<u>ANNEXURE A:</u> Curriculum Vitae

STEVEN E. COOPER. - DIRECTOR

DATE OF BIRTH: 15 June 1952

QUALIFICATIONS:

Bachelor of Science Engineering
(Electrical) 1978, University of NSW

Master of Science (Architecture) 1990,
University of Sydney

MEMBERSHIPS:

Member, Australian Acoustical Society

Fellow, Institution of Engineers, Australia
Chartered Professional Engineer

Member, Institute of Noise Control Engineering

Member of Committee AV/10 – Whole Body Vibration (1986 to present), Committee EV/11 – Aircraft & Helicopter Noise (1986 to present), AV/4 – Architectural Acoustics (1996 – 1999), and Committee EV/10/4 – Railway Noise (1998 to 2007)

NSW Division, Australian Acoustical Society
Membership Committee since 1978 to 1997

EXPERIENCE:

The Acoustic Group Pty Ltd
Incorporated in 2003

Steven Cooper Acoustics Pty Ltd
Incorporated in 1995

James Madden Cooper Atkins Pty Ltd
Incorporated in 1981

James A. Madden Associates Pty Ltd
Appointed Associate Director 1980
Appointed Associate 1979
Appointed Engineer 1978

20-22 FRED STREET, LILYFIELD, 2040, NSW, AUSTRALIA
ph: (612) 9555 4444 fx: (612) 9555 4442 tag1@acoustics.com.au
A.B.N. 73 082 704 701

The Acoustic Group was formed to provide specialised services and research in Acoustics and Vibration and draws on the considerable experience of Mr Cooper from his position from 1982-1995 as Principal and Partner of James Madden Cooper Atkins and from 1995-2003 as Principal of Steven Cooper Acoustics. His particular areas of acoustical expertise include machine and vibration monitoring, acoustical design of auditoria, studios and entertainment venues, traffic and helicopter noise, laboratory instrumentation, precision analysis system, legal assignments and expert witness.

He has considerable experience in vibration measurement and assessment in industry for both Machinery Operating Condition and Occupational Exposure Levels.

His experience in the measurement and assessment of noise emission from industry and licensed premises is extensive having produced numerous assessment reports and noise control designs for clients, statutory bodies and courts. He has been an invited Guest Lecturer on Noise Assessment to NSW Policy Academy for their Noise Familiarisation Course run by the State Pollution Control Commission, a guest lecturer for the Faculty of Architecture at the University of NSW, and a lecturer on noise issues for seminars/workshops run by the Australian Industries Group, the Australian Environment Network and NEERG Seminars.

He is the acknowledged leader in the measurement, assessment and design of helipad/heliport operations, military aircraft noise assessments, and is a major contributor to various Australian Standards. Mr Cooper is the recipient of an Engineering Excellence Award in the Environment Category from the Institution of Engineers in 1997 for the TRW No. 2 Forge Project.

Projects in which he has been involved include the ICI Botany Complex (Noise and Vibration), APM Matraville Paper Mill (Site noise control), Manildra Flour Mill, Sydney CBD, Granville & Gosford Heliports, ANEF Validation and NPD testing for F111, FA-18, JSF aircraft, Iroquois, Squirrel, Sea King, Sea Hawk, Blackhawk, Super Seasprite, Tiger and MRH90 helicopters, acoustical assessments for Licensed Premises, Studios, Auditorias etc.

PAPERS & PUBLICATIONS

“Design for Noise Reduction – Dual Occupancies” 5th Annual Conference, Local Government Planners Association of NSW, November 1979

“Is Exposure to High Levels of ‘Rock’ Music a Major Health Hazard to Patrons and Staff” 10th International Congress on Acoustics – Sydney, July, 1980

“Hornsby Shire’s General Sound Insulation Code for Residential Flat Buildings” 10th International Congress on Acoustics – Sydney, July, 1980

“Archiving Reproducing Piano Rolls” 10th International Congress on Acoustics – Sydney, July, 1980

“Road Traffic Noise and Local Government Controls”, Graduate School of the Built Environment, University of NSW, February, 1981

"Noise Levels of Rock Music and Possible Effects on Young People's Hearing" Scientific Meeting NSW Division, Australian Acoustical Society, April, 1981

"Noise Assessment of Licensed Premises" NSW Police Noise Familiarisation Course, Policy Academy Sydney, July, 1981

"Noise Effects on Staff in Entertainment Venues" Australian Live Theatre Council, May, 1983

"Noise Pollution" Shout – August 1987, Journal of the Registered Clubs Association of NSW

"The Roles and Needs of Expert Witnesses", Development, Local Government and Environmental Seminar for Sly & Russell, Sydney, November, 1987

"Noise Limits for Helicopters", "Helicopters Noise and the Community", "Flight Techniques to Reduce Noise", Helicopter Noise Seminar – NSW Branch of the Helicopter Association of Australia, April, 1988

"Intensity Measurements of the Ampico/Duo Arts Parts 1 & 2" The AMICA News Bulletin (USA), Vol 25 No. 4, July, 1988

"Community Perceptions, Case Studies and Control of Noise" – Australian Conservation Foundation – Sydney Branch, September, 1988

"Helicopter Noise Assessment", Australian Acoustical Society Conference, Victor Harbour, South Australia, November, 1988

"Noise Considerations for the Establishment of Helipads/Heliports", Rotortech '89, Sydney, October, 1989

"An Investigation of the Alternatives to Sabine's Equation in the Determination of Absorption Coefficients using the Room Method", Master of Science Thesis, University of Sydney, March, 1990

"Noise Control – Decibels per dollars. A Practical Approach", The Stock Feed Manufacturers', Association of Australia Conference, Canberra, March, 1990

"Community Response to Aircraft & Helicopter Noise – Proposed PhD Research", Technical Meeting of the Australian Acoustical Society, NSW Division being a Review of Acoustics Research at Sydney University, May, 1991

"A Practical Method for the Assessment of Noise Controls for Aircraft Noise Intrusion", Second Sydney Airport Coalition Public Meeting, Petersham Town Hall, Sydney, September, 1991

"Are Regulatory Noise Limits in Australia Exterminating the Helicopter Industry?", Inter-Noise 91, Sydney, December, 1991

"Consideration of Alternative Acoustic Criteria for Assessment of Aircraft Noise in Wilderness & National Park Areas", Progress Report of Noise Criteria Working Group, Blue Mountains Fly Neighbourly Advice, July, 1994

"Are Regulatory Noise Limits in Australia Exterminating the Helicopter Industry?", Second Pacific International Conference on Aerospace Science & Technology, Melbourne, March, 1995

"Sound Proofing of a Forge", Acoustics Australia, Vol 26 (1998), No 2

"AS2021 – What Does it Mean Now?", Australian Mayoral Aviation Council Conference 1998

"Upgraded Plants and Retrospective Application of Modified Noise Criteria – Case Studies", Australian Industry Group, January, 1999

"Revision of Australian Standard AS2021", Airport Operators Conference, Melbourne, May, 1999

"Living with Your Neighbour's Noise", Neighbourhood Disputes Seminar, LAAMS, Sydney, May, 2000

"What Triggers the New EPA Noise Policies – Tips & Traps", Australian Environment Business Network Noise Pollution Seminar, June, 2001

"Practical Environment Management – Noise Issues", Australian Environment Business Network Environment Management Practitioners Workshop, August 2002, November 2002, February 2003, May 2003, August 2003

"Environmental Issues Management – Noise", Australian Industries Group Practical Methods and Technologies Seminar, October, 2002

"The INM Program is a much better program than HNM for helicopter modelling, but ….", SAE A-21 Helicopter Noise Working Group Meeting, Las Vegas, March, 2004

"Noise Certification, is the Helicopter Industry selling itself short?", HeliExpo 2004, Las Vegas, March, 2004

"Derivation & Use of NPD Curves for the INM", Helicopter Noise Workshop, American Helicopter Society Conference, June, 2005

"Problems with the INM: Part 1 – Lateral Attenuation", Noise of Progress Acoustics Conference 2006, New Zealand

"Problems with the INM: Part 2 – Atmospheric Attenuation", Noise of Progress Acoustics Conference 2006, New Zealand

"Problems with the INM: Part 3 – Derivation of NPD Curves", Noise of Progress Acoustics Conference 2006, New Zealand

"Problems with the INM: Part 4 – INM Inaccuracies", Noise of Progress Acoustics Conference, 2006, New Zealand

"Reviewing the Role of the Expert in Land & Environment Court Cases", NEERG Seminars, Sydney, August 2007

"JSF Aircraft Noise Issues for Australia", F35 ESOH Working Group Meeting, Washington, September 2007

"Acoustic Experts - Noise Under Pressure?" Getting it Together in the Land & Environment Court: Compiling Joint Expert Reports, NEERG Seminars, Sydney, October 2007

"What can go wrong acoustically", NEERG Seminar Dealing with DAs in 2009, Sydney, May 2009

"Community Response to Impulse Noise & Vibration", Training Area Noise & Vibration Workshop, Department of Defence, Canberra, June 2009

"Acoustics & Noise". Regulations & Implementation of DAs & SEPP65, NEERG Seminars, Sydney, March 2010

"INM Getting it to work Acoustically", 20th International Congress on Acoustics, Sydney, August 2010.

"Military Aircraft Noise in the Community", 20th International Congress on Acoustics, Sydney, August 2010.

"Sound Therapy Restores hearing – Fact or fiction? A personal experience of an acoustician", 20th International Congress on Acoustics, Sydney, August 2010.

"Alternative Aircraft Metrics – Useful or like moving the deck chairs on the Titanic", 20th International Congress on Acoustics, Sydney, August 2010.

"Issues arising from Incorrect Acoustic Conditions", Getting it Just Right, NEERG Seminars, Sydney, September 2010

"Avoiding/repairing acoustic disasters in DAs", Managing the DA Process from Go to Whoa, NEERG Seminars, Sydney, March 2011

"Aircraft Noise Measurements can be fun", Australian Acoustical Society NSW Division, August 2011

"INM Problems, Military Operations and AS2021 and the JSF", Australian Acoustical Society Victorian Division, September 2011

"Wind Farm Noise – An ethical dilemma for the Australian Acoustical Society?", Acoustics Australia –Vol 40, No2, August 2012

"Are Wind Farms too Close to Communities?", Australian Environment Foundation 2012 Annual Conference, October 2012

SPONSORED TECHNICAL REPORTS (Brief Selection only):

Noise Radiation and Reduction on a Fibreglass Minesweeper – HMAS Rushcutter for Carrington Slipways P/L, JMCA Report 16.1650.R1

Occupational Vibration Exposure Levels on Euclid Dump Trucks and Coal Haulers at Utah Blackall Mine Queensland, JMCA Report 16.1648.R1-R3

Thermal Expansion and Misalignment on a Gas Turbine Alternator at Shell Clyde Refinery, JMCA Report 17.1716.R1-R3

Acoustic Appraisal and Control – ABC Perth TV & Radio Studio Complex, JMCA Report 17.1607.R3

Southern Arterial Route – Pyrmont to St. Peters for NSW Department of Main Roads, JMCA Report 16.1647.R1

Building Structure Vibration Department of Social Security, East Point Centre Computer Installation, JMCA Report 15.1542.R2

Blower House Acoustic Controls (Building and Silencer Designs) St. Marys, Quakers Hill, Glenfield, Macquarie Fields and Hornsby Heights Pollution Control Plants, JMCA Reports 10.1014 & 14.1416

The Application and Use of ANEF Contours for Aircraft Noise Control, SCA Report 25.3127.R3 for Submission to the Senate Inquiry into Aircraft Noise at KSA

An Acoustical & Vibration Investigation into Freight Rail Operations in the Hunter Valley, SCA Report 26.3387.R1-R41

TRW No 2 Forge Noise Minimisation Study, SCA Reports 26.3314.R12-R19

Acoustical Assessment, Proposed Extension of Dock Hours, Westfield Shoppingtown, Parramatta SCA Reports 28.3766.R8-R12

Noise Impact Assessment, Proposed Service Centre, Cnr Cowpasture Road & Hoxton Park Road, Hoxton Park, SCA Report 30.3934.R1

Acoustical Assessment, Proposed Extension of Operating Hours, Westfield Shoppingtown Hornsby, SCA Report 30.3928.R3

Acoustical Assessment Aircraft Operations, RAAF Williamtown and Salt Ash Weapons Range, SCA Report 32.4190.R6

Acoustical Assessment Pollution Reduction Program No. 7, Shoalhaven Starches Plant, Bombaderry, SCA Report 32.3849.R17

HMAS ALBATROSS 2013 ANEF, Derivation of NPD Curves, SCA Report 33.4185.R11

Acoustical Assessment, Proposed Residential Development, Glenning Valley, Wyong, SCA Report 33.4303.R1

Acoustic Assessment, Proposed Groundwater Cleanup Project, Botany Industrial Park, TAG Report 34.4372.R3

Acoustic Design Report, Stage 1 Development Application for Bathurst Hospital, TAG Report 35.4477.R2

Acoustic Assessment, SCT Freight Complex - Stage 1, Brolgan Road, Parkes, TAG Report 36.4523.R1

Noise Disturbance in Residential Apartments as a Result of Building Expansion/Contraction, Bluewater Point Apartment Complex, Minyma, Queensland, TAG Report 36.4578.R1

Acoustic Design Report, Westfield Centrepoint Refurbishment, TAG Report 37.4472.R5

Construction Noise and Vibration Impact Assessment, Westfield Sydney City Refurbishment, TAG Report 37.4472.R6

Proposed Shao Lin Temple Development Site Near HMAS Albatross: Noise Assessment Report, TAG Report 37.4586.R1

TIGER ARH NPD Curves, TAG Report 37.4510.R15

Acoustical Assessment, Point Piper Marina, TAG Report 38.4705.R9

Rail Traffic Noise Impacts, Residential Sub-division, Isedale Road, Braemar, TAG Report 40.4865.R1

Acoustic Compliance Testing, New Buildings, RMAF BASE Butterworth, TAG Report 40.4386.R3

Acoustic Compliance Assessment, RAAF Base Williamtown – Off Base NMT Calibration, TAG Report 40.4421.R18

<u>APPENDIX B:</u> **Australian Acoustical Society CODE OF ETHICS**

1. Responsibility

The welfare, health and safety of the community shall at all times take precedence over sectional, professional and private interests.

2. Advance the Objects of the Society

Members shall act in such a way as to promote the objects of the Society.

3. Work within Areas of Competence

Members shall perform work only in their areas of competence.

4. Application of Knowledge

Members shall apply their skill and knowledge in the interest of their employer or client, for whom they shall act in professional matters as faithful agents or trustees.

5. Reputation

Members shall develop their professional reputation on merit and shall act at all times in a fair and honest manner.

6. Professional Development

Members shall continue their professional development throughout their careers and shall assist and encourage others to do so.

EXPLANATORY NOTES

1. Responsibility

In fulfilment of this requirement members of the Society shall:

1. avoid assignments that may create conflict between the interests of their clients, employers, or employees and the public interest.
2. conform to acceptable professional standard and procedures, and not act in any manner that may knowingly jeopardise the public welfare, health, or safety.
3. endeavour to promote the well-being of the community, and, if over-ruled in their judgement on this, inform their clients or employers of the possible consequences.
4. contribute to public discussion on matters within their competence when by so doing the well-being of the community can be advanced.

2. Advance the Objects of the Society

Appropriate objects of the Society as listed in the Memorandum of Association are:

Object (a)
To promote and advance acoustics in all its branches and to facilitate the exchange of information and ideas in relation thereto.

Object (e)
To encourage the study of acoustics, highlight excellence in acoustics and to improve and elevate the general and technical knowledge in any manner considered appropriate by the Society.

Object (g)
To encourage research and the publication of new developments relating to acoustics.

3. Work within Areas of Competence

In all circumstances members shall:

1. inform their employers or clients if any assignment requires qualifications and/or experience outside their fields of competence, and where possible make appropriate recommendations in regard to the need for further advice.
2. report, make statements, give evidence or advice in an objective and truthful manner and only on the basis of adequate knowledge.
3. reveal the existence of any interest, pecuniary or otherwise, that could be taken to affect their judgement in technical matters.

4. Application of Knowledge

Members shall at all times act equitably and fairly in dealing with others. Specifically they shall:

1. Strive to avoid all known or potential conflicts of interest, and keep employers or clients fully informed on all matters, financial or technical, that could lead to such conflicts.
2. refuse compensation, financial or otherwise, from more than one party for services on the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.
3. neither solicit nor accept financial or other valuable considerations from material or equipment suppliers in return for specification or recommendation of their products, or from contractors or other parties dealing with their employer or client.

5. Reputation

No member shall act improperly to gain a benefit and, accordingly, shall not:

1. pay nor offer inducements, either directly or indirectly, to secure employment or engagement.
2. falsify or misrepresent their qualifications, or experience, or prior responsibilities nor maliciously or carelessly do anything to injure the reputation, prospects, or business of others.
3. use the advantages of privileged positions to compete unfairly.
4. fail to give proper credit for work of others to whom credit is due nor to acknowledge the contribution of others.

6. Professional Development

Members shall:

1. strive to extend their knowledge and skills in order to achieve continuous improvement in the science and practice of acoustics.
2. actively assist and encourage those under their direction or with whom they are associated to advance their knowledge and skills.

APPENDIX C: Ethics Article

Technical Note

Note: Technical notes are aimed at promoting discussion. The views expressed are not necessarily those of the editors or the Australian Acoustical Society. Contributions are not formally peer-reviewed.

WIND FARM NOISE – AN ETHICAL DILEMMA FOR THE AUSTRALIAN ACOUSTICAL SOCIETY?

Steven Cooper, The Acoustic Group, Lilyfield NSW 2040
drnoise@acoustics.com.au

Not since the opening of the Third Runway at Sydney Airport has there been so much publicity in Australia concerning noise – in this case wind farms. Putting aside the issue of noise versus inaudible noise there is a question being raised as to Members of the Society breaching the Code of Ethics. This is not the old question of Professional versus Learned Society. Reliance upon criteria contained in Guidelines or Standards may be an excuse by consultants that in turn places the "fault" on the SA EPA and the New Zealand Standard. However, if people making complaints to no avail and leave their homes because of the wind farm "noise" what is the responsibility of Members of the AAS to the community?

INTRODUCTION

The April 2012 edition of the Australian Acoustical Society's journal (Acoustics Australia – Vol 40, No. 1) provided a series of papers and technical notes relating to wind farm noise [1]. However, the articles supporting wind farms did not discuss the acoustic impact of the wind farms. The articles referred to criteria and compliance with the criteria. The articles did not identify the basis of the criteria or the acoustic impact of wind farms even when they complied with the nominated criteria.

It is evident from the recent public forums conducted by Senators Madigan and Xenophon in South Australia, Victoria and New South Wales that wind farm "noise" is an issue in the community [2,3]. The degree of claims for and against wind farm noise is reminiscent of the aircraft noise debate (with the introduction of jet aircraft to Australia) [4] and the third runway at Sydney Airport [5].

Examination of the aircraft noise debate finds acoustic and socio-acoustic research undertaken in Australia by Members of the Society. Examination of the wind farm noise issue finds a different position.

Members of the Society had been at the forefront of preparing acoustic and vibration Guidelines and Standards in Australia [6] to protect the community from a wide range of noise sources and invariably rely upon overseas experience/standards that are then compared or evaluated with Australian situations.

For example with respect to road traffic noise, we had Standards/Guidelines that originally followed the UK Department of Environment [7] recommendations (rather than US Department of Transport criteria). Work undertaken by the ARRB and Dr Stephen Samuels (and others) lead to a modification of the British criteria to account for Australian road conditions.

AIRCRAFT NOISE IMPACTS IN AUSTRALIA

In the initial stages for aircraft noise assessment Australia adopted the US NEF system [8]. As a result of community concerns about aircraft noise, and a Commonwealth government inquiry (HORSCAN report) [4] led to the noise study by the National Acoustics Laboratory [9] to then result in the ANEF system used for aircraft noise assessments in Australia. Changes have been proposed to the aircraft noise standard, citing the community's response to aircraft noise and the need for supplementary acoustic metrics. However the use of the N60, N70 or N80 descriptor [10] has not been presented in terms of any socio-acoustic surveys and therefore there is a fundamental problem of implementing N60/N80 criteria without any basis to support that criteria.

In the original NAL report on aircraft noise there is the dose response curve for ANEF versus affected people which is slightly different to the curve in Australian Standard AS 2021 [11]. Contained in the NAL report is a dose response for the N70 that can be placed in the context of the unacceptable/acceptable limits for the ANEF system and in turn the building site acceptability tables in AS 2021.

The NAL report does not provide any regression curves showing a basis for N60 or N80. Therefore, as presented previously [12-15], there are issues as to substantiating the number of events that may be applied to the N60 and N80 for an acceptable aircraft noise impact.

In undertaking research work with Fergus Fricke at Sydney University [16] most postgraduate students became aware that Fergus pulled/pushed you sideways to look into different aspects of your subject which required further investigation and a broadening of the material that was the subject of the research. It is such an approach that students of acoustics (of which all members of the Society can still said to be students) can benefit in their daily use of acoustics to have in the back of their mind when there is a problem the quote of Professor Julius Summer Miller "Why is it so?".

This is the exact situation when faced with the challenge of measurements from helicopter operations not agreeing with the international computer modelling led to investigating the matter of lateral attenuation. Investigation found that the attenuation algorithms in the computer model [8] were wrong, had been wrong for many years, and people were unaware of that fact. Investigations, including going back to the original reference documents [17,18] to uncover the problem, which was verified with additional testing leading to that material being presented to the US Aircraft Standards Committee in 2003 [19], accepted and two years later INM was amended to overcome that issue.

Similarly in seeking to validate military aircraft operations with the computer model we kept on getting incorrect results for high frequency noise which under the same investigative concept lead to querying the results. Testing over a number of years led to identification that the original model for determining atmospheric attenuation coefficient per hundred metres was not carried out in any vast chamber or airfields, ovals or similar. The attenuation coefficients were determined from a stainless steel sphere of 1.68 m diameter on a theoretical basis [20].

Utilising measurement data for aircraft operations under different atmospheric conditions found the universal attenuation coefficients [8,21] did not agree with field measurement for aircraft [22] and monitoring at industrial sites.

These results revealed that if one utilises the atmospheric attenuation contained in various International and American standards in computer models there can be errors. And in particular there can be significant errors if one is dealing with high frequency noise, particularly with respect to the discharge of high velocity steam where there is a significant component of the noise source occurring above 2000 Hz.

It is in light of the above background material and the fact that throughout Australia there are hundreds of residents in proximity to wind farms who claim to be adversely affected, and in some cases so affected that they leave their properties, that must be of concern to members of the Society where there are repeated responses that these people are imagining the problem.

It would appear that the reaction of the community to wind farms is not that dissimilar to communities that were subject to the aircraft noise following the introduction of the jet engine that ultimately led to the famous NAL study. The number of people affected by wind farms is not as great as that affected by airports simply because wind farms are not located in suburban areas. However, in taking into account the percentage of people affected in the area covered by the nominated noise level criteria it would seem to be more than 10% of the population are seriously affected.

MEASUREMENT OF WIND FARM NOISE FOR THE COMMUNITY

I and a number of acousticians in Australia have been requested to undertake reviews of wind farm applications and/or conduct measurements of wind farms. This is not dissimilar to requests for peer reviews of acoustic reports for Development Applications or Compliance Tests for a range of typical noise sources, domestic, road, rail, air traffic, and industrial developments.

These reviews and testing have raised a number of issues as to the adequacy of the original assessments, the accuracy of the measurements and question the acceptability of noise limits which are simply matters that an appropriately qualified and experienced acoustic engineer/consultant would undertake.

Such investigations and assessments have raised concerns as to the adequacy of the guidelines and also the results of compliance testing undertaken by various organisations that include Members of the Australian Acoustical Society.

As a result of undertaking the assessments and providing those reports in the public domain I and other consultants have been labelled by wind farm power entities as being "anti-wind farm" or having close ties to "anti-wind farm lobby groups".

Having discussed this very fact with other Members of the Society who have been so labelled and do not accept such accusations, I have stated a number of times that I am not anti-wind farm but have been simply presenting the facts as to what has been generated by such installations that requires further investigation.

If one is to be labelled as anti-wind farm when simply presenting the facts of what is occurring as a result of undertaking work for the community, then it must be the case that the acoustic consultant/engineer who undertakes work for wind farm applicants should equally be labelled by the wind farm industry as "pro-wind farm".

Both the "anti-wind farm" and "pro-wind farm" acousticians who are Members of the Society would undoubtedly disagree with such labelling and should identify the fact that they are truly independent in carrying out such assessments. Furthermore, if those persons are Members of the Society then they could bring to their defence that there is an obligation to abide by the Code of Ethics of the Australian Acoustical Society [23].

So how can persons undertaking assessments "for or against" wind farms of the noise impact of wind farms be a dilemma for the Australian Acoustical Society you may ask.

CODE OF ETHICS

From the Code of Ethics, that appears on the Society's website, one can see there is the Responsibility for the members of the Society:

The welfare, health and safety of the community shall at all times take precedence over sectional, professional and private interests.

The explanatory notes in the Code of Ethics in referring to Responsibility requires members of the Society to:

- conform to acceptable professional standard and procedures, and not act in any manner that may knowingly jeopardise the public welfare, health, or safety.
- endeavour to promote the well-being of the community, and, if over-ruled in their judgement on this, inform their clients or employers of the possible consequences.
- contribute to public discussion on matters within their competence when by so doing the well-being of the community can be advanced.

The explanatory notes in the Code of Ethics in referring to Work within Areas of Competence requires members of the Society to:

- report, make statements, give evidence or advice in an objective and truthful manner and only on the basis of adequate knowledge

- reveal the existence of any interest, pecuniary or otherwise, that could be taken to affect their judgement in technical matters.

NOISE IMPACT

A significant number of wind farm assessments follow a generic format. Whether there is identification of primarily the South Australian EPA Wind Farm Guidelines [24,25] or the New Zealand Wind Farm Standard [26,27], the assessment in terms of those guidelines uses the ambient noise level to provide regression line curves, use of a criterion of 35, or 40 dBA and background +5 dB, whichever is the greater value.

The acoustic assessment generally provides the results of computer predictions using the A-weighted value to then indicate compliance with the criteria contained in Guidelines/ Standard.

The noise assessment in relation to the application provides predicted levels in terms of the substation and construction activities that are related to relevant guidelines, and may include an assessment of noise from power lines to indicate significant separation distance to residence to not present at an issue. In some cases there is identification of the acoustic impact of the substation, construction activities, and power lines [28-31].

However in the generic wind farm assessments there is no actual noise assessment of the wind farm, i.e. the assessment simply states compliance with the relevant guidelines and that is it.

The generic wind farm "noise assessment" considers the noise outside residences and does not identify to the community the audibility of the wind farm, the relationship of the guideline criteria with respect to the acoustic environment of the area, the percentage of time in which there will be audible noise as a result of weather conditions, or conversely a reduction in noise as a result of weather conditions.

The generic wind farm "noise assessment" does not report the situation of residents hearing the noise inside their homes or having sleep being disturbed or that some residents experience disturbance even when there is compliance with the guidelines noise limit. The "noise assessment" does not indicate situations in Australia where residents (host and non-hosts) leave their homes to live elsewhere.

The question is now being asked in the community, and invariably will be asked in courts of law, whether the absence of that material in the "noise assessment" is a Breach of Code of Ethics.

The Association of Australian Acoustical Consultants (AAAC), of which firms become members of that Association, have a Code of Professional Conduct [32] which goes one step further than the AAS in the section on Professional Standards:

- To maintain the standards of business and personal conduct reasonably expected of a professional
- To act with professional responsibility and integrity in my dealings with the community and clients, employers, employees and students
- To provide professional opinions in an objective and truthful manner, avoiding statements that may be demeaning, misleading or unethical
- Not to misrepresent one's skills and experience
- To undertake work only in areas of competence, unless the client is informed of the member's limitations
- To maintain a proper sense of responsibility to the client, broader community, employees, the profession and the environment.

In attending various rural dwellings to undertake wind farm noise measurements questions have been raised by the occupants as to the conduct of members of the AAAC and the AAS in relation to monitoring and reporting of the results/impact.

RURAL NOISE ENVIRONMENTS

Acousticians in Australia that are aware of the origins of Australian Standard AS 1055 [33,34] will be well aware that it follows that the general scenario outlined for other standards and its primary function as per its original title was "Noise Assessment in Residential Areas".

Accordingly AS 1055 is not really a document that is appropriate for rural areas and the background levels that were suggested for our various categories may be appropriate in suburban areas. However for areas removed from traffic the lowest background level in AS 1055 would not necessarily apply in such areas.

Rural areas removed from main roads and the like, and being areas nominated for wind farm developments can experience background levels less than 20 dBA in the day and night, and can also experience ambient L_{eq} levels less than 30 dBA during the day and less than 25 dBA at night.

A fundamental question that communities exposed to wind farms raise is how can the guidelines substantiate 35, or 40 dBA as an acceptable base level at night in rural areas?

The SA EPA Guidelines refer to an indoor sleep disturbance level of 30 dBA by reference to a WHO Guideline [35]. However there is a failure to correctly identify that the WHO guidelines were referring to suburban areas impacted by traffic noise and did not provide criteria for rural areas or consider wind farm noise. The draft New South Wales Wind Farm Guidelines [36] specifically clarified the WHO guideline sleep arousal related to noise in suburban areas from traffic [37].

The situation of background levels in residential bedrooms which are between 10 dBA and 20 dBA, even with turbines operating, must be a fundamental issue of concern for the Members of the Society for a guideline that suggests 40 dBA is an acceptable level at night (as an external level) or 30 dBA as an internal level.

If the "pro-wind farm" acoustician's defence to inadequate reporting assessment or consideration of the community's health relies upon Guidelines or Standards that have been issued for wind farms, then apparently blame may be to the authors of the Guidelines or the Standards committees which include Members of the Society.

It could well be argued that when the first version of the guidelines were prepared by the South Australian EPA they did not have the benefit of an existing wind farm to undertake measurements and determine the appropriateness of the draft guideline and then the guideline.

It would appear historically that the original SA EPA guidelines were based upon overseas material in part. However, there does not appear to be any reference in the document to identify where the base criteria have been substantiated for use in Australian rural communities, i.e. socio-acoustic study to support the limits.

OUTCOMES

The current public debate as to noise impact from wind farms would appear to be more complex than just the "Learned Society of Professional Institution" question raised by Fergus Fricke [38] in the same 1982 AAS Bulletin that reported on the NAL 1982 Aircraft Noise Report.

If further work finds there is a health issue as a result of "noise" generated by wind farms and there are "acoustic assessments" that state there are no health impact no sleep impacts, and no infrasound, then what happens?

REFERENCES

[1] *Acoustics Australia*, Special Issue: Wind Turbine Noise, **40**(1), 1-96 (2012)

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APPENDIX D: ARE WIND FARMS TOO CLOSE TO COMMUNITIES?

Currently, state planning legislation in Australia suggests separation distances of 1-2km from wind farms. Noise limits incorporated in the various State guidelines and used for assessment purposes have no scientific studies to support the basis of the limits. The use of a dB(A) limit set well above the natural ambient background level does not protect the health and well-being of the community. The noise concepts used for wind farms in NSW ignore the fundamental premise of not creating 'offensive noise' as defined in The Protection of the Environment Operations Act. Examination of 'noise levels' received by residents in proximity to wind farms reveals the presence of audible and inaudible sound that extends well past the nominal separation distances of 1-2km. The silence of the individual state Environmental Protection Authorities in addressing these issues is deafening.

Some twelve months ago I was requested to undertake a peer review of an acoustic assessment in relation to a proposed wind farm in central New South Wales. The process of reviewing an acoustic assessment report is relatively straight forward. Examination of the acoustic report found a number of significant technical omissions with respect to the project's specifications issued by the NSW Department of Planning and Infrastructure for the preparation of the Environmental Assessment.

Examination of the 'acoustic assessment' found there was a numerical analysis of potential noise emission levels of the wind farm, but no actual assessment of the impact to advise residents what they would experience.
In the process of reviewing the assessment it was identified that there are a number of wind farms in Australia that are subject to complaints from residents on the basis of noise disturbance and that in some cases some residents have left their homes to obtain relief.

Initial Assessment

As part of the peer review there was a request to attend a number of residential properties in proximity to the Capital Wind Farm to quantify the extent and magnitude of noise emitted from that wind farm. The result of that investigation has led to further attendances at residential properties in proximity to wind farms in both Victoria and South Australia and as such has identified a number of pertinent issues.

Going back to the original attendance at the first residential property, because it appeared the major issue was related to disturbance at night, there was a concentration of monitoring during that period. On the first night of testing there was negligible wind in the area and therefore there was no noise disturbance and measurements of the ambient noise revealed a relatively quiet environment.

The following night presented a different situation, in that the turbines were operating, although there was no apparent wind at the residential property. The noise from the turbines was audible outside the residence and not considered to be excessive and did not appear to correlate with the claims of disturbance.

Inside the dwelling there was some noise detected, but again on a subjective basis I did not consider the noise to be significant. However the resident was able to clearly detect the noise by reason of being sensitised to the noise. Instrumentation was set up to monitor inside and outside the dwelling.

The resident identified that since the operation of the wind farm her sleep was regularly disturbed, she experienced headaches and at times would be woken up as though being startled, but not knowing what caused the event, and at other times would wake up in an extreme state of panic.

The monitoring revealed there to be the presence of low frequencies in the audible range and also frequencies below the audible range. The monitoring suggested a periodic pattern which is associated with the operating speed of the turbine multiplied by the number of blades (which is identified as the blade pass frequency) and then harmonics (multiples) of that frequency. Attendance at other dwellings some 2 – 3 km from the wind farm found similar measurement results and varying levels of disturbance reported by residents.

Measurement Difficulties

The typical approach in dealing with general noise in the environment is to utilise in the first instance the A-weighted value which covers the audible spectrum of sound and utilises a curve that approximates the response of the human ear (see Figures 1 & 2).

The nature of the A-weighting curve reduces the impact of low frequency noise such that low frequency noise or frequencies below what the ear can hear in the frequency domain (identified as infrasound) do not get picked up in the A-weighted value.

Figure 3 shows noise emission levels for turbines (as sound power levels in 1/3 octave bands) with the A-weighting filter applied versus the same data without the A-weighting filter.

In general acoustic terms when one refers to dB(A) guidelines they seek to set criteria based upon a level that satisfies 90% of the people for 90% of the time. For typical noise sources one considers a noise threshold for disturbance to be around 5 dB (decibels) above the background level, and therefore it is not uncommon to find specifications written in terms of background plus 5dB(A).

Noise criteria used for wind farms in Australia tend to be based on a set of guidelines issued in 2003 by the South Australian EPA which only consider the noise in terms of the A-weighted value.

Normally, any measurements that occur in an area where the wind speed is greater than 5 metres per second are ignored for the purpose of background level measurements.

However, the operation of wind turbines requires wind. The presence of wind creates a noise across the microphone and therefore one can have a different background level dependent on the wind at the receiver location. For wind farm assessments there are two criteria utilised in the guidelines, the first one being background plus 5 dB(A), and the second one being a base level of 35 or 40 dB(A). The criteria normally expressed are the greater of the base level or background + 5 dB(A).

Therefore to determine the criteria to be applied to the subject development the procedure to date has been to determine the ambient background level at residential receivers versus the wind that would occur at either a height of 10 metres above ground level at the wind farm or at the hub height of the turbines. The guidelines require one to plot the background level versus the turbine wind speed and then to provide a regression curve of background level versus wind speed.

There are a number of issues with that procedure in that the regression analysis looks to obtain an average noise level versus the wind speed at the subject turbine that is reported to be relevant to the receiver location.
However on attending residential properties in proximity to wind farms it is obvious that due to the topography of the area the wind at the turbine under certain directions would produce a different impact at the residential receivers than for other directions.

As the regression graph that is obtained prior to the construction of the wind farm becomes the determining criteria for compliance purposes the community has some issues as to the relevance of the use of the regression line in view of different wind directions and the resultant noise that occurs at residential receivers. For example, compliance testing in relation to the Capital Wind Farm found the background level with the wind farm turned off to be lower than the regression line background level determined at the application stage.

The second issue of concern in relation to the relevance of the regression lines is that in many cases the instrumentation used for monitoring cannot measure low enough, and therefore the data that is obtained by the monitoring is automatically skewed away from the actual background levels and gives a false average.

Figure 4 shows the results of measurements on the side of a hill in rural South Australia with no trees for 500 metres and no wind farms for 20 kms. The regression line is of the background level versus the wind at 1.5 metres above ground. In this case instrumentation that can measure below 20 dB(A) was used with a standard 100mm windscreen. Because the graph relates to the wind speed at the microphone it shows a different relationship to the typical regression graphs for a location versus the hub height wind speed.

The third issue in terms of wind farm noise that is different from other industrial premises, is the use of a regression line of the data automatically places that curve above a level that would satisfy 90% of the population for 90% of the time.
A fourth issue of concern is the criteria obtained from the guidelines. It becomes obvious when one looks at the regression curves, that for relevantly low wind speeds when the turbines operate, the real background level at residential receivers is significantly below the base line criteria of 35 or 40 dB(A). Therefore the generation of noise levels permitted by the guidelines would be clearly audible in the rural environment.

A fifth issue of concern is whether the windscreen used for measurements is appropriate for the task in hand in that the passage of wind across the windscreen generates a noise other than that created by the wind and therefore leads to erroneous baseline data. In this regard the need for secondary windscreens and ground plane microphones has been raised with suggestions for the current procedure there is a deliberate use of microphone placement to provide an advantage to the wind farm, by elevating the background level.

Acoustic Criteria

One of the principle issues in terms of wind farm noise, is utilising limits typically encountered in suburban areas that do not reflect the acoustic environment in rural areas removed from traffic and industrial sources. Two social surveys in Sweden and one in the Netherlands for relatively small turbines have clearly shown for the same level of noise emission a greater disturbance in rural communities than in suburban communities.

Another issue is that wind turbines are getting bigger and more powerful over time. Measurements indicate stronger low frequency components from larger turbines. Therefore reference to previous wind farms as not being an issue to communities is not an appropriate response if one does not identify the size of the turbines in both physical size and capacity. For example, studies related to one or two 700 kW turbines that create an impact, cannot be taken as equivalent to a wind farm having 30 to 100 turbines with a generating capacity of 3000 kW for each turbine.

The noise levels set out in the guidelines permit a clearly audible noise at rural residential receivers, even when one uses the A-weighted concept that for general noise assessment throughout the state would be levels that are considered unacceptable for residential receivers.

The above issues of concern relate to the use of the A-weighted values which as set out above and shown by the weighting curves in Figures 2 & 3, do not address the low frequency and infrasound components generated by turbines. This becomes an issue in that there are instances of residential dwellings being subject to noise levels that clearly comply with the guidelines yet the persons who occupy those dwellings are adversely affected by the operation of the turbines.

Therefore if residents are subject to noise that interferes with their rest and repose, gives rise to headaches, and makes the occupancy of their residence unsuitable to the extent that some people leave, sometimes on medical advice, then clearly the A-weighted concept is incorrect. However the Environmental Protections and Health Authorities ignore such complaints.
It is in this regard that emphasis has been placed by acoustic researchers around the world to look at other components that exist in the acoustic signature of turbines that is not necessarily picked up in the A-weighted concept.

Figures 5 & 6 show 1/3 octave band noise levels recorded in relatively close proximity to operational turbines in South Australia where there are no interfering noises from wind, road traffic, residential or agricultural activities. In proximity to the turbine there are low frequency components and also infrasound components evident in the acoustic signature. The figures show the difference between a position to the side and in front of the turbine by breaking the sound into spectrum components by way of 1/3 octaves rather than just the dB(A) value.

However a better presentation to identify the unique characteristics of turbines is to analyse across sections of the frequency spectrum when expressed in a linear (i.e. no weighting) relationship.

Low Frequency and Infrasound

It is by use of the linear relationship and narrow band analysis that the unique spectral (frequency distribution) characteristics associated with turbines become evident. There are frequencies that occur below the range of sounds audible to the human ear, and are signals that are readily detected if one has the instrumentation capable of measuring down to such frequencies and measures in a linear format rather than A-weighted format.

The narrow band spectrum recorded in proximity to the turbines shown in Figure 7 clearly indicates the blade pass frequency and multiple harmonics of the blade pass frequency.

One can also look at the variation in the overall noise level to determine a modulation in the signal that is received by the microphone.

Measurements conducted at residential receivers removed from the wind farm have found the presence of the discreet signature of the turbines with those components being detected both outside and inside the dwellings (see Figures 8 & 9).

The resistance to sound provided by the building envelope is much greater at high frequencies than low frequencies, and presents a problem with buildings being unable to adequately attenuate these low frequency components. Furthermore in some cases the building itself may be subject to vibration or the rooms can have natural resonances that can give an enhancement of the infrasound signals, and/or the physical vibration of the building generates such internal noise levels.

The relevance of the low frequency noise, in acoustic terms is significant when one considers that the propagation of sound over distance varies dependent upon the characteristics of the sound source and the frequencies of concern.

Figure 10 provides the measurements recorded external to a dwelling 8km from the Waterloo Wind Farm expressed in 1/3 octave bands. There are some low frequency and infrasound levels but no distinct pattern.

However, at this location, a low frequency rumble was clearly audible and to the residents completely out of character to the natural environment.

If one assumes a turbine has a sound power level of say 103 dB(A) then on a 6 dB attenuation per doubling of distance (without allocating any additional loss for topography) then the typical figure quoted of 35 dB(A) at 1 km would become 17 dB(A) at 8 km.

In a background level of 27 dB(A) shown in Figure 10 under normal dB(A) noise assessment one would expect the turbines to be barely audible/inaudible external to the residence and inaudible inside the residence. However this was not the case.

Figure 11 shows the narrow band levels simultaneously recorded inside (blue) and outside (red) using the narrow band technique to reveal the turbine blade pass frequency and multiple harmonics. Using the measurements near the turbine at the frequency of 4 Hz (80 dB at 150 metres) to achieve only a 20 dB reduction over 8 kms shows that 6 dB per doubling of distance cannot be applied to these frequencies.

The general approach by the use of the dB(A) parameter is to consider individual turbines as a hemispherical radiation point source where the attenuation (reduction in sound) is taken at 6 dB per doubling of the distance. However when one examines the flow characteristic of turbines with respect to the low frequency and infrasound components, measurements reveal the radiation does not occur as a hemispherical source but as a line source which leads to a lower rate of attenuation.

There are a number of facilities around the world that are used for the monitoring of nuclear explosions and seismic activity that concentrate on the low frequency/infrasound components in both an airborne noise and ground vibration. Staff at these facilities have significant expertise in monitoring such levels and a number of these establishments have conducted work in relation to wind turbines. They have found that if turbines are within 30km of such establishments then the operation of those facilities can be compromised. Clearly the sensitive nature of those facilities is different to that of residential dwellings and accordingly a lower separation distance would apply.

However work undertaken by the Federal Institute for Geosciences and Natural Resources specifically into the propagation of low frequency noise, by persons having a significant degree of experience in such measurements, has clearly demonstrated that the propagation characteristics of the infrasound measurements are entirely different to the general A-weighted propagation assumed for turbines (see Figure 12).

Therefore in terms of acoustic criteria applicable to the low frequency and infrasound components associated with turbines the use of dB(A) is entirely inappropriate and, as the guidelines used in South Australia or the New Zealand Standard ignore such components, then the absence of an appropriate criteria for low frequency and infrasound presents some difficulty for the Environmental Authorities fulfilling their role to protect the community from adverse impacts.

In fact the South Australian guideline claims that a well maintained modern wind farm does not produce infrasound. This would appear to be an incorrect statement by reference to the results in proximity to the turbines and the presence of those frequencies in the acoustic signature detected at a residential dwelling out to 8km from the Waterloo Wind Farm.

Some researchers have referred to the use of the dB(G) curve for evaluation of infrasound. The G-weighting is shown in Figure 13 in both a linear and a logarithmic presentation. However as the blade pass frequency of turbines is below 1 Hz, the dB(G) curve may not be appropriate. Alternatively the use of Linear (no weighting) over a restricted bandwidth may be appropriate.

This issue in terms of different propagation rates and the resultant level detected at residence becomes important in that the recent research of Salt and Lichtenhan (2011) and Salt Kaltenbach (2011) as reported by Richard James[1] has confirmed that there is physiological response to modulated infrasound at levels below the threshold of perception (for pure tones) that may start at amplitudes as low as 60dB(G). Similarly Dr Swinbanks (UK researcher) has identified that a modulation of the signal stimulates the auditory system at levels much lower than that normally attributed to pure tone assessment.

In his paper, R. James has identified that investigations many years ago in relation to low frequency and infrasound noise impacts in industry which were well known with respect to diesel generators, power stations and engine rooms on ships and that in the 1970's and early 1980's considerable investigation occurred into low frequency and infrasound that would now fall under the classification of noise-induced sick building syndrome.

Of recent times there have been claims that infrasound produced by wind farms is similar to or less than that obtained in the natural environment. One report used by the wind industry in Australia to support such a claim finds reliance upon 1/3 octave band results, that on a closer examination, leads one to question the results that have been provided.

Figure 14 shows a 10 minute time splice of the dB(A) level for an exposed location near Collector. At the time of the monitoring there was a wind blowing from the south that over the 10 minute average was found to have a mean wind speed of 3 m/s with peaks gusting up to 7.2 m/s.

Figure 15 compares the narrow band spectra for 0 – 50 Hz (upper graph) with the 1/3 octave spectrum (lower graph). As the comparison shows while there may be designated frequencies in the 1/3 octave bands that fall in the infrasound region, there is no harmonic or distinct pattern in the narrow band spectra.

Hence it can be seen that utilising 1/3 octave band material as a crux for comparison of wind farm environments versus natural environments is an incorrect methodology.

When one considers the low frequency and infrasound noise and the reduced capacity of a building to attenuate such noise, then the issue of concern with respect to wind turbines becomes more of an indoor problem than an outdoor problem. Accordingly, if the acoustic criteria only consider external noise levels, then the obvious deficiency in terms of the appropriate criteria for wind turbines becomes clearly obvious.
The application of noise criteria applied in suburban areas verses utilising the same criteria in rural areas is easily understood to be an unsuitable situation when one considers the obvious difference in the acoustic environments.

Reference is often made to guidelines produced by the World Health Organisation that refer to noise levels suitable for protecting persons sleeping without identifying that those guidelines relate to traffic noise impact in suburban areas.

Typically reference to the WHO guideline fails to identify the nature at low frequency characteristics give rise to a difference in the subjective impact of a noise, or the fact that the WHO guidelines do not discuss wind turbines or alternative criteria for quiet rural areas.

If residents across Australia in proximity to wind farms identify sleep and health issues as a result of turbines and yet other members of the household are not affected in such situations, then this is not dissimilar to an individual's response to other types of noise. If one considers the appreciation or enjoyment of music then a discussion with your family or colleagues will reveal different tastes of music and in some instances an extreme degree of annoyance when persons experience different types of music.

For example lovers of opera may not necessarily enjoy or even accept any music associated with rap music and it is not uncommon for young people to demand opera music to be turned off.

I have met with residents in proximity to various wind farms where one person is able to detect when the wind farm is operational by either a presence in the head or body, whilst the partner is unable to detect any such effects. The difference response/reaction of individuals must be taken into account.
Furthermore the length of exposure to the turbines must also be taken into account.

Adverse Impacts

The SA EPA Guidelines indicate that for residential receivers that have a financial relationship with the wind farm that adverse impact occurs if the occupants of the dwelling experience sleep disturbance. Interestingly there is no actual definition of an adverse noise or health impact contained in the guideline.

There is a common response to the objection to wind farms on the basis of noise by drawing attention to the lack of scientific evidence linking wind farm operations with health impacts. However there is also a lack of scientific evidence to prove that wind farm operations do not create health impacts.
The reason for the lack of scientific evidence for both scenarios is simply because the appropriate scientific studies have not been undertaken. There are a number of "peer reviews" quoted in relation to wind farm impacts. However, examination of those reviews find that in general they are simply literature reviews and not actual scientific studies that incorporate real-world data as to the operation of a wind farm, the physiological and medical response of the community with appropriate analysis.

On my review of the material unless one has the raw acoustic data to identify what the residents are exposed to as a result of the operation of the wind farm that is then being followed by the appropriate sleep studies, questionnaires and then medical studies of the persons so affected, then one cannot causally link the said noise source to that the reaction.

From an acousticians viewpoint it seems to me that there are two distinct steps to be undertaken is establishing the **Relationship of wind farm noise to impacts**.

Step 1
Use Acousticians and Psychoacousticians

- **Acoustic measurements - of wind farm noise**
- **Psychoacoustic assessment of community response**

Step 2 (Following Step 1 + on site sleep studies, with acoustic measurements)
This involves multidisciplinary research involving acousticians and psychoacousticians, together with experienced medical practitioners, researchers and clinicians, including but not limited to the following speciality areas:

- **Sleep Physicians & physiologists**
- **Ear Nose & throat physicians and physiologists**
- **Neuroscientists**
- **Psychiatrists & Psychologists**
- **Cardiologists and cardiac physiologists**
- **Endocrinologists**
- **Rural General Practitioners**
- **Occupational Health Physicians**

With the results of such studies then an answer to the question of the Relationship of wind farm noise impacts can be obtained.

Separation Distances

Clearly from the measurement results discussed above, separation distance from wind farms must be greater than the nominal 1 to 2 km. Obviously a separation distance of 100 km would ensure that there would be no impact. The answer lies somewhere in between.

As noted above in acoustic terms socio-acoustic surveys take samples of the population impacted to varying degrees by a noise and determine a level at which 10% of the population are seriously/highly affected.

The results of such surveys may indicate that there are other factors (other than noise) that may influence the response of the community. For example, the socio-acoustic study conducted in the late 1970s in relation to aircraft noise in Australia found only a 17% correlation associated with noise and that there were other factors such as fear of the aircraft crashing and interference with television reception that influenced the community's response to aircraft operations. The results of that study led to the development of noise criteria for residential occupancies in proximity to airports.

Neither the SA EPA guidelines nor the New Zealand Standard for wind farms identifies any socio-acoustic studies to support the base criteria set out in those documents. Furthermore whilst the nominated criteria may be suitable for suburban environments communities in proximity to wind farms do not accept such levels for rural environments.

Residents around the Waterloo Wind Farm have been the subject of two community surveys.

The first survey was conducted by an Adelaide University student in 2011 and the second by a community member Mary Morris.

Frank Wang's original survey showed that of the study participants, who all lived within 5 km of the Waterloo Wind Farm, 50% of them were moderately to severely impacted by the noise.

The Mary Morris conference sent out 230 surveys to every household within 10 km of the turbines and received a 40% response rate. 49% of the respondents were negatively affected by some or all of: noise, shallow flicker, sleep deprivation, interference. Another 17 respondents indicated they noticed the above affects and/or that the effects varied, but they were not affected. The remaining respondents said they were not affected.

The extent of the population living within 10km of the Waterloo Wind Farm that is affected by the operation of the wind farm indicates a significantly higher proportion of the population than the nominal concept in socio-acoustic surveys of setting benchmark criteria for 10% of the persons seriously affected.
The results of the two surveys seriously question the appropriateness of the SA EPA Guideline base noise limit to avoid adverse noise effects on people caused by the operation of wind farms.

If one utilised either of the two studies then under a socio-acoustic basis the separation distance from wind farms of the size of the Waterloo wind farm must be greater than 5 km. On a dB(A) basis the noise limit that would relate to such a separation distance is below 25 dB(A) and, is significantly lower than either the SA EPA guideline or the New Zealand Standard.

If one cannot, at the present time, nominate a separation distance then the appropriate mechanism to protect the community is to require, under the current methodology a noise limit of 25 dB(A) or background +5 dB(A) **whichever is the lower**.

Clearly a secondary criterion that addresses the low frequency and infrasound impacts needs to be identified and the appropriate place for consideration of those impacts is inside dwellings. The provision of an internal noise criterion presents difficulty in light of the different types of construction that is encountered in rural environments. The use of a linear value, a dB(C) value or dB(G) value, and whether such values are full range or limited in the frequency domain, is a matter that is subject to further investigation and should be incorporated in part of the scientific studies discussed in the previous section.

Conclusion

There are communities around Australia that are impacted by wind farms.

In some instances there are residents who leave their dwellings, and when they are relocated to dwellings removed from the wind farms they identify they are no longer adversely impacted and their sleeping patterns return to normal.

The provision of wind farms in rural Australia has generated significant conflict in the communities and it is often stated to me by residents that the wind farms are destroying communities.
Therefore at the present point in time the separation distances that exist from wind farms, that are generally based upon a dB(A) noise level are clearly inadequate.

Accordingly the answer to the question of wind farms being too close to communities is in the affirmative.
The responsibility of the environmental and health authorities in Australia must be to protect the community from adverse health effects. The most common complaint from the community concerning wind farms is related to sleep disturbance. With continual sleep disturbance then other health effects come into play.

At the present point in time wind farm operators rely upon criteria nominated by the regulatory authorities with the fall back position that if their wind farm complies with the nominated criteria then it is no longer their issue.

So as to guarantee that there are no adverse impacts from wind farms then the separation distances must be increased.

In the absence of any scientific studies to identify the appropriate separation distance then an applicant/wind farm operator should be required **to guarantee that there will be no adverse noise effects, no offensive noise, no sleep disturbance and no adverse health effects if the subject wind farm was to proceed.**

Similarly there is an issue for the determining authority to provide a similar guarantee, particularly if the authority was to approve the application based on unsubstantiated acoustic criteria which has no technical basis of guaranteeing there will be no impacts.

As there is no material provided by an operating wind farm to prove that the operations do not generate adverse noise effects, do not generate offensive noise, do not generate sleep disturbance and have no adverse health effects, then it would appear that if the authority was to grant approval and the wind farm complied with the noise limits nominated by the Authority for the environmental assessment, and health impacts were found to occur then the Authority (not the applicant) would be liable.

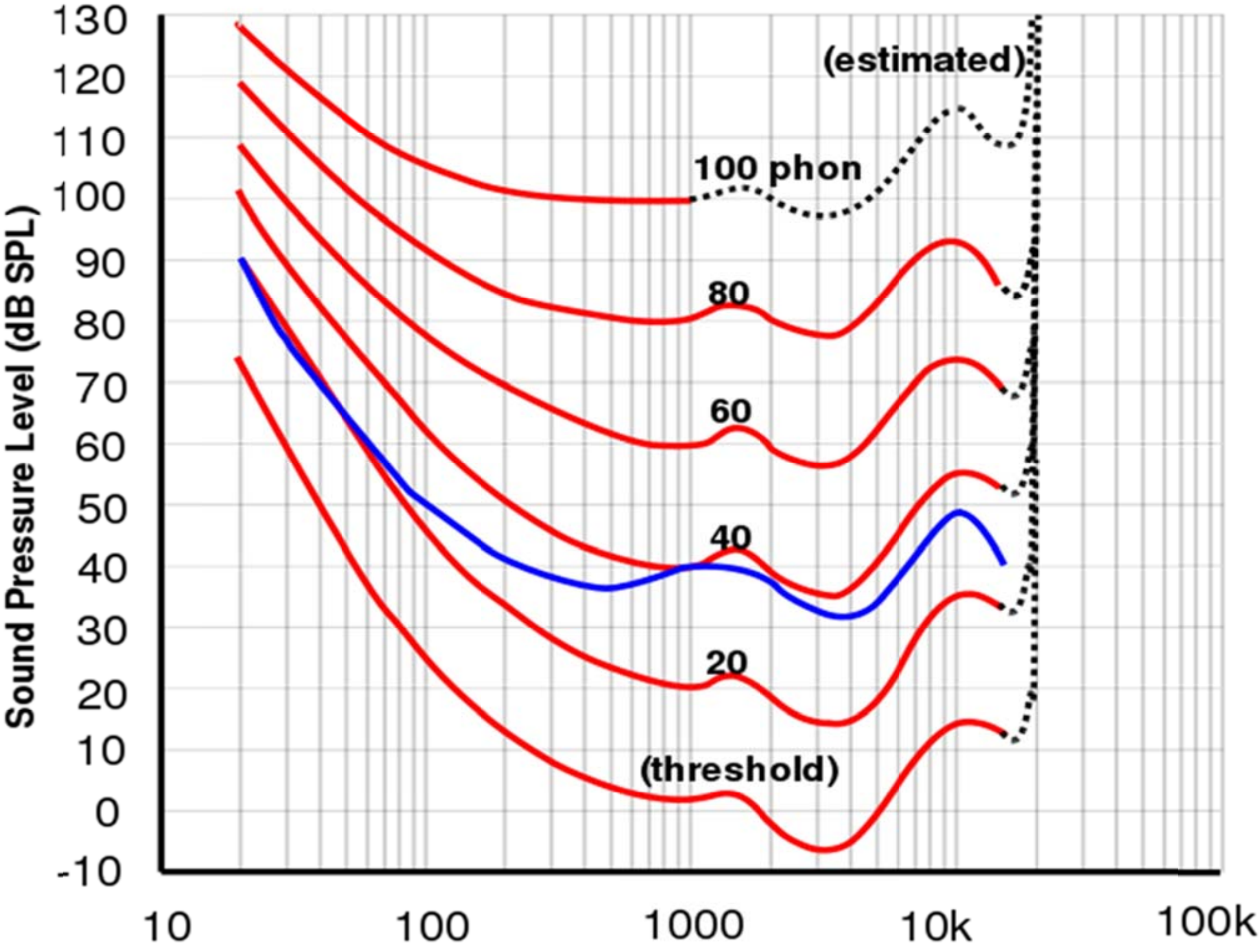


FIGURE 1 Equal-loudness contours (red) (from ISO 226: 2003 revision) and Original ISO Standard (blue) for 40 phons

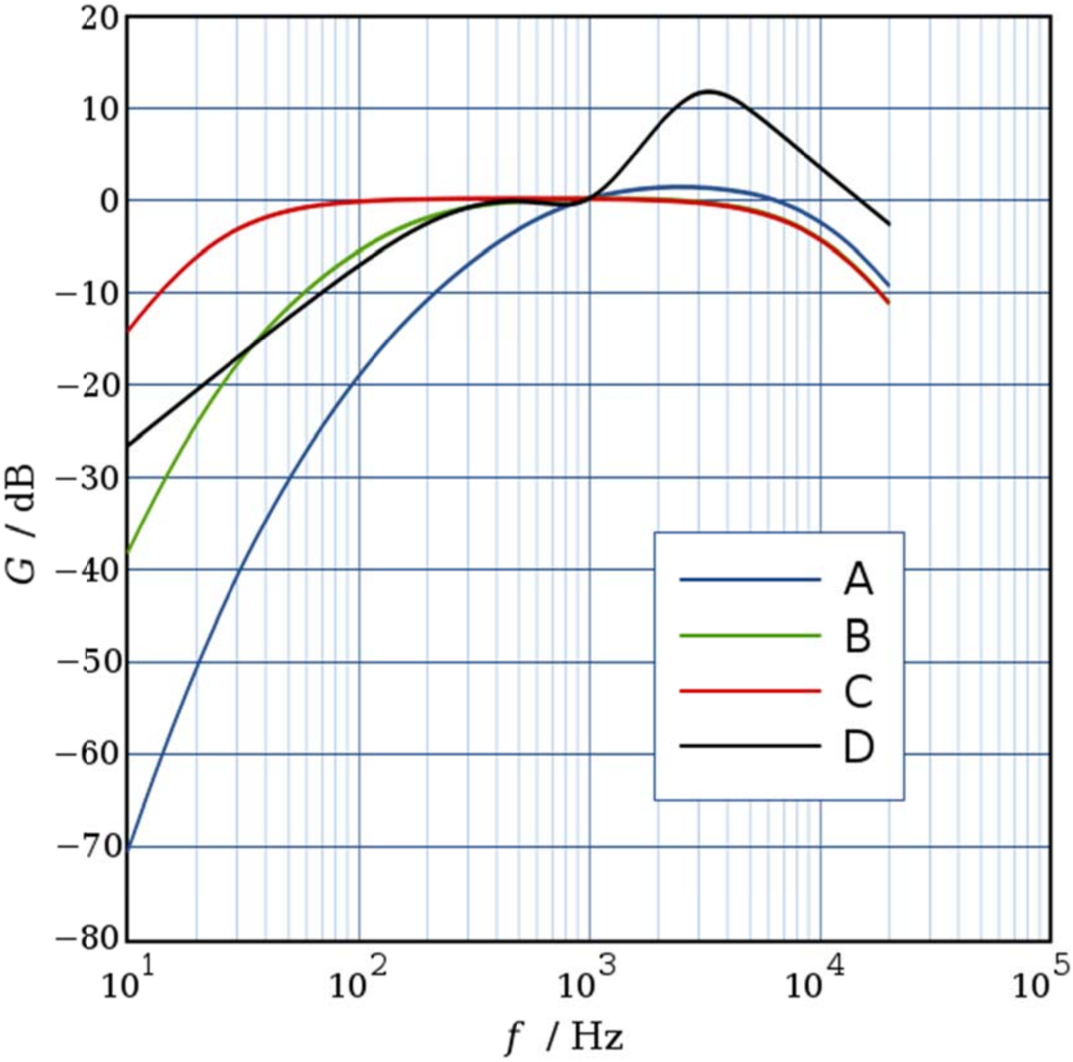


FIGURE 2 Normal Frequency Weighting curves

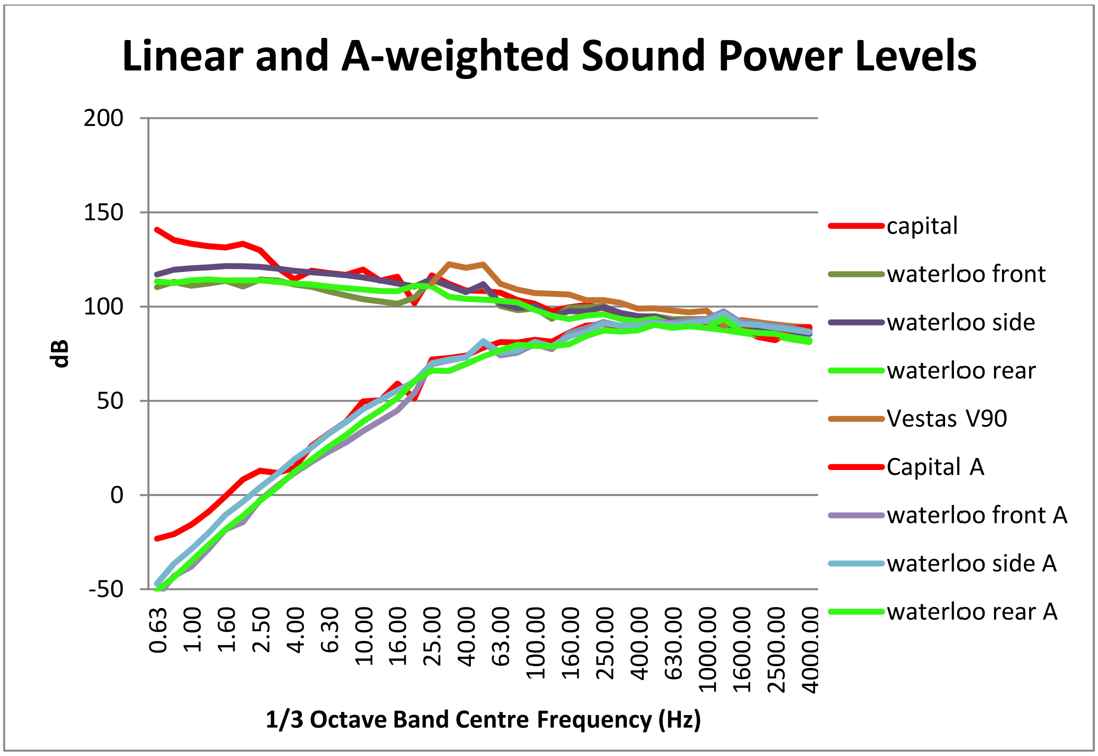


FIGURE 3 Turbine Sound Power Levels (Linear versus A-weighted)

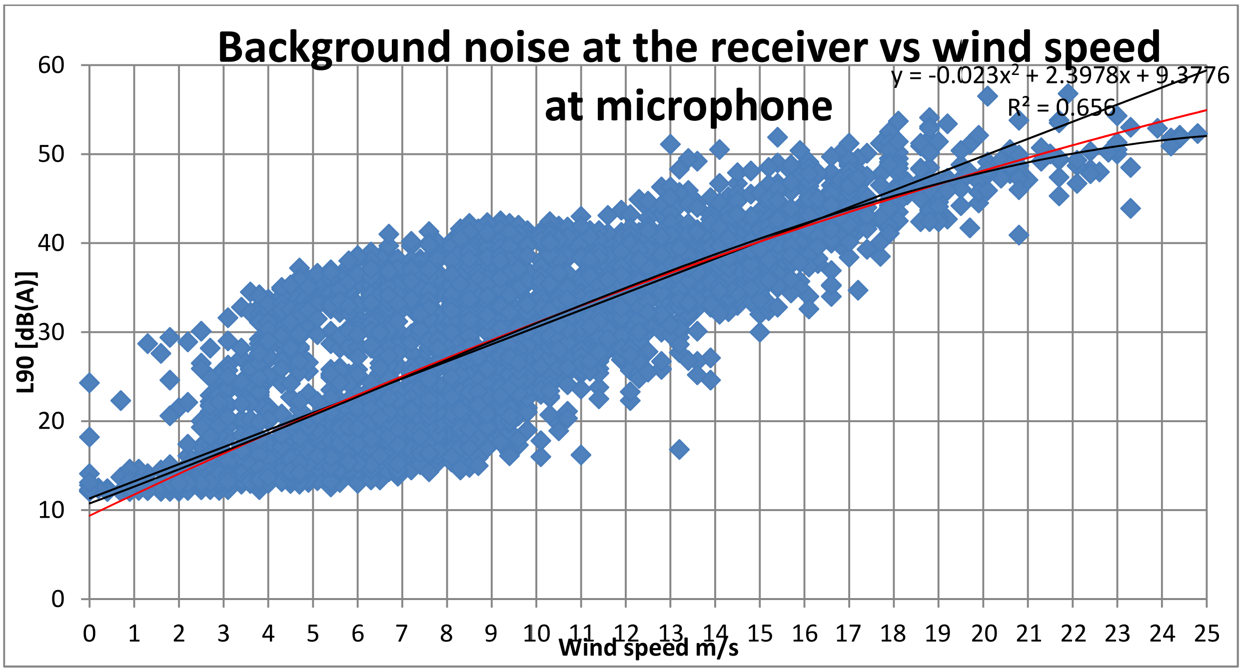


FIGURE 4 Exposed Hillside (furrowed ground) – No Turbines, No Trees within 500 metres

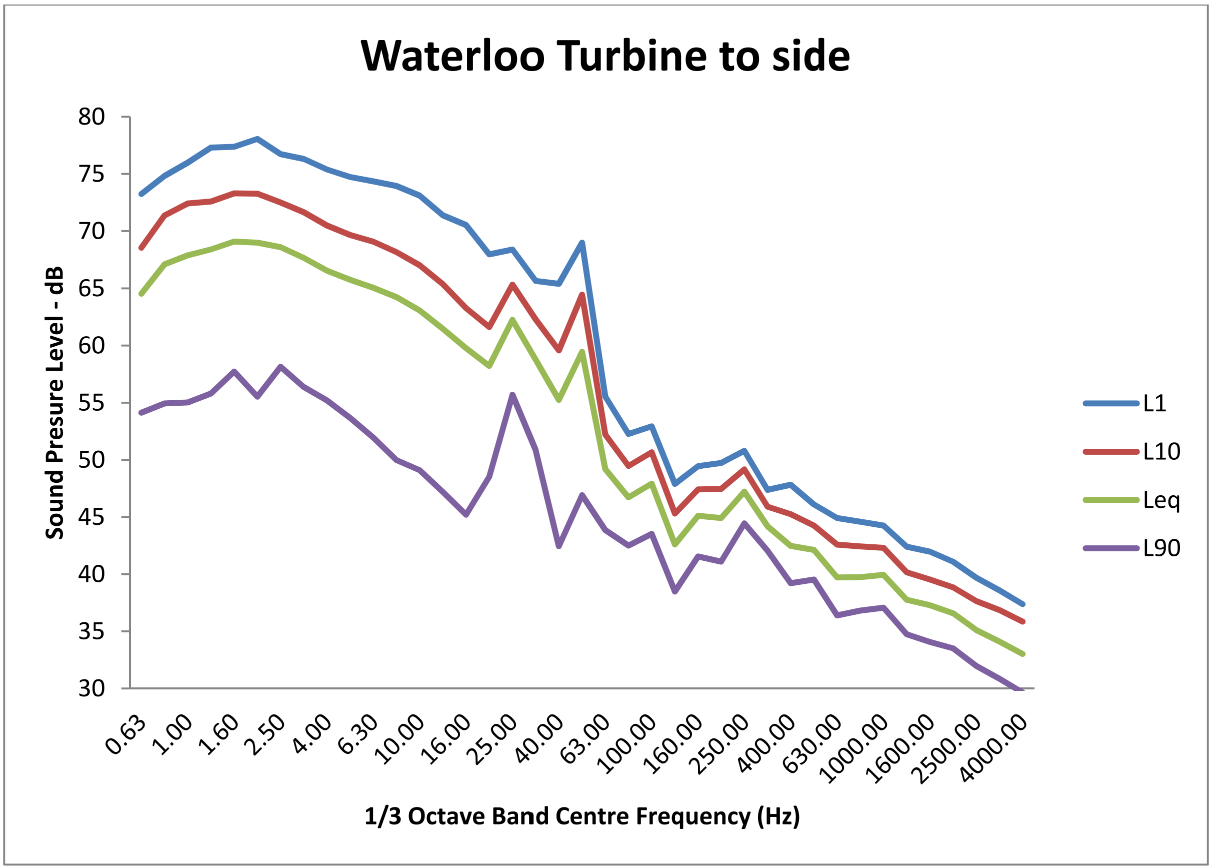


FIGURE 5 At 150 metres from tower

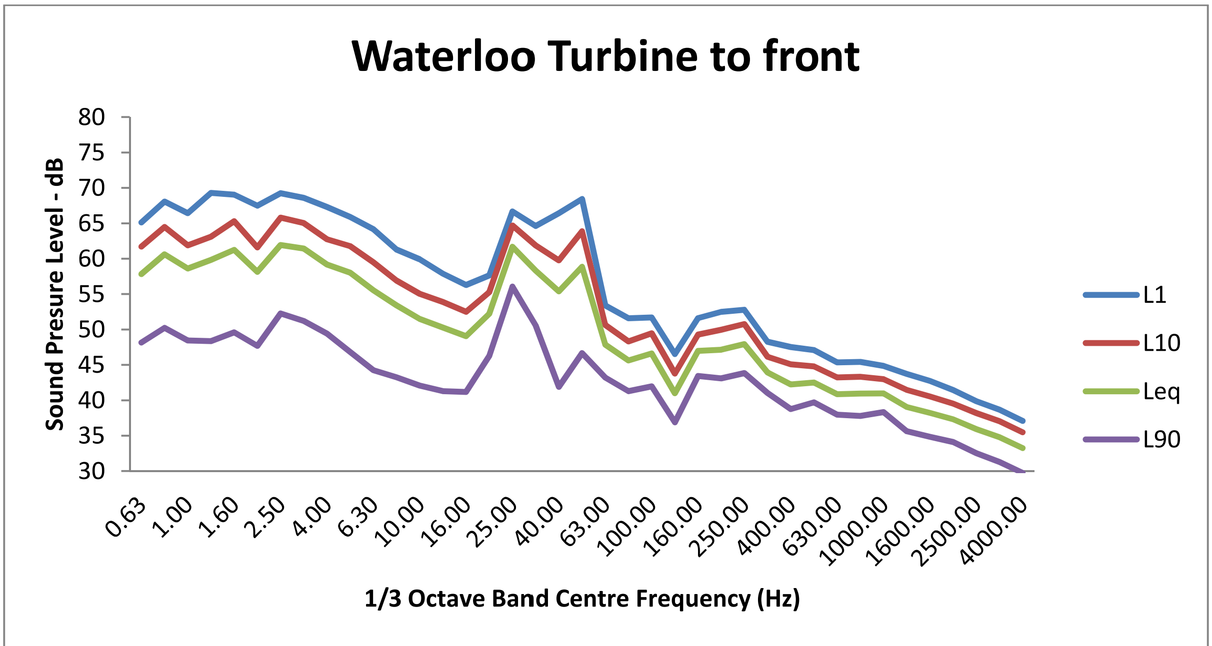


FIGURE 6 At 150 metres from tower

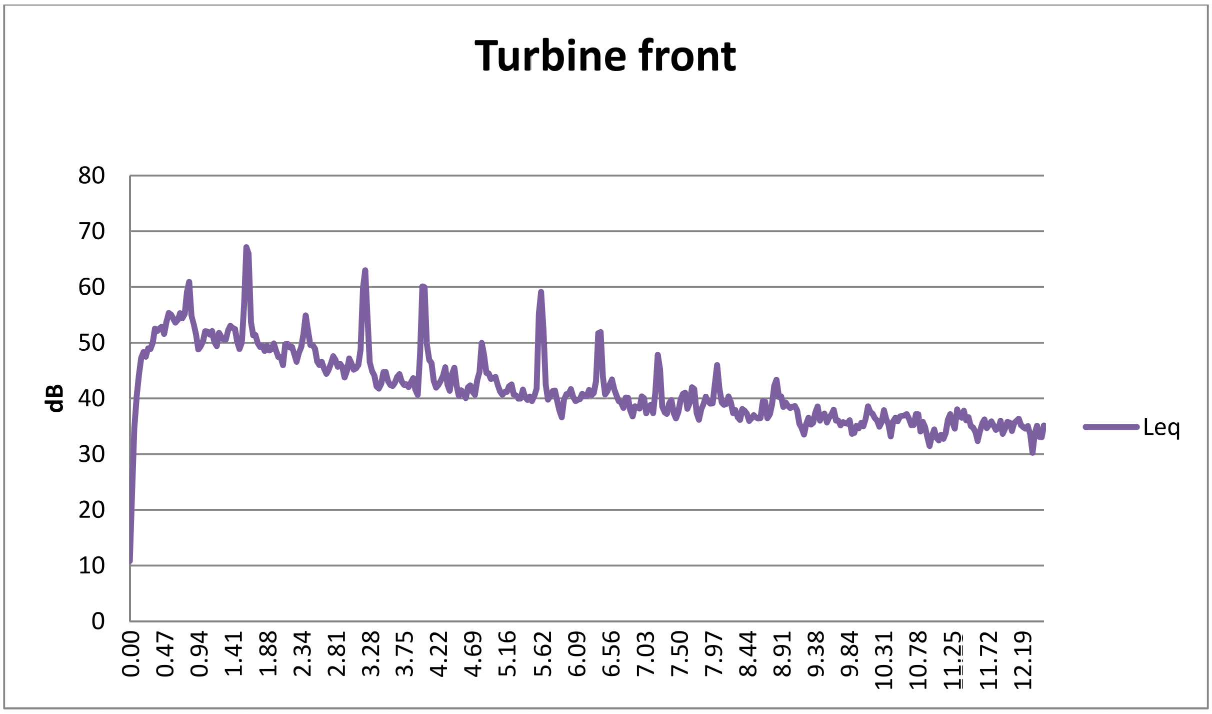


FIGURE 7: 0 – 12.5 Hz at 150 metres from tower

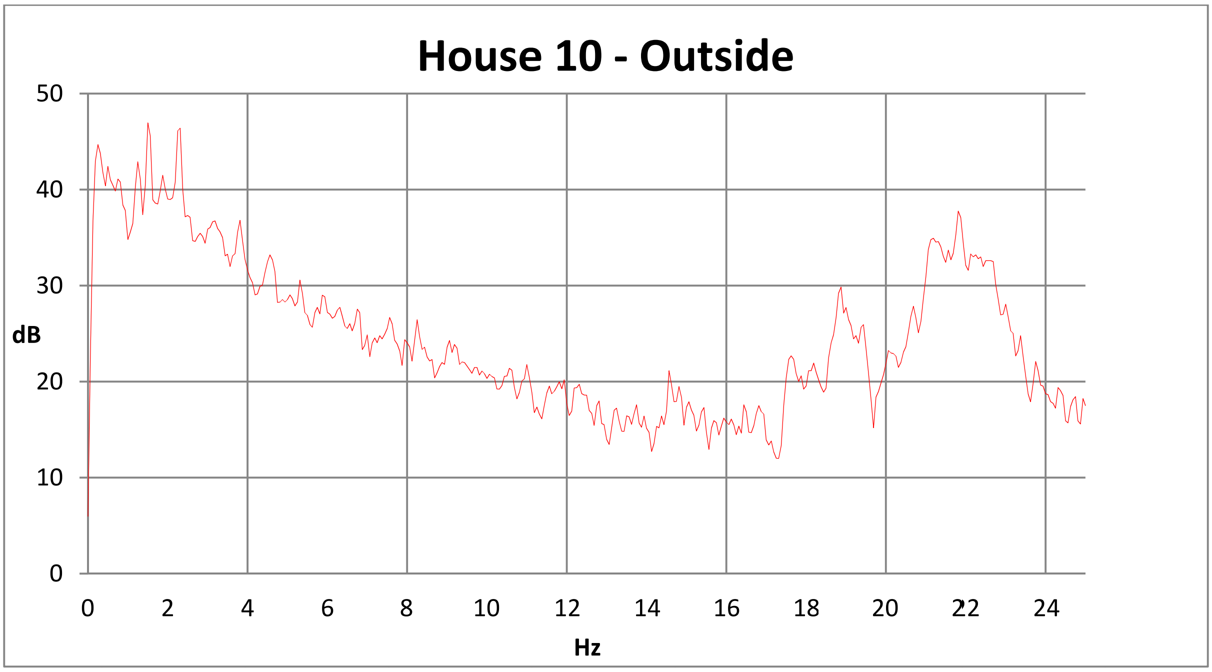


FIGURE 8 External Measurements approximately 1300 metres from nearest turbine

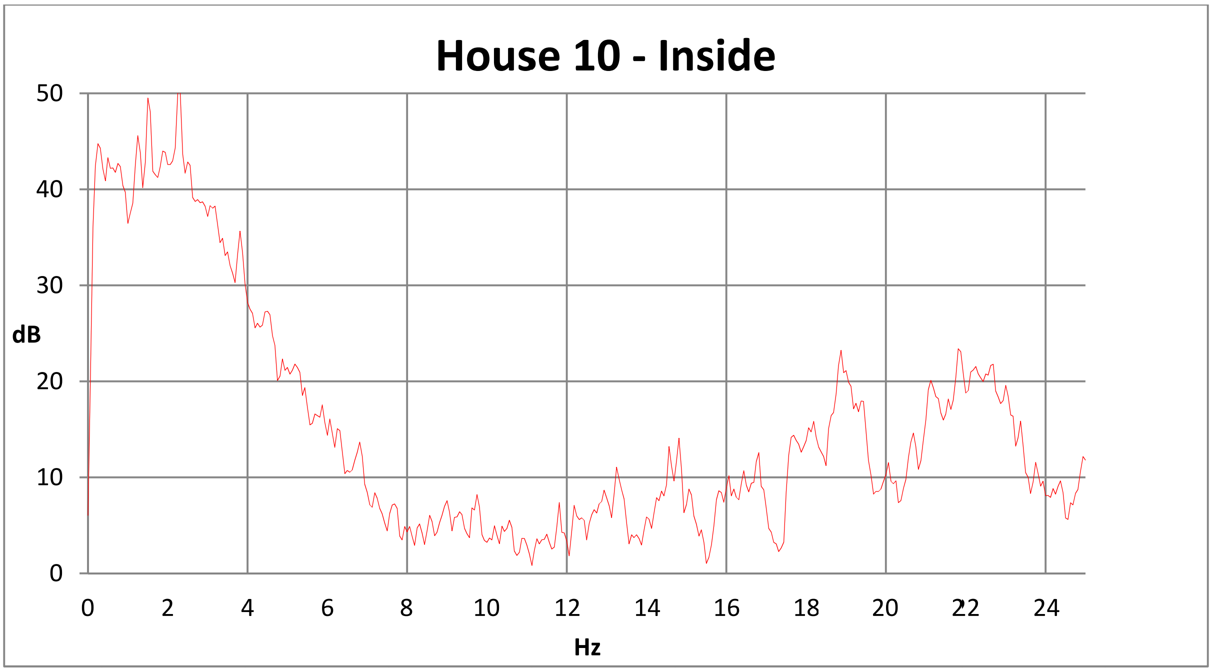


FIGURE 9 Internal Measurements approximately 1300 metres from nearest turbine

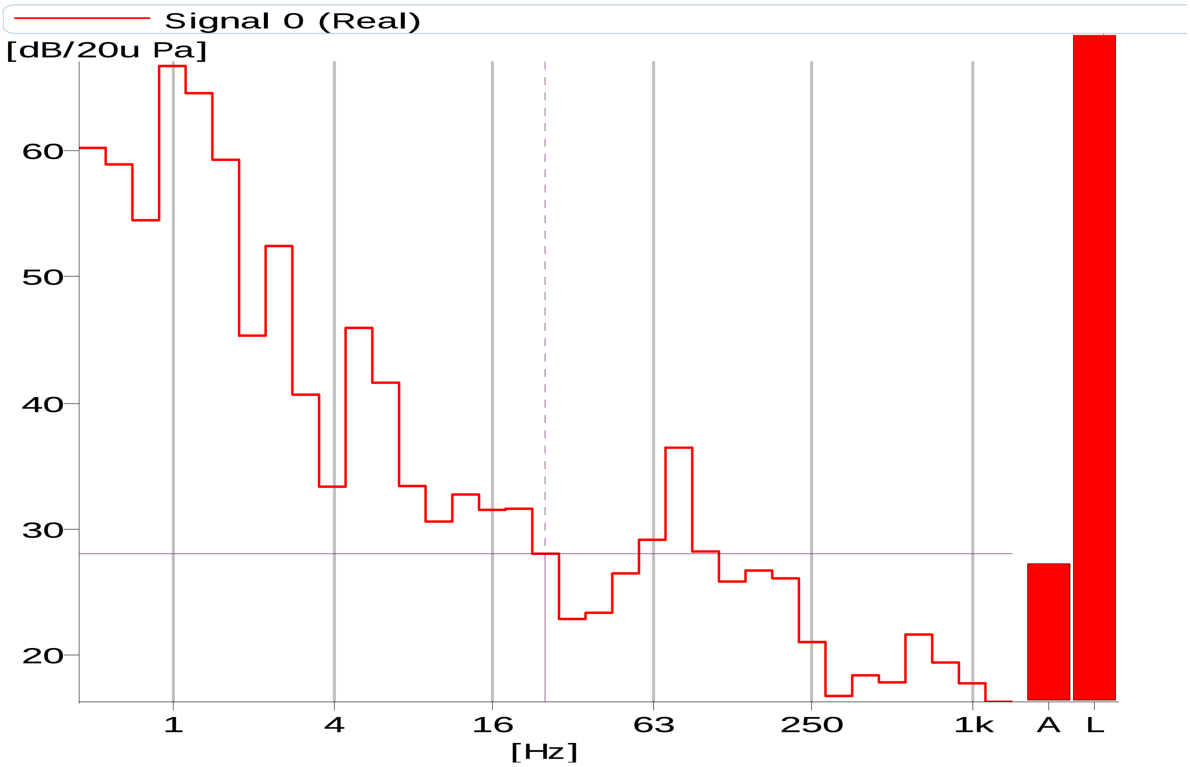


FIGURE 10 External Measurements approximately 8000 metres from nearest turbine

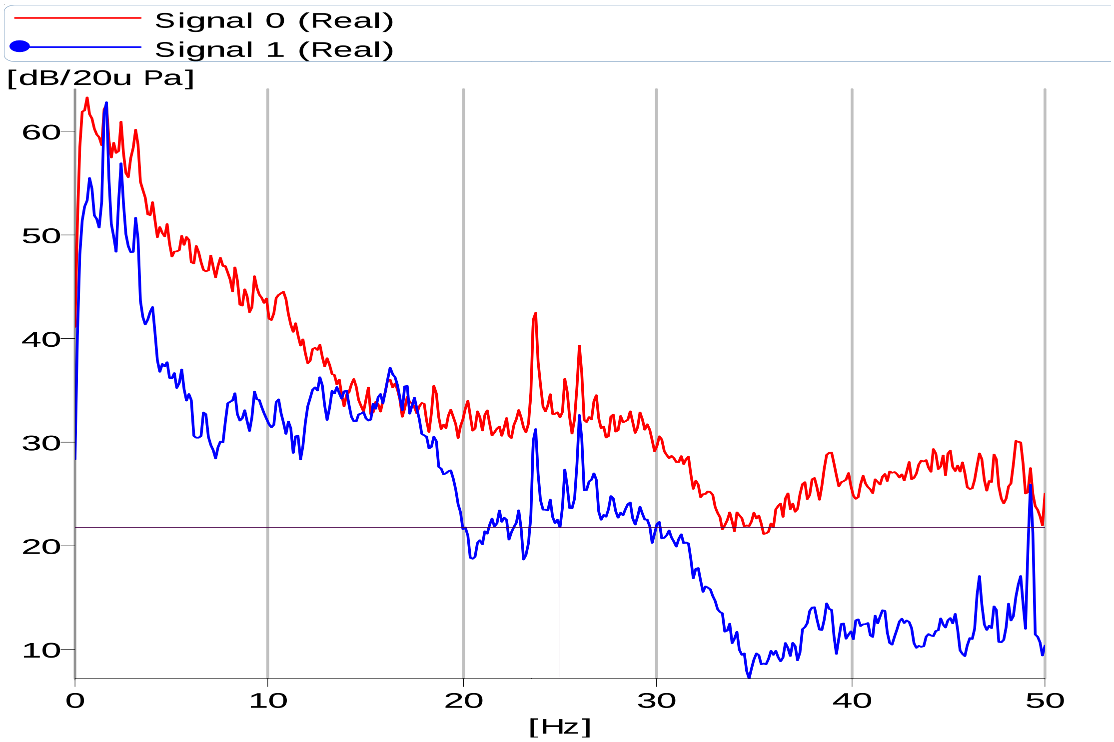
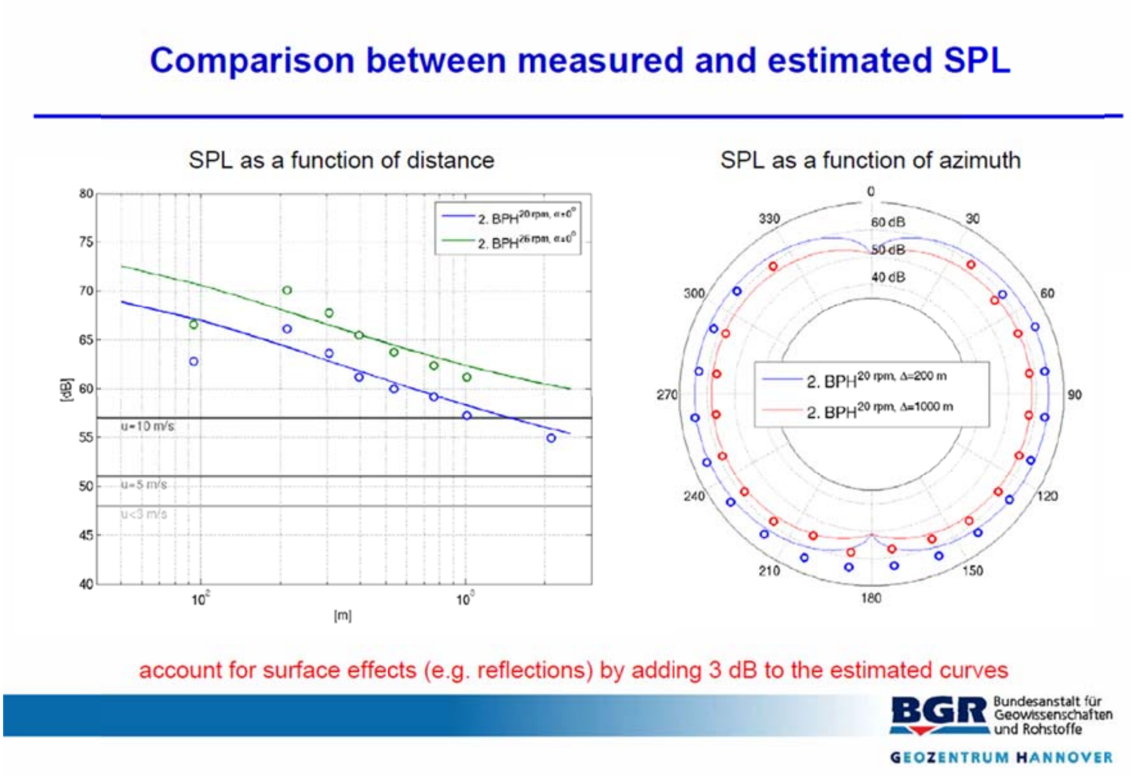


FIGURE 11 External and Internal Measurements approximately 8000 metres from nearest turbine



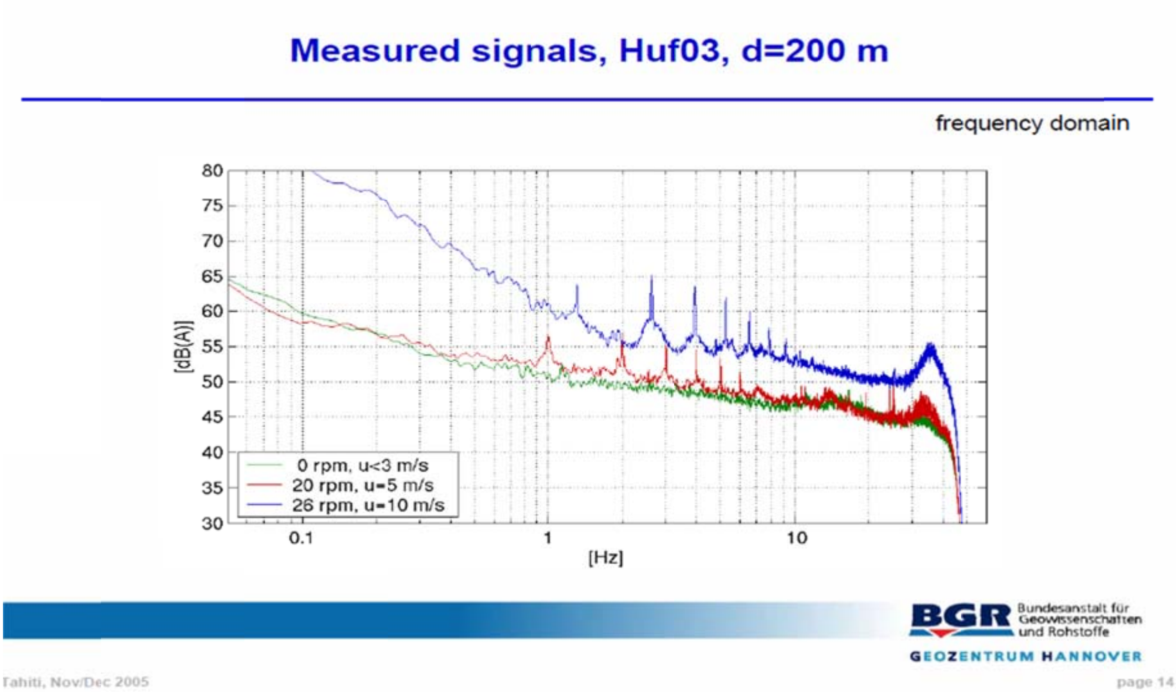
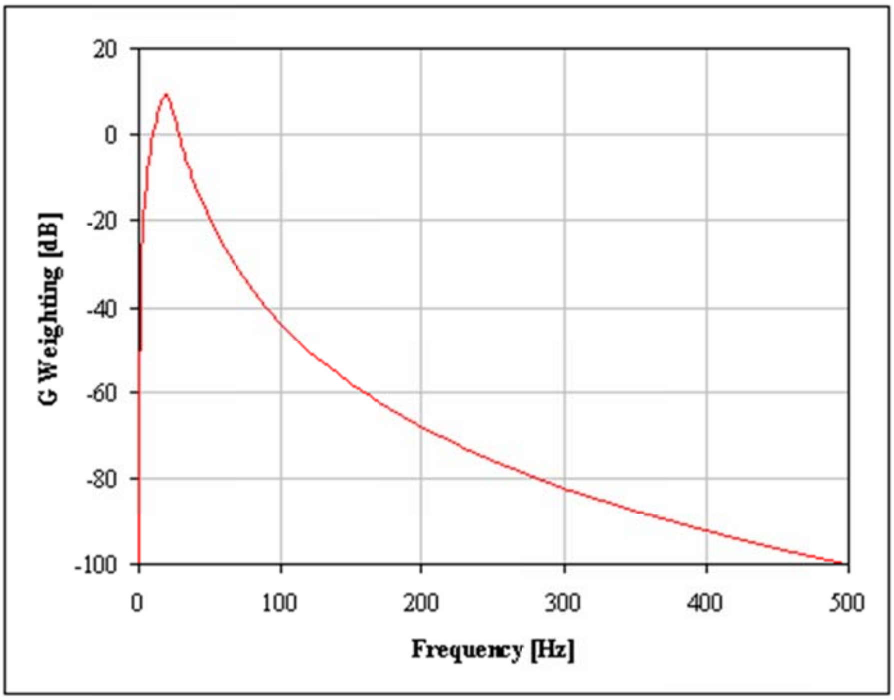


FIGURE 12 The inaudible noise of wind turbines, Ceranna, Hartmann and Henger, Federal Institute for Geosciences and Natural Resources (Hannover, Germany) Infrasound Workshop Nov 28 , 2005 Tahiti

G weighting purportedly reflects human response to infrasound. The curve is defined to have a gain of zero dB at 10Hz. Between 1Hz & 20Hz the slope is approximately 12dB per octave. The cut-off below 1Hz has a slope of 24dB per octave, and above 20Hz the slope is -24 dB per octave.



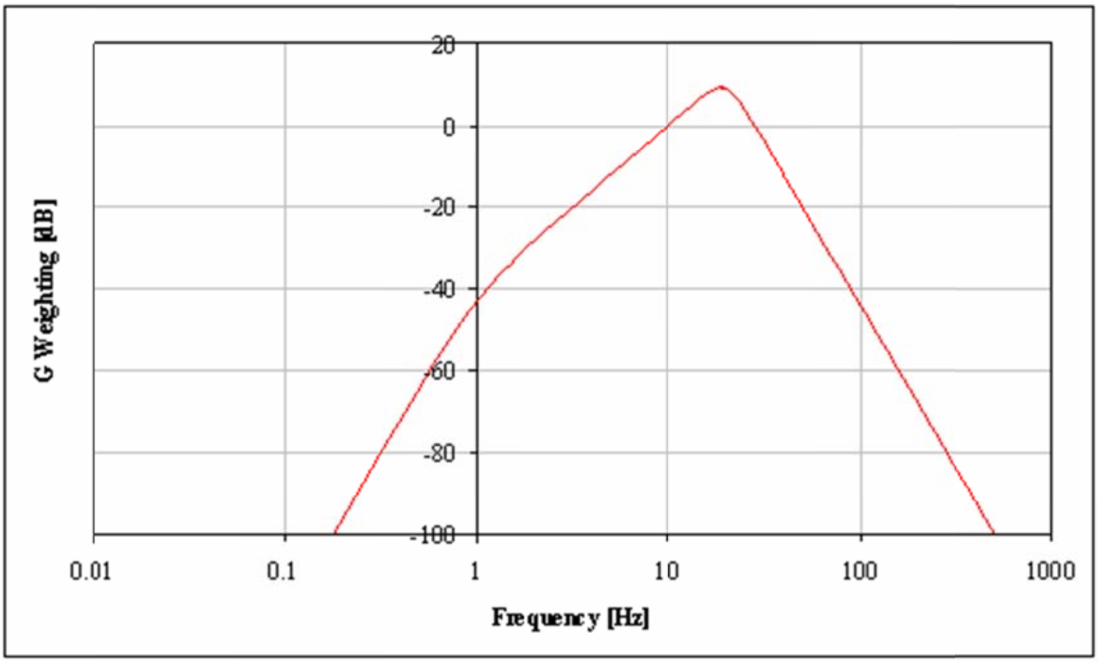


FIGURE 13 G-Weighted Overall Level

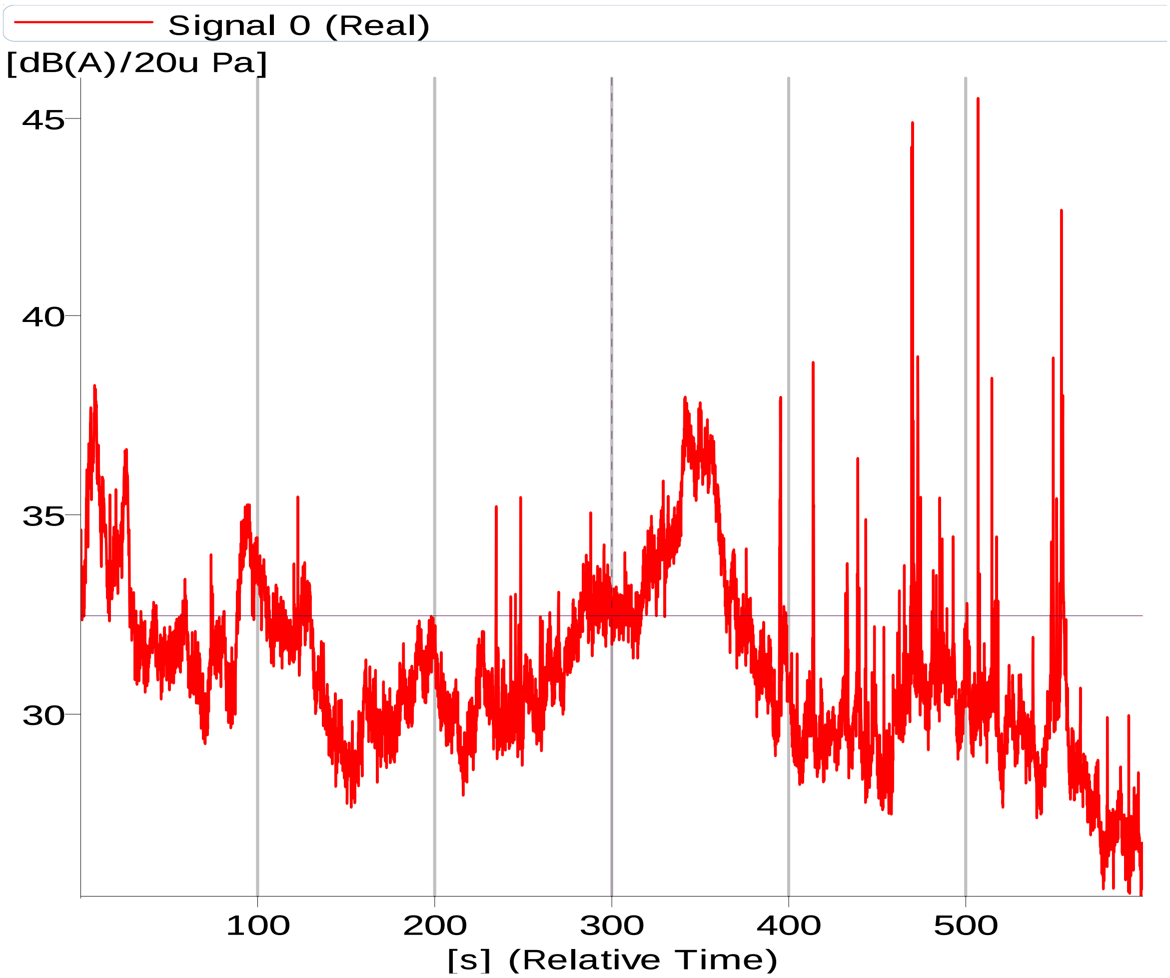


FIGURE 14: Ambient Noise Level for varying wind (up to 7m/s gusts) + birds

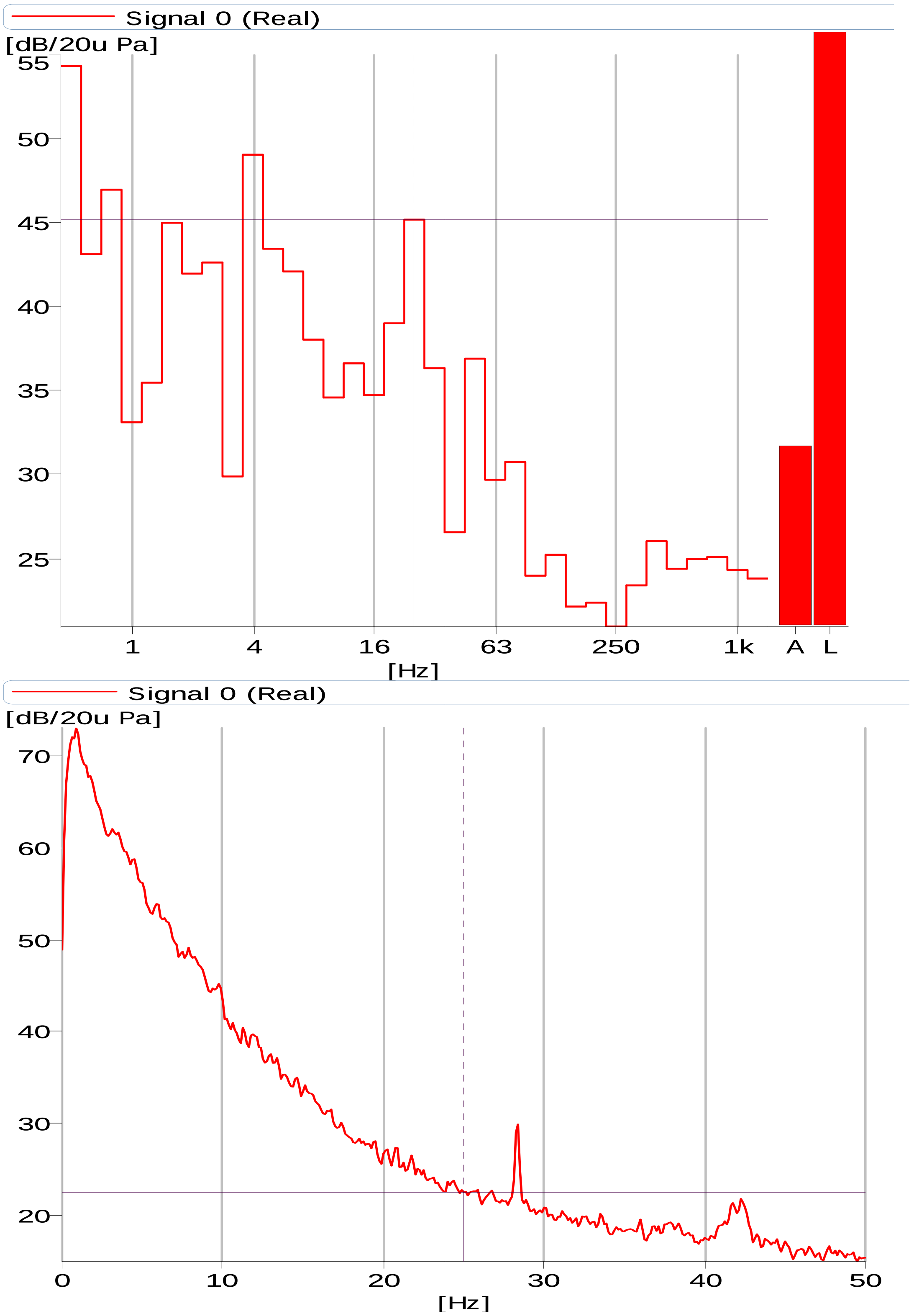


FIGURE 15 : 1/3 Octave and Low frequency FFT for 10 minute sample in Figure 14

APPENDIX E: Typical Regression Curves

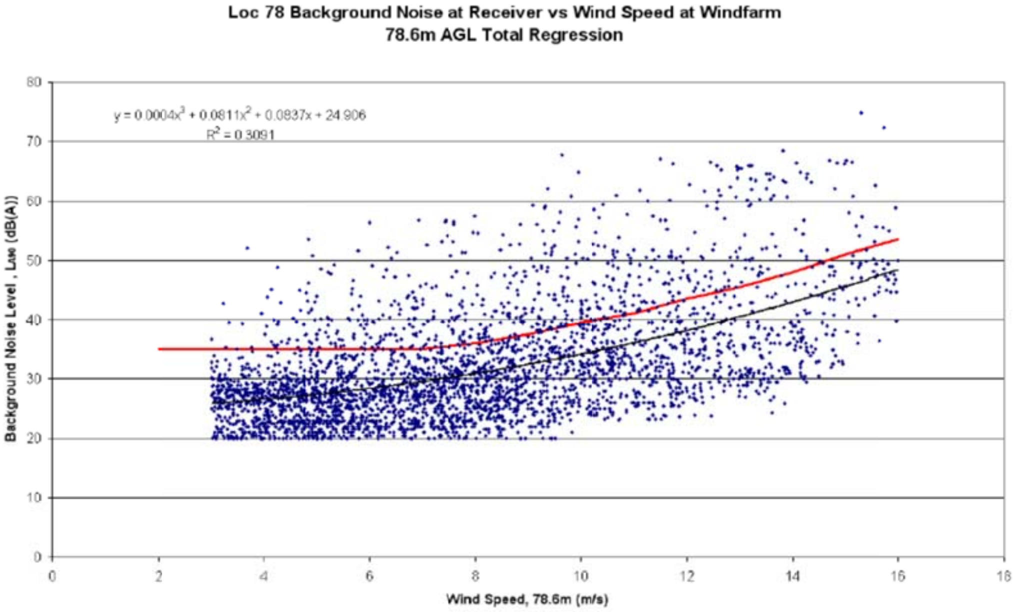


Figure 12.5 – Background noise at receiver Residence 78 versus wind speed at wind farm

Flyers Creek Application

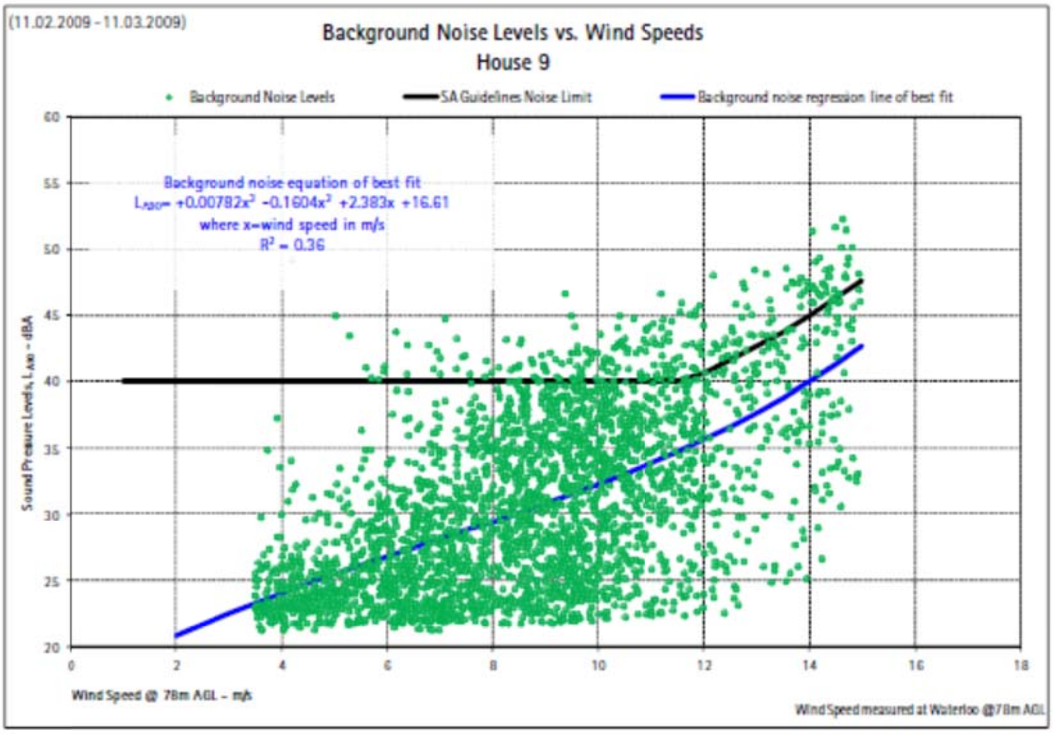


Figure 4: House 9 background noise monitoring results and noise limits

Waterloo 2 Application

APPENDIX E: ANNEX A of IEC 41400-11

Annex A
(informative)
Other possible characteristics of wind turbine noise emission and their quantification

A.1 General

In addition to those characteristics of wind turbine noise described in the main text of this standard, the noise emission may also possess some, or all, of the following:

- infrasound;
- low-frequency noise;
- impulsivity;
- low-frequency modulation of broad band or tonal noise;
- other, such as a whine, hiss, screech or hum, etc., distinct impulses in the noise, such as bangs, clatters, clicks, or thumps, etc. (

These areas are described briefly below, and possible quantitative measures discussed. (It should be noted that certain aspects of infrasound, low frequency noise, impulsivity and amplitude modulation are not fully understood at present. Thus it may prove that measurement positions farther away from the wind turbine than those specified in the standard may be preferable for the determination of these characteristics. (

A.2 Infrasound (

Sound at frequencies below 20 Hz is called infrasound. Although such sound is barely audible to the human ear, it can still cause problems such as vibration in buildings and, in extreme cases, can cause annoyance. If infrasound is thought to be emitted, an appropriate measure is the G-weighted sound pressure level according to ISO 7196. (

A.3 Low frequency noise (

A disturbance can be caused by low-frequency noise with frequencies in the range from 20 to 100Hz. The annoyance caused by noise dominated by low frequencies is often not adequately described by the A-weighted sound pressure level, with the result that nuisance of such a noise may be underestimated if assessed using only an L_{Aeq} value. (

It may be possible to decide whether the noise emission can be characterised as having a low-frequency component. This is likely to be the case if the difference between the A and C-weighted sound pressure levels exceeds approximately 20 dB. (

In these circumstances, low-frequency noise may be quantified by extending the one-third octave band measurements described in the main body of the text, down to 20 Hz. For one- third octave bands, the 20, 25, 31,5 and 40 Hz bands should additionally be determined. (

Narrowband spectra for frequencies below 100 Hz should be determined using a bandwidth smaller than one-half the blade passage frequency.

A.4 Impulsivity

An impulsive, thumping sound may be emitted from a wind turbine due, for example, to the interaction of the blade with the disturbed wind around the tower. Impulsivity is a measure of the degree of this thumping.

A quantification of impulsivity can be obtained from the average of several measurements of the difference between the C-weighted ‘impulse hold’ and maximum C-weighted ‘slow’ sound pressure levels.

The impulsive character can also be displayed by recording the filtered sound pressure signal using a 31,5 Hz octave band filter.

A.5 Amplitude modulation of the broad band noise

In some cases, it is possible that the broadband noise emitted by a wind turbine is modulated by the blade passage frequency giving rise to a characteristic “swishing” or “whooshing” sound.

This modulation can be displayed by recording the measured A-weighted sound pressure level with time weighting F for at least ten blade passes by the turbine.

The characteristics of this modulation can be influenced by local atmospheric conditions (see Annex C), and for this reason such conditions should be recorded during measurements.

A.6 Other noise characteristics

If the noise emission contains a whine, hiss, screech, hum, bang, clatter, click, thump, etc., then this characteristic should be reported. As full a description as possible of the noise should be given in words, and any measurements that illustrate the nature of the noise should be taken.