Cuadrilla Bowland Ltd

Lancashire Shale Gas Exploration Sites

Regulation 22 Information - Noise

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Summary

This document sets out additional information in relation to noise from drilling and hydraulic fracturing at two proposed shale gas exploration sites: Preston New Road and Roseacre Wood.

The noise assessment in the Environmental Statement (ES) was undertaken using the methodology set out in British Standard BS5228: Part 1: 2009+A1: 2014[1], consistent with Government noise policy[2] and other infrastructure projects. No significant effect due to noise was identified, provided that hydraulic fracturing pumping operations did not take place at night.

Subsequent discussions with Lancashire County Council Planning Officers (LCC) led to noise mitigation being proposed to reduce off site noise levels from drilling to meet night time noise levels based on the Government's Planning Practice Guidance (PPG)[3] and the Technical Guidance to the National Planning Policy Framework[4] (NPPF) in relation to minerals workings. The levels that could be achieved were set out in emails to LCC in mid-January 2015.

Following the issuing of the Officer's Report in January 2015 to the Development Control Committee additional information related to noise mitigation measures for the sites was submitted by Arup to LCC in two papers entitled 'Noise Mitigation Proposals - Preston New Road Exploration' and 'Noise Mitigation Proposals - Roseacre Wood' . This additional mitigation would further reduce noise to a level below the World Health Organization (Europe) Night Noise Guideline (NNG). With regard to Government noise policy, the NNG is described by WHO (Europe) as Lowest Observable Adverse Effect Level (LOAEL)[5].

Arup's two papers described the additional noise mitigation measures proposed by the applicant to achieve a night time noise level that would be lower than the level that Cuadrilla had already committed to in earlier email correspondence to LCC (in mid-January 2015) for both sites. This document provides further information on these additional mitigation measures as well as describing the noise modelling and other assessment work undertaken to inform the noise level that can be achieved with additional mitigation.

The outcomes of the mitigation of drilling noise are summarised in the following table. For each proposed site, the noise levels are assessed at the most exposed façade of the closest residential property: Staining Wood Cottages at Preston New Road; and Old Orchard Farm at Roseacre Wood.

[1] BS5228: Part 1: 2009+A1: 2014. *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise*

[2] Noise Policy Statement for England, 2010; National Planning policy Framework (section 123), 2012; and Planning Practice Guidance | Noise, 2014.

[3] http://planningguidance.planningportal.gov.uk/blog/guidance/minerals/assessing-environmental-impacts-from-minerals-extraction/noise-emissions/

[4] Department for Communities and Local Government, 2012. *Technical Guidance to the National Planning Policy Framework.*

[5] World Health Organization, 2009. *Night Noise Guidelines for Europe. The evidence for the LOAEL is long term exposure to permanent noise sources such as road traffic and aviation noise. There is no evidence this applies to temporary sources, and application to temporary sources is likely to be precautionary.*

Site and receiver location	ES noise level	Level with initial* mitigation	Level with additional** mitigation
Preston New Road: Staining Wood Cottages	44dBL_{Aeq}	42dBL_{Aeq}	39dBL_{Aeq}
Roseacre Wood: Old Orchard Farm	42dBL_{Aeq}	40dBL_{Aeq}	37dBL_{Aeq}
*Mitigation proposed in December 2014 **Additional mitigation proposed in January 2015, as described above			

Free-field mitigated drilling noise levels compared with the ES predictions

At night, these may be compared with WHO Europe Night Noise Guidelines, which define a LOAEL of 40dB$L_{night,outside}$[6].

This document sets out information that was requested at a meeting between the applicant, LCC and Jacobs (5th February 2015) and as set out in a Jacobs' Technical Note (dated 11 February 2015 and handed over at a meeting on the 18th February 2015 – see Appendix A). The information was formally requested in a letter from LCC (26th February 2015) under Regulation 22 of the Town and Country Planning (Environmental Impact Assessment) Regulations 2011. This document contains:

- Details of the noise modelling procedures and assumptions;
- Refinements to the noise models submitted in the ES;
- Description of how the efficacy of the noise mitigation measures has been calculated;
- Details of additional noise mitigation proposed; and
- An outline noise management plan, which would be completed in full should planning permission be granted.

LCC's planning officers confirmed (at a meeting on the 5th February 2015 and at a subsequent meeting on the 18th February 2015) that no additional mitigation measures are required to reduce the noise levels at either of the two sites for fracturing during the day, as the noise levels that can be achieved during the day with the mitigation measures proposed (as set out in emails sent by the Applicant to LCC in mid-January 2015) are sufficiently low.

[6] Defined as an 'annual average'

1 Introduction

This document sets out additional environmental information in relation to noise from drilling and hydraulic fracturing at two proposed shale gas exploration sites: Preston New Road and Roseacre Wood. Appendix A provides Jacobs' technical note setting out the required information.

The noise assessment in the Environmental Statement (ES) was undertaken using the methodology set out in British Standard BS5228: Part 1: 2009+A1: 2014[7], consistent with Government noise policy[8] and other infrastructure projects. No significant effect due to noise was identified, provided that hydraulic fracturing pumping operations did not take place at night.

Subsequent discussions with Lancashire County Council Planning Officers (LCC) led to noise mitigation being proposed to reduce off site noise levels from drilling to meet the night time noise levels based on the Government's Planning Practice Guidance (PPG)[9] and the Technical Guidance to the National Planning Policy Framework[10] (NPPF) in relation to minerals workings. The levels that could be achieved were set out in emails to LCC in mid-January 2015.

Following the issuing of the Officer's Report to the Development Control Committee for the sites, two papers, entitled 'Noise Mitigation Proposals - Preston New Road Exploration' and 'Noise Mitigation Proposals - Roseacre Wood' were submitted by Arup to LCC on the 22nd January 2015.

Drilling is required to be a 24-hour process. With additional mitigation, noise at night from drilling operations at each of the two proposed sites would be further reduced to a level below the World Health Organization (Europe) Night Noise Guideline (NNG). With regard to Government noise policy, the NNG is described by WHO (Europe) as Lowest Observable Adverse Effect Level (LOAEL)[11].

This document provides information on the additional mitigation measures that was first requested at a meeting between the applicant, LCC and Jacobs (5th February 2015) and as set out in a Jacobs' Technical Note (dated 11th February 2015 handed over at a meeting on the 18th February 2015 – see Appendix A). The information was formally requested in a letter from LCC (26th February) under Regulation 22 of the Town and Country Planning (Environmental Impact Assessment) Regulations 2011.

In response to the request for further information, this document contains:

- Details of the noise modelling procedures and assumptions;
- Refinements to the noise models submitted in the ES;

[7] BS5228: Part 1: 2009+A1: 2014. *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise*
[8] Noise Policy Statement for England, 2010; National Planning policy Framework (section 123), 2012; and Planning Practice Guidance | Noise, 2014.
[9] http://planningguidance.planningportal.gov.uk/blog/guidance/minerals/assessing-environmental-impacts-from-minerals-extraction/noise-emissions/
[10] Department for Communities and Local Government, 2012. *Technical Guidance to the National Planning Policy Framework.*
[11] World Health Organization, 2009. *Night Noise Guidelines for Europe. The evidence for the LOAEL is long term exposure to permanent noise sources such as road traffic and aviation noise. There is no evidence this applies to temporary sources, and application to temporary sources is likely to be precautionary.*

- Description of how the efficacy of the noise mitigation measures has been calculated;
- Details of additional noise mitigation proposed; and
- An outline noise management plan, which would be completed in full should planning permission be granted.

LCC's planning officers confirmed (at a meeting on the 5th February 2015 and at a subsequent meeting on the 18th February 2015) that no additional mitigation measures are required at either of the two sites to reduce the noise levels for fracturing during the day, as the noise levels that can be achieved during the day with the mitigation measures proposed (as set out in emails sent by the Applicant to LCC in mid-January 2015) are sufficiently low.

2 Noise Modelling Information

2.1 Calculations Methodology

The assessment in the ES was based on data taken from Spectrum Acoustics' reports describing the determination of the sound power levels, as referenced in the ES[12,13]. For both drilling and hydraulic fracturing, the modelling reported in the ES assumed a point source for the whole site.

The ES reported no significant effects from noise, and as such it would not be necessary to provide additional noise mitigation, other than restricting the hours during which hydraulic fracturing pumping could operate. This was on the basis of the assessment undertaken using the ABC method described in BS5228-1, which showed compliance with, or only slight exceedence of, the criteria defined using this method and only a small number of affected properties.

Subsequently, noise mitigation options have been investigated, for which more detailed noise source models were created, using data for individual items of plant and discrete noise sources. This enabled the effects of screening and other mitigation options to be investigated. The following describes the assessments undertaken and the assumptions made.

2.1.1 Environmental Statement: Point source noise models

These models were based on measurements made by Spectrum Acoustics (SA) at Cuadrilla's earlier drilling and hydraulic fracturing sites in Lancashire, as noted above (Section 2.1).

SA reported a series of measurements around the site perimeter from which they had calculated a single sound power level for the whole site operation using standard methods. In addition, SA took measurements at more distant locations.

Arup found that SA's calculated sound power level based on site perimeter measurements led to an under-prediction of the noise levels at SA's more distant measurement locations. A correction was therefore applied to the point source

[12] Sound Power Assessment. Drillmec HH-220 Drilling Rig Operated by Cuadrilla Resources Limited, Report Ref PJ2809/PJ/10193, September 2010
[13] Sound Power Assessment. Frac Operations. Preese Hall Exploration Site, Report Ref PJ2877/PJ/10193, September 2010

noise level to make predictions consistent with the more distant data, leading to a conservative assessment, by increasing the assumed source noise level by:

- +3.7dB for drilling
- +5.0dB for fracturing

The data from SA provided octave band spectra and these have been used in the noise modelling, for fracturing and for drilling. The source corrections were applied equally at all frequencies.

2.1.2 Directivity

SA's report on drilling noise from the HH-220 drilling rig (referred to above – reference 12 of the preceding page) summarises the drilling noise measurement results, the data showing the sound level to have some directivity, described as follows:

> *Based on the apparent sound power levels applicable to each side of the well site, the following approximate directivity factors can be established:*

Side	***Main equipment item on side***	***Directivity (dB)***
A	*Workshop / Stores*	*-2*
B	*Mud Tank / Shaker Tables*	*0*
C	*Drill Pipe Carousel*	*-2*
D	*Generators*	*+3*

As described in Section 2.1.1 above, a correction was applied to ensure the point source model was consistent with the more distant measurements. To do this, a correction was applied that is greater than the reported directivity in any direction and therefore compensates for directivity, albeit more in some directions than in other directions.

Directivity of fracturing noise was addressed in a similar way and based on SA's report on the Preese Hall site (referred to above - reference 13 of the preceding page).

> *Based on the apparent sound power levels applicable to each side of the exploration site, the following approximate directivity factors can be established:*

Side	***Main equipment item on side***	***Directivity (dB)***
A	*Water tanks*	*-1*
B	*Workshop / Site offices*	*+2*
C	*Service Rig*	*-1*
D	*Separator*	*+2*

2.1.3 Propagation and attenuation of sound

Noise modelling and the propagation of sound from the site used SoundPlan[14] software, which is a well-established, industry-standard, 3D noise modelling package that implements ISO 9613-2:1996[15] and has the following features:

- Distance attenuation
- Ground absorption
- Assumes down wind conditions
- Source directivity
- Atmospheric attenuation
- Diffraction

A 3D model was created that includes not only the sound sources, but also the topography, ground cover and buildings.

Table 1 to **Table 4** present the parameters used in the SoundPlan model.

Ground absorption	Applicable to:	Used in the model for:
G = 0	100% hard ground such as asphalt, water or industrial sites	Roads, water bodies
G = 1	100% soft ground such as fields, forests or grass	All other areas

Table 1 Ground absorption parameters

Parameter	Value
Reflection order	1
Max search radius (m)	5000
Max reflection distance from receiver (m)	200
Max reflection distance from source (m)	50
Allowed tolerance (dB)	0.001

Table 2 SoundPlan calculation parameters

[14] See http://www.soundplan.eu/english
[15] *ISO 9613-2: 1996 Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation*

Parameter	Two Storey	Single Storey
Height of building (m)	8.00	3.50
Height of first receiver above ground floor (m)	1.50	1.50
Height of floors (m)	2.80	2.80
Number of floors	2	1
Number of basement floors	0	0

Table 3 SoundPlan buildings properties

Parameter	Value
Air pressure	1013.3 mbar
Rel. Humidity	70.0%
Temperature	10.0°C
Meteorological Correction.	Zero (worst case assumption)

Table 4 SoundPlan atmospheric properties (SoundPlan default values)

For the fracturing noise assessment, noise levels are calculated and presented at 1.5m above ground level, since the noise would generally be experienced outdoors or in ground floor rooms during the day. Drilling noise was calculated at an elevation of 4m above ground level to determine noise impacts at first floor level to assess noise impacts at bedroom windows.

2.1.4 Error and uncertainty

The approach taken to modelling and the predicted noise levels are considered to provide a reasonable worst case for each scenario for the following reasons:

- Noise propagation assumes downwind conditions in all directions from the noise source(s).
- As noted in Section 2.1.1 above, the source noise levels from SA's reports were adjusted to match the more distant measured noise levels rather than those at the site perimeter by adding 3.7dB for drilling and 5.0dB for fracturing.
- The assessments all focus on the most exposed façade of the single closest residential dwelling to each site. At properties at greater distance from the site and at facades without a direct line of sight to the site, noise levels will be lower than those tabulated/reported.
- Night time noise levels are calculated at first floor window level; daytime calculated levels reflect outdoor living space and ground floor rooms.

3 Post-ES noise source model refinements and mitigation

The mitigation options that have been proposed since the ES was produced are described and assessed below. To enable the mitigation options to be quantified, the point source noise models were refined as set out in this section. Again, a conservative approach to prediction was taken, including:

- The source noise level is assumed to be that for the drilling phase of the process, whereas other phases of the process cause lower noise levels.
- The assumed efficacy of much of the mitigation is conservative.

Additionally, the noise barrier heights assessed in the noise modelling are at the low end of the ranges presented in the visualisation study report and therefore present a conservative assessment of the mitigation that could be achieved.

3.1 Fracturing noise

Mitigation in the form of noise barriers has been proposed in relation to a request from Natural England to reduce noise levels so as to avoid disturbance to wildfowl in fields adjacent to the proposed sites. This required individual noise sources to be established and attributed with locations and source noise levels. The model was based on the layout of plant as shown in SA's Preese Hall report, which is reproduced in **Figure 1** below.

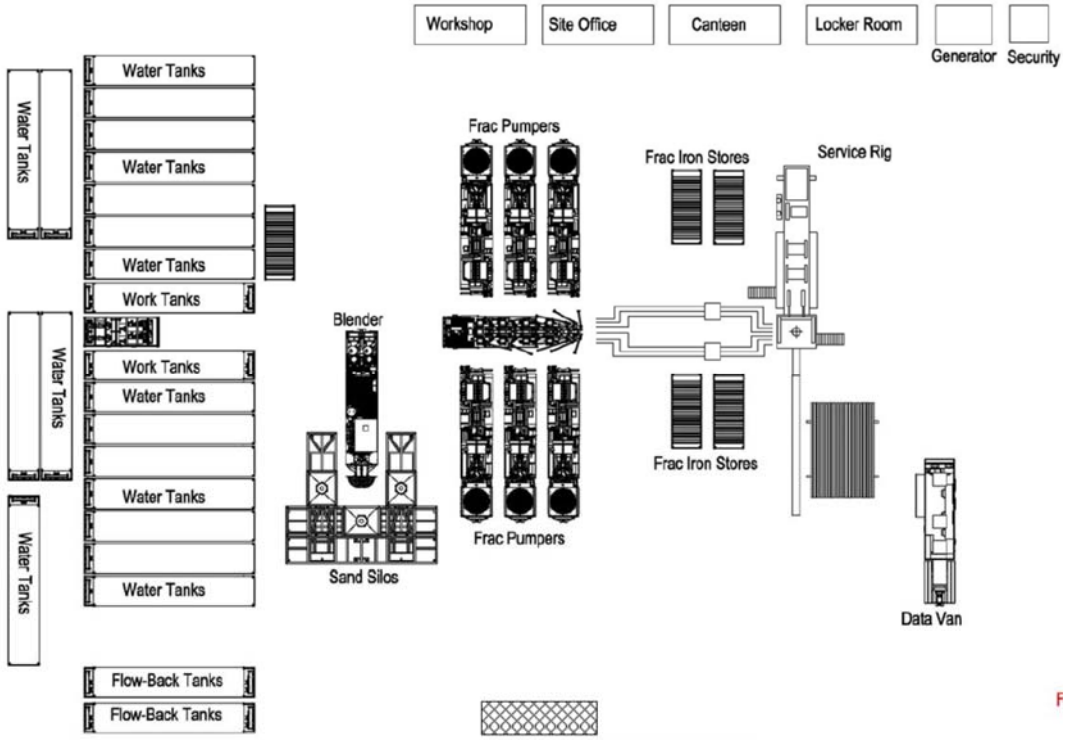

Figure 1 Fracturing site layout (from SA's Preese Hall report)

The refined noise model assumed six fracturing pumps, each consisting of a pump, fan and engine (generator). Arup's in-house library of sound measurement

data was used to define spectrum shapes and relative noise levels for each of these three source types. The proxy equipment used was:

- Fan – 15kW cooling tower fan from Baltimore Aircoil Company
- Pump – Mach 4 Freightliner fire engine pump; engine revving to drive pump
- Generator – 630KVA Detroit V16 diesel engine

The spectra are given in **Table 5**.

Source	Octave band centre frequency (Hz)								dB(A)
	63	125	250	500	1000	2000	4000	8000	
Fan	115	116	113	112	110	104	98	93	114
Pump	88	94	102	105	103	100	94	90	96
Engine	103	112	111	112	111	112	106	100	105

Table 5 Fracturing pump elements noise spectra – point source sound power levels.

3.1.1 Mitigation of fracturing noise

The combined noise level from six pumps was adjusted to replicate the distant unmitigated point source noise levels presented in the ES. Mitigation was then designed in the form of a noise barrier positioned 2m from the pumps. The height of the barrier was determined to protect birds in the adjacent fields identified by the ecological assessment. The solution was found to be a solid noise fence, 5m high and topped with a 1m return angled at 45° projecting into the enclosure.

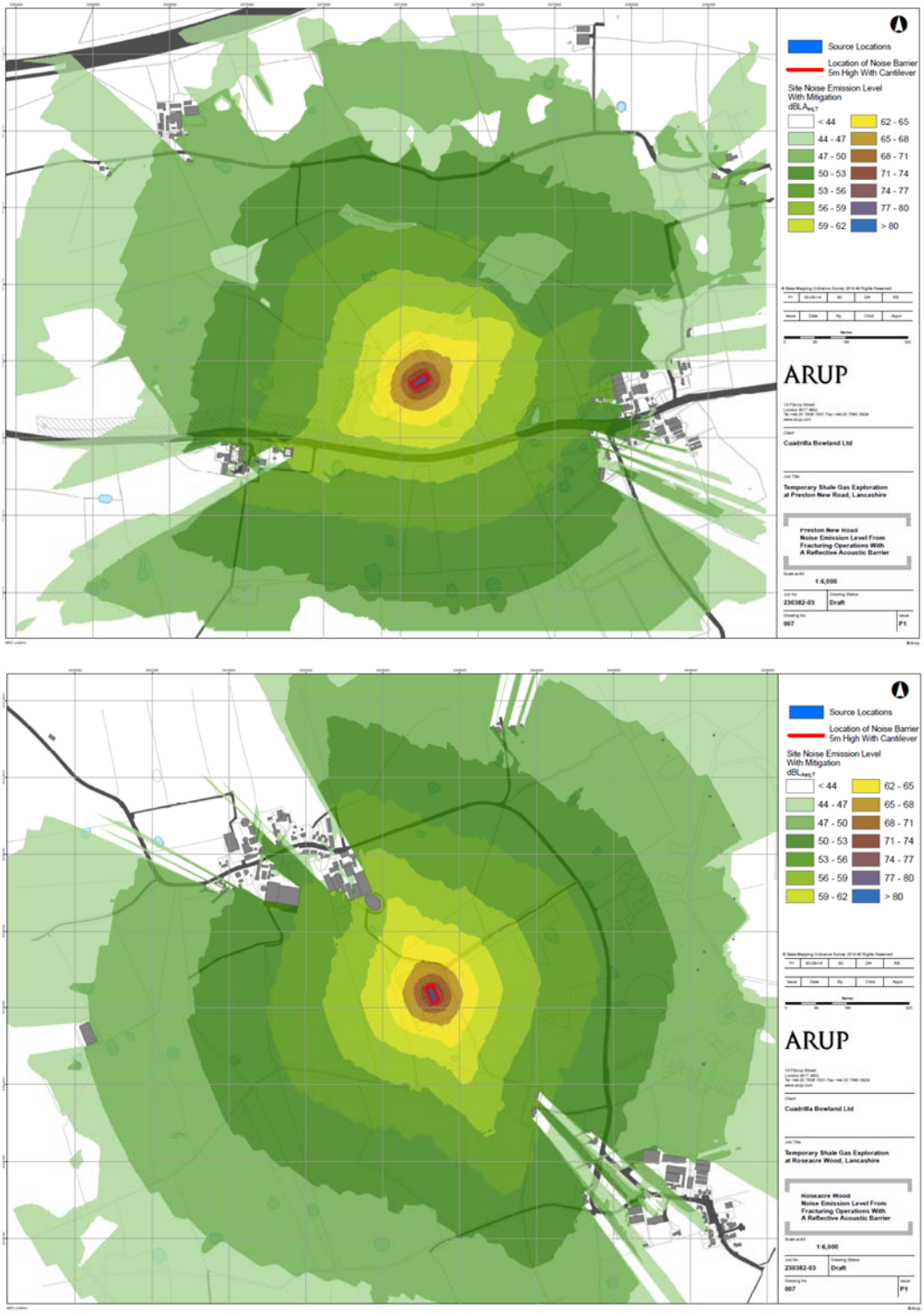

Figure 2 Noise maps for mitigated fracturing noise (top – Preston New Road; bottom – Roseacre Wood)

Table 6 summarises the maximum noise reduction that is achieved at the closest dwellings by the proposed screening of the fracturing pumps. The amount of reduction depends on the location within the proposed exploration site of the fracturing pumps, but no scenarios lead to higher noise levels at the closest dwellings than those presented in the ES.

Site and receiver location	Free field noise level from the ES (no mitigation) (dBL_{Aeq})	Predicted maximum noise level reduction due to barrier (dBL_{Aeq})	Noise level with barrier in place (dBLAeq)
Preston New Road: Staining Wood Cottages	62	-9	53
Roseacre Wood: Old Orchard Farm	54	-2	52

Table 6 Noise reduction at closest dwellings due to fracturing noise barrier

3.2 Drilling noise

To quantify the relative noise emissions of the elements of the drilling equipment, measurements were made at the Horse Hill drill site, Horley, East Sussex[16] (**Figure 2**), where the same HH-220 drilling rig that is proposed for use in Lancashire was operating. Details of the measurements, measurement locations and results are given in Appendix C; a brief summary is provided below.

The site was an operational drill site, operated by a third party. The measurements were therefore necessarily made without interference with or interruption of the drilling process. Individual items of plant could not be tested separately, so noise measurements were made close to each but in the presence of other site noise.

Figure 2 Horse Hill drill site (left – taken from planning application documents; right – © GoogleEarth). Scale bar from site to closest dwelling is approximately 350m.

The measured noise levels made close to the sources were used to create a three dimensional noise model of the entire drill site (**Figure 3**) as follows.

The drilling rig layout was reproduced in the noise model using three dimensional 'building' objects, 'noise barrier' objects, horizontal 'screens' and area sources. The measurement locations grouped into two categories: measurements close to a single piece of equipment; and more distant measurements around the site, which

[16] Details of the site and planning approval are at http://www.horsehilldev.co.uk/company-detail/2304135-the-plan

included contributions from multiple sources. These measurement locations were reproduced in the model and source levels were added as area sources to the sides and top of corresponding building objects based upon the near field equipment measurements. The measurements identified the principal noise sources to be:

- Main rig and hydraulic power unit
- Shale shakers
- Generators and
- Mud pumps

The model was then iteratively run with adjustments made to each of the area source levels until the results at the more distant measurement locations were reproduced as closely as possible to provide a calibrated noise model. **Table 6** compares the calibrated noise model with the more distant measurements.

Measurement location*	**Measured level (dBL_{Aeq})**	**Calibrated model level (dBL_{Aeq})**	**Difference dB(A)**
5	74.6	75.9	+1.3
6	69.2	69.4	+0.2
7	73.0	72.7	-0.3
8	81.0	80.5	-0.5
15	83.4	83.8	+0.4
16	75.1	75.6	+0.5
17	65.1	67.9	+2.8
18	66.7	68.6	+1.9
21	76.0	74.9	-1.1
*See site layout plan in Appendix C			

Table 6 Calibrated noise model

In addition to the measurements described above, a noise logger was installed on the earth bund towards one corner of the site which logged statistical noise levels every minute for approximately 19 hours. These logged noise levels were compared with the drilling operations log and separated into three classes: sliding, drilling or other. Drilling refers to use of the top drive to rotate the drill string, whereas sliding is progressing the bore without use of the top drive. For each operation class, an $L_{Aeq,1h}$ was calculated from the logged noise level. These levels are summarised in **Table 7**.

Operation	**Noise level at logger ($dBL_{Aeq,1h}$)**
Sliding	60.4
Drilling	62.3
Other	61.1

Table 7: Operation noise levels at the corner of the site

The location of the remote noise monitor was reproduced in the noise model and, after the equipment levels were calibrated in the noise model, resulted in a drilling noise level at the logger of 62.4dBL_{Aeq}.

It should be noted that the noise logger was downwind of the drilling rig, so the calibration has been made to a level that will provide conservative (i.e. high) predicted impacts.

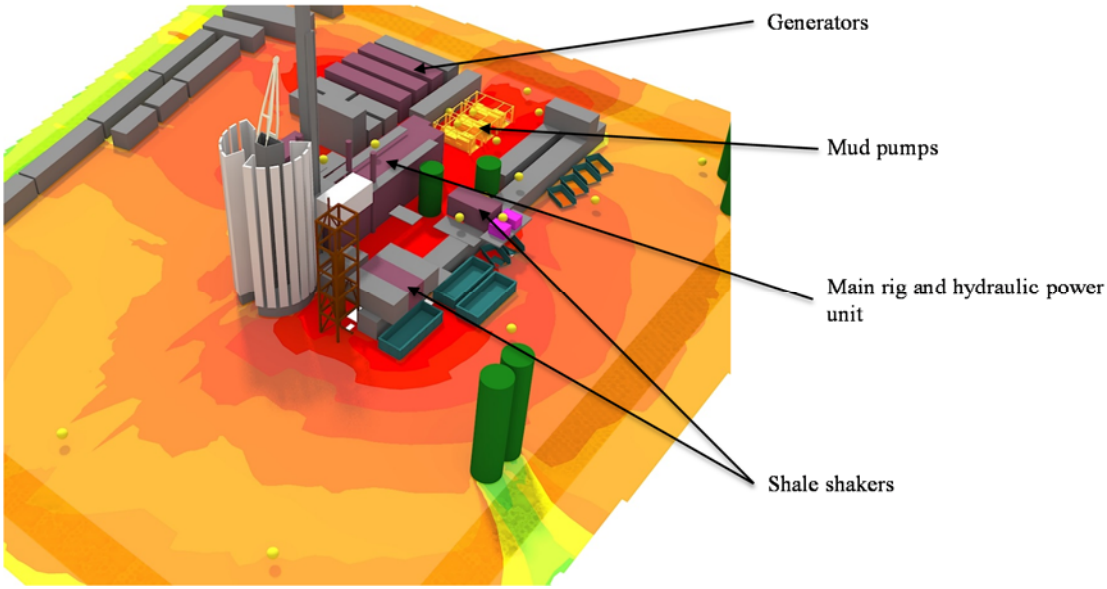

Figure 3 3-dimensional noise model

The calculated sound power levels for each of the items of the drilling equipment used in the noise model are given in **Table 8**.

Drilling equipment	Octave band centre frequency (Hz)									dB(A)
	31.5	63	125	250	500	1000	2000	4000	8000	
Generator Sets	90	87	92	80	76	74	68	62	55	80.4
Generator Louvres	86	83	88	66	64	63	56	48	42	73.1
Mud Pumps	84	86	86	89	83	79	76	75	68	85.9
Shale Shaker	95	92	89	83	80	78	76	75	71	84.2
Drilling Rig	87	83	83	92	80	75	69	66	61	85.1
Drill Head	87	86	83	86	84	81	76	69	63	85.7
HPU	82	81	83	86	79	73	72	69	62	81.8
HPU Louvres	81	81	84	87	77	73	72	69	61	81.8

Table 8 Drilling plant calibrated sound power levels per metre, dB

The drill site noise model was incorporated into the same three dimensional digital terrain model for each proposed drill site as used in the ES.

3.2.1 Mitigation of drilling noise

Various mitigation options were investigated. In addition to the measures applied to individual elements of the plant, noise barriers around the site perimeter and the

location of the drilling equipment within the proposed site boundary were also investigated.

Table 9 and Table 10 summarise the mitigation options assessed and the reductions in noise levels attributable to each.

Mitigation	Benefit / noise reduction	Justification
4m high noise barrier fence	Variable depending on the source and receiver locations	Conventional noise barrier calculation implemented by SoundPlan
Sound absorption in enclosures to drilling rig shale shakers (doors closed)	Source level reduced by 5dB	Horse Hill measurements were with shale shaker doors open; these would be closed. The BS5228-1 guidance on enclosures is as below
Sound absorption in enclosures to generators, including louvres	Assumed 4dB	Generators as measured were partially enclosed. Mitigation taken to be lower than the reductions quoted by BS5228-1
Enclosures to drilling rig mud pumps	No reduction included in the model but some effect expected	BS5228-1 Table B.1 5-10dB for engine enclosures BS5228-1 Table B.4 gives ≥6dB for partial enclosures (with sound absorption)
Rubber bushings to reduce pipework vibration	Not quantifiable but some beneficial effect expected	No reduction made in source noise levels. Any reduction would be over and above that assumed

Table 9 Initial methods for drilling noise mitigation

Mitigation	Benefit / noise reduction	Justification
7m high sound barrier around the main rig and hydraulic power unit	5dB(A)	Based on PowerClad[17] system (900gsm) transmission loss data. The applicant's proposals are a more substantial system, so 5dB is likely to be a cautious estimate
Interventions to the hydraulic power unit (e.g. acoustic louvres); attenuators to generator exhausts, etc.	1dB(A)	Model includes a modest reduction for additional mitigation to various elements. BS5228-1 Table B.4 shows even an open sided shed (at the open side) treated with sound absorbing material will reduce noise emission by 1dB

Table 10 Methods for additional mitigation of drilling noise

Site and receiver location	ES noise level	Level with initial* mitigation	Level with additional** mitigation

[17] See http://www.itpltd.com/en/product/powerclad-acoustic-insulated-sheeting

Preston New Road: Staining Wood Cottages	44dBLAeq	42dBLAeq	39dBLAeq
Roseacre Wood: Old Orchard Farm	42dBLAeq	40dBLAeq	37dBLAeq
*Mitigation proposed in December 2014 **Additional mitigation proposed in January 2015 in response to recommendation for refusal, as described above			

Table 11 summarises the drilling noise levels achieved at the most exposed facades of the closest dwellings.

The additional mitigation would further reduce noise levels to below the WHO's Night Noise Guideline, also defined as the LOAEL, of 40dBL_{Aeq}.

Site and receiver location	**ES noise level**	**Level with initial* mitigation**	**Level with additional** mitigation**
Preston New Road: Staining Wood Cottages	44dBL_{Aeq}	42dBL_{Aeq}	39dBL_{Aeq}
Roseacre Wood: Old Orchard Farm	42dBL_{Aeq}	40dBL_{Aeq}	37dBL_{Aeq}
*Mitigation proposed in December 2014 **Additional mitigation proposed in January 2015 in response to recommendation for refusal, as described above			

Table 11 Summary of free-field mitigated drilling noise levels and comparison with the ES predictions

4 Acoustic characteristics

Noise characteristics were not discussed in the ES. The following provides further supporting information to demonstrate that this does not affect the outcomes of the assessment. Characteristics considered are impulsivity, tonality and low frequency noise.

4.1 Impulsivity

Jacobs' letter to LCC dated 16 December 2014 noted:

> *…it is implied that during normal drilling operations there are no impulsive aspects to the noise.*

This is taken to be in relation to the SA report describing the determination of the sound power levels, as referenced in the ES[18].

SA's report from the Anna's Road[19] site also states:

[18] Sound Power Assessment. Drillmec HH-220 Drilling Rig Operated by Cuadrilla Resources Limited, Report Ref PJ2809/PJ/10193, September 2010

[19] Noise Impact Assessment for Lateral drilling of Sidetrack Borehole Anna's Road Exploration Well Site, Westby, Blackpool, Report Ref PJ3084/12320, January 2013

> *… noise emission from the drilling operations is essentially steady…, During the overnight period there were occasional higher noise 'spikes' produced by transient or impulsive events at the well site, however, only 4 of these produced noise levels 10dB(A) above the steady LAeq noise level of 65dB(A).*
>
> *Impulsive events are commonly defined as 'regular' if they occur 10-15 times over a period (reference WHO guidelines for community noise), so in this case the transient or impulsive events, would be best described as occasional.*

This indicates that there are no impulsivity characteristics that would change the assessment approach for noise associated with drilling. Another SA report, on the impacts of drilling noise on wintering birds[20], supports this:

> *Whilst there will be occasional higher LAmax levels above the 50dB(A) significant effect level, such higher levels of impulsive, or transient, noise from drilling operations have been shown to be an occasional, rather than a regular occurrence.*

At the Horse Hill drill site, observations and measurements were made of the drilling process in the vicinity of each element of the drilling rig. Subjectively, little impulsivity was observed for the majority of the plant, with the exception of the process for adding a new pipe to the drill string. This created only a small number of intermittent impulses, which were confined to a period of a few minutes as each additional pipe was added.

It is our professional opinion that, at the distance of the closest dwellings, such impulsive characteristics of drilling noise are very unlikely to have any impact.

With regard to the fracturing process, impulsive noise events are not associated with the main sources of noise (diesel engine, pump, fan) required for the process.

4.2 Tonality

The evidence available at the time of preparing the ES, taken from SA's reports, indicated no tonal content to the noise. SA's report from Anna's Road[21] stated:

> *Tonal noise emission is not generally associated with well site operations, with the major equipment items having a broadband noise signature.*

To investigate this further, the Horse Hill measurement data taken by Arup have been considered, both in terms of subjective assessment and by reference to BS4142:2014. The measurements made close to each source provide a worst case, since, as noted in BS4142, "*The prominence of tonal or impulsive sound from a source can be masked by residual sound*". The one-third octave objective method from Annex C of BS4142 has been used, which is as follows:

> "*For a prominent, discrete tone to be identified as present, the time-averaged sound pressure level in the one-third-octave band of interest is*

[20] Noise Impact Assessment on Wintering Birds. Anna's Road Exploration Well Site, Westby, Blackpool, Report Ref PJ3056/12320, October 2012
[21] Noise Impact Assessment for Lateral drilling of Sidetrack Borehole Anna's Road Exploration Well Site, Westby, Blackpool, Report Ref PJ3084/12320, January 2013

required to exceed the time-averaged sound pressure levels of both adjacent one-third-octave bands by some constant level difference.

The level differences between adjacent one-third-octave bands that identify a tone are:
• 15 dB in the low-frequency one-third-octave bands (25 Hz to 125 Hz);
• 8 dB in the middle-frequency one-third-octave bands (160 Hz to 400 Hz); and
• 5 dB in the high-frequency one-third-octave bands (500 Hz to 10 000 Hz)"

For each of the main sources of noise, Appendix B illustrates the spectral content. Subjectively, much of the plant had no tonal quality, however there was a tonal content to some items, which generally appears as in the 200Hz 1/3 octave band and associated with the hydraulic power unit. The source was not identified in detail on site, but appeared to be radiated from hydraulic pipework. It is therefore expected that this could be readily mitigated if the tonal characteristic were to exist and be discernible at distances as great as the closest properties.

No data were acquired during the Horse Hill study to enable the noise character at distance to be assessed. However, given the low levels of noise predicted at the closest dwellings, it is considered that any tonal content will not have any impact.

4.3 Low frequency noise

Concerns have been expressed about the possible effects of low frequency noise.

All the relevant standards and guidance recommend that A-weighted sound pressure levels should be used to rate and assess noise impacts. The frequency content associated with the proposed fracking and drilling processes is similar to that of other sources of sound covered by the guidance and there is nothing to suggest that a separate consideration of low frequency noise is necessary. In fact, problems associated with low frequency noise are quite infrequent if not rare.

In view of the nature of the noise sources and the low levels of noise predicted it is concluded that low frequency noise is very unlikely to give rise to any adverse effect.

4.4 Summary

It is concluded from the above that there are no noise characteristics that would change the impact of the noise associated with the proposed works.

5 Noise Management Plan

All Best Practicable Means, as defined by Section 72 of the Control of Pollution Act 1974, will be used to control and minimise noise from the site. This will ensure that significant adverse effects will be avoided and that any adverse impacts will be minimised as far as is reasonably practicable.

The following provides a draft framework for a noise management plan for discussion with LCC.

1. General

2. Working Hours
- Normal working hours
- Start up and shut down periods
- Repair and maintenance works
- Extended working hours – foreseeable specific activities
- Extended working hours – emergency or unforeseen activities

3. Noise Control
- Plant selection
- Inventory of plant and noise levels
- Operating practices
- Maintenance and repair of equipment
- Noise trigger levels (including time dependency)
    - Warning levels
    - Action levels
- Noise mitigation

4. Prediction of Noise Levels

5. Noise Monitoring
- Equipment specification
- Calibration procedures
- Noise sensitive receptors
- Monitoring locations
- Data recording and reporting
- Access to data

6. Complaints procedure
- Community liaison and on-site contact
- Escalation procedure

7. Pre-mobilisation existing noise levels survey

Appendix A

Jacobs' Technical Note

A1 Jacobs' Technical Note

The following provides the text from Jacobs' Technical Note, which set out the additional information required. Text in ***bold italics*** identifies where within Arup's report the information is provided.

1. Purpose

To enable LCC to fully appraise the further information on noise submitted by the applicant in response to the Regulation 22 request, all input data, any assumptions used in computer models (or spreadsheets), and the mitigation proposals must be clearly set out.

This technical note is intended as a checklist to assist the applicant when providing this information. Where the information on this checklist is not available or otherwise cannot be provided, the applicant is advised to consult with LCC at the earliest opportunity.

2. Overview

An overview of the proposed drilling rig, ancillary equipment and processes is required. This should include:

- Descriptions of proposed drilling rig and ancillary equipment: ***see Section 3.2, Figure 4 & Appendix C1.3.***
- Proposed operational procedures / methods of working: ***see Section 3.2.***
- Identification of the primary sources of noise emissions: ***see Section 3.2, Appendix C1.3 & Table C.1.***

3. Noise sources

Details of the noise measurements undertaken at the operational drilling rig at the Horse Hill site:

- Equipment used for the measurements: ***see Appendix C1.2.1 & C1.2.2***.
- Records of equipment calibration: ***see Appendix D***.
- Weather conditions: ***see Appendix C1.2.3***.
- Measurement general procedure: ***see Appendix C1.2.4 & C1.2.5***.
- Measurement locations, durations and measured 1/1 or 1/3 octave band Sound Pressure Levels (dB ref 2 x 10^{-5} Pa): ***see Appendix C1 Figure C1-2*****:** Noise Measurement Locations ***& Table C1.***
- Corrections applied to measured levels for the influence of other noise sources: ***see Section 3.2 & Table 7.***

- The procedure adopted for converting Sound Pressure Levels to Sound Power Levels (dB ref 1 x 10-12 W): ***see Section 3.2 & Table 7.***

4. Modelling

Details regarding the layout of the proposed drilling rig and selected calculation parameters:

- CAD files of the drilling rig layout (including any external references, in AutoCAD DWG or DXF format), geo-referenced to British National Grid coordinates (OSGB36 projection) and in metre units: ***see Section 3.2, Figure 4 & Appendix C1.3 Figure C1-2.***
- Heights for each item of plant / building / structure, specifying at which stage they will be installed at the site. Each structure to be clearly marked on the plant layout drawings: ***see Section 3.2, Figure 4 & Appendix C1.3 Figure C1-2.***
- Selected calculation methodology (e.g. ISO 9613-2): ***see Section 2.1.3***.
- Parameters for the calculation methodology (e.g. ground effect values for surfaces, air temperature, relative humidity): ***see Section 2.1.3.***
- The operating scenarios included in the modelling, indicating times/frequency of occurrence, the mechanical equipment that will be operating for each scenario: ***see Section 3.2 (Drilling) & Section 3.1 (Fracturing).***
- A schedule of the noise sources in the model identifying:
    - Sound Power Levels (dB ref 1 x 10-12 W): ***see Section 3.2 Table 9 (Drilling) & Section 3.1 Table 5 (Fracturing).***
    - The operation of plant (e.g. continuous or intermittent) and any on-time corrections: ***see Section 3.2 (Drilling) & Section 3.1 (Fracturing).***
    - Dimensions of noise source including the heights, and whether it is modelled as a point line or area noise emitter: ***see Figure 4 & Appendix C Figure C1-2 (Drilling) & Figure 1 (Fracturing).***
    - Identification of any noise sources exhibiting intermittent, tonal or other identifiable acoustic characteristics: ***see Section 4.2.***
- Receptor locations and heights above ground: ***see Section 2.1.3.***
- Predicted noise levels at receptors for the operational scenarios considered, clearly identifying if a façade correction is included in the predicted level: ***see Section 3.2.1, Table 11 (Drilling) & Section 3.1.1, Table 6 (Fracturing).***
- A statement on how measurement and prediction error is considered: ***see Section 2.1.4.***

5. Noise Mitigation

It is recommended that the applicant summarises the measures to be employed to mitigate noise. Information that would support this includes:

- A schedule of the proposed noise mitigation measures, indicating the expected reduction in predicted levels that each measure may achieve: ***see Section 3.2.1, Table 10, Table 11 (Drilling) & Section 3.1.1, Table 6 (Fracturing).***
- An indicative noise management plan as a form of ongoing noise mitigation: ***see Section 5.***

6. Objector Concerns

It is recommended that the applicant takes the opportunity to consider the concerns raised by objectors in respect of noise.

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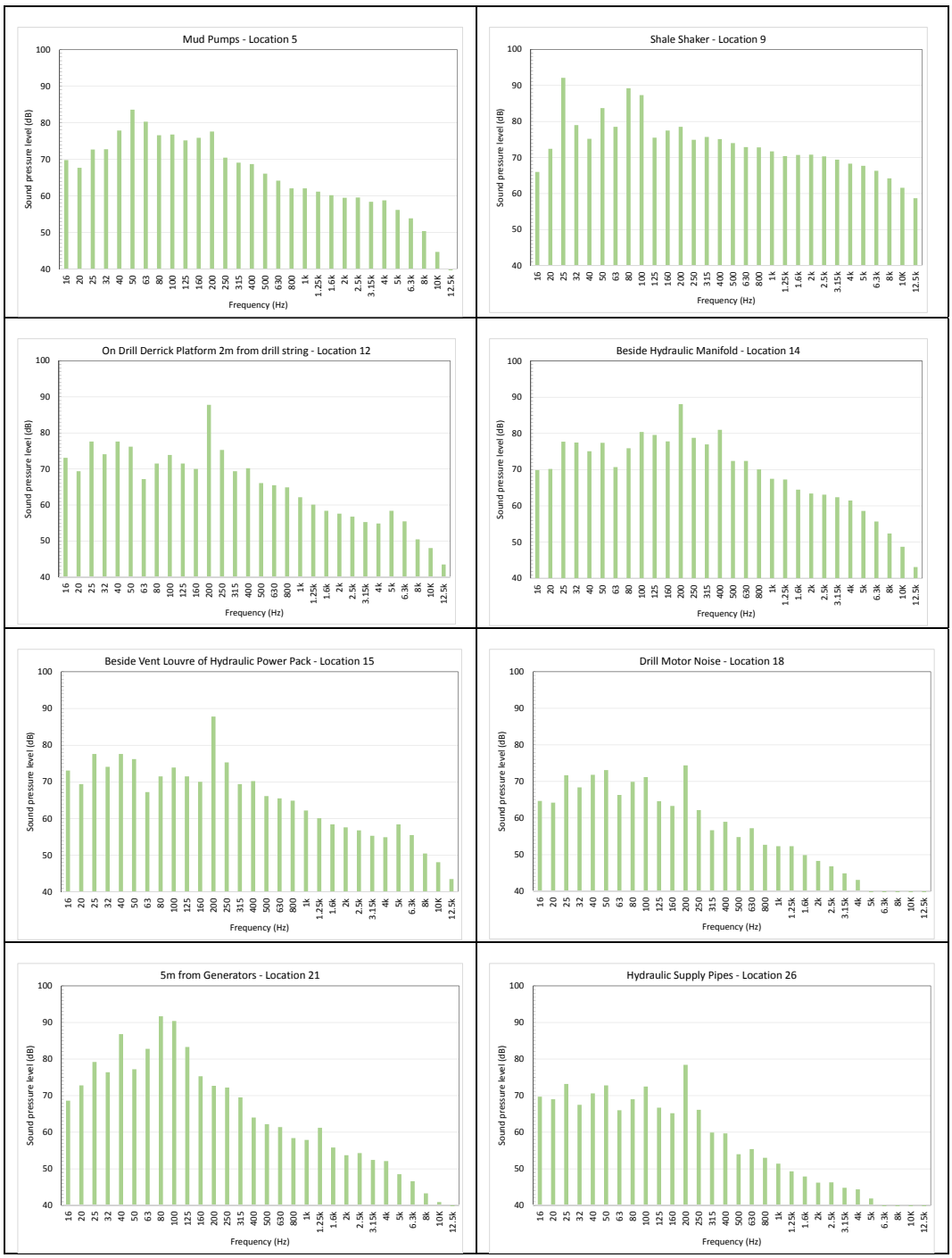
Appendix B

Spectra for plant source noise for tonality assessment

B1 Spectra for plant source noise for tonality assessment



Appendix C

Horse Hill Drill Site Noise Study

C1 Horse Hill Survey

C1.1 Introduction

A noise survey was undertaken of the Cuadrilla Drilling Rig No.50 whilst operating at Horse Hill near Gatwick. The survey was undertaken by Dr David Hiller and Mr Andrew Officer of Arup on 8 and 9 October 2014.

The purpose of the survey was to measure noise from individual items of plant within the drill site, to provide data for a three dimensional noise model. This would then allow detailed assessment of possible mitigation options for the proposed Lancashire exploration sites.

In addition, a continuous recording of the sound levels was made to provide a detailed picture of how the total noise from the site varies with time.

C1.2 Survey equipment and methodology

The following instrumentation was used. Calibration certificates are appended at Appendix D.

C1.2.1 Attended measurements

- Bruel & Kjaer 2260 'Investigator' – Class 1 precision sound level analyser
- Bruel & Kjaer 4189 ½" Pre-polarised condenser microphone
- Bruel & Kjaer 4231 Class 1 sound pressure level calibrator

C1.2.2 Unattended logger measurements

- RION NL-32 Class 1 sound level meter/logger
- RION UC-53A ½" Pre-polarised condenser microphone
- RION NA-74 Class 1 sound pressure level calibrator

C1.2.3 Meteorological conditions

Weather conditions, whilst not ideal, were satisfactory for undertaking measurements close to plant. Occasional squally showers accompanied by a south to south-south westerly wind briefly interrupted some of the measurements.

The wind direction during the survey was from the site and generally towards the logging sound level meter throughout, providing a worst case assessment. When the logger was set up, the wind was recorded as being from the south gusting occasionally up to 5.5m/s. When the logger was recovered the following morning, the wind was still blowing from the same direction at 2-3m/s with gusts occasionally up to 5m/s. **Figure C1-1** provides a partial record during the night

time and early morning of Thursday 9th October 2014 from Gatwick Airport, approximately 3km south of the drill site.

These conditions, while not ideal for environmental noise surveys, were such that they would not be expected to reduce the measured noise levels compared with those that would have been recorded under more favourable conditions.

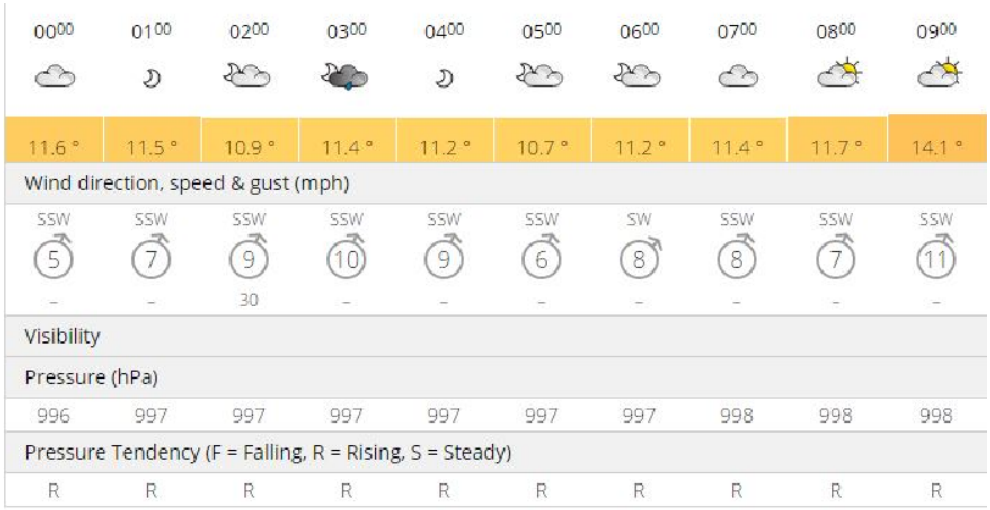


Figure C1-1: Partial record of weather during survey from Gatwick airport

C1.2.4 Attended survey methodology

For the measurements of individual items of plant, the 2260 sound level analyser was used to collect broadband and ⅓ octave band spectra. The meter was either set on a tripod 1.5m above local ground or hand held where a tripod could not be used.

Measurement durations were dependent upon the time variability of the source or activity being recorded but in all cases were of sufficient duration to be representative of the plant or process.

C1.2.5 Unattended (logger) survey

For the unattended noise survey, the RION NL-32 logger was set up on the perimeter bund at the north east corner of the drill site (see **Photograph C1-1**). This logged 1 minute noise samples throughout the day and night whilst the drill site was active. The logger automatically stored the L_{Aeq}, L_{A10F}, L_{A90F} and L_{AmaxF} indices.

Photograph C1-1: Noise logger on the perimeter bund, NE corner of site

C1.2.6 Instrumentation calibration

All of the sound measurement equipment used conforms to IEC/BS 61672-1:2003 class 1 standard. The calibration of the sound measurement instrumentation (sound level meters, pre-amplifiers and microphones) were checked before and after each survey period to confirm that there was no significant drift at the calibration level and frequency.

All Arup instrumentation is calibrated annually by accredited laboratories to national and international standards. Calibration certificates for the equipment used are at Appendix D.

C1.3 Measurement locations

A total of 26 noise measurement locations were used, some close to equipment to identify source noise levels and others at greater distances from individual plant but within the drill site compound. **Figure C1-2** below, illustrates these locations.

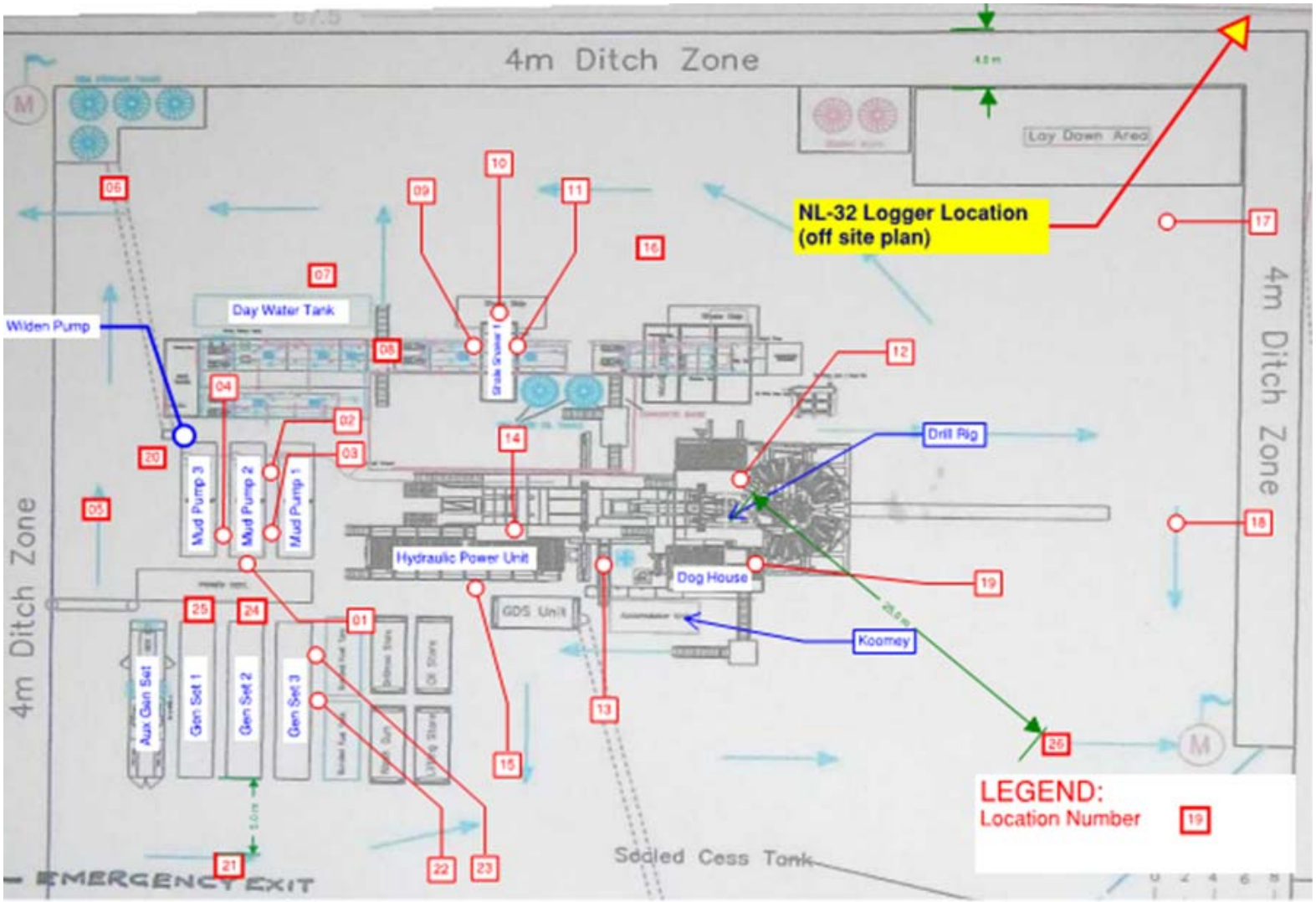


Figure C1-2: Noise Measurement Locations

The following photographs illustrate a selection of the measurement locations:

Location 1: 1m from Mud Pump No.2 (electric motor end)

Location 3 - between Mud Pump No.1 and 2, alongside pumps

Location 5 – Approximately 9m from Mud Pump No.3 (Mud Pump noise dominant noise source)

Location 8 – Shale Shaker

Location 9 – Side on and 1m from Shale Shaker (enclosure hatch open)

Location 12 – approx. 4m from drill string

Location 19: Outside Doghouse, approx. 2m from drill string

C1.4 Results

Table C1 presents the broad band noise data measured at each equipment location.

Figure C1-3: Noise profile recorded at NE corner of drill site on perimeter bundillustrates a time history of the 1 minute samples collected at the unattended logger. **Figure C1-4** presents separately the L_{Aeq} time history for clarity. The noise profile is from 13:14hrs on 8 October to 08:15hrs on 9 October 2014.

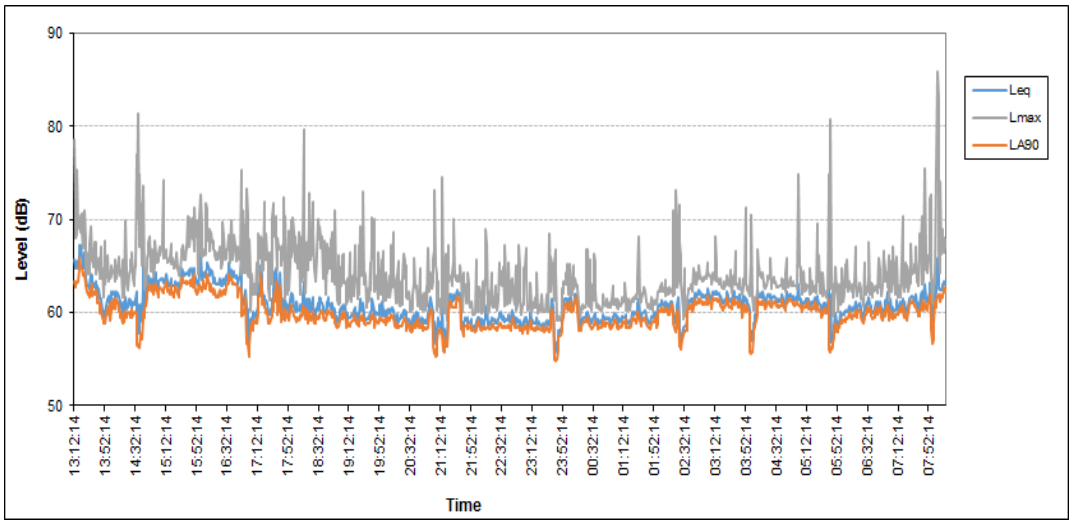


Figure C1-3: Noise profile recorded at NE corner of drill site on perimeter bund

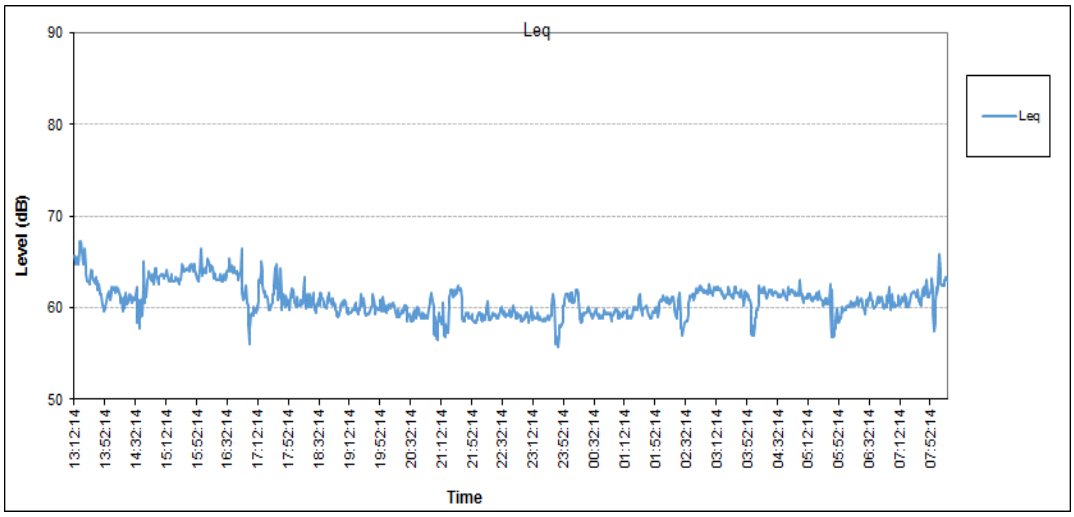


Figure C1-4: Noise profile recorded at NE corner of drill site on perimeter bund (L_{Aeq} only)

Date	Loc No.	Time		Noise Level, dB (A)				Comments
		Start	Finish	L_{90}	L_{10}	L_{max}	L_{eq}	
08.10.14	1	13:53	13:54	90.8	91.6	92.3	91.3	1m from Mud Pump No.2
08.10.14	2	13:55	13:56	90.4	91.6	92.8	91.1	Between Mud Pump No.1 and 2, at pump end
08.10.14	3	13:58	13:59	92.4	93.0	93.5	92.7	Between Mud Pump No.1 and 2, at electric motor end
08.10.14	4	14:01	14:02	90.8	91.6	92.3	91.4	Between Mud Pump No.2 and 3, at electric motor end (Pump 3 not working)
08.10.14	5	14:03	14:04	73.8	75.0	76.9	74.6	Approx. 9m from Mud Pump No.3 (Tonal LF component, 'pulsing' in character, noticeable at all above locations).
08.10.14	6	14:08	14:13	68.2	70.0	71.5	69.2	At corner of site near silos. Banging* noise from mix/active plant. LF increase at c.2 minutes – extra plant started up in direction of SET. Approximately 7m from closest corner of tanks.
08.10.14	7	14:16	14:21	71.8	73.8	75.8	73.0	Banging* as at 6, LF from pump-maybe guy cleaning walkway with pressure hose 8m from closest edge of plant.
08.10.14	8	14:23	14:24	80.2	81.6	83.0	81.0	Banging* as 6 & 7 plus contours. Noise from separators and associated plant. Sources ~ 4m above ground; banging* sounds lower than platform (@4m)
08.10.14	9	14:28	14:29	82.2	83.0	83.7	82.7	Handheld c.1m from side of Shale Shaker (housing access panel open)
08.10.14	10	14:30	14:31	82.6	83.2	83.7	83.0	Inside Shale Shaker housing, end on to shaker.
08.10.14	11	14:32	14:33	80.2	80.8	81.4	80.6	Other side of Shale Shaker, drill rig side. (housing access panel open)
08.10..14	12	14:49	14:50	78.0	79.4	80.5	78.8	On drilling platform, approx. 2m from drill string. All noise is perceived to be coming from the platform superstructure, not from top drive, whilst drilling
08.10.14	13	15:08	15:09	78.0	80.0	82.6	79.0	On walkway between drill and hydraulics. Tonal, perceived as pulsating noise character.
08.10.14	14	15:10	15:10	81.8	83.0	84.4	82.5	Close to hydraulic manifold, level with and adjacent to drill platform.
08.10.14	15	15:17	15:18	82.8	83.8	86.0	83.4	Beside louvres on hydraulic pumps. Bottom is 2m above ground; top 4m.
08.10.14	16	15:54	15:56	74.4	75.4	77.1	75.1	Tanker lorry uploading content from cuttings tank ~2m from lorry pump

Date	Loc No.	Time		Noise Level, dB (A)				Comments
		Start	Finish	L_{90}	L_{10}	L_{max}	L_{eq}	
08.10.14	17	15:59	16:04	63.6	66.4	76.1	65.1	Wind gusting up to ~3m/s blowing towards measurement position. Whining from top drive just audible. Banging* from clearly audible. Top drive becoming increasing audible. Dominant noise towards end..
08.10.14	18	16:10	16:11	64.2	66.4	73.4	65.7	Top drive dominant noise. Pipe handler working but no noise audible – until couple of bangs. c.25-30m from edge of pipe handler
08.10.14	18	16:19	16:23	64.9	68.4	70.8	66.7	Whining of top drive; generators etc more audible than Pos 17. Wind now quite light. Top drive is below top of pipe handler frame.
08.10.14	19	16:26	16:27	77.2	79.4	80.8	78.5	Outside doghouse. 2m from drill. Top drive c.7-8m above us.
08.10.14	19	16:48	16:49	78.6	82.8	84.2	80.9	Top drive ~2m above platform
08.10.14	19	16:52	16:57	71.0	82.2	100.0	79.3	Start of process to make new connection
08.10.14	19	16:58	17:01	64.2	76.8	102.9	81.0	Connecting new pipe
08.10.14	19	17:01	17:03	64.8	72.0	87.5	70.6	Pipe handling process. Bumps and few clangs from machinery
08.10.14	20	17:12	17:13	85.6	91.6	94.3	89.4	Wilden Pump running (without muffler attached) @ approx. 5m
08.10.14	21	08:43	08:44	75.0	76.8	80.0	76.0	Approximately 5m from generators (generator enclosure containers are approx. 2.5m high, sat directly onto ground)
08.10.14	22	08:46	08:47	78.0	79.0	79.9	78.6	Approximately 1m from generator; alongside side access doors
08.10.14	23	08:49	08:50	79.4	81.6	83.8	80.8	Approximately 0.5m from generator air intake louvres
08.10.14	24	08:50	08:50	75.4	79.6	82.1	77.9	At rear of Generator set 3, whilst top drive and pipe string being lifted up to insert new pipe section
08.10.14	25	08:53	08:54	75.6	77.2	78.5	76.4	End of generator set 2 (mud pump now running too – just been switched on)
08.10.14	26	10:01	10:02	68.2	70.0	71.4	69.3	Tonal noise – from hydraulics? Drill in ‘Sliding’ mode now.
08.10.14		10:13	10:13	76.6	78.2	79.4	77.5	Halfway up stairs from Koomey – mud system pipes noisy
08.10.14		10:14	10:15	82.4	83.2	84.1	82.9	At bottom of same stairs. Drill still in ‘Sliding’ mode

Date	Loc No.	Time		Noise Level, dB (A)				Comments
		Start	Finish	L_{90}	L_{10}	L_{max}	L_{eq}	
08.10.14	15	10:20	10:21	82.6	83.2	83.9	83.0	Next to HPU louvres
* Pump that was banging was running temporarily to pump out drainage ditch; off @ 16:08								

Table C1 Drill site measurements (8 October)

Appendix D

Measurement Equipment
Calibration Certificates

D1 Bruel and Kjaer – attended measurements

Certificate of Calibration

Issued by University of Salford (Acoustics Calibration Laboratory)
UKAS ACCREDITED CALIBRATION LABORATORY NO. 0801

Page 1 of 2

APPROVED SIGNATORIES
Claire Lomax [✓] Andy Moorhouse [ ]
Gary Phillips [ ] Danny McCaul [ ]

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UKAS CALIBRATION 0801

University of Salford MANCHESTER

Certificate Number: 01604/1 Date of Issue: 9 December 2013

CALIBRATION OF A SOUND CALIBRATOR

FOR:	Arup Acoustics Parkin House 8 St Thomas Street Winchester Hampshire SO23 9HE
FOR THE ATTENTION OF:	Andy Officer
DESCRIPTION:	Calibrator with housing for one-inch microphones and adaptor type UC 0210 for half-inch microphones.
MANUFACTURER:	Bruel & Kjaer
TYPE:	4231
SERIAL NUMBER:	2022703
DATE OF CALIBRATION:	9 December 2013
TEST PROCEDURE:	CTP06 (Laboratory Manual)

Test Engineer (initial): ..... Name: Gary Phillips

Calibrations marked 'Not UKAS Accredited' in this certificate have been included for completeness.

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognised national standards, and to the units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full except with the prior written approval of the issuing laboratory.

Certificate of Calibration

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Page 2 of 2

Certificate Number: 01604/1 Date of Issue: 9 December 2013

MEASUREMENTS

The sound pressure level generated by the calibrator was measured using a calibrated, WS2P condenser microphone as specified in the certificate. The calibration was carried out with the calibrator in the half-inch configuration.

Five determinations of the sound pressure level, frequency and total distortion were made.

The results have been corrected to the reference pressure of 101.325 kPa using manufacturer's data.

RESULTS

Coupler configuration:	Half-inch
Microphone type:	GRAS 40AG
Output level (dB re 20μPa):	94.09 dB ± 0.10 dB
Frequency (Hz):	999.84 Hz ± 0.12 Hz
Total Harmonic Distortion (%):	0.46 % ± 0.16 % (Not UKAS Accredited)

Average environmental conditions at the time of measurement and maximum deviation from the stated average:

Pressure:	102.057 kPa ± 0.021 kPa
Temperature:	22.9 °C ± 0.2 °C
Relative humidity:	41.1 % ± 0.2 %

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

All measurement results are retained at the acoustic calibration laboratory for at least four years.

Certificate of Calibration

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UKAS ACCREDITED CALIBRATION LABORATORY NO. 0801

Page 1 of 2

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UKAS CALIBRATION 0801

University of Salford MANCHESTER

Certificate Number: 01604/2 Date of Issue: 17 December 2013

VERIFICATION OF A TYPE 1 SOUND LEVEL METER to BS7580 Part 1

FOR:	Arup Acoustics Parkin House 8 St Thomas Street Winchester Hampshire SO23 9HE
FOR THE ATTENTION OF:	Andy Officer
CALIBRATION DATE:	17 December 2013
TEST PROCEDURE:	CTP08 (Laboratory Manual)

Sound Level Meter
Manu: Bruel & Kjaer Model: 2260 Serial No: 2034406

Microphone
Manu: Bruel & Kjaer Model: 4189 Serial No: 2470768

Preamp
Manu: Bruel & Kjaer Model: ZC 0026 Serial No: -

Associated Calibrator
Manu: Bruel & Kjaer Model: 4231 Serial No: 2022703 Adaptor: UC0210

Test Engineer (initial): GP Name: Gary Phillips

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognised national standards, and to the units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full except with the prior written approval of the issuing laboratory.

Certificate of Calibration

Issued by University of Salford (Acoustics Calibration Laboratory)
UKAS ACCREDITED CALIBRATION LABORATORY NO. 0801

Certificate Number: 01604/2 Date of Issue: 17 December 2013

SET-UP INFORMATION

The instrument was running software module BZ 7202 version 1.2. The reference range, reference SPL, primary indicator range, pulse range and linearity range as specified by the manufacturer have been used. The instrument was adjusted to read 94.2 dB (A) in response to the associated calibrator. This reading was obtained from the calibration certificate of the calibrator, 01604/1 and information in the manufacturer's instruction manual, when the instrument is fitted with the supplied UA0237 windshield, with the S.I. Correction set to Frontal.

MEASUREMENTS

The levels of self-generated noise were:

A:	**13.6 dB**
C:	**17.0 dB**
Lin:	**21.2 dB**

At the end of the tests the indication of the sound level meter in response to the associated sound calibrator was 94.3 dB (A) which corresponds to the following level at 101.325 kPa:

Sound Pressure Level 94.3 dB (A)
This reading should be used henceforth to set up the sound level meter for field use.

THE SOUND LEVEL METER WAS VERIFIED ACCORDING TO THE PROCEDURE GIVEN IN BS7580: Part 1 1997 WITH THE FOLLOWING EXCEPTIONS:

The microphone corrections applied as specified in BS 7580: Part 1: 1997 were obtained from a frequency response measurement by this Laboratory using the electrostatic actuator method. The response in isolation is not covered by our UKAS accreditation.

A stricter test than that specified in 5.5.10 and 5.5.11 of BS 7580 has been used by not applying the low level signal.

STATEMENT OF RESULT:

THE SOUND LEVEL METER CONFORMS TO THE TYPE 1 REQUIREMENTS OF BS7580: PART1 1997

Instruments used in the verification procedure were traceable to National Standards. The method of acoustic calibration employed a standard sound pressure calibrator for the 1 kHz test whilst the tests at 125 Hz and 8 kHz were performed by the electrostatic actuator method. The uncertainty of the Laboratory's 1 kHz calibrator was ±0.10 dB. The uncertainty of the standard calibrator is not included in the applied tolerances. It is assumed that the sound level meter was manufactured in accordance with BSEN60651: 1994 Type 1, and BSEN60804: 1994 Type 1.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. All measurement results are retained at the acoustic calibration laboratory for at least four years.

D2 Rion – unattended measurements

Certificate of Calibration

Issued by University of Salford (Acoustics Calibration Laboratory)
UKAS ACCREDITED CALIBRATION LABORATORY NO. 0801

Page 1 of 2

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UKAS CALIBRATION
0801

University of Salford MANCHESTER

Certificate Number: 01910/1 Date of Issue: 30 June 2014

CALIBRATION OF A SOUND CALIBRATOR

FOR:	Arup Acoustics Parkin House 8 St Thomas Street Winchester Hampshire SO23 9HE
FOR THE ATTENTION OF:	Andy Officer
DESCRIPTION:	Calibrator with housing for one-inch microphones and adaptor type NC-74-002 for half-inch microphones.
MANUFACTURER:	Rion
TYPE:	NC-74
SERIAL NUMBER:	35173547
DATE OF CALIBRATION:	30/06/2014
TEST PROCEDURE:	CTP06 (Laboratory Manual)

Test Engineer (initial): ..... Name: Gary Phillips

Calibrations marked 'Not UKAS Accredited' in this certificate have been included for completeness.

Certificate of Calibration

Issued by University of Salford (Acoustics Calibration Laboratory)
UKAS ACCREDITED CALIBRATION LABORATORY NO. 0801

Certificate Number: 01604/1 Date of Issue: 9 December 2013

MEASUREMENTS

The sound pressure level generated by the calibrator was measured using a calibrated, WS2P condenser microphone as specified in the certificate. The calibration was carried out with the calibrator in the half-inch configuration.

Five determinations of the sound pressure level, frequency and total distortion were made.

The results have been corrected to the reference pressure of 101.325 kPa using manufacturer's data.

RESULTS

Coupler configuration:	Half-inch
Microphone type:	GRAS 40AG
Output level (dB re 20μPa):	94.09 dB ± 0.10 dB
Frequency (Hz):	999.84 Hz ± 0.12 Hz
Total Harmonic Distortion (%):	0.46 % ± 0.16 % (Not UKAS Accredited)

Average environmental conditions at the time of measurement and maximum deviation from the stated average:

Pressure:	102.057 kPa ± 0.021 kPa
Temperature:	22.9 °C ± 0.2 °C
Relative humidity:	41.1 % ± 0.2 %

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

All measurement results are retained at the acoustic calibration laboratory for at least four years.

Certificate of Calibration

Issued by University of Salford (Acoustics Calibration Laboratory)
UKAS ACCREDITED CALIBRATION LABORATORY NO. 0801

Certificate Number: 01604/2 Date of Issue: 17 December 2013

SET-UP INFORMATION

The instrument was running software module BZ 7202 version 1.2. The reference range, reference SPL, primary indicator range, pulse range and linearity range as specified by the manufacturer have been used. The instrument was adjusted to read 94.2 dB (A) in response to the associated calibrator. This reading was obtained from the calibration certificate of the calibrator, 01604/1 and information in the manufacturer's instruction manual, when the instrument is fitted with the supplied UA0237 windshield, with the S.I. Correction set to Frontal.

MEASUREMENTS

The levels of self-generated noise were:

A:	**13.6 dB**
C:	**17.0 dB**
Lin:	**21.2 dB**

At the end of the tests the indication of the sound level meter in response to the associated sound calibrator was 94.3 dB (A) which corresponds to the following level at 101.325 kPa:

Sound Pressure Level 94.3 dB (A)
This reading should be used henceforth to set up the sound level meter for field use.

THE SOUND LEVEL METER WAS VERIFIED ACCORDING TO THE PROCEDURE GIVEN IN BS7580: Part 1 1997 WITH THE FOLLOWING EXCEPTIONS:

The microphone corrections applied as specified in BS 7580: Part 1: 1997 were obtained from a frequency response measurement by this Laboratory using the electrostatic actuator method. The response in isolation is not covered by our UKAS accreditation.

A stricter test than that specified in 5.5.10 and 5.5.11 of BS 7580 has been used by not applying the low level signal.

STATEMENT OF RESULT:

THE SOUND LEVEL METER CONFORMS TO THE TYPE 1 REQUIREMENTS OF BS7580: PART1 1997

Instruments used in the verification procedure were traceable to National Standards. The method of acoustic calibration employed a standard sound pressure calibrator for the 1 kHz test whilst the tests at 125 Hz and 8 kHz were performed by the electrostatic actuator method. The uncertainty of the Laboratory's 1 kHz calibrator was ±0.10 dB. The uncertainty of the standard calibrator is not included in the applied tolerances. It is assumed that the sound level meter was manufactured in accordance with BSEN60651: 1994 Type 1, and BSEN60804: 1994 Type 1.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. All measurement results are retained at the acoustic calibration laboratory for at least four years.

Certificate of Calibration

Issued by University of Salford (Acoustics Calibration Laboratory)
UKAS ACCREDITED CALIBRATION LABORATORY NO. 0801

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APPROVED SIGNATORIES
Claire Lomax [✓] Andy Moorhouse [ ]
Gary Phillips [ ] Danny McCaul [ ]

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UKAS CALIBRATION 0801

University of Salford MANCHESTER

Certificate Number: 01604/2 Date of Issue: 17 December 2013

VERIFICATION OF A TYPE 1 SOUND LEVEL METER to BS7580 Part 1

FOR:	Arup Acoustics Parkin House 8 St Thomas Street Winchester Hampshire SO23 9HE
FOR THE ATTENTION OF:	Andy Officer
CALIBRATION DATE:	17 December 2013
TEST PROCEDURE:	CTP08 (Laboratory Manual)

Sound Level Meter						
Manu:	Bruel & Kjaer	Model:	2260	Serial No:	2034406	
Microphone						
Manu:	Bruel & Kjaer	Model:	4189	Serial No:	2470768	
Preamp						
Manu:	Bruel & Kjaer	Model:	ZC 0026	Serial No:	-	
Associated Calibrator						
Manu:	Bruel & Kjaer	Model:	4231	Serial No:	2022703	Adaptor: UC0210

Test Engineer (initial): ..... Name: Gary Phillips

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