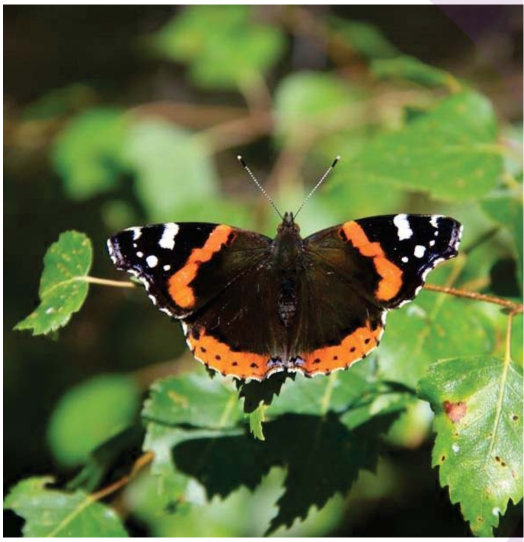
ICL Boulby

Boulby Mine Noise Monitoring

Report



Wood Group UK Limited – November 2021

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Document revisions

No.	Details	Date
1	Initial Draft	30/07/2021
2	First Issue	01/11/2021

Executive summary

This report has been produced for the purpose of investigating ambient noise levels in the region of Boulby Mine and to help determine whether the System 7 fan can resume evening and night-time operations, as ICL Boulby have generally halted this use after receiving noise complaints from local residents.

To inform the investigation, acoustic monitoring was undertaken at two noise sensitive receptors close to Boulby Mine to determine ambient noise levels. Subjective observations were undertaken during the deployments and collections of equipment, and regular audio recordings taken during the measurements. Investigations have been carried out over a period where Covid-19 precautions have limited safe access for surveyors to site, so the survey was carried out without simultaneous reference measurements on the site itself.

The measured data was processed and analysed, comparing the following elements to determine whether it was possible to objectively demonstrate whether there was, or was not, a noise issue clearly associated with the System 7 fan:

- wind direction;
- plant operating status;
- System 7 fan operating status; and
- damper position on System 7 fan.

No significant conclusions could be drawn on the effect of the above elements on ambient noise levels at either location as there was no clear correlation between the measured noise levels and the periods when the plant was operating. The results do however indicate that any noise issue is not so severe that it resulted in objectively identifiable noise outside the receptor properties during the survey. Conducting further measurements at both locations concurrently, along with an additional location on Site, could help to draw more informed conclusions. This is because changes on site would be visible from the onsite measurements, allowing this to be matched up with measurements undertaken at the receptors, to determine whether site activity has an effect on ambient noise levels at receptors.

wood.

Contents

1. Introduction

Boulby Mine is a mine located in Saltburn-by-the-Sea, with the first shaft sinking taking place in 1968, the first shaft production in 1973 and full production starting in 1976. The Site operates daily with different shift patterns, with some days consisting of full plant shutdown.

Concerns over potential noise impacts have been raised by residents living near the Site, particularly in relation to the System 7 fan and as a result the fan has usually been turned off at 6pm every day since 7th January 2021.

Noise monitoring was undertaken at two locations in close proximity to Boulby Mine between 15th April and 21st May 2021 to investigate whether the System 7 fan could be turned back on regularly during night-time periods to help with the extraction of dust.

To establish what is affecting noise levels at the noise sensitive receptors, analysis has been carried out on:

- wind direction;
- plant operating status;
- System 7 fan operating status; and
- damper positions within the System 7 ductwork.

2. Terminology

This section provides explanations and definitions for terms which may be used in this report.

2.1 The decibel scale, A-weighting & typical sound levels

The ratio between the quietest audible sound and the loudest tolerable sound is a million to one in terms of the change in sound pressure. Due to this wide range, a scale based on logarithms is used in noise level measurement. The scale used is the decibel (dB) scale which, in terms of human response to airborne sound, typically covers a range of 0 to 140 dB, corresponding to the intensity of the Sound Pressure Level (SPL).

The ear has the ability to recognise a particular sound depending on the pitch or frequencies found at the source. Microphones cannot differentiate noise in the same way as the ear; to counter this the noise measuring instrument can apply a correction to correspond more closely to the frequency response of the ear. The correction factor is called 'A-weighting' and the resulting measurements are written as dBA or dB(A). 'A-weighting' refers to the sound level that represents the human ear's response to sound. The frequency weighting may be included in the descriptor (see Section 2.2), in which case the unit is normally described by dB.

The dB(A) unit is internationally accepted and has been found to correspond well with people's subjective reaction to sound. Typical dB(A) sound levels for familiar sounds are given in **Table 2.1**.

Table 2.1 Typical sound levels[1]

Approximate noise level dB(A)	Example
0	Threshold of hearing for normal young people.
20	Recording studio, ambient level.
40	Quiet residential neighbourhood, ambient level.
60	Department store, restaurant, speech levels.
80	Next to busy highway, shouting.
100	Textile mill; press room with presses running; punch press and wood planers, at operators' position.
120	Ship's engine room, rock concert, in front and close to speakers.
140	Moon launch at 100m; artillery fire, gunner's position.

2.2 Sound power, sound level indices and other descriptors

The sound levels given in **Table 2.1** are sound pressure levels (L_p) and describe the sound level at a point in space. Sound power levels (L_w) are used to describe the sound output of a sound source. Sound levels vary over time depending on sound generating activities. The following indices are used to take account of these variations:

[1] Bies, D.A., Hansen, C.H., 2009. Engineering Noise Control: Theory & Practice. 4th Edition. Abingdon: Spon Press.

- $L_{Aeq,T}$ - the equivalent continuous sound level. This is the sound level of a steady sound having the same energy as a fluctuating sound over the same period. Ambient sound levels are described with this index. $L_{Aeq,T}$ is considered the best general-purpose index for environmental sound, as it is the index which generally best represents how sound levels are perceived;
- $L_{A90,T}$ - this noise index represents the sound level exceeded for 90% of the measurement period and is used to indicate quieter times during the measurement period. In BS 4142:2014+A1:2019[2] (BS 4142) assessments it is usually referred to as the background sound level, and describes the quietest 10% of a measurement period; and
- L_{Amax} - is the maximum recorded sound level during the measurement period.

In addition, the following descriptors are often used in noise assessments:

- **Ambient sound** is the totally encompassing sound in a given situation, at a given time, usually composed of sound from many sources near and far;
- **Residual sound** is defined in BS 4142 as the sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient sound. This is the case when a sound source/proposed development is yet to be installed and/or be operational. The residual sound level is the equivalent continuous A-weighted sound pressure level deemed to represent the residual sound ($L_r = L_{Aeq,T}$) at the assessment location over a given time interval *T*;
- **Specific sound level** is defined in BS 4142 as the equivalent continuous A-weighted sound pressure level produced by a specific sound source (i.e. the sound source under assessment in accordance with BS 4142) at the assessment location over a given reference time interval *T;*
- **Rating level** is defined in BS 4142 as the specific sound level with the addition and inclusion of any acoustic characteristic feature corrections of the sound. If no acoustic features are present, then the rating level is equal to the specific sound level;
- **Fast time weighting** is where a sound pressure level measurement using a 125 ms moving average time weighting period has been used;
- **Tonality** is an acoustic feature which represents the sound level of a source that has a dominant 'pitch' characteristic similar to a sine wave or musical note. Sounds with a perceptible tone are more easily noticeable and should therefore carry a character correction where deemed appropriate under the guidance in BS 4142;
- **Impulsivity** is an acoustic feature where the sound level of a source is highly variable over time. Humans are more sensitive to impulsive sound when compared to a continuous sound of the same sound pressure level. Therefore, an acoustic character feature correction can be applied when deemed appropriate under the guidance in BS 4142.
- **Intermittency** is an acoustic feature considered in BS 4142. Humans are more sensitive to sounds that are intermittent in nature when compared to a continuous sound of the same specific sound level. Therefore, a correction can be applied for the presence of such a characteristic.
- **Free field** signifies that a sound measurement has been undertaken in 'free field' conditions i.e. away from any reflecting facades, other than the ground, e.g. building facades, close boarded fence work etc.; and

[2] British Standards Institute (2019). *BS4142 + A1:2019 Methods for rating and assessing industrial and commercial sound*. BSI: London.

- **Façade level:** A standard correction of +3 dB may be added to a free field sound level to estimate the sound level 1 m away from a façade, to account for both the sound upon the façade and the reflected sound from the façade. When considering the break in of external sound into a room, the sound level which is incident upon the façade, rather than the façade level, is considered because only the incident sound will pass through the fabric of the building, whilst reflected sound travels away from the building. The standard +3 dB façade correction is most applicable in situations where the façade has a relatively unobstructed angle of view of the source (i.e. an uninterrupted 180° angle of view of the source in the horizontal plane).

3. Methodology and approach

Wood completed sound monitoring at two different locations, Location 1 between 15th and 25th April 2021 and Location 2 between 6th and 21st May 2021. The purpose of the survey was to quantify the acoustic environment at the two locations during different time periods to assess various factors and determine if it is possible to reinstate the running of the System 7 fan during the evening and night-time periods.

The survey methodology is summarised as follows:

- continuous long term sound level monitoring was undertaken over a period of 10 days (Location 1) and 16 days (Location 2). Monitoring locations are presented in **Figure 3.1** and described in **Table 3.1**;
- the sound level meters (SLMs) used for the surveys were calibrated before each measurement along with a post-monitoring level check with no significant drift in calibration recorded. Windshields were fitted to the microphones to minimise the effects of any wind induced sound; and
- details of the monitoring instrumentation (model / serial numbers etc.) are presented in **Appendix A**. All measurements were conducted, where possible, in accordance with BS 7445-1:2003 *Description and measurement of environmental noise Part 1: Guide to quantities and procedures*[3].

BS 7445-1:2003 details standardised guidance for the measurement of environmental noise. The pertinent details of BS 7445-1:2003 adopted here are as follows:

- instrumentation to measure equivalent A-weighted sound pressure level conforming to type 1 as given in BS EN 61672-1:2013 *Electroacoustics – Sound level meters Part 1: Specifications*[4];
- all equipment calibrated, and the calibration shall follow the manufacturer's instructions. All Wood sound monitoring equipment is calibrated at an accredited laboratory at a minimum interval of 24 months. To maintain confidence in recorded sound levels, sound level meters were field calibrated prior to and after use with the recommended manufacturer's calibrator. No significant drift (i.e. greater than 0.1 dB) in calibration was recorded; and
- minimise the influence of reflections by, whenever possible, undertaking measurements at least 3.5m from any reflective surface other than the ground. The preferred measurement height is 1.2 – 1.5m above the ground.

The surveyor conducting the work was fully competent, being a Member of the Institute of Acoustics and holding the Institute of Acoustics Certificate of Competence in Environmental Noise Measurement.

At the request of the resident, the monitoring position at Location 2 was altered slightly during the survey, on 18/05/2021 between 10:45 – 11:00, and remained in the re-located position for the remainder of the survey.

[3] British Standard Institution (2003). *BS 7445-1:2003 Description and measurement of environmental noise Part 1: Guide to quantities and procedures*. BSI, London.
[4] British Standard Institution (2013). *BS EN 61672-1:2013 Electroacoustics – Sound level meters Part 1: Specifications*. BSI, London.

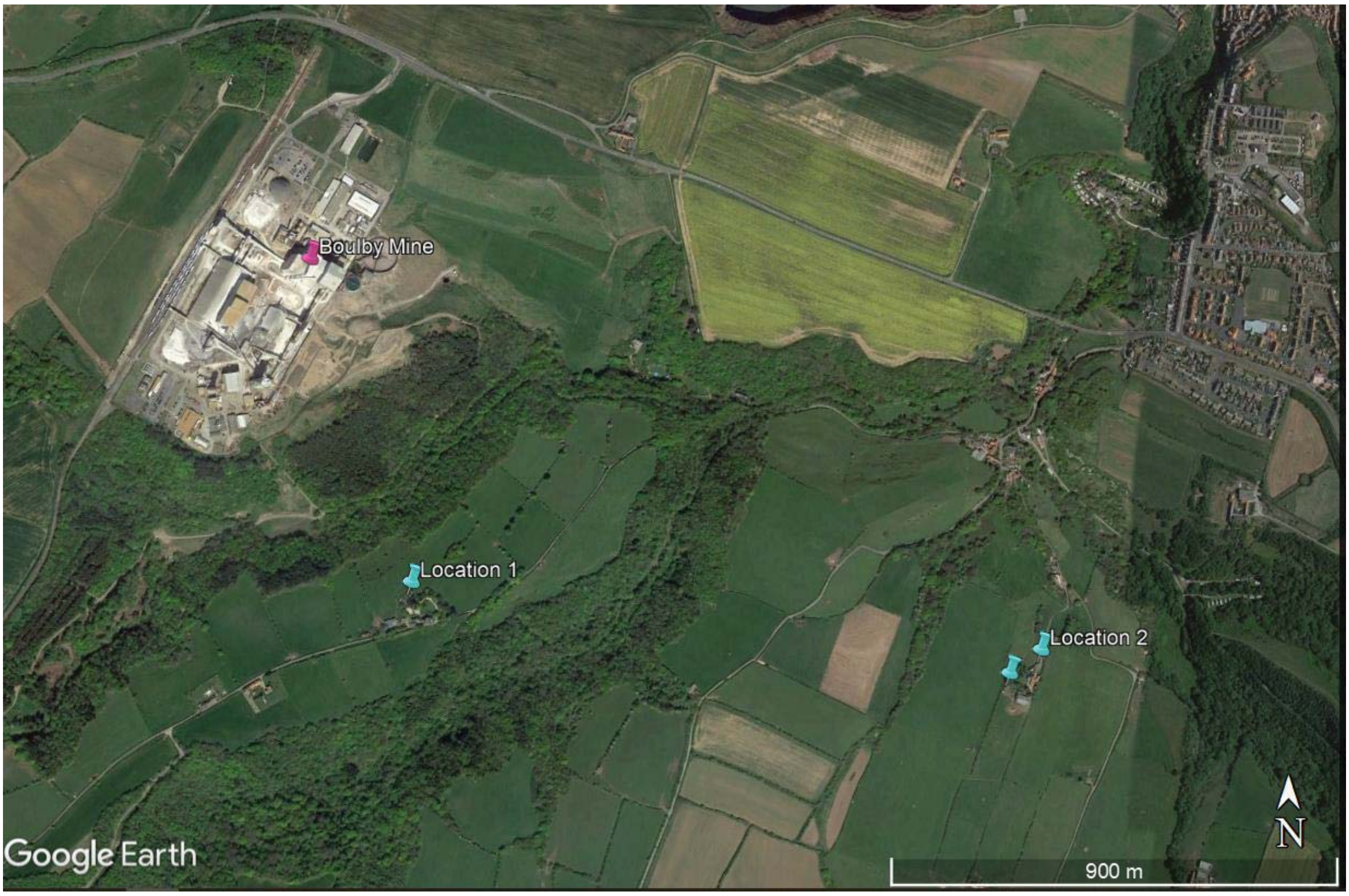
Table 3.1 Sound monitoring locations

Position reference	Description	British Grid Reference (Northing, Easting)
Location 1 (Ridge Hall Cottages)	Located to the southeast of the Site on Ridge Lane	476434, 517588
Location 2 (Cooper House)	Located to the southeast of the Site off Borrowby Lane	477649, 517428 477708, 517479

Meteorological conditions

A data logging weather station was located with the sound level meter at Location 1 and Location 2 for the duration of the survey. Unfortunately, due to an equipment failure, meteorological data for Location 1 had to be taken from other nearby weather stations. Further details on the meteorological data collected and used for the analysis are given in **Section 4.1**.

Figure 3.1 Sound monitoring locations



4. Analysis

Noise levels vary over time depending on sound generating activities, such as road traffic passing by, aircraft flying overhead, a person talking nearby or someone undertaking works such as drilling or sawing. As stated in **Section 2.2**, there are a number of indices used to take account for these variations.

$L_{Aeq,T}$ is considered the ambient noise level, capturing the equivalent continuous sound level. This is easily influenced by short term noise events, such as talking, shouting, drilling and aircraft passing by.

$L_{A90,T}$ represents the sound level exceeded for 90% of the time and is often referred to as the background sound level. As plant noise is usually continuous, $L_{90,T}$ levels are more likely to be influenced by plant noise than short term noise events.

In general, both $L_{Aeq,T}$ and $L_{A90,T}$ levels will be higher during the daytime, as typically traffic flows on the road and rail networks will be higher and construction activities are undertaken.

It can be seen in **Figure 4.1** and **Figure 4.2** that the noise levels at both locations follow this pattern of higher daytime levels and lower night-time levels and much larger variations in $L_{Aeq,T}$ compared to $L_{A90,T}$ levels. At Location 2, there are a few instances of high $L_{A90,T}$ levels, particularly on 13th May 2021 and 16th May 2021. As Location 2 is a working farm, the noise increases seen here are due to activities at the Location, rather than influenced by activities at Boulby Mine.

When plant noise is a dominant contributor to the sound environment, $L_{A90,T}$ levels will show as a steady constant level. **Figure 4.1** and **Figure 4.2** show the diurnal change described above, suggesting that plant noise is not a dominant contributor to the sound environment at either location.

Mitigation work has been carried out on the System 7 fan, which has historically been the subject of complaints regarding tonal noise. The tone has been identified as lying within the one-third octave band centred on 100 Hz.

To establish what is affecting noise levels at the noise sensitive receptors, analysis has been carried out on:

- wind direction;
- plant on / off states; and
- damper positions within the System 7 ductwork.

The results of this analysis are reported in the following sections.

Figure 4.1 Location 1 – $L_{Aeq,T}$ and $L_{A90,T}$ broadband levels

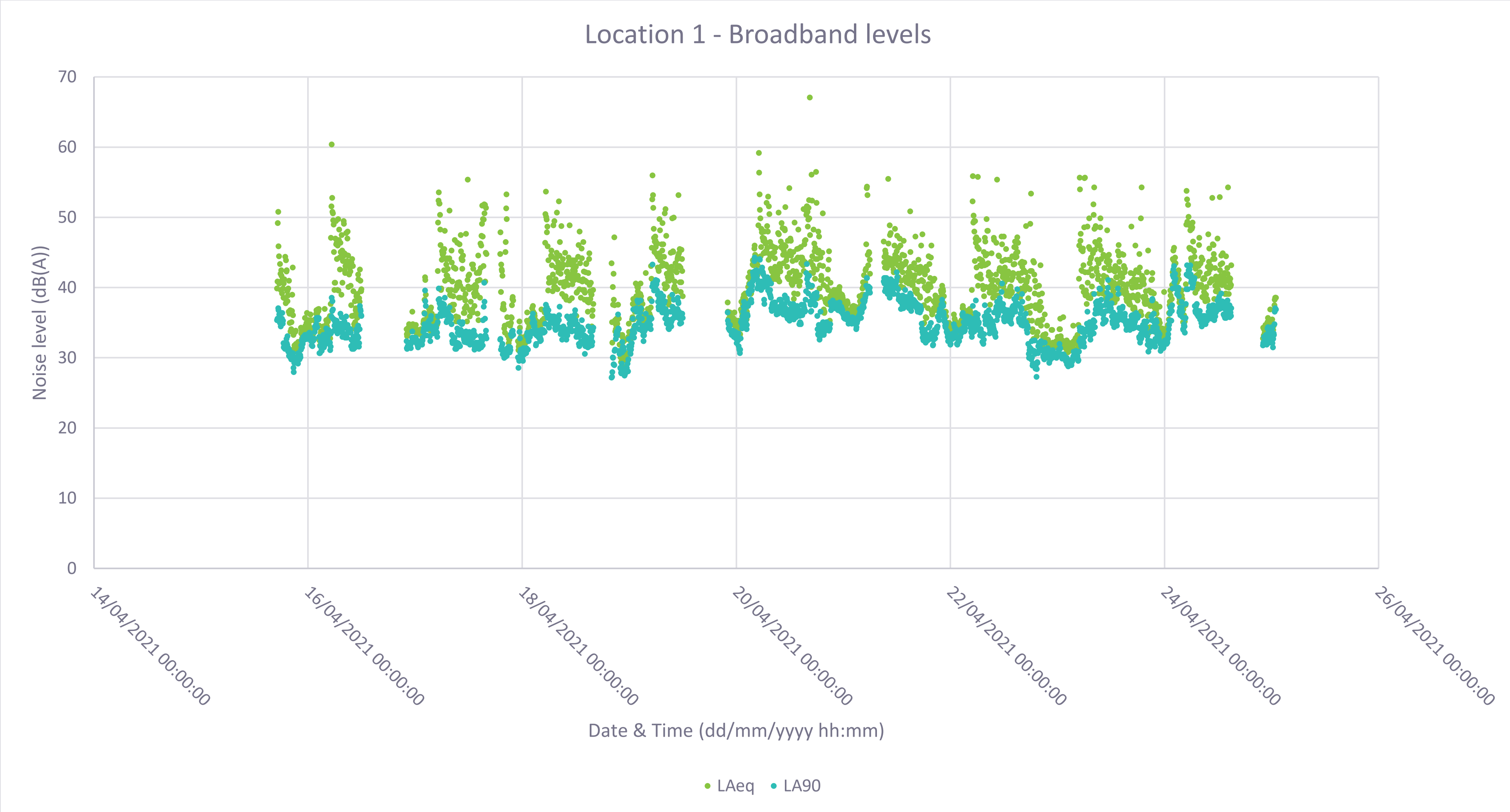
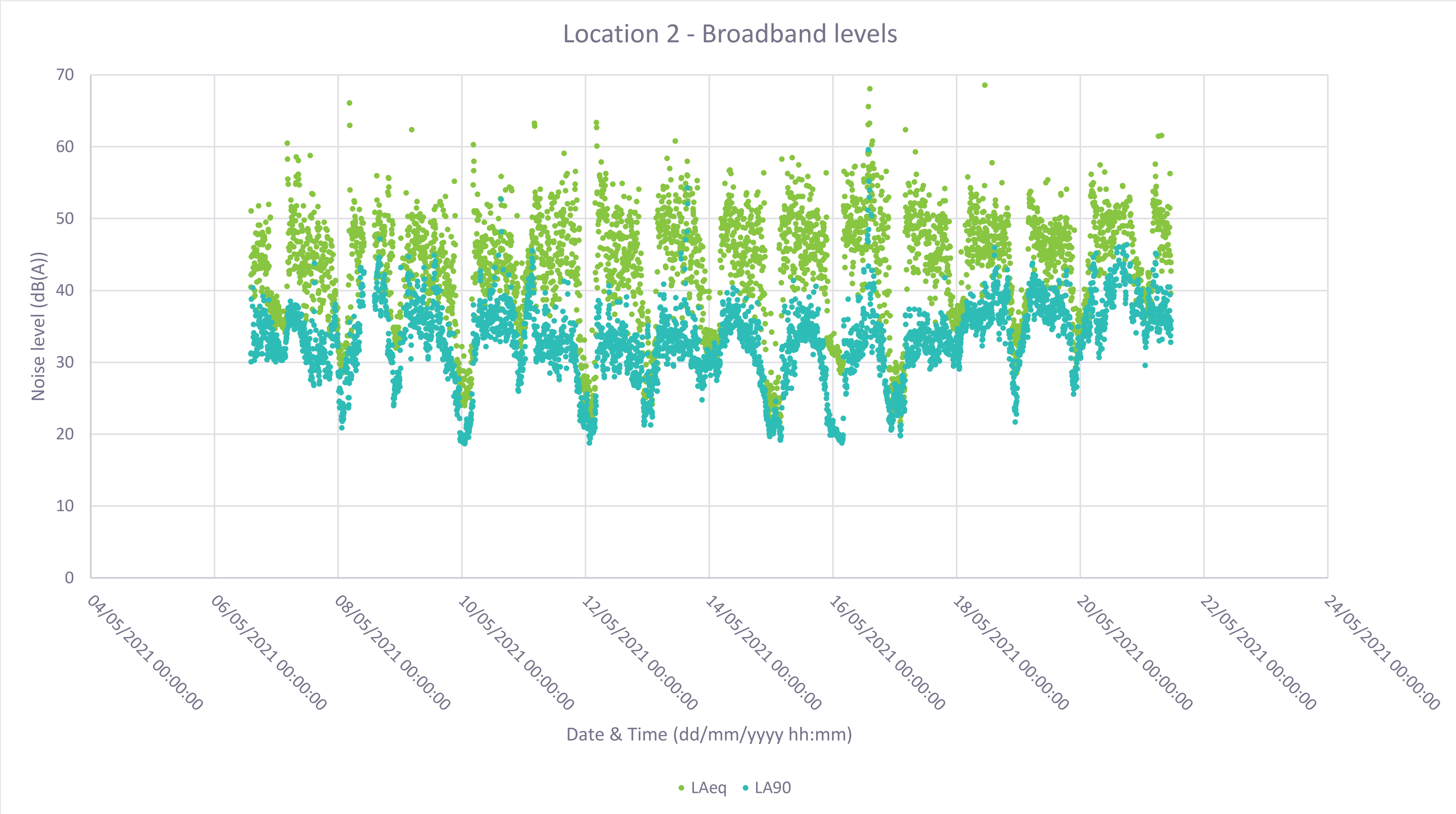


Figure 4.2 Location 2 – $L_{Aeq,T}$ and $L_{A90,T}$ broadband levels



4.1 Meteorological conditions

Location 1

Due to an equipment failure at Location 1, weather data has been taken from nearby weather stations[5]. Wind speed data was taken from the Loftus Samos weather station, approximately 4km from the site, with the highest wind speed recorded of 6.7 m/s. Wind speeds above 5 m/s occurred in 22 of 168 data samples used, or 13.1% of the time. Wind direction data was taken from the Durham Tees Valley Airport weather station, approximately 40km from the site. Whilst this can give an indication of what the wind direction conditions were at the site, given the coastal location of the site, this will not be entirely accurate.

Location 1 is located approximately 700 m from the mine in a south / south-easterly direction. Of the 238 data samples used, the wind direction was SE or SSE for 20 of them, or 8.4% of the time. Unfortunately, due to the nature of the data gathered, there are several gaps in the dataset, and this should only be used as an indication of conditions in the area.

No rain was recorded during the noise monitoring at Location 1. Due to the unreliability of noise measurements in high winds, periods where wind speeds were above 5 m/s have not been included this analysis.

Figure 4.3 displays the wind speed and wind direction for Location 1, with the dashed lines representing the direction of Location 1 in relation to the mine (southeast – south southeast).

Figure 4.1 displays the A-weighted $L_{Aeq,T}$ and $L_{A90,T}$ levels recorded throughout the measurement period. As mentioned earlier, it shows a typical pattern of higher noise levels in the daytime and quieter levels during the night-time periods.

Figure 4.4 and **Figure 4.5** display the one-third octave band $L_{eq,T}$ and $L_{90,T}$ levels for the 80 Hz, 100 Hz and 125 Hz octave bands. From the graphs, there is no obvious display of dominance in the 100 Hz one-third octave band which had previously been identified as a tonal one-third octave band at Location 1.

Table 4.1 below shows the noise levels for different time periods (daytime, evening, and night-time), comparing levels where the wind was in a southeast / south south-easterly direction to all other wind directions.

Table 4.1 Noise levels for different time periods

Time period	Southeast / south southeast		Other wind directions		Specific wind direction $L_{Aeq,T}$ – other wind directions $L_{Aeq,T}$	Specific wind direction $L_{A90,T}$ – other wind directions $L_{A90,T}$
	$L_{Aeq,T}$	$L_{A90,T}$	$L_{Aeq,T}$	$L_{A90,T}$		
Monday – Friday 07:00 – 19:00	42	36	46	37	-4	-1
Monday – Friday 19:00 – 23:00	37	32	39	34	-2	-2
Monday – Friday 23:00 – 07:00	-	-	44	36	N/A	N/A
Saturday 07:00 – 13:00	-	-	43	35	N/A	N/A

[5] Loftus Samos weather station, source: https://www.weatherhq.co.uk/weather-station/loftus-samos and Durham Tees Valley Airport Station, source: https://www.wunderground.com/history/daily/gb/darlington/EGNV/date/2021-4-25

Time period	Southeast / south southeast		Other wind directions		Specific wind direction $L_{Aeq,T}$ – other wind directions $L_{Aeq,T}$	Specific wind direction $L_{A90,T}$ – other wind directions $L_{A90,T}$
	$L_{Aeq,T}$	$L_{A90,T}$	$L_{Aeq,T}$	$L_{A90,T}$		
Saturday 13:00 – 23:00	-	-	44	34	N/A	N/A
Saturday 23:00 – 07:00 (Saturday into Sunday morning)	-	-	41	34	N/A	N/A
Sunday 07:00 – 23:00	-	-	42	34	N/A	N/A
Sunday 23:00 – 07:00 (Sunday into Monday morning)	-	-	43	37	N/A	N/A

Due to the wind conditions during the survey, a direct comparison can only be made for Monday – Friday between 07:00 – 19:00 and 19:00 – 23:00. As can be seen, the noise levels are louder in other wind directions, however the wind direction was only southeast / south southeast for 78 data points compared to 2154 data points for all other wind directions. More data points, along with more reliable data, may be required to be able to draw any specific conclusions on whether wind direction affects the noise level at Location 1.

Location 2

Location 2 is located approximately 1.6 km from the mine in a south-easterly direction. Of the 2169 10-minute data samples collected, the wind direction was ESE, SE or SSE for 102 of them, or 4.7% of the time. The highest wind speed recorded in this direction at this location was 1.8 m/s.

Rain was recorded during 116 of the 2169 10-minute data samples collected. Noise levels recorded during these periods have been excluded from the analysis. There were no wind speeds recorded above 5 m/s, therefore no data has been excluded due to high winds.

Figure 4.6 displays the wind speed and wind direction for Location 2, with the dashed lines representing the direction of Location 2 in relation to the mine (east southeast - southeast – south southeast).

Figure 4.2 displays the A-weighted $L_{Aeq,T}$ and $L_{A90,T}$ levels recorded throughout the measurement period. As mentioned earlier, it shows a typical pattern of higher noise levels in the daytime and quieter levels during the night-time periods, with a few instances of higher $L_{Aeq,T}$ and $L_{A90,T}$ levels. Upon analysis, it is understood that the outliers are due to farming activities at Location 2.

Figure 4.7 and **Figure 4.8** display the one-third octave band $L_{eq,T}$ and $L_{90,T}$ levels for the 80 Hz, 100 Hz and 125 Hz octave bands. From the graphs, there is no obvious display of dominance in the 100 Hz one-third octave band at Location 2.

Table 4.2 below shows the noise levels for different time periods (daytime, evening, and night-time), comparing levels where the wind was in an east southeast / southeast / south south-easterly direction to all other wind directions.

Table 4.2 Noise levels for different time periods

Time Period	East southeast / southeast / south south east		Other wind directions		Specific wind direction $L_{Aeq,T}$ – other wind directions $L_{Aeq,T}$	Specific wind direction $L_{A90,T}$ – other wind directions $L_{A90,T}$
	$L_{Aeq,T}$	$L_{A90,T}$	$L_{Aeq,T}$	$L_{A90,T}$		
Monday – Friday 07:00 – 19:00	49	36	49	37	0	-1
Monday – Friday 19:00 – 23:00	46	35	45	33	1	2
Monday – Friday 23:00 – 07:00	50	37	48	35	2	2
Saturday 07:00 – 13:00	49	33	50	37	-1	-4
Saturday 13:00 – 23:00	51	27	48	37	3	-10
Saturday 23:00 – 07:00 (Saturday into Sunday morning)	44	26	48	35	-4	-9
Sunday 07:00 – 23:00	47	29	51	40	-4	-11
Sunday 23:00 – 07:00 (Sunday into Monday morning)	44	26	47	30	-3	-4

It can be seen from **Table 4.2** that on weekdays between 07:00 – 19:00 the noise levels were approximately the same, regardless of wind direction. Between 19:00 – 23:00 and 23:00 – 07:00 on weekdays, it is noted that the noise levels were marginally louder in the east southeast / southeast / south southeast directions compared to other wind directions, and also experienced higher $L_{Aeq,T}$ levels during the 13:00 – 23:00 period on Saturdays. For the remainder of time periods, the noise levels were lower in the east southeast / southeast / south southeast directions compared to other wind directions. It is also important to note that at weekends $L_{A90,T}$ levels are shown to be around 10 dB quieter, which is considered a significant difference.

However, as mentioned above, the wind direction was only east southeast / southeast / south southeast for approximately 5% of the time, therefore the results may be more reliable for the other wind directions, due to the greater number of datapoints available.

As the noise levels are both lower and higher for different time periods in the east southeast / southeast / south southeast wind directions, no significant conclusions can be drawn on the effects of wind direction on noise levels at Location 2.

Figure 4.3 Location 1 – Wind direction and speed

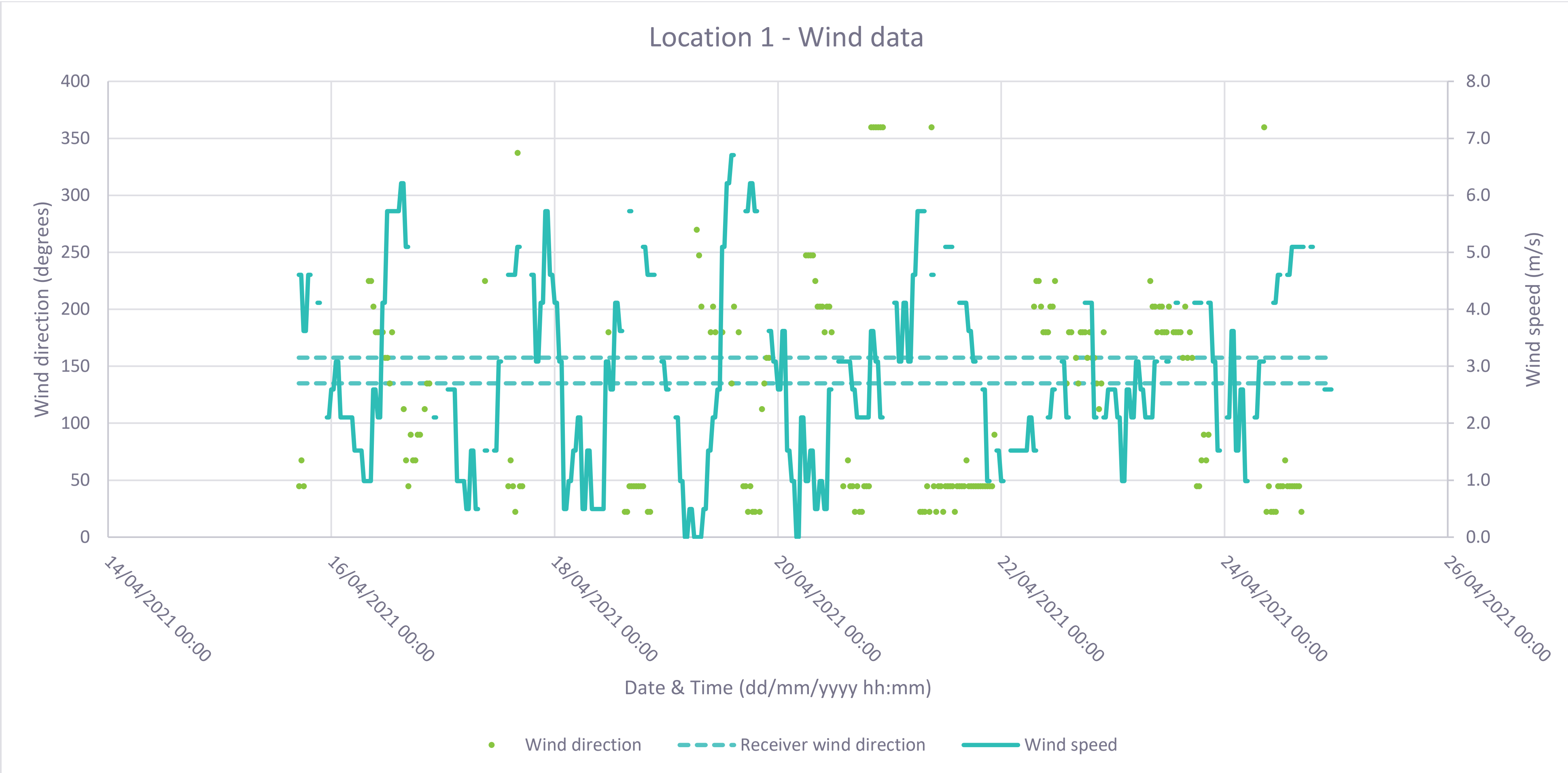


Figure 4.4 Location 1 – $L_{eq,T}$ 80 Hz, 100 Hz and 125 Hz octave band levels

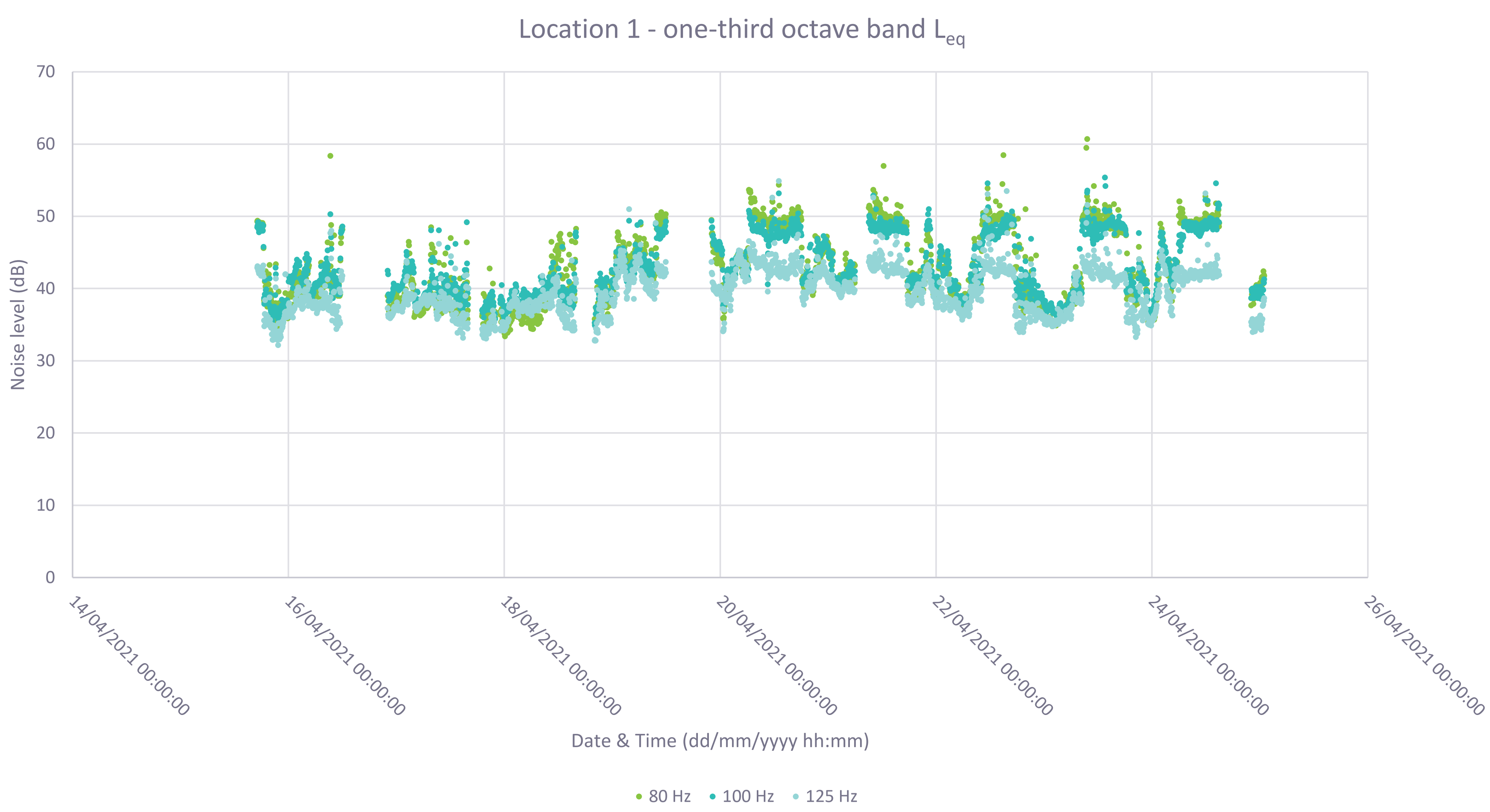


Figure 4.5 Location 1 – $L_{90,T}$ 80 Hz, 100 Hz and 125 Hz one-third octave band levels

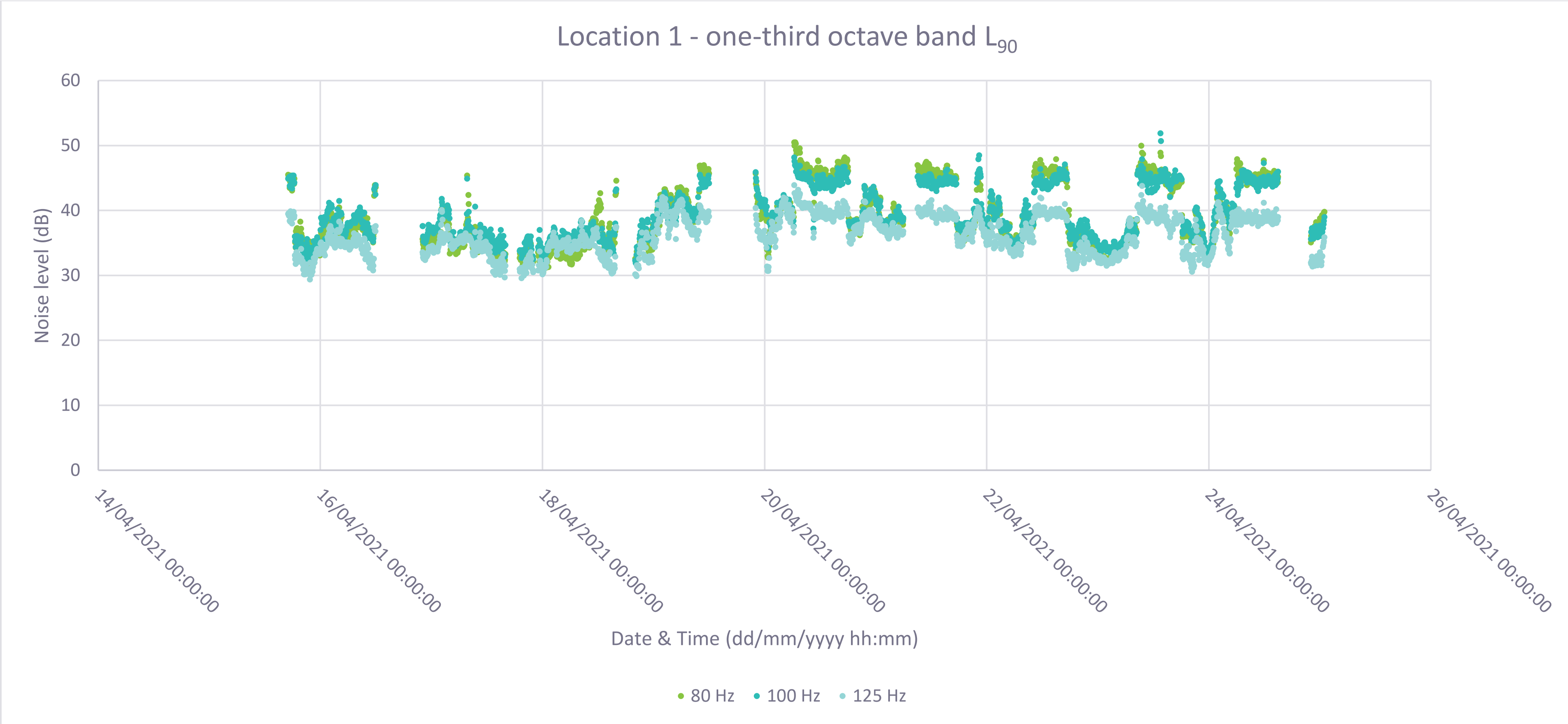


Figure 4.6 Location 2 – Wind direction and speed

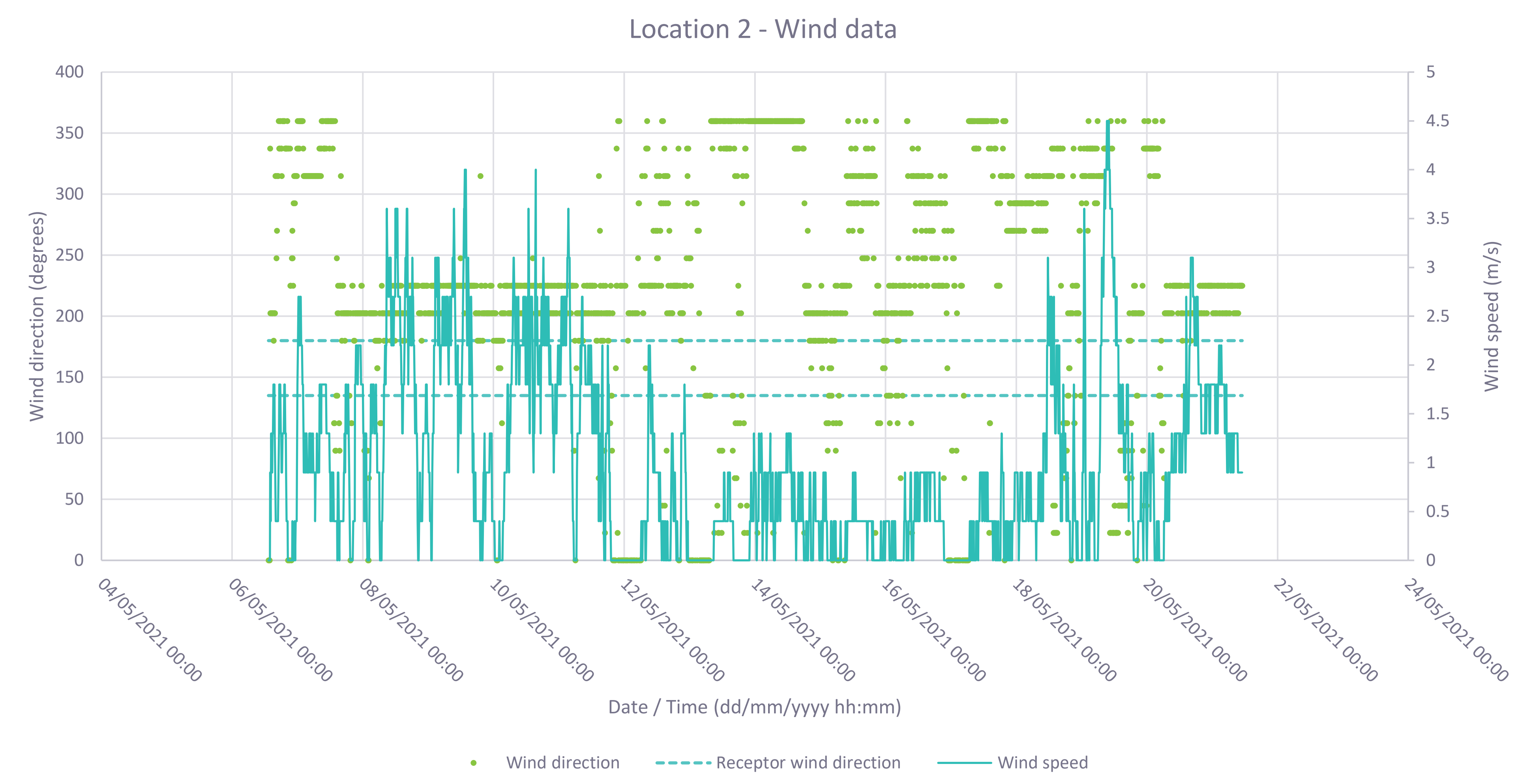


Figure 4.7 Location 2 – $L_{eq,T}$ 80 Hz, 100 Hz and 125 Hz one-third octave band levels

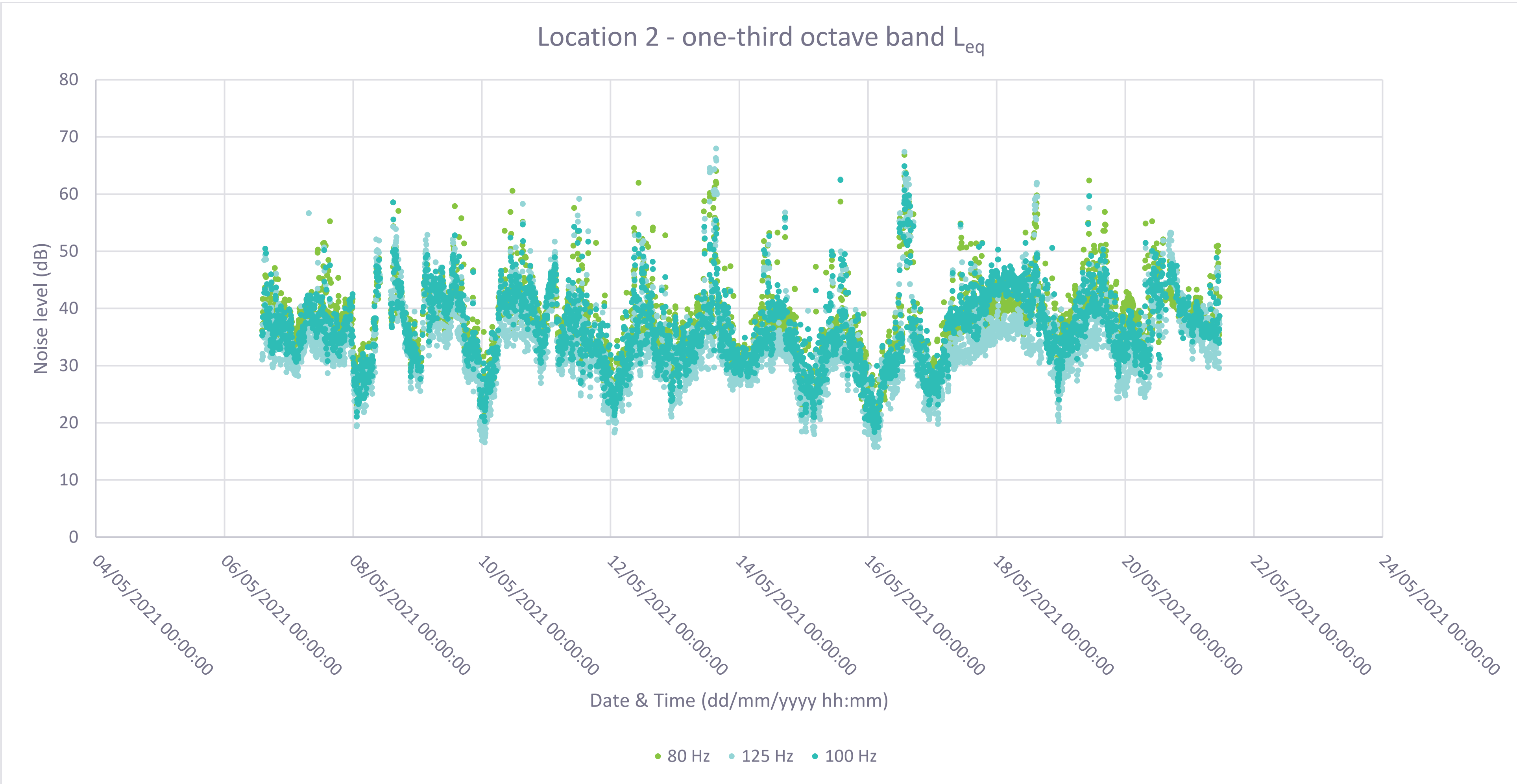
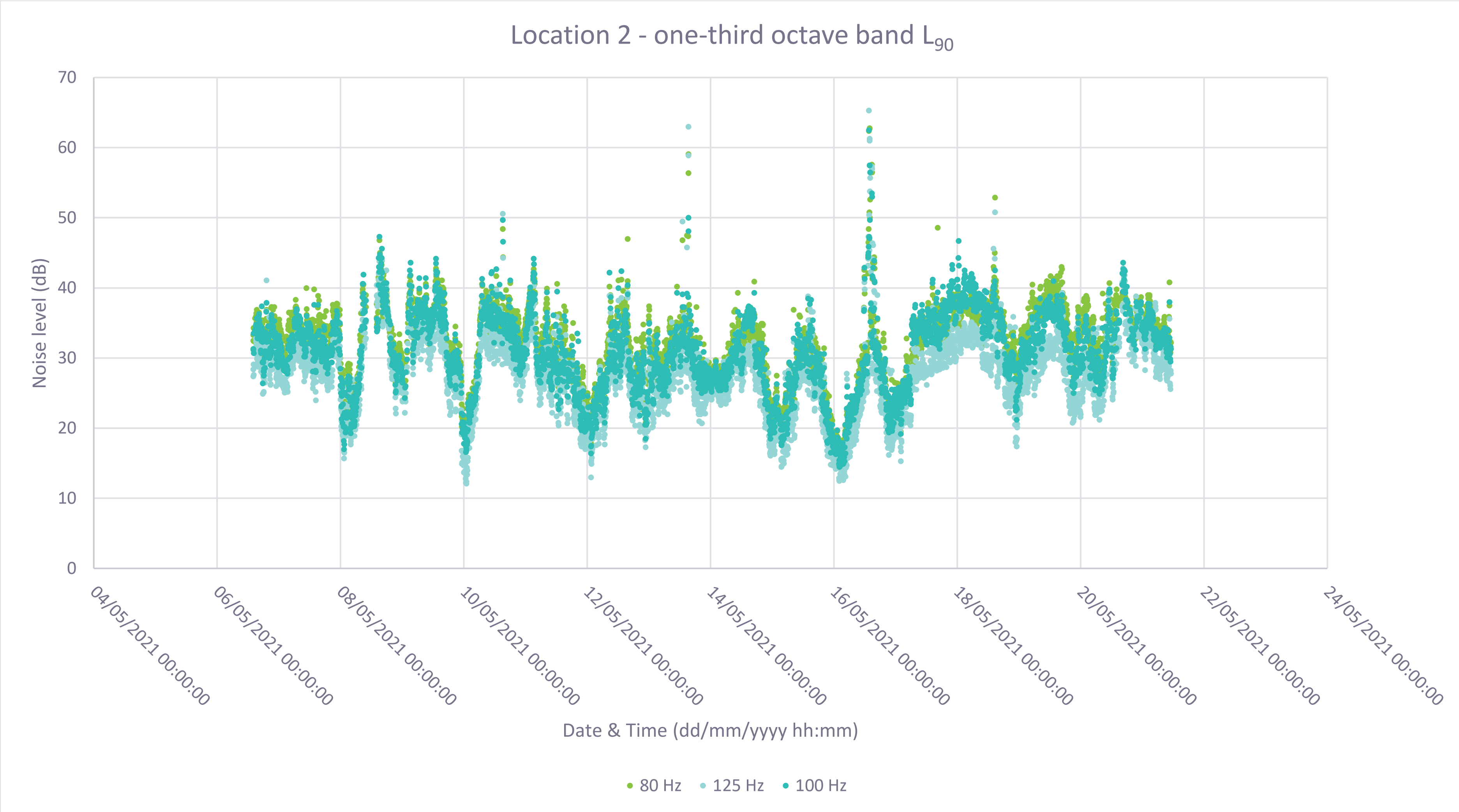


Figure 4.8 Location 2 – $L_{90,T}$ 80 Hz, 100 Hz and 125 Hz one-third octave band levels



4.2 Plant operating status

During the course of the noise measurements, plant at the mine was switched on and off at various intervals. The schedule can be seen below in **Table 4.3**.

Table 4.3 Plant on/off schedule

Date	Time	Plant status
15/04/2021	Start of measurement at location 1	Off
16/04/2021	14:00	On
16/04/2021	18:00	Off
18/04/2021	20:00	On
19/04/2021	04:00	Off
19/04/2021	12:00	On
19/04/2021	18:00	Off
20/04/2021	08:00	On
21/04/2021	12:00	Off
21/04/2021	16:00	On
22/04/2021	04:00	Off
22/04/2021	06:00	On
22/04/2021	15:00	Off
22/04/2021	18:00	On
23/04/2021	04:00	Off
24/04/2021	00:00	On
25/04/2021	04:00	Off
06/05/2021	Start of measurement at location 2	Off
06/05/2021	18:00	On
07/05/2021	04:00	Off
07/05/2021	06:00	On
07/05/2021	07:00	Off
07/05/2021	18:00	On
07/05/2021	22:00	Off
08/05/2021	02:00	On

Date	Time	Plant status
08/05/2021	03:00	Off
08/05/2021	06:00	On
08/05/2021	12:00	Off
08/05/2021	14:00	On
09/05/2021	04:00	Off
09/05/2021	08:00	On
10/05/2021	02:00	Off
13/05/2021	22:00	On
15/05/2021	14:00	Off
16/05/2021	10:00	On
16/05/2021	22:00	Off
17/05/2021	06:00	On
18/05/2021	00:00	Off
18/05/2021	06:00	On
18/05/2021	12:00	Off
18/05/2021	16:00	On
19/05/2021	12:00	Off
19/05/2021	16:00	On
19/05/2021	20:00	Off
20/05/2021	00:00	On
20/05/2021	04:00	Off
20/05/2021	06:00	On
20/05/2021	20:00	Off
21/05/2021	00:00	On
21/05/2021	02:00	Off
21/05/2021	06:00	On
21/05/2021	08:00	Off

Noise levels during various time periods have been compared for when the plant was on versus when the plant was off. The results of the analysis are discussed below.

Location 1

Figure 4.9 shows the measured $L_{Aeq,T}$ and $L_{A90,T}$ levels along with a series of vertical lines showing when the plant was switched on and off. In general, it is shown that similar noise levels are measured when the plant is off compared to when the plant is on. There is no period where the $L_{A90,T}$ remains steady within the 'plant on' period as would be expected if industrial noise was the dominant source.

Table 4.4 below shows the noise levels of different time periods (daytime, evening, and night-time), comparing when the plant was on and when the plant was off.

Table 4.4 Noise levels for different time periods

Time period	Plant on		Plant off		Plant on $L_{Aeq,T}$ – plant off $L_{Aeq,T}$	Plant on $L_{A90,T}$ – plant off $L_{A90,T}$
	$L_{Aeq,T}$	$L_{A90,T}$	$L_{Aeq,T}$	$L_{A90,T}$		
Monday – Friday 07:00 – 19:00	47	38	44	36	3	2
Monday – Friday 19:00 – 23:00	39	35	37	33	2	2
Monday – Friday 23:00 – 07:00	42	37	45	36	-3	1
Saturday 07:00 – 13:00	44	37	43	34	1	3
Saturday 13:00 – 23:00	42	36	45	33	-3	3
Saturday 23:00 – 07:00 (Saturday into Sunday morning)	36	34	41	34	-5	0
Sunday 07:00 – 23:00	37	31	43	34	-6	-3
Sunday 23:00 – 07:00 (Sunday into Monday morning)	37	34	47	39	-10	-5

Instances where $L_{Aeq,T}$ noise levels are louder when the plant is on (Monday – Fridays 07:00 – 19:00 and 19:00 – 23:00, along with Saturdays 07:00 – 13:00) see a difference of 3, 2 and 1 dB respectively, whilst instances where the noise levels are quieter when the plant is on have differences of between 3 and 10 dB, depending on the time period. This data suggests that other factors may have a bigger influence on the ambient noise levels at Location 1.

Looking at $L_{A90,T}$ levels, instances where the plant is on tend to have higher $L_{A90,T}$ noise levels, with the exception of Sundays (both daytime and night-time). The difference in levels (between 1 – 3 dB louder) are considered small, but perceptible. This data could suggest that the plant operating status does affect background noise levels at Location 1, however, as the $L_{A90,T}$ levels are both higher and lower when the plant was operating for different time periods, no significant conclusions can be drawn on the effect of plant operating status on noise levels at Location 1.

Location 2

Figure 4.10 shows the measured $L_{Aeq,T}$ and $L_{A90,T}$ levels along with a series of vertical lines showing when the plant was switched on and off. In general, it is shown that similar noise levels are measured regardless of whether the plant is off or on. There is no period where the $L_{A90,T}$ remains steady within the 'plant on' period as would be expected if industrial noise was the dominant source.

Table 4.5 below shows the noise levels of different time periods (daytime, evening, and night-time), comparing when the plant was on and when the plant was off.

Table 4.5 Noise levels for different time periods

Time period	Plant on		Plant off		Plant on $L_{Aeq,T}$ – plant off $L_{Aeq,T}$	Plant on $L_{A90,T}$ – plant off $L_{A90,T}$
	$L_{Aeq,T}$	$L_{A90,T}$	$L_{Aeq,T}$	$L_{A90,T}$		
Monday – Friday 07:00 – 19:00	50	37	48	37	2	0
Monday – Friday 19:00 – 23:00	45	34	44	33	1	1
Monday – Friday 23:00 – 07:00	46	34	49	36	-3	-2
Saturday 07:00 – 13:00	50	36	-	-	N/A	N/A
Saturday 13:00 – 23:00	48	38	48	33	0	5
Saturday 23:00 – 07:00 (Saturday into Sunday morning)	45	38	48	33	-3	5
Sunday 07:00 – 23:00	51	41	50	33	1	8
Sunday 23:00 – 07:00 (Sunday into Monday morning)	44	27	48	31	-4	-4

Similar to Location 1, instances where $L_{Aeq,T}$ noise levels are louder when the plant is on (Monday – Friday 07:00 – 19:00 and 19:00 – 23:00, along with Sundays 07:00 – 23:00) see small differences (2, 1 and 1 dB respectively), whereas instances where the $L_{Aeq,T}$ noise levels are quieter when the plant is on experience differences of 3 to 4 dB, depending on the time period, with similar $L_{Aeq,T}$ noise levels experienced on Saturdays 13:00 – 23:00. This data suggests that other factors may have a bigger influence on the ambient noise levels at Location 2.

Looking at $L_{A90,T}$ levels, instances where the plant is on tend to have higher $L_{A90,T}$ noise levels, with the exception of weekday evenings and Sunday nights where the differences are similar to the $L_{Aeq,T}$ levels. Sunday daytime shows a much higher background noise level when the plant was on, however upon further analysis Sunday 16th May included farming activities, likely being the cause of the high $L_{A90,T}$ levels causing such a big difference. When the period 13:10 – 14:15 is removed from the analysis (when farming activities were taking place), the change drops to 3 dB louder. This data could suggest that the plant operating status does affect background noise levels at Location 2, however, as the $L_{A90,T}$ levels are both higher and lower when the plant was operating for different time periods, no significant conclusions can be drawn on the effect of plant operating status on noise levels at Location 2.

It can be seen from **Figure 4.4**, **Figure 4.5**, **Figure 4.7** and **Figure 4.8** that there is no obvious display of dominance in the 100 Hz one-third octave band, which had previously been identified as a tonal one-third octave band, at either location.

It is recommended that any future noise measurements at noise sensitive receptors also include noise measurements close to the plant under investigation on site, so any periods of complaints or high noise activity can be matched up and investigated further.

Figure 4.9 Location 1 - $L_{Aeq,T}$ and $L_{A90,T}$ levels with plant operating times shown

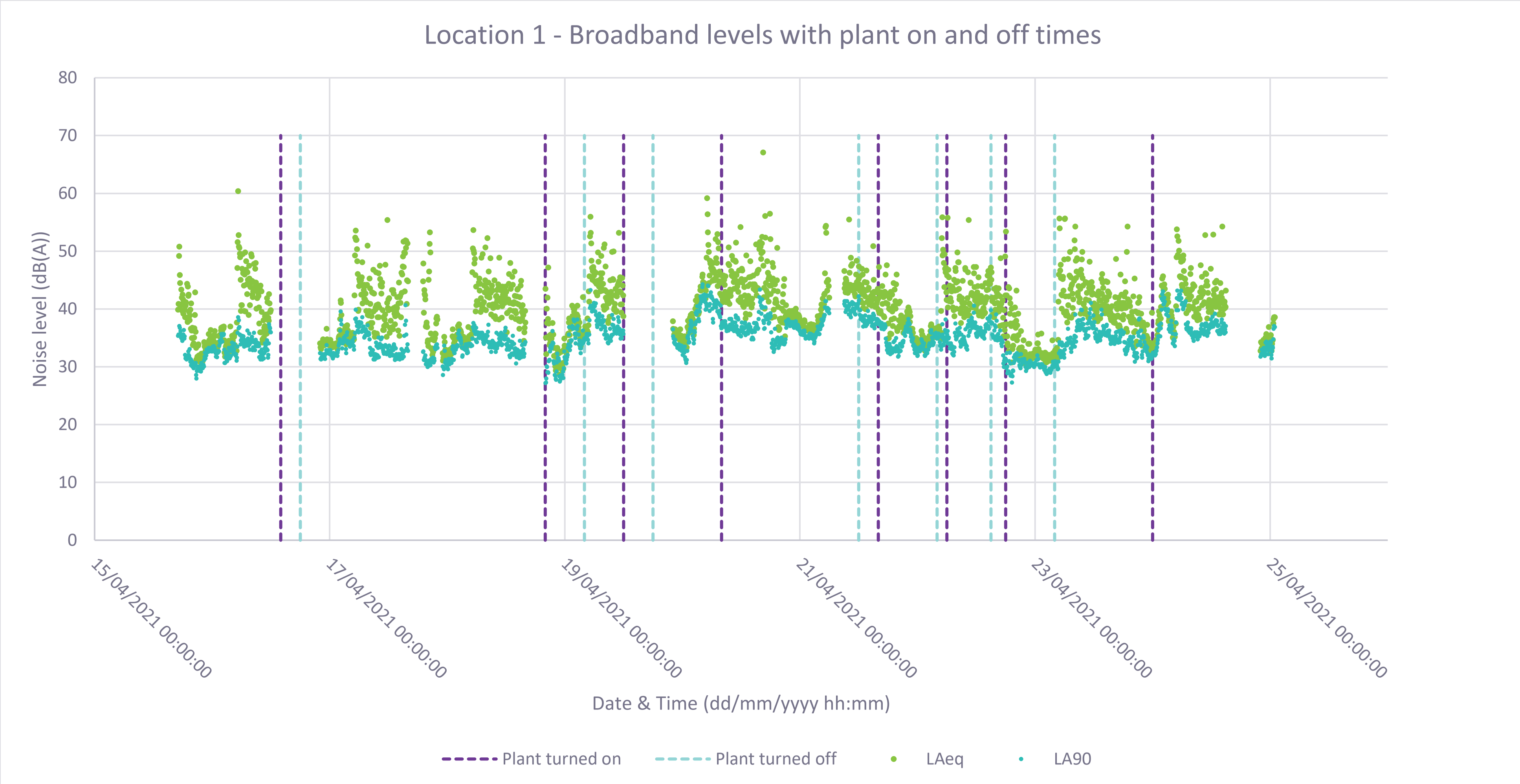
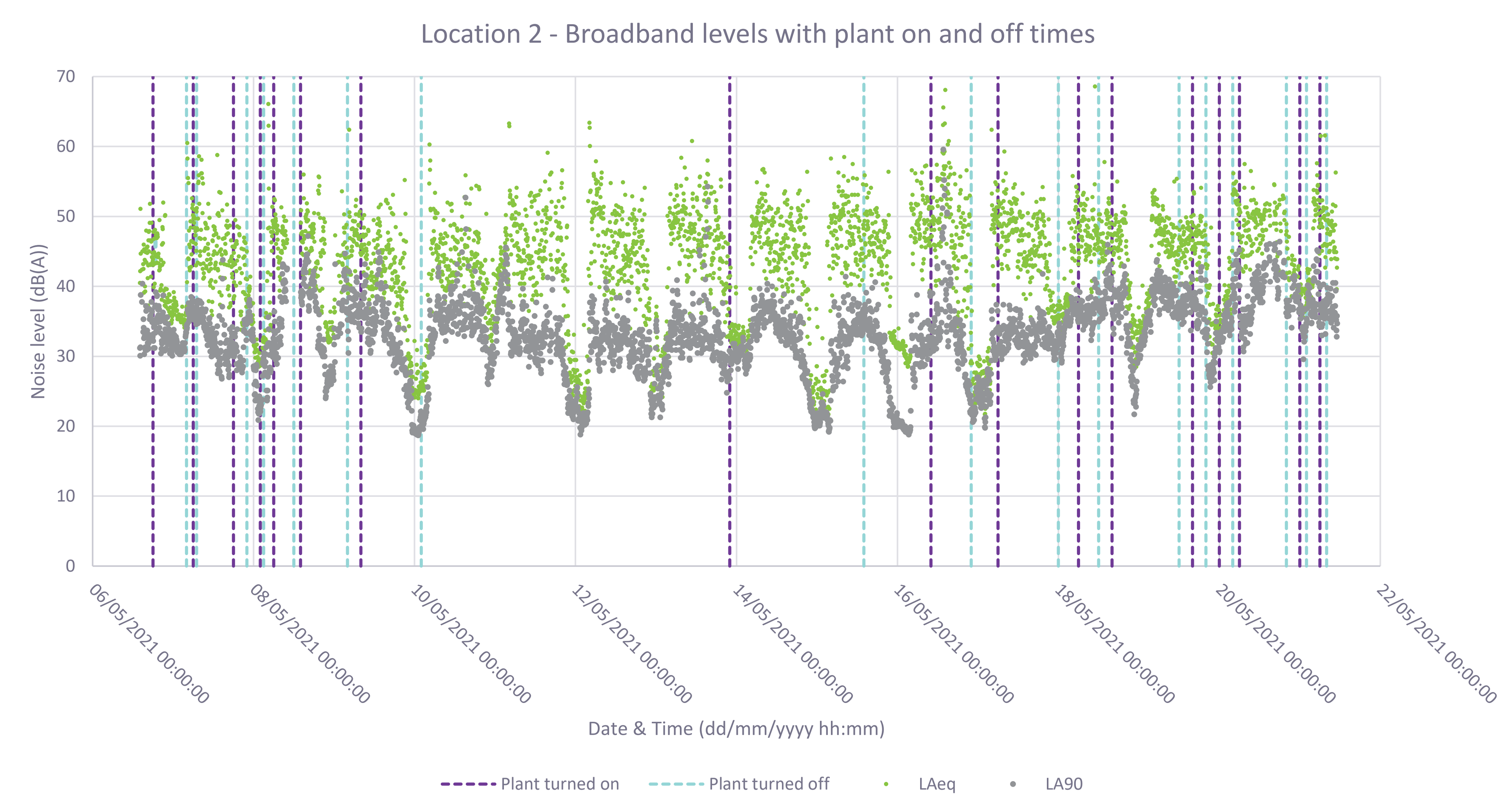


Figure 4.10 Location 2 – $L_{Aeq,T}$ levels with plant operating times shown



4.3 System 7 fan operating status

During the course of the noise measurements, the System 7 fan in particular at the mine was switched on and off at various intervals. The schedule can be seen below in **Table 4.6**.

Table 4.6 System 7 fan on/off schedule

Date	Time	System 7 fan status
15/04/2021	Start of measurement at location 1	On
15/04/2021	18:00	Off
16/04/2021	11:00	On
16/04/2021	18:00	Off
18/04/2021	15:00	On
18/04/2021	18:00	Off
19/04/2021	09:00	On
20/04/2021	00:00	Off
20/04/2021	06:00	On
20/04/2021	18:00	Off
21/04/2021	06:00	On
21/04/2021	17:00	Off
22/04/2021	10:00	On
22/04/2021	17:00	Off
23/04/2021	08:00	On
23/04/2021	19:00	Off
24/04/2021	05:00	On
24/04/2021	17:00	Off
06/05/2021	Start of measurement at location 2	On
06/05/2021	16:00	Off
07/05/2021	06:00	On
07/05/2021	16:00	Off
08/05/2021	05:00	On
08/05/2021	17:00	Off

Date	Time	System 7 fan status
09/05/2021	06:00	On
09/05/2021	17:00	Off
10/05/2021	06:00	On
10/05/2021	17:00	Off
11/05/2021	11:00	On
11/05/2021	12:00	Off
11/05/2021	15:00	On
11/05/2021	16:00	Off
12/05/2021	09:00	On
12/05/2021	10:00	Off
12/05/2021	15:00	On
12/05/2021	16:00	Off
14/05/2021	12:00	On
14/05/2021	17:00	Off
15/05/2021	06:00	On
15/05/2021	16:00	Off
16/05/2021	05:00	On
16/05/2021	20:00	Off
17/05/2021	06:00	On
18/05/2021	17:00	Off
19/05/2021	07:00	On
19/05/2021	08:00	Off
19/05/2021	10:00	On
19/05/2021	18:00	Off
20/05/2021	07:00	On
20/05/2021	08:00	Off
20/05/2021	12:00	On
20/05/2021	17:00	Off
21/05/2021	06:00	On

Noise levels during the various time periods have been compared for when the System 7 fan was on versus when the System 7 fan was off. The results of the analysis are discussed below.

Location 1

Figure 4.11 shows the measured $L_{Aeq,T}$ and $L_{A90,T}$ levels along with a series of vertical lines showing when the fan was switched on and off. In general, it is shown that lower noise levels are measured when the fan is off compared to when the fan is on, however this also tends to coincide with a change from daytime into the evening and night-time measurement periods, where levels are expected to be lower due to diurnal patterns as explained at the start of this section. There is no period where the $L_{A90,T}$ remains steady within the 'System 7 fan on' period as would be expected if industrial noise was the dominant source.

Table 4.7 below shows the noise levels of different time periods (daytime, evening and night-time), comparing when the System 7 fan was on and when the System 7 fan was off.

Table 4.7 Noise levels for different time periods

Time period	Fan on		Fan off		Fan on $L_{Aeq,T}$ – fan off $L_{Aeq,T}$	Fan on $L_{A90,T}$ – fan off $L_{A90,T}$
	$L_{Aeq,T}$	$L_{A90,T}$	$L_{Aeq,T}$	$L_{A90,T}$		
Monday – Friday 07:00 – 19:00	46	37	44	34	2	3
Monday – Friday 19:00 – 23:00	36	34	38	34	-2	0
Monday – Friday 23:00 – 07:00	46	40	44	36	2	4
Saturday 07:00 – 13:00	44	37	43	34	1	3
Saturday 13:00 – 23:00	44	37	44	33	0	4
Saturday 23:00 – 07:00 (Saturday into Sunday morning)	-	-	41	34	N/A	N/A
Sunday 07:00 – 23:00	40	33	42	34	-2	-1
Sunday 23:00 – 07:00 (Sunday into Monday morning)	-	-	43	37	N/A	N/A

Instances where $L_{Aeq,T}$ noise levels are louder when the System 7 fan is on (Monday – Fridays 07:00 – 19:00 and 23:00 – 07:00, along with Saturdays 07:00 – 13:00) see a difference of 2, 2 and 1 dB respectively, whilst instances where the noise levels are quieter when the System 7 fan is on also have a difference of 2 dB. This could suggest that other factors may have an equivalent influence on the ambient noise levels at Location 1.

Looking at $L_{A90,T}$ levels, instances where the System 7 fan is on tend to have higher $L_{A90,T}$ noise levels, with the exception of Sunday daytime and weekday evenings. The difference in levels (3 – 4 dB where positive) are considered sufficient to be perceptible if due to a specific noise source. This data could suggest that the System 7 fan operating status does affect background noise levels at Location 1. However, as the $L_{A90,T}$ levels can also be lower with the System 7 fan operating, no significant conclusions can be drawn on the effect of plant operating status on noise levels at Location 1.

Location 2

Figure 4.11 shows the measured $L_{Aeq,T}$ and $L_{A90,T}$ levels along with a series of vertical lines showing when the System 7 fan was switched on and off. In general, it is shown that similar noise levels are measured regardless of whether the System 7 fan is on or off. There is no period where the $L_{A90,T}$ remains steady within the 'System 7 fan on' period as would be expected if industrial noise was the dominant source.

Table 4.8 below shows the noise levels of different time periods (daytime, evening and night-time), comparing when the System 7 fan was on and when the System 7 fan was off.

Table 4.8 Noise levels for different time periods

Time period	Fan on		Fan off		Fan on $L_{Aeq,T}$ – fan off $L_{Aeq,T}$	Fan on $L_{A90,T}$ – fan off $L_{A90,T}$
	$L_{Aeq,T}$	$L_{A90,T}$	$L_{Aeq,T}$	$L_{A90,T}$		
Monday – Friday 07:00 – 19:00	49	37	49	37	0	0
Monday – Friday 19:00 – 23:00	45	33	45	33	0	0
Monday – Friday 23:00 – 07:00	48	35	48	35	0	0
Saturday 07:00 – 13:00	59	36	-	-	N/A	N/A
Saturday 13:00 – 23:00	49	39	47	34	2	5
Saturday 23:00 – 07:00 (Saturday into Sunday morning)	50	36	46	35	4	1
Sunday 07:00 – 23:00	52	41	45	28	7	13
Sunday 23:00 – 07:00 (Sunday into Monday morning)	49	35	47	29	3	6

It can be seen that at weekends the $L_{Aeq,T}$ levels are higher when the System 7 fan is on, however the levels are approximately the same during the weekday time periods. This data suggests that other factors may have a bigger influence on the ambient noise levels at Location 2.

Looking at $L_{A90,T}$ levels, instances where the System 7 fan is on also tend to have higher $L_{A90,T}$ levels at the weekends, but similar levels during the weekday time periods. Sunday daytime shows a much higher background noise level when the plant was on, however upon further analysis Sunday 16th May included farming activities at Location 2. This is the likely cause of the high $L_{A90,T}$ level on Sunday 07:00 – 23:00. When the period 13:10 – 14:15 is removed from the analysis (when farming activities were taking place), the change drops to 9 dB louder, which is still a significant difference.

This data could suggest that the System 7 fan operating status does affect background noise levels at Location 2, possibly that it influences the background only when other local noise sources reduce to a minimum. However, as the $L_{A90,T}$ levels show both a significant difference and little change (depending when the measurement was made), no significant conclusions can be drawn on the effect of System 7 fan operating status on noise levels at Location 2.

It can be seen from **Figure 4.4**, **Figure 4.5**, **Figure 4.7** and **Figure 4.8** that there is no obvious display of dominance in the 100 Hz one-third octave band, which has previously been identified as a tonal one-third octave band, at either location.

It is noted that as the fan was usually shut down at 18:00 during the survey, there is very little data for the night-time periods with the System 7 fan on and equally little data for the daytime periods with the System 7 fan off due to its daytime operation. Therefore, it is recommended that, if possible, more data is collected to get a more even spread of data points over the relevant time periods. It is also recommended that any future noise measurements at noise sensitive receptors also include noise measurements close to the plant under investigation on site, so any periods of complaints or high noise activity can be matched up and investigated further.

Figure 4.11 Location 1 - $L_{Aeq,T}$ and $L_{A90,T}$ levels with System 7 fan operating status shown

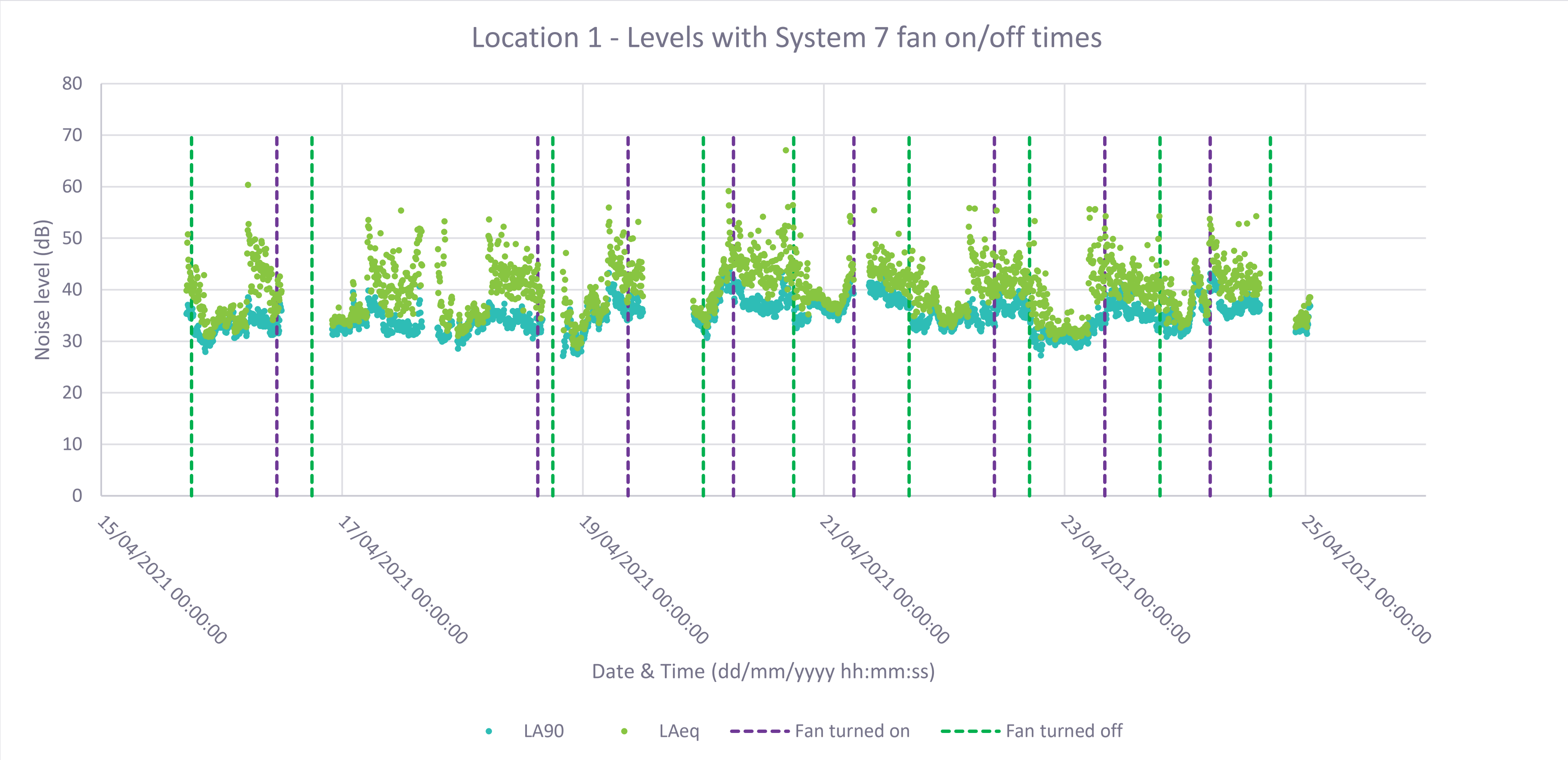
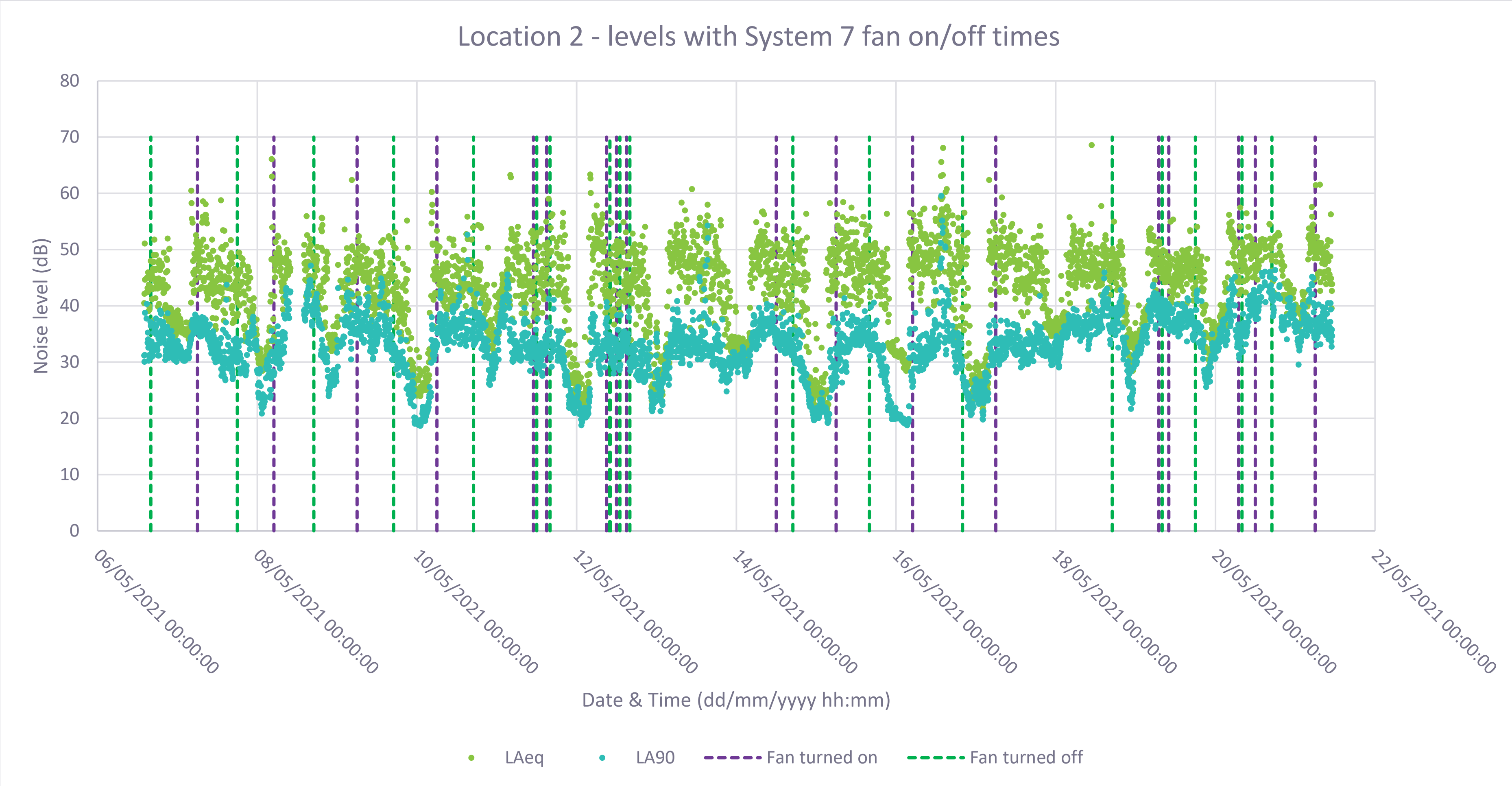


Figure 4.12 Location 2 - $L_{Aeq,T}$ and $L_{A90,T}$ levels with System 7 fan operating status shown



4.4 Damper positioning on System 7 fan

During the noise monitoring at Location 2, the position of a damper on the System 7 fan (atmosphere side) was altered to see how this affected the noise levels. The System 7 fan is located on the east side of a building (**Figure 4.13**) and was previously determined to be the main cause of complaints at noise sensitive receptors.

Figure 4.13 Location of System 7 fan

The position of the damper is controlled by a lever, as shown in **Figure 4.14**. The position was altered, and the fan switched on as described in **Table 4.9**.

Figure 4.14 Damper position lever

Table 4.9 Damper position descriptions

Position description	Date & time	Plant performance	Motor amps
Fully shut	19/05/2021 06:00	Koppern online	48
25% open	18/05/2021 06:00	Koppern online	47
50% open	17/05/2021 06:00	Koppern online	49
75% open	21/05/2021 08:00	Sahut & Koppern online	48

The ambient and background noise levels at Location 2 have been compared for each lever position for the 30 minutes following the fan power-on. **Table 4.10** and **Figure 4.15** show the results of this analysis.

Table 4.10 Noise levels with different damper lever positions, dB

Damper position	Date & time	$L_{Aeq,T}$	$L_{A90,T}$	80Hz $L_{eq,T}$	100 Hz $L_{eq,T}$	125 Hz $L_{eq,T}$	80 Hz $L_{90,T}$	100 Hz $L_{90,T}$	125 Hz $L_{90,T}$
Shut	19/05/2021 06:00 – 06:30	48	40	39	35	35	34	31	26
25% open	18/05/2021 06:00 – 06:30	47	37	40	45	37	37	40	33
50% open	17/05/2021 06:00 – 06:30	51	32	35	38	32	30	34	28
75% open	21/05/2021 08:00 – 08:30	48	39	38	37	34	35	33	31

During the measurements, 1 minute of audio was recorded for every 10 minutes of measurement. After listening back to the recordings, the observations were as follows:

Table 4.11 Observations from audio recordings

Date & time	Observations
17/05/2021 06:05	Birdsong and cockerel crowing (x3)
17/05/2021 06:15	Birdsong and cockerel crowing (x1)
17/05/2021 06:25	Dogs barking / howling, birdsong and distant road traffic
18/05/2021 06:05	A rhythmic clicking noise, sheep baaing and birdsong
18/05/2021 06:15	A rhythmic clicking noise, distant road traffic and birdsong
18/05/2021 06:25	Cockerel crowing (x4), a rhythmic clicking noise and birdsong
19/05/2021 06:05	Birdsong and distant road traffic
19/05/2021 06:15	Road traffic, birdsong and sheep baaing
19/05/2021 06:25	Road traffic and birdsong
21/05/2021 08:05	Birdsong and road traffic
21/05/2021 08:15	Birdsong, road traffic and sheep baaing
21/05/2021 08:25	Birdsong, sheep baaing and road traffic

It can be seen on **Figure 4.15** that the ambient noise level recorded at the different lever positions was broadly similar, with the exception of when the damper was 50% open, where the noise levels recorded are higher and show less spread than other damper positions, and slightly lower $L_{A90,T}$ noise levels.

Given the large propagation distance from source to receiver (approximately 1600m), along with the influence of external factors such as weather conditions, road traffic levels, birdsong and sheep, no significant conclusions can be drawn from this data.

Figure 4.16 shows the 80, 100 and 125 Hz one-third octave band levels for the 75% open position. It can be seen that there is no obvious display of dominance in the 100 Hz one-third octave band.

Figure 4.15 $L_{Aeq,T}$ levels with different damper positions

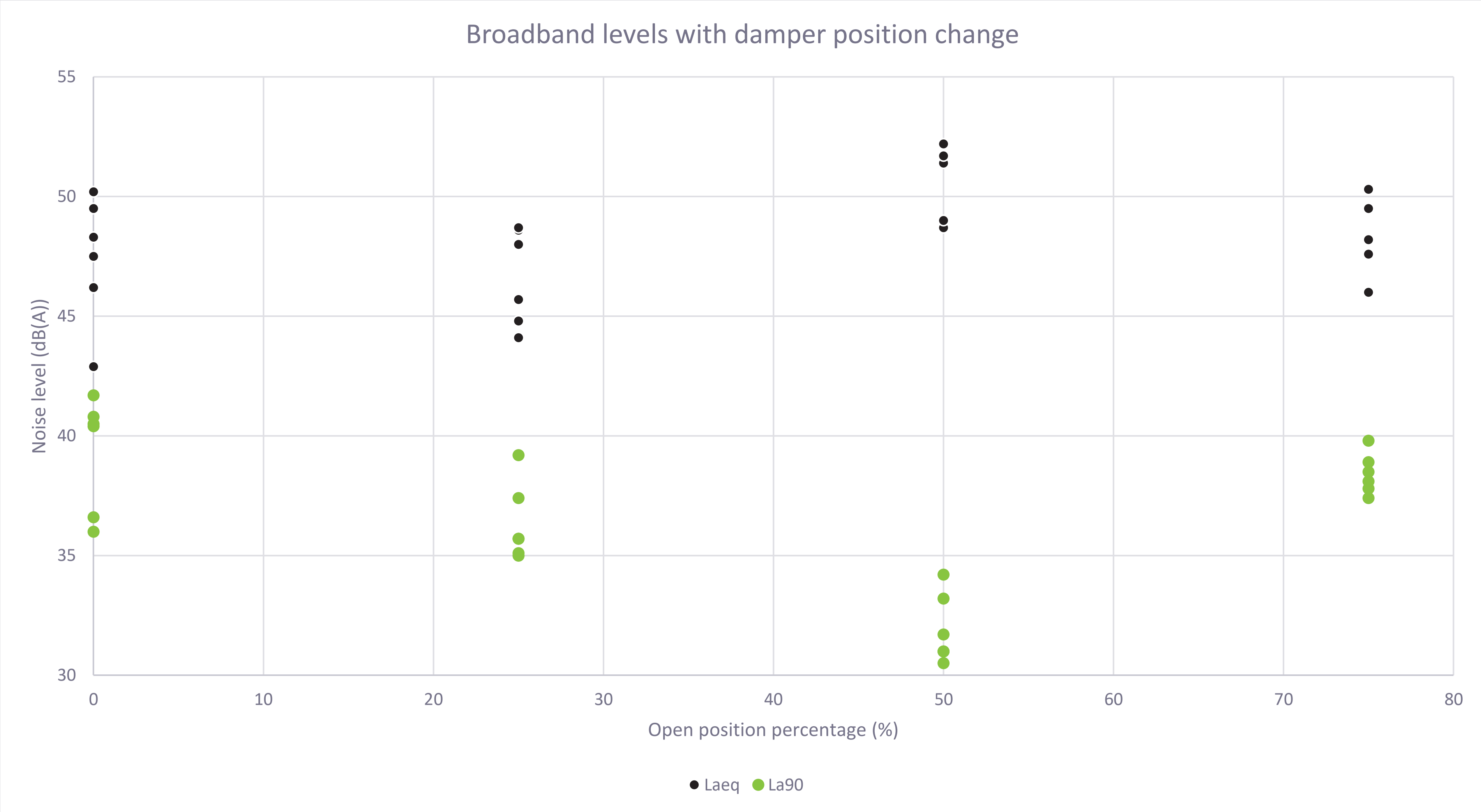
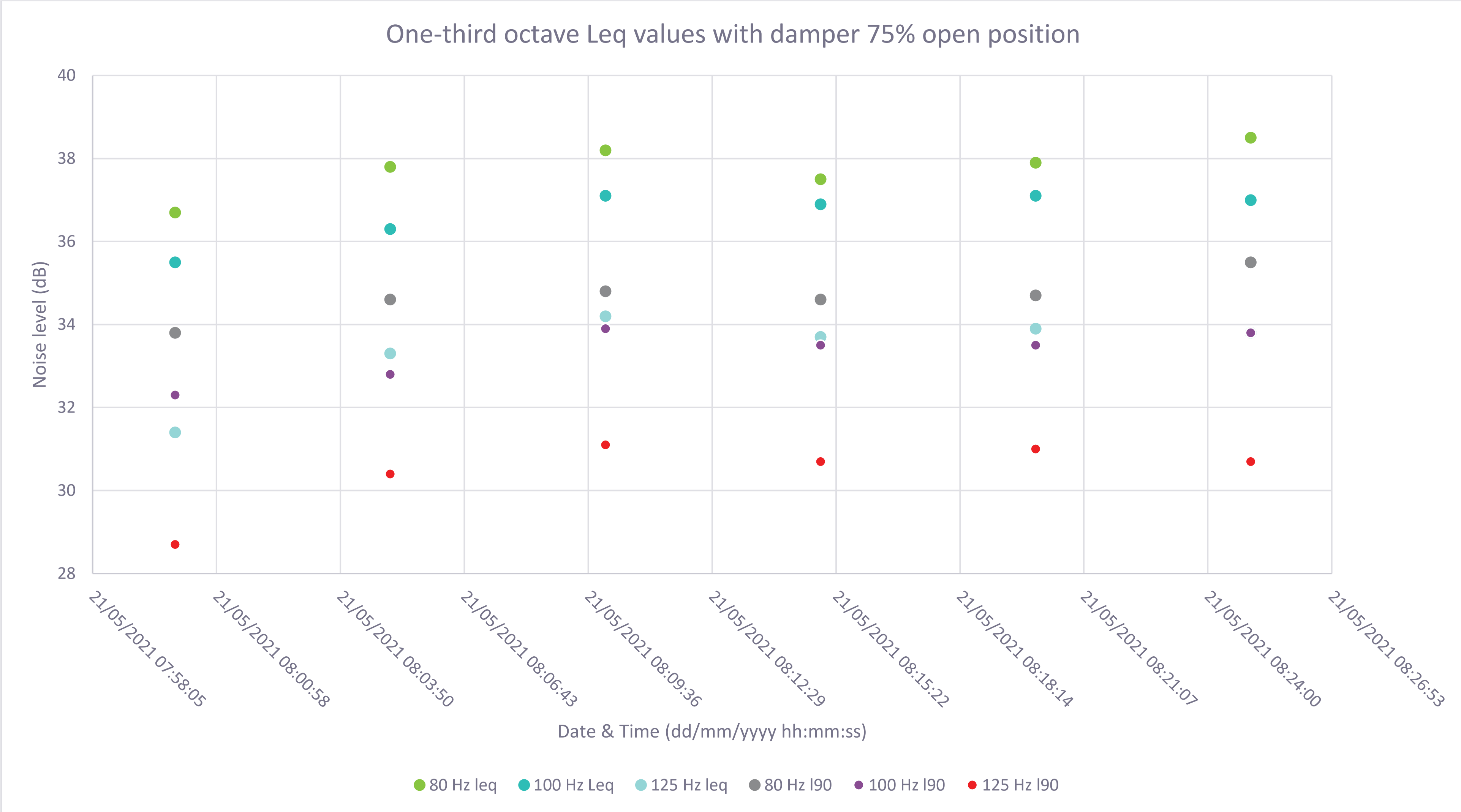


Figure 4.16 One-third-octave band $L_{eq,T}$ and $L_{90,T}$ levels with a 75% open position



5. Conclusions

This report has been produced for the purpose of investigating ambient noise levels at nearby noise sensitive receptors and whether it is possible to return to turning the System 7 fan on during the evening and night-time periods at Boulby Mine.

To inform the investigation, acoustic monitoring was undertaken at two locations close to the Site. Subjective observations were undertaken during deployments and collections of equipment and audio recordings were made during the measurements.

To establish what is affecting the ambient noise levels at the noise sensitive receptors, analysis has been carried out on the following elements with the associated outcomes:

- wind direction:
  - ambient and background noise levels were louder in other wind directions (compared to the wind direction of Site to receiver) at Location 1, however there was significantly less data available for the Site to receiver wind direction compared to the other wind directions;
  - ambient and background noise levels were both louder and quieter in the direction of Site to receiver at Location 2, depending on the time period. Again, there was significantly less data available for the Site to receiver wind direction compared to the other wind directions;
  - there is no obvious dominance of the 100 Hz one-third octave band, which had previously been identified as a tonal one-third octave band, at either location; and
  - no significant conclusions can be determined on the effects of wind direction based on the above, however more data points for both locations and more reliable weather data for Location 1 may help in drawing a conclusion about wind direction and noise levels.
- plant operating status:
  - ambient and background noise levels were both quieter and louder when plant on Site was on (compared to when plant on Site was off), depending on the time period, at both locations;
  - at Location 1, when ambient noise levels were low (such as during the night-time periods and weekends), there could be a significant difference in the $L_{Aeq,T}$ when comparing the plant operating status (up to 10 dB), compared to when ambient noise levels were higher (weekdays), and differences were only up to 3 dB;
  - background noise levels at Location 1 tended to be higher when plant was operating, with differences of up to 3 dB, however Sunday daytime and night-time background levels were lower when the plant was operating;
  - at Location 2, instances where plant was on and the ambient noise levels were low (during the night-time periods) saw differences of up to 4 dB compared to when noise levels were higher, and differences were only up to 2 dB (during the daytime on both weekdays and weekends);
  - background noise levels at Location 2 tended to be higher when plant was operating and, once farming activities were taken into account, could see differences of 5 dB. However, there were also time periods where the background noise level was lower with the plant operating;

- there is no obvious dominance of the 100 Hz third-octave band, which had previously been identified as a tonal one-third octave band, at either location;
- based on the data collected, no significant conclusions can be made tying the effects of the plant being operational to the ambient noise level at the receptors. The data may show a correlation between background noise levels and the operating status at both locations, however given that background levels were both higher and lower when the plant was operating at different time periods means that no clear conclusions can be drawn; and
- further sound measurements undertaken at the receptors in conjunction with the measurement of noise levels on Site could help to draw a conclusion on whether the plant operating affects ambient and background noise levels.

- System 7 fan operating status:
  - ambient noise levels were both quieter and louder when the System 7 fan was on (compared to when the fan was off), depending on the time period, at Location 1 and either louder or similar at Location 2;
  - at Location 1, background noise levels were generally 3 – 4 dB louder with the fan on compared to the fan off, with the exception of Sunday daytime which experienced lower noise levels;
  - at Location 2, background noise levels could see a significant difference when the System 7 fan was on compared to when it was off (around 10 dB) at the weekends, however experienced similar levels whether the fan was on or off on weekdays;
  - there is no obvious dominance of the 100 Hz one-third octave band, which had previously been identified as a tonal one-third octave band, at either location;
  - the data collected could suggest that the System 7 fan operating status does affect background noise levels at both locations, however there is limited data for certain time periods and operating status (i.e. there is limited data with the fan operating at night, and limited data with the fan off during the daytime periods); and
  - further sound measurements undertaken at the receptors in conjunction with the measurement of noise levels on Site could help to draw a conclusion on whether the System 7 fan operating status affects ambient and background noise levels.
- damper positioning:
  - ambient noise levels measured for 30 minutes following the powering-on of plant with the damper in different positions were broadly similar;
  - when the damper was in a 50% open position, the ambient noise levels recorded were higher and showed less spread than other damper positions, however had lower $L_{A90,T}$ levels;
  - notes made from audio recordings made every 10 minutes noted the main noise sources as birdsong, cockerel crowing, sheep, and road traffic noise, not plant from Site;
  - there is no obvious dominance of the 100 Hz one-third octave band, which had previously been identified as a tonal one-third octave band; and
  - no significant conclusions can be made on the effects of the damper position on ambient noise levels at receptors due to the large propagation distances involved and other external factors. Repeating the measurements at receptors along with concurrent measurements on Site may help to draw a conclusion regarding the System 7 fan noise.

Overall, the monitoring concluded that, based on the factors investigated and the data available, the Site noise was not of a sufficient level when operating to be clearly discernible within the general ambient noise at the receptors. In order to obtain conclusions, more measurements could be conducted concurrently at both locations, along with measurements on Site. This would allow a more detailed analysis process as changes on site would be visible from onsite measurements and could be matched up more precisely with measurements undertaken at receptors to determine whether the Site condition has an effect on ambient noise levels at receptors.

Appendix A
Equipment calibration details

Table A.1 NL52 – 28 Calibration Details

Manufacturer	Instrument	Type	Serial Number	Calibration Date
Rion	Sound Level Meter	NL – 52	00331828	29/03/2021
Rion	Pre Amplifier	NH – 25	21779	29/03/2021
Rion	Microphone	UC – 59	04895	29/03/2021

Table A.2 NL52 – 29 Calibration Details

Manufacturer	Instrument	Type	Serial Number	Calibration Date
Rion	Sound Level Meter	NL – 52	00331829	29/03/2021
Rion	Pre Amplifier	NH – 25	21780	29/03/2021
Rion	Microphone	UC – 59	04896	29/03/2021

Table A.3 NL52 – 33 Calibration Details

Manufacturer	Instrument	Type	Serial Number	Calibration Date
Rion	Sound Level Meter	NL – 52	1143533	29/03/2021
Rion	Pre Amplifier	NH – 25	43550	29/03/2021
Rion	Microphone	UC – 59	7393	29/03/2021

Table A.4 Calibrator C6 Calibration Details

Manufacturer	Instrument	Type	Serial Number	Calibration Date
Rion	Calibrator	NC – 74	34251556	26/03/2021