

IN THE ENVIRONMENT COURT
WELLINGTON

ENV-2010-WLG-000114

IN THE MATTER of the Resource Management Act 1991
("the Act")

AND

IN THE MATTER of an application under section 311 of
the Act

BETWEEN Palmerston North City Council

Applicant

AND New Zealand Wind Farms Limited

Respondent

AFFIDAVIT OF MICHAEL MIKLIN HALSTEAD

SWORN 1 SEPTEMBER 2014



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I, Michael Miklin Halstead of Wellington, Acoustic Engineer, swear:

INTRODUCTION

1. My name is Michael Miklin Halstead. I am an Associate with Marshall Day Acoustics.
2. I have personal knowledge of the matters set out in this affidavit and its contents are true and correct to the best of my knowledge and belief.

QUALIFICATIONS AND EXPERIENCE

3. I have the following qualifications and experience relevant to the evidence I shall give:
 - (a) I hold a Bachelors degree in Industrial Engineering;
 - (b) I am a member of the New Zealand Acoustical Society and the Resource Management Law Association;
 - (c) I have had 26 years experience assessing and advising on the environmental sound effects of various projects, including wind farms, gas production plants, electricity substations and roading projects for corporate, industrial and public sector clients;
 - (d) My experience with wind farms includes consenting for the Te Apiti, Waitahora, Castle Hill, and Te Rere Hau Eastern Extension wind farms, measurements for Tararua 3 and West Wind, and research on propagation of wind turbine noise; and
 - (e) I served as Chair of the NZS6801-6802 (noise measurement and assessment standards) revision committee, and I was a member of the NZS6808 (wind farm noise) 2010 standard revision committee.

SCOPE OF EVIDENCE

4. I have been engaged by New Zealand Windfarms Limited ("**NZWF**") to carry out measurement and assessment of noise from the Te Rere Hau wind farm ("**TRH**"). The results of this work has been presented in the Marshall Day Acoustics report of 18 February 2014, *Te Rere Hau Noise Compliance, Noise Survey Results and Discussion* ("**Marshall Day Acoustics Report**").
5. In this evidence I will address the following issues:
 - (a) Summary of the issues in dispute;

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- (b) Background and Summary of the 18 February 2104 Marshall Day Acoustics Report;
- (c) Discussion of criticisms by Mr Reutersward; and
- (d) Discussion of criticisms by Mr Lloyd.

SUMMARY OF ISSUES

6. I understand there to be two main noise issues which are in dispute between myself and the noise experts for Palmerston North City Council ("**PNCC**"), namely:

- (a) The appropriate periods for measurements of TRH; and
- (b) The assessment of tonality from TRH.

Before I present the details of my opinions on these matters I will first explain what I believe to be the substance of these differences.

Periods of Monitoring

7. Apart from collecting a data set over periods required by NZ6808 and the conditions of consent, NZWF accepted PNCC's noise expert's request to collect some broader testing results. This was set out in the Measurement Specification agreed between NZWF and PNCC via myself and Mr Lloyd. As noted this additional monitoring data is not specified or required by NZ6808 or the conditions of consent.

8. The Measurement Specification includes a set of monitoring requirements around the state of operation of turbines on the wind farm, specifically, whether each turbine is switched on at a given time, and whether it is actually rotating and generating electricity at that time.

9. While we agree that the turbines should all be made available for operation during measurements, the extra monitoring requirement that the rotation of turbines be recorded has now given rise to one of the main areas of dispute between PNCC and NZWL. Mr Lloyd and Mr Reutersward have presented evidence supporting a test of compliance on the basis of worst-case conditions (i.e. when most turbines are rotating), rather than the average noise level across all conditions, as required by NZS6808:1998 and the Consent Conditions.

10. The details of this issue in dispute are set out as follows:

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- (a) Under NZS6808, compliance testing is carried out by measuring wind speed (at the meteorological mast on the wind farm) and noise level (at neighbouring dwellings) in 10-minute periods, over the course of several weeks. A scatter plot is produced, plotting noise level vs wind speed. A regression line is drawn through these points, and after subtracting the contribution of ambient noise (from sources other than the turbines as assessed when the turbines are not running), this "turbine noise level" is compared against a noise limit.
- (b) Concern has been raised at TRH and other wind farms that it would be unfair to include in this scatter plot periods when turbines were taken out of service, as this would skew the result by lowering the average noise level across the measurement period. I agree with this concern, and have eliminated data points where fewer than 95% of the installed turbines are available for operation (e.g. they are manually switched off, or are under repair). In the Marshall Day Acoustics Report this condition (where at least 95% of the turbines are available for operation) is called the "Operational" condition. For clarity in this affidavit I will refer to analysis of this condition as the "NZS6808 assessment".
- (c) Within the Measurement Specification there was also a request by PNCC to consider a second operational condition of whether the turbines are actually rotating and generating electricity. During the course of normal operation, turbines may start and stop rotating in response to the local wind conditions near the turbines. At times some turbines may rotate while others do not. This occurs as the wind speed varies at locations across the site, and in some cases the wake produced by one turbine affects the available wind energy of another turbine, causing it to slow or stop. This natural starting and stopping of turbines is not a deviation from the natural activity of the wind farm, and should be included in the assessment of noise emissions. This is recognised in consent condition 6 which specifically refers to "actual operation" as "operation of the wind farm with all installed turbines made operable as that would be for normal operation, regardless of the winds on any given day".

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- (d) To address the PNCC request that this operational condition be illustrated, I prepared a parallel analysis of noise emissions set out in the Marshall Day Acoustics Report. As already alluded to, the condition where at least 80% of the turbines are rotating and generating electricity (and 90% of the turbines in close proximity to the dwelling at which noise is being measured are rotating) is called the "Operating" condition in the Report. For clarity in this affidavit I will refer to analysis of this condition as "worst-case" analysis.
- (e) I have kept these two analyses distinct in my report because only the "Operable" condition is relevant to the NZS6808:1998 assessment required in the conditions of consent. By contrast the "Operating" condition is a type of worst-case analysis, as it eliminates many data points associated with natural operation of the wind farm. The data points removed are generally quieter, not only because there is less turbine noise emission, but also because there is less wind across the site to produce noise in trees and vegetation. Because of the removal of this data, the result is skewed upwards, and does not reflect the average noise emission of the wind farm, and cannot be directly related to the background sound level in the absence of turbines which was measured including these 'eliminated' wind conditions.
11. The PNCC noise experts are seeking to assess the noise level of TRH on the average of only the worst-case conditions, rather than on the average of all operating conditions of the wind farm, as is required under NZS6808:1998 and the Conditions of Consent.
12. To recap, it is my opinion that the "worst case" analysis is not appropriate as it would not allow assessment of all wind conditions, for instance the case where local wind at some parts of the farm is low while some turbines are operating. This local wind situation is commonly known to give rise to complaints near wind farms.

Assessment of Tonality

13. The PNCC experts suggest that subjective assessment of tonality should carry significant weight in the question of whether a tonal penalty should apply. These experts also suggest that the objective method I have used to assess

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tonality (the method agreed during joint conferencing) is not appropriate.

14. While subjective assessment of tonality can be a fast means of ruling in or ruling out tonality in clear-cut situations, the presence of penalisable tonality has never been a clear-cut situation since the outset of the investigation into the noise generated from this wind farm.
15. It is my opinion that a subjective assessment would not be useful. Because of this I have employed the objective method of tonality assessment that was agreed between the experts, and implemented it in the manner described by the IEC measurement standard that was referenced in those discussions of the experts. This is an internationally agreed analysis method, and the method I used implemented this in a way which is consistent with that standard. I have tested the hypothetical situation of detecting closely spaced tones that is raised in Mr Reutersward's evidence, and have found that this methodology correctly assesses and penalises that situation.
16. I will now turn to consider the matters in more detail.

BACKGROUND

Marshall Day Acoustic Report – February 2014

17. In late 2010 I was engaged by NZWF to measure the sound level and sound character of the Te Rere Hau wind farm in response to concerns raised by neighbouring residents and PNCC. The concerns raised include:
 - (a) Whether the noise limits used in compliance reports are correct;
 - (b) Whether the wind farm noise levels measured and reported in compliance reports are sufficiently representative of operating conditions to satisfy the requirement to demonstrate compliance;
 - (c) Whether the sound character of the wind farm has been correctly assessed in deciding whether to impose a special audible characteristic ("**SAC**") penalty, specifically around the question of tonality, but also including amplitude modulation.
18. Further to this review, I was commissioned to carry out an extensive set of measurements of TRH, and of the ambient

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noise level of the environment when the wind farm was shut down.

19. The measurements were carried out with the assistance of a Measurement Specification which was agreed between PNCC and NZWF.
20. While it was agreed that this Measurement Specification would be used to collect a data set for the purposes of discussion, it was never suggested or agreed that this would replace or amend the conditions of consent.
21. The stated purpose of this Measurement Specification was to provide "an accurate picture of the current acoustic performance of the wind farm and its effects on the receiving environment"¹. The Measurement Specification included specific requirements for monitoring the performance of each wind turbine and also extra restrictions for analysing noise in relation to turbine operation (both of which are additional to the conditions of consent).
22. While initially my brief was solely to gather data, while making these measurements it became apparent that the compliance of the wind farm with the consent conditions was an important issue, hence the inclusion of this assessment in my report.
23. The conclusion of this investigation was presented in the already referred to Marshall Day Acoustics Report. This Report contains a summary of the data collected, and also uses the data to assess compliance in accordance with NZS6808 and the consent conditions. This includes an assessment of tonality and amplitude modulation.

The analysis of the "worst case scenario" in the Report

24. In addition, an analysis was made of the sound level of TRH using the restricted data set introduced in the Measurement Specification. Although this approach is not part of the NZS6808 requirements or the conditions of consent, this information was requested by PNCC to understand the sound emissions of the wind farm under the highest noise output conditions.
25. It is important to note that this condition is a subset of the period of "actual operation" described in the conditions of

¹ Measurement Specification, paragraph 1

consent and anticipated by NZS6808. "Actual Operation" (referred to in my report as the "operational" condition) means that all or nearly all turbines are available for normal operation, that is they have not been manually disabled (switched off) or are otherwise out of service.

26. By contrast, the condition I describe as "Operating" in the Report is essentially a "worst case" analysis based on the additional restrictions in the Measurement Specification. This approach eliminates data points from some wind conditions by only analysing noise levels when at least 80% of the turbines are generating power; and at least 9 of the 10 nearest turbines to each property are generating power; and when both of the most visible turbines to the Harrison Hill Road / Ridgeview Road properties are generating power.
27. During the course of natural operation, the wind conditions across TRH vary, such that some turbines may experience higher or lower wind speeds than the reference wind speed at the met mast anemometer. This results in some turbines producing more or less power, or some turbines stopping rotation until wind conditions change. Under the "worst case" analysis these data points would be excluded, even though they would be considered "actual operation" and be an important part of the NZS6808 assessment required by the consent conditions.
28. For a given wind speed, the turbine noise level under the "worst case" analysis will be slightly higher than the average level across all periods at that wind speed (as required by the NZS6808 assessment) – there are more wind turbines rotating, and on average the turbines are operating at higher wind speeds.
29. The "worst case" analysis can also not be used for assessment purposes because the ambient noise level data is longer valid. The ambient noise contribution associated with "worst case" conditions will also be higher than that used in the NZS6808 analysis – a higher average wind speed across the farm will produce more noise from trees and other vegetation.
30. If an analysis were made of the ambient noise level during only those times associated with the "worst case" wind conditions, this would affect the outcome in two ways:
 - (a) The ambient noise would make a higher contribution to the overall level when the wind farm is operating,

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which would need to be subtracted in order to determine the turbine contribution; and

- (b) A noise limit based on this higher ambient noise level would be higher if the wind farm were to be assessed in this way rather than the way required by NZS6808 and the consent conditions.
- 31. The conclusion of the Marshall Day Acoustics Report is that when assessed according to NZS6808 and the consent conditions, the noise emissions from TRH comply with the applicable noise limits at all properties under all conditions.
- 32. The Report also presents the noise levels using only the data points related to the "worst-case" conditions. The finding is that at one property these worst-case noise levels exceed the NZS6808 noise limits by 1 decibel, during East-South-East winds of 7 – 8 metres per second. If the ambient noise data were also restricted to the 'worst case' data (paras 28 to 30), this 1 decibel exceedance would probably disappear.
- 33. It is important to note that this finding does not constitute non-compliance with respect to the conditions of consent or NZS6808. The information was provided as a response to the query by PNCC regarding this specific worst-case situation.

The assessment of tonality

- 34. The assessment of tonality has been a focus of the proceedings to date. The character of the noise from the turbines contains several characteristics which are at times audible and identifiable at dwellings, and one of these corresponds to a tone which is significant when measured 60 metres from a turbine.
- 35. The subjective audibility of this tone has been debated since the first noise assessments were carried out, and my initial engagement in this project was to provide objective measurements of tonality to assist with this discussion. These measurements have been met with some criticisms that they were not taken at appropriate times, leading to the present approach where continuous recordings of sound at each dwelling have been analysed exhaustively.
- 36. The recordings yielded many periods which contained identifiable tones, although most of these were due to sound not related to the wind farms. Typical sounds responsible for these tones include motor vehicles, airplanes, and animals.

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37. Of the tones with frequencies close to those observed near the turbines (as described in section 11.4 of my 18 February 2014 report), most were again caused by sources other than the wind farm. These were clearly identified by listening to the recordings and identifying the source (for example hearing a truck drive past, or a cow moo).
38. Some events were identified in which identifiable tones were emitted by the wind farm at a low level. This occurred at the Wallace, Irvin, Linforth, and Stewart dwellings. None of these tones exceeded the agreed threshold at which a penalty would be applied.

RESPONSE TO AFFIDAVIT OF REUTERSWARD

39. The evidence of Reutersward addresses two main issues:
- (a) The operational state of the turbines during testing; and
 - (b) The appropriateness of the tonality testing method.
- I address these issues as follows.

Operational State of Turbines

40. Mr Reutersward comments that "turbines may switched on or off to respond to local wind conditions across the site." This use of the term "switched on or off" is different from our usage of the term. My use of switching on or off refers to a manual intervention of normal operation, rendering the turbines unavailable for use. His use appears to also include the case where wind speeds near the turbine are low, and the turbine operation programming automatically parks a turbine until wind speeds fall within a specified range for a certain amount of time.
41. The critical distinction is that a compliance test should be made when turbines are in the state described by Condition 6: "the operation of the wind farm with all installed turbines made operable as they would be for normal operation, regardless of the winds on any given day". If the wind condition is such that some turbines stop rotating, this is still part of "actual operation" and should be included in the NZS6808 assessment.
42. Mr Reutersward draws from the modelling requirements in NZS6808, which is based on the case where all turbines are generating sound. The assumptions of the modelling method

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should not be confused with the compliance testing procedure. Compliance testing is a direct test of performance against a noise criterion, not a verification of a prediction model. In my opinion it is not relevant to consider the requirements of modelling when conducting compliance measurements.

43. The modelling procedure in NZS6808 also uses a sound propagation technique which utilises down wind conditions from every wind turbine to the receiver location (ISO9613). This clearly could never be replicated in a monitoring procedure and in my opinion would be an absurd objective for a monitoring procedure.
44. Mr Reutersward refers in his paragraph 22 to carrying out a worst-case operational noise level assessment. I agree that the additional restrictions of the Measurement Specification seeks to achieve this, but that this is not a required or relevant part of an NZS6808 compliance test, and is not the assessment identified in the Conditions of Consent.

Tonality Assessment

45. Mr Reutersward comments on the drawbacks of using Joint Nordic Method version 1, which he states is incorporated into Edition 1 of IEC61400-11. He notes that the second iteration of the Joint Nordic Method, known as "JNM2", incorporates improvements to the method which provide a more precisely specified means of identifying tones, which produce a more reliable assessment.
46. The testing method agreed in Joint Statement 1 is **Edition 2** IEC61400-11, the 2002 version. Edition 2 incorporates improvements to the tonality assessment procedure added in response to the same issues raised in JNM2. This overcomes the difficulties of multiple tone detection and poor specification of method. I have specifically tested the hypothetical case where there are closely spaced tones, and determined that the methodology correctly identifies and penalises these tones.
47. The penalty threshold from JNM1 (a 5dB step) has been retained because that was specifically imposed by the conditions of consent. As discussed previously, IEC61400-11 does not contain a penalty threshold; the appropriate threshold for the 5dB penalty was agreed during joint conferencing and has been implemented in my assessment.

48. In regards to tones with varying frequency, the IEC61400-11 method specifically targets this by subdividing the measurement period into short intervals which are individually analysed.
49. Although I agree with Mr Reutersward that the absence of a tone in the nearfield would give a good indication that tonal problems are not likely to occur in the far field, this is not the only test for the absence of penalisable tonality. As discussed in paragraph 24-25 of Reutersward's evidence there are many reasons that the level of tonal audibility can change when assessed in the far field, and for this reason this assessment is correctly carried out at receiver locations.
50. The conclusion of this assessment is that sound received at the subject dwellings from Te Rere Hau wind farm contains no tones for which a penalty would be applicable.

RESPONSE TO AFFIDAVIT OF LLOYD

51. The evidence of Mr Lloyd also focuses primarily on the "operating" vs "operational" condition of the wind farm during testing, and on tonality assessment.

Operational State of Turbines

52. Mr Lloyd draws on Clause 4.4.2 of NZS6808 to consider the appropriate state of the wind farm during compliance measurement. I note that Clause 4.4.2 refers to the method of prediction of wind farm sound to be used during AEE preparation, not to compliance testing for which there is a separate section. If as Mr Lloyd suggests, measurements should only be taken when all turbines are in full power production, it would not be possible to test noise emissions at low to moderate wind speeds when some turbines do not operate, or produce less than full sound output. Ironically, it is often these low flow conditions that give rise to noise complaints (when background wind noise is lower), and this would result in an incomplete assessment.
53. Mr Lloyd also refers to the example given in NZS6808 where a two-turbine farm is discussed. He concludes that both turbines must be operating in this example, but in fact there is no data given about turbine operating state in these examples, nor is any direction given to collect or interpret this data.

54. The reference in Mr Lloyd's para 8(b)(i) to measurement of "non-operational" turbines implies that turbines are artificially removed from service during the test. This is not the case – if turbines were purposefully switched off, those periods are not included in my NZS6808 assessment. However if turbines stop rotating in response to the natural changes of wind conditions, this is considered part of the "actual operation" of the wind farm which must remain part of the compliance assessment.
55. The method prescribed by NZS6808 is in fact a form of averaging over all operational conditions, and this is only correctly achieved when all operational conditions are included in the assessment. This is accomplished in the NZS6808 assessment we have carried out, but is not accomplished by the worst case analysis in the Measurement Specification.
56. The intent of NZS6808 is not to provide a worst-case assessment, but rather to provide an assessment over the average conditions.
57. While a "worst case assessment" may have been the reason the PNCC requested the additional measurement restrictions be considered, this is not included or implied in either NZS6808 or the conditions of consent.

Tonality Assessment

58. Mr Lloyd and I agree that there are sounds in the near field of the turbines at Te Rere Hau which are tonal at that location. However, it should also be noted that a separate assessment of tonality at greater distance from the turbine, carried out by Hegley & Associates, indicates that there is no penalisable tonality at the distances where dwellings would be.
59. However the presence or absence of a tonal penalty during the AEE stage does not automatically carry forward to the compliance testing process. During compliance testing the actual effects are assessed at dwellings, and that is the fundamental purpose of both the AEE and of the tonality assessment. This approach allows the penalty to be assessed on the basis of the actual noise effects at dwellings.
60. Mr Lloyd asserts that NZS6808 does not anticipate tonality appearing during commissioning in a different way to that identified during sound power level measurement near to the

turbines. This assertion is not consistent with the presence of a separate section (5.3) in NZS6808 for assessing special audible characteristics during compliance assessment. The fact that this procedure mentions subjective testing means that it is anticipated this procedure would be necessary after installation, rather than simply relying on information known at the time of AEE preparation.

61. Mr Lloyd brings into question the appropriateness of assessing tonality at the dwellings rather than near the turbine. This approach of assessing at the dwellings has already been agreed in paragraph 22 of the first Joint Statement of acoustic experts that the appropriate location for SAC assessment is at the dwelling. This is where the tonality assessment has been carried out in my investigation.
62. Mr Lloyd suggests that residents' impression form a subjective assessment of tonality, and criticises my report for not providing a subjective assessment. While residents' impressions are a useful indicator which can direct further investigation, they are neither independent nor expert. The investigation I have carried out in my Report regarding tonality is the response to their concerns, and provides the most comprehensive data available on the level of tonality experienced the wind farm. I note that while subjective opinions of tonality in obvious cases are useful as a fast means of conclusion of the matter, the presence of penalisable tonality in this case has been contentious before my first involvement in the project, and had already moved beyond the point where a subjective opinion alone would be valuable.
63. The methodology agreed during joint conferencing was to apply the method of IEC61400-11 2002, and to apply the 5 dB step penalty as required in the consent conditions and described by JNM1. It was agreed that this testing would occur at the dwellings.
64. I agree with Mr Lloyd that discovering the absence of any tonality near a turbine is a useful means of ensuring that a turbine will not have tonality at dwellings. However the converse is not necessarily true, as tones can be attenuated by distance and air absorption in the propagation to dwellings and masked by the ambient noise environment. Measurement near the turbines does not constitute an appropriate means to assess actual effects at dwellings. As

agreed during joint conferencing, the assessment of the actual effects of tonality depends on measurements at the dwellings.

65. As discussed in response to Mr Reutersward's comments, measurement of tonality was carried out using the IEC61400-11 2002 method, which is clearly defined in that standard. The specific tones of interest were identified by analysis of measurements taken near a representative sample of turbines. Tones which appeared in these measurements had the potential to be audible at dwellings, and so the investigation at dwellings focussed on these frequencies.
66. The cases where tones are identified but are found not to be attributable to TRH were determined by listening. This work was carried out by myself and my colleague Steve Arden. In all cases there was no doubt even to a lay person that the sounds in questions were airplanes, trucks, cows, or other sources. Both Mr Arden and I have visited TRH and the dwellings surrounding it on many occasions, and are well aware of the characteristics of the tones emitted and received, and as a result both of us are qualified to subjectively discriminate between wind farm tones and obvious extraneous sources.
67. As discussed previously, the sample size used in this assessment is far in excess of a normal tonality assessment, and was carried out specifically in response to concerns about measuring at the wrong time. Although equipment failure did occur in some instances, the large sample size allowed us to cover the entire range of relevant wind speeds.
68. The measurement locations were agreed at the outset of the project, and represent agreed locations which would be representative of the community.
69. The exclusion of 'non-turbine tones' occurred as a result of detailed measurements near the turbines (to indicate which tones are produced by the turbines and therefore could be emitted by the wind farm), and by expert judgement of the subjective character of sounds, which is as basic as recognising the sound of a car or a cow.
70. The conclusion of this investigation is that while there are sounds emitted by TRH which are identifiable by residents as being wind farm related, the fact that the wind farm noise is audible does not mean the tonal penalty should be applied.

The wind farm tones have been carefully assessed using the agreed procedure and are below the agreed threshold where a penalty would be imposed.

SUMMARY

71. The NZ Standard and the conditions of consent require the wind farm to be measured and assessed over a wide range of wind conditions (i.e. what the residents experience). In contrast, the additional procedure in the Measurement Specification requires only a specific set of high wind conditions to be included by ignoring parts of the natural operation of the wind farm and in fact exaggerates the acoustic impact of the wind farm by producing an inherently biased result.
72. While this analysis procedure can be used to analyse the wind farm noise under specific conditions, it does not comply with the procedures in NZS6808 or the conditions of consent.
73. The analysis procedure using 'worst case' conditions only, reveals a 1 decibel exceedance of NZS6808 at one property during East-South-East winds of 7 – 8 m/s only.
74. The assessment of effects of a wind farm (both noise level and tonality) must be carried out where the effects occur – at the residences, not next to the turbine where no-one lives or works.
75. I conclude that the Te Rere Hau wind farm complies with its consent conditions when assessed in accordance with NZS6808 as required in the conditions of consent.

Michael Miklin Halstead



SWORN at WELLINGTON this 1 day of September, 2014
before me



Belinda Jane Malby
Solicitor
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A solicitor of the High Court of New Zealand