Flyers Creek Windfarm – Technical Review of Supporting Documentation

- Final
- 12 July 2013

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Glossary

Term	Description
dB	Sound pressure levels are expressed in decibels as a ratio between the measured sound pressure level and the reference pressure. The reference pressure is $2x10^{-6}$ Pascal (Newtons per square meter).
dB(A)	The A-weighted sound pressure level in decibels, denoted dB(A) is the unit generally used for the measurement of environmental, transportation or industrial noise. The A-weighting scale approximates the sensitivity of the human ear when it is exposed to normal levels and correlates well with subjective perception over a number of different types of sounds. An increase or decrease in sound level of approximately 10 dB corresponds to a subjective doubling or halving in loudness. A change in sound level of 3dB is considered to be just noticeable.
dB(C)	The unit used for measuring occupational health and safety maximum industrial noise levels in Australia is the C-weighted sound pressure level in decibels, denoted dB(C). C-weighting has a relatively flat response when compared to an A-weighting network.
L_{A10}	The A weighted sound pressure level that is exceeded for 10% of the measurement period. It is often referred to as the average of the maximum values.
L_{A90}	The A weighted sound pressure level that is exceeded for 90% of the measurement period. Usually used to represent the background noise level.
L_{eq}	The equivalent continuous sound level. The steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.
L_{Aeq}	The A weighted equivalent continuous sound level is denoted L_{Aeq}.
L_{Max}, L_{FMax}, L_{SMax} L_{AMax}, L_{AFMax}, L_{ASMax}	The maximum measured linear (un-weighted or Z) sound pressure level. The L_{Max} variations, L_{FMax}, L_{SMax} are the L_{Max} levels using the "Fast" and "Slow" networks respectively. The A-weighted variations are also used in various guidelines and standards, L_{AMax}, L_{AFMax} and L_{ASMax}.
Frequency	The rate of repetition of a sound wave. The unit of frequency is the Hertz (Hz),defined as one cycle per second. Human hearing ranges approximately from 20 Hz to 20,000 Hz. For design purposes, the octave bands between 63 Hz to 8 kHz are generally used. The most commonly used frequency bands are octave bands. For more detailed analysis each octave band may be split into three one-third octave bands or in some cases, narrow frequency bands.
Background Noise Level	i. The lower ambient noise level, usually defined as the value of the time varying ambient noise level exceeded for 90% of the measurement time. Usually defined in the dB(A) scale - L_{A90}.
Acoustic Spectrum	ii. The sound pressure level (or sound power level) as a function of frequency (eg octave band, 1/3 octave or narrow band). Generally used to identify noise sources or items contributing disproportionately to an overall noise level.

1 Introduction

The Department of Planning and Infrastructure (DoPI) has requested that SKM provide expert advice in the field of Noise Impact Assessment for the Flyers Creek Wind Farm Environmental Assessment (EA) (Aurecon, May 2011), with respect to various draft Response to Submissions.

SKM was to provide the following Project Advice:

- Review of the documentation provided by the Department with regard to the Director-General's requirements for the EA and of the relevant planning guidelines with particular regard to the draft NSW Wind Farm Planning Noise Guidelines (2013), the South Australian Environment Protection Authority's Wind Farms – Environmental Noise Guidelines, 2003 and industry standards and legislation.

The review would be provided in the form of a report providing independent expert advice and commentary on the:

- Proponent's Noise Assessment and associated documentation, and if necessary, identifying gaps in the documentation to be addressed by the Proponent to ensure consistency of the project with the above Guidelines; and
- Suitability of the proposed mitigation and/or management and/or protection measures if required.

This report details our findings.

2 Documents Reviewed

The following documents were reviewed.

- Director General's Requirements Section 75F of the Environmental Planning and Assessment Act 1979 – Noise Impacts
- The Noise Impact Assessment prepared by Vipac (21 December 2010) Reference 50B-08-0089-TRP-773906-2 and the Background Noise Monitoring Survey Report prepared by Vipac 7 June 2010 Reference 50B-08-0089-TRP-771535-1;
- Flyers Creek Wind Farm Environmental Assessment Chapter 12 Noise
- The reviews of the Vipac Noise Impact Assessment (21 December 2010) prepared by L. Huson & Associates (November 2011) and the Acoustic Group (15 December 2011);
- The review of the Acoustic Group report (15 December 2011) by Sonus (March 2012); and
- The review of the Acoustic Group report (15 December 2011) and L. Huson & Associates report (November 2011) by Vipac (25 January 2012).

3 Director General EA requirements

The DG EA requirements include the following with respect to Noise Impacts:

1) Include a comprehensive noise assessment of all phases and components of the project. The assessment must identify noise sensitive locations, baseline conditions based on monitoring results, the levels and character of the noise criteria, modelling assumptions and worst case and representative noise impacts.
2) Noise impacts under operating meteorological conditions (wind speeds from cut in to rated power) including impacts under conditions that exacerbate impacts. The probability of such occurrences must be quantified.
3) If any agreements with residents are proposed for areas where noise criteria cannot be met, then provide sufficient information to enable a clear understanding of what criteria have been used.
4) Clearly outline the noise mitigation and management measures that would be applied to the project. This must include an assessment of the feasibility, effectiveness and reliability of the proposed measures and any residual impacts after these measures have been incorporated.
5) Include a contingency strategy that provides for additional noise attenuation should higher noise levels than predicted result.
6) Include an assessment of vibration impacts associated with the project.

4 The Vipac Reports

4.1 Noise Impact Assessment Report

The Vipac Flyers Creek Wind Farm Noise Impact Assessment report dated 21 Dec 2010 states that predicted noise levels are assessed against the SA 2003 guidelines (SA03) as required by the DG EA.

This report includes a description of the background noise level measurements and criteria. The report state that there are approximately 100 receivers within 3 km of the proposed wind farm and divides these between “relevant” and “non-relevant”. It is assumed that this means within 3 km of any given wind turbine (WT). This is not stated clearly. Further, the reason for nominating only residences within 3 km is not stated.

The report states that the receivers are listed in Appendix C with details. Only some details are provided. There is no indication of the acoustic environment at each receiver. This information is important in assessing the choice of background noise level which forms the basis of the criterion for each receiver location as indicted in Table 5-1 of the Vipac report. It is not possible to assess the validity of the choices in Table 5-1 without this and it is not clear that Vipac have been to each location so that the choice nominated in Table 5-1 is validated.

On page 7 paragraph 2, it states that “the maximum variation between the four monitored sites utilised for non-logged neighbours is approximately 3 db”. So why not use the lowest background noise level at all receiver locations? No explanation is provided for the choices in Table 5-1.

A statement is made about a “small disparity between daytime and night time results (page 7 last para). No explanation is provided about what this is and what it means.

In the last para on page 7, reference is made to each of the five monitored sites (as per the background noise level report which refers to five sites) whereas in para 2, reference is to “between the four monitored site”? Which is correct?

Table 5-2 heading refers to 78.6m AGL reference. The next line states Wind Speed at 76m AGL? In Chapter 12 Noise of the EA, on page 12-7, refers to 80 metre high monitoring masts?

Table 5-3 provides noise criteria for each of “five” monitored sites from wind speed at 10m AGL 3 – 9 m/s. But SA03 requires criteria from cut in up to rated power so criteria for at least two additional wind speeds are required?

Vipac refers to the use of both the CONCAWE and ISO propagation algorithms. For the CONCAWE model, G was chosen as 0.7 while for ISO, G was set to zero. There is no explanation of why both models were used, the rationale for the choice of G. The Institute of Acoustics, in their July 20121 discussion document on the ETSU, recommended various parameters be set when using ISO. Such information is missing in the Vipac report for both the ISO and CONCAWE predictions. The EA requires that all modelling assumptions be clearly stated. This has not been done and the assumptions must be provided clearly.

In para 3 on page 9, it is stated that "the accuracy of the noise model is likely to be at least +/- 2 dBA". What is meant by "accuracy" here? There are too many qualifiers in this sentence ie "likely to be" and "at least"? These are hedge words and not helpful. Indeed, in Section 6.2 of the report on page14, there is a discussion of "Model Accuracy" with an opening statement "We acknowledge that the 95% confidence level of the ISO model used under high propagation conditions may be in the order of +/- 4 to 5 dBA. This is quite different and the implication in using 2 dBA rather than 4 to 5 dBA is huge! The discussion in Section 6.2 does not particularly help. Seeing the statement has been made earlier on page 10 that ISO results are used as this model gave slightly higher results, what is the point of mentioning the Concawe model in this section (points 2 and 3)? The first dot point says that ISO offers an "accurate estimate". A 95% uncertainty of +/- 4 to 5 dBA could not really be considered an "accurate estimate"! This would not give a great level of comfort to residents potentially being affected and if the prediction is out by + 5 dBA in practice, what can be done to rectify the situation (the noise mitigation discussion will be addressed later)? Also, point 4 of Section 6.2 needs validation. Why does a non-uniform wind field yield better results rather than worse? Normally, ideal conditions on to a fan or turbine give the best results while non-uniform real world flow gives worse results? Finally, a statement is made about a number of conservative assumptions being made but these are not listed or discussed to validate the statement. With respect to the wind blowing in all directions so that all residences are downwind from every turbine, the statement is made that this is "nearly impossible". This situation is indeed impossible rather than not nearly impossible.

On page 9, reference is made to the modelled height of 85m which will be the hub height for the GE model if it is chosen. There is no discussion about the impact of the 85m height versus the other heights nominated earlier in the report (see above)? The WTG sound power data is given in Appendix E of the report. It is stated "The sound power output, measured at 10m AGL (in accordance with IEC 61400-11) …". The wind speed is measured at 10m AGL, not the sound power.

The last para on page 9 of the report deals with a psychoacoustic response to wind farm noise and, as such, should be placed in a section dealing with noise impact.

Appendix G includes the predictions using Concawe. Why are these included if they are not used? Where are the ISO predictions which are claimed to be used? Appendix I includes noise prediction contours for both ISO and Concawe. Again, why is the Concawe prediction included if not used?

The EA requires that worst case and representative noise impacts be documented. Only worst case impacts have been documented

The EA requires that noise mitigation, monitoring and management measures be clearly outlined and that an assessment of feasibility, effectiveness and reliability of the proposed measures be provided. This has not been done and must be provided. In addition, the EA requires a contingency strategy to be provided for additional attenuation in the event that higher noise levels than predicted are measured following commissioning and/or noise agreements with landowners not eventuate. This must be provided.

4.2 Background Noise Monitoring Survey Report

The Vipac Flyers Creek Wind Farm Background Noise Monitoring Survey report dated 7 June 2010 describes background noise levels at five locations in the vicinity of the proposed wind farm. The report indicates that these five locations were chosen after "investigation (and discussion / agreement with Aurecon and Infigen Energy) showed them as being representative of groups of residences situated in different sectors around the proposed wind farm".

As stated above, there is no indication of the acoustic environment at each receiver. This information is important in assessing the choice of background noise level which forms the basis of the criterion for each receiver location as indicted in Table 6-5 of this report. It is not possible to assess the validity of the choices in Table 6-5 without this and it is not clear that Vipac have been to each location so that the choice nominated in Table 6-5 is validated. No explanation in terms of the discussion with Aurecon and Infigen is given to allow assessment of the choices. This needs to be provided. Section 6.2 states that "This exercise aims to identify the representative site that is most similar to a specific neighbour residence location". More information to justify the choice for each site is required. Why not choose the lowest background noise level measured for all sites? The potential impact of trees in the vicinity and the distance of the logger from the residences should be provided.

Section 4 deals with equipment and set up. Table 4-1 provides some details but the noise floor of each logger is not provided. This information must be provided.

The report states that the "microphones were protected with high wind speed windshields in accordance with the manufacturer's instructions". The information showing the performance of the windshield used ie the noise level versus wind speed needs to be provided.

With respect to wind speeds at representative hub height, the statement is made that there were three masts and that there was only a small difference between average wind speeds between these masts. More information needs to be provided to justify this statement and to support the use of the central mast wind speeds for all locations. Greater simplicity is not in itself a justification. The discussion in Chapter 12.6.2 of the Environmental Assessment provides more information than the Vipac report! Why is this the case? In Section 12.6.2 it states that the southern mast was less suitable? This contradicts the implication of the Vipac background noise level report that suggests all masts were equally good?

In Section 5, there is a discussion of microphone level wind speeds. Only three locations were measured rather than at all five locations. The reason for this needs to be explained and the validation of data at the two non-measured locations needs to be provided.

SA03 requires criteria from cut in up to rated power so criteria for at least two additional wind speeds are required in Table 6-4?

The EA requires that the proponent must determine noise impacts under operating meteorological conditions which may include impacts under meteorological conditions that exacerbate impacts. The EA requires that the probability of such occurrences be quantified. This has not been done and must be done.

SA03 requires that the correlation co-efficient should be specified for each polynomial up to the third order from the linear and that the best correlation coefficient should be used to provide the fitted line. These correlation coefficients should be provided.

5 The Acoustics Group Review

This report is critical of many aspects of the Vipac reports. Some of these criticisms are valid while others, we believe, are not.

In Section 2, the Acoustics Group (AG) correctly identifies that the Vipac report has not provided information concerning the probability of occurrences of meteorological conditions that exacerbate impacts as required by the EA.

In Section 2, the AG correctly notes that the contradiction between the Vipac report which talks about a +/- 4 to 5 dB uncertainty at the 95% confidence level while in Section 12.8.2 of the Environmental Assessment, it is stated that "the accuracy of the model is likely to be at least +/- 2 dBA", This latter description is much less than the Vipac report suggests. The AG report correctly asserts an issue because in Section 12.11.1 of the Environmental Assessment, it is stated that the uncertainty of 2 dBA should be added to the predicted noise levels. However, if the uncertainty is 4 to 5 dBA as suggested in the Vipac report, then 4 to 5 dBA should be added, not just 2 dBA!

The AG report in Section 3 states correctly that the Vipac report did not identify the lower limit of the sound level meters used for background noise level monitoring. However, while these loggers may not be able to measure the "true ambient background" on some occasions when the level is very low, we do not agree that this presents a problem in the setting of the criteria as the impact of this will be very small if any at all as the criterion at low wind speeds is set at 35 dBA and only increases at higher wind speeds.

We do not agree that there is a need to document ambient noise levels below 3 m/s as asserted by the AG as the SA03 requires that the data span from cut in wind speed to rated power only and not below cut in speed

In Section 3.2, the AG review correctly identifies that the Vipac report should provide information in relation to the distance of the noise loggers from the residences and that if more than 20m (AS03 requires the location to be within 20m), an explanation should be provided. In this section, the AG report refers to "we are instructed …". It is not clear as to who instructed them and as to whether the instruction is correct or not. A description by Vipac would solve this.

The AG report in Section 3.3 questions the correlation of the met tower wind and the microphone wind speed and suggests that without this information "one is simply left with the position of trusting Vipac". While not required by SA03, this information would be beneficial.

In Section 3.4, the AG report refers to the absence of wind direction information. However, we note that SA03 simply calls for the data to be "collected for a sufficient period to cover the range of wind speeds and directions generally expected at the wind farm site. It does not require identification of wind direction as such (we note, however, that the SA Wind Farm Guidelines 2009 (SA09) states that at least 500 points should be collected for the worst-case wind direction). SA03 does require that **compliance checking** be repeated at different times of the year when valid concerns exist.

In Section 4.0 first para, the AG report implies that the criteria being related to the wind speed at the reference height rather than the wind speed at the noise monitoring location is incorrect. This is NOT the case and the Vipac approach is correct.

In Section 4.1, the AG report refers to there being "a lack of data in relation to significant characteristics". We note that only tonality is referred to in SA03 as needing to be added to the predicted noise level. No other characteristics need to be included in the predictions. Tonality is only required if tonality is expected to be an issue. Vipac have stated that the manufacturers are actively looking at fixing any tonality issues and we believe that this assertion can be taken at face value. Further, we do not agree with the AG statement that the Vipac suggestion that tonality will not be audible at residential receivers "is an unjustified and unsubstantiated assertion".

In Section 4.2, the AG report suggests that "a beating effect may occur" between multiple wind turbines. Such occurrences have been documented at other sites only in very rare circumstances. As this is the case, we do not believe that this is something that needs to be identified as an issue at this time.

In this section, the AG report states that using A-weighted noise levels "fails to address matters of infrasound, which is sound below the range of frequencies detected or perceived by the human ear". We do not agree that infrasound is sound below the range of "frequencies" detected but rather that detection is level dependent. Further, we believe that the A-weighted criteria in SA03 are sufficient to protect residents with respect to infrasound. It is only where the infrasonic level is high (eg of the order of 85 – 90 dB) and there is a significantly falling spectrum with increasing frequency that the A weighting will not relate to annoyance. For most environments, the infrasonic level is in the range of say 50 – 70 dB and there is also energy in higher frequencies. Indeed, the SA09 states that "this general approach recognises the unique noise generating characteristics of wind turbines and the particular ambient noise environments of most sites". This SA09 is stating that the noise character due to wind turbines is accounted for.

In this section, the AG report also takes exception to the Vipac statement "current wind turbine design is not a significant source of low frequency noise or infrasound – even nearby (less than 500m) any infrasound is well below the threshold of human perception and would not cause health effects". The recent SA EPA report "Infrasound Levels Near Wind Farms and in Other Environments" dated January 2013 suggests that infrasonic levels due to wind farms are similar to or no worse than infrasound from many other industrial or other noise sources and in the environment. No apparent similar health effects are claimed from these other sources as there are from wind farms.

The AG report further states that the Vipac report does not address the EA requirement to identify the levels and character of the noise (eg tonality, impulsiveness etc). It is true that the Vipac report does not address impulsiveness but this is not a characteristic usually associated with wind turbines, The Vipac report does address tonality in Section 6 of their report.

The AG report, in Section 4.3, states that the Vipac report does not address the issue of meteorological conditions. This is a valid criticism and Vipac should address this. The AG report suggests that temperature inversions "can dramatically alter the propagation of noise". This would appear to be over dramatizing the situation. When a wind turbine is operating particularly in the mid to upper range of it's wind speed range, temperature inversions that could affect a distant receiver would tend to not to occur.

In Section 4.4.4, the AG report criticizes the Vipac report "However, the **"Noise Impact Assessment" section of the report does not actually discuss the noise impact of the wind farm. This would appear to be a fundamental inadequacy in the acoustic assessment**". The AG report criticizes reliance on the WHO guidelines. However, SA03 has specified that compliance with 35 dBA as a criterion (or background noise level + plus 5 dBA whichever is greater) is the method of checking compliance and further states in Section 2 that "if the noise generated does not exceed the background noise by more than 5 dBA, the impact will be marginal and acceptable." Thus SA03 has determined that impact should be "assessed" in this manner. If AG wish to dispute this method of assessment, then they will need to discuss this with the SA EPA. . This submission process is not the forum or means to debate public policy. Meanwhile, compliance with the SA03 approach to impact assessment is all that is currently required to be demonstrated by a potential developer.

The whole discussion in Section 5 of the AG report with respect to "Genuine Noise Impact Assessment – The Relevance and Adequacy of Present Guidelines is therefore not relevant to this development proposal. The SA03 guideline sets the approach that must be taken and until this guideline (or SA09) is superseded by a further updated guideline, the SA03 is what a developer is mandated to satisfy. This submission process is not the forum or means to debate public policy. Indeed, the DoPI has provided the opportunity for public comment on the Draft NSW Wind Farm Guidelines.

On page 23 of the AG report, it suggests that "reliance upon wind at the turbine provides confusion in identifying the background level at residential properties". This seems to be a misunderstanding by the AG of the application of this data.

On page 24, the AG report states that "the occurrence of temperature inversions in rural areas at night results in a significantly more stringent noise criteria". This is not correct. The criteria are the same but the likelihood of an exceedance may be higher at night if indeed temperature inversions occur.

In Section 6, the AG report refers to noise level measurements conducted by AG at the Capital wind farm. We note a generic concern regarding the measurements of low frequency noise and in particular infrasound by the AG. The AG report does not contain any photos showing the logger set up and the environment in which the loggers were placed.. The AG does not provide any details of how the noise level measurements at Capital were conducted and of what mechanisms were used to minimise the impact of wind on the microphones. There is no reference to wind conditions in particular, either at the loggers or at turbine hub height nor of the noise floor of each logger, It is understood that AG would not have had access to wind speeds at turbine hub height nor to turbine operational speed but this lack of information means that the data reported is not in context. In relation to Low Frequency Noise and Infrasound, the AG refers to simultaneous measurements taken using Bruel & Kjaer Type 4189 microphones. These are ½ inch free field microphones with a nominal frequency response 6.3 Hz to 20 KHz. In addition, the preliminary analysis used a 22.4 Hz high pass filter. Yet the spectra in Appendix F show data down to 1 Hz. Further, there is no information about the noise floor of this instrumentation.

The AG have publicly criticised the recently published SA EPA study "Infrasound Levels Near Wind Farms and in Other Environments" dated January 2013 AG has stated that "the authors chose to utilise a time response of 10 second averaging, rather than fast response… Clearly the use of long term averaging time

reduces the impact of fluctuations or modulation associated with the emission of low frequency in infrasound noise from turbines. This is important, because it provides a lower measured level that occurs and as such reduces the level that would be identifies as the peaks the ear "hears" rather than the "averages". [this is copied verbatim including the errors].

There is a major concern with regard to the analysis used by AG to obtain the results in Appendices F and G. AG set the CPB analyser to use fast response exponential averaging at 50 ms sampling rate for 100 seconds (page 31). We note that the averaging time to obtain the correct level for LFN & IS increases as the frequency decreases. The reasons for this are a consideration of filter response time and that "the time required for the amplitude to approach its final value is of the order of 1/B where B is the filter bandwidth" (Randall 1977).

- For deterministic signals, this means that the product $BT \geq 1$.
- For random signals, this requirement increases to $BT \geq 16$.
- For constant percentage bandwidth filters, this can be modified to:
- $bnR \sim 1$ where b = relative bandwidth and nR = the number of periods of frequency f in time TR

This relationship is a manifestation of the physical requirement that a measurement of bandwidth B requires a measurement time of at least 1/B. (Randall 1977).

In addition to filter response time, one needs to consider the length of time required to achieve a desired level of filter ripple. For random signals, "when a narrow band noise of bandwidth B is applied to an RMS detector with averaging time TA, the relative standard deviation of the measured RMS level can be expressed in decibel form as

- $\phi = 4.34 / \sqrt{BT_A}$ dB (Randall 1977)

This tells us that to obtain the results with a given level of accuracy, the time over which the data has to be averaged must increase as the frequency of the 1/n-octave filters and thus the bandwidth of the analysis is decreased. To achieve a standard deviation that is less than say 1 or 2 dB, it is necessary to consider much longer averaging times than would be used for higher frequencies. Tables 1 and 2 below show the times required, in seconds, for various frequencies and for a one third octave bandwidth.

Table 1 Time Required for a 1 dB Standard Deviation Using 1/3 Octave Band Filtering

Frequency	Hz	1	10	20	50	100
Bandwidth	Hz	0.23	2.3	4.6	11.5	23
Std Deviation	dB	1	1	1	1	1
Averaging Time	Seconds	82	8	4	2	1

Table 2 Time Required for a 2 dB Standard Deviation Using 1/3 Octave Band Filtering

Frequency	Hz	1	10	20	50	100
Bandwidth	Hz	0.23	2.3	4.6	11.5	23
Std Deviation	dB	2	2	2	2	2
Averaging Time	Seconds	20	2	1	0	0

It can be seen that this is the basis for the recommendation in ISO 7196 “Acoustics – Frequency weighting characteristics for infrasound measurements” Appendix A.5 which states “The integrating time constant chosen should be sufficiently long for the observed value to be representative of the noise being measured. Usually, this will be the case for an integration time/time constant of 10 s. When frequencies in the upper part of the 1 Hz to 20 Hz band mainly contribute a value as low as 1 s may be used.” A time constant of 10 seconds means an averaging time of 20 seconds. From the Tables above, it can be seen that at 1 Hz and using a third octave filter, the standard deviation of the RMS signal would be of the order of only 2 dB.

On page 31, AG has stated that “As the sound pressure level in the low frequency spectrum was found to vary at a very fast rate, short sample measurements over 100 seconds were undertaken to show the variation in level …” He further states “The concept of a time varying signal requires one to show a variation over time. Appendix G1 shows in the upper graph the statistical variation over the short sample for one third octave band analysis. The CPB analyser was set to fast response exponential averaging at 50 ms sampling rate for the hundred seconds. The lower figure shows the variation in the 10 Hz 1/3 octave band and the dB(A) over the sample period. The lower figure in Appendix G1 reveals the 10 Hz 1/3 octave band to vary nearly 30 dB over the 100 second sample whilst the A-weighted level varied up to 15 dB(A) during the sample period of time.”

However, in making this statement, AG have not accounted for the error associated with filter response. As discussed above, to minimise filter error, the bandwidth by time product (BT) needs to be greater than 1 for a deterministic signal and greater than 16 for a random signal.

This formula above for calculating the standard deviation is for random signals and is not even valid for BT as low as 1, let alone <1. The minimum BT product should, in practice, perhaps be at least 9, to give a result close to 1.5 dB. What it boils down to is that for averaging times less than one period of the frequency you are effectively sampling the signal at, the RMS values are meaningless (except that the corresponding mean square values can be integrated to give the right value of BT product which will then be valid).

As an example, a sinewave sampled 4 times per period (thus obeying the sampling theorem) could give the samples (0, 1, 0, -1), or (1/Ö2, -1/Ö2, 1/Ö2, -1/Ö2), both giving the same mean square value (0.5) when integrated and averaged over any whole number of periods, but if the individual values are converted to dBs, the first set of samples would contain two values of minus infinity, while the second set would be four constant values (no variation). Any other set of samples obeying the sampling theorem would also give the

correct mean square (and RMS) value when integrated over a sufficient number of samples (Randall, 2013).

As per Tables 1 and 2 above, to limit the standard deviation to either 1 or 2 dB, requires a longer averaging time of 20 -100 seconds at 1 Hz and 2 – 10 seconds at 10 Hz. An absolute minimum of the order of say 10 periods would be required.

Clearly, the AG claims using a 50 msec averaging time results in standard deviations which would be totally random depending on where in the cycle you sampled. Any claims of a variation in level of up to 30 dB can therefore not be supported.

A further general comment regarding the measurements by AG is that AG does not seem to distinguish between the total measured noise level and the wind turbine noise level. When comparing noise levels for compliance assessment, the wind turbine noise level alone needs to be compared with the criterion. This is a very important point. When measuring the ambient noise level at any location potentially influenced by an operational wind turbine, there are two contributors to the measured overall noise level. These are the actual wind turbine noise level itself and the contribution due to background noise level at the same location (this being due to other near and distant noise sources in the area). To determine compliance of a wind farm with the criterion, one has to subtract off the contribution due to this background noise before comparing the wind turbine noise level with the criterion. So for example, if the total measured noise level at a given location with the wind turbine operational is 36 dBA and the background noise level has been previously documented as 33 dBA, then the wind turbine noise level will be 33 dBA.

On page 31, the statement is made that “With the turbines operating there was a noticeable fluctuation in the low frequency 1/3 octave band components which in a generic sense are attributed to infrasound”. Firstly, it is not clear at all what this means. What is meant by low frequency here and how does this then become attributed to “infrasound”? How do we know that this fluctuation is related to the wind turbine source as opposed to random local fluctuations? It is further stated that “However no noise associated with the turbines could be detected inside the dwelling because the sound pressure levels recorded in those bands are below the nominal threshold of hearing for those frequencies”. This means that the AG agrees that perception is hearing threshold based.

The AG report, in Appendix F3 and F4,shows spectra outside and inside respectively. AG points out that there are peaks around 10 Hz and 22 Hz. We note that in both these plots, the level of infrasound decreases with lowering of the frequency. This could be due to the high pass filter being used.

Comparisons between FFT spectra in Appendix G on different nights between 7 Hz and 25 Hz as suggested by the AG cannot be made without consideration of repeatability and uncertainties of measurement which at these frequencies is quite large. We note that the spectrum reported in the bedroom of House G13 shows a higher level at around 50 Hz with the turbine off than when it is on!

On page 33, the AG states that “because of the bandwidth the low frequency peaks in the spectra are not evident”. This does not make sense. If there was energy there, it would be reflected in the spectrum shape.

On page 34, the AG states that "Whilst the turbines were not audible in the bedroom, the EPA INP assessment would say **there is low frequency noise present**". This is true but what is it's significance? ? The AG further states that "The LFN concept from Broner would say that there is low frequency noise present". Again, based on the dBC in Table 2, this is true but what is the practical consequence? And "the OHC criteria from Salt would say the resident would be subject to the influence of infrasound". Again, what does this mean practically speaking?

On page 36, reference is made to Appendix J. This Appendix includes data collected by the AG using both an ARL logger and a SVAN 957 logger. No information regarding these loggers is provided by AG. A plot of wind turbine power output versus time is also included. A review of the wind turbine power output versus the measured logger noise levels shows that often the logger noise level is high when the power output is low or the logger noise level is constant independent of turbine output. So drawing conclusions from the unattended logger noise level data is not supported.

On page 36, the AG report states that "noise from the Woodlawn wind farm was clearly audible inside the bedroom as can be seen from the graphs". It is not clear how one can see this from the graphs?

On page 37, in reference to Appendix K2, the AG report states that "Occasionally noise from the turbines was audible external to the building". The significance of this is not apparent as the degree of audibility is not clarified.

On page 38, the AG report states that "House 20 was found to exhibit resonant peaks … and therefore the dwelling would in acoustic terms be considered "live" and readily excited from external energy". In reality, all rooms would exhibit some form of "resonance" at low frequencies. However, the term "live" usually refers to reverberation in a room which is not related to resonant peaks.

On page 38, the AG refers to low frequency noise detected inside the dwellings with measurable increases above the background levels". It is not clear what this means as fluctuations in level occur naturally and how could these be attributed to the wind turbines?

In summary, the AG report makes various statements about the Vipac report, some of which are considered valid. The AG report also makes many statements about wind farm noise levels and character that are not considered valid or relevant. Only some of these have been addressed above.

6 The L Huson Review

The Huson review questions the terminology “best sound profile in its class” as contradictory to the idea of it being representative. This is not a major point as Vipac indicate that if a wind turbine is chosen with a higher sound power level than that modelled, the prediction will be repeated.

Huson correctly states that the basis for the noise impact assessment is the SA03 guidelines.

Huson raise the question re the use by Vipac of only three wind speed loggers and of only two rainfall detectors rather than the use at each noise logger. Vipac should explain why they chose these only.

Huson raises the question of correcting for excessive wind speed at the microphone. Huson criticizes the simplistic approach of discarding data when the local wind speed exceeds 5 m/s. However, SA03 does allow this approach.

Huson points out that rainfall at two sites is used to remove rainfall “affected” data at all five sites. Huson correctly notes that rainfall is localised so that it would be better to have rainfall data at all sites.

Huson queries that data should be removed due to equipment failure. Vipac should explain in more detail which data is included and which isn’t.

Huson points out correctly that apparently background noise curves have been applied to other locations based on an “educated guess procedure”. We agree that Vipac needs to provide more information to justify why the lowest background noise data is not applied to all locations.

Huson queries the regression analysis curve for location 89. We agree that Vipac needs to explain the choice of logger at this location and at location 78. Vipac should also explain the potential impact of absence of wind data in mid November 2009.

With respect to the trend analysis, Huson acknowledges that the SA guidelines allow linear to third order polynomials and correctly point out that correlation coefficients should be stated for all orders.

We agree with Huson that it would seem more appropriate to use met masts that are “local” to the residential areas that are the nearest. Vipac should better explain why the single central met mast is appropriate given the large physical spread of the wind turbines and the localised residential locations.

Huson questions whether other alternative turbines have similar emission operating modes as for the GE turbine. Vipac should indicate that this is the case.

Huson raises questions re the noise level predictions. Some of the points made in this section seem valid and Vipac should explain itself better. Sonus raises the issue of the accuracy of +/- 2 dBA versus +/- 5 dBA and queries what this means with respect to compliance. This is a good question. They suggest that if compliance is not achieved, then it is not known how compliance will be ensured. This is a good point and Vipac needs to address how non-compliance will be addressed in practice once the wind farm is operational. This question relates to the EA requirement to define mitigation strategies etc.

Huson points out that modelling parameters need to be reported. This is a good point and Vipac should report all relevant parameters as described in SA09,

Huson state that "No account has been made for the turbulence effects of upwind turbines that can increase noise emissions above those used for the modelling". Huson does not bring any references to support that this effect does indeed occur at the spacings at which these turbines are set apart. Evans and Cooper (2012) have reported that wake effects are minimal, if any at all, at practical turbine spacings.

Huson queries how compliance can be checked if the background sound levels have not been measured at the different locations. This is a valid point. However, this query affects all wind farm locations. In practice, the wind farm noise level can be determined by shutting down the wind farm and measuring the background sound level and by then turning the wind farm back on and measuring the operational noise level and then subtracting the background level.

Huson queries the statement by Vipac in Section 6 of their Noise Impact Assessment report in relation to the level of infrasound and that it is well below threshold and therefore "would not cause health effects". Huson considers this statement to be biased and states that the Senate inquiry report acknowledges that there is no peer reviewed research to support this statement about infrasound. We agree that the statement "would not cause health effects" should be removed from this section as it is not relevant to the question of the predicted noise levels.

Huson quotes a lengthy extract from the WHO guideline in relation to the outdoor target noise level of Leq 45 dBA. This criterion is based on the assumed nominal noise level reduction of 15 dBA for an open window. If the open window noise level reduction is lower than 15 dBA, and Huson suggests it could be as low as 3 dBA, then the outdoor criterion level would have to be reduced to minimise the possibility of sleep disturbance. This is a good point and Vipac should explain the impact of this reduced open window effect.

7 The Vipac Response to Review Reports

Vipac responded to the Acoustics Group and L Huson Reviews. Below we comment on these responses.

7.1 Acoustic Group Report

Vipac stated that they have used the newer version of the SA EPA Wind Farm Noise Guidelines (SA09) over the SA03 because they wanted to provide a more robust assessment in line with the new/current guidelines. We state that, if this is the case, then Vipac should have indeed followed all of the recommendations in SA09. They have not done this.

With respect to uncertainties, the higher uncertainty, even under high propagation conditions, is very relevant. What Vipac haven't done, as indicated above in Section 4, is state what percentage of time the high propagation conditions are relevant and in which direction.

With respect to the background noise report, it is appropriate to include details about the noise floor of the loggers. Note that SA09 does state that "the lower limit of the instrument measurement range must be chosen to provide accurate measurements which might be limited by the noise floor of the data acquisition device". It is therefore very appropriate to provide the noise floor detail for each logger used.

Vipac is correct that at low wind speeds, a low noise floor will not affect the criterion. Only the polynomial might be slightly affected.

We agree that industrial noise regulations should not and do not apply to wind turbines.

We agree that wind speeds below cut in are not included in setting the criteria.

Vipac have explained the rationale for changing the logger location at Location 12 and should provide similar information for all logger locations.

The discussion in Section 2.2.3 is good and should have been included in the initial report. It should be expanded a little to provide as much detail as possible.

In Section 2.2.4, Vipac state that there is no requirement to breakdown background noise measurements by wind direction. While this is true based on SA03, SA09 does suggest that at least 500 points should be collected for the worst case wind direction. As Vipac has stated that they wish to comply with SA09, then this information should be provided.

We agree that the noise level data is to be paired with the wind speed data collected at hub height (or at 10M AGL).

With respect to turbine sound power and tonality, we accept that the proponent will not install a wind turbine which displays tonality and further noise modelling will be performed if a new turbine is chosen.

In Section 2.3.2, Vipac examines the question of low frequency noise and, in particular, of infrasound. They correctly identify that the level of infrasound is well below the threshold of hearing and bring references to

support this. Evidence for health effects is indeed anecdotal with no peer reviewed research supporting health effects. Thus Vipac has considered these in their assessment and has deemed them to be non problematic. We accept this based on current research.

Section 2.3.3 states that meteorological conditions have been included via inclusion in the CONCAWE model. This is not acceptable and there needs to be a specific discussion in relation to meteorological conditions in the area.

We agree that different noise sources have different guidelines and that compliance of each type of noise source with it's guideline is required. The WHO guideline is included as relevant for protection of sleep disturbance.

Acceptable impact is indicated by compliance with the noise levels as specified in SA03 and SA09.

We are in agreement with the statements by Vipac in the Conclusion except where indicated that more information be provided by Vipac.

7.2 L Huson Report

We agree that Vipac have followed the correct approach by assessing impact in accordance SA03 and SA09.

We are comfortable that if another wind turbine is selected, modelling will be conducted.

With respect to measuring wind speed at each microphone, SA09 actually states as follows: "If wind data from the single wind speed monitor are not representative for all of the noise monitoring locations, the wind speed should be measured separately at each of the locations". Thus Vipac would need to justify why they did not measure wind speed at all five noise loggers. They do not appear to have done this.

Vipac state that they have used wind screens working effectively at wind speeds up to 7 m/s. However, they do not provide any evidence and indeed acknowledge that there is no data provided by the manufacturer as to the exact response. So in that case, how does Vipac know that their data is not wind affected even below 5 m/s? Removing data for wind speeds above 5 m/s is fine but maybe the data is affected below 5 m/s?

Vipac state that only data collected was included in the graphs. We suggest that gaps in the plots be left with a notation where dates are not contiguous.

We suggest that Vipac needs to be more specific about how and why background noise levels were applied to each location.

The issue at location 89 needs to be explained better as per the statement in response. The statement "does not significantly affect the results" needs to be explained.

Yes, it is typical to only provide the best fit correlation coefficient but the SA does require all three to be listed.

Yes, one mast can be used across all sites if it is representative. Vipac needs to more fully justify that this is the case here,

We are happy to accept modelling based on the GE 2.5 x l wind turbine and accept that more modelling will be conducted if another turbine is chosen.

We accept that the SoundPlan noise propagation model has not been altered.

With respect to the general +/- 2 dB “accuracy” and the +/- 5 dB “safety margin” for high propagation conditions, Vipac state “An added safety margin ensured a conservative model”. We are not sure what this latter statement means in this context. Also, the terms accuracy and safety margin need to be defined.

We agree that the use of ISO9613 and the CONCAWE needs to better explained by Vipac as this has been confusing. Further, the assumptions re parameters used needs to expanded and justified as required by SA09.

8 The Sonus Review

Sonus was engaged by Infigen to conduct a review of the Acoustics Group. Sonus lists a number of elements that they state would need to be included in the AG report if the AG conclusions are to be considered valid.

1. Background noise data at locations 78 and 89. Sonus recommended re-analysis. We state that this is not really necessary but can be done.

2. Noise logger at location 12. Sonus recommends no further action. We agree.

3. AG requirements above that required by the SA guidelines. Sonus recommends no further action. We agree.

4. AG call for prediction of tonality. Sonus recommends no further action. We agree.

5. AG call for assessment of modulation etc. Sonus recommends no further action. We agree.

6. AG call for taking into account the effect of temperature inversion. We agree with Sonus that the modelling include this but we believe that Vipac has made clear enough all input data assumptions and should provide more details.

7. SA Guidelines vs EPA Noise Protection Policy. Sonus recommends no further action. We agree.

8. AG results from Capital wind farm. Sonus highlights deficiencies with respect to the AG method. We agree with the Sonus criticisms.

9. Sonus criticizes the infrasound results included by AG as there is no information provided to verify the correct procedures have been followed and that appropriate instrumentation has been used. We agree with the Sonus criticisms.

10. AG claims that residents are subject to the influence of infrasound. We agree with the Sonus criticism of the AG claim. We also point out that everyone is “subject to the influence of infrasound” whatever that means, at similar or higher levels than may occur due to a wind farm as we are all exposed to such levels in our every-day environments.

9 Conclusion and Recommendations

We have reviewed the Proponent reports and reports by The Acoustics Group and L Huson critical of the proponent's reports.

We find that some criticisms of the Vipac reports are valid and we recommend that Vipac provide more detailed information to support the proponent's application:

These details include:

1. More information to be provided on the meteorological conditions in the area particularly on dominant wind directions and the probability of occurrences of conditions that exacerbate impacts.

2. Clearly outline noise mitigation, monitoring and management measures that would be applied to the project

3. Clearly define input data to the ISO and CONCAWE models and explain clearly what was used and why?

4. Clearly explain the choice of noise logger locations and the rationale for choosing the background noise levels for each residential location.

5. Clearly explain the rationale for choosing the single mast as a basis for wind data.

6. Cleary explain the difference between "accuracy' and "uncertainty". Clearly explain the application of +/- 4 – 5 dB and the implication with respect to certainty of compliance and management of potential exceedances.

These requirements are explained and detailed in the reviews above, Further details are particularly included in Section 4 and Section 7.2 above.

We find that the AG report makes various statements about the Vipac report, some of which are considered valid. The AG report also makes many statements about wind farm noise levels and character that are not considered valid or relevant. Only some of these have been addressed above. We also find that some aspects of the AG report would be more appropriately addressed in another forum as the submission process is not the forum or means to debate public policy.

We find some of the Huson criticism's to be valid and have indicated where we support these. There are some that we believe do not require further response by Vipac.

Sonus have reviewed the AG report and we have indicated where we agree with their response. We have also indicated where we believe more information should be provided.

We have also seen Vipac's response to the AG and Huson reports. We have indicated where we believe more information is required.

If the information is provided and found to be satisfactory, then we believe the proponents of the Flyers Creek Wind Farm would have satisfied their obligations in relation to the DG requirements and SA03.

10 References

- Randall R. B. (1977) “Application of B&K Equipment to Frequency Analysis” Bruel & Kjaer September
- Randall R. B. (2013) Personal Communication.