A framework for the regulation of environmental noise

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ABSTRACT

Efforts to regulate environmental noise can be identified in such instruments as regulations approved by State parliaments; in policies and guidelines; in local laws; in special exemptions; and in conditions imposed on environmental notices, licences, approvals and legal judgements. Innovative approaches are therefore needed if environmental noise regulation is to be efficient and effective in the future. A framework is presented for the regulation of environmental noise, based on three key elements: protection, fairness and certainty. In relation to protection, this paper outlines the issues around what is to be protected, under what circumstances and to what extent, in the context of current research on the effects of environmental noise. While aiming for appropriate protection, it is also necessary to optimise fairness and certainty of outcome – for both the noise emitters and receivers – requiring that a balance be struck between all three elements. The framework is applied through various examples drawn from the author's noise regulatory experiences, including transportation noise, blasting and noise from wind farms. The framework is intended to assist, not only government regulators, but any who have input into environmental noise regulatory processes.

1. INTRODUCTION

The regulation of environmental noise has proven elusive and complex, as reflected in the various approaches that have been adopted in Australia over the past 50 or so years. These regulatory challenges can be attributed to the vast array of potential noise sources needing to be controlled, the diversity of likely community impacts and reactions they may cause, and the range of possible noise management strategies that can be employed.

A framework is presented for the regulation of environmental noise, based on the author's experience in the area. The framework comprises three key elements or values: *protection*, *fairness* and *certainty* – these elements need to be held in balance in order to achieve effective environmental outcomes.

The element of *protection* is discussed in the context of noise amenity versus public health, with particular reference to aircraft noise; and the framework is applied through various examples of noise regulatory approaches taken from the Western Australian (WA) experience. This paper focuses on airborne environmental noise and its impacts on humans, however the framework can also be applied to regulation of noise as it affects terrestrial or marine animals.

2. THE FRAMEWORK

2.1 Environmental noise regulation

The regulation of environmental noise may need to be enacted through any of a range of possible instruments, including regulations approved by state parliaments; policies and guidelines; local laws; special exemptions; conditions imposed on environmental approvals, licences and notices; and conditions on land use planning approvals and legal judgements. In addition, in WA there are provisions creating exemption where the noise emitter complies with an approved noise management plan (NMP), for example on a construction site or shooting range. While compliance with a noise regulatory instrument is mandatory in many cases, it is common for guidelines and some policies to be non-mandatory. The framework can be applied in any of these cases, and also to non-statutory instruments such as Australian Standards.

Generally speaking, the regulatory instrument will comprise several elements:

- *Definitions* – these will specify who is bound under the instrument. This is normally a person who may emit noise: either one individual, a group of people, an entity such as an industry, or indeed any person in the state (in the case of general legislation). If the instrument covers a type of activity, equipment or noise emission, or a location from which it may be emitted, this will be specified.

- *Protection provisions* – these may specify permitted noise levels, times of day at which given noise levels or operations may be allowed, and so on.
- *Management provisions* – these provisions are intended to clarify technical details such as the location and methodology for noise measurements; actions that may be required and their time frames; and enforcement details including penalty provisions.

These instruments may be developed by state government regulators or policy officers, local government or police officers, acoustic consultants, lawyers and others. The person developing the instrument may have considerable noise expertise – with or without regulatory skills – or may have little noise background. It is also common for a range of lay persons, including elected representatives, industry representatives, academics and community members to have input to a regulatory instrument.

In this paper the term 'regulator' is used to represent any of these persons who may be involved in the development of a regulatory instrument for environmental noise.

2.2 The framework

The framework that is proposed in this paper is aimed at achieving good environmental outcomes for all interested parties. It is based on achieving a balance between three elements or values: *protection*, *fairness* and *certainty*. These can be represented as shown in Figure 1.

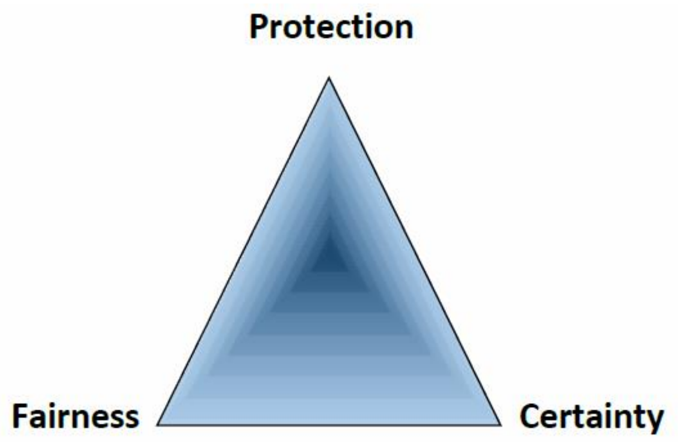

Figure 1. Pictorial representation of the framework

These three elements are discussed further below:

- ***Protection*** – Governments act to regulate to protect something that may not otherwise be protected if market forces are allowed to operate unfettered. When protecting communities it is common to see legislation covering health, safety, amenity, environmental values and so on. When developing a regulatory approach, the regulator needs to be cognisant of who or what is being protected, against what risks or dangers, to what extent and under what circumstances. In relation to environmental noise, this means that the regulator needs a good understanding of the effects of noise on humans, and of the issues of concern to the community that is to be protected.
- ***Fairness*** – both the regulatory process and the outcome need to be fair to all parties. The community needs to be able to see that the process and outcome will provide a reasonable degree of *protection* from the noise, and especially from any aspect of the noise that may be of particular concern. Similarly the process and outcome need to be fair to the noise emitter, such that the required control measures can be seen to be reasonable, feasible and practicable. The issues here are consistency, flexibility and practicability.
- ***Certainty*** – the regulatory outcome needs to provide a reasonable degree of certainty to all parties, such that both the noise emitter and the community know how much noise can be emitted and when. It is crucial that

any conditions attached to the regulatory instrument are clear and enforceable; and noise measurement results satisfy traceability requirements. Key issues are clarity and enforceability.

Protection appears at the top of the framework diagram because it is the primary driver for the regulatory instrument in the first place. Clearly there needs to be a healthy balance between the three values: if *protection* is to be pursued at all costs then *fairness* will suffer. An overemphasis on *fairness* however is likely to lead to an outcome that is overly complex, as the instrument must be 'split' again and again to account for every possible situation. Similarly an overemphasis on *certainty* – for example by oversimplification – can lead to the instrument lacking flexibility and hence *fairness*.

A simple example may serve to illustrate. Figure 2 shows a sign purporting to regulate environmental noise.

Figure 2. One approach to regulation of environmental noise

Firstly, this sign offers the ultimate degree of *protection*: prohibition. One may well ask: is there a compelling reason why the environment needs to be protected to this extent, or is this overkill? Perhaps a reasonable amount of noise may be acceptable at times in the interests of *fairness*. *Certainty* is sorely lacking here: what constitutes 'unnecessary noise' and who decides? When and where does the prohibition apply? What is the penalty and by whose authority is it enforced?

The answer here may well be 'shoot first and ask questions later'!

The framework outlined above is intended to give the regulator some pause for thought towards achieving an effective balance between *protection*, *fairness* and *certainty* in a given situation. Successful implementation of the framework requires a robust and accountable process that enables meaningful consultation, strong technical noise input and a degree of regulatory skill.

3. PROTECTING AMENITY AND HEALTH

Given the range of human reactions to environmental noise, inevitably there will be those who believe the level of *protection* provided is inadequate and others who regard it as unnecessary. It is therefore important for a regulator to be clear as to who and what is being protected.

3.1 Individual or community

It is important to consider who it is that the regulatory instrument is intended to protect. At the outset it is prudent to focus on protecting a community rather than trying to regulate to protect the amenity or health of a few vocal individuals (the exception may be when an enforcement notice needs to be issued to protect one complainant). This is because it is possible to predict the reaction of a community to noise, but extremely difficult to predict the reaction of an individual. Providing a consistent outcome for a community goes to the issue of *fairness*, both for the noise emitter and for the community.

Within communities, vulnerable groups such as children and the elderly may need a particular type or level of *protection* that differs from that provided for the general community. However, it may be impractical to protect groups such as shift workers (who need to sleep during the day) to the same extent as those who keep normal hours, given that allowable noise levels are generally higher during the day than at night. Special premises such as those used for schools, residential care and places of worship may need particular attention.

3.2 Amenity or health

The primary consideration is whether the regulatory instrument is directed at protecting the amenity or the health of the community, or both. For the purpose of this paper *amenity* may be taken to be affected if reactions to environmental noise include annoyance, disturbance of activities, fear, dislike of the neighbourhood and the like; and *health* if the longer-term reactions to noise include physiological outcomes such as heart disease, or their precursors such as sleep disturbance or hypertension (high blood pressure). If for example the major objective of a regulatory instrument is the prevention of noise complaints from industry, then the daytime noise criteria would reflect the need to protect *amenity* rather than *health*. Where the noise emissions at night are significant, the criteria would be aimed at protecting against sleep disturbance as a *health* issue.

The author here makes the general observation that, over about the last 50 years, noise regulatory policy in Australia has evolved from basic complaint-driven *amenity* to include *health*. Table 1 gives some examples of the major noise regulatory approaches and the decades in which they emerged.

Table 1. Emergence of major environmental noise regulatory approaches in Australia

Decade of emergence	Policy driver	Environmental noise regulatory approach
1960s	Complaints	Legislation aimed at resolving noise complaints, e.g. ‘background + 5dB(A)’
1970s	Planning	Policies aimed at proactively setting noise goals for residential and industrial areas, based on noise levels found by experience to reasonably match community expectations for the type of area
1980s	Dose-response	Transportation noise policies aimed at protecting a percentage of the population (say 90%) from being ‘highly annoyed’ by noise, based on community response surveys
2000s	Health impact	Policies aimed at ensuring protection of public health (in addition to amenity), based on epidemiological research into health effects of noise

In the case of transportation noise policy, it is common to see noise criteria that allow for higher noise levels than would be allowed for industry. This may reflect such factors as the perception of community benefits flowing from transportation, a greater community tolerance of transportation noise, and acceptance of the need for control measures to be practicable. It is therefore instructive to consider *protection* from transportation noise from the perspectives of *amenity* versus *health*. Aircraft noise is a case in point.

Aircraft noise policy in Australia has largely been developed from the landmark 1982 report prepared by Hede and Bullen for the National Acoustic Laboratories on community reaction to aircraft noise (Hede and Bullen 1982). That report established a strong socio-acoustic survey methodology; and analysed the results of interviews with 3,575 residents around the major airports in Sydney, Melbourne, Adelaide, Perth and Richmond Air Base. The survey results were grouped into those ‘seriously affected’ and ‘moderately affected’ by aircraft noise: the term ‘affected’ being used to include responses including annoyance, activity disruption (e.g. reading, listening, talking and sleeping), desire to complain, general reaction and fear. As a result, apart from self-reported sleep disturbance, the study can be described (in the terms used in this paper) as assessing *amenity* rather than *health*.

The survey results were correlated against various noise indices determined from noise measurements around the various airports. The strongest correlation was found to be with a modified Noise Exposure Forecast known as $NEF_{3,6}$, later to be the basis for the Australian Noise Exposure Forecast (ANEF). Figure 3 shows the study results in terms of the percentage of the population likely to be ‘seriously affected’ and ‘moderately affected’ versus $NEF_{3,6}$ noise levels (the ‘moderately affected’ numbers include those ‘seriously affected’).

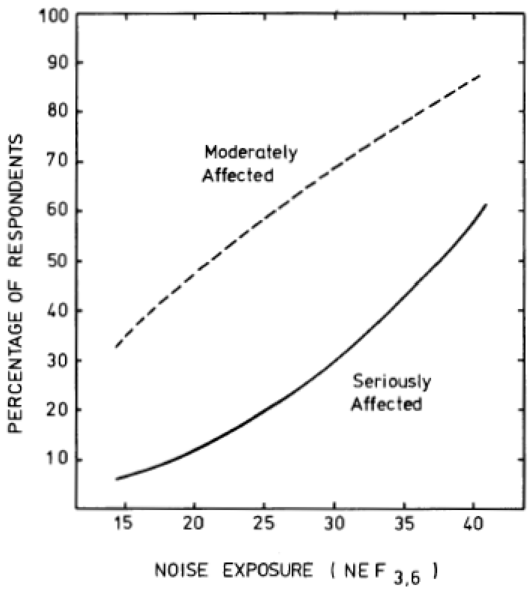

Figure 3. Community reaction to aircraft noise (Hede and Bullen 1982)

These findings have formed the basis of the ANEF and the associated Australian Noise Exposure Index (ANEI). The ANEF is a forecast for a nominated future scenario, while the ANEI represents the actual noise exposure over a given year. For example, Figure 3 indicates that a noise exposure forecast of 20ANEF would protect almost 90% of the population from being 'seriously affected' by aircraft noise in the future; or a noise exposure of 25ANEI would suggest that about 20% of the population would currently be 'seriously affected' by the noise.

The ANEF metric has informed land use planning policies around major Australian airports for some years. In the WA context, State Planning Policy 5.1 Land use planning in the vicinity of Perth Airport (WAPC 2015:3) specifies (in part) that, for the land areas between the 20 and 25ANEF contours:

> *Noise insulation is not mandatory for residential development within this noise exposure zone. Some areas however, may experience peak aircraft noise levels in excess of the Indoor Design Sound Levels specified in AS2021, and noise insulation is recommended in such cases.*

It is instructive to consider the implications of this provision for *protection* of community *health*. The Noise and Flight Path Monitoring System report prepared by Airservices Australia for Perth Airport for the fourth quarter of 2010 (ASA 2011) sets out the quarterly measured $L_{Aeq,night}$ noise levels (2300-0600 hours) for the various noise monitoring locations. The average $L_{Aeq,night}$ levels over the year for three monitoring locations are compared with the estimated ANEI values for these locations for 2010 (Perth Airport 2011) in Table 2 below.

Table 2. Comparison of night noise exposure levels with estimated ANEF and ANEI values for Perth Airport

Metric	Year	Gibbs St Primary School, Cannington	Queens Park Primary School, Queens Park	Water Authority, Guildford
$L_{Aeq,night}$	2010	54	57	55
ANEI	2010	~18	20	~18
$L_{Aeq,night}$	2013	55	59	56
ANEF	2059	23	24	~25

Table 2 also includes the average $L_{Aeq,night}$ levels for the year 2013 (ASA 2014) – the last year that these levels were reported on – and the ANEF levels for the year 2059 (Perth Airport 2014). It should be noted that the ANEI and ANEF values given in Table 2 are rough estimates obtained by visual inspection of the noise contour maps and interpolation or extrapolation as needed.

This is a somewhat crude analysis, obtained by comparing results of a night time index with a 24-hour index, for which the values are only estimates. Nevertheless, aircraft noise levels at night are relatively high in Perth, where the night noise comprises a significant component of the ANEI and ANEF. For example, the average $L_{Aeq,24h}$ levels in 2013 at the Queens Park and Guildford monitors were only 2.4dB and 2.8dB above the average $L_{Aeq,night}$ levels respectively (Perth Airport 2011). This is due to the absence of a curfew at Perth. The analysis in Table 2 does indicate that in 2010 there were noise monitors lying close to the 20ANEF contour with $L_{Aeq,night}$ noise levels in the order of 54-57dB. Aircraft noise levels at these locations had increased to 55-59dB by 2013, and are likely to increase further in the future as noise levels approach the ultimate capacity ANEF values in 2059.

Research over recent decades – particularly since 2002 when Directive 2002/49/EC of the European Union led to a range of epidemiological studies testing the effects of noise on previously-studied cohorts – has identified significant risks of *health* outcomes, such as heart disease, caused by environmental noise at similar night noise levels to those near the 20ANEF contour for Perth Airport. For example, the World Health Organisation's Night Noise Guidelines for Europe (WHO 2009) identify a range of noise effects for which there is at least limited evidence: biological effects (changes in stress hormone levels); well-being effects (tiredness, irritability, complaints, impaired social contact and cognitive performance); and physiological effects (insomnia, hypertension, obesity, depression in women, heart attack, reduced life expectancy, psychiatric disorders and occupational accidents). The guidelines describe the health impact of noise exposures above $L_{Aeq,night}$ of 55dB as follows (WHO 2009:108):

> *The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.*

Since the time of the WHO guidelines further research has strengthened the association between noise and heart disease; and studies are being conducted into a wider range of *health* outcomes relating to noise, including stroke, breast cancer, diabetes and Alzheimers Disease (Basner et al. 2015). It appears that this field of work is likely to continue to unearth further findings of relevance to environmental noise policy.

One can conclude from the above that night noise levels in the areas within the 20ANEF contour around Perth Airport are not just an *amenity* issue: they are a public *health* issue. If sufficient weight were to be given to *protection* in the context of *health* outcomes in the formulation of land use planning policy around Perth Airport, then there would be stronger planning controls in the areas above 20ANEF, for instance mandatory noise insulation of new dwellings in the 20-25ANEF area. At the project level, the regulators and decision-makers assessing a land use planning proposal for new residential development in an area above 20ANEF need to give proper weighting to the *health* aspects of the aircraft noise when balancing *protection* against *fairness* and *certainty*. There is also an argument for introducing a noise insulation program for existing dwellings and schools in the high noise areas.

Road and rail traffic noise policies also need to emphasise community *health* along with *amenity*, and it is noted that recent efforts to update road noise policies in Australia are cognisant of this issue (VicRoads 2015). It is likely that these types of research findings will increasingly influence *protection* considerations in future transportation noise policy decisions, and it is crucial that regulators follow the advances as research progresses.

3.3 Other considerations

The above discussion is predicated on the use of A-weighted noise levels as the main basis for setting noise criteria that will provide a given degree of *protection*. Of course there are further considerations, including the possible presence in the noise emissions of characteristics such as low frequency or infrasound content, tonality, impulsiveness or modulation, which may need to be incorporated into a regulatory instrument. In general, these may be thought of as *amenity* considerations, as they may make the noise more annoying than a constant, broadband noise of the same level.

4. APPLICATION OF THE FRAMEWORK

While the above discussion focused on *protection*, considerations of *fairness* and *certainty* can best be addressed through some examples of application of the framework taken from the author's experience with different regulatory challenges.

4.1 Traffic noise

Road and rail noise policy in Western Australia during the 1990's was a hotch-potch of separate policies and approaches for noise from roads, freight rail and passenger rail; these policies belonged to the responsible road, rail, environmental and planning agencies of the day. In order to develop a whole-of-government policy for road and rail noise a working group was assembled from representatives of the relevant agencies in the late 1990s. While the framework as outlined above was not consciously followed during the working group process, it was inherent in the way the policy evolved, and to a considerable extent the framework grew out of this work.

With regard to *protection*, the group considered this from two points of view: protecting the community from excessive noise; and protecting transport corridors from potential constraints caused by encroachment of noise-sensitive uses. This meant that the policy would need to address both noise from new road and rail infrastructure and noise from existing roads and railways as it might affect new noise-sensitive developments.

In relation to community impacts, the working group initially considered criteria used in other Australian states and overseas; these criteria were generally found to be in the range $L_{Aeq,day}$ 50-60dB and $L_{Aeq,night}$ 45-55dB. As noted above, up to this time *amenity* issues – in particular annoyance – were generally accepted as a primary driver of noise policy. In 1999 the World Health Organisation considered that the critical effects of noise on dwellings were on sleep, annoyance and speech interference; in regard to *health* noise was thought to be only weakly associated with cardiovascular disease at relatively high $L_{Aeq,24}$ levels of 65-70dB (WHO 1999). To protect the majority from serious annoyance, the recommended WHO guidelines at that time were $L_{Aeq,day}$ of 55dB; and, to protect bedrooms with windows open, $L_{Aeq,night}$ of 45dB (WHO 1999). The working group's early considerations regarding *protection* were therefore seen to be weighted towards *amenity* issues.

During the 2000s *health* issues gradually gained more weight in the working group's consideration of *protection*, as epidemiological research on the effects of noise on cardiovascular health began to demonstrate stronger associations. As a result, $L_{Aeq,night}$ noise levels above 55dB were considered unacceptable, even though these levels may be difficult to achieve in some scenarios, particularly for freight rail.

Before recommending noise criteria, the working group considered *fairness*. The first issue was whether or not to apply the same noise criteria for roads as for railways. From 1998, Miedema's meta analysis of annoyance studies into road, rail and aircraft noise was accepted as a benchmark (Miedema, 1998). The results of his multilevel analysis for road and rail noise were expressed as relationships between the percentage of the population highly annoyed by the noise (%HA) and the corresponding Day-Night noise exposure (DNL). DNL is a 24-hour index obtained by combining $L_{Aeq,Day}$ (0700 to 2200 hours) with an $L_{Aeq,Night}$ (2200 to 0700 hours), which is adjusted by +10dB. DNL is more commonly referred to as $L_{DN.}$ Miedema's equations are as follows:

Road: $$\%HA = 0.24(DNL - 42) + 0.0277(DNL - 42)^2 \quad (1)$$

Rail: $$\%HA = 0.28(DNL - 42) + 0.0085(DNL - 42)^2 \quad (2)$$

For a DNL of 55dB(A), equations (1) and (2) indicate that 7.8% of the population would be highly annoyed by road traffic compared with 5.1%HA for rail. The difference increases at a DNL of 60dB(A), with 13.7%HA for road traffic and 7.8%HA for rail traffic. While recognizing the annoyance differences between road and rail, and that some countries in Europe had a related 'rail bonus' policy, the working group felt that the policy would be fairer and clearer if the same criteria applied for both road and rail.

Fairness is also highly dependant on the feasibility and practicability of achieving a given noise criterion. In this regard the working group evaluated the practicability of achieving various criteria levels for new road and rail proposals, and found that it was generally feasible to achieve $L_{Aeq,day}$ of 60dB and $L_{Aeq,night}$ of 55dB for noise receivers at ground floor level. Lower levels of 55 and 50dB respectively were found to be achievable in some situations but would require noise barriers at heights considered impractical in a number of other situations.

Other *fairness* issues included the practicability of meeting a given noise criterion in a new residential development adjacent to a major road or railway. For example, it was considered that external noise levels should be achieved in at least one outdoor area on each residential lot (e.g. a screened rear yard), but need not be achieved in both the front and rear yards. Where the outdoor noise criteria are not achieved, internal noise criteria would apply.

In the end, State Planning Policy 5.4, Road and Rail Transport Noise and Freight Considerations in Land Use Planning (SPP5.4) was released in 2009 (WAPC 2009), just after WHO released its Night Noise Guidelines for Europe (WHO 2009). Guidelines for implementation of SPP5.4 were released shortly afterwards, and were updated in 2014 (WAPC 2014). Balancing of the various considerations around *protection* and *fairness* led to the following noise criteria for proposed new railways and major roads and new noise-sensitive developments: 'limit' levels $L_{Aeq,day}$ of 60 dB and $L_{Aeq,night}$ of 55dB; and 'target' levels 55dB and 50dB, respectively. Noise reduction measures are required in order to meet the limit levels, while target levels are to be achieved where practicable; the levels within the margin between the target and the limit are to be as low as practicable. SPP5.4 states the following regarding the development of its noise criteria (WAPC 2009:8):

> *The noise criteria were developed after consideration of road and rail transport noise criteria in Australia and overseas, and after a series of case studies to assess whether the levels were practicable. The noise criteria take into account the considerable body of research into the effects of noise on humans, particularly community annoyance, sleep disturbance, long-term effects on cardiovascular health, effects on children's learning performance, and impacts on vulnerable groups such as children and the elderly. Reference is made to the World Health Organization (WHO) recommendations for noise policies in their publications on community noise and the* Night Noise Guidelines for Europe*.*

Certainty was regarded as important throughout the working group process, and this is particularly evident in the detail of the specification of the noise criteria and the noise assessment methodology, and where these apply. Much of this detail appears in the implementation guidelines for SPP5.4 (WAPC 2014).

There were however several areas where the working group was unable to come up with definitive policy measures. A review paper (Macpherson 2011) identified the following issues where *certainty* would have been enhanced by the addition of further noise criteria in SPP5.4: for recreational areas, regenerated noise from tunnels, major infrastructure redevelopments, freight handling facilities, and rural areas where noise levels are below the target values.

4.2 Airblast noise

The WA Environmental Protection (Noise) Regulations 1997 (WA 1997) contained a special regulation dealing with airblast noise, which appears below.

> *11. (1) In this regulation —*
>
> ***"airblast level"*** *means a noise level resulting from blasting;*
>
> ***"$L_{Linear\ peak}$"*** *means the maximum reading in decibels (dB) obtained using the "P" time-weighting characteristic as specified in AS 1259.1-1990 with all frequency-weighting networks inoperative and with sound level measuring equipment that complies with the requirements of Schedule 4.*
>
> *(2) The provisions of this regulation apply to airblast levels and where they apply they have effect in place of regulation 7.*
>
> *(3) No airblast level resulting from blasting on any premises or public place, when received at any other premises, may exceed —*
>
> *(a) 125dB $L_{Linear\ peak}$ between 0700 hours and 1800 hours on Monday to Saturday inclusive; or*
>
> *(b) 120dB $L_{Linear\ peak}$ between 0700 hours and 1800 hours on a Sunday or public holiday.*
>
> *(4) Notwithstanding subregulation (3), airblast levels for 9 in any 10 consecutive blasts (regardless of the interval between each blast), when received at any other premises, must not exceed —*

(a) 120dB $L_{Linear\ peak}$ between 0700 hours and 1800 hours on Monday to Saturday inclusive; or

(b) 115dB $L_{Linear\ peak}$ between 0700 hours and 1800 hours on a Sunday or public holiday.

(5) No airblast level resulting from blasting on any premises or public place, when received at any other premises, may exceed —

(a) 90dB $L_{Linear\ peak}$ outside the periods between 0700 hours and 1800 hours on any day except where that blasting is carried out in accordance with regulation 8.28 (4) of the Mines Safety and Inspection Regulations 1995*; or*

(b) the levels specified in subregulations (3) and (4) outside the periods between 0700 hours and 1800 hours, as appropriate for the time when it was intended that the blast be fired, if the exception in paragraph (a) applies.

A review of the regulations in 2011 proposed to reduce the allowable airblast levels by 5dB, to bring them into line with those in other states (WA 2011a). However, the consultation process raised a number of *fairness* issues with the wording of regulation 11, principally that the requirement to achieve the allowable airblast levels "when received at any other premises" unfairly restricted blasting practices that may have little or no noise impact (WA 2011b). For example, the boundary of a receiving premises adjacent to a quarry may be far from the homestead, hence the regulation protects a less-sensitive area where no person may even be present, while overprotecting the (more sensitive but more distant) homestead. Similarly it was argued that a receiving premises that is industrial would be less sensitive to airblast noise than would a residential premises.

Applying the framework to this example, the review considered the issue initially from the point of view of *protection*: firstly, the intent was to protect persons against being unduly startled by the blast; and while protecting against the fear of damage to the house, there was no intent to protect against structural damage per se. Secondly, it was appropriate that the level of *protection* for persons in 'noise sensitive' buildings such as rural homesteads be set at levels 5dB below the existing levels, in order to better prevent complaints, and to provide the same degree of *protection* as in other states. Thirdly, the existing airblast levels were considered adequate for persons in less-sensitive areas on a rural property, such as the paddocks on a farm or an industrial site. Fourthly, it was considered appropriate that the airblast limits should not apply at a location where it could be shown that no person was present at the time of the blast.

These considerations in relation to *protection* were also aimed at achieving greater *fairness,* as the person conducting blasting (blaster) would be able to avoid the impractical blasting restrictions often required to meet the requirements of regulation 11. The clarifications provided by the first three points were also considered to improve *certainty* for the blaster. The fourth point (no person present at the time of the blast) however raised questions about *certainty*: how could an enforcement officer prove that a blaster (who had exceeded the limits when a person was present) could not have believed on reasonable grounds that no person was present at the time of the blast? It was however considered that there were adequate precedents for this type of regulatory approach, hence *certainty* was felt to be satisfied.

It should be noted that the introduction of measures to improve *fairness* inevitably makes an instrument more complex: in this case the number of subclauses in regulation 11 increased from 5 to 11, and the number of definitions from 2 to 6, when the regulation was amended.

The above changes were included in the amended regulations of 2014 (WA 2014).

4.3 Windfarm noise

Windfarms have presented a unique challenge to the noise regulator, as the noise level received from the windfarm tends to increase with the wind speed. This has led to regulatory approaches based on comparison of the predicted noise level for a particular wind speed with the measured background noise level at the receiver location at that wind speed. Large amounts of data are required in order to enable robust regression analyses to establish a 'curve' of background noise levels versus wind speed for each location of interest. Normally these analyses need to take into account such factors as wind direction, poor weather, the equipment noise floor and possible seasonal variations.

The results of these analyses can be so detailed and complex as to be confusing for a decision-maker such as a regional local government tasked with assessment of a windfarm proposal without access to the necessary expertise. In such a case *certainty* suffers, since neither the decision-maker nor the community may have sufficient confidence in the analysis to be sure that the community will be adequately protected.

It can be argued that the policy of allowing windfarm proponents to use the rising background noise level as the base for comparison should not be seen as a 'right' but as a privilege, given that all other industrial proponents must comply with either a fixed noise criterion level or with a background noise level taken under the quietest typical conditions. This privilege may be forfeit when the analysis becomes overly complex. Windfarm proponents would reasonably argue that the allowance is an appropriate exercise of *fairness*.

Aside from the assessment of predicted noise levels against statistical analyses of background noise levels – all carried out using A-weighted values – there is the lingering issue of potential health effects associated with infrasound and low frequency noise (ILFN). The 2013 systematic review of the human health effects of windfarms carried out by the University of Adelaide on behalf of CSIRO (Merlin et al. 2013:170) concluded as follows:

> *The quality and quantity of evidence available to address the questions posed in this review was limited. The evidence considered does not support the conclusion that wind turbines have direct adverse effects on human health, as the criteria for causation have not been fulfilled. Indirect effects of wind farms on human health through sleep disturbance, reduced sleep quality, quality of life and perhaps annoyance are possible. Bias and confounding could, however, be possible explanations for the reported associations upon which this conclusion is based.*

It would seem that, from the standpoints of *protection* and *certainty*, possible effects of ILFN cannot be ruled out at this stage. Application of the 'precautionary principle' would be relevant here, as discussed by Gullett (2000:95):

> *The principle does not equate a "no risk" policy but rather requires greater weight to be given to environmental and public health protection in the all too common situation where there is insufficient scientific information available upon which to base decisions. Its most specific instruction is for us to be responsive to problems created by scientific uncertainty. The two central elements of the principle are that we should be confident about predictions of future environmental effects of activities before allowing them and that we should not wait for conclusive proof of environmental harm before adopting appropriate remedial measures.*

One approach to the application of the precautionary principle in relation to windfarms is for the decision-maker to require an assessment of predicted ILFN levels compared with the threshold of hearing curves, as suggested in the 2010 draft National Wind Farm Development Guidelines (EPHC 2010); or (to be more conservative) with a curve that is one or two standard deviations below the normal curve. Such an approach may at least provide some *certainty* to the community, the proponent and the decision-maker that the ILFN is unlikely to be audible.

A significant risk to windfarm proponents is that others outside the immediate decision-making process will seek to impose a 'simple' solution in order to regain *certainty*. In the case of windfarms the obvious alternative to endless ILFN assessment and background noise analysis is to establish a simple setback distance, for example 2km. While such approaches may provide a high level of *protection* and *certainty*, proponents may well argue that it is at the sacrifice of *fairness*.

This paper does not set out to provide an answer to this issue; and WA does not have a specific policy position on it, apart from reasonable application of the general noise regulations. The objective here is merely to show that the conscious use of the framework by all parties involved in the deliberations that comprise policy development and project decision-making can assist in achieving good, balanced outcomes in complex areas such as this.

5. CLOSING REMARKS

The regulation of environmental noise is a complex task, given the range of noise sources potentially requiring some form of regulation and the range of regulatory options that can be invoked. A framework has been outlined in this paper that can be applied generally to the regulation of environmental noise. The three elements, or values, in the framework – *protection*, *fairness* and *certainty* – need to be kept in balance if good environmental outcomes are to be achieved.

Overlying the three values that underpin the framework is the need to avoid overcomplication and the opposite, oversimplification: the former is usually a symptom of an overemphasis on *fairness*, while the latter attempts to achieve *certainty*, but often at the sacrifice of *fairness* and/or *protection*.

A clear understanding of what is to be protected provides the regulator with an essential tool to evaluate and resolve the tension between *protection* and *fairness*. Participants in the regulatory process, especially those with noise expertise, need to be aware of research trends in the area of environmental noise and public health if *protection* is to be properly served.

Resolving the tensions between *protection*, *fairness* and *certainty* requires that those regulators who have technical expertise are able to clearly explain to others in the process why a given level of *protection* is needed, or why a particular control measure may be impracticable and therefore unfair. All those involved in the regulatory process need to gain an understanding of the issues related to *fairness* and *certainty* as they affect the particular situation.

Conscious application of the framework will assist in achieving acceptance of the regulatory instrument that results. Successful implementation of the framework requires a robust and accountable process that enables meaningful consultation, strong technical noise input and a degree of regulatory skill.

REFERENCES

ASA 2011, *Noise and Flight Path Monitoring System Perth Quarterly Report October – December 2010*, Airservices Australia, Canberra, 2011

ASA 2014, *Noise and Flight Path Monitoring System Perth Quarterly Report October – December 2013*, Airservices Australia, Canberra, 2014

Basner, M, Brink, M, Bristow, A, de Kluizenaar, Y, Finegold, L, Hong, J, Janssen, SA, Klaboe, R, Leroux, T, Liebl, A, Matsui, T, Schwela, D, Sliwinska-Kowalska, M & Sörqvist, P 2015, *ICBEN review of research on the biological effects of noise 2011-2014*, Noise & Health, March-April 2015, Volume 17:57-82

EPHC 2010, *National Wind Farm Development Guidelines – Draft*, Environment Protection Heritage Council, Canberra, 2010

Gullett, W 2000, *The precautionary principle in Australia: policy, law and potential precautionary EIAs*, Risk: Health, Safety and Environment, 11(2), 2000:93-124

Hede, AJ, & Bullen, RB 1982, *Aircraft noise in Australia: A survey of community reaction*, National Acoustic Laboratories NAL Report No.88, Australian Government Publishing Service, Canberra, 1982

Macpherson, J 2011, *Development of a State Planning Policy for Road and Rail Transport Noise – the Western Australian Experience*, Proceedings of 10th International Congress on Noise as a Public Health Problem (ICBEN), London, 2011:1008-1015

Merlin, T, Newton, S, Ellery, B, Milverton, J & Farah, C 2013, *Systematic review of the human health effects of wind farms,* National Health and Medical Research Council, Canberra, 2013

Miedema, HME 1998, Revised DNL-Annoyance Curves for Transportation Noise, Proceedings of 7th International Congress on Noise as a Public Health Problem (ICBEN), Sydney, 1998:491-496

Perth Airport 2011, *Perth Airport 2010 Australian Noise Exposure Index (ANEI)*, Drawing No. FS 9650, Perth Airport Pty Ltd, Perth, 2011

Perth Airport 2014, *Perth Airport Master Plan 2014*, Perth Airport Pty Ltd, Perth, WA, 2014

VicRoads 2015, *Traffic Noise Reduction Policy Review – Discussion Paper*, VicRoads (the Roads Corporation of Victoria), Kew, Victoria, 2015

WA 1997, *Environmental Protection (Noise) Regulations 1997*, (as at 11 December 1997), Government of Western Australia, Perth, WA, 1997

WA 2011a, *Proposed Environmental Protection (Noise) Amendment Regulations 2010 amending the Environmental Protection (Noise) Regulations 1997 – Proposed Changes to Airblast Limits – Discussion Paper*, Department of Environment and Conservation, Bentley, WA, 2011

WA 2011b, *Proposed Environmental Protection (Noise) Amendment Regulations 2010 amending the Environmental Protection (Noise) Regulations 1997 – Report on Public Consultation*, Department of Environment and Conservation, Bentley, WA, 2011

WA 2014, *Environmental Protection (Noise) Regulations 1997*, (as at 19 May 2014), Government of Western Australia, Perth, WA, 2014

WA 2015, *Environmental Protection Act 1986*, (as at 27 April 2015), Government of Western Australia, Perth, WA, 2015

WAPC 2009, *State Planning Policy 5.4, Road and Rail Transport Noise and Freight Considerations in Land Use Planning*, Western Australia Planning Commission, Perth, WA, 2009

WAPC 2014, *Implementation Guidelines for State Planning Policy 5.4, Road and Rail Transport Noise and Freight Considerations in Land Use Planning,* Western Australia Planning Commission, Perth, WA, 2014

WAPC 2015, *State Planning Policy 5.1 Land use planning in the vicinity of Perth Airport*, Western Australia Planning Commission, Perth, WA, 2015

WHO 2009, *Night Noise Guidelines for Europe*, World Health Organisation, Copenhagen, Denmark, 2009