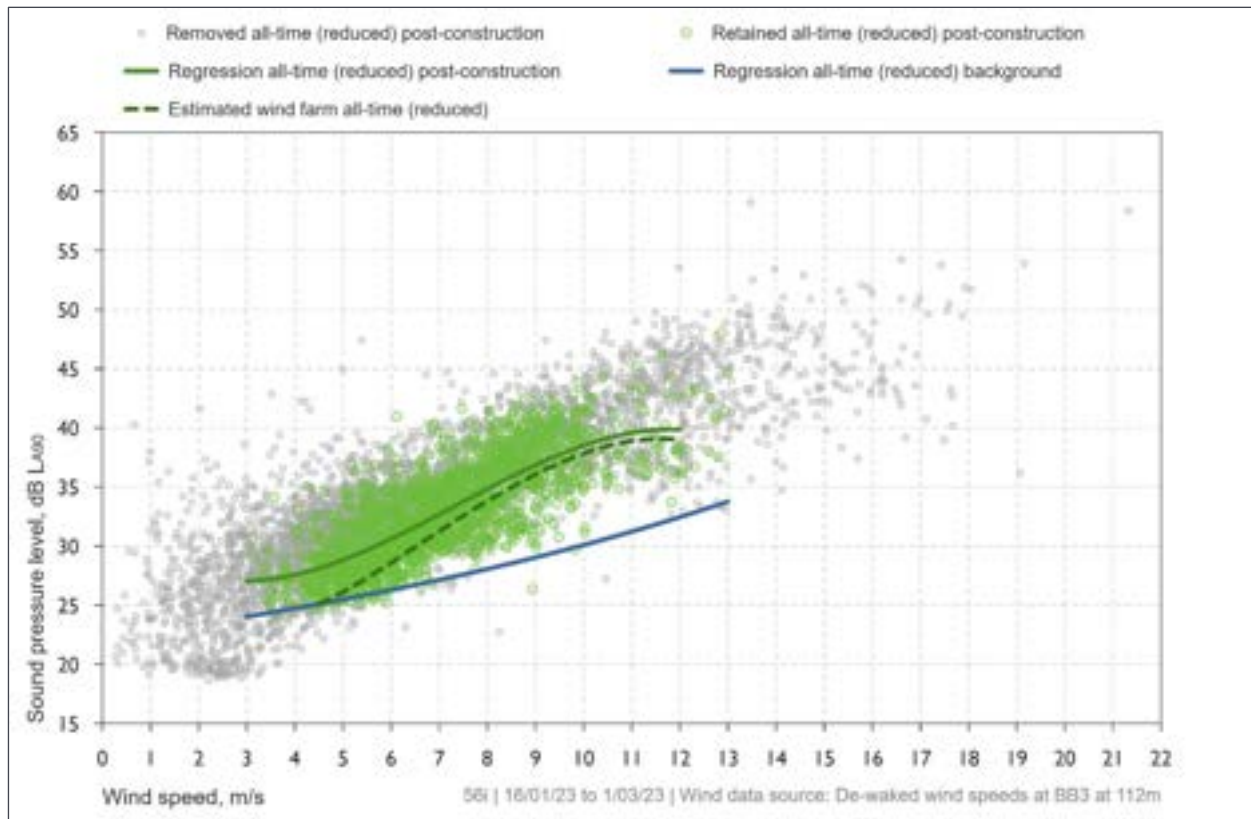


Figure 144: Intermediate 56i – post-construction noise levels and noise limits versus site wind speed - all-time (reduced)



Y5 Intermediate 56i tonality assessment

Figure 145: Intermediate 56i tonality adjusted total-construction noise levels versus site wind speed – all-time (reduced)

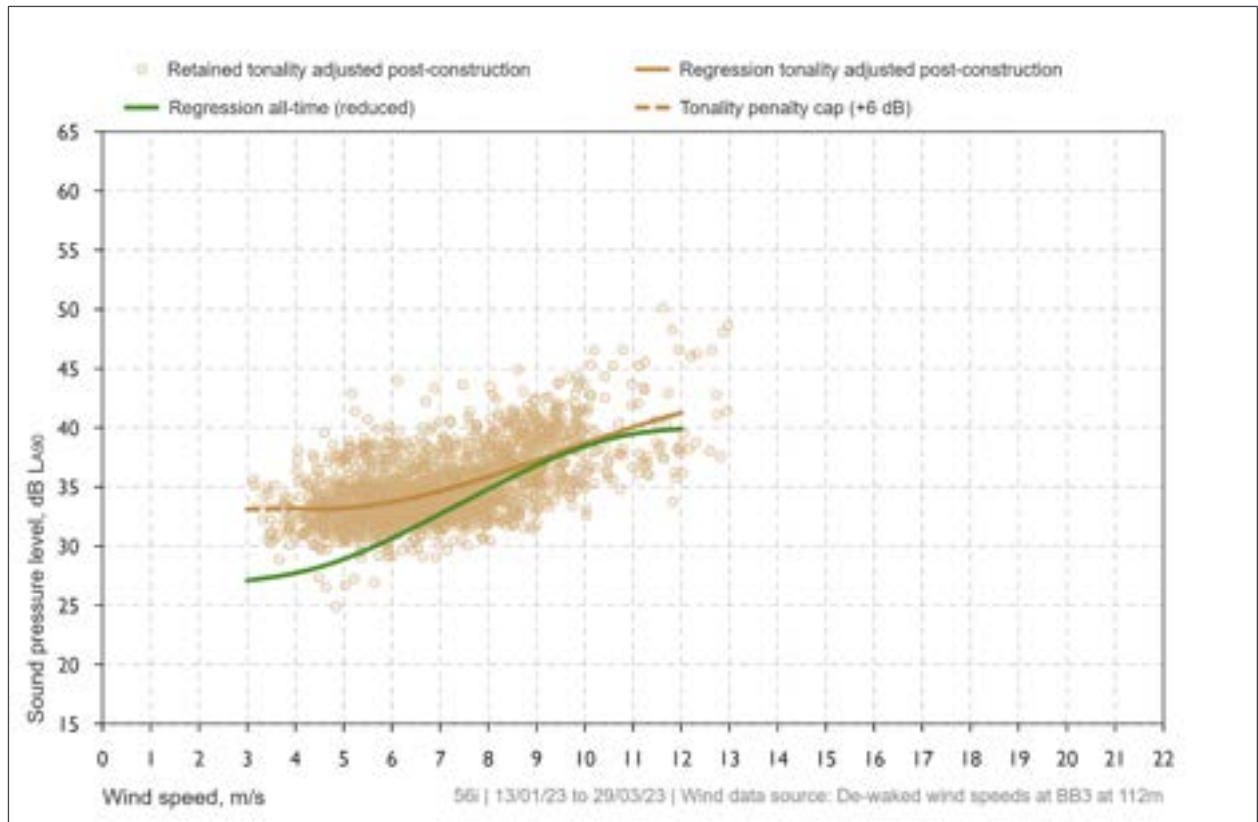


Table 149: Intermediate 56i tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[2]	33.2	33.2	33.7	34.6	35.8	37.2	38.7	40.0	41.2	- ^[1]
Post-construction regression - no penalties	27.1	27.6	28.8	30.6	32.7	34.8	36.9	38.5	39.6	39.9	- ^[1]
Penalty adjustment	6.0 ^[2]	5.6	4.4	3.1	1.9	1.0	0.3	0.2	0.4	1.3	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 Tonality penalty values are capped at a maximum penalty of 6.0 dB

Y6 Receiver 56 compliance assessment

Table 150: Receiver 56 compliance assessment based on extrapolation from intermediate 56i, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 56i	27.1	27.6	28.8	30.6	32.7	34.8	36.9	38.5	39.6	39.9	- ^[1]
Background noise level intermediate 56i	24.0	24.7	25.5	26.3	27.1	28.1	29.0	30.1	31.2	32.4	- ^[1]
Background adjustment intermediate 56i	-2.9	- ^[2]	-2.7	-2.0	-1.4	-1.0	-0.8	-0.7	-0.7	-0.9	- ^[1]
Extrapolation correction	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	- ^[1]
Tonality adjustment intermediate 56i ^[4]	6.0	5.6	4.4	3.1	1.9	1.0	0.3	0.2	0.4	1.3	- ^[1]
Estimated tonality adjusted wind farm noise level receiver 56 ^[3]	28.3	< 31.3	28.6	29.8	31.3	32.9	34.5	36.1	37.4	38.4	- ^[1]
Noise limit receiver 56 ^[5]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	- ^[1]
Compliance margin	-11.7	-8.7	-11.4	-10.2	-8.7	-7.1	-5.5	-3.9	-2.6	-1.6	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 A background adjustment cannot be calculated when the difference between total noise level and background noise level is less than 3 dB

3 Upper values are provided for the estimated tonality adjusted wind farm noise levels where background adjustments are not available

4 Noise monitoring was not conducted at the receiver – the tonality adjustment from the intermediate location is therefore provided as a conservative indication of tonality

5 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

APPENDIX Z INTERMEDIATE 58i

Z1 Intermediate 58i location data

Table 151: Intermediate 58i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	718637	5801560

Figure 146: Intermediate 58i aerial view – noise monitor location

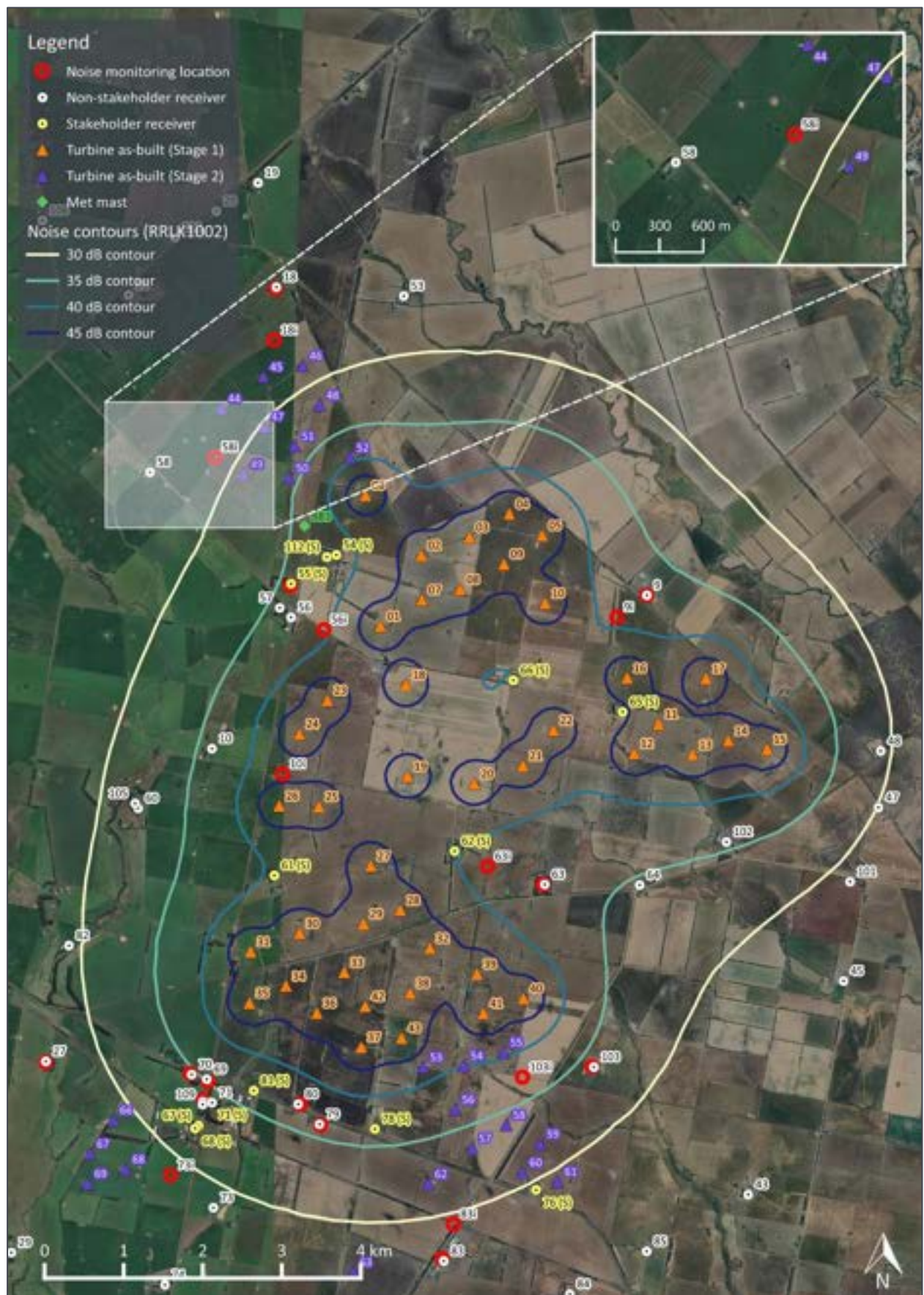
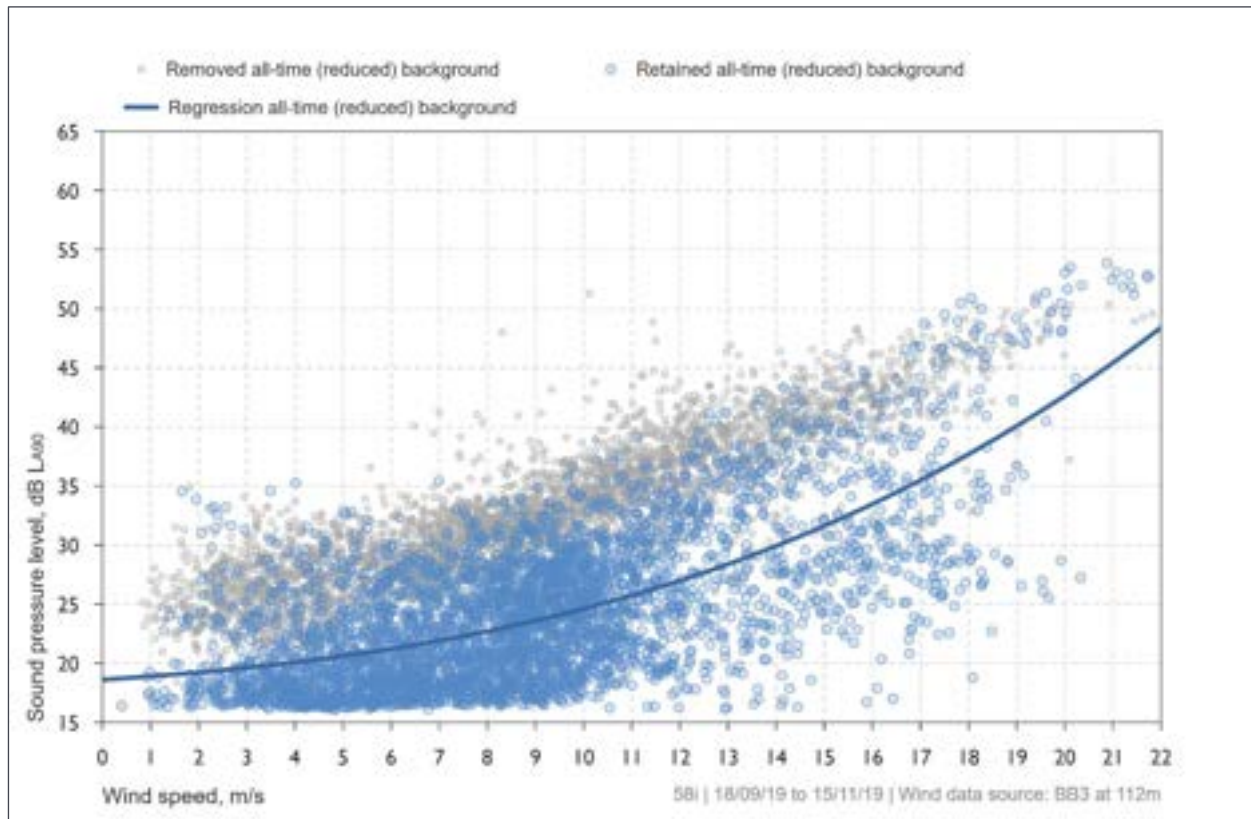


Table 152: Intermediate 58i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

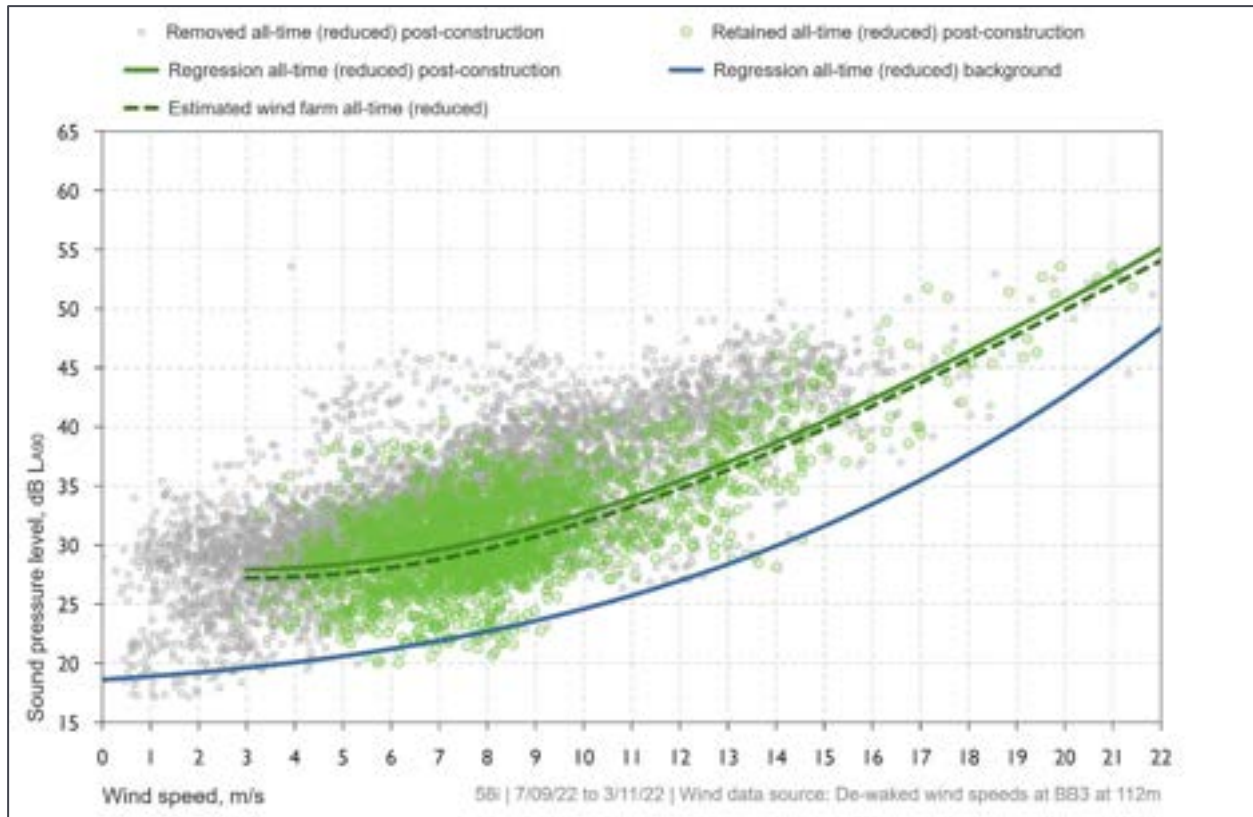
Z2 Intermediate 58i background noise data

Figure 147: Intermediate 58i - derived background noise levels and noise limit – all-time (reduced)



Z3 Intermediate 58i post-construction measurement data – all wind speeds

Figure 148: Intermediate 58i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



Z4 Intermediate 58i post-construction measurement data summary – assessment wind speeds

Table 153: Intermediate 58i assessment data summary – number of data points

Data points	All-time (reduced)
Collected	7271
Removed	5168
Retained	2103

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 154.

Table 154: Intermedia 58i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3041
Rainfall	901
Extraneous noise	69
Wind farm operations curtailed	3554
Wind speeds outside assessment range	1138

Figure 149: Intermediate 58i post-construction noise levels and wind speed time history

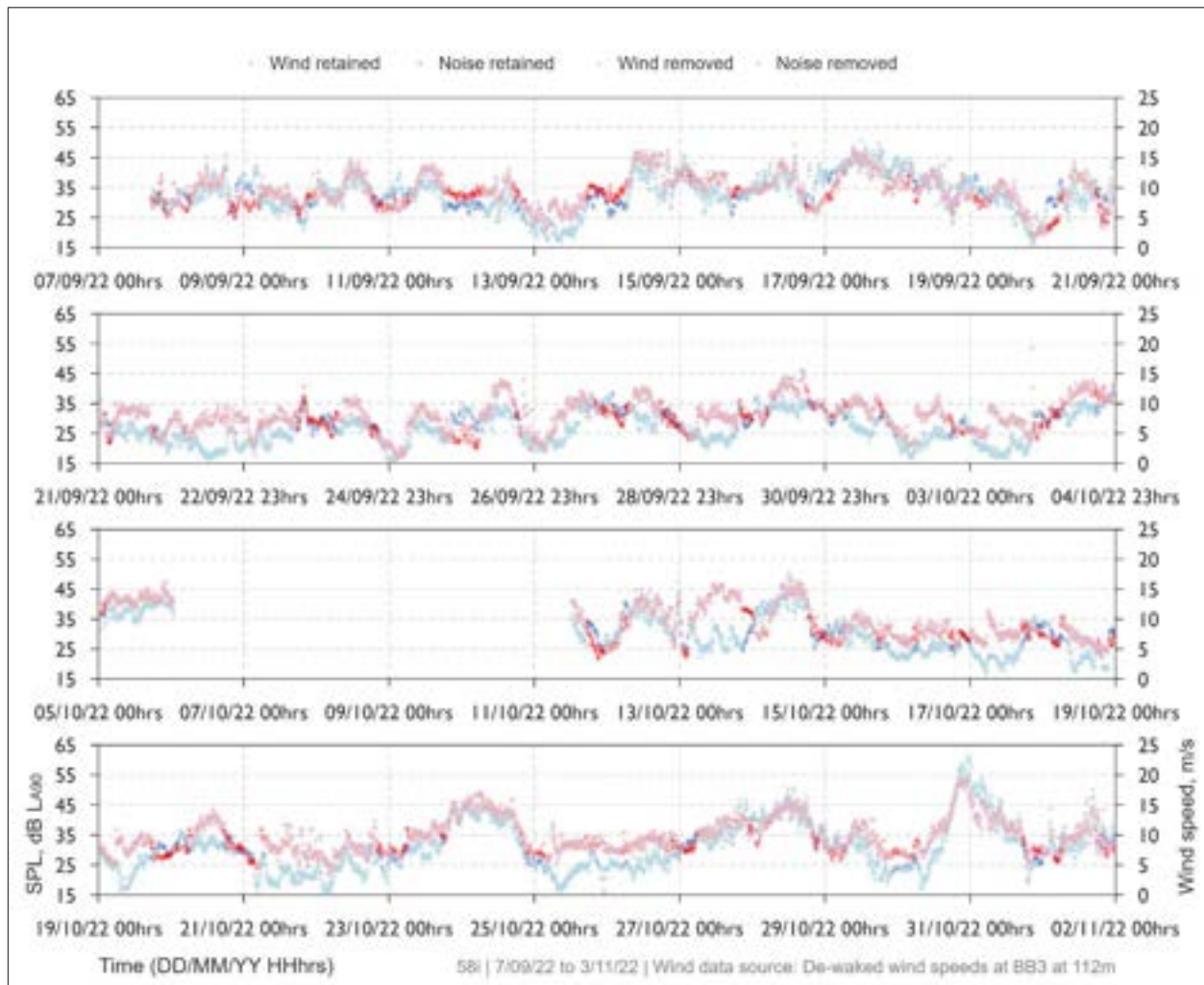
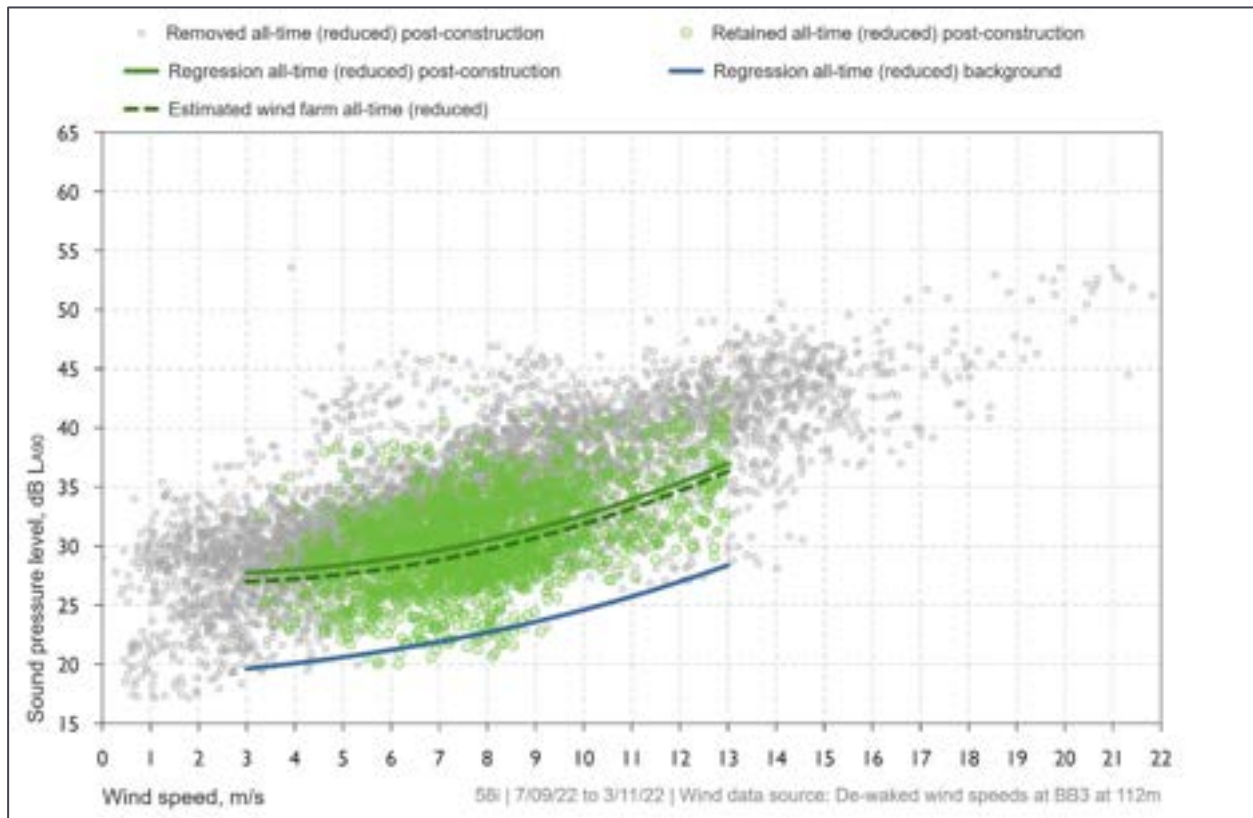


Figure 150: Intermediate 58i – post-construction noise levels versus site wind speed – all-time (reduced)



Z5 Intermediate 58i tonality assessment

Figure 151: Intermediate 58i – tonality adjusted total-construction noise levels versus site wind speed – all-time (reduced)

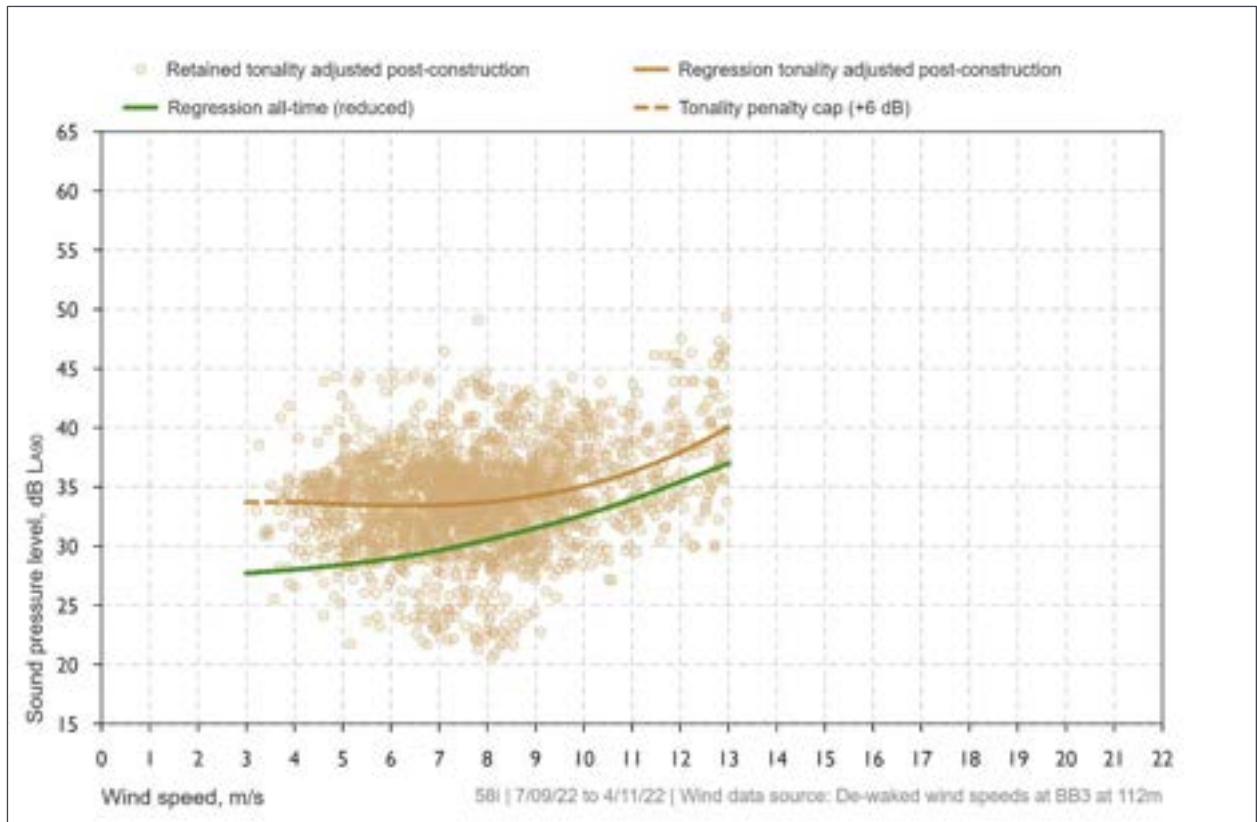


Table 155: Intermediate 58i tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	33.7	33.5	33.4	33.5	33.7	34.2	35.1	36.3	37.9	40.0
Post-construction regression - no penalties	27.7	28.0	28.4	28.9	29.6	30.5	31.5	32.6	33.9	35.4	37.0
Penalty adjustment	6.0 ^[1]	5.7	5.1	4.5	3.9	3.2	2.7	2.5	2.4	2.5	3.0

1 Tonality penalty values are capped at a maximum penalty of 6.0 dB

Z6 Receiver 58 compliance assessment

Table 156: Receiver 58 – compliance assessment based on extrapolation from intermediate 58i, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 58i	27.7	28.0	28.4	28.9	29.6	30.5	31.5	32.6	33.9	35.4	37.0
Background noise level intermediate 58i	19.6	20.1	20.6	21.2	21.9	22.7	23.6	24.6	25.7	27.0	28.4
Background adjustment intermediate 58i	-0.7	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.7	-0.7	-0.7	-0.6
Extrapolation correction	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Tonality adjustment intermediate 58i ^[1]	6.0	5.7	5.1	4.5	3.9	3.2	2.7	2.5	2.4	2.5	3.0
Estimated tonality adjusted wind farm noise level receiver 58	32.2	32.1	31.9	31.8	31.9	32.1	32.6	33.6	34.8	36.4	38.6
Noise limit receiver 58 ^[2]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Compliance margin	-7.8	-7.9	-8.1	-8.2	-8.1	-7.9	-7.4	-6.4	-5.2	-3.6	-1.4

1 Noise monitoring was not conducted at the receiver – the tonality adjustment from the intermediate location is therefore provided as a conservative indication of tonality

2 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

APPENDIX AA INTERMEDIATE 63i

AA1 Intermediate 63i location data

Table 157: Intermediate 63i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	722090	5796383

Figure 152: Intermediate 63i aerial view – noise monitor location

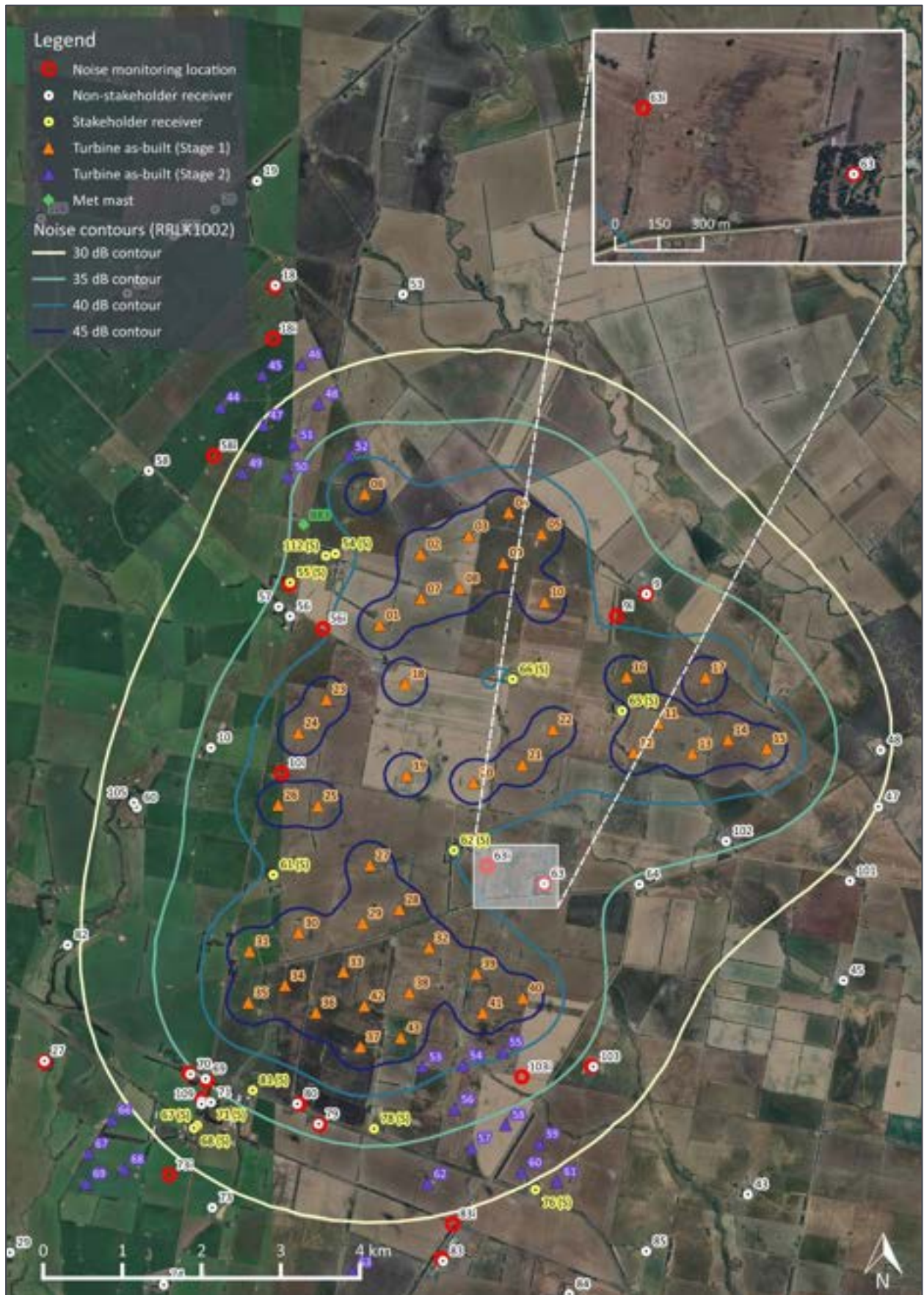
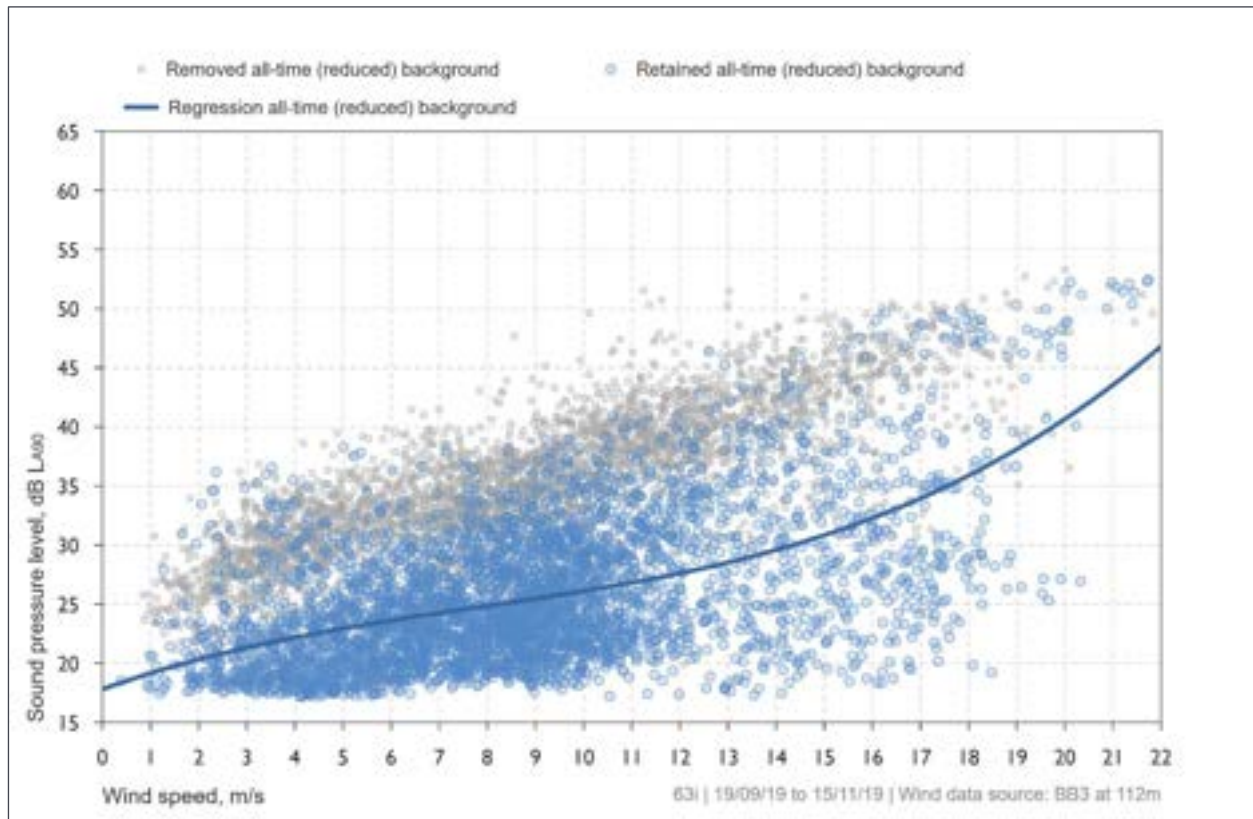


Table 158: Intermediate 63i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

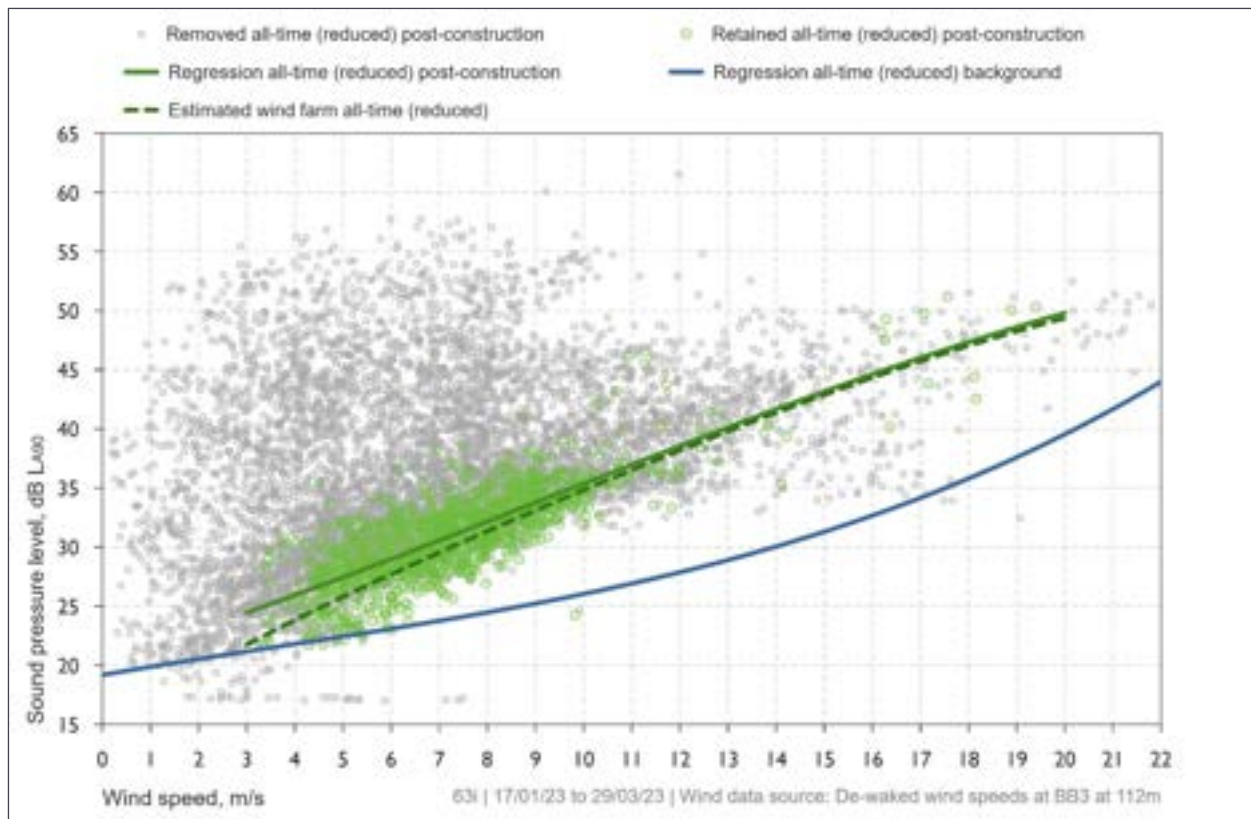
AA2 Intermediate 63i background noise data

Figure 153: Intermediate 63i - derived background noise levels and noise limit – all-time (reduced)



AA3 Intermediate 63i post-construction measurement data – all wind speeds

Figure 154: Intermediate 63i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



AA4 Intermediate 63i post-construction measurement data summary – assessment wind speeds

Table 159: Intermediate 63i assessment data summary – number of data points

Data points	All-time (reduced)
Collected	7471
Removed	6431
Retained	1040

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 160.

Table 160: Intermedia 63i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3124
Rainfall	346
Extraneous noise	2673
Wind farm operations curtailed	4266
Wind speeds outside assessment range	1092

Figure 155: Intermediate 63i post-construction noise levels and wind speed time history

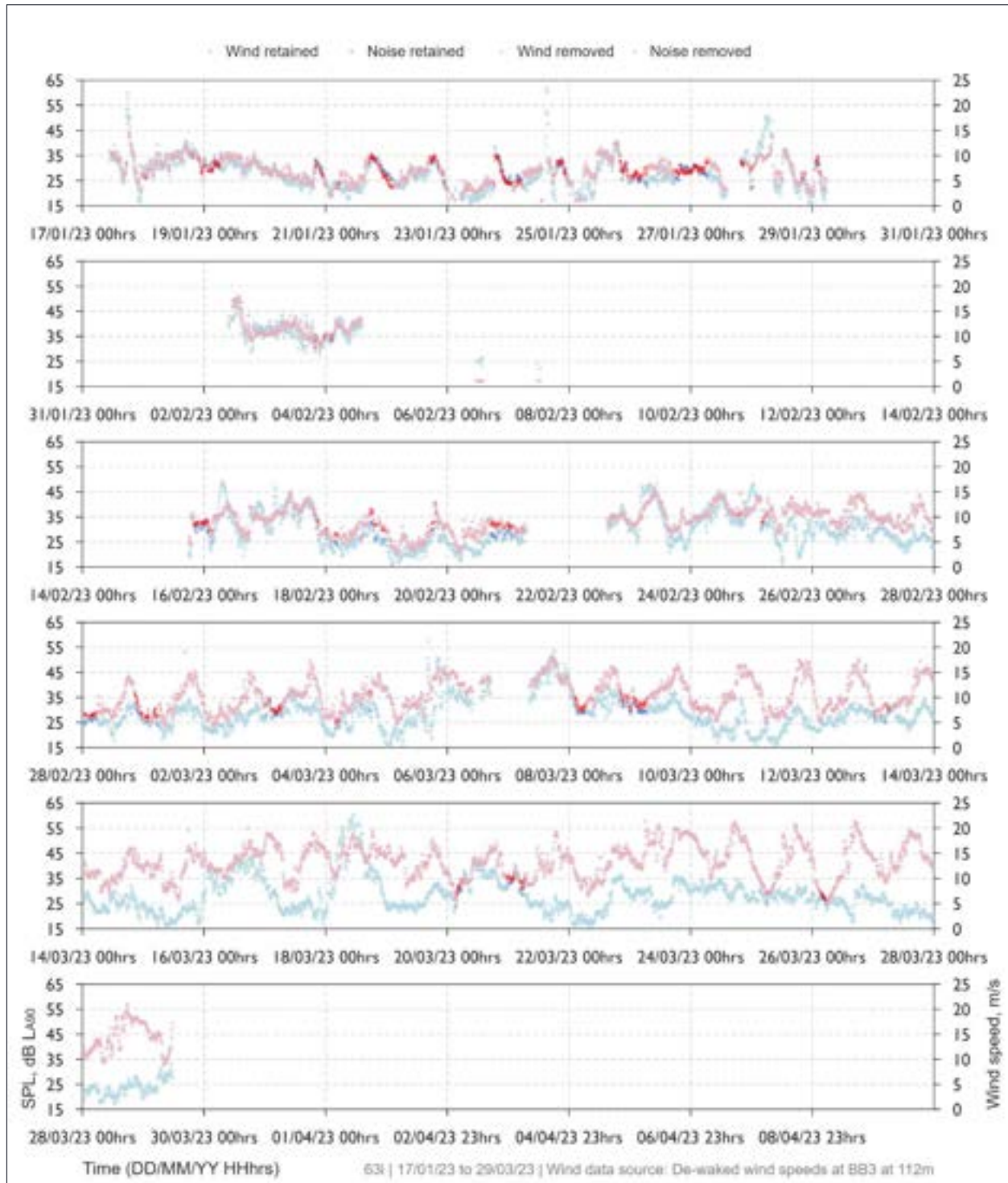
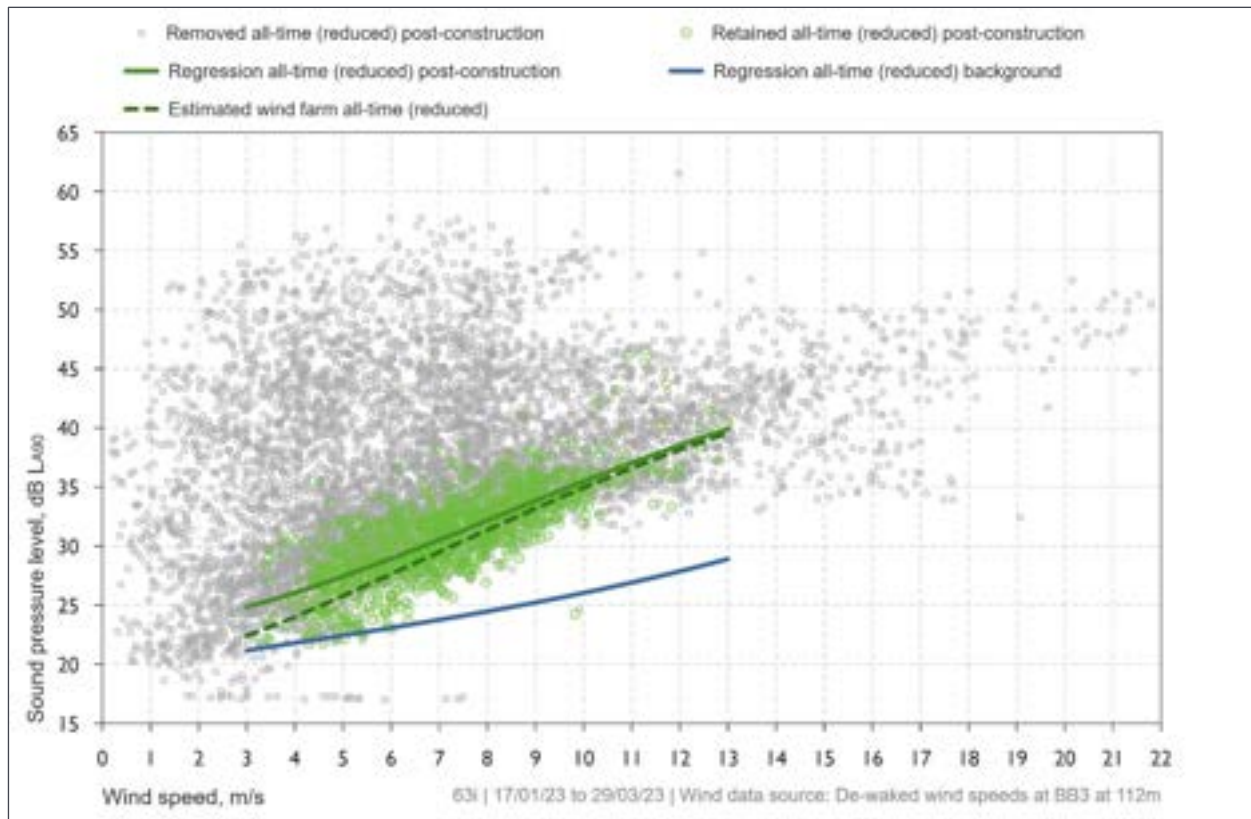


Figure 156: Intermediate 63i – post-construction noise levels and noise limits versus site wind speed - all-time (reduced)



AA5 Intermediate 63i tonality data

Tonality data for intermediate 63i are provided as reference information only. The tonality assessment for receiver 63 is based on data obtained at receiver 63.

Figure 157: Intermediate 63i – tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

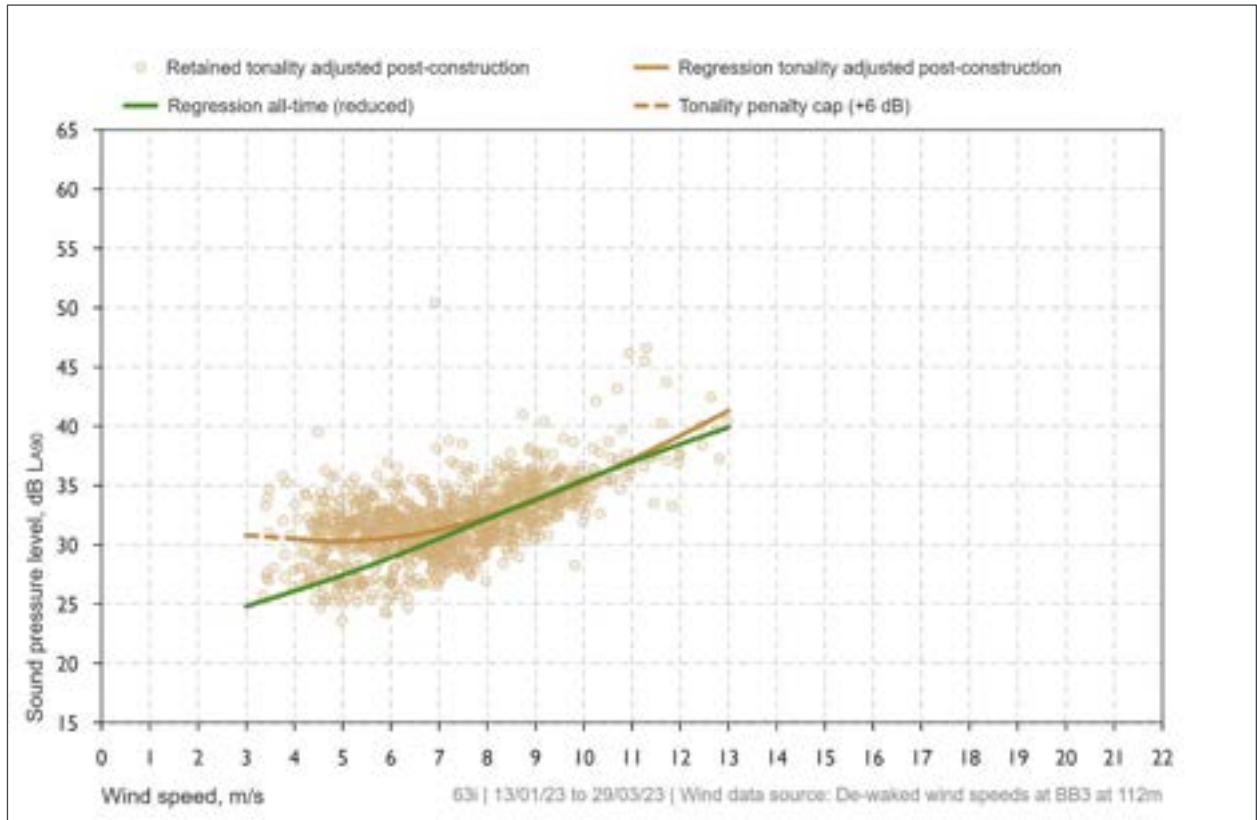


Table 161: Intermediate 63i tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	30.5	30.3	30.6	31.3	32.3	33.7	35.4	37.2	39.2	41.3
Post-construction regression - no penalties	24.8	26.1	27.4	28.9	30.5	32.2	33.8	35.5	37.0	38.5	39.9
Penalty adjustment	6.0 ^[1]	4.4	2.9	1.7	0.8	0.1	0.0	0.0	0.2	0.7	1.4

1 Tonality penalty values are capped at a maximum penalty of 6.0 dB

AA6 Receiver 63 compliance assessment

Refer to Appendix N6.

APPENDIX BB INTERMEDIATE 73i

BB1 Intermediate 73i location data

Table 162: Intermediate 73i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	718079	5792481

Figure 158: Intermediate 73i aerial view – noise monitor location

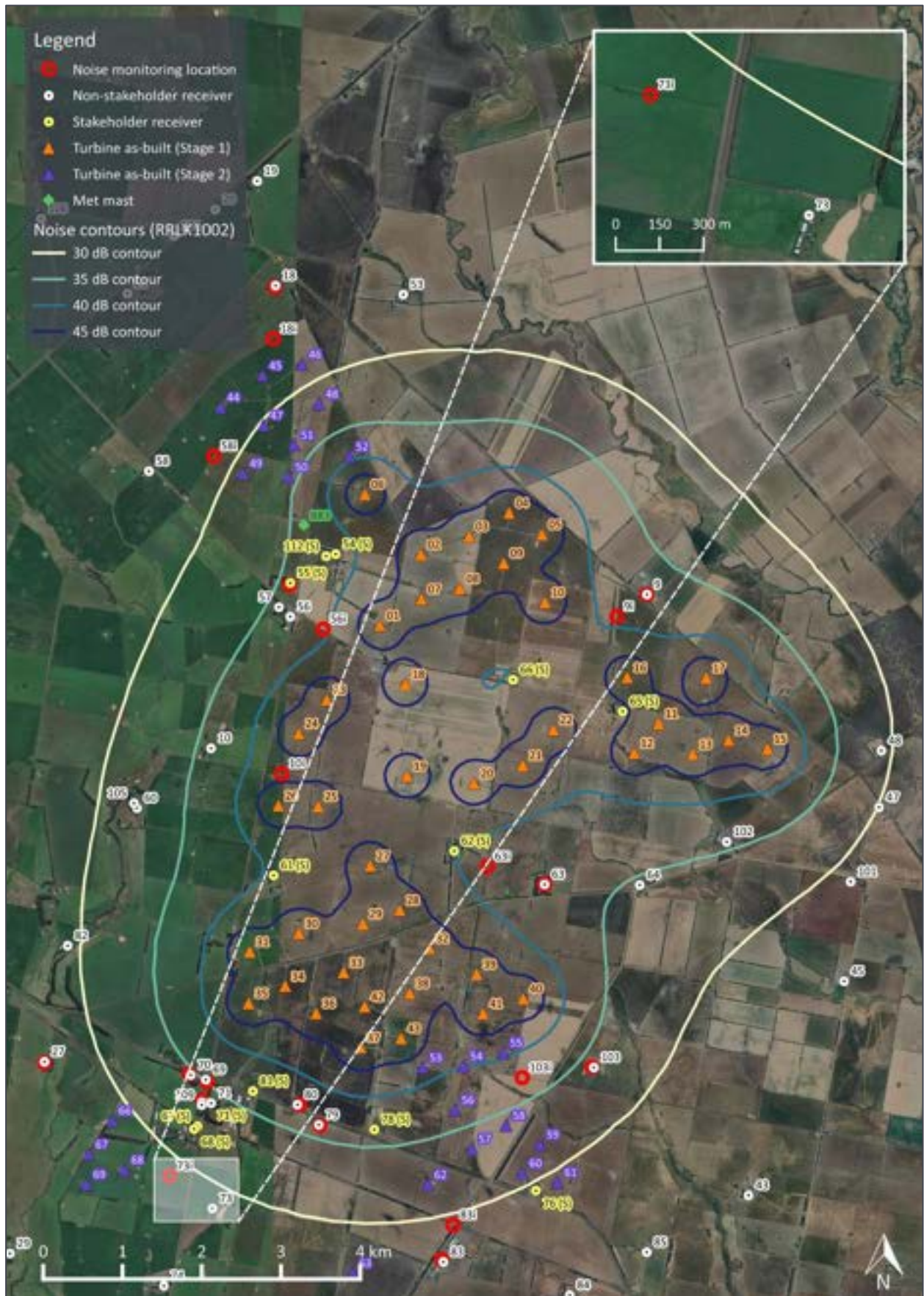
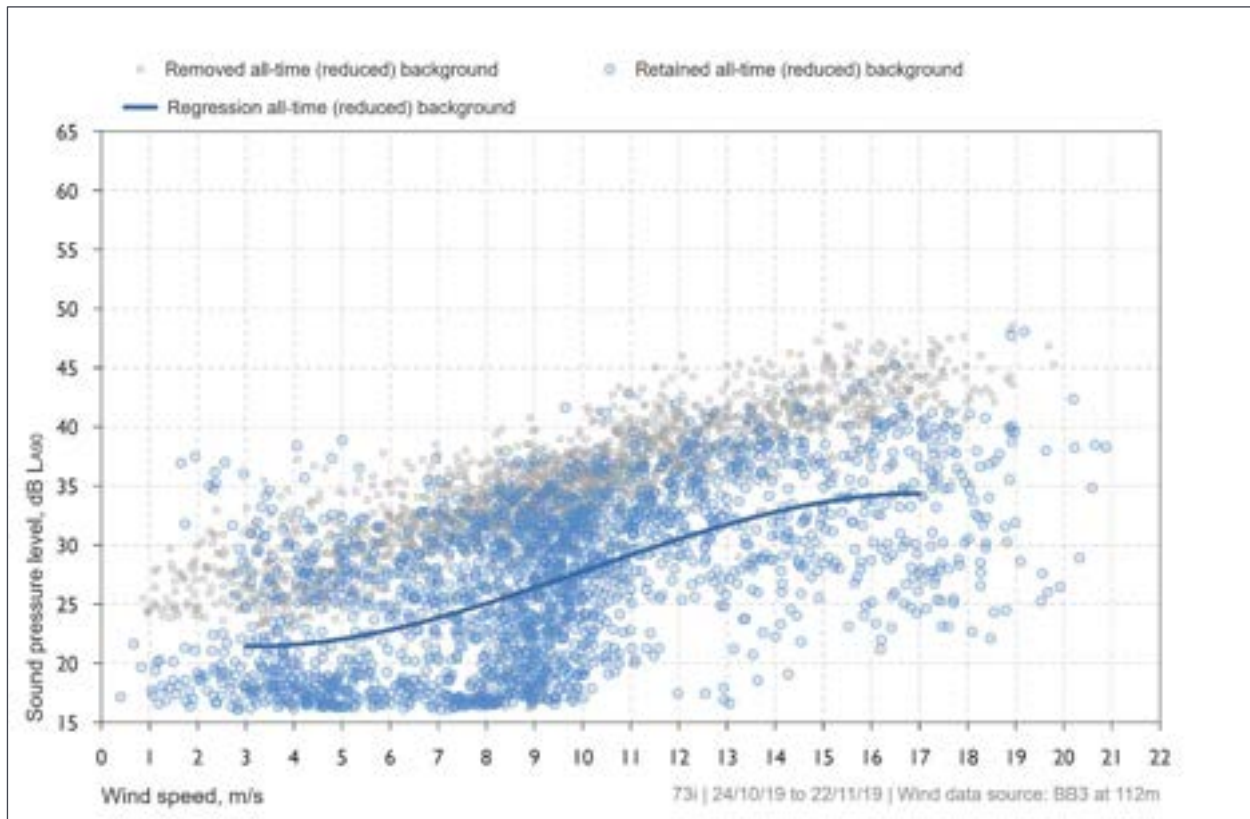


Table 163: Intermediate 73i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

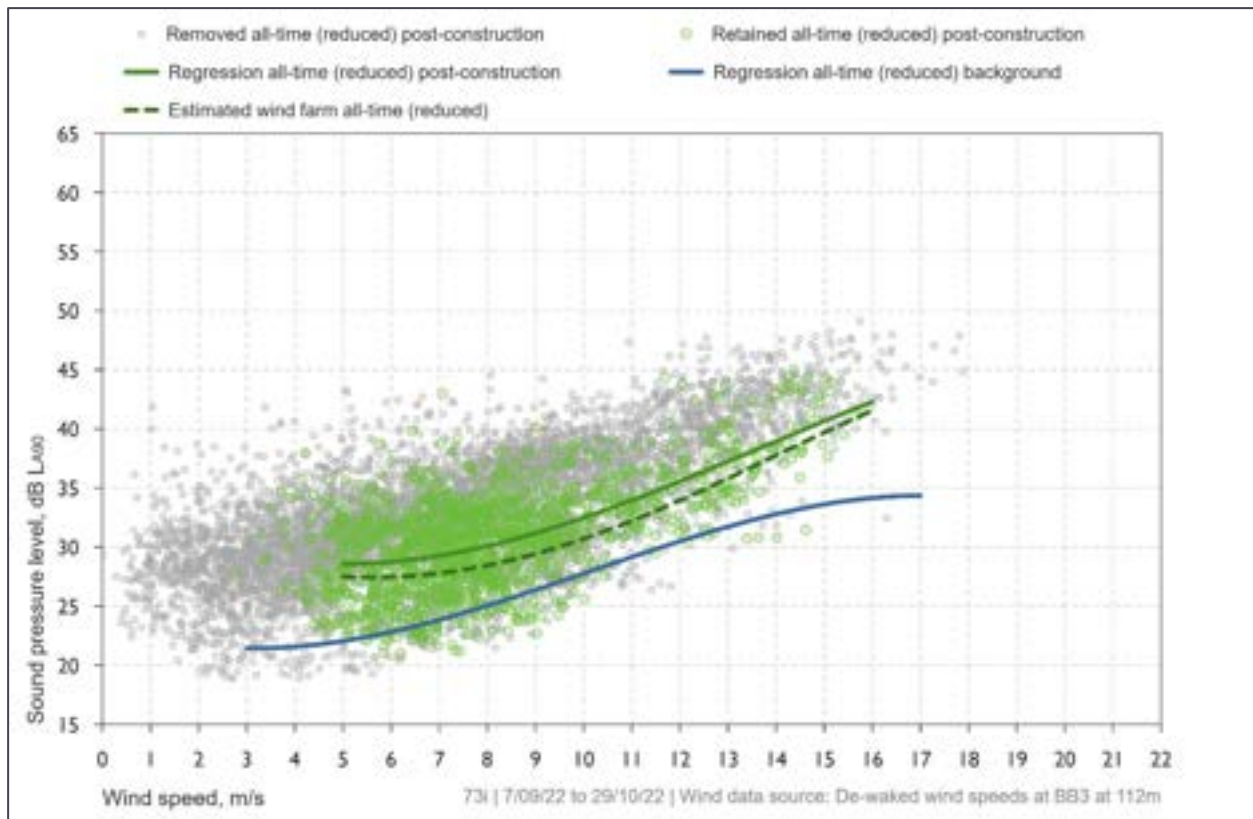
BB2 Intermediate 73i background noise data

Figure 159: Intermediate 73i - derived background noise levels and noise limit – all-time (reduced)



BB3 Intermediate 73i post-construction measurement data – all wind speeds

Figure 160: Intermediate 73i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)



BB4 Intermediate 73i post-construction measurement data summary – assessment wind speeds

Table 164: Intermediate 73i assessment data summary – number of data points

Data points	All-time (reduced)
Collected	7240
Removed	5800
Retained	1440

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 165.

Table 165: Intermedia 73i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)
Periods from 0700 – 1700 hrs	3026
Rainfall	2225
Extraneous noise	285
Wind farm operations curtailed	3905
Wind speeds outside assessment range	1088

Figure 161: Intermediate 73i post-construction noise levels and wind speed time history

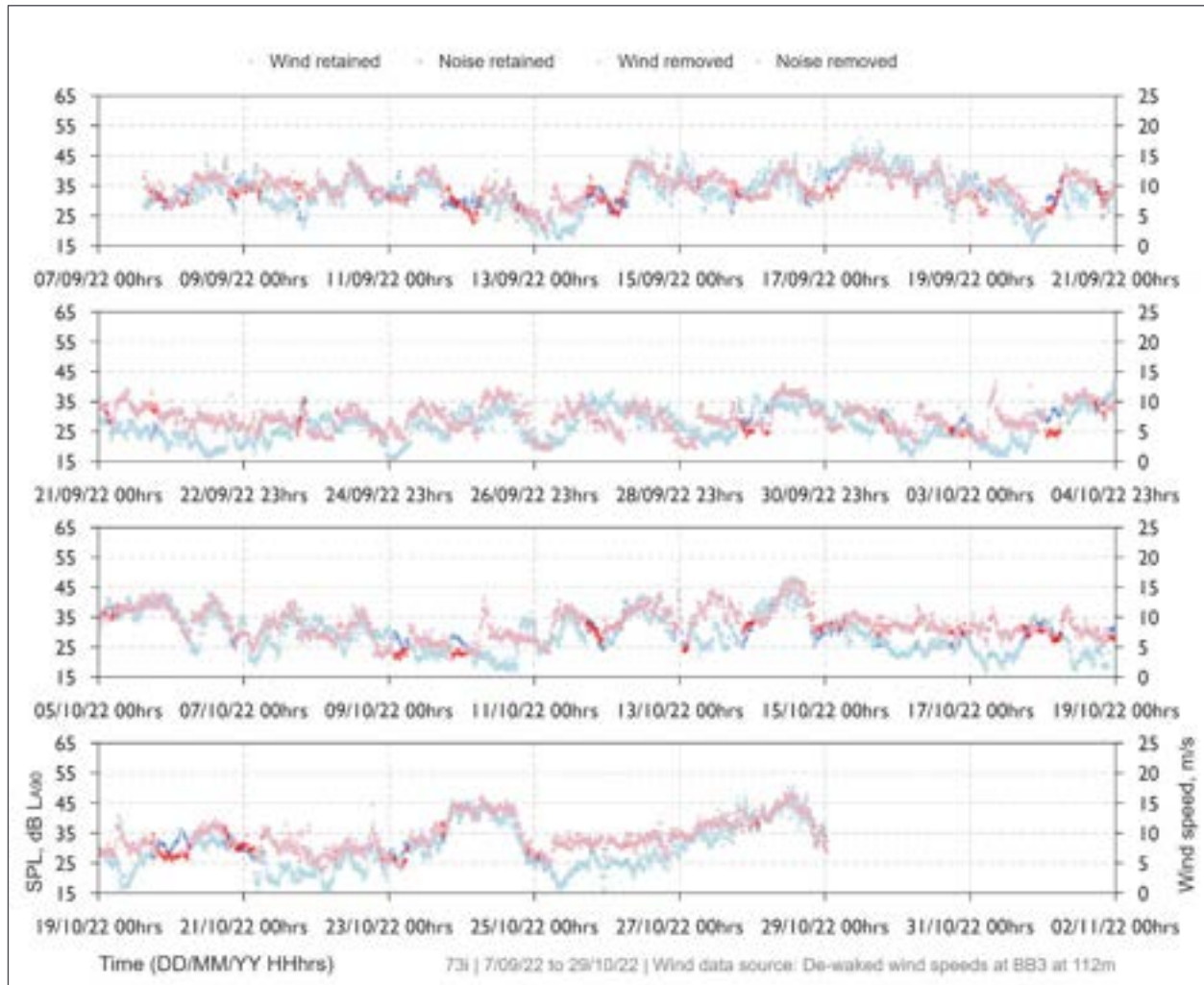
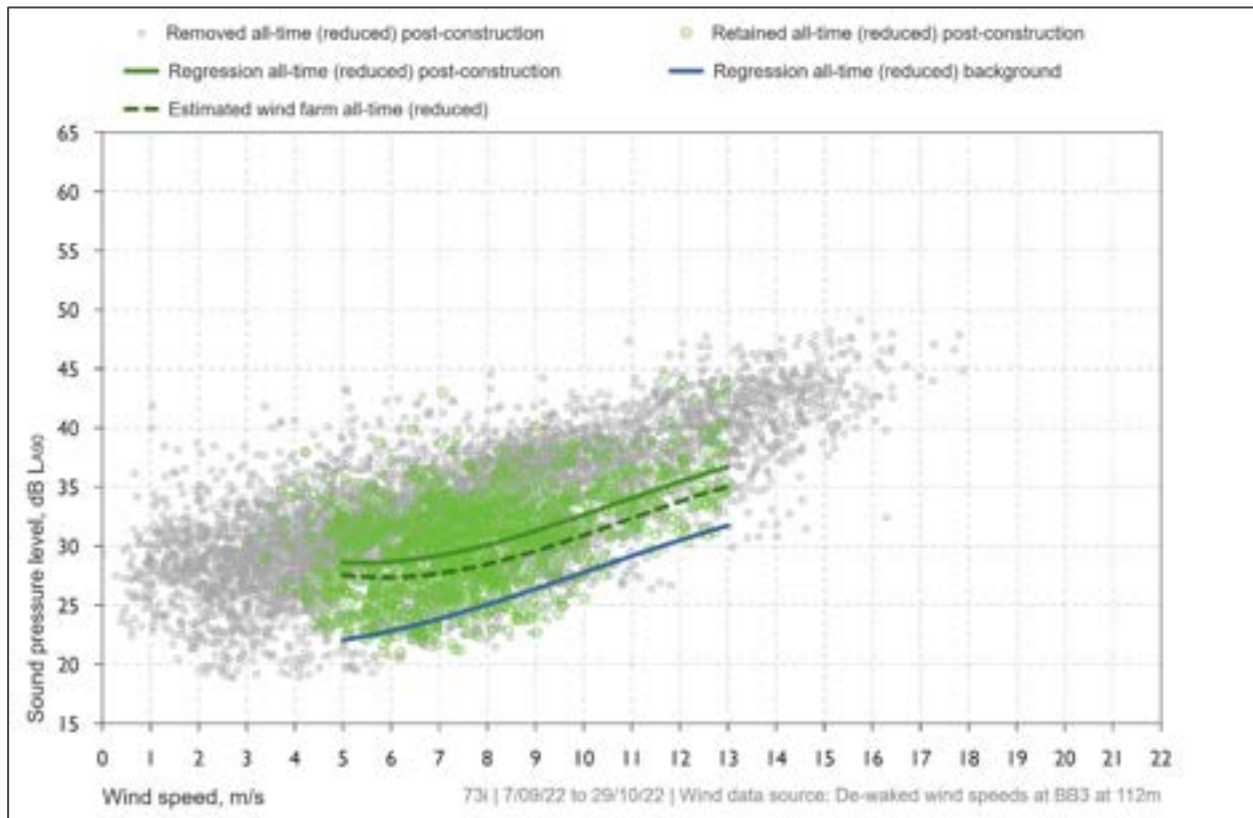


Figure 162: Intermediate 73i – post-construction noise levels versus site wind speed– all-time (reduced)



BB5 Intermediate 73i tonality assessment

Figure 163: Intermediate 73i - tonality adjusted post-construction noise levels versus site wind speed

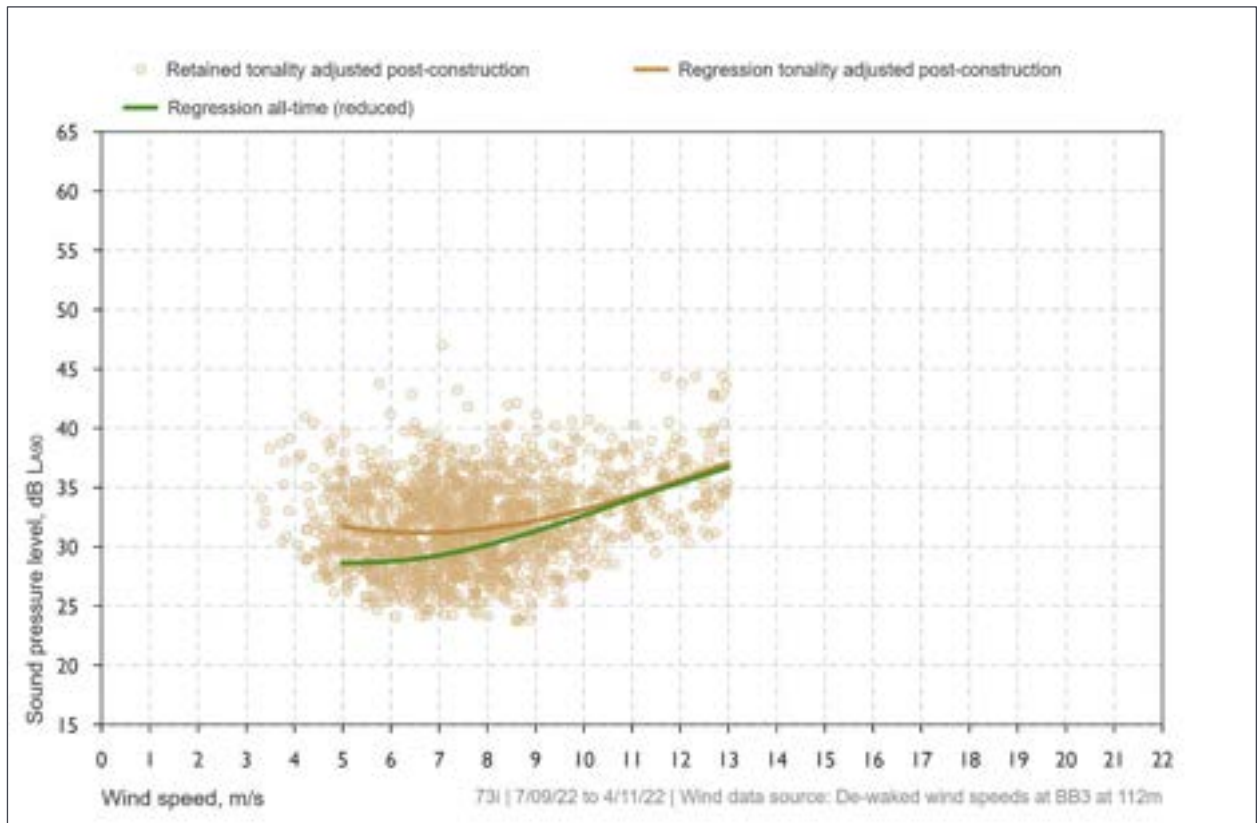


Table 166: Intermediate 73i – tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	- ^[1]	31.7	31.3	31.2	31.5	32.2	33.1	34.3	35.6	37.1
Post-construction regression - no penalties	- ^[1]	- ^[1]	28.6	28.7	29.2	30.1	31.3	32.6	34.1	35.4	36.7
Penalty adjustment	- ^[1]	- ^[1]	3.1	2.6	2.0	1.4	0.9	0.5	0.2	0.2	0.4

1 Outside valid wind speed range of the regression analysis

BB6 Receiver 73 compliance assessment

Table 167: Receiver 73 compliance assessment based on extrapolation from intermediate 73i, dB L_{A90} – all-time (reduced)

Description	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Total noise level intermediate 73i	- ^[1]	- ^[1]	28.6	28.7	29.2	30.1	31.3	32.6	34.1	35.4	36.7
Background noise level intermediate 73i	- ^[1]	- ^[1]	22.0	22.8	23.8	25.0	26.4	27.8	29.2	30.5	31.7
Background adjustment intermediate 73i	- ^[1]	- ^[1]	-1.1	-1.3	-1.5	-1.6	-1.7	-1.7	-1.7	-1.7	-1.7
Extrapolation correction ^[2]	- ^[1]	- ^[1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tonality adjustment intermediate 73i ^[3]	- ^[1]	- ^[1]	3.1	2.6	2.0	1.4	0.9	0.5	0.2	0.2	0.4
Estimated tonality adjusted wind farm noise level receiver 73	- ^[1]	- ^[1]	30.6	30.0	29.7	29.9	30.5	31.4	32.6	33.9	35.4
Noise limit receiver 73 ^[4]	- ^[1]	- ^[1]	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Compliance margin	- ^[1]	- ^[1]	-9.4	-10.0	-10.3	-10.1	-9.5	-8.6	-7.4	-6.1	-4.6

1 Outside valid wind speed range of the regression analysis

2 Predicted noise level difference between receiver 73 and intermediate 73i less than 1 dB – extrapolation then reduces to 0 dB when uncertainty of 1 dB accounted for

3 Noise monitoring was not conducted at the receiver – the tonality adjustment from the intermediate location is therefore provided as a conservative indication of tonality

4 Background noise monitoring was not conducted at the receiver – the background noise related limits are therefore not available for this receiver

APPENDIX CC INTERMEDIATE 83I

CC1 Intermediate 83i location data

Table 168: Intermediate 83i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	721655	5791862

Figure 164: Intermediate 83i aerial view – noise monitor location

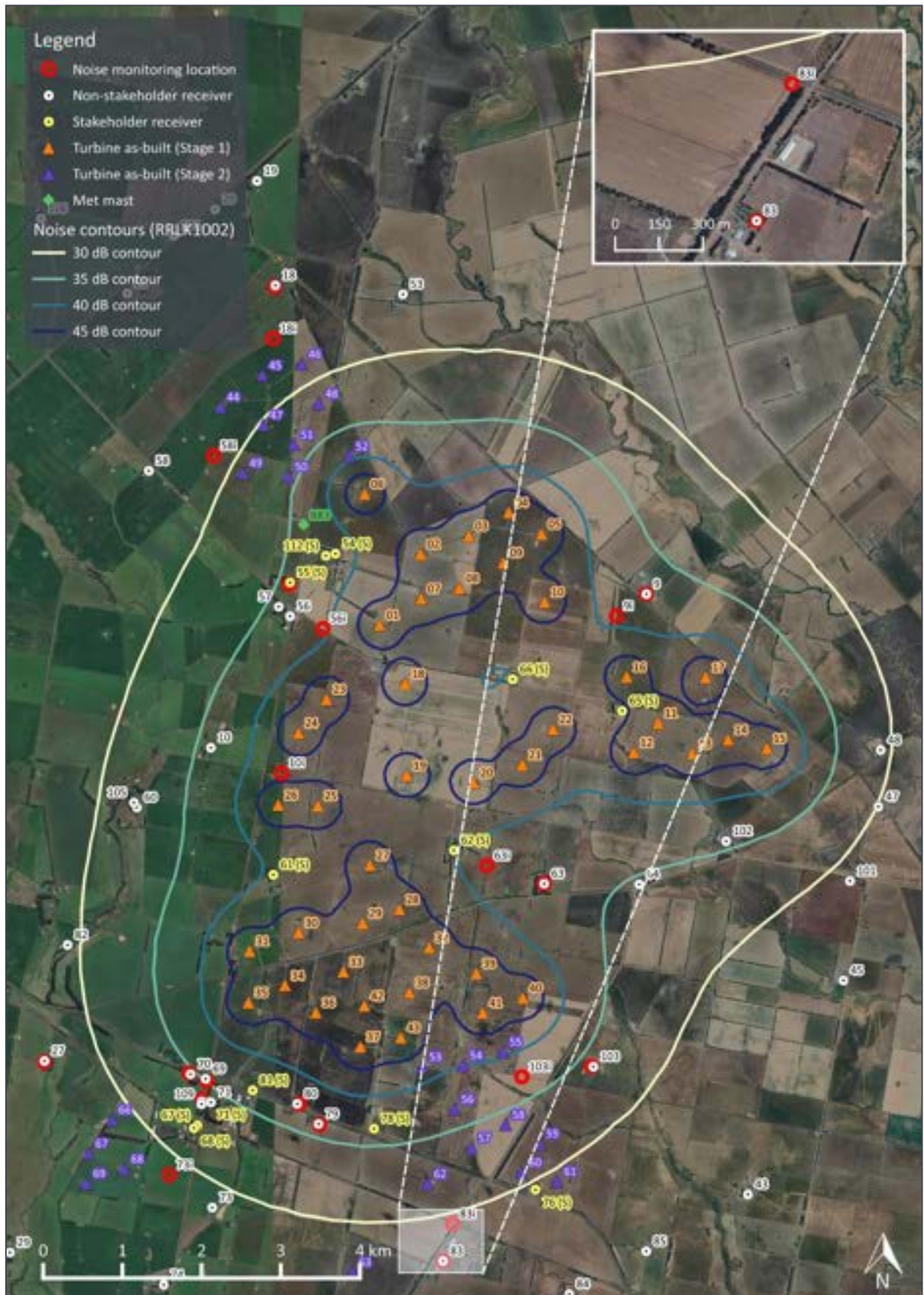


Table 169: Intermediate 83i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

CC2 Intermediate 83i background noise data

Figure 165: Intermediate 83i - derived background noise levels and noise limit – all-time (reduced)

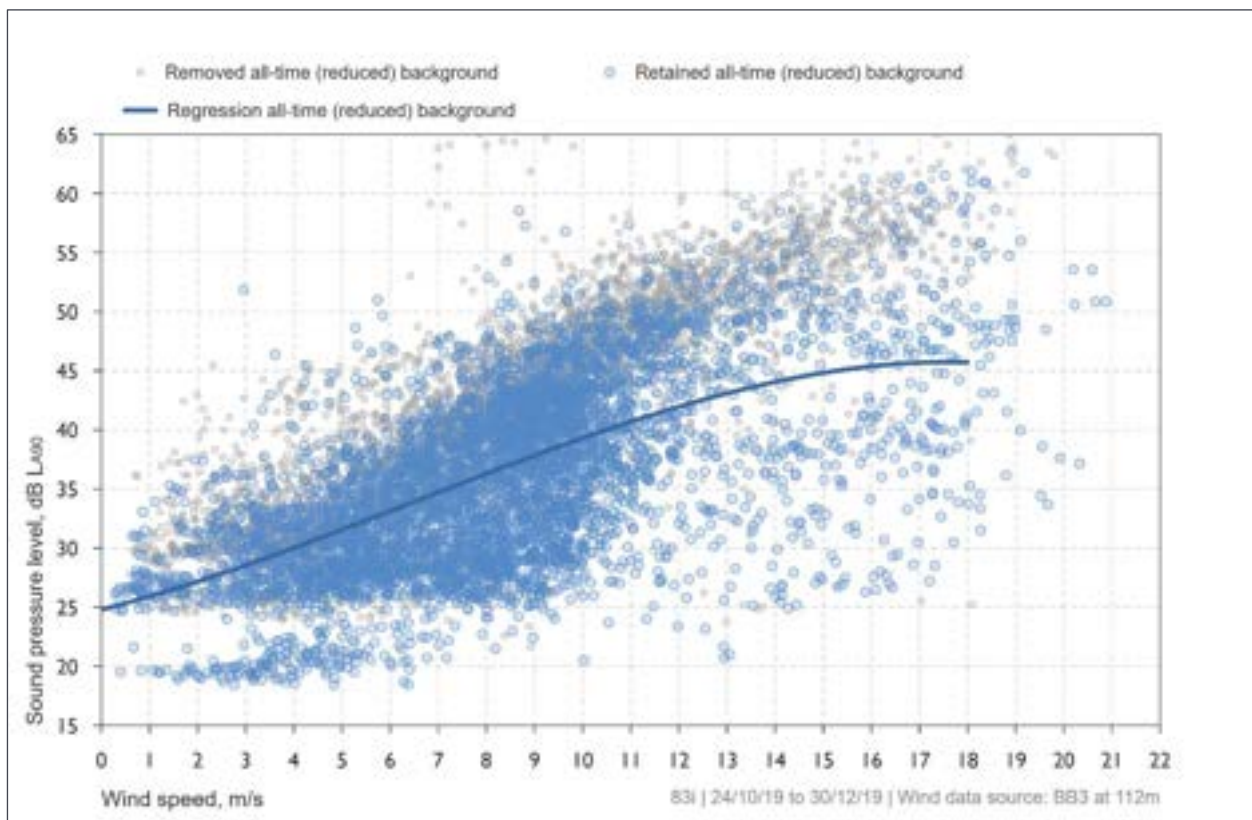
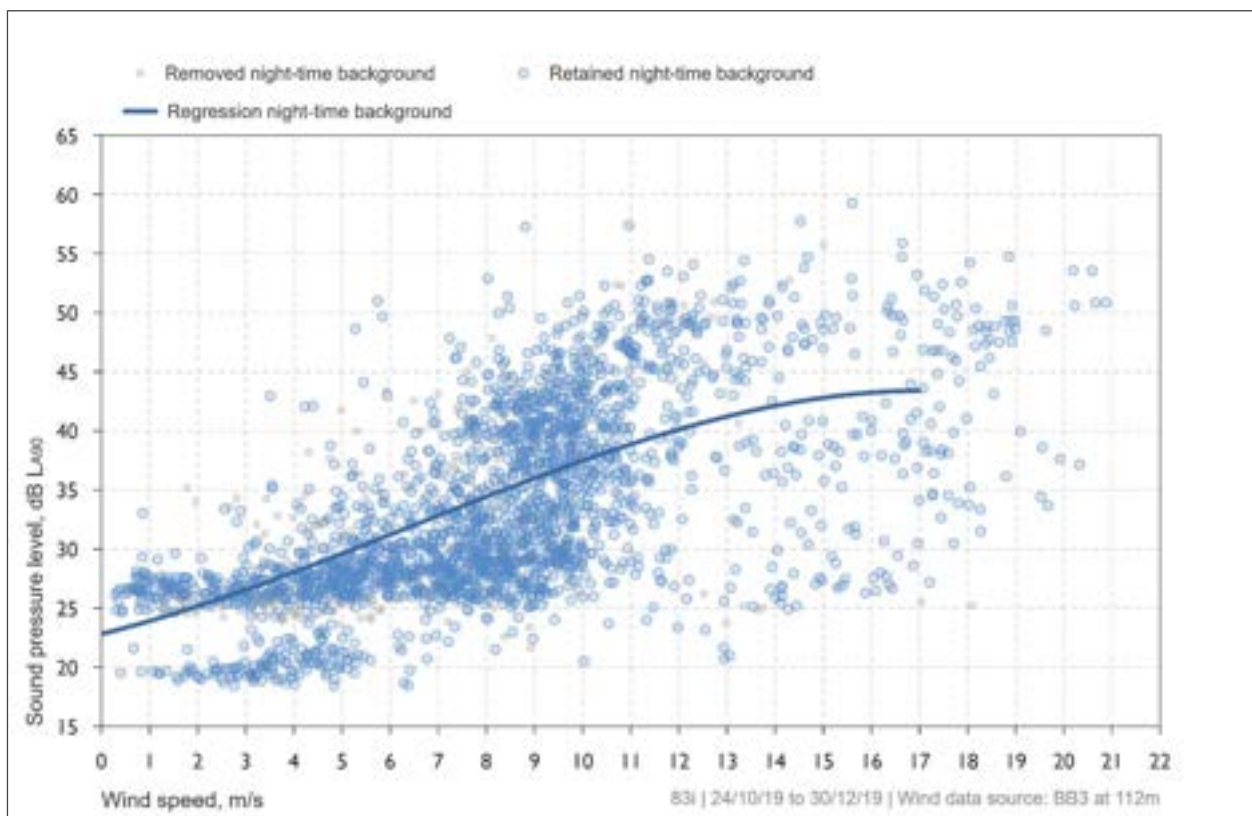


Figure 166: Intermediate 83i - derived background noise levels and noise limit – night-time



CC3 Intermediate 83i post-construction measurement data – all wind speeds

Figure 167: Intermediate 83i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

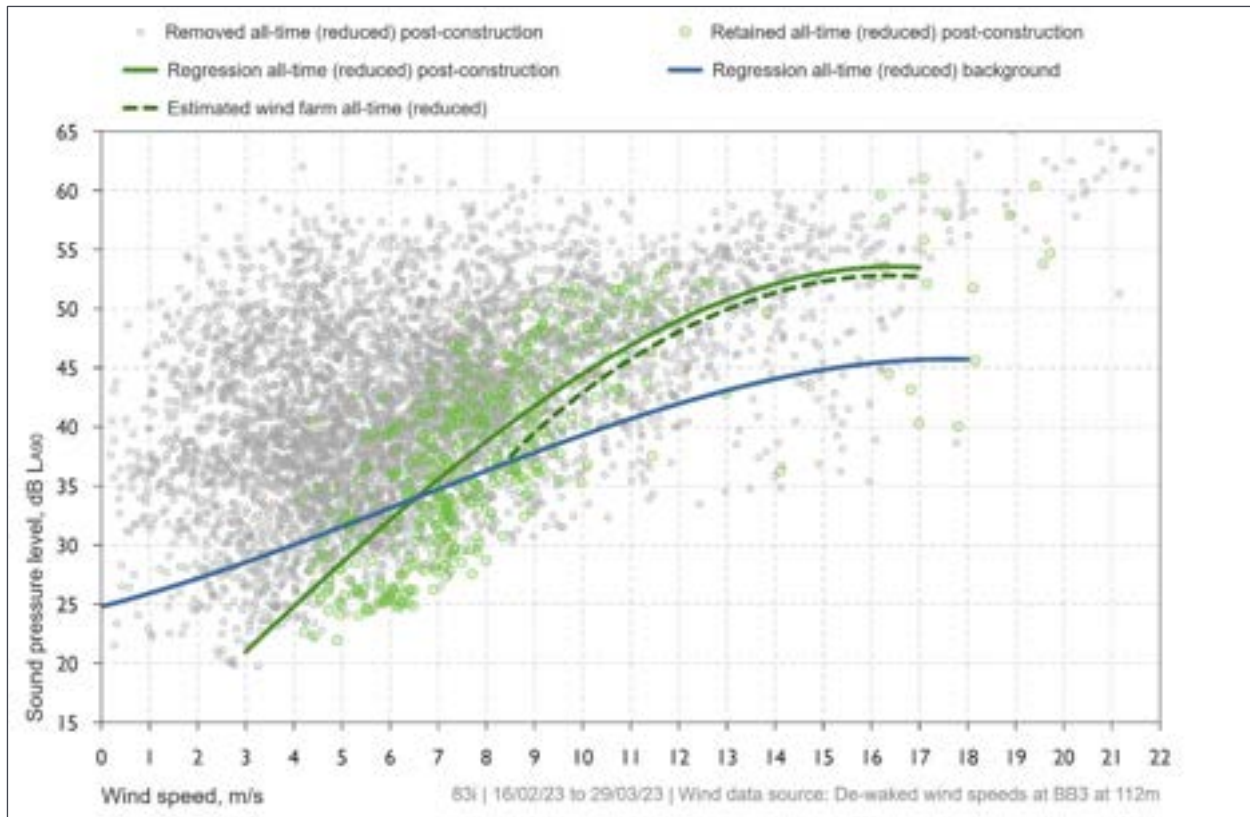
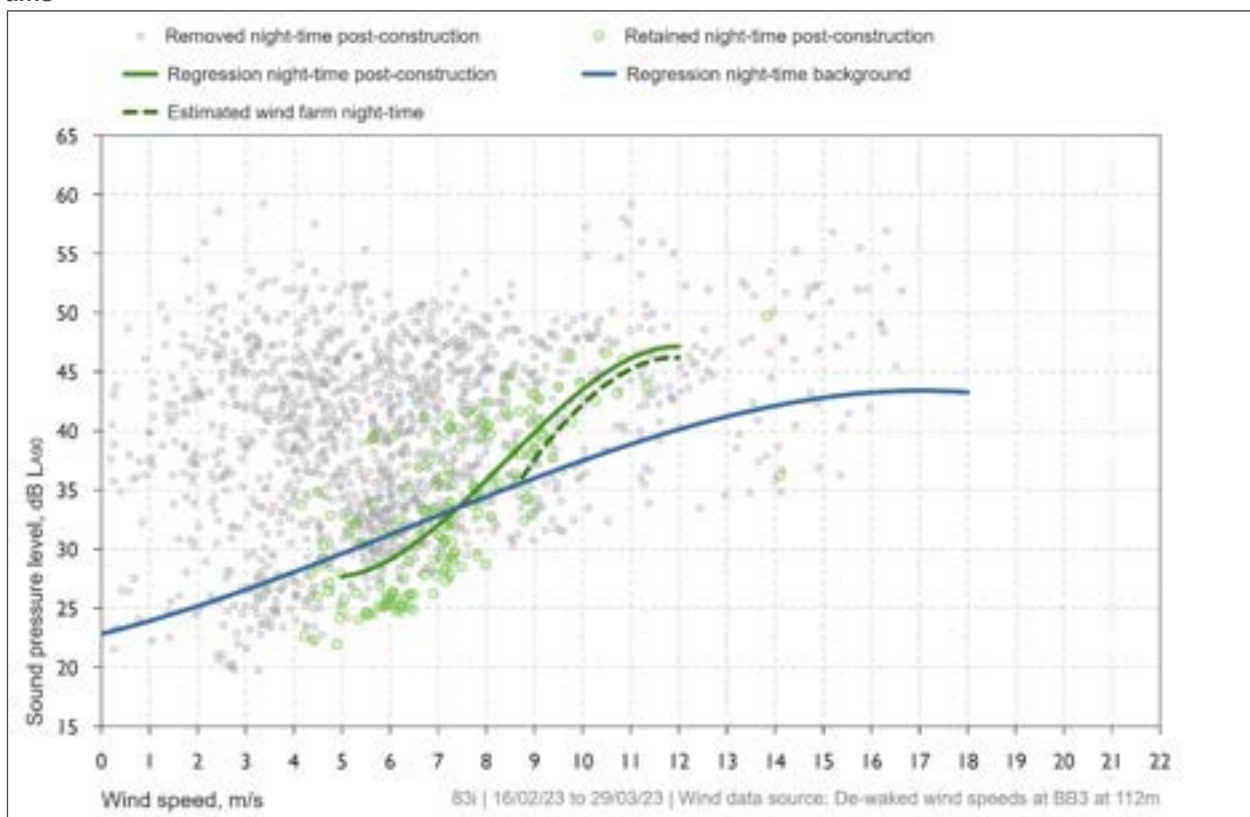


Figure 168: Intermediate 83i – post-construction noise levels and minimum noise limits versus site wind speed – night-time



CC4 Intermediate 83i post-construction measurement data summary – assessment wind speeds

Table 170: Intermediate 83i assessment data summary – number of data points

Data points	All-time (reduced)	Night-time (2200 – 0500 hrs)
Collected	5430	1560
Removed	5000	1388
Retained	430	172

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 171.

Table 171: Intermediate 83i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)	Night-time (2200 – 0500 hrs)
Periods from 0700 – 1700 hrs	3026	-
Rainfall	99	0
Extraneous noise	2546	1124
Wind farm operations curtailed	3053	800
Wind speeds outside assessment range	830	250

Figure 169: Intermediate 83i post-construction noise levels and wind speed time history

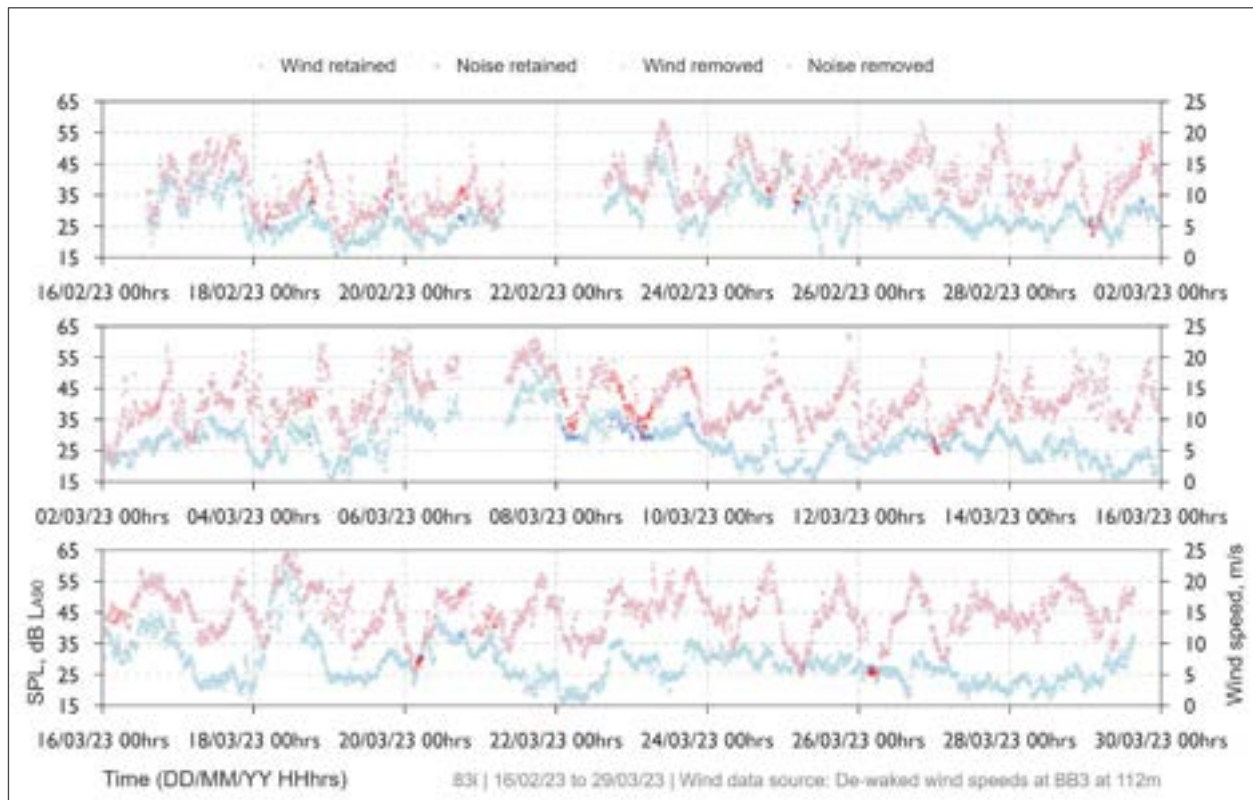


Figure 170: Intermediate 83i – post-construction noise levels versus site wind speed, dB L_{A90} – all-time (reduced)

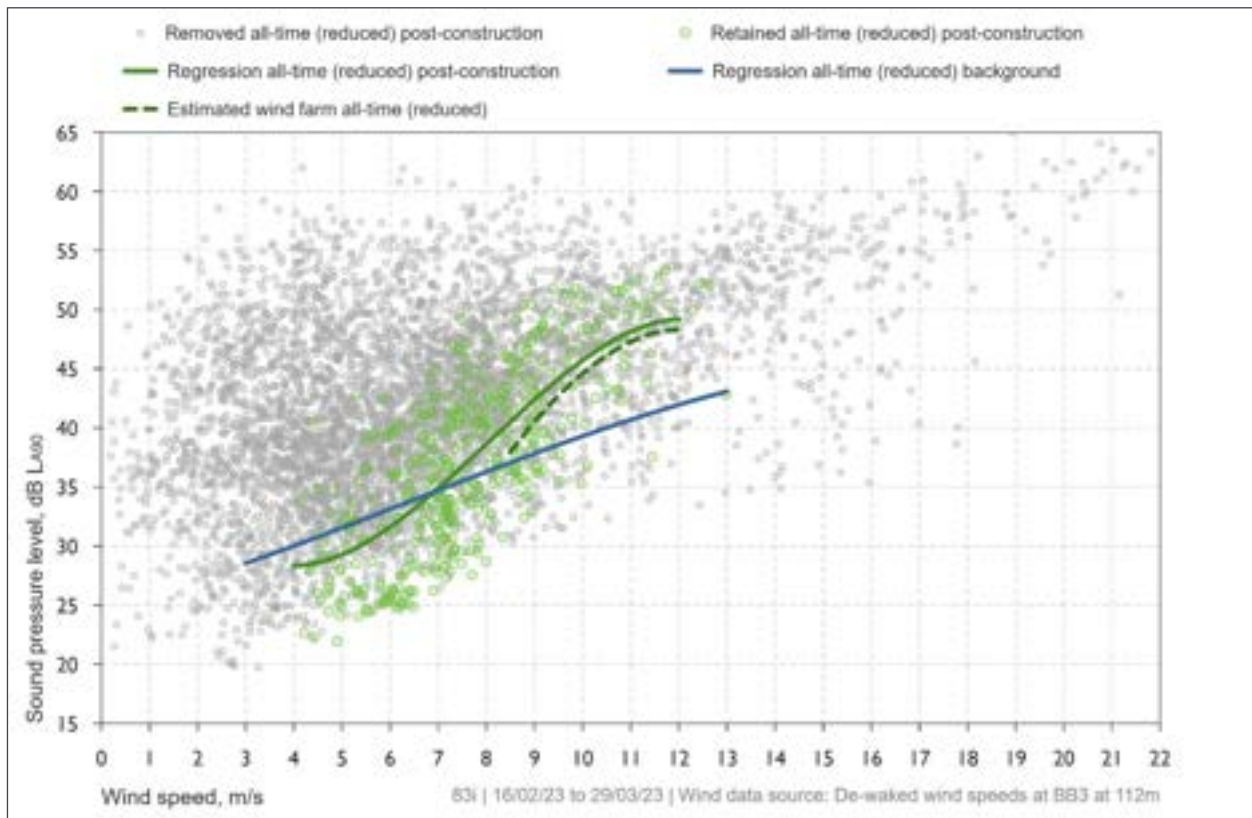
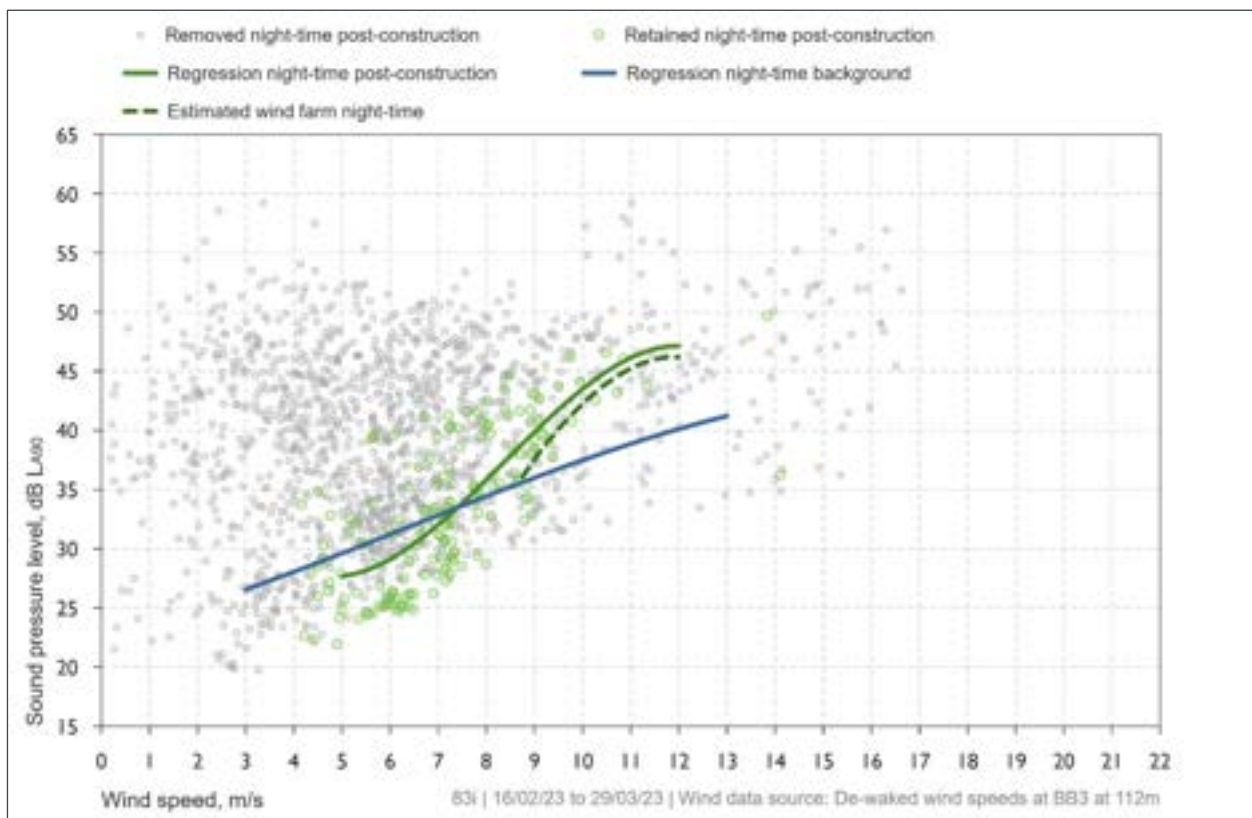


Figure 171: Intermediate 83i – post-construction noise levels versus site wind speed, dB L_{A90} – night-time (2200 – 0500 hrs)



CC5 Intermediate 83i tonality data

Tonality data for intermediate 83i are provided as reference information only. The tonality assessment for receiver 83 is based on data obtained at receiver 83.

Figure 172: Intermediate 83i – tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

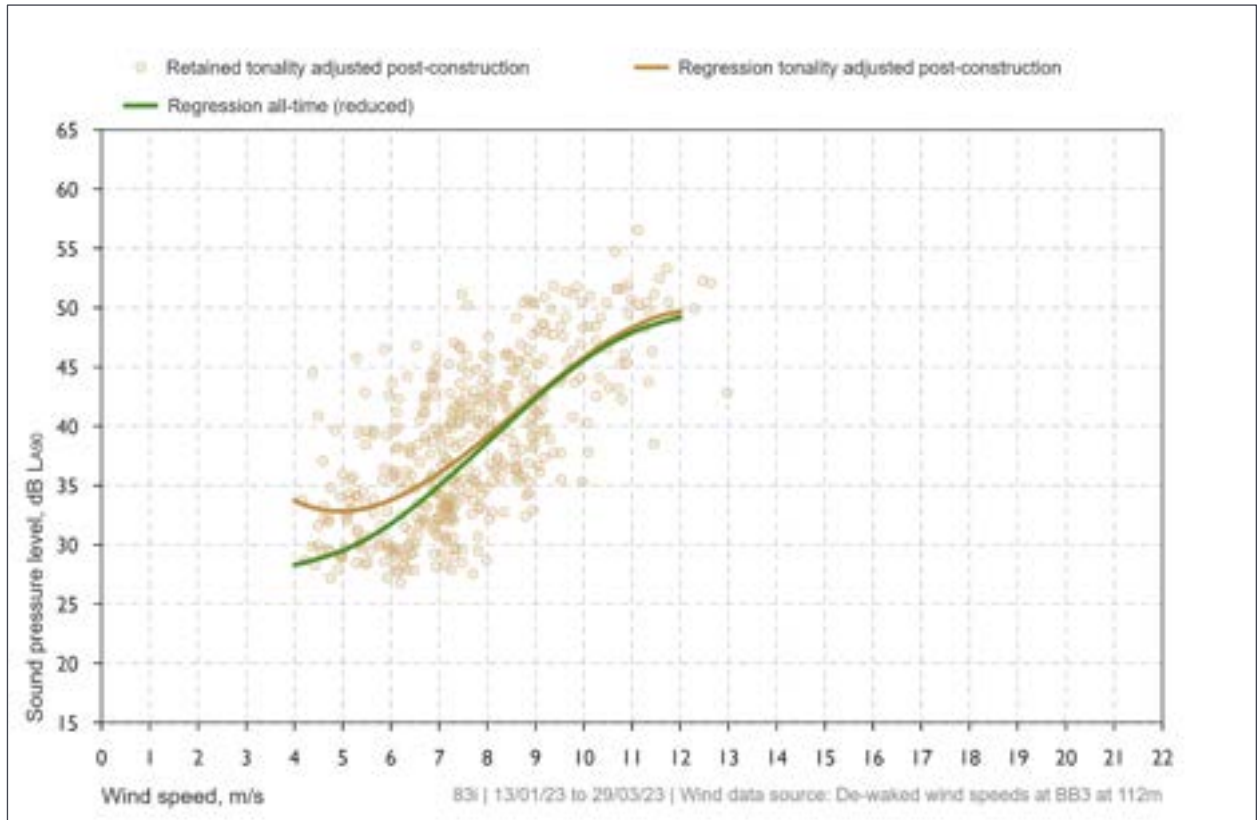


Table 172: Intermediate 83i tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	33.7	32.8	33.8	36.0	39.1	42.5	45.8	48.3	49.7	- ^[1]
Post-construction regression - no penalties	- ^[1]	28.3	29.3	31.6	34.9	38.6	42.4	45.7	48.1	49.2	- ^[1]
Penalty adjustment	- ^[1]	5.4	3.5	2.2	1.1	0.5	0.1	0.1	0.2	0.5	- ^[1]

1 Outside valid wind speed range of the regression analysis

Figure 173: Intermediate 83i – tonality adjusted post-construction noise levels versus site wind speed – night-time (2200 – 0500 hrs)



Table 173: Intermediate 73i – tonality penalty calculation, dB LA90 – night-time (2200 – 0500 hrs)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	- ^[1]	31.1	31.4	33.3	36.3	39.6	42.9	45.4	46.6	- ^[1]
Post-construction regression - no penalties	- ^[1]	- ^[1]	27.7	29.1	32.0	35.8	39.9	43.5	46.1	47.2	- ^[1]
Penalty adjustment	- ^[1]	- ^[1]	3.4	2.3	1.3	0.5	0.0	0.0	0.0	0.0	- ^[1]

1 Outside valid wind speed range of the regression analysis

CC6 Receiver 83 compliance assessment

Refer to Appendix S6.

APPENDIX DD INTERMEDIATE 103I

DD1 Intermediate 103i location data

Table 174: Intermediate 103i noise monitor coordinates – MGA 94 Zone 54

Location	Easting	Northing
Noise monitoring location	722530	5793720

Figure 174: Intermediate 103i aerial view – monitor location

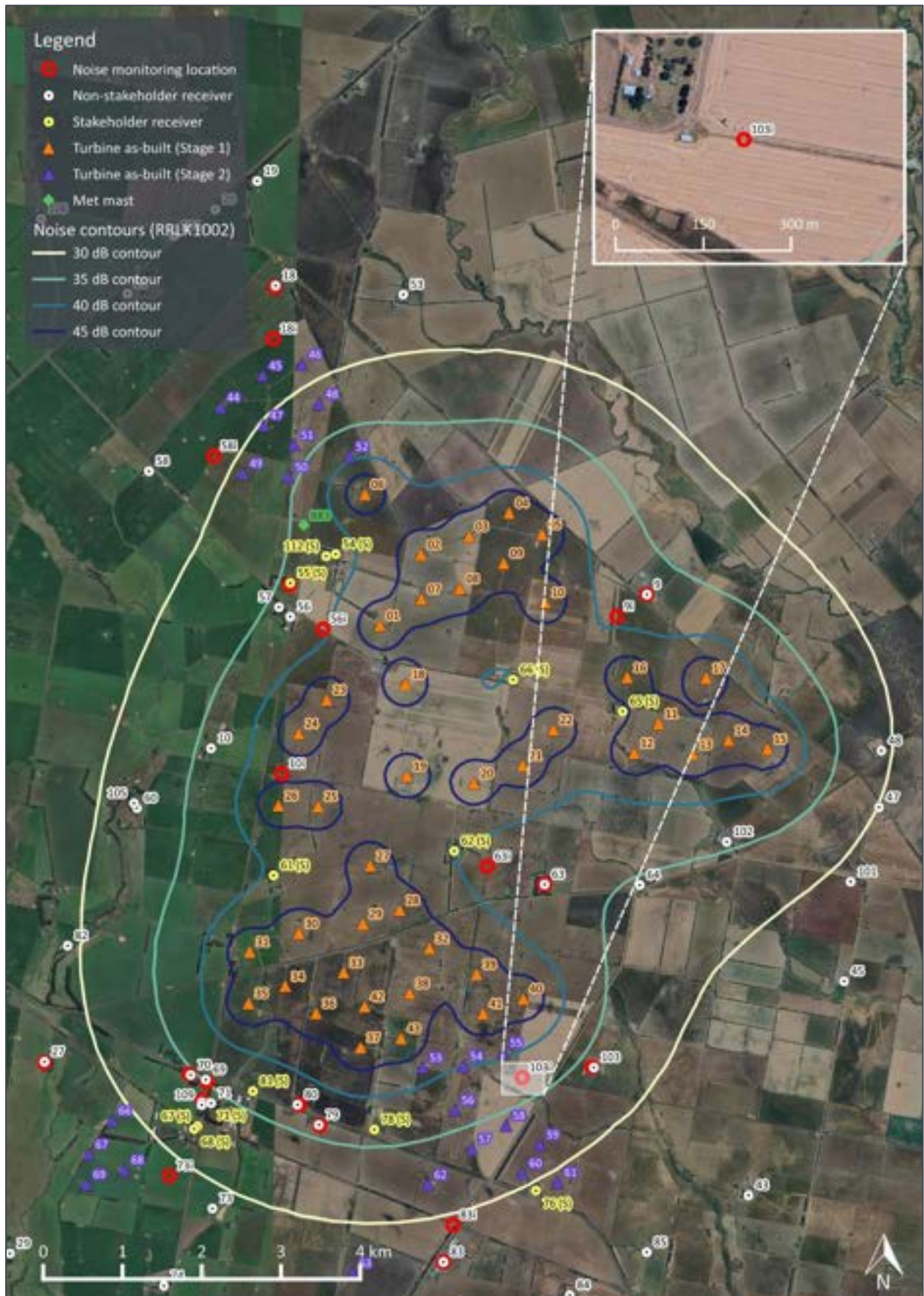


Table 175: Intermediate 103i monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

DD2 Intermediate 103i background noise data

Figure 175: Intermediate 103i - derived background noise levels and noise limit – all-time (reduced)

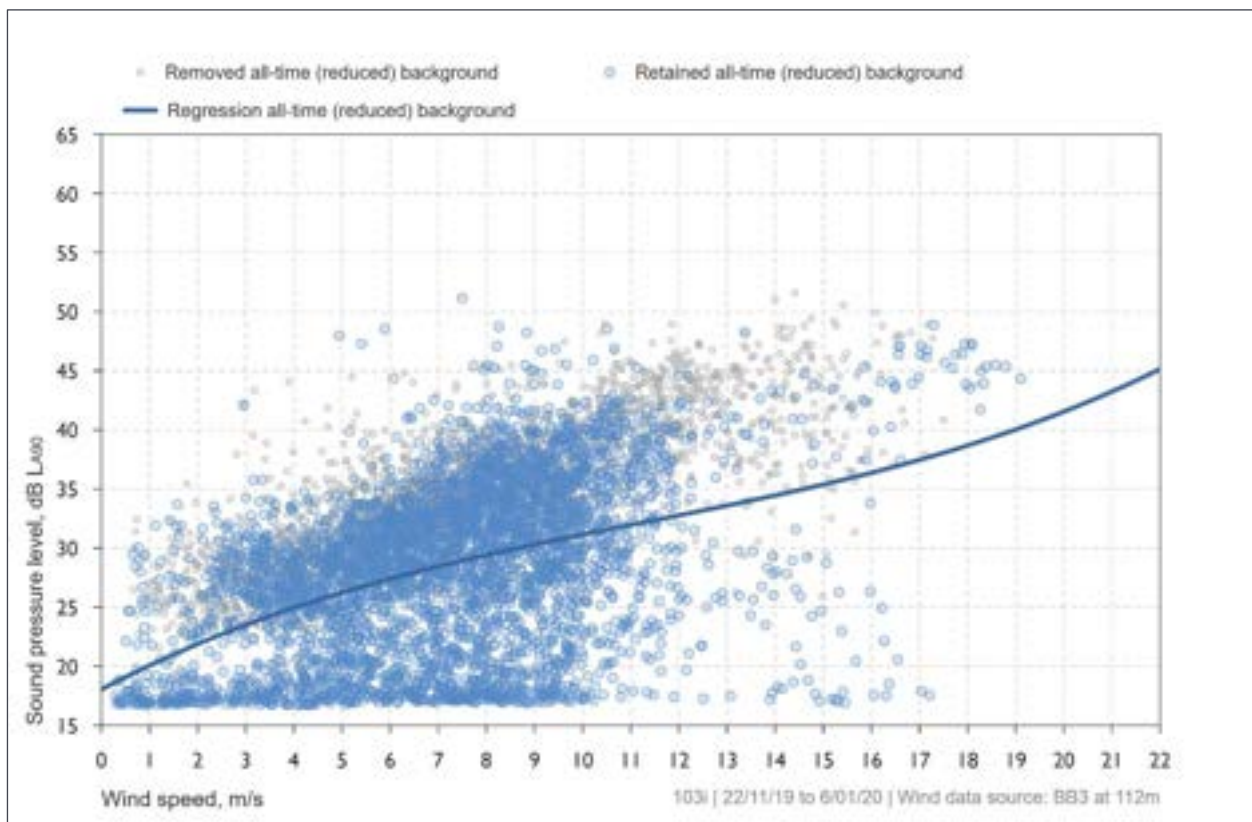
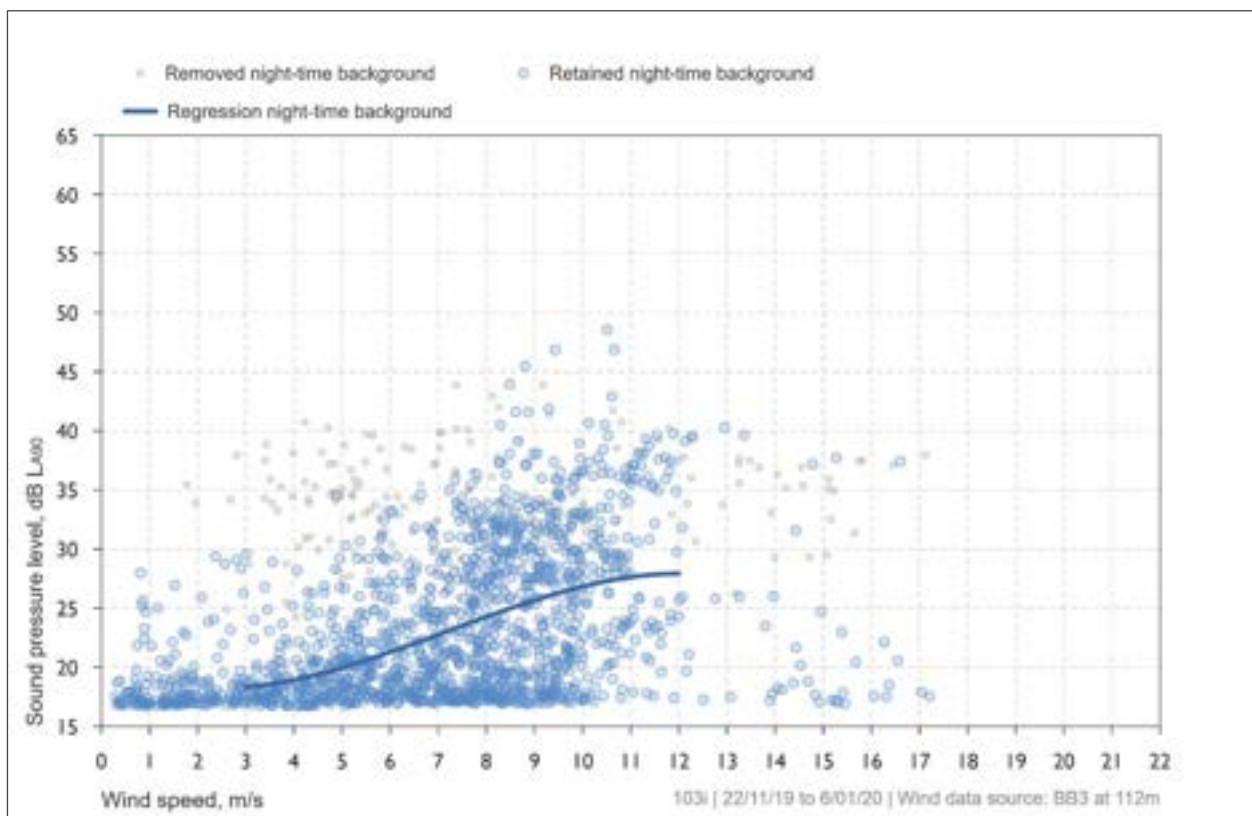


Figure 176: Intermediate 103i - derived background noise levels and noise limit – night-time



DD3 Intermediate 103i post-construction measurement data – all wind speeds

Figure 177: Intermediate 103i – post-construction noise levels and minimum noise limits versus site wind speed – all-time (reduced)

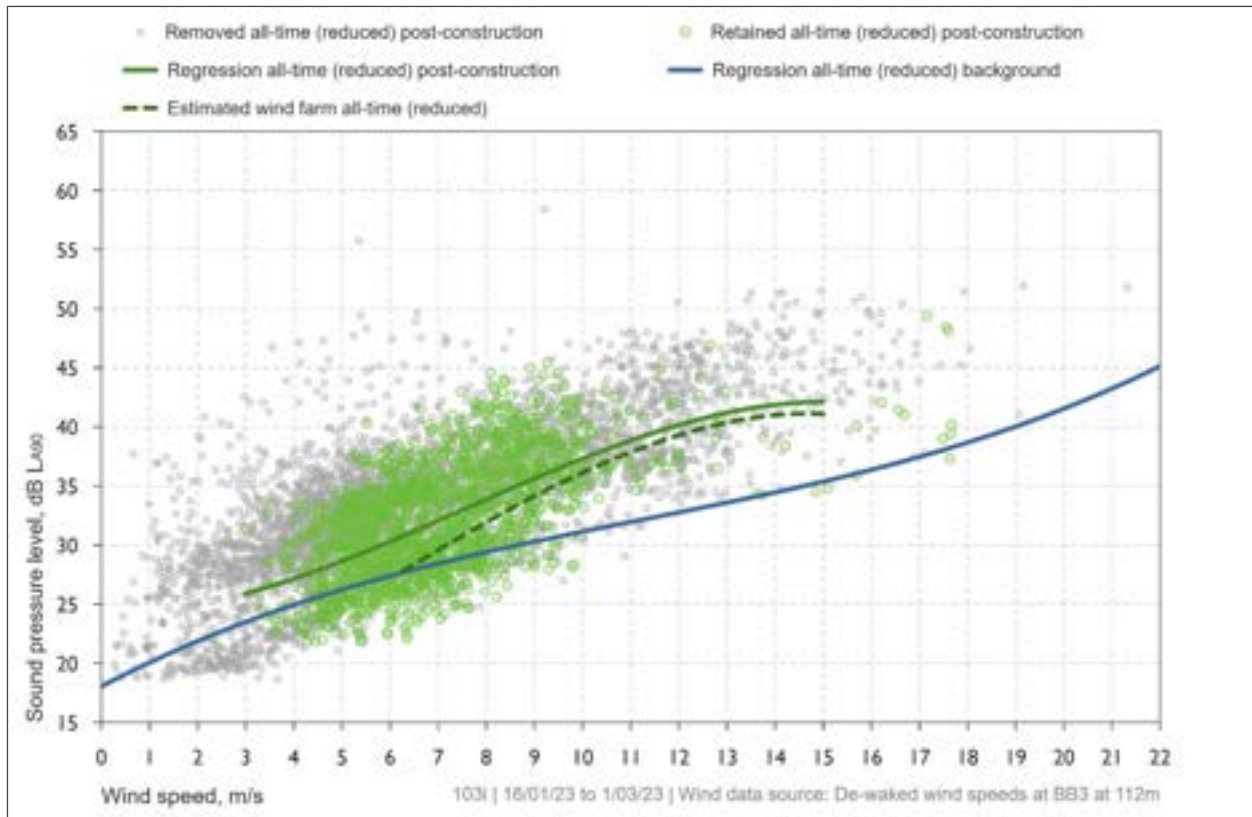
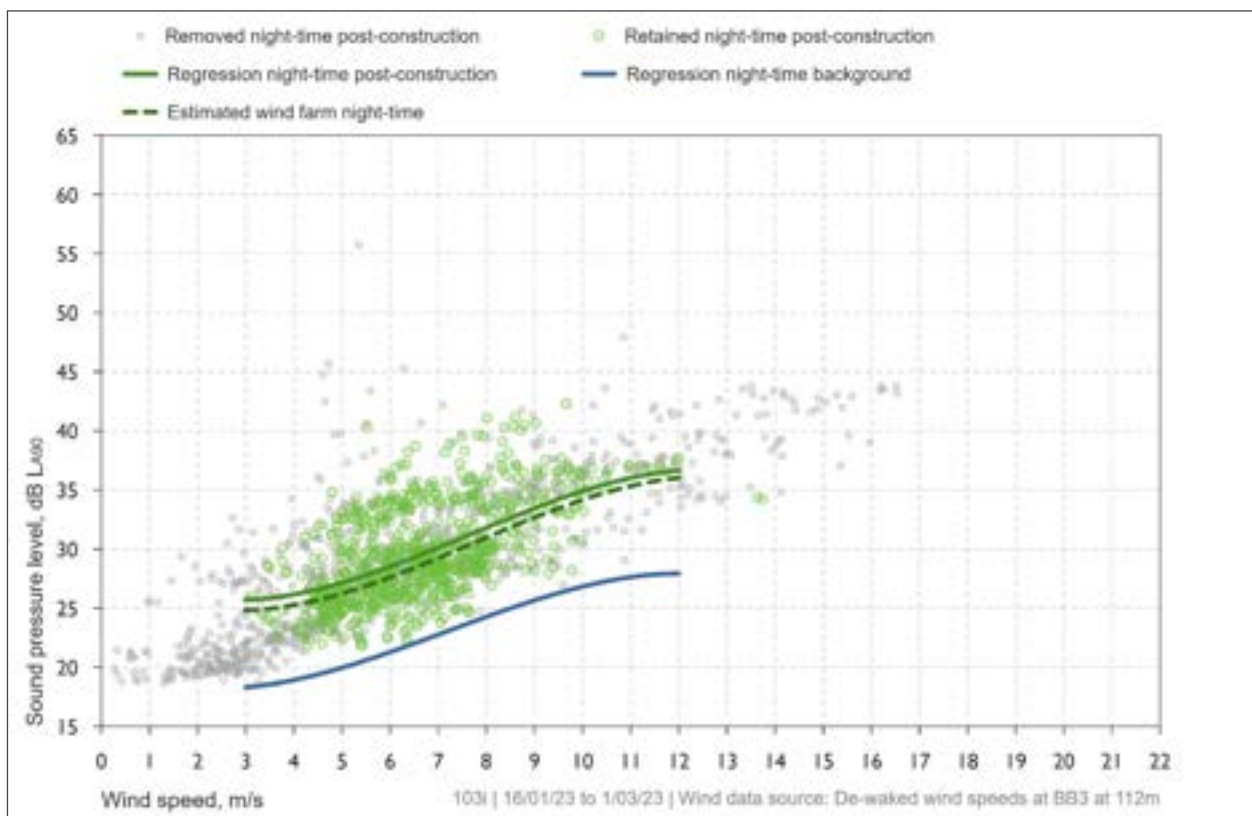


Figure 178: Intermediate 103i – post-construction noise levels and minimum noise limits versus site wind speed – night-time



DD4 Intermediate 103i post-construction measurement data summary – assessment wind speeds

Table 176: Intermediate 103i assessment data summary – number of data points

Data points	All-time (reduced)	Night-time (2200 – 0500 hrs)
Collected	5730	1645
Removed	4026	898
Retained	1704	747

The removed data relates to the data filters used to remove periods from 0700 – 1700 hrs, when rainfall occurred, extraneous noise was identified (see Section 4.3.1), the wind farm's operation was curtailed (see Section 4.3.2), or hub height wind speeds were outside the assessment range. A 10-minute period is removed when one or more of the data filters apply (e.g. a 10-minute period when both rainfall and elevated insect noise was identified). This means that the total number of removed data point will be less than or equal to the sum of the data points removed due to each data filter.

The number of data points removed due to each data filter are summarised in Table 177.

Table 177: Intermediate 103i assessment summary – number of removed data points per filter

Data filter	All-time (reduced)	Night-time (2200 – 0500 hrs)
Periods from 0700 – 1700 hrs	2375	-
Rainfall	435	89
Extraneous noise	164	84
Wind farm operations curtailed	3115	806
Wind speeds outside assessment range	672	236

Figure 179: Intermediate 103i post-construction noise levels and wind speed time history

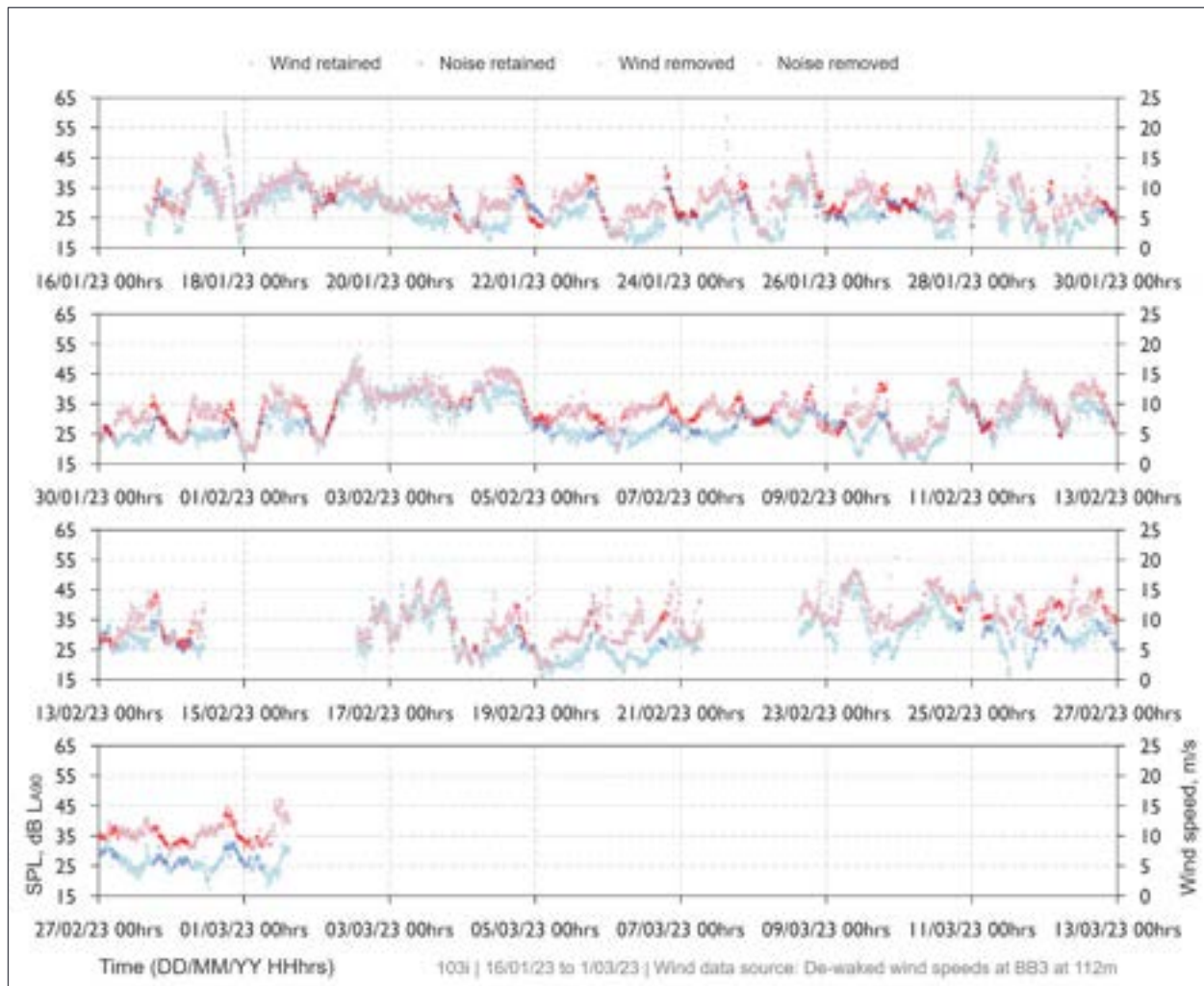


Figure 180: Intermediate 103i – post-construction noise levels versus site wind speed, dB LA90 – all-time (reduced)

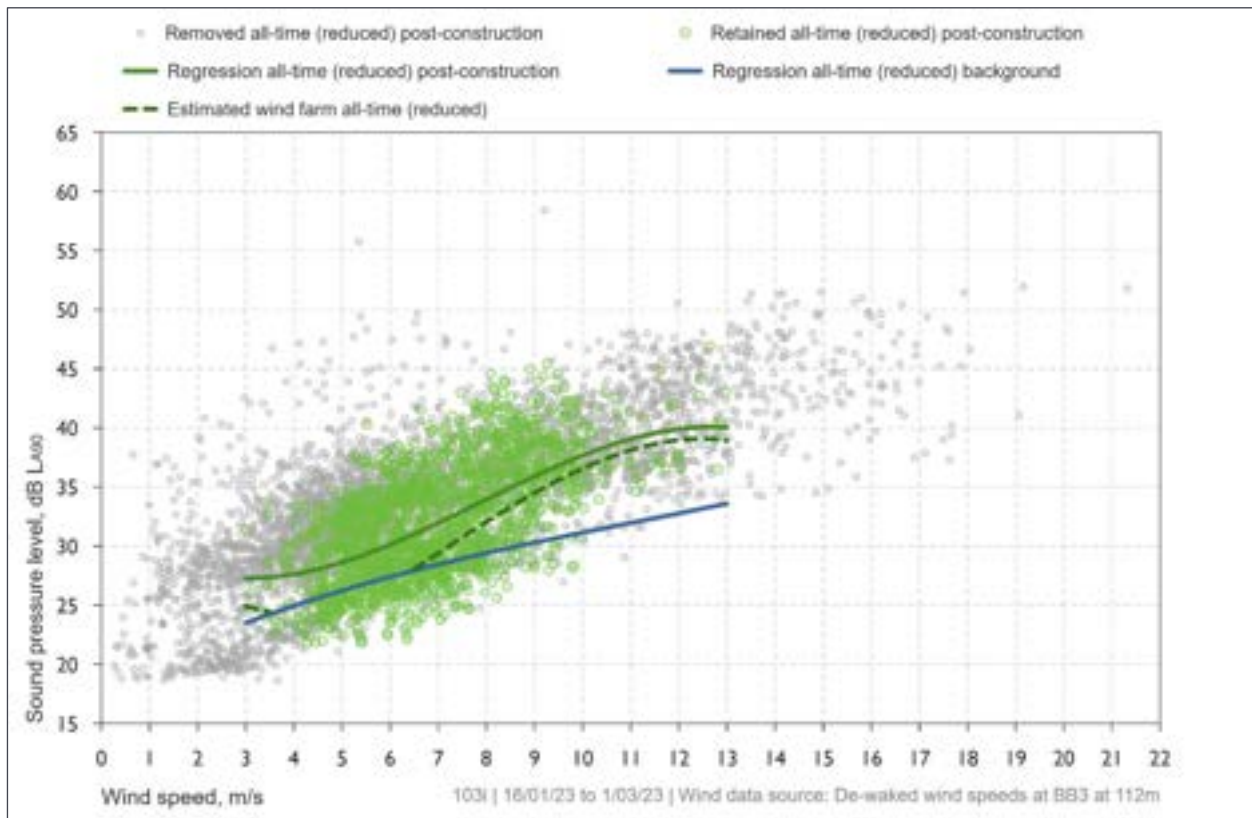
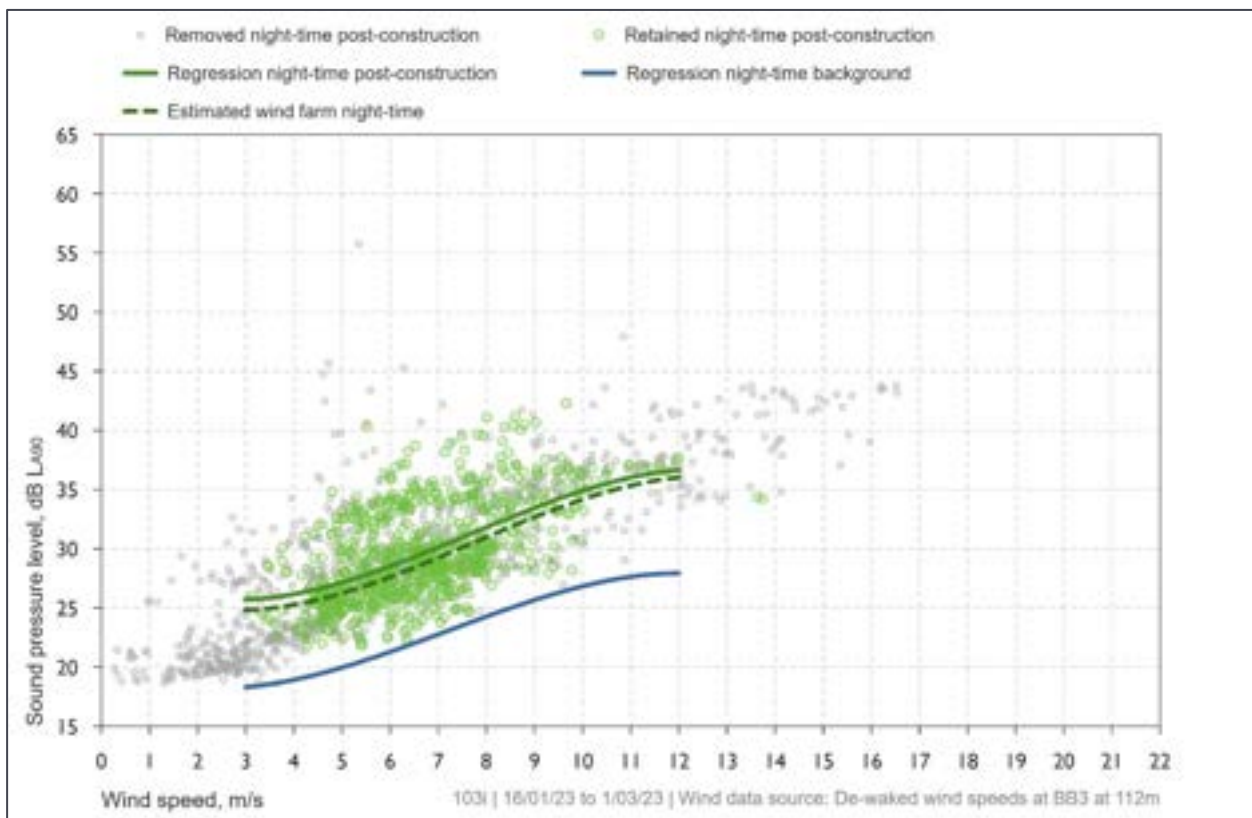


Figure 181: Intermediate 103i post-construction noise levels versus site wind speed, dB LA90 – night-time (2200 – 0500 hrs)



DD5 Intermediate 103i tonality data

Tonality data for intermediate 103i are provided as reference information only. The tonality assessment for receiver 103 is based on data obtained at receiver 103.

Figure 182: Intermediate 103i – tonality adjusted post-construction noise levels versus site wind speed – all-time (reduced)

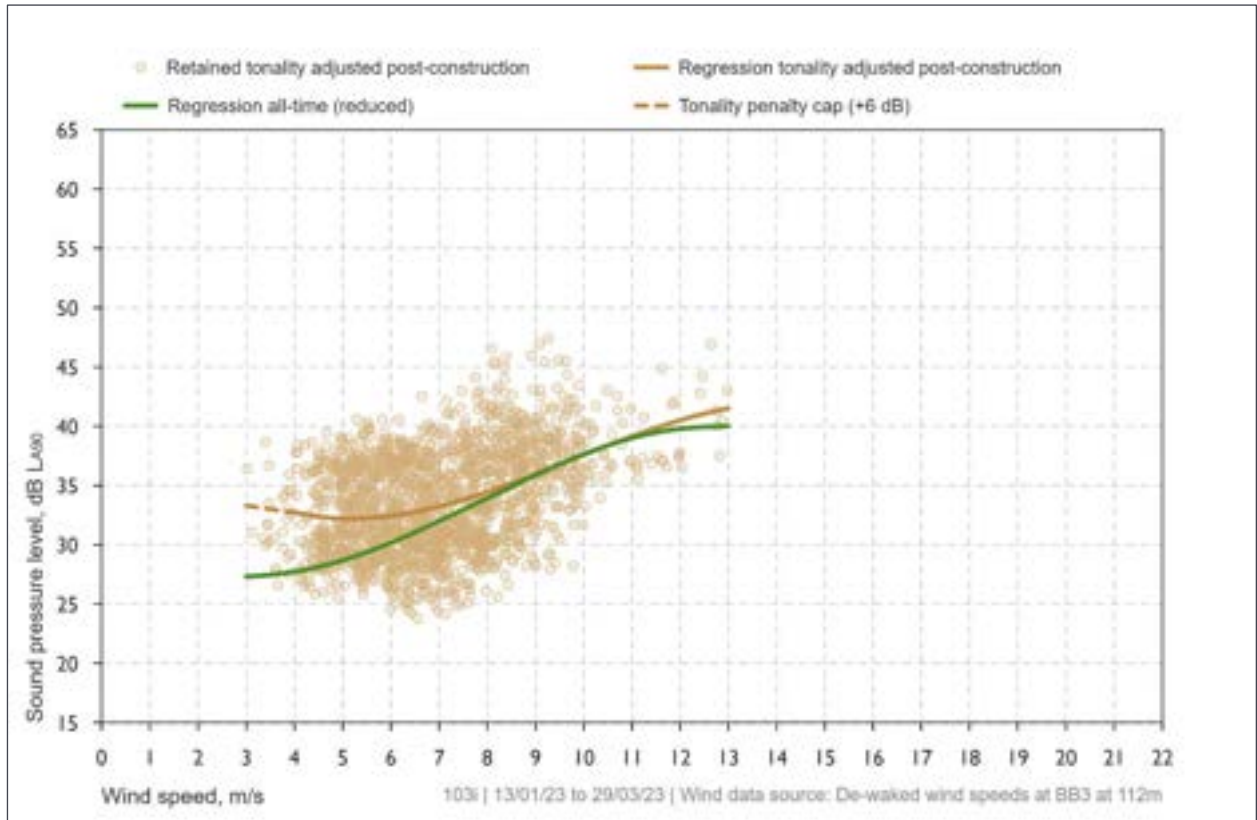


Table 178: Intermediate 83i tonality penalty calculation, dB LA90 – all-time (reduced)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	- ^[1]	32.7	32.2	32.4	33.2	34.5	36.0	37.6	39.1	40.5	41.5
Post-construction regression - no penalties	27.3	27.6	28.6	30.1	32.0	33.9	35.9	37.7	39.1	39.9	40.0
Penalty adjustment	6.0 ^[1]	5.1	3.6	2.3	1.2	0.6	0.1	0.0	0.0	0.6	1.5

1 Tonality penalty values are capped at a maximum penalty of 6.0 dB

Figure 183: Intermediate 103i – tonality adjusted post-construction noise levels versus site wind speed – night-time (2200 – 0500 hrs)

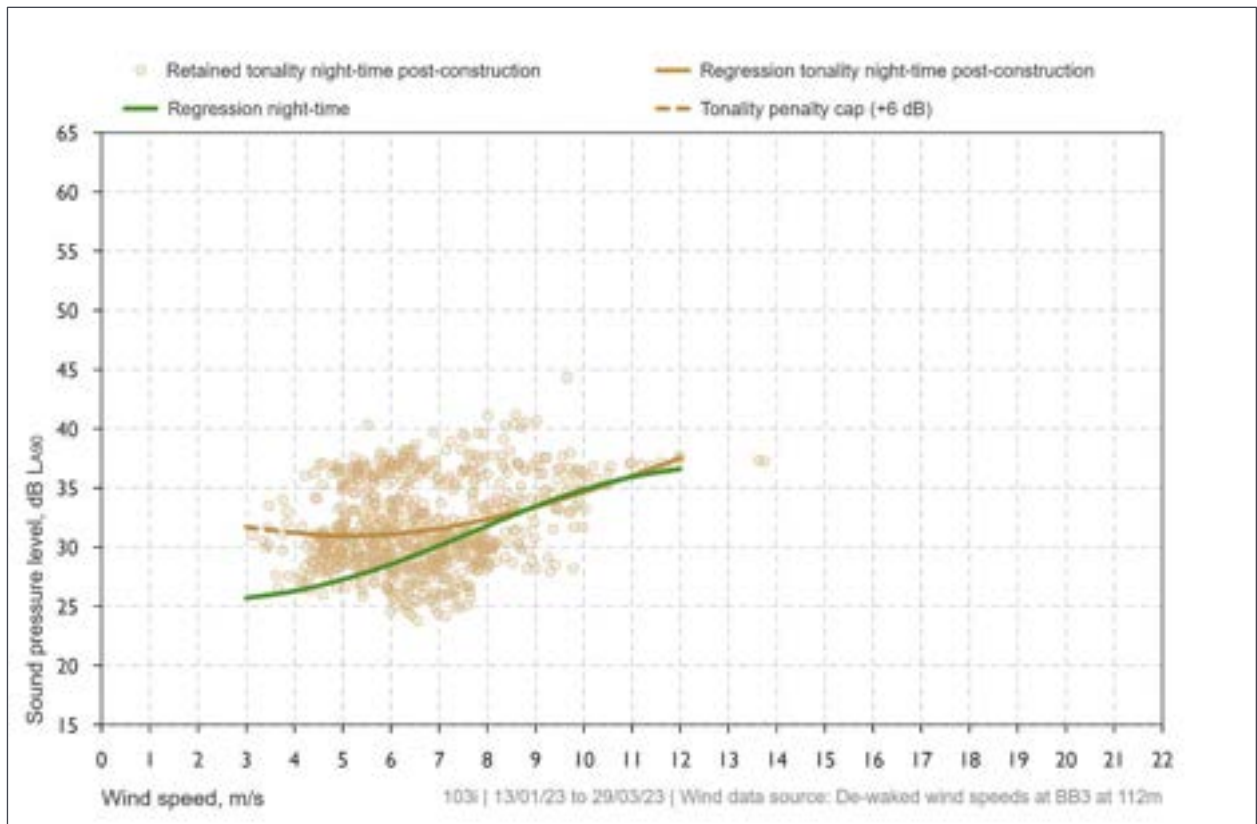


Table 179: Intermediate 73i – tonality penalty calculation, dB LA90 – night-time (2200 – 0500 hrs)

Item	Hub height wind speed, m/s										
	3	4	5	6	7	8	9	10	11	12	13
Post-construction regression - with penalties	31.9	31.2	31.0	31.1	31.6	32.4	33.4	34.6	36.0	37.5	- ^[1]
Post-construction regression - no penalties	25.7	26.2	27.2	28.5	30.1	31.8	33.5	34.9	36.0	36.6	- ^[1]
Penalty adjustment	6.0 ^[2]	5.0	3.8	2.6	1.5	0.6	0.0	0.0	0.0	0.9	- ^[1]

1 Outside valid wind speed range of the regression analysis

2 Tonality penalty values are capped at a maximum penalty of 6.0 dB

DD6 Receiver 103 compliance assessment

Refer to Section T6.

APPENDIX EE DOCUMENTATION

Update Section 8.3 of NZS 6808 specifies the information to be included in a compliance assessment report. The information requirements, and the report section(s) where the information has been provided, are detailed below.

Table 180: NZS 6808 reporting requirements for compliance assessments

Section 8.3 subclause	Reporting requirement	Report section
(a)	Description of the sound monitoring equipment including any ancillary equipment;	Section 4.2 and Appendix D
(b)	A statement confirming the use of A-frequency-weighting;	Section 4.2
(c)	The location of sound monitoring positions;	Section 4.1
(d)	Description of the anemometry equipment including the height AGL of the anemometer;	Section 4.2 and Appendix H
(e)	Position of wind speed measurements;	Appendix H
(f)	Make and model of the wind turbines;	Section 2.1
(g)	Number of operational wind turbines;	Section 2.2
(h)	Time and duration of monitoring period;	Section 4.2
(i)	Averaging period for both sound and wind speed measurements;	Section 4.2
(j)	Atmospheric conditions: the wind speed and direction at the wind farm position and rainfall shall be recorded;	Section 4.2 and Appendix H
(k)	Number of data pairs measured (wind speed in m/s, sound in L_{90});	Appendix J to Appendix DD
(l)	description of the regression analysis;	Section 4.3
(m)	Graphical plots showing the data scatter and the regression lines;	Appendix J to Appendix DD
(n)	Graphical plots showing the data scatter and the regression lines for both the background and the wind farm in operation;	Appendix I
(o)	Assessment of special audible characteristics; and	Section 5.2, Section 5.3, Appendix F and Appendix J to Appendix DD
(p)	A statement that the wind farm complies with relevant limits – or not – as determined from the results of the measurements.	Section 5.4