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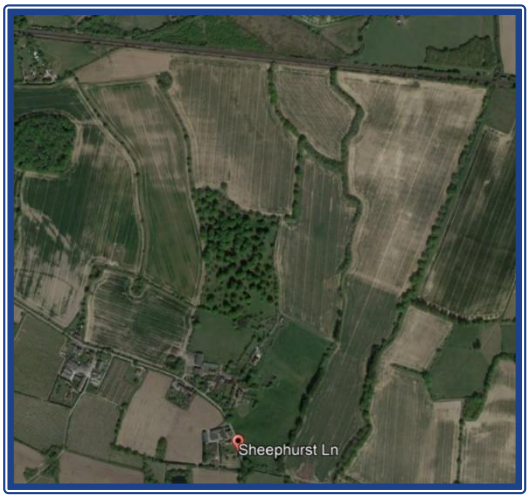

Technical Report:

Noise Impact Assessment for an Energy Storage System off Sheephurst Lane, Marden, Kent

Project Ref: 10253

Noise Impact Assessment

Date of Issue:	2nd March 2022
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Contents

Rev 1	Draft version for approval	8th September 2021
Rev 2	New Site layout and new equipment information	28th February 2022

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1. Executive Summary

1.1. The Battery Energy Storage Site (BESS) will comprise and energy storage barn and fenced compound. The barn will have 3 PCS inverters and associated plant and the outside compound will have 8 battery containers, HVAC units and auxiliary transformer.

1.2. The HV compound will have a new 132/33kV 40MVA transformer surrounding by a steel palisade fence.

1.3. This assessment uses BS 4142:2014 and NPSE methodology to determine the impact of the proposed development on the two noise sensitive receptors identified as NSR1 – 8 Little Sheephurst Cottages and NSR2 Willow Cottage off Sheephurst Lane.

1.4. Ambient and background sound levels were determined at representative locations of the noise sensitive receptors between Friday 20th August and Monday 23rd August 2021. At P1 (NSR1), the night-time ambient and background sound levels were $L_{Aeq,15min}$ 37dB and $L_{A90,15min}$ 28dB and at P2 (NSR2) the levels were $L_{Aeq,15min}$ 28dB and $L_{A90,15min}$ 19dB respectively. Due to the relevant rating and background sound levels at each receptor location NSR1 was assessed using BS412 and NSR2 by NPSE guidance.

1.5. At NSR1 the specific sound level, determined by noise modelling, was 26dB(A). The specific sound level was subject to a +3dB penalty for change of acoustic character to gain a rating level of 29dB.

1.6. The BS 4142 assessment indicated a low impact at NSR1. At night, noise from the HV compound is unlikely to be distinctly audible so consequently sleep will not be disturbed. The impact during the day will be negligible.

1.7. At NSR2, the NPSE assessment indicated a noise level at night below the NOEL of 30dB(A). Therefore, the BESS noise is unlikely to be distinctly audible, disturb sleep, or induce a change in behaviour of receptors.

1.8. No mitigation measures are required for the development.

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2. Introduction

2.1. Statkraft propose the installation of a Battery Energy Storage Site (BESS) and HV compound as part of a wider Solar Farm development at land to the north of Sheephurst Lane, Marden in Kent.

2.2. To accompany the planning application dBC were appointed by Origin Power Services to undertake a full BS 4142:2014 noise impact assessment.

2.3. To assist the determination of noise levels at the receptor locations dBC constructed a noise model of the compounds. The model was used to investigate noise mitigation measures to reduce the impact to low at the nearest noise sensitive receptors to the compound.

2.4. The site visits and report were undertaken by Mick Lane, Senior Acoustic Consultant at dB Consultation Limited, a practicing acoustician for over 15 years, Full Member of the Institute of Acoustics (MIOA) and experienced in noise assessment in many industrial and commercial sectors.

2.5. This report has been reviewed by Danny Blacklock BEng(Hons), MSc, CEng, MIET, MIOA Managing Director of dB Consultation Limited, a practicing acoustician for over 25 years, Full Member of the Institute of Acoustics (MIOA) and experienced in noise assessment in many industrial and commercial sectors.

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3. Assessment Criteria

BS 4142:2014 Method for rating and assessing industrial and commercial sound

3.1. BS 4142 provides a robust method for 'rating' external noise levels from factories, industrial premises or fixed installations of an industrial nature. The methods described in this British Standard use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident.

3.2. The method is based on the difference between the background noise level without the industrial noise and the specific noise level of the industrial noise source at the receiver location.

3.3. The noise level from the industrial source (referred to as the specific noise level) can be weighted to determine a rating level by adding acoustic penalties for tonality, intermittency, impulsivity or acoustic features that make the sound distinctive, penalties are applied for their impact at the receptor location. These methods refer to a sliding scale between +0dB up to +9dB, depending on the severity and can be combined for different acoustical features.

3.4. The background noise level is then subtracted from the rating level (the specific noise level plus any acoustical correction factors) and the difference used to assess the impact, as shown in the Table 1 below;

Difference	Assessment
Around +10dB or more	Indication of Significant Adverse Impact
Around +5dB	Indication of an Adverse Impact
0dB or below	Indication of Low Impact

Table 1: Explanation of BS 4142:2014 assessment terms

3.5. BS 4142 Section 11 Note 2 states that '*Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night*' In light of this, dBC has assessed BESS levels at NSR2 against the ambient levels only using NPSE guidance not background levels in this case.

Noise Policy Statement for England (NPSE)

3.6. The NPSE sets out the long-term vision of the Government's policy on noise, which in essence is to promote good health and a good quality of life through the effective management of noise within the context of Government Policy on sustainable development.

3.7. The NPSE outlines three aims for effective management and control of environmental, neighbourhood and neighbour noise:

- *Avoid significant adverse impacts on health and quality of life;*
- *Mitigate and minimize adverse impacts on health and quality of life; and*
- *Where possible, contribute to the improvement of health & quality of life.*

3.8. In its aims, the NPSE uses key phrases "significant adverse" and "adverse" and these are related to the following terms which are currently being applied to noise impacts.;

- *NOEL – No Observed Effect Level – this is the level below which no effect can be detected or measured,*
- *LOAEL – Lowest Observed Adverse Effect Level – which is the level above which adverse effects on health and quality of life can be detected; and*
- *SOAEL – Significant Observed Adverse Effect Level – which is the level above which significant adverse effects on health and quality of life occur.*

3.9. The NPSE notes that it is not possible to have a single objective noise-based measure that defines SOAEL that would be applicable in all situations, consequently the NOEL, LOAEL and SOAEL are likely to change for the location, noise type and times. It is the acoustician who should identify relevant SOAEL levels taking into account the noise source exposures and receptors.

3.10. The following extract from ANC-AVO-Residential-Design-Guide-January-2020-v1.1 describes the general perception of noise as noise rises above each threshold.

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Perception	Examples of Outcomes	Increasing Effect Level	Action
Not present	No Effect	No Observed Effect	No specific measures required
Present and not intrusive	Noise can be heard, but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life.	No Observed Adverse Effect	No specific measures required
		Lowest Observed Adverse Effect Level	
Present and intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum
		Significant Observed Adverse Effect Level	
Present and disruptive	The noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid [Note 1]
Present and very disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory.	Unacceptable Adverse Effect	Prevent

Extract from ANC-AVO-Residential-Design-Guide-January-2020-v1.1

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4. Site Description

4.1. The solar farm, BESS and HV compound would be located on agricultural land north of Sheephurst Lane Marden, Kent.

4.2. The site, receptors, NSR1 and NSR2 and environmental monitoring, locations P1 and P2 have been marked on Fig. 1. Locations as detailed in drawing no. SCUKX-MARDN-001-100C PV layout [09.07.21] supplied by the client.

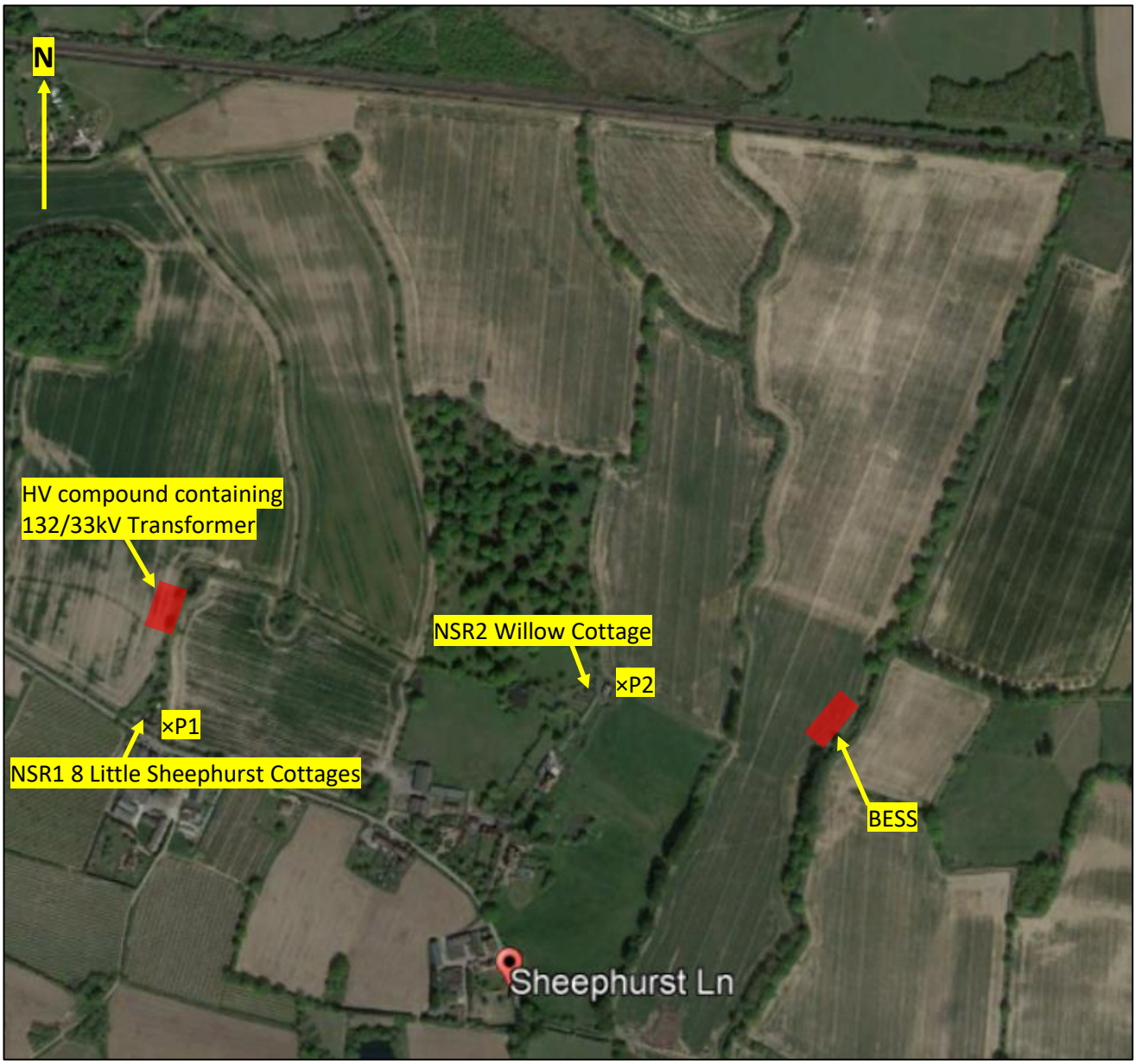

Fig. 1: Site Location

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4.3. The extent of the solar farm is shown on Fig. 2, extract of drawing number 27899/050 RevB Issued February 2022.

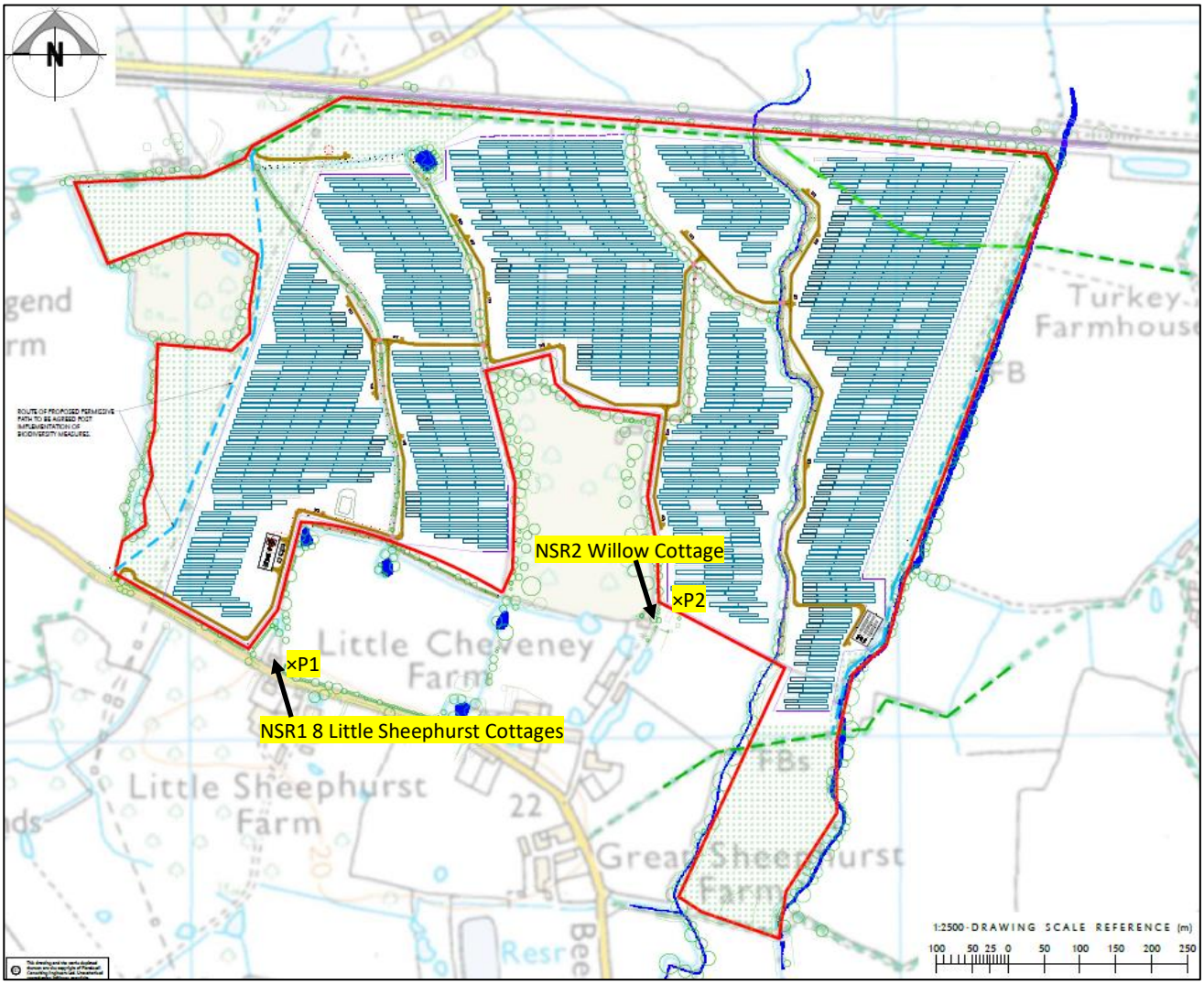

Fig. 2: Extent of Solar Farm

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4.4. The BESS on this site will be in a barn and fenced compound as shown below, extract of drawing number 27899 - 004 Rev A - Energy Storage Barn Proposed Layout.

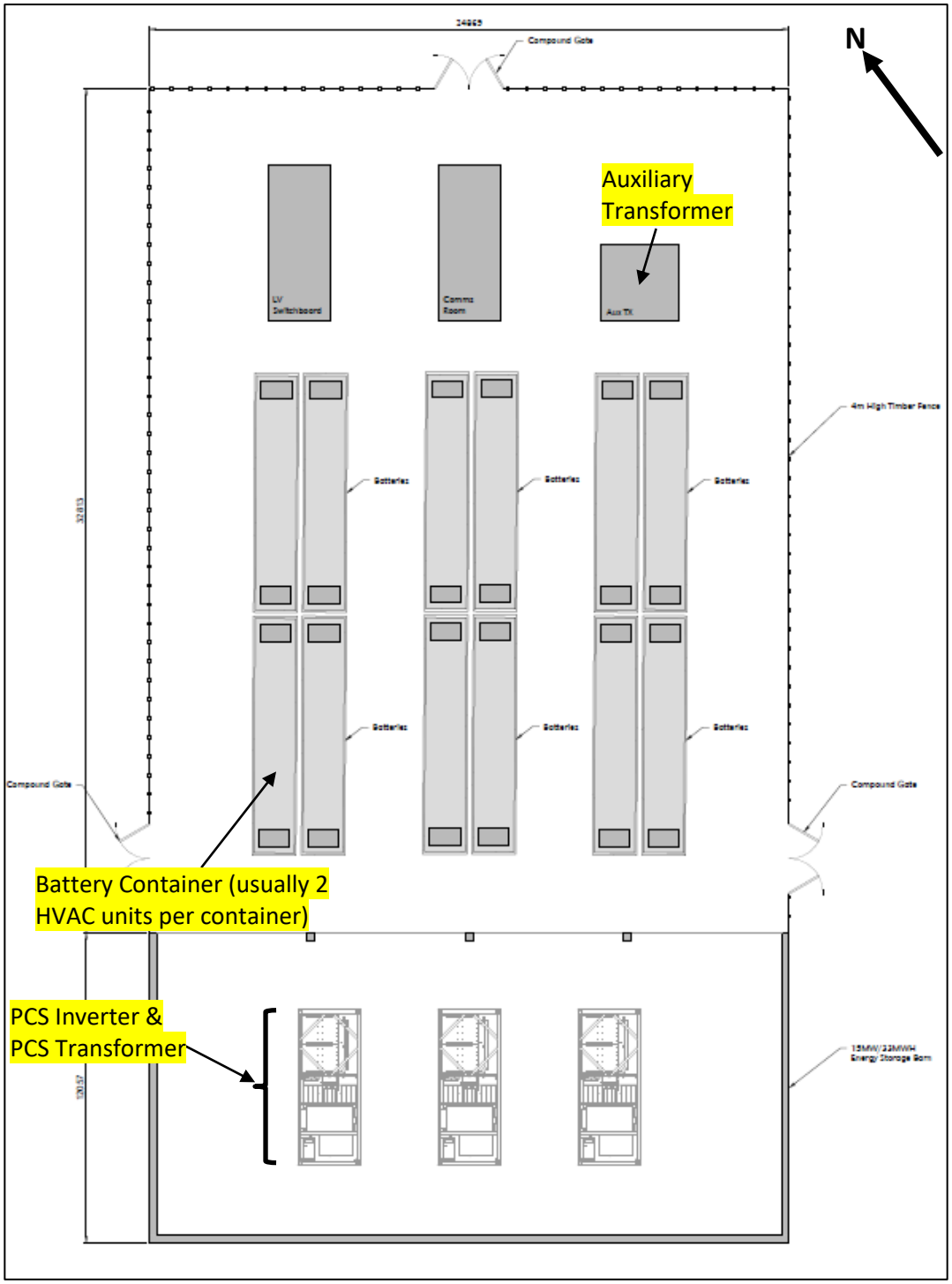

Fig. 3: BESS Layout Plan

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4.5. The BESS will consist of 8 battery storage containers (12 are shown above), 16no. HVAC units, usually 2 units per container, 3no. PCS Inverters and 3no. PCS transformers.

Fig. 4: SC1000TL Power Conversion System (PCS)

4.6. The barn will be three sided, open toward the timber compound and clad in timber. The compound timber fencing will be 4m high.

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4.7. The HV compound layout will be the same as shown in Fig. 5 for a similar BESS site in Childerley, Cambridge.

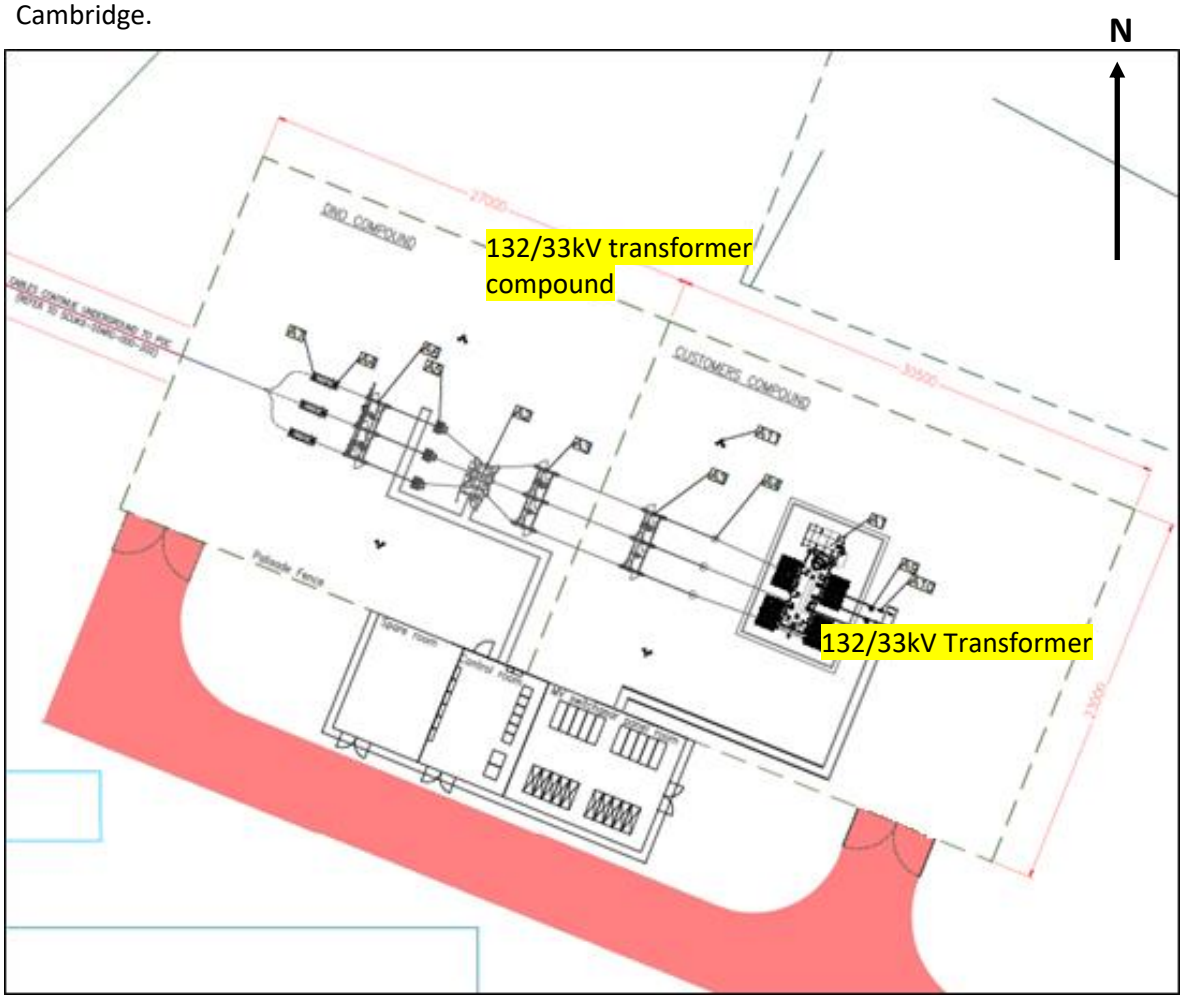

Fig. 5: HV compound Layout

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4.8. The HV compound contains the following plant and equipment although the only item that will produce noise continually will be the 132/33kV Transformer. Only the transformer noise has been assessed.

HV yard equipment	**No.**
Single-pole surge arrester	6
Three-poles disconnector (equipped with a earthing switch)	1
Three-poles disconnector (without a earthing switch)	2
Dead tank circuit breaker (three-pole switching) equipped with toroidal current transformers (at least 3 CTs)	1
Single-pole capacitive voltage transformer	3
Single pole isolator (145 kV)	3
132/33kv Power transformer	1
MV surge arresters	3
Single pole isolator (MV side of the transformer)	3
MV busbar	1

4.9. There are 14 field substations spaced around the solar panel area of the site. These emit very low noise, L_w70dB. These units do not impart any change to the noise levels at NSR1 or NSR2 when operating so they have been considered but not shown in the noise model.

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5. Specific Sound Level

5.1. The specific sound level at NSR1 and NSR2 will be sound pressure level determined by CadnaA noise model calculation from all the noise emission plant (PCS Inverters, PCS Transformers, HVAC units and the 132/33kV Transformer) to be installed as part of the BESS and HV compound.

5.2. The noise emission from the equipment has been assumed to be equivalent to the client-supplied data for a similar development in Childerley, Cambridge which was assessed in dBC report document reference dBC/Origin/10213/ML/004 issued in March 2021. The equipment, dimensions and sound emission data is shown in Table 2 on page 14.

5.3. It should be noted that the 3no. PCS inverters and transformers will be installed in a traditional agricultural barn that is timber clad. The breakout from the barn was calculated using the weighted sound reduction index, R_w25dB for 20mm pine (cladding).

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Equipment List: 10MW Battery Energy Storage – Sheephurst Lane, Marden in Kent

						Per Unit				
No	**Item**	**Purpose**	**Rating**	**Number**	**Supplier Scope**	**Size (metres)**	**Volume**	**Floor space**	**Weight per unit**	**Noise emissions**
1	Battery container	Container	2500kWh	8	Sungrow	L9.2 x H2.896 x W1.6	86.1m^3	29.7m^2	42000kg	N/A
2	Battery HVAC Unit	Maintain the battery container at the optimum temperature		16	CATL	L0.800 x H2.052 x W0.750	1.231m^3	0.6m^2	350Kg	L_w 79 dBA
3	Inverter (PCS)	External	1.1MVA	48	Sungrow	L1.606 x H2.065 x W0.960	3.18m^3	1.54m^2	1400kg	L_p 66 dBA @ 1m
5	Transformer	2.5MVA	33/0.69kV	16	Eletrafo	L2.450 x H2.200 x W1.600	3.92 m^3	3.92m^2	6100Kg	L_w 63 dBA
6	Software system	Located within the battery container		1	TBC	Very small				N/A
7	DNO Switch Room	For housing DNO Switchgear/Protection		1	ICP	L 4 x W 4.1 x H 4	65.6m^3	16.4m^2		N/A
8	Client Switch Room	For housing Clients Switchgear/Protection		1	ICP	L 6.1 x W 3 x H 3.5	64.05m^3	18.3m^2		N/A
9	Auxiliary Transformer	For Providing LV Supply	33kV/400V 1MVA	1	ICP	L2.0 x W2.0 x H 1.175	4.7m^3	4.0m^2		L_p 65dB @ 1m

Table 2: Client supplied Energy Storage Compound plant sound emission

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5.4. The octave band data to be used to construct the noise model and undertake this assessment is shown in Table 3 below. This data is the same as used for the Childerley site in Cambridge.

Plant	Lw dBA	1/1 octave band centre frequencies 31.5Hz to 8kHz								
		31.5	63	125	250	500	1k	2k	4k	8k
HVAC unit	79	85	89	83	80	76	72	69	63	63
PCS Inverter	83	-	79	82	83	82	78	71	69	68
PCS Transformer	63	-	53	68	67	64	50	43	36	37
Auxiliary Transformer	81	-	71	86	85	82	68	61	54	55
132/33kV Transformer	87	-	82	97	96	93	79	72	65	65

Table 3: Overall and 1/1 octave band sound power levels

5.5. dBC has assumed the same operating conditions for the BESS at Marden as for the site in Childerley, Cambridge. From the Childerley report '*dBC were informed the energy storage site may operate for a maximum of 6hrs in any 24hr period and only in 2hr blocks. dBA has assumed the system has the potential to supply electricity at full load over a full 15min period at any time of day, therefore the assessment of site noise will focus upon night-time noise*'.

5.6. If the plant has a low impact at night, it follows that the impact will be low during the day.

5.7. CadnaA noise modelling software version 2021 was used to determine the worst-case scenario specific sound level at NSR1 and NSR2. CadnaA images of the noise model are shown in the Appendix of this report.

5.8. Table 4 shows the overall dB(A) and 1/1 octave band (dB) specific sound levels at NSR1 and NSR2.

NSR	Time of Day	Specific Sound Level dB(A)	1/1 octave centre band frequency, Hz dB					
			63	125	250	500	1k	2k
1	Night	26	29	31	28	26	15	8
2	Night	24	37	30	26	23	19	11

Table 4: Specific sound level in dB(A)

Please note: The specific sound level has been determined with all the BESS plant and the new 132/33kV transformer operating because ultimately all plant associated with the new development will operate simultaneously.

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5.9. To gain a rating level at NSR1 for assessment, the specific sound level is corrected for tonality, impulsivity, intermittency and other acoustic characteristics assessed at the receptor location.

5.10. dBC has determined a representative night-time background sound level at P1 of 28dB $L_{A90,15min}$. The night-time modal ambient level was 37dB $L_{Aeq,15min}$. A specific sound level that is below the background and significantly below the background may not be audible at NSR1.

5.11. For a robust assessment dBC has added 3dB for change of acoustic character but due to the existing ambient sound levels affecting NSR1 no penalties will be added for intermittency, impulsivity and tonality in this case.

5.12. The rating level for assessment at NSR1 will be 29dB.

5.13. Due to the very low specific sound and background NSR2 will be assessed using NPSE guidance only.

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6. Background Sound levels

6.1. The ambient and background sound levels were measured at two locations representative of the nearest noise sensitive receptors, NSR1 and NSR2, to the compounds. The monitoring locations are shown in Fig. 1 on page 7 and further described in Table 5 below.

Location	Photo	Noise Sources
P1 1.5m high on a field boundary, adjacent to NSR1 (8 Little Sheephurst Cottages). The HV compound will be 125m to the north of NSR1		Local and distant road traffic, rail traffic, air traffic, wildlife and domestic activity
P2 1.5m high adjacent to a field boundary, adjacent to NSR2 (barn next to Willow Cottage) the BEES compound is 250m east of NSR2		Local and distant road traffic, rail traffic, air traffic, wildlife, domestic and farm activity

Table 5: Monitoring Locations

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6.2. The monitoring took place between 20th and 23rd August 2021.

6.3. The monitoring kit details are shown in Table 6 below. The sound level meters and calibrator have been calibrated in a UKAS accredited laboratory within the last two years. Certificates are available upon request.

Location	Equipment	Type	Serial Number
P1	Sound Level Meter	Nor140	1403454
	Calibrator	Nor1251	34682
	Outdoor microphone	GRAS-41 AL#06	44949
P2	Sound Level Meter	Nor140	1403455
	Calibrator	Nor1251	34682
	Outdoor microphone	GRAS-41 AL#07	42111

Table 6: Monitoring kit

6.4. The weather during the monitoring period has been summarised below.

Date	Time	Weather	Temperature °C	Wind Speed ms^{-1}	Wind Direction
20th August	Day 07:00 – 23:00	Cloudy, sunny intervals	16-19	2.7-4.0	SW/SSW
20th/21st August	Night 23:00 – 07:00	Clear	14-16	3.1-4.0	SSW/SSE
21st August	Day 07:00 – 23:00	Sunny intervals	16-19	3.1	SSE
21st/22nd August	Night 23:00 – 07:00	Cloudy	13-16	4.0	SSW
22nd August	Day 07:00 – 23:00	Cloudy, sunny intervals	15-20	1.8-4.0	NW
22nd/23rd August	Night 23:00 – 07:00	Clear	14-16	1.8	NW
23rd August	Day 07:00 – 23:00	Cloudy, sunny intervals	14-19	3.6-4.5	N

Table 7: Weather

6.5. The sound level meters were set up to measure in 15min periods.

6.6. The parameters measured were overall $L_{Aeq,15min}$ and $L_{A90,15min}$.

6.7. Graph 1 shows the statistical analysis of the overnight background sound levels, $L_{A90,15min}$ at P1.

6.8. From Graph 1, dBC has determined a representative night-time background sound level at P1 of 28dB $L_{A90,15min}$. The night-time modal ambient level was 37dB $L_{Aeq,15min}$.

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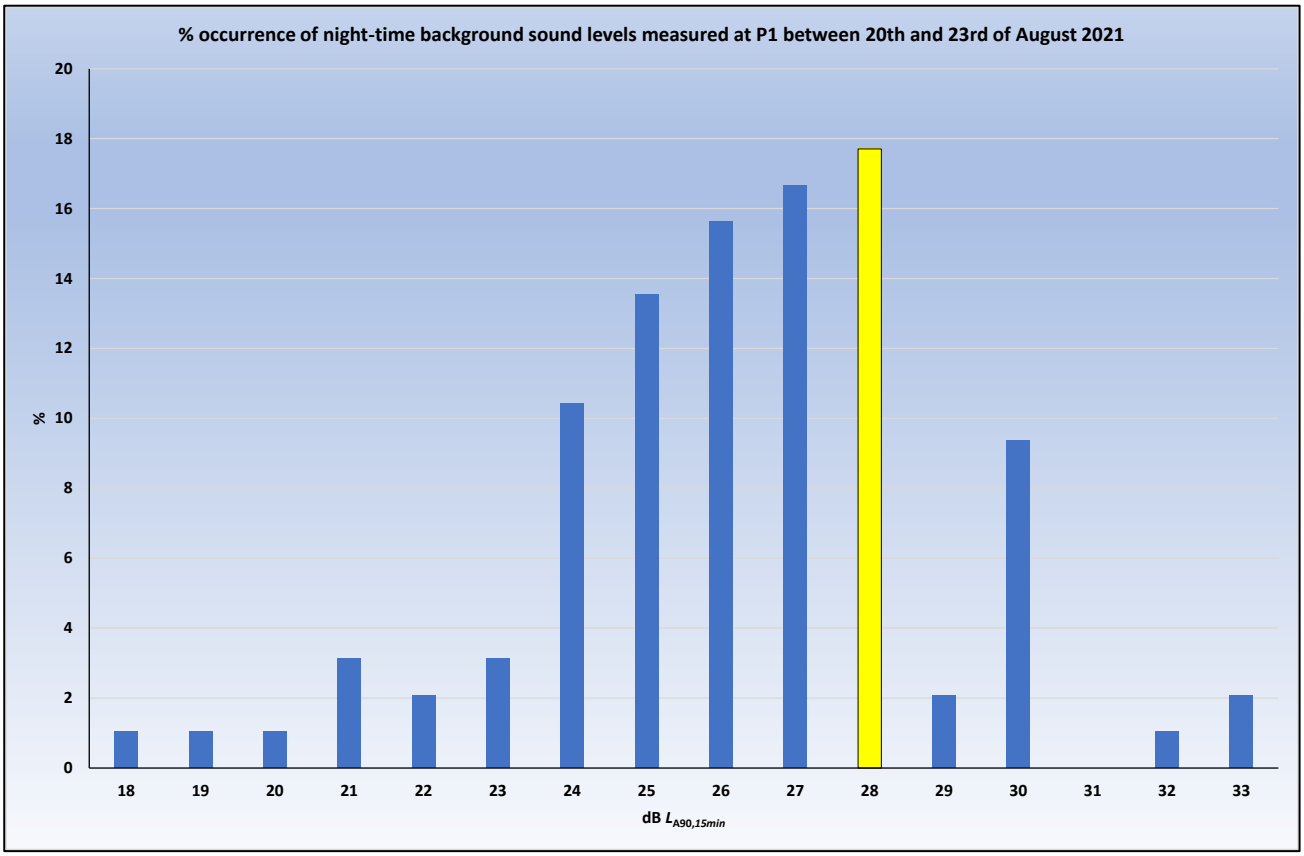
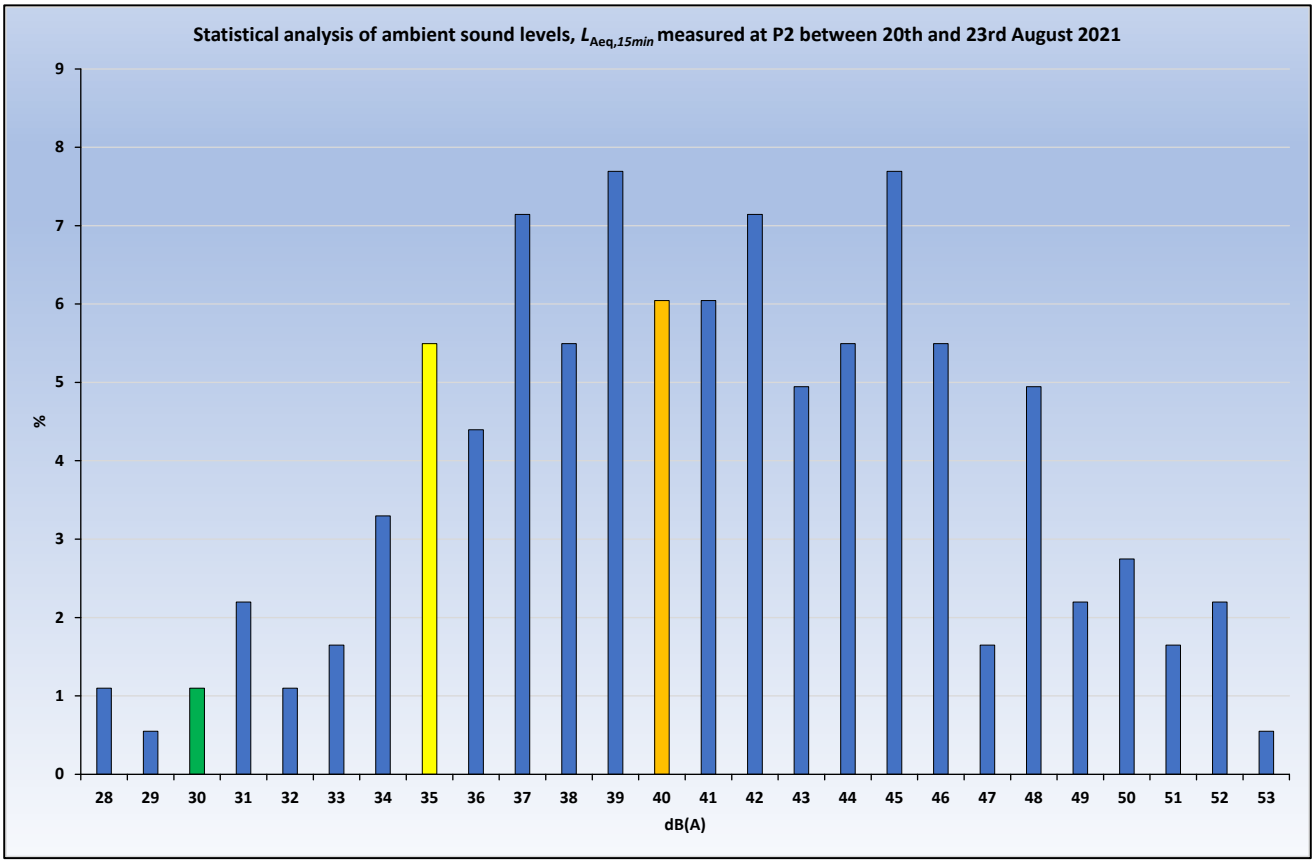


Graph 1: Statistical Analysis of the night-time background sound levels at P1

6.9. The rating and background sound level is very low at P2, so an assessment of absolute levels using guidance methodology in NPSE as detailed in Section 3 Page 7 has been undertaken for NSR2 Willow Cottage.

6.10. The statistical analysis of the ambient sound levels at NSR2 is shown in Graph 2.



Graph 2: Statistical Analysis of the night-time ambient sound levels at P2

6.11. For the assessment of absolute levels at NSR2, the following NOEL, LOAEL and SOAEL terms have been determined from the ambient sound levels measured at P2 on during the survey.

No Observed Effect Level, NOEL 30dB(A) **Green**

Lowest Observed Adverse Effect Level, LOAEL 35dB(A) +5dB **Yellow**

Significant Observed Adverse Effect Level, SOAEL 40dB(A) +10dB **Orange**

6.12. The BS4142 and NPSE Assessment are detailed in Section 7.

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7. Assessment

BS 4142 Assessment – NSR1 8 Little Sheephurst Cottages

7.1. The night-time BS 4142:2014 assessment of the noise emission from the HV and BESS compounds at the external façade of NSR1 is shown in Table 8.

Results	Level	BS 4142 Relevant Clause	Commentary
Measured Ambient Sound level	N/A	7.3.1	The noise source is not present at the moment so ambient measurements not possible, not installed.
Residual Sound Level	N/A	7.3.2	Not operating
Background Sound level	$L_{A90,15min}$ = 28dB	8.1.2	Background measured at representative location of NSR1 in 15 min periods with no source
Night-time assessment period of 15min		7.2	
Calculated Specific Sound Level	$L_{p,15min}$ = 26dB	7.3.6	Determined by calculation of all contributing sources using CadnaA noise model
Rating level	29dB	9.2	+3dB penalty explained in paragraph 5.11
Background Sound level	28dB	8.1.1	
Excess of rating over background sound level	**+1dB**	11	**Assessment indicates that noise mitigation measures are not required for the process during the night-time**
Depending on context the assessment indicates a low impact		11	
Uncertainty of assessment	Low	10	The excess of +1dB above the background sound level, with background sound levels measured over an extended period so there is a high degree of certainty for the assessment.

Table 8: BS 4142:2014 Assessment for the proposed development at NSR1

7.2. The BS 4142:2014 assessment indicates that the noise emission from the BESS and HV compounds would have a low impact at NSR1.

7.3. The night-time modal noise level at P1 was 37dB(A) so it is unlikely that the noise from the development would be audible.

7.4. The rating level is very low so it is unlikely that the noise would be disturb sleep.

7.5. No Local Authority criteria for the development noise emission has been received by dBC at this stage. So, no conclusion of compliance can be made at his time.

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NPSE Assessment – NSR2 Willow Cottage

7.6. The model determined sound level at NSR2 was 24dB(A) at night. The NOEL limit was determined as 30dB(A) given the measured ambient sound levels at P2. The NSR2 level is below the NOEL level.

7.7. The specific sound is unlikely to be distinctly audible, disturb sleep, or induce a change in behaviour of receptors. Therefore, no mitigation measures are required for the development.

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8. Conclusions

8.1. dBC were informed the energy storage site may operate for a maximum of 6hrs in any 24hr period and only in 2hr blocks. dBC has assumed the system has the potential to supply electricity at full load over a full 15min period at any time of day, therefore the assessment of site noise will focus upon night-time noise.

8.2. The noise emission from the BESS and HV compound site were assessed at the two noise sensitive receptor locations NSR1 – 8 Little Sheephurst Cottages and NSR2 Willow Cottage.

8.3. The (worst-case) specific sound levels at the receptor locations were 26dB(A) at NSR1 and 24dB(A) at NSR2. Given the ambient and background sound levels measured at each receptor location NSR1 was assessed using BS 4142 and NSR2 with NPSE guidance.

8.4. A 3dB penalty was added to the specific sound level for change of acoustic character at NSR1 to gain a rating level of 29dB.

8.5. At NSR1, the representative background sound level was 28dB $L_{A90,15min}$.

8.6. The BS 4142:2014 assessment indicated a low impact at NSR1. Mitigation measures will not be required for the development.

8.7. Using NPSE guidance, the specific sound level at NSR2 is below the NOEL, so the impact will be negligible and unlikely to be audible or disturb sleep.

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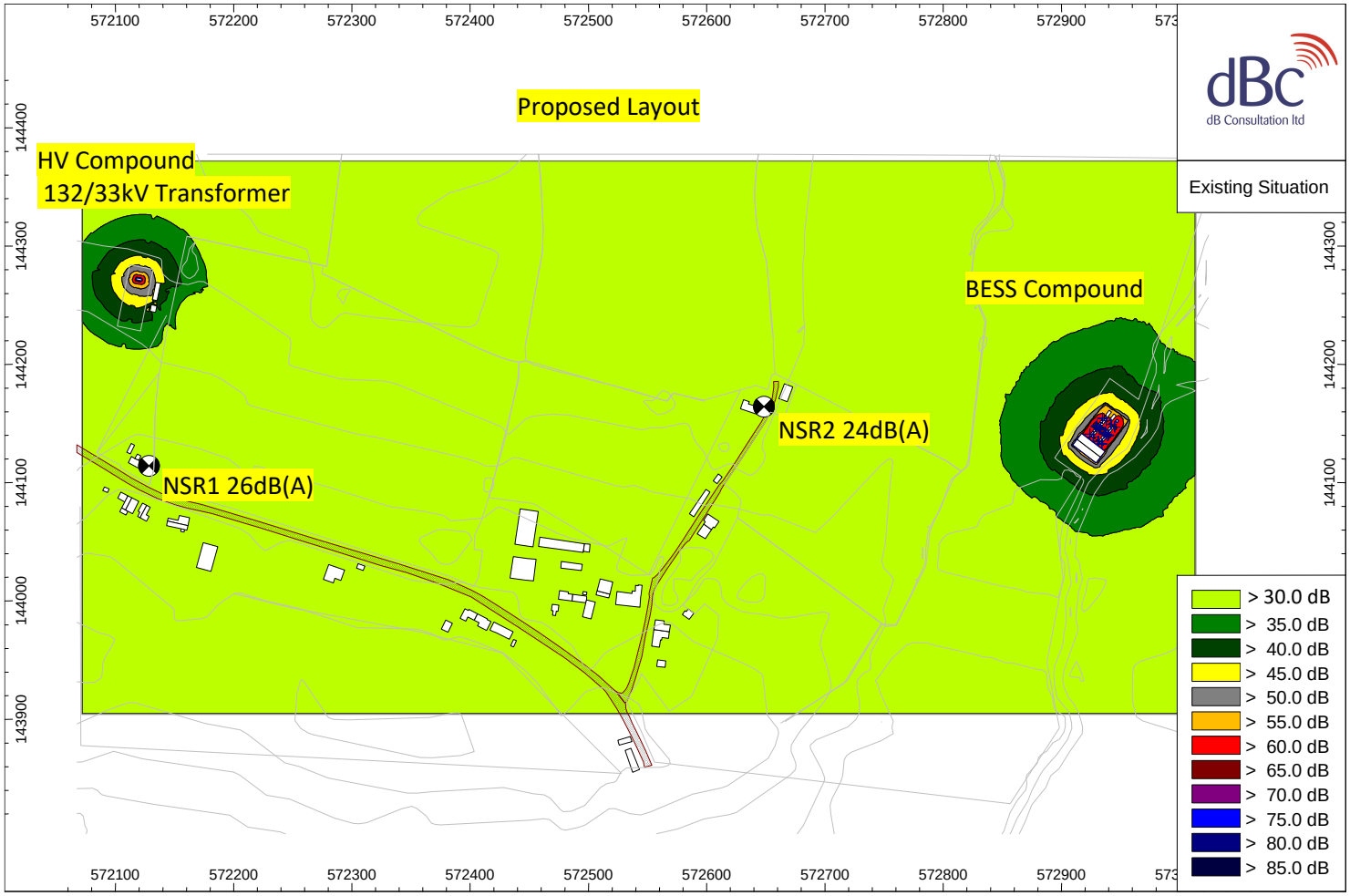
9. *CadnaA Images.*



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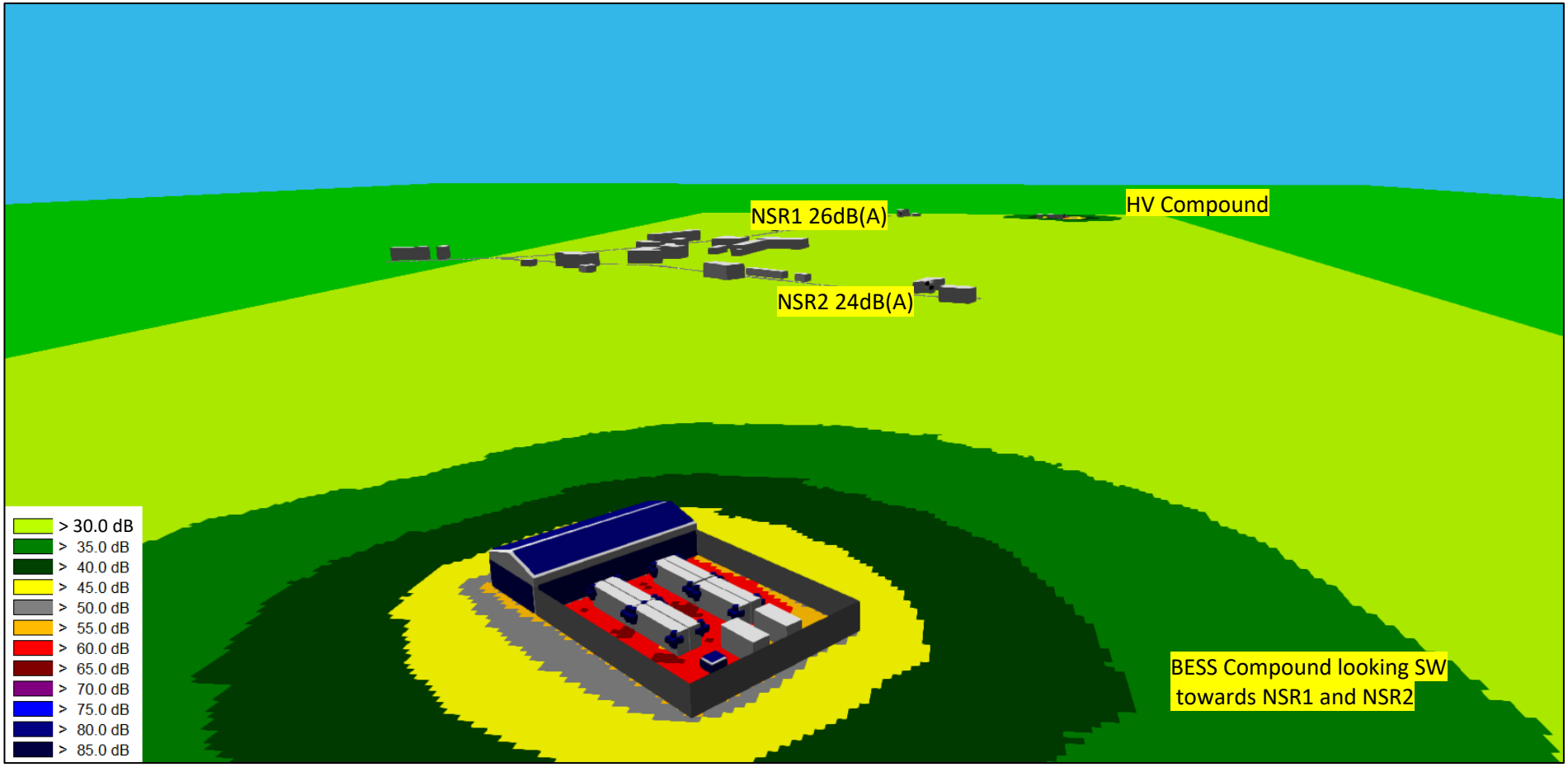

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10. Glossary of Acoustic Terminology.

dB(A)

The human ear is less sensitive to low (below 125Hz) and high (above 16kHz) frequency sounds. A sound level meter can be used to duplicate the ear's variable sensitivity to sound across a spectrum of frequencies. This is achieved by building a filter into the instrument with a similar frequency response to that of the average ear. This is called an "A-weighting filter". Measurements of sound made with this filter are called A-weighted sound level measurements and the unit is dB(A).

$L_{eq,T}$

The sound from noise sources often fluctuates widely during a given period of time. An average value can be measured, the equivalent sound pressure level Leq. The Leq is the equivalent sound level which would deliver the same sound energy as the actual fluctuating sound measured in the same time period (T).

$L_{10,T}$

This is the minimum level exceeded for not more than 10% of the time period (T). This parameter is often used as a "not to exceed" criterion for noise.

$L_{90,T}$

This is the minimum level exceeded for not more than 90% of the time period (T). This parameter is often used as a descriptor of "background noise" for environmental impact studies.

L_{fmax}

This is the maximum sound pressure level that has been measured over a period using a fast time constant.

Octave Bands

In order to completely determine the composition of a sound it is necessary to determine the sound level at each frequency individually. Usually, values are stated in octave bands. The audible frequency region is divided into 10 such octave bands whose centre frequencies are defined in accordance with international standards.

Addition of noise from several sources

Noise from different sound sources combine, on a logarithmic scale, to produce a sound level higher than that from any individual source. Two equally intense sound sources operating together produce a sound level which is 3dB higher than one alone and 3 identical sources produce a 5dB higher sound level.

Attenuation by distance

Sound which propagates from a point source in free air attenuates by 6dB for each doubling of distance from the noise source. Sound energy from line sources (e.g. stream of cars) drops off by 3dB for each doubling of distance.

Subjective impression of noise

Sound intensity is not perceived directly at the ear; rather it is transferred by the complex hearing mechanism to the brain where acoustic sensations can be interpreted as loudness. This makes hearing perception highly individualised. Sensitivity to noise also depends on frequency content, time of occurrence, duration of sound and psychological factors such as emotion and expectations. The following table is a reasonable guide to help explain increases or decreases in sound levels for many acoustic scenarios.

Change in sound level (dB)	Change in perceived loudness
1	Imperceptible
3	Just barely perceptible
6	Clearly noticeable
10	About twice as loud
20	About 4 times as loud

Barriers

Outdoor barriers can be used to reduce environmental noises, such as traffic noise. The effectiveness of barriers is dependent on factors such as its distance from the noise source and the receiver, its height and its construction.

Reverberation control

When sound falls on the surfaces of a room, part of its energy is absorbed and part is reflected back into the room. The amount of reflected sound defines the reverberation of a room, a characteristic that is critical for spaces of different uses as it can affect the quality of audio signals such as speech or music. Excess reverberation in a room can be controlled by the effective use of sound-absorbing treatment on the surfaces, such as fibrous ceiling boards, curtains and carpets.