

Report Number: A04609 – 01 – D1

**Resource Management Act 1991
Partial Section 42A Report**

Turitea Wind Farm: Noise Effects

**As described in:
Applications for Resource Consent
Submitted to:
Manawatu-Wanganui (Horizons) Regional Council
Palmerston North City Council
Tararua District Council
By Mighty River Power**

25 June 2009

Prepared for:
The Board of Inquiry
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Document control

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1.0 PREAMBLE

- 1.1 The Board of Inquiry appointed by the Ministry for the Environment has commissioned this report in accordance with Section 42A of the Resource Management Act 1991 (RMA) to consider the environmental noise effects and content of submissions relating to noise associated with the construction, operation and maintenance of the Turitea Wind Farm on various ridgelines at the northern end of the Tararua Ranges.
- 1.2 This report has been prepared by Jeremy Trevathan. I am an Acoustic Engineer and a Director of Acoustic Engineering Services Limited, an acoustic engineering consultancy based in Christchurch, New Zealand. I hold the degrees of Bachelor of Engineering with Honours and Doctor of Philosophy in Mechanical Engineering (Acoustics) from the University of Canterbury. I am an Associate of the New Zealand Planning Institute.
- 1.3 I have seven years experience in the field of acoustic engineering consultancy and have a strong publication record in international literature. My particular areas of expertise include the use of computational methods in acoustics and sound transmission through built structures.
- 1.4 I have been involved with a number of environmental noise assessment projects throughout New Zealand, and have previously presented evidence at Council Hearings and Environment Court proceedings. I have acted on behalf of applicants, submitters and as a peer reviewer for Councils. Recently I have been involved with the Mill Creek Wind Farm in Wellington, the Chatham Islands Wind Farm and Wellington City Council Plan Change 32 & 33 (Renewable Energy Facilities).

2.0 THE APPLICATION AND PROPOSAL

2.1 Mighty River Power has applied to the Palmerston North City Council and Tararua District Council for Resource Consents relating to land usage for the Turitea Wind Farm in August 2008. Details of the proposal can be found in the Resource Consent Applications (“the application”), and in documents and evidence subsequently submitted by Mighty River Power, and are not reproduced here. I understand aspects of the application other than noise will be addressed in reports prepared by planning and other experts which, when viewed in conjunction with this report, will complete a section 42A report relating to the application.

2.2 The other noise experts involved with the project are:

- *Mr Nevil Hegley* of Hegley Acoustic Consultants (HAC) who has been engaged by Mighty River Power.
- *Mr Chris Day* and *Mrs Siiri Wikenning* of Marshall Day Acoustics (MDA) who have been engaged by Mighty River Power.
- *Mr Nigel Lloyd* of Acousafe Consulting and Engineering who has been engaged by the Palmerston North City Council.
- *Dr Robert Thorne* who has been engaged by the Tararua Aokautere Guardians, the Friends of Turitea Reserve and Huatau Marae.

I understand that others who have made significant comment on noise issues include:

- *Dr David Black* of Enviromedix, who has been engaged by Mighty River Power.
- *Mr Jeffrey Baker* of the Palmerston North City Council.
- *Mr Douglas Pringle*, a submitter and landowner in the Ngarere Park subdivision.
- *Dr Peter Phillips* of Dialogue Consultants, who has been engaged by Mighty River Power

2.3 During the preparation of this report, I have not had the opportunity to communicate directly with the other noise experts involved with the project. I did have the opportunity to visit the site and surrounding area on the 12th of June 2009. I did not have the opportunity to undertake any objective noise analysis at the site, nor any detailed noise modelling or analysis. Accordingly, this report is based solely on the following documents, and my subjective observations from the site and surrounding area:

- Turitea Wind Farm *Assessment of Environmental Effects* prepared by Mighty River Power and dated August 2008.

- Report *Proposed Wind Farm Turitea Assessment of Noise Effects* prepared by Hegley Acoustic Consultants (Report # 7720), dated August 2008 and appended to the *Assessment of Environment Effects* as Appendix M.
- Letter *Turitea Wind Farm – Interim Section 92 Request* prepared by the Palmerston North City Council, dated 3 September 2008.
- Letter *Turitea Wind Farm – Interim Section 92 Request #2* prepared by the Palmerston North City Council, dated 10 September 2008.
- Letter *Turitea Wind Farm – S92 Request* prepared by Hegley Acoustic Consultants, dated 17 September 2008.
- Report *Proposed Wind Farm Turitea Assessment of Noise Effects* prepared by Hegley Acoustic Consultants (Report # 7720), dated December 2008.
- Letter *Turitea Wind Farm Update* prepared by Hegley Acoustic Consultants, dated 16 January 2009.
- Document *Turitea Wind Farm, Section 92 Requests for Further Information – Consolidated Responses* prepared by Mighty River Power, dated January 2009.
- Letter *Turitea Wind Farm* prepared by Hegley Acoustic Consultants, dated 24 March 2009.
- Report *Turitea Wind Farm, Acoustic Peer Review* prepared by Marshall Day Acoustics, dated 27 April 2009.
- Statement of Evidence of Chris Day, dated 27 April 2009.
- Statement of Evidence of Nevil Hegley, dated 1 May 2009.
- Statement of Evidence of David Black, dated 1 May 2009.
- Statement of Evidence of Douglas Pringle, undated.
- Statement of Evidence of Jeffrey Baker, dated 21 May 2009.
- Statement of Evidence of Nigel Lloyd, dated 19 May 2009.
- Statement of Evidence of Robert Thorne on behalf of Tararua Aokautere Guardians and Friends of Turitea Reserve, dated May 2009
- Statement of Evidence of Robert Thorne on behalf of Huatau Marae, undated
- Rebuttal Evidence of Chris Day, dated 5 June 2009.
- Rebuttal Evidence of Nevil Hegley, dated 5 June 2009.
- Rebuttal Evidence of David Black, dated 5 June 2009.
- Rebuttal Evidence of Peter Phillips, dated 5 June 2009.
- Document *Meeting to discuss social survey matters in relation to the proposed Turitea Wind Farm*, undated.
- Document *Joint statement of expert witnesses – Noise*, dated June 2009

2.4 I note that the majority of review and analysis which forms the basis of this report was completed before the document *Joint statement of expert witnesses – Noise* (dated June 2009) was received by my office on the 23rd of June 2009. In this joint statement the noise experts appear to have found some common ground, and made concessions

on matters contested in some detail in the body of previous evidence. I have therefore attempted to find a balance when considering the agreements reached by the experts, and when examining the often conflicting evidence they had previously presented. With regard to the latter, I have endeavoured to focus on issues which are of substance and which have gone unresolved.

- 2.5 As a general observation I have concern over comments made by both Mr Hegley and Mr Day regarding outputs from expert caucusing relating to other projects. The implication is that in the 'agreed statements' from such processes, experts may have indicated agreement with regard to matters they do not in fact agree with, to expedite the process. My understanding of the caucusing process is that experts are to determine and report clearly on both matters which they can and cannot reach agree on, and why. I trust that the *Joint statement of expert witnesses – Noise* (dated June 2009) has been produced on this basis.

3.0 WIND TURBINE NOISE - ACOUSTICAL CRITERIA

3.1 The basis of the assessment of this Application from a noise point of view must be a set of acoustical criteria which, if complied with, will provide a reasonable level of surety that noise affects associated with the proposal are no more than minor, and that unreasonable noise will be avoided.

Opinions of other experts

3.2 The various noise experts express a wide range of views on this matter. These opinions are generally not presented with a clear explanation of the reasons for these opinions. As noted in 2.4 above, the position of some experts appears to have changed in the *Joint statement of expert witnesses – Noise* (dated June 2009).

3.3 In the report *Proposed Wind Farm Turitea Assessment of Noise Effects* (“the ANE”) prepared by Hegley Acoustic Consultants (dated December 2008), Mr Hegley states that he believes the effects of the development will be no more than minor based on compliance with NZS6808:1998, even in a low background sound environment (page 28).

3.4 Throughout the various exchanges of correspondence Mr Hegley’s position regarding the draft Standard DZ6808 v2.5 (dated 9th February 2009) remains unclear. He states on a number of occasions that the adoption of the draft Standard would not alter his analysis or conclusions in regard to this application. While I can accept that the adoption of the draft Standard may not alter his conclusions (for example, if he is of the opinion that the secondary noise limit discussed in section 5.3 of that Standard is not applicable for this project, or that it would readily be complied with using the general mitigation measures already presented in his reports and evidence), it is difficult to accept that the adoption of the draft Standard would not change his analysis. Clearly even if the secondary noise limit was considered to be not applicable, additional analysis would be required to illustrate that this is so.

3.5 In paragraph 2.24 of Mr Hegley’s Rebuttal Evidence he states that the draft Standard cannot be used with confidence. However in the *Joint statement of expert witnesses – Noise* (dated June 2009) Mr Hegley does place some weight on the detail of the draft Standard with regard to the application of secondary noise limits. He has ultimately agreed to such a limit under conditions which he believes are in line with the intention of the Standards Committee.

- 3.6 An area of consensus is that the Palmerston North City District Plan night time noise limit in the area is 40 dBA L_{10} , applied “at or within the boundary of any land zoned for residential purpose or at or within the boundary of any land in the Rural Zone”. An exclusion is however provided for wind farms, which are instead to be assessed and ultimately controlled “by reference to” NZS 6808:1998.
- 3.7 What has not been discussed by any expert is that the District Plan night time noise limit is expressed as an L_{10} noise level. In accordance with section 4.4.2 note 2 of NZS6808:1998 which describes a difference of typically up to 5 dBA between the L_{10} and L_{95} wind farm noise level, the District Plan night time noise limit would equate to an equivalent wind farm noise limit of 35 dBA L_{95} . It is also noted that this limit is applied at the boundary of any site; even within the rural zone (i.e. the notional boundary concept is not used). It should be borne in mind therefore, that a wind farm operating in accordance with NZS6808:1998 (minimum noise limit of 40 dBA L_{95} at the notional boundary of a dwelling) would be unlikely to comply with the more stringent District Plan night time noise limit (equivalent 35 dBA L_{95} noise limit at the rural site boundary).
- 3.8 As both Mr Hegley and Mr Day have argued that there is nothing which distinguishes wind farm noise from general industrial noise in terms of intrusiveness (a separate wind turbine noise Standard is only required due to the problems of measuring wind turbine noise in the presence of wind), it would appear to follow that the night time noise rules in the Palmerston North District do provide a higher degree of protection than that generally provided by NZS6808:1998.
- 3.9 This finding is therefore in apparent conflict with statements by Mr Hegley that the proposal will comply with the noise limits outlined in the District Plan (it is unclear however whether such statements have been misworded by Mr Hegley, who instead meant that noise will comply with the guideline limits outlined in NZS6808:1998, and therefore by proxy, the District Plan).
- 3.10 I note that on page 5 of the report *Turitea Wind Farm, Acoustic Peer Review* prepared by Marshall Day Acoustics it is stated that the District Plan rules provide a good indication of acceptable noise levels for those affected by the wind farm. As outlined above such an approach appears to support a standard more stringent than the minimum 40 dBA L_{95} guideline noise limit contained in NZS6808:1998.
- 3.11 It is therefore difficult to reconcile this finding with the position reached generally in the MDA Peer Review and then repeated in paragraph 2.9 of Mr Day’s rebuttal evidence that “the District Plan does not apply especially low noise limits in this area” and Mr

Day's ultimate opinion that the secondary noise limit of DZ6808 is not justified (Day Rebuttal Evidence, paragraph 2.2).

- 3.12 However I do observe with interest the discussion in section 5.5 of the MDA Peer Review. It is stated that for some receiver locations the effects will be more than minor during low background noise periods, but on balance “when also considering the national / regional significance of the renewable energy source” affects are considered reasonable. The Board should therefore be mindful that any statements made by Mr Day with regard to the significance of the noise effects of the proposal already appear to have taken into account his (presumably non-expert) understanding of the positive effects of the proposal.
- 3.13 Another issue of major contention relates to the view held by Messrs Hegley and Day (at least until the drafting of the joint statement of expert witnesses) that the guideline minimum noise limit of 40 dBA L_{95} recommended in NZS6808:1998 must be applied without exception, as the PNCDP states that wind farm noise is to be assessed and controlled by reference to NZS 6808:1998. On this matter I favour the view of Mr Lloyd who notes that NZS6808:1998 refers to the minimum 40 dBA L_{95} limit as a “guideline”, and specifically notes that another limit may be appropriate in some circumstances. Mr Hegley then attempts to initiate a circular argument by stating that the District Plan refers to NZS6808:1998 with no expectations (Hegley Rebuttal Evidence, paragraph 5.15) – however as above, the Standard itself allows for exceptions. I do not therefore support the position of Messrs Hegley and Day which appears to be that only by prescribing a minimum limit of 40 dBA L_{95} may one act in complete accordance with NZS6808:1998.
- 3.14 I also observe that under the Resource Management Act significant emphasis is placed on the concept of ‘reasonableness’. It would seem overly bureaucratic, fastidious and ultimately unreasonable to insist on a course of action in strict accordance with a rule in light of evidence that suggested the underlying objectives of the RMA may be better served through an alternative approach. This is especially true in relation to matters which were not foreseen when the rule was put in place.
- 3.15 I am therefore in favour of a much more informed approach, which considers appropriate acoustical criteria from first principles. I am mindful of Mr Day's suggestion in paragraph 2.24 of his Rebuttal Evidence that reliance should be placed on the Standard as this represents the combined wisdom of a group of experts. However, I do not think that the presence of a Standard therefore absolves an expert of their professional responsibility to undertake research and form their own opinions. Such an approach is not at all uncommon – one example with which I am familiar where both Mr

Hegley and MDA have supported a regime which departs significantly in some aspects from the relevant Standard (NZS 6809:1999) in relation to the management of noise at the Port of Nelson.

- 3.16 Two areas which I consider relevant relate to the ultimate aims of acoustical criteria for wind farm noise, and wind farm noise controls internationally.

Aim of acoustical criteria

- 3.17 Under the Resource Management Act, the ultimate aim of any acoustical criteria must be to ensure that noise emissions are limited to a reasonable level. With regard to the audible acoustic aspects of wind turbine noise, all experts seem to be in agreement that the prevention of sleep disturbance is the primary aim (Hegley ANE page 28, Day Rebuttal Evidence paragraph 2.3). I note from the summary of submissions shown in Appendix C of Dr Black's evidence that concerns about sleep disturbance also featured strongly in the submissions.

- 3.18 The matter of annoyance is however more complex. Any audible noise may cause annoyance in some percentage of the population. I am in agreement here with Messrs Hegley and Day that generally the lowest noise limits are required to prevent sleep disturbance, and that the limits implemented to provide reasonable protection against annoyance are somewhat higher (hence the typical 5 to 15 dBA difference between day and night time noise limits in most Districts). I therefore cannot agree with Dr Thorne's implied view that the magnitude of sleep disturbance and annoyance effects are comparable for a given noise level. Nor can I agree with Mr Lloyds view that noise limits more stringent than those required for sleep protection are necessary to prevent the 'undue audibility' of noise at quiet times (Lloyd Evidence paragraphs 16 and 36), if in saying this he means that such audibility may lead to unacceptable levels of annoyance. I note Mr Lloyd has supported a secondary noise limit *only during night time* in the joint statement of expert witnesses, and has adopted a similar position during the Council Hearing for the Motorimu Wind Farm. I cannot see how during these periods (10 pm to 7 am) such a rule would provide any additional benefit other than with regard to sleep disturbance.

- 3.19 Unfortunately the draft DZ6808 Standard does not provide clear guidance with regard to these matters, stating only that the secondary noise limit may be desirable "to afford a greater degree of protection during evening and night time". During evening time, such a limit could conceivably be for the prevention of annoyance during outdoor living. But it would then stand to reason that such a limit should also have been recommended during weekends and public holidays, when people also value outdoor amenity. During

- night time such a rule could most logically be interpreted as relating to sleep disturbance. This view is supported by the reference in DZ6808 (and also the references made by Mr Day) that the District Plan rules may provide an indication of whether a location requires a “higher degree of protection of amenity”. If such an indication were provided, it would be in terms of restrictive *night time* noise levels – daytime levels more restrictive than the minimum 40 dBA L_{95} (45 dBA L_{10}) noise limit outlined in NZS6808:1998 are rarely encountered.
- 3.20 With regard to whether it is reasonable to consider that wind turbine noise emissions which complied with a minimum 40 dBA L_{95} noise limit may cause sleep disturbance affecting a significant proportion of a population in some situations, a range of guidance is available.
- 3.21 Almost all of the noise experts make reference to the World Health Organisation (WHO) internal noise guideline of 30 dBA L_{eq} for the protection of sleep. I do note however that the applicability of this guideline has been somewhat confused through the process with Mr Hegley repeatedly warning against the use of this guideline as the WHO document does not refer specifically to wind turbines, despite elsewhere both Mr Hegley and Mr Day stating that wind turbine noise in effect is equivalent to general industrial noise, and Mr Hegley stating in paragraph 12.8 of his Evidence that the WHO guidelines are “one of the more relevant documents”.
- 3.22 I consider the Australian / New Zealand Standard AS/NZS 2107:2000 *Recommended design sound levels and reverberation times for building interiors* to also be a relevant document, being the Standard referred to in section 8.6.4 of the recently updated NZS6802:2008 for guidance on appropriate indoor noise levels.
- 3.23 AS/NZS 2107:2000 states that for sleeping areas of houses in areas with negligible transportation, that the level of noise that has been found to be acceptable by most people for the environment and also not to be intrusive is 25 dBA L_{eq} . For sleeping areas of houses near minor roads, the level of noise that has been found to be acceptable by most people for the environment and also not to be intrusive is 30 dBA L_{eq} . In paragraph 5.14 of his Rebuttal Evidence Mr Hegley has stated that he is not aware of any indication that lower background warrants a lower noise level with regard to sleep disturbance. Reference to and the use of AS/NZS2107:2000 is widespread around New Zealand, and I am surprised that Mr Hegley is unaware of this Standard.
- 3.24 With regard to how these internal levels relate to an acceptable outdoor noise level, the level of noise reduction as it travels from outdoors to indoors is of critical importance. Mr Day in paragraph 4.7 of his Rebuttal Evidence has relied on an outdoor / indoor

reduction of 15 dBA. While I accept that the use of 15 dBA is widespread (for example, it is referred to in commentary C5.1.2 of DZ6808), the use of 10 dBA is also common (for example, section 4.4.1 of NZS 6808:1998).

- 3.25 With external wind farm noise levels of 40 dBA L_{95} (42.5 dBA L_{eq}), a 15 dBA reduction would indicate an internal noise level of 27.5 dBA L_{eq} , and a 10 dBA reduction would indicate an internal noise level of 32.5 dBA L_{eq} . Therefore, one need only to expect either that a 10 dBA reduction is appropriate and conservative, or that a 25 dBA L_{eq} internal noise limit is appropriate in low background noise conditions, to conclude that a secondary noise standard may be justified to provide adequate protection of sleep in some circumstances.
- 3.26 Messrs Hegley, Day and Lloyd appear to disagree with such a conclusion, but as discussed above, have not presented detailed or cohesive reasons for their opinions. I would cautiously agree with selected statements of Dr Thorne to the effect that a 35 dBA L_{95} limit may be required to prevent moderate levels of sleep disturbance in low ambient noise environments. For the reasons discussed above, I would not agree that such a limit is required in all background noise environments, nor that such a rule is also required to prevent moderate levels of annoyance (unless they annoyance is a secondary response to the sleep disturbance).

International Guidance

- 3.27 In line with Mr Day's principle of giving more weight to guidelines which have benefited from the input of many experts, I consider it relevant to briefly consider wind farm noise guidelines internationally which, when viewed as a collective, have undoubtedly benefited from the contribution of a great many more experts than NZS6808.
- 3.28 It is observed that generally wind farm guidelines are most developed in a number of European countries. In Great Britain, the document ETSU-R-97 provides a general recommendation that night time wind farm noise levels should not exceed 43 dBA L_{90} , and daytime noise should be within the range 35 to 40 dBA L_{90} . These conclusions are based fundamentally on considerations of sleep disturbance (including disturbance of outdoor daytime sleep – hence the lower daytime limit). The highest sound pressure level recommended for noise from wind turbines in Sweden is 40 dBA L_{eq} (37.5 dBA L_{95}) outside dwellings, however it is stated that in noise sensitive areas a lower value is preferable. The recommended highest sound pressure level for noise from wind turbines in Denmark is 45 dBA L_{eq} outside dwellings, and 40 dBA L_{eq} (37.5 dBA L_{95}) in noise sensitive areas. The night time noise limit for the most noise sensitive locations in Germany is 35 dBA L_{eq} (32.5 dBA L_{95}). The night time wind farm noise limits in the

Netherlands start at 40 dBA L_{eq} (37.5 dBA L_{95}) for wind at 1 m/s, and increase with wind speed to 50 dBA L_{eq} at 12 m/s.

3.29 In Australia NZS6808:1998 has been adopted by several States since its introduction, while others rely on a guideline which has been prepared by the South Australian Environmental Protection Authority in February 2003, an interim revision of which was issued in December 2007 after an extensive review in 2005 / 2006. The acoustical criteria in this document requires predicted wind farm L_{eq} noise levels not to exceed 35 dBA L_{eq} (32.5 dBA L_{95}) or the background noise by more than 5 dB, whichever is greater.

3.30 The above review indicates that a noise limit of 35 dBA L_{95} during times of quiet background sound or in noise sensitive locations would certainly not be out of keeping with the 'typical' approach to such matters internationally.

Conclusions regarding acoustical criteria for wind turbine noise

3.31 My overall conclusion from the above analysis is that a 'secondary noise limit' in the order of 35 dBA L_{95} or the background plus 5 dB (whichever is greater) can be justified where background noise levels are low during night time, and in situations where the District Plan night time noise rules provide for a greater level of protection than that inherent in a minimum 40 dBA L_{95} noise limit at the notional boundary of a dwelling.

3.32 I consider this finding to be very much in line with the intent of the text of DZ6808. In spite of the reservations which Mr Hegley and Mr Day express in the joint statement of expert witnesses, the draft Standard clearly states that a secondary noise limit may be considered where there are low background noise levels or where the District Plan (either in objectives, policies or rules) promotes or requires a higher degree of protection. In paragraph 4.7 of the joint statement of expert witnesses Mr Hegley and Day appear to be contending that the wording of the draft Standard does not accurately reflect the intent of the committee – that it was intended to be a both/and situation, not an either/or. I have no knowledge of the intent of the Standard Committee, but such a fundamental typographical error seems unlikely.

3.33 In any case, in the Palmerston North District as discussed above, the existing noise limit at night time is 40 dBA L_{10} (35 dBA L_{95}) at the actual boundary of rural sites. I therefore consider that both the criteria outlined in 3.32 above are met, at times of low background noise.

3.34 I acknowledge that in the Tararua District the current night time noise limit is 45 dBA L_{10} , so the case for a secondary noise standard would not appear as clear cut. However, it seems preferable for the sake of consistency that the same rules are applied in both Districts.

4.0 WIND TURBINE NOISE – PREDICTED LEVELS

- 4.1 When considering the predicted noise levels presented by the various experts, it is important to maintain a clear perspective on the role of such predictions, both at this ‘Consenting’ stage of the process, and during detailed design (as currently proposed under Condition 9 of the joint statement of expert witnesses).
- 4.2 I accept Mr Hegley’s evidence that at the Consent stage of a project insufficient detailed information is available to provide comprehensive noise predictions. I therefore consider the role of noise predictions presented at the Consent stage of this project to be:
- (i) To allow potential submitters to obtain a reasonable understanding of the expected noise levels at their dwelling (and when viewed in conjunction with the Assessment of Noise Effects, to obtain a reasonable understanding of the likely effects of this noise).
 - (ii) To enable the Applicant to illustrate to the Board that it is practicable and realistic for the project in general terms to ultimately operate in accordance with the acoustical criteria which have been deemed appropriate.
- 4.3 At the detail design stage, I would see the role of the noise predictions as allowing the Consent Holder to determine, and then to illustrate to the Council, how exactly the project will operate in accordance with any Conditions. I consider that these predictions should be detailed and accurate enough to allow determination of which turbines will be de-rated (if compliance cannot be achieved with unrestricted operation), by how much they will be de-rated and under what circumstances, and then that control systems will be in put in place so the wind farm operates under these constraints from commissioning. I do not consider it acceptable to use subsequent noise monitoring to provide feed-back as part of a trial-and-error process to confirm what controls are required. If subsequent monitoring reveals non-compliances, these should be unanticipated. If subsequent monitoring confirms that compliance is being achieved (as it should), then the Consent Holder may be able to determine the extent of any conservatisms, and modify the control regime if there is sufficient ‘headroom’.
- 4.4 In this regard I agree entirely with the comments made by Mr Lloyd in paragraph 88 of his Evidence, where he states that measurements post commissioning should not be used to verify non-compliances. I am concerned by some statements made by Mr Hegley, for example in paragraph 7.19 of his Evidence, where he states that it will be necessary to “check the noise as set out above or de-rate closer turbines”.

- 4.5 This section therefore considers the noise predictions which have been presented to date with regard to paragraph 4.2 above, and comments on matters relating to the predictions required under proposed Condition 9 of the joint statement of expert witnesses.
- 4.6 There is considerable discussion by the noise experts relating to the noise predictions originally presented by Mr Hegley, stemming in part from the peer review of Mr Day. There are many specific points to be made here concerning the various predictions and their presentation. However, I feel as noted in paragraph 4.1 above, that one needs to maintain perspective in the consideration of these matters, keeping in mind what the role of such prediction is. I can therefore confirm that I ultimately agree with paragraph 2.1 of the joint statement of expert witnesses with regard to the noise contours presented in figure 43 of Mr Hegley's Evidence (when supplemented with the 35 dBA noise contour attached as Appendix A to the joint statement of expert witnesses) which provide a reasonable prediction of noise from the proposed wind farm. As discussed below, I also except that some of Dr Thorne's predictions provide a similar reasonable presentation of the expected noise levels (despite the apparent misunderstanding of these by the other experts).
- 4.7 Therefore, with regard to these predictions serving their purpose under 4.2(i) above, my major concern relates to the timing of the provision of this information in the context of the submission and Hearing process. Until this information was provided on the 23rd of June 2009, Mr Hegley's original reports and evidence had never presented a figure showing a complete 35 dBA downwind noise contour, nor a complete list of dwellings at which a noise level of greater than 35 dBA (or 40 dBA for that matter) is expected. Page 34 of the ANE (dated December 2008) states that the purpose of the predictions is to "provide a noise envelope". It is difficult to see how this had been achieved until the advent to the agreed 35 dBA downwind noise contour was presented.
- 4.8 Accordingly, during the submission period many potentially affected residents had no reasonable way of ascertaining what noise levels they may be subject to, and where these levels fell in terms of the various discussions of NZS6808:1998 and DZ6808 primary and secondary noise limits. However, to make a determination or recommendation as to if or how this matter should be considered by the Board is not within my area of expertise.
- 4.9 Setting aside the above, there are a number of specific matters arising from the various discussions relating to the predictions which appear to have been left unresolved or are of particular concern. A number of these matters are discussed below, in the hope that this will allow for a structured consideration of the issues, and provide guidance to the

Councils Principal Planner who, under proposed Condition 9, will be responsible for resolving any such issues if they are not resolved through this process and arise again in the detailed *Noise Prediction Report*.

Model inputs

Digital ground model

- 4.10 The digital ground model refers to the three-dimensional terrain data upon which the computational model is based. Mr Hegley clearly states on a number of occasions that he has used a ground model characterised by 20 metre contours. The MDA modelling used more refined 5 metre contour data and they considered this “appropriate for a project of this size” (Day Evidence, paragraph 2.17). However, despite acknowledging this difference in paragraph 2.5 of his Rebuttal Evidence, Mr Day appears to become confused in paragraph 2.17 of the same evidence, saying both the HAC and MDA modelling used 5 metre ground contours. Whilst I am of the opinion that the use of 20 metre or 5 metre contour data will make a negligible difference to the predicted results (and so it is not critical which has been used at the Consenting stage of the project), if however 5 metre data is available, this should be used in any further detailed analysis under proposed Condition 9. It is not explained why Mr Hegley did not use the ‘best’ data available.

Turbine sound power data

- 4.11 Figure 41 of the ANE (dated December 2008) shows the sound power of the turbine used in the initial predictions. On this figure it is stated: “according to IEC61400-11 is assumed”. This statement is curious, and gives no confidence that the data was actually obtained in full accordance with IEC61400-11. However, as final turbine selection has not been completed and a completely different turbine may be used, any uncertainty in this data for the V90 is not particularly relevant during this Consenting stage. Obviously if this same data were to be submitted under proposed Condition 8 it should not be accepted if it is not actually in accordance with IEC61400-11.
- 4.12 A further statement regarding turbine sound power is made on page 4 of the MDA peer review, which appears to imply that both the sound power level at 8.5 m/s and 10.0 m/s has been assumed to continue up to 25 m/s. Obviously this cannot be the case and I am not sure of the purpose of this statement. It is accepted that for the V90 turbine sound power levels above 10.0 m/s will not exceed the maximum sound power (observed at 8.5 m/s), and this has no further relevance to the analysis.

Source height

- 4.13 Page 6 of the ANE (dated December 2008) states that a source height of 80 m +/- 5 m has been “adopted”. In such a model a specific source height is required, so clearly a range has not been adopted. It is then stated that reducing the assumed source height to 75 m would reduce expected noise levels. No statement is made regarding the affect on noise levels of increasing the source height to 85 m. However, further information provided in paragraph 5.2 of Mr Hegley’s Evidence states that a +/- 5 m difference to the assumed source height “will not alter the predicted noise levels by more than a fraction of a decibel”. Based on modelling I have undertaken, I agree.
- 4.14 This is however the first of several instances where I see cause to disagree with Mr Hegley’s ultimate presentation of the predicted noise levels (for example Table 2 and 3 of the ANE) to one decimal place. The variation in height discussed will be capable of changing predicted results by more than 0.1 dB. As such, to present the results to one decimal place constitutes spurious accuracy, and may create a misleading impression with regard to the level of certainty in the predicted levels.

Noise prediction algorithm

- 4.15 There is some discussion of the noise prediction algorithm used (ISO9613 vs. Concauwe) – mostly resulting from the fact that Mr Hegley and MDA use different algorithms. Based in part on the document *Stakeholder Review & Technical Comments NZS6808:1998 Acoustics - Assessment and Measurement of Sound from Wind Turbine Generators* referenced as footnote 1 of Mr Days Rebuttal Evidence, I am satisfied that the various matters discussed by Mr Hegley and Mr Day will not have compromised Mr Hegley’s ultimate ability to produce a reasonable prediction of expected noise levels suitable for this phase of the project. There are however a number of residual matters which I believe warrant a fuller discussion, before the Council Principle Planner is called on to make a judgement as to the suitability of any detailed noise prediction report eventually submitted in accordance with proposed Condition 9.
- 4.16 The difference between a software package, and a prediction algorithm should be appreciated. A confusion of this terminology is made by Messrs Hegley, Day and Lloyd on a number of occasions. A single software package (be it commercially available, or ‘home-grown’) may be able to implement a number of different noise prediction algorithms (for example, SoundPLAN the software package used by MDA, can implement both ISO9613 and Concauwe algorithms). It is therefore concerning that, for example, in the MDA peer review the source of difference between the MDA and HAC predicted results is attributed to the different software packages used – MDA using

SoundPLAN and Mr Hegley using HAC developed software. I would contend that the major reason for the differences is the use of the different prediction algorithms (ISO9613 and Concawe).

- 4.17 Leading on from this, in paragraph 2.17 of his Rebuttal Evidence Mr Day states that both models are “directly comparable in their input data”. But this cannot be the case, as the Concawe model requires the input of a Pasquill Stability Category and wind speed (and so can deal explicitly with the influence of wind and stability of the atmosphere), while ISO9613 does not (being restricted to the consideration of noise levels under moderate downwind conditions (2 - 5 m/s), averaged over independent situations). Accordingly ISO9613 results represent an average level which may be suitable for comparison with measurements (which are obtained over a wide range of metrological conditions). Concawe on the other hand is restricted to the consideration of a specific atmospheric situation.
- 4.18 To this end, I am surprised that none of the other experts have asked Mr Hegley what Pasquill Stability Category and wind speed he has assumed, as this is a fundamental potential explanation for differences between the predicted results.
- 4.19 Paragraph 12.3 of Mr Hegley’s evidence states “I am of the opinion the predictions are as accurate as current technology allows”. Then again in his rebuttal evidence he states “I am not aware of any better technique that would improve the prediction accuracy”. Mr Hegley therefore appears unaware of the document *Stakeholder Review & Technical Comments NZS6808:1998 Acoustics - Assessment and Measurement of Sound from Wind Turbine Generators* referenced as footnote 1 of Mr Day’s Rebuttal Evidence, which concludes “ISO9613 would appear to most accurately predict measured sound levels”.
- 4.20 I note also that Concawe predictions are generally not valid within 100 metres of a noise source. Individual software developers may treat predictions in this area differently – no indication has been provided of how it is treated in the HAC software. I am surprised that the MDA Peer Review has not commented on this, as it is an obvious reason for the significant difference in MDA and HAC predictions for close-proximity sources. Although I do note that paragraph 2.1 of the joint statement of expert witnesses states that it was agreed that the HAC predictions are reasonable at greater than 200 metres. Perhaps this is recognition of this limitation of Concawe.
- 4.21 There are some positive aspects to the HAC software and Concawe method – for example the treatment of noise barriers as described by Mr Hegley in the Consolidated s92 Response. If ISO9613 were to be used, the artificial measures to limit barrier

- attenuation used by Mr Hayes in the Project West Wind and Mill Creek predictions would be recommended (increasing the source height to 22 % above actual blade tip height and limiting attenuation due to barriers to 12 dB).
- 4.22 MDA imply on page 2 and 9 of their peer review that they would not consider the use of Concawe best practice for modelling wind farm noise. Mr Hegley does not attempt to justify the use of this algorithm. In fact, in paragraph 5.17 of his Rebuttal Evidence he states that his model included an assumption that each receiver is downwind from all sources simultaneously, and that the MDA modelling did not. ISO9613 as implemented in SoundPLAN is based on an assumption that each receiver is downwind from all sources simultaneously. Mr Hegley's lack of familiarity with ISO9613 is concerning.
- 4.23 It appears that Mr Hegley would intend to use Concawe to undertake modelling for the Noise Prediction report required under proposed Condition 9. I would hope that such an approach would not be to the satisfaction of the Council Principle Planner, as it is not best practice.
- 4.24 Further to the above, in paragraph 5.19 of his Rebuttal Evidence Mr Hegley states that he intends to undertake predictions for specific wind directions during the detail design phase of the project, as opposed to maintaining an assumption that a receiver is simultaneously downwind from each source (a method he refers to as "the envelope approach" – although for the avoidance of confusion it is noted that Mr Hegley uses this term to refer to a number of unrelated matters).
- 4.25 This approach would appear problematic as the wind rose shows a 30 degree range for the prevailing winds, thus every wind direction in this range would need to be considered for each receiver to establish an average level (as the level will be a function of the receiver location relative to the wind farm and exact wind direction). I note also that generally speaking such an approach departs considerably from anything which appears to be anticipated under NZS6808:1998 or DZ6808. Section 4.4 of the MDA Peer Review states that they agree with the 'all receivers downwind' approach adopted by Mr Hegley at that time. I would be interested in their opinion of Mr Hegley's proposition to abandon this approach for the detailed design phase, if this is in fact what is being proposed
- 4.26 On page 10 of Mr Hegley's letter dated 17 September 2008 he refers to "field testing of the prediction model". I would be interested to know if the "envelope approach" model was used in these his predictions, or a model based on specific wind directions which he appears to contemplate for the detail design.

4.27 In any event, I note that the case study reported in the document *Stakeholder Review & Technical Comments NZS6808:1998 Acoustics - Assessment and Measurement of Sound from Wind Turbine Generators* referenced as footnote 1 of Mr Day's Rebuttal Evidence found little difference between modelling of specific wind directions, and "the envelope approach". I would therefore not be confident that such an approach would lead to a significant decrease in predicted noise levels for the majority of receivers, as is anticipated by Mr Hegley.

Temperature and humidity

4.28 In his letter of response to the s92 Request (dated 17 September 2009) Mr Hegley states that his modelling has assumed a temperature of 20 degrees and relative humidity of 80 %. Since night time noise transmission is most relevant in this case, I would favour Dr Thorne's more conservative (resulting in higher noise levels) selection of 10 degrees, although these variables only have a minor affect on predicted noise levels.

Ground attenuation

4.29 Mr Hegley has used a ground factor of 0.0 while MDA appear to have used a ground factor of 1.0. This discrepancy would be expected to lead to a difference in the order of 3 dBA in the results. I agree with Mr Hegley's approach and his stated reasoning. This is in line with section 4.5.1.3 of American Standard ANSI S12.18 – 1994 which states "At grazing angles of greater than 20°, which can commonly occur in the case of an elevated source, soft ground becomes a good reflector of sound and can be considered hard ground". I would support a ground factor of 0.0 being used in the noise prediction report required under proposed Condition 9.

Model outputs

Receiver locations

4.30 My biggest concern with regard to how the output of the noise modelling is presented relates to the locations at which noise level predictions are provided and/or the lack of meaningful noise contours (until the issue to the joint statement of expert witness on the 23rd of June 2009). Whilst obviously a much more comprehensive approach can be taken (and is expected) in the detailed noise prediction report required under proposed Condition 9, it is only the information which has been provided to date which submitters have had the opportunity to consider. As outlined below, I have concerns about whether

this information has been sufficient to allow potential submitters to reasonably consider the proposal.

- 4.31 The selection of points at which predicted noise levels are presented appears indiscriminate. Mr Hegley refers to these points in a variety of manners including “all of the closer noise sensitive sites”, “each of the houses closest to the site”, “all sites of interest” and “the notional boundary of each dwelling adjacent to the wind farm”. A simple review of aerial images confirms that the “Monitoring Points” certainly do not include each of the dwellings within the 35 dBA contour, for example. Page 10 Mr Hegley’s response to s92 Request (dated 17 September 2008) he refers to these positions as “nominated receiver locations”. It is not clear who they have been nominated by, or why.
- 4.32 The fact that the receiver locations are only ever shown on a small scale figure with minimal annotation (and have not, for example, been presented along with a secondary descriptor such as Street Address or owner name) makes it very difficult to establish what dwellings have been selected, and why. I have overlaid portions of the ‘Site Layout’ attached at Appendix C to the MDA Peer Review (which provides a clearer illustration of the receiver positions than the figures provided by Mr Hegley) on aerial images, an example of which is shown in figure 4.1. However, this analysis did not provide any further clarity as to why some dwellings had been nominated as ‘Monitoring Points’ and others had not.



Figure 4.1 – An example of receiver locations included and excluded, in ‘Monitoring Point’ analysis

4.33 On page 9 of Mr Hegley’s response to the s92 Request (dated 17 September 2008), in answer to a request to identify all dwellings within the 35 dBA contour he states that based on the “envelope approach” his ‘Monitoring Points’ are the relevant monitoring points. As discussed previously, Mr Hegley uses the term “envelope approach” to refer to a number of unrelated matters. In this case, its meaning is not clear. The reason for only classing a limited number of affected dwellings as ‘Monitoring Points’ is never given. Although entering all such receivers into the prediction software is a little tedious, the model can then quickly calculate levels at multiple points, and I see no reason why this was not done.

4.34 One issue arising from this approach is that Mr Day appears to mistakenly assume that the “Monitoring Points” represent each relevant receiver, and ultimately concludes on this basis that exactly 58 dwellings are expected to experience noise levels at over 35 dBA (MDA Peer Review page 5). This raises serious concerns about the rigor of the MDA peer review – I appreciate that they have not had the opportunity to visit the site, but a simple review of aerial imagery would have prevented this error.

4.35 It is clear from the partial 35 dBA contours presented initially by Mr Hegley, the contours presented by Dr Thorne and the agreed 35 dBA contour finally presented in the joint statement of expert witnesses that there are many more dwellings within the 35 dBA

contour. For example based on any of these noise contours the whole of the subdivision based around Pacific Drive will experience noise levels in excess of 35 dBA. I count in excess of 100 dwellings in this area alone.

- 4.36 I note that in paragraph 5.19 of Mr Day's Rebuttal Evidence he does not directly refute the accusation that he has underestimated the number of dwellings within the 35 dBA noise contour. He instead contends that the potentially most effected dwellings have been considered. By 'most affected' he appears to mean those expected to be exposed to the highest noise levels. However I note that the further a receiver is from the wind farm, (very generally) the poorer the correlation may be between local and wind farm wind speed, and therefore between wind turbine noise and any masking ambient noise at the receiver. Therefore, it is not necessarily those dwellings closest to the wind farm where compliance may be most difficult.
- 4.37 I generally find that Dr Thorne's estimates as to the number of dwellings within each of the various noise contours to appear reasonably realistic. Accordingly, I also agree with Mr Lloyd's opinion expressed in paragraph 29 of his Evidence that the number of sites expected to receive noise levels exceeding 35 dBA is greater than 70. Obviously a more accurate estimate would now be able to be developed with the advent of the agreed 35 dBA noise contour, which generally confirms the opinions of Dr Thorne and Mr Lloyd.
- 4.38 With regard to the actual noise levels presented at the various 'Monitoring Points', comparison between the versions of tables 2 and 3 included in the original ANE (dated August 2008), the amended ANE (dated December 2008) and Mr Hegley's Evidence indicate that between the December ANE and Mr Hegley's evidence many of the predicted noise levels have decreased (the adjustment when 9 turbines were deleted had already been incorporated into the December 2008 ANE, so this does not explain these changes). At MP52 for example, the predicted noise level decreased 0.1 dB between the August 2008 and December 2008 reports in response to the turbine deletion (and in agreement with Table 1 of Mr Hegley's letter dated 16 January 2009), but when finally presented in his evidence the level has decreased by a further 0.7 dB, with no explanation provided. Similarly I note that the level shown on figure 23 (Noise measurement site 4) of the December 2008 ANE has actually increased when shown in Mr Hegley's evidence (again figure 23). Again no explanation is provided.

Noise contours

- 4.39 As with the presentation of the 'Monitoring Point' positions, the noise contours presented by Mr Hegley, although being calculated in a great level of detail (over a 50

metre grid) are presented at a small scale, with little reference information or annotation. I also note that in the revised ANE (dated December 2008) and in Mr Hegley's Evidence, while the eliminated 9 turbines are no longer shown in the figure, inexplicably the noise contours have not been updated to reflect the revised proposal. Also in the revised ANE (dated December 2008), figure 43 (Down wind noise contours) is missing in its entirety, although still referred to in the text.

- 4.40 I note Mr Hegley's response to Dr Thorne's presented noise contours (Hegley Rebuttal Evidence, paragraph 2.6) and am surprised at his dismissal of Mr Thorne's predictions as being based on an inferior calculation method. It seems obvious that Dr Thorne has simply used a large calculation grid (the grid appears to be of the order of 500 metres, compared to the 50 metre grid used by Mr Hegley) which has the affect of 'smoothing' the noise contours. There is a very valid school of thought that suggests such an approach provides a better general appreciation for the noise propagation from the wind farm, as opposed to the highly detailed noise contours presented by Mr Hegley, which some may consider to represent a spurious level of accuracy.
- 4.41 I have overlaid the noise contours produced by Dr Thorne and Mr Hegley (including the agreed 35 dBA contour) and can confirm that the results are as similar as could reasonably be expected in general terms (however such a comparison is also made difficult by the fact that Mr Hegley's contours still appear to reflect the original proposal (131 turbines) and that he does not present contours which do not include the effects of other wind farms).
- 4.42 The issue of the incomplete 35 dBA contour presented in Mr Hegley's reports and evidence was a concerning aspect of the proposal until the advent of the agreed 35 dBA contour in the joint statement of expert witnesses. I completely agree with Mr Lloyd (Lloyd Evidence paragraph 14) in that the noise contours presented by Mr Hegley until that time did not show the complete 35 dBA noise contour – which in very simple terms extended off the sides of the page, and could have been shown in its entirety if the image scale had been decreased or the page size increased.
- 4.43 I cannot understand the motivation for or meaning of Mr Hegley's explanation as to why Mr Lloyd is wrong in this regard (Hegley Rebuttal Evidence paragraph 5.2). Similarly, in response to a specific s92 request relating to this matter, Mr Hegley has argued that NZS6808:1998 only requires the production of a 40 dBA contour at the consenting stage, and a 35 dBA contour at the detailed design stage. NZS6808:1998 does not comment on such matters - again the motivation for or meaning of these statements is unknown. In the consolidated s92 response (dated January 2009) Mr Hegley argued that only a complete 40 dBA contour needs be shown as this is the "baseline

requirement” of the District Plan and NZS6808. There is no part of NZS6808:1998 which suggests only dwellings within the 40 dBA contour are of relevance – in fact, quite the contrary. I accept that like the 40 dBA contour, the 35 dBA contour will ‘move’ during the detailed design; however that does not seem a valid reason for simply not presenting a 35 dBA contour.

- 4.44 However, I note that Mr Hegley has now included an agreed 35 dBA noise contour as part of the joint statement of expert witnesses, and assume therefore he has conceded on whatever position he previously held on the matter.
- 4.45 As discussed above, the production of this information so late in the processes raises concerns with regard to whether submitters have been provided with a reasonable opportunity to form an opinion on the proposal. Also it means that matters such as Mr Hegley’s claim that he has not underestimated the number of dwellings within the 35 dBA contour (Hegley Rebuttal Evidence, paragraph 5.3) have not been resolved.
- 4.46 In addition, no explanation has been provided for why the 35 dBA contour originally presented in Mr Hegley’s reports and evidence extended such a large distance from the site, and how he has modified this to produce the ‘agreed 35 dBA noise’ contour (and how this could possibly occur without the other contours changing). I note that the process would have been aided considerably by MDA presenting noise contours as part of their Peer Review, and question why they did not do so.

Uncertainties

- 4.47 There are some inconsistencies with the way uncertainties relating to the presented noise levels have been presented and discussed. I accept however that at this Consent Stage of the project the noise predictions are preliminary in any event, so such considerations are not of particular importance. The matter of uncertainties is therefore one that the Council Principle Planner under proposed Condition 9 will be required to form an opinion on – that is, with regard to whether the results presented in the detailed Noise Prediction Report provide adequate certainty of compliance.
- 4.48 I observe that because a comprehensive noise monitoring program is proposed, the level of certainty in the results need not be as high as a situation where compliance was to be proven through prediction alone. I would consider in this case a situation where the median result indicated compliance with a level of uncertainty in the order of +/- 3 dBA to be acceptable. In a situation where no monitoring was proposed, I would consider that the noise levels representing the upper limit of the 95th percentile should be compared to the compliance levels.

4.49 Matters which should be resolved in the Noise Prediction Report, and may be suitable for further discussion at this stage of the process are as follows:

- Figure 41 of the ANE (dated December 2008) clearly indicates that the sound power of the turbine has an accuracy of +/- 2 dBA. On page 9 of the Mr Hegley's response to the s92 request (dated 17 September 2008) he states that the input data was "reported in accordance with the requirements of the relevant ISO Standards so can be assumed to be accurate". I cannot see how Mr Hegley can reconcile this statement with his figure 41.
- On page 9 of the Mr Hegley's response to the s92 request (dated 17 September 2008) Mr Hegley also states that his predictions have an accuracy of the order of +/- 1.5 dBA. This cannot be the case if the base data used already has an uncertainty of +/- 2 dBA.
- On page 5 of the ANE (dated December 2008) Mr Hegley states that generally an accuracy of +/- 2 dBA has been shown for overall predictions when compared with subsequent monitoring. In paragraph 4.8 his Evidence he states that comparisons between measured and predicted results indicate an over prediction by 2 to 3 dBA. In paragraph 5.18 of Mr Hegley's Rebuttal Evidence he states that the actual noise levels are expected to be "significantly less" than those predicted. These statements appear inconsistent.

4.50 In section 4.5 of the MDA peer review Mr Day expresses the option that a +/- 2 dB difference between *predictions* is acceptable. It is difficult to reconcile this with Mr Hegley's statements that he expects to observe *measured* noise levels to be within +/- 1.5 dB of his predictions.

4.51 In paragraph 5.17 of Mr Hegley's Rebuttal Evidence, he describes various "factors of safety" which have been included in the model. However, for both of the examples given (assumed zero ground factor and reduced barrier effectiveness with distance) I note that he then provides a physical explanation as to why this is required (elevated source, and the fact that barriers have reduced effectiveness at distance). Such items are therefore not "factors of safety" but rather are required to ensure the predictions reflect reality.

Cumulative noise levels

4.52 This proposal is unique in that the site is located between the existing Te Rere Hau wind farm which currently exhibits special audible characteristics, and the consented Motorimu wind farm. There therefore exists the possibility that some dwellings adjacent

to the Turitea wind farm will also receive noise from one of these other wind farms. I consider that there are a number of matters relating to these possible cumulative effects which require further discussion and resolution.

- 4.53 Page 4 of the MDA Peer Review states that “all relevant cumulative effects have been taken into account”, however as evidenced by the subsequent discussions in Rebuttal Evidence, there remains significant uncertainty about how such effects have been considered.
- 4.54 Mr Hegley never confirms explicitly whether or not the special audible characteristics currently exhibited by the Te Rere Hau wind farm have been taken into account in the noise modelling presented. Mr Day states that the model can cope with such effects and refers to Mr Hegley’s Rebuttal Evidence. However Mr Hegley, without clearly stating his position, appears to be of the opinion that Te Rere Hau is currently operating in breach of its Conditions, and so considers that only the case where Te Rere Hau is operating ‘legally’ (i.e. no special audible characteristics) should be considered. If this is the case, this matter would benefit from input from a Planning or Legal expert.
- 4.55 More generally, predicted noise levels for dwellings close to Te Rere Hau and Motorimu with and without contributions from Turitea have not been presented, so it is difficult to appreciate what the extent of cumulative noise effects might be, and what other practical matters need to be considered. For example, if compliance relies on the de-rating of some turbines, how will this be coordinated between the different wind farms?

Conclusions

- 4.56 It is therefore concluded that the noise predictions provided to date are adequate to inform the Consent process, albeit only due to the late introduction of the agreed 35 dBA noise contour. I have concerns that prior to this, it may have been difficult for submitters to gain a reasonable understanding of the noise affects likely to be associated with the proposal from the information supplied.
- 4.57 I do not however consider the information provided to date relating to cumulative effects to be adequate to enable an informed discussion and decision in relation to these matters.
- 4.58 A number of matters have been raised regarding expectations for the level of analysis to be included in the Noise Prediction Report required under proposed Condition 9. While I appreciate that considerations in this level of detail are not appropriate for inclusion in any Condition of Consent, I would be in favour of the Board providing some

direction on these matters in any Decision, rather than deferring further discussion of these matters until the Council Principal Planner is presented with a Noise Prediction Report for approval under proposed Condition 9.

5.0 NOISE MONITORING

- 5.1 As with the wind farm noise predictions, when considering the discussions of noise monitoring presented by the various experts, it is important to maintain a clear perspective on the role of such monitoring, both at this 'Consenting' stage of the process, and during detailed design (as currently proposed under Condition 9 of the joint statement of expert witnesses).
- 5.2 I consider the role of noise monitoring at the Consent stage to be to (i) allow the Applicant, submitters and the Council to understand the typical ranges of background noise experienced in the area at representative locations, and to gain an appreciation for the relevant wind speed / background noise level relationships, and to (ii) provide an indication of the range of noise limits which are likely to be established in representative areas based on a 'background plus 5' type noise limit regime and, when this information is combined with the preliminary wind turbine noise level predictions, to illustrate that it will be practicable for the development in general terms to comply with the acoustical criteria.
- 5.3 At the detail design stage, the noise monitoring must be used to determine the applicable noise limit at each relevant location. Comparison with the detailed noise predictions must then be used to determine what control regime (if any) is required for the development to operate in accordance with the applicable acoustical criteria. As a result of this process, as outlined earlier, there must be a reasonable degree of certainty that the wind farm operation will comply with the acoustical criteria from commissioning. I do not consider it acceptable to use subsequent noise monitoring to provide feedback to a trial-and-error process.
- 5.4 This section therefore considers the noise monitoring which has been undertaken to date, and discusses considerations for the monitoring which is proposed during the detailed design and post-construction phases of the project.

Noise measurements undertaken to date

- 5.5 Noise monitoring has been presented for 16 locations. I am generally in agreement with Mr Hegley and Mr Day that this level of noise monitoring is adequate for the Consent stage of the project, with reference to 5.2 above. I do however have a number of concerns regarding the way this monitoring was undertaken and the results presented, and consider that it could have better served the process. I would expect these matters to be addressed in any subsequent monitoring and reporting.

Measurement sites

- 5.6 Page 13 of the ANE (dated December 2008) states that the preliminary noise measurement sites were selected because they are “representative”. However, in Mr Hegley’s reports and evidence the measurement sites are only shown on a small scale figure, with the locations being indicated by circles which are in effect over 500 metres in diameter. There is no further description is provided. As Mr Pringle has detected, the locations supposedly relating to these measurement sites supplied by Mr Hegley in his letter of response to the s92 request (dated 17 September 2009) inexplicably bear no resemblance to the locations indicated in his figure 2. Appendix C of the MDA Peer Review provides the clearest indication of the actual location of the measurement sites however, again as pointed out by Mr Pringle; at least one of these locations is approximately 500 metres from the location described by Mr Hegley, creating doubt in the reliability of the MDA Peer Review Appendix C.
- 5.7 Therefore, based on the information provided, there is no way to understand if or why the locations are representative, or indeed where exactly they were. Such information would have enabled a much more meaningful review of the noise data obtained.

Measurement period and presentation of data

- 5.8 Initially Mr Hegley reported that a 10 day measurement period was used. He then corrected this to a *minimum* 10 day period. Although the figures (for example ANE dated December 2008 figures 4 to 19) are presented with no indication of units along the horizontal axis which is labelled simply “time”, if it is assumed the numbers along this axis relate to time in 24 hour notation (as appears more than likely), it is straight forward to establish that while the majority of the measurements are reported over a 10 to 14 day period, two of the graphs cover only a 8 day period, and one a 4 day period (Generally I also note that figures 4 to 19 of the ANE are inexplicably presented with a variety of different ranges and scales on each axis, making direct comparison difficult). It is not obvious how Mr Hegley could have been mistaken about these measurement periods, or why this is not commented on in the MDA Peer Review.
- 5.9 The underlying issues relates to the number of data points required on a wind speed vs. background sound level graph to allow a valid ‘best-fit’ curve to be established. NZS6808 recommends a 10 day monitoring period with 10 minute samples, providing 1440 measurements. I note Mr Hegley marks on some of these graphs “not enough data to be accurate” at high wind speeds where there are few data points (for example, figure 22), but does not comment further.

- 5.10 In paragraph 18 of Mr Lloyds Evidence he states that he supports an analysis divided into day / night, and the two prevailing wind directions as per section 4.4.5 of NZS6808:1998. As described below, I would question whether the realities of such a monitoring program have been appreciated.
- 5.11 Based on his preliminary monitoring, in accordance with Mr Lloyds request Mr Hegley presents 'night only' analysis which only considers data obtained from 10 pm to 7 am (reducing the number of data points to typically 540), and then ultimately night time / prevailing wind figures for some locations.
- 5.12 While DZ6808 contemplates night-only analysis and therefore wind speed vs. background sound level graphs with as few as 540 data points (DZ6808 C5.3.1 (c)), for a situation such as that at the Turitea wind farm where the wind only blows from the south east approximately 15 % of the time, typically only 80 data points would be obtained over a 10 day monitoring period when considering a night time / south east wind analysis. Accordingly, the night only / prevailing wind figures presented by Mr Hegley clearly are based on very sparse data (for example figures 36 and 37 of Hegley Evidence), and I doubt the resulting 'best fit' curves would pass the test of the validity of a regression curve – which is that the curve would not change if further data were added to the sample.
- 5.13 To produce a valid curve for a night time analysis of a wind direction which occurs only 15 % of the time, based on the minimum suggestion of DZ6808 of 540 data points, a minimum monitoring period of at least 60 days would be required.
- 5.14 It would therefore seem relevant to consider whether the monitoring proposed under Condition 10 is realistic – especially considering the commitment of Mr Hegley to undertake such monitoring at all dwellings within the 35 dBA noise contour (Hegley Evidence, paragraph 6.9). I note that the MDA Peer Review suggested that the monitoring task being committed to by Mr Hegley was unrealistic – even when they had mistakenly concluded that there were only 58 monitoring positions within the 35 dBA noise contour and likely only considered a 10 days monitoring period at each location.

Existing noise environment

- 5.15 On a number of occasions Mr Hegley states that the site is well clear of any existing industrial activity (for example Hegley Evidence paragraph 7.1). Elsewhere Mr Hegley emphasises the similarity between wind farm noise and industrial noise. The site is close to the existing Te Rere Hau wind farm, and will be close to the Motorimu wind farm. During my site visit, in a south easterly wind, the Te Rere Hau wind farm was

quite audible in the vicinity of turbine zone 001. Noise from the Te Rere Hau wind farm therefore seems likely to have contaminated noise measurements in the vicinity of sites 3, 4, 11 and 12. A major issue which therefore needs to be clarified by Mr Hegley is how valid noise monitoring will be undertaken at these and similar residential sites, which are exposed to noise from Te Rere Hau (and potentially Motorimu in the future).

5.16 With regard to the general noise environment revealed through the preliminary noise measurements, Mr Hegley in his letter dated 24 March 2009 has described how in a number of locations wind generates significant noise in adjacent trees, even at very low local wind speeds. It is difficult to put these comments in context, as the sites have not been clearly identified as discussed above, and local wind measurements have not been undertaken. However it is difficult to completely accept these explanations for the constant elevated background noise at these sites, when a subjective measure of wind speed such as the Beaufort Scale would suggest that at wind speeds below 1.5 m/s leaves do not rustle.

5.17 These statements are also difficult to understand when viewed in the context of Mr Hegley's response in paragraph 12.20 of his Evidence to a submitter regarding the future removal of trees. He states that wind speeds of 8 to 9 m/s do not generate significant noise in pine plantations, and thus the removal of the trees will not significantly influence the background levels. I do not see how this position can be supported, especially in light of Mr Hegley's earlier comments. I do think there is an interesting and valid discussion to be had relating to whether the change in background sound conditions due to the future removal of trees should be considered. NZS6808 suggests that existing trees should be considered as part of the background sound.

5.18 In paragraph 2.8 of Mr Day's Rebuttal Evidence he states that it is misleading to call the area generally quiet, and that primary production activity may generate significant noise in the area. He then gives examples of such activities (which I observe are generally temporary in nature) and then refers to Mr Hegley's monitored noise levels as proof that this is so. As above, Mr Hegley attributes the high levels recorded in various locations exclusively to wind noise or wind in trees. In no case does he mention the type of sources which Mr Day describes as making a significant contribution to the background sound levels generally over the area.

Future noise measurements

5.19 Based on the above, with regard to the ongoing noise monitoring which would be required under the proposed Conditions of Consent, it would be appropriate to address the following matters:

- 5.20 Minimum measurement periods required to produce valid wind speed vs. background sound level regression curves must be determined. If there is no reason that the minimum 60 day monitoring period considered in this report cannot be reduced, then the practicality of such a measurement program must be considered.
- 5.21 Following on from the above, and in light of the agreed 35 dBA noise contour, while I agree that the repeated statements of Mr Hegley with regard to noise monitoring each dwelling within the 35 dBA contour are admirable, I consider that this commitment will ultimately be reneged upon, so this concession should be made now. I consider the suggestion of MDA (which is in line with DZ6808) that clusters of like dwellings may be considered together to be a reasonable one.
- 5.22 An explanation is required as how ‘existing’ noise levels will be measured in locations already affected by wind farm noise. I am not convinced this will be practicable. If that is the case, it may be necessary to assume the most stringent noise limit under all conditions at these locations. As outlined in section 9 below, I would propose to add specific instructions to the proposed Conditions relating to the exclusion of noise from any other wind farm from background noise monitoring.

6.0 EXPECTED COMPLIANCE

- 6.1 I consider that the matter of expected compliance should be of primary interest to the Applicant. Under the proposed Conditions acoustical criteria will be put in place, a detailed noise prediction report prepared which provides reasonable levels of assurance of compliance, and any necessary controls will be implemented from the commissioning of the wind farm. If the detailed analysis reveals that compliance will only be achieved with some wind turbines switched off, then that will be the case. This is a risk the Applicant must bear, and a result of them not being able to commit to a specific design during the Consenting stage.
- 6.2 However, at this stage of the Consent process, I would consider it the Applicants responsibility to illustrate that it is realistic to comply with any Conditions. In this regard, it seems accepted that compliance will only be achieved through controlling the function of some wind turbines in certain wind speeds and directions.
- 6.3 Mr Hegley has spoken on many occasions about “de-rating”, “down-rating” and “noise balancing” turbines, but has not provided a more detailed explanation, even in response to a specific s92 request. On page 43 of the ANE (dated December 2008) Mr Hegley states “it can be shown there are practical methods to control the noise by de-rating selected WTGs”. I am unsure of the meaning of this statement in this context – it may be able to be shown that de-rating is a practical method of control, but it certainly hasn’t been shown in any of the documentation presented in relation to this project to date.
- 6.4 The most obvious way to satisfy the requests of the various experts would have been to provide a turbine sound power vs. wind speed graph for a de-rated turbine. This data could have then been easily added into the models of Messrs Hegley, Day or Thorne to illustrate the effectiveness in reducing the overall wind farm noise levels at specific locations.
- 6.5 Nevertheless, even without this information I am comfortable that compliance will ultimately be achieved as in the situation that de-rating and other noise reduction techniques do not work as the Applicant envisages, the offending turbines would simply have to be switched off. I therefore generally agree with the opinions expressed by Messrs Hegley and Day, that the project could realistically operate in compliance with the proposed conditions, subject to the control of the operation of some turbines in some circumstances.
- 6.6 In some ways, Dr Thorne must also accept this conclusion in principle – as switching off the 50 ‘frontage turbines’ which he identifies during an easterly wind must be accepted

to have the some effect for residents to the west of the wind farm as if these turbines were physically removed. Similarly, paragraph 6.25 of Dr Thorn's Evidence states that the scheme will not comply if all turbines consented. Surely it must be conceded that if the turbines were consented but non-operational compliance would be achieved.

- 6.7 With regard to the specific figures which compare derived noise limits with predicted noise levels produced by Mr Hegley to date, of particular concern is figure 23 (site 4) where the version of the figure presented in the ANE reports dated September and December 2008 shows a minor exceedence of the derived noise limit based on the regression curve plus 5 dB. However when this same figure is presented in Mr Hegley's evidence the derived limit has inexplicably moved up, so the predicted noise levels appear to comply. I have overlaid the various figures and can confirm they remain identical in all other regards (including the equation quoted in the top right hand corner which reportedly describes the regression curve). I therefore cannot determine the source of this error, but am concerned that the latest figure now falsely indicates expected compliance at this location.
- 6.8 A similar situation is observed in figure 8 contained in the s92 response letter of Mr Hegley (dated 17 September 2008), where the derived noise limit does not follow the regression curve at wind speeds over 7 m/s, again making noise appear to comply at this location, when in fact it will not.
- 6.9 Under the proposed Conditions 9, the Council Principal Planner would be responsible for detecting and ensuring the correction of any similar errors in the detailed analysis.

7.0 SPECIAL AUDIBLE CHARACTERISTICS

- 7.1 Generally, with regard to the possibility of the likely wind turbines to be used at Turitea exhibiting special audible characteristics, it is difficult not to find Mr Hegley's evidence relating to measurements and observations of the same type of wind turbine operating in a similar environment compelling. For this reason, and because of the comprehensive conditions agreed relating to special audible characteristics, I am satisfied that this matter has been dealt with in a reasonable manner. There are however some minor matters of note which have arisen during my review.
- 7.2 In the ANE (dated December 2008) Mr Hegley states that the potential for special audible characteristics has been "eliminated" through modern turbine selection. I would suggest that this wording is too strong, although I agree that the advent of special audible characteristics is unlikely. In particular those currently subject to noise containing special audible characteristics generated by the modern Windflow turbines used at Te Rere Hau may have difficulty accepting this assurance.
- 7.3 The excerpt from the "Windtest" report presented on page 35 of the ANE (dated December 2008) is presented as proof that the turbines will not generate a tonal sound at more than 500 metres. I note as the Windtest report is not appended to the ANE and no further context is given, the excerpt provided is meaningless – the fact that the audibility of the tone is reduced by 10 dB only means something if we know how loud the tone was to be with.
- 7.4 Similarly, Mr Hegley's statement on page 46 that a 'low frequency tone' may be an issue is puzzling – as evidenced by the Te Rere Hau situation, a tone at any frequency may be of concern. In addition, his figure 47 shows only that no tone is visible in a 1/3 octave analysis.
- 7.5 I note that figure 47 of the ANE (dated December 2008) does show that the sound will be audibly dominated by noise in the 63 Hz to 125 Hz third octave bands. It is not obvious how this is consistent with the last sentence on page 50 which states "advances in modern wind turbine technology have meant that in most cases low frequency noise have been reduced to below detectable levels". I'm unsure of the original context of this quote, however if 'low frequency noise' is taken to be that in the range 20 to 200 Hz, then clearly Mr Hegley's figure 47 would refute this claim. If 'low frequency noise' is taken to be infrasound, then by very definition such sound is below the threshold of hearing and cannot be detected.

7.6 Therefore, overall I do not consider that these paragraphs in the ANE are particularly helpful and consider that they may be difficult for submitters to understand or reconcile with their observations of other wind farms. Ultimately however, based on previous detailed studies I have undertaken, I am of the opinion that the turbines will not generate low frequency noise which would be expected to cause annoyance at greater levels than is suggested by the consideration of the dBA levels only.

8.0 CONSTRUCTION NOISE

8.1 I agree that compliance with the New Zealand Construction Noise Standard NZS6803:1999 will ensure that noise effects are not unreasonable, when taking into account the matters outlined in the Forward of that Standard. Both relevant District Plans clearly anticipate the use of this Standard. I agree from the data presented by Mr Hegley that it appears realistic to anticipate compliance with that Standard through adoption of the best practicable option.

8.2 With regard to the prohibition of night time traffic on Kahuterawa and Greens Roads, I agree with Mr Lloyd that this could reasonably be dealt with as part of the traffic management plan.

9.0 CONDITIONS

- 9.1 Throughout their reports and evidence, the various noise experts have made a number of comments regarding proposed conditions, and offered a range of opinions. I understand that all such discussions are now superseded by the Conditions and discussion contained in the joint statement of expert witnesses. I will therefore confine this discussion to the Conditions attached to Mr Lloyd's *Statement of Evidence* (dated 19 May 2009), and the *Joint Statement of Expert Witnesses - Noise* (dated June 2009).
- 9.2 I agree with proposed Conditions 1 and 2 relating to construction noise and with proposed Rule 3 relating to non-turbine related operational noise, and note that the Palmerston North City District Plan rules have essentially been adopted.
- 9.3 I agree with Mr Lloyd's proposed Condition 4 relating to the primary noise limit. I do not agree with Dr Thorne's position that a constant noise limit of 35 dBA L_{eq} is appropriate, as I find no evidence that noise at the levels permitted under the proposed Condition 4 would cause a more than minor adverse effect other than during the night time periods covered by the secondary rule (discussed below). I also find no evidence that it is unreasonable to allow a relaxation of limits in higher background noise environments.
- 9.4 With regard to the acoustical parameter used in any rule (L_{95} vs. L_{eq}) I consider that the numerical difference between these parameters is sufficiently minor such that priority should be given to aligning the parameter with that which will be ultimately used to verify compliance. In a situation where compliance was to be proven only through prediction, the limit should therefore be phrased on terms of dBA L_{eq} . In this situation where verification of compliance will ultimately be through measurement, I consider that the presentation of a rule in terms of dBA L_{95} is appropriate.
- 9.5 With regard to Condition 4, I would suggest the reference to notional boundary be changed to include "and any existing residentially zoned property boundary" in line with the other similar agreements of the experts, and that the final wording where the Condition currently reads "existing at the date of issue of consent" be amended in line with any finding of the Board as a result of legal and planning submissions with regard to this matter (that is, to what extent, if any, 'as-of-right' and other future dwellings should be provided protection). I agree with Mr Lloyd's proposed Condition 5, subject to the same provisos as Conditions 4.
- 9.6 With regard to Condition 6, my position is made clear earlier in this report – with regard to the comments by Messrs Hegley and Day that the secondary noise limit should only apply "in circumstances intended by the Standards Committee", based on the actual

wording of DZ6808 I cannot see the basis of their objection, and consider that in any case both the low background noise and District Plan guidance provisions are met. I therefore support Mr Lloyd's position as stated in paragraph 4.8 of the joint statement of expert witnesses.

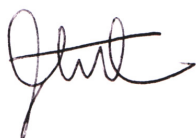
- 9.7 Further to the above, I consider that the position of Messrs Hegley and Day with regard to appropriate wording for Condition 6 to be untenable, as such wording appears to simply defer a decision about whether the secondary rule applies or not to a later, less appropriate, time. Therefore, should the Board be of a mind that the secondary noise limit was not clearly appropriate; I would favour the abandonment of Conditions 5 and 6 in their entirety, rather than adoption of the Condition 6 wording supported by Messrs Hegley and Day.
- 9.8 My remaining concern regarding Mr Lloyd's proposed Condition 6 relates to the 25 dBA level which must be achieved for it to apply. I am concerned that when using noise monitoring equipment with a noise floor of, for example 22 dBA (as is used by Mr Hegley), any noise level measured below 22 dBA will be artificially reported as 22 dBA. There is evidence of such artefacts, for example, in figures 22 and 24 of Mr Hegley's Evidence where a disproportionate number of measurement points are clustered along the 22 dBA gridline. I am concerned about how such a limitation may skew the subsequent regression curve fitted to the data. Because the noise level of interest (25 dBA) is not far above the noise floor (22 dBA), artefacts at the noise floor level may lead to a falsely high the regression curve.
- 9.9 This can be illustrated with a simple one dimensional example: if one considers a measured noise sample at a given wind speed of 30 dBA, and a second sample at the same wind speed of 15 dBA. If then a regression analysis were undertaken to find the point of 'best fit' between the two, the halfway point of 22.5 dBA would be selected. If however the equipment had a noise floor of 22 dBA, then the second sample would have falsely been reported as 22 dBA. The best fit point between the first and secondary sample would then appear to be 26 dBA.
- 9.10 In the absence of a reasonable resolution to the above matter, I would be in support of an amalgamation of Conditions 5 and 6 into a single Condition which applied a secondary noise limit from 10 pm to 7 am with no additional caveats.
- 9.11 With regard to Condition 10 I would recommend the inclusion of a definition of daytime (10 pm to 7am) and night time (10 pm to 7 am) for the avoidance of doubt. Also, I consider the sentence "where there are seasonal difference due to water levels in streams for example then measurements shall reflect those difference" to be unclear

and its intended function should be clarified, and if it is to be retained, the wording made clearer.

9.12 I consider that the final two sentences of Mr Lloyd's proposed Condition 10 should be replaced with the wording in line with clause 7.2.5 of DZ68086 as follows: "Extraneous sound levels caused by events including high local wind speeds exceeding the microphone wind shield rating, precipitation, insects, fauna should as far as practicable be identified and removed from the data set". The following sentence should also be added to Condition 10: "Wind farm sound from any other wind farm shall not be considered as part of the background sound level".

9.13 With regard to the new Condition 18 outlined in paragraph 3.4 of the joint statement of expert witnesses, I would recommend the term "wave files" is replaced, either with the correct specific computer audio file extension terminology "*.wav file", if this is really what is intended, or with an appropriate generic term such as "audio file".

9.14 I agree with the remaining conditions, including Mr Lloyd's proposed Condition 15.



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