NSW Industrial Noise Policy (2000)

(Superseded)

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ISBN 0 7313 2715 2
EPA 00/1

Cover photo: Australian Picture Library / Corbis
January 2000
Printed on recycled paper

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1 Policy framework

1.1 Overview of the policy

The adverse effects of noise on communities are well reported in the literature (for review see Berglund & Lindvall, eds, 1995). These vary from direct effects (including noise-induced hearing loss, speech interference, sleep disturbance and annoyance), to indirect or secondary effects, such as long-term effects on physical and mental health as a result of long-term annoyance and prolonged disturbance to sleep. The World Health Organization defines health as a state of complete physical, mental, and social well-being, not just as the absence of disease (WHO 1947). Community reaction to noise has been noted as a likely indirect cause of adverse health effects (Job 1996).

The overall aim is to allow the need for industrial activity to be balanced with the desire for quiet in the community.

The broad operating objectives involve requirements to protect, restore and enhance the quality of the environment in New South Wales. In so doing, the EPA must have regard to the need to maintain ecologically sustainable development, reduce the risks to human health and prevent the degradation of the environment. This policy seeks to promote environmental well-being through preventing and minimising noise. It provides the framework and process for deriving noise limit conditions for consents and licences that will enable the EPA to regulate premises that are scheduled under the *Protection of the Environment Operations Act 1997.*

The specific policy objectives are:

- to establish noise criteria that would protect the community from excessive intrusive noise and preserve amenity for specific land uses—these are set out in *Section 2*
- to use the criteria as the basis for deriving project specific noise levels
- to promote uniform methods to estimate and measure noise impacts, including a procedure for evaluating meteorological effects—these are set out in *Sections 3 to 6*
- to outline a range of mitigation measures that could be used to minimise noise impacts—these are set out in *Section 7*
- to provide a formal process to guide the determination of feasible and reasonable noise limits for consents or licences that reconcile noise impacts with the economic, social and environmental considerations of industrial development—this is covered in *Section 8*
- to carry out functions relating to the prevention, minimisation and control of noise from premises scheduled under the Act.

1.2 Who is the policy for?

The policy is technical in orientation and is directed towards industry, acoustic practitioners and consent authorities that require a degree of technical detail to assess impacts properly and develop mitigation methods.

Responsibility for applying the policy lies with:

- the land-use planner (such as a local council and the Department of Urban Affairs and Planning—DUAP), through taking account of likely impacts at an early stage in the planning process so that incompatible developments are appropriately located; also, in recognising the importance of maintaining separation distances between industry and residents. In locating potentially noisy developments, it is essential to recognise that mitigation of the effects of noisy activities once these are established will be limited by cost and design factors.
- the land-use managers and regulators (such as local government, DUAP and the EPA), who act as determining authorities and as regulators of land-use activities. Their role is in providing adequate regulation of noise to preserve amenity and in ensuring compliance with noise conditions.

- the noise-source proponent and manager, through consideration of noise issues at the planning stage of a project and through direct control of the noise impacts by the appropriate combination of noise management tools and engineering design of the source.

1.3 Scope of the policy

The policy is specifically aimed at assessing noise from industrial noise sources scheduled under the new *Protection of the Environment Operations Act 1997*. It will be used as a guide by Environment Protection Authority (EPA) officers for setting statutory limits in licences for these sources. Local government is an independent regulator for noise under the legislation, and thus has discretion in dealing with noise within its area of responsibility. The policy is designed for large and complex industrial sources and specifies substantial monitoring and assessment procedures that may not always be applicable to the types of sources councils need to address. However, local government may find the policy helpful in the carrying-out of its land-use planning responsibilities (for example, the setting of targets in local and regional environmental plans).

In general, the types of noise sources dealt with in the policy are:

- facilities (encompassing *all* the activities taking place within the property boundary of the facility) usually comprising many sources of sound, including

  —industrial premises

  —extractive industries

  —commercial premises

  —warehousing facilities

- maintenance and repair facilities

- individual industrial sources, such as

  —heating, ventilating and air conditioning (HVAC) equipment

  —rotating machinery

  —impacting mechanical sources

  —other mechanical equipment and machinery such as conveyors

  —mobile sources confined to a particular location, such as draglines and haul trucks.

The policy's focus is on the noise emitted from industrial sites and how this may affect the amenity of nearby receivers. Internal or occupational noise within any workplace is a separate issue administered by the WorkCover Authority under the *Occupational Health and Safety Act 1983*.

Examples of noise sources that are NOT dealt with by the policy are:

- transportation corridors (roadways, railways and air corridors)
- motor sport facilities
- construction activities
- noise sources covered by regulations (domestic / neighbourhood noise).

Noise from vehicle movements associated with an industrial source is covered by the industrial noise source policy if the vehicles are not on a public road. If the vehicles are on a public road, the *Environmental Criteria for Road Traffic Noise* (EPA 1999) apply.

In particular instances specific noise criteria may be defined for sources where the standard approach is not appropriate, for example, wind farms.

1.4 Applying the policy

The assessment of noise impact is complex and subjective, and is rarely (if ever) able to be considered in isolation from other social and economic aspects of a development or activity. The policy outlines processes to help strike a feasible and reasonable balance between the establishment and operation of industrial activities and the protection of the community from noise levels that are intrusive or unpleasant.

In summary, noise management involves the following main steps:

1. Determining the project specific noise levels for intrusiveness and amenity that are relevant to the site or the area (*Section 2*).

2. Measuring and determining existing background and ambient noise levels, using the method relevant to the expected level of impact (as outlined in *Section 3)*.

3. Where the proposed development is expected to produce annoying noise characteristics, adjustments are to be applied to the noise levels produced by the development in question (as outlined in *Section 4)*.

4. Predicting or measuring the noise levels produced by the development in question, having regard to meteorological effects (such as wind, temperature inversions) (see *Section 5*).

5. Comparing the predicted or measured noise level with the project-specific noise levels and assessing impacts (*Section 6*).

6. Considering feasible and reasonable noise mitigation strategies where the project-specific noise levels are exceeded (*Section 7*).

7. Negotiation between the regulatory / consent authority and the proponent and between the community and the proponent to evaluate the economic, social and environmental costs and benefits from the proposed development against the noise impacts (*Section 8*).

8. The regulatory / consent authority sets statutory compliance levels that reflect the achievable and agreed noise limits for the development (*Section 9*).

9. Monitoring of environmental noise levels from the development to determine compliance with the consent / licence conditions (*Section 11*).

1.4.1 Principles underpinning the noise criteria

The industrial noise source criteria set down in *Section 2* are best regarded as planning tools. They are not mandatory, and an application for a noise-producing development is not determined purely on the basis of compliance or otherwise with the noise criteria. Numerous other factors need to be taken into account in the determination. These factors include economic consequences, other environmental effects and the social worth of the development. The criteria help to determine consent / licence conditions because they provide information on the likely effect of any environmental noise associated with the development.

Within the community, there is a very large range of human reaction to noise. There are those in the community who are very sensitive to noise. This noise-sensitive sector of the population will react, often strongly, to intruding noises that are barely audible within the overall noise environment, or will have an expectation of very low environmental noise levels. On the other hand, there are those within the community who find living in noisy environments, such as near major industry, on main roads or under aircraft flight paths, an acceptable situation. The bulk of the population lies within these two extremes, being unaffected by low levels of noise and being prepared to accept levels of noise that are commensurate with living in an urban, industrialised society.

The criteria in this document (*Section 2*) have been selected to protect at least 90 per cent of the population living in the vicinity of industrial noise sources from the adverse effects of noise for at least 90 per cent of the time. Provided the criteria in this document are achieved, then it is unlikely that most people would consider the resultant noise levels excessive. In those cases when the project-specific noise levels are not, or cannot be, achieved, then it does not automatically follow that those people affected by the noise would find the noise unacceptable.

1.4.2 Existing versus new development

The assessment procedures in the policy can apply to any one of the following three situations:

- new development impacts—for example, new industrial premises proposed near an existing residential area
- modification of an existing development and its impact—for example, proposed expansion of an existing industrial premises
- noise associated with existing development.

Existing noise sources

The application of the criteria to existing sources of noise would occur where significant modifications (such as to warrant serious and / or ongoing development consent or EPA approval) are made to existing developments or where complaints are received.

In applying the policy to existing operations it is acknowledged that the scope for applying feasible and reasonable mitigation measures to existing noise sources is usually far more limited than for new developments. Careful consideration of noise impacts and the feasible and reasonable mitigation measures available at these sites may result in less stringent noise limits than would ideally apply. Sometimes the resultant noise limits will be above the criteria. The assessment and management of existing premises is dealt with in *Section 10*.

Greenfield sites

In assessing developments proposed for 'greenfield' (undeveloped) areas, the policy allows controlled increases above background noise levels in a similar manner to previous policy and planning practice. (See case study (a) in *Appendix A, Section A2.*)

1.4.3 Prevention of noise impacts

Avoiding co-location of incompatible uses

Judicious land use and project planning can often prevent potential noise problems from occurring. This policy should be used to consider the implications of proposing or allowing new noise-sensitive developments near noise generators and of proposing or allowing new noise-generating developments near established noise-sensitive developments such as schools, hospitals or homes. The criteria will help in the first instance to identify sites where it would be difficult, if not impossible, to avoid noise impacts over time, and will therefore help in an informed process for making decisions about land-use zoning or site selection by developers.

The criteria can also be used to identify the need for planning and building-design mitigation measures for managing the relationship between noise-generating activities and noise-sensitive developments.

The types of strategies that could be used by planners and project proponents include:

- considering noise impacts when planning the development of areas, and incorporating suitable measures such as:
  - —spatial separation between noisy activities and noise-sensitive areas through locating less-noise-sensitive land uses (active recreation areas or access ways) in high noise areas
  - —taking advantage of any natural topographical features that can be used to screen noise impacts when planning land use in an area
  - —subdivision layout to maximise the area shielded from noise
  - —using intervening structures such as multi-level buildings to act as barriers. Buildings used as barriers should incorporate noise-quietening principles into their building design to ensure appropriate internal conditions.
- incorporating appropriate building design to minimise noise impacts, for example:
  - —including acoustic design principles when planning landscaping for a site by examining the suitability of earth berms, walls or fences to act as barriers
  - —building design to locate noise-insensitive areas such as kitchens, storage areas and laundries towards the noise source; minimising the size and number of windows oriented towards the noise source; replacing conventional roof design with eaves by a flat roof with parapets; using the building structure to shield outdoor areas
  - —using construction techniques that have good attention to sealing air gaps around doors and windows exposed to noise; using solid core doors; and using thicker window glass or double glazing.

It is also important that there be a mechanism for providing information on existing noise impacts from approved facilities to members of the public seeking to move into areas, in order to avoid unrealistic expectations of noise amenity in affected areas.

1.4.4 Noise criteria and assessment

Two criteria

The policy sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses.

Assessing intrusiveness

For assessing intrusiveness, the background noise needs to be measured. An objective procedure is outlined in *Section 3.1*.

The intrusiveness criterion essentially means that the equivalent continuous (energy-average) noise level of the source should not be more than 5 decibels (dB) above the measured background level.

Assessing amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. (See *Table 2.1.)* The criteria relate only to industrial-type noise and do not include road, rail or community noise. The existing noise level from industry is measured. (See *Section 3.2.*) If it approaches the criterion value, then noise levels from new industries need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion. (See *Table 2.2.*) For high-traffic areas there is a separate amenity criterion (*Section 2.2.3*). The cumulative effect of noise from industrial sources needs to be considered in assessing impact (*Section 2.2.4*).

Project-specific noise levels

For a particular project, the more stringent of the intrusive or the amenity criteria sets the project-specific noise levels for that project. Generally, the intrusive criterion applies for all new industries until an area begins to become more developed, causing increased noise levels. At this stage the amenity criterion starts to take over as the applicable criterion. Where several new industries are proposed for a new area, care must be taken to ensure that equitable levels are set for each proposed industry (*Section 2.2.4*).

Accounting for annoying noise characteristics

A noise source may exhibit a range of particular characteristics that increase annoyance, such as tones, impulses, low frequency noise and intermittent noise. Where this is the case, an adjustment is applied to the source noise level received at an assessment point before it is compared with the project-specific noise level to account for the additional annoyance caused by the particular characteristic. Application of these modifying factors is described in *Section 4*.

Accounting for the effect of meteorology on noise levels

When assessing noise impacts, the project-specific noise levels are expected to apply under weather conditions characteristic of an area. These conditions may include calm, wind and temperature inversions. In this regard, the policy addresses the increase in noise that results from atmospheric temperature inversions and wind effects.

The policy sets the following procedure for assessing temperature inversions (*Section 5.2*):

- an initial screening test is done to identify whether any further assessment of meteorological effects on noise is warranted
- where the effect is significant, the proponent may choose to use default meteorological values to predict the increased noise levels. These defaults have been provided so that potentially costly on-site monitoring can be avoided.
- alternatively, the proponent can reject the default values and derive parameters by direct measurement
- the increased noise level is then predicted using the meteorological parameters established.

This procedure is based on an extensive study of the prevalence of temperature inversions and draws on substantial field data.

The noise levels predicted under existing meteorological conditions for each receiver are then compared with the project-specific noise levels, to establish whether the meteorological effect will cause a significant impact.

Wind may also increase noise levels downwind of the source. The policy specifies a procedure for assessing the significance of wind effects, and a default wind speed to be used in the assessment where these effects are found to be significant (*Section 5.3*).

1.4.5 Applying noise mitigation strategies

Where noise impacts are predicted, noise-source managers should seek to achieve the criteria by applying feasible and reasonable mitigation measures. In this context feasibility relates to engineering considerations and what can practically be built, and reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors:

- noise mitigation benefits—amount of noise reduction provided, number of people protected
- cost of mitigation—cost of mitigation versus benefit provided
- community views—aesthetic impacts and community wishes
- noise levels for affected land uses—existing and future levels, and changes in noise levels.

A range of mitigation measures is described in *Section 7*.

1.4.6 Negotiating noise impacts

If, after all feasible and reasonable mitigation measures are applied, the resultant noise emissions exceed the project-specific noise levels, then the residual level of impact needs to be balanced against any social and economic benefits derived from the source of the noise. Negotiation between the regulatory / consent authority, the community and the proponent to establish achievable noise limits is described in *Section 8*. This negotiation process is in addition to the direct consultation that normally occurs throughout the impact assessment process between the proponent and the community.

1.4.7 Setting noise limits in consent and licence conditions

In setting noise limits, the regulatory / consent authorities need to consider the technical practicalities of mitigation, the amount of noise reduction provided, community views, benefits arising from the development and cost of achieving the project-specific noise levels recommended here, along with the environmental consequences of exceeding the project-specific noise levels. It is important that the project-specific noise levels are not automatically interpreted as conditions for consent, without consideration of the other factors. In many instances, it may be appropriate to set noise limits for a development above the project-specific noise levels recommended in this document (*Section 9*).

1.4.8 Land acquisition

Licences issued by the EPA do not contain conditions related to land acquisition.

The noise criteria contained in this document have *not* been derived for the purpose of land acquisition. As previously stated they are designed to protect against intrusiveness and to preserve amenity, and drive a process of applying all feasible and economically reasonable avoidance and mitigation measures. To meet these purposes the noise criteria have been based around identifying the upper (rather than the average) level of impact. They seek to restrict the risk of people being highly annoyed to less than 10 per cent, and to meet this for at least 90 per cent of the time.

Resolving noise problems through land acquisition is viewed as an option of last resort. Where land acquisition is applied, this is done via the development consent process, which is administered by the relevant planning authority. The development consent may contain conditions related to land acquisition.

The determination of when projected noise levels are so high and intractable that circumstances warrant land acquisition will depend on a range of factors. Noise is only one of those. In some instances, disadvantages in one area may be traded against benefits in another area. The weighing-up of all of the relevant factors is the role of the planning system.

It is important to reiterate there is no single identifiable noise level that all people will find acceptable or unacceptable. Annoyance increases with increasing noise, but at any given noise level there will be a wide variation in the range of individual reactions to noise. In extreme cases health can be affected, but generally it appears that annoyance can occur well before there is a question of health impact.

The various assessed levels of impact around an industrial noise source could be described as a zone of affectation, characterised by annoyance. Within this zone could lie a much smaller zone closer in to the source where impacts were greater and justified acquisition of residences. The border between the annoyance and acquisition zones would be represented by a noise level well above both the background level and the EPA's criteria. If the noise from industry were sufficient to alter the character of the area substantially and / or cause health impacts, then land acquisition might be an option. Land acquisition is rarely a practical approach in heavily developed areas.

1.4.9 Monitoring of noise levels against consent or licence conditions

Monitoring of environmental noise levels from a development to determine compliance with the limits set in consent / licence conditions is essential for proper management of noise sources. Procedures to manage non-compliance with consent / licence conditions are also provided (*Section 11*).

1.5 Summary of approach

Figure 1.1 provides an overview of the main processes involved in applying the policy. The flow charts in *Figures 1.2* to *1.6* present a step-by-step guide to how the policy works, with references to relevant sections in the policy.

Worked case studies outlining the assessment process are set out in *Appendix A*.

Figure 1.1. Applying the policy

Project-specific noise levels

Derive project-specific noise levels from applying monitored existing noise levels to the general noise criteria for intrusiveness and amenity. (See *Figure 1.3* for details.)

Assessment

Proponent estimates likely noise impacts under existing weather conditions (this may include temperature inversion conditions where they are significant) and includes any adjustment for noise characteristics.

Mitigation

If project-specific noise levels are exceeded, proponent examines feasible and reasonable mitigation measures, considering community preferences, and determines resultant noise levels.

Decision-making process

Where resultant noise levels exceed project-specific noise levels, then the regulatory/consent authority either accepts the resultant level or negotiates if a better level of control is thought achievable.

Where project-specific noise levels are exceeded, proponent assesses the level of impact by comparing resultant noise levels against the project-specific noise levels (for example, noise exceeds project-specific noise levels by X dB, number of people affected, likely impacts on activities, % of time impact occurs) and factoring-in economic and social benefits from the development.

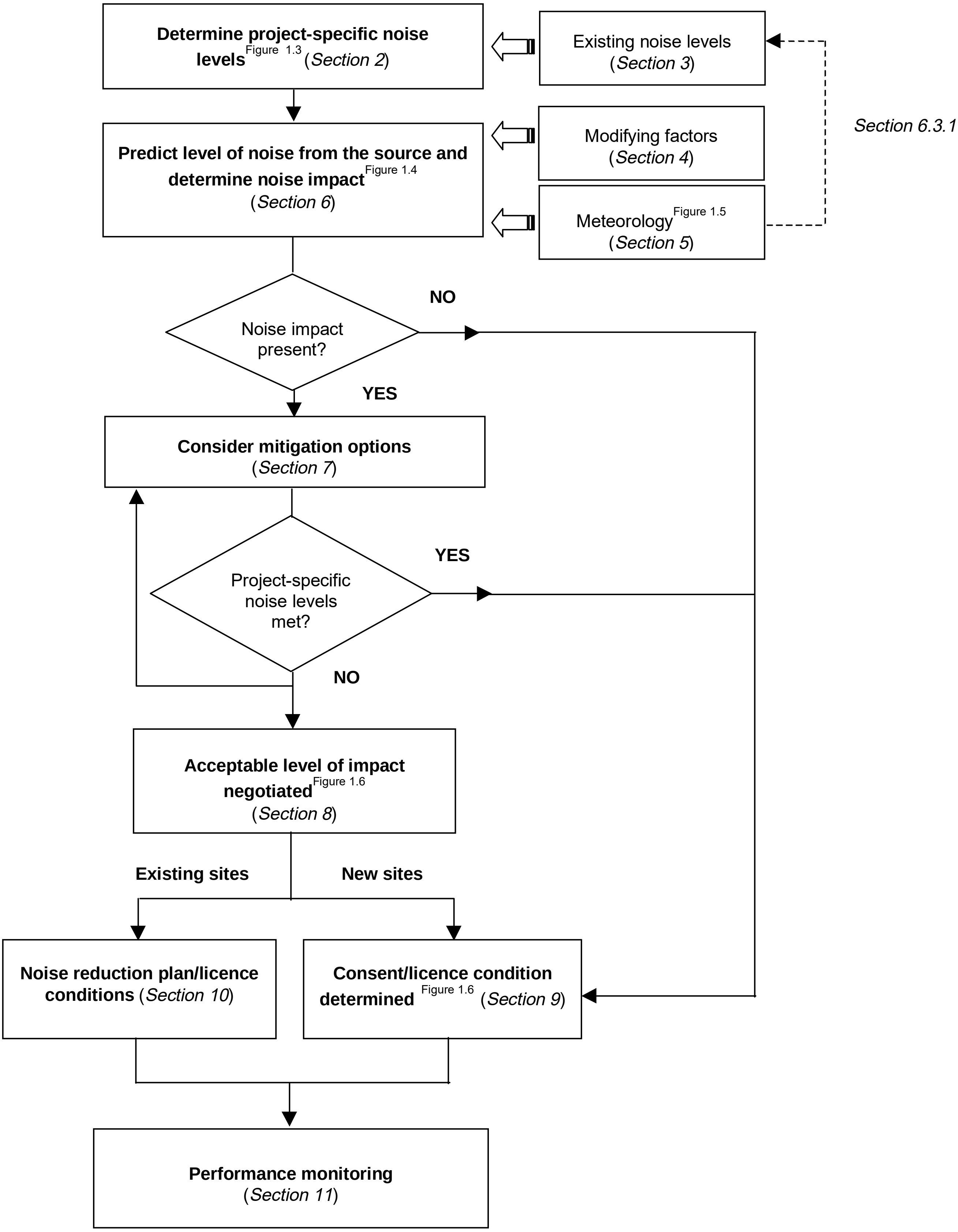
Conditions

Consent and licence conditions are set after carefully considering the benefit of full compliance with the project-specific noise levels, balanced against the overall social, economic and environmental benefits of the development. The consent and licence conditions may include the noise limits to be achieved and other related conditions, but acquisition levels may be included in only the development consent.

Monitoring environmental noise performance

Compliance with consent/licence conditions.

Figure 1.2. The overall process of assessing and managing noise impacts



Note: Dotted line indicates an optional process

Figure 1.3. Determining the project-specific noise levels

Measure existing noise levels (*Section 3*)

i.e. existing background (L_{A90}) (*Section 3.1*) and existing ambient industrial noise (L_{Aeq}) (S*ection 3.2*)

Where the proponent desires, more detailed monitoring and analysis linking existing noise levels and weather conditions can be made. (*Section 6.3.1*)

Determine representative existing noise levels from measured levels (*Section 3*)

i.e. rating background level (RBL) (*Section 3.1.2*), existing ambient level (*Section 3.2*)

Determine intrusiveness criteria (*Section 2.1*)

i.e. $L_{Aeq,15\ minute} \leq$ RBL plus 5 dB

Determine alternative intrusiveness criteria for specific weather conditions identified in any detailed monitoring analysis that was done.

Determine amenity criteria (*Section 2.2*)

1. Determine type of receiver (*Table 2.1, Sections 2.2.1 & 2.2.2*)
2. Determine acceptable noise level (ANL) for receiver, $L_{Aeq,period}$ (*Tables 2.1 & 2.2*)
3. Amenity criterion is either:
   - 'ANL' where existing ambient level is more than 6 dB below ANL; or
   - '< ANL' where existing ambient level is between 'ANL+1 dB' and 'ANL – 6 dB'; or
   - 'existing ambient level minus 10 dB' where existing ambient level is greater than 'ANL+1 dB' and existing noise levels are unlikely to decrease in future; or
   - 'ANL – 10 dB' where existing ambient level is greater than 'ANL+1 dB' and existing noise levels are likely to decrease in future; or
   - 'existing traffic noise level ($L_{Aeq,\ period}$) minus 10 dB' where existing traffic noise level is ≥ 10 dB above ANL (high traffic criterion, *Section 2.2.3*)

Determine alternative amenity criteria for specific weather conditions identified in any detailed monitoring analysis that was done.

Project-specific noise levels applicable to project

The lower of the intrusive criterion and the amenity criterion.

Note: Dotted line indicates an optional process

Figure 1.4. Predicting source noise level and determining impact

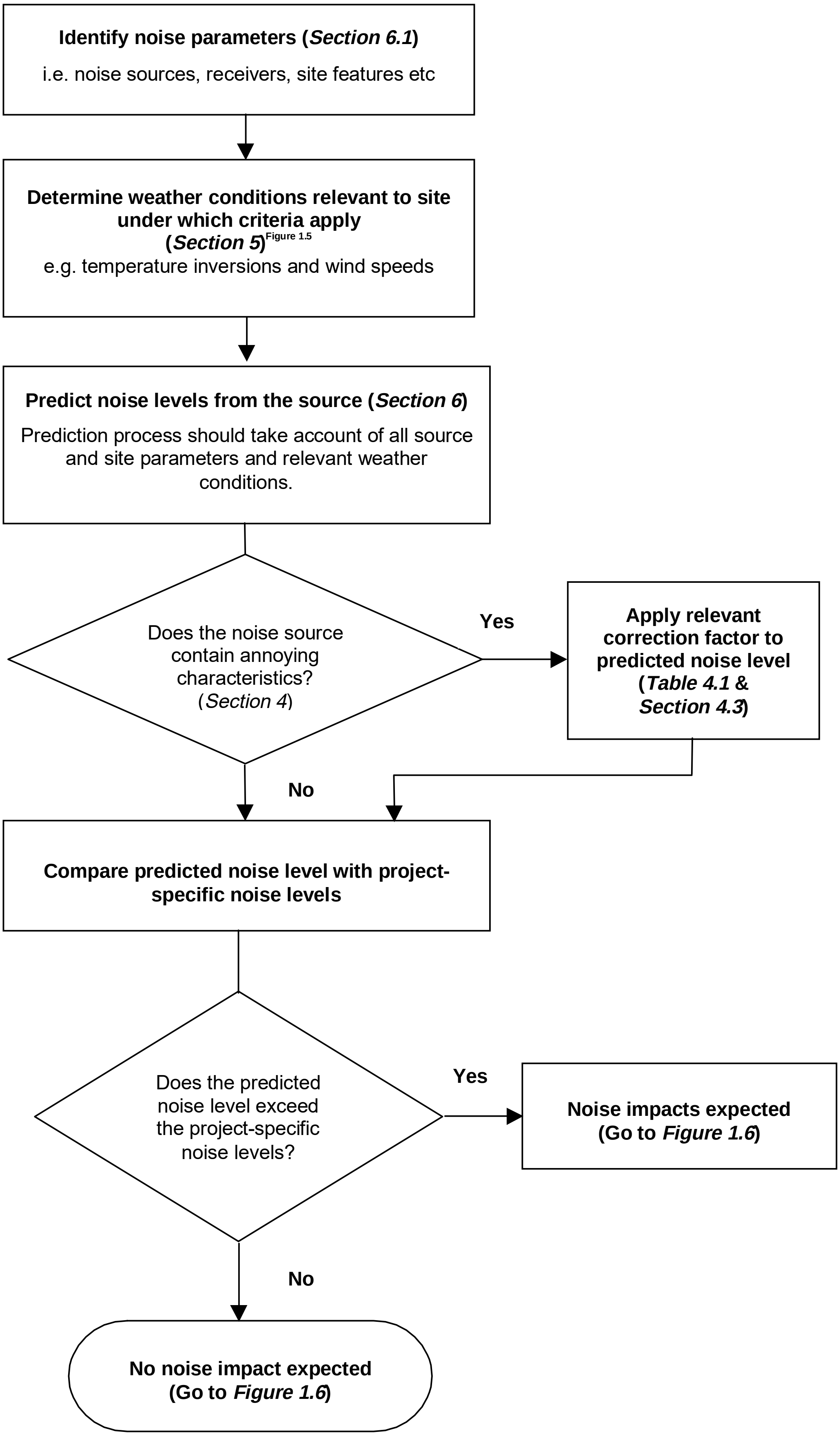
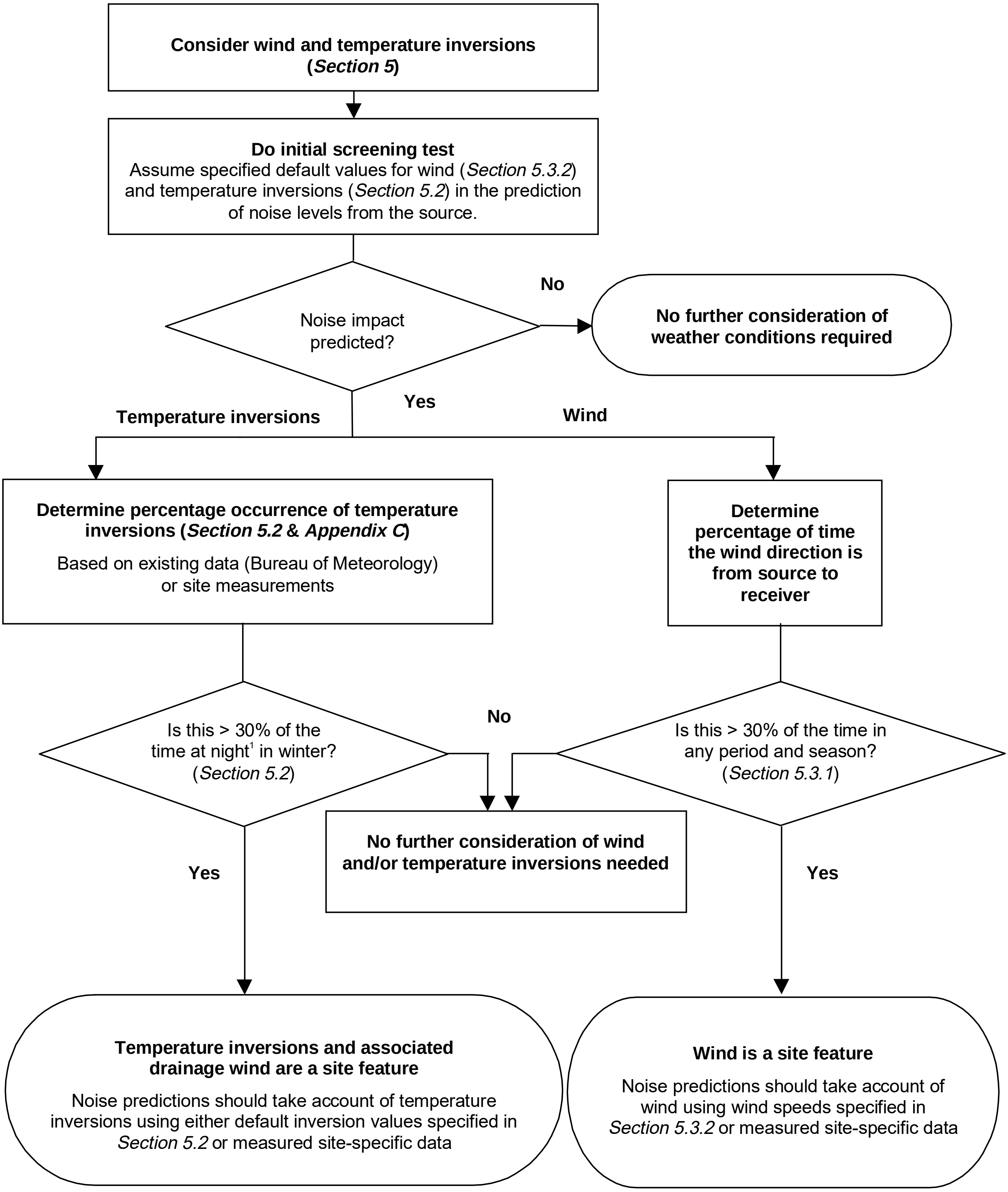
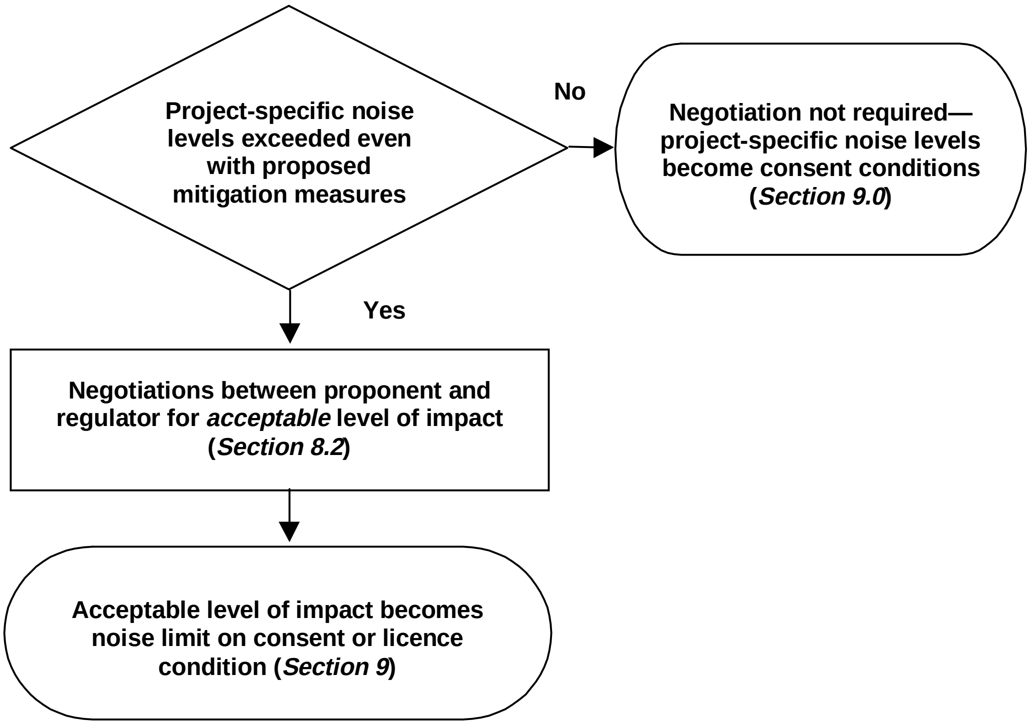


Figure 1.5. Assessing the likelihood of wind and temperature inversions enhancing noise impacts at a site

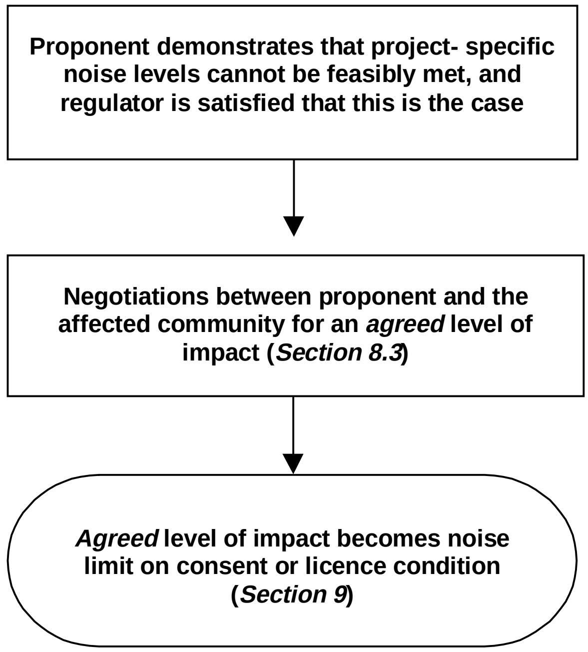


[1] For the purpose of determining the frequency of inversions, night is defined as the period from 1 hour before sunset to 1 hour after sunrise, taken to be 6 pm to 7 am.

Figure 1.6. Negotiation process and consent/licence limits



Or alternatively,



2 Industrial Noise Criteria

The assessment procedure for industrial noise sources has two components:

- controlling intrusive noise impacts in the short term for residences
- maintaining noise level amenity for particular land uses for residences and other land uses.

In assessing the noise impact of industrial sources, both components must be taken into account for residential receivers, but, in most cases, only one will become the limiting criterion and form the project-specific noise levels for the industrial source. The worked case studies in *Appendix A* show how both components work together.

The procedures specified in the policy differentiate between low- and high-noise-risk developments, with simpler procedures available for developments with low noise risk. Differentiation between these two types of developments is on the basis of magnitude (for example, level of noise expected) and extent of impact (for example, expected area of affectation). Hence, a development that is likely to make excessive noise affecting a large area can be considered to be a high-risk development, and vice versa for low risk.

2.1 Intrusive noise impacts

The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor), measured over a 15-minute period, does not exceed the background noise level measured in the absence of the source by more than 5 dB.

To account for the temporal variation of background noise levels, the method outlined in *Section 3.1* is recommended for determining the background noise level (rating background level—RBL) to be used in the assessment. This approach aims to result in the intrusive noise criterion being met for at least 90% of the time periods over which annoyance reactions can occur (taken to be periods of 15 minutes).

Adjustments are to be applied to the level of noise produced by the source that is received at the assessment point before comparison with this criterion. Where the noise source contains annoying characteristics—such as prominent tonal components, impulsiveness, intermittency, irregularity and dominant low-frequency content—adjustments as outlined in *Section 4* apply.

Procedures for considering meteorological effects such as temperature inversions and wind are outlined in *Section 5* to account for characteristic weather conditions under which the intrusiveness criterion applies.

The intrusiveness criterion is summarised as follows:

$$L_{Aeq,\ 15\ minute} \leq \text{rating background level plus 5}$$

where:

$L_{Aeq,\ 15\ minute}$ represents the equivalent continuous (energy average) A-weighted sound pressure level **of the source** over 15 minutes. **Other descriptors may be used as appropriate provided they can be justified on the basis of being characteristic of the source (see *Section 2.3*).** This is to be assessed at the most-affected point on or within the **residential** property boundary—or, if that is more than 30 m from the residence, at the most-affected point within 30 m of the residence.

Rating background level is the background level to be used for assessment purposes as deter-mined by the method outlined in *Section 3.1*.

A 15-minute sampling period is used when measuring the level of intrusive noise. There has been no definitive research to quantify the time period over which annoyance to intrusive noise varies. Clearly, annoyance reactions are likely to occur over periods of less than a day, and there will be variations depending on individual tolerance and characteristics of the noise. The 15-minute period has been selected as a reasonable estimate of the period over which annoyance may occur. This time period has been used by the EPA for some time, and experience has shown that it is a reasonable approach to assessing intrusive noise impacts.

In some rural situations, the rating background level may be the same for the day and night. In these cases, it is recognised that excursions of noise above the intrusiveness criterion during the day would not usually have the same impact as they would at night. This is due to the more sensitive nature of activities likely to be disturbed at night (for example, sleep and relaxation).

2.2 Protecting noise amenity

To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in *Table 2.1*. Meeting the acceptable noise levels in *Table 2.1* will protect against noise impacts such as speech interference, community annoyance and, to some extent, sleep disturbance. These levels represent current best practice for assessing industrial noise sources, based on research and a review of assessment practices used overseas and within Australia.

Table 2.1 also includes recommended maximum noise levels for different land uses. These recommended maximum values provide guidance on an upper limit to the level of noise from industry. In all cases it is expected that all feasible and reasonable mitigation measures would be applied before the recommended maximum noise levels are referenced.

In some instances it may not be possible to achieve even the recommended maximum noise level, even after all feasible and reasonable noise mitigation has been applied. Such cases are expected to have a large adverse noise impact. Where a proposed development exceeds the recommended maximum noise levels in *Table 2.1*, substantial benefits in other areas, including a high degree of social worth, would need to be demonstrated.

Where the existing noise level from industrial noise sources is close to the acceptable noise level, the noise level from any new source(s) must be controlled to preserve the amenity of an area. If the total noise level from industrial sources already exceeds the acceptable noise level for the area in question, the L_{Aeq} noise level from any new source should not be greater than:

- 10 dB below the acceptable noise level if there is a reasonable expectation that existing levels may be reduced in the future; or
- 10 dB below the existing level if there is no such reasonable expectation that existing levels will fall (for example, in cases where surrounding areas are fully developed) and no significant changes to land use are expected.

Table 2.2 sets out the implications of this requirement for noise from industrial sources.

Adjustments are to be applied to the source noise level received at the assessment point, before comparison with this criterion, where the noise source contains annoying characteristics such as prominent tonal components, impulsiveness, intermittency, irregularity and dominant low-frequency content, as outlined in *Section 4*.

Procedures for considering meteorological effects such as temperature inversions and wind are outlined in *Section 5* to account for characteristic weather conditions under which the amenity criteria apply.

In determining the existing L_{Aeq} noise level from industry, noise from transportation-related sources (road traffic, rail traffic and aircraft) may be excluded. Criteria for noise from these sources are defined separately. Research and experience indicates that residents distinguish and respond separately to noise from road traffic, rail traffic, aircraft and industrial sources, rather than registering an overall noise annoyance related to the total L_{Aeq} noise level. *Section 3.2* gives guidance on how to determine existing noise levels. Practical means by which transportation noise (road traffic in particular) may be excluded from a measurement of existing noise levels are presented in *Section 3.2.1*.

Where existing traffic noise levels are continuously high, the existing level of the traffic noise (determined by using the method outlined in *Section 3.2*) can be 10 dB or more above the recommended acceptable noise level shown in *Table 2.1*. In these situations the industrial source may be inaudible, even where it produces noise levels higher than the acceptable noise level. The criterion to be applied in this case is set out in *Section 2.2.3*.

Table 2.1. Amenity criteria

Recommended L_{Aeq} noise levels from industrial noise sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended $L_{Aeq.}$ Noise Level, dB(A) *(see Note 8 in Section 2.2.1)*	
(*see Notes in Section 2.2.1*)			**Acceptable** *(See Note 11)*	**Recommended Maximum** *(See Note 11)*
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
	Urban	Day	60	65
		Evening	50	55
		Night	45	50
	Urban/Industrial Interface – for existing situations only	Day	65	70
		Evening	55	60
		Night	50	55
School classroom—internal	All	Noisiest 1-hour period when in use	35 *(See Note 10)*	40
Hospital ward				
—internal	All	Noisiest 1-hour period	35	40
—external	All	Noisiest 1-hour period	50	55
Place of worship—internal	All	When in use	40	45
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Active recreation area (e.g. school playground, golf course)	All	When in use	55	60
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75

Where there is a reasonable expectation that the cumulative noise level from industrial sources could increase in future (for example, through the development of further new sources), this should be considered in setting noise levels, as outlined in *Section 2.2.4*.

Table 2.2. Modification to acceptable noise level (ANL)* to account for existing level of industrial noise

Total existing L_{Aeq} noise level from industrial sources, dB(A)	Maximum L_{Aeq} noise level for noise from new sources alone, dB(A)
≥ Acceptable noise level plus 2	If existing noise level is *likely to decrease* in future: acceptable noise level minus 10 If existing noise level is *unlikely to decrease* in future: existing level minus 10
Acceptable noise level plus 1	Acceptable noise level minus 8
Acceptable noise level	Acceptable noise level minus 8
Acceptable noise level minus 1	Acceptable noise level minus 6
Acceptable noise level minus 2	Acceptable noise level minus 4
Acceptable noise level minus 3	Acceptable noise level minus 3
Acceptable noise level minus 4	Acceptable noise level minus 2
Acceptable noise level minus 5	Acceptable noise level minus 2
Acceptable noise level minus 6	Acceptable noise level minus 1
< Acceptable noise level minus 6	Acceptable noise level

** ANL = recommended acceptable L_{Aeq} noise level for the specific receiver, area and time of day from Table 2.1.*

2.2.1 Notes to support the noise level tables

1. The recommended acceptable noise levels refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated.

2. In assessing noise levels at residences, the noise level is to be assessed at the most-affected point on or within the residential property boundary or, if this is more than 30 m from the residence, at the most-affected point within 30 m of the residence.

3. In assessing noise levels at commercial or industrial premises, the noise level is to be assessed at the most-affected point on or within the property boundary.

4. Where internal noise levels are specified in *Table 2.1*, they refer to the noise level at the centre of the habitable room that is most exposed to the noise and are to apply with windows opened sufficiently to provide adequate ventilation. In cases where the gaining of internal access for monitoring is difficult, then external noise levels 10 dB above the internal levels apply.

5. In assessing noise levels at passive and active recreational areas, the noise level is to be assessed at the most-affected point within 50 m of the area boundary.

6. Types of receivers are defined as follows. *Section 2.2.2* offers some guidance for the selection of the appropriate receiver types.

   Rural—means an area with an acoustical environment that is dominated by natural sounds, having little or no road traffic. Such areas may include:

   —an agricultural area, except those used for intensive agricultural activities

   —a rural recreational area such as resort areas

   —a wilderness area or national park

   —an area generally characterised by low background noise levels (except in the immediate vicinity of industrial noise sources).

   This area may be located in either a **rural, rural-residential, environment protection**

zone or scenic protection zone, as defined on a council zoning map (Local Environmental Plan (LEP) or other planning instrument).

Suburban—an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristics:

—decreasing noise levels in the evening period (1800–2200); and / or

—evening ambient noise levels defined by the natural environment and infrequent human activity.

This area may be located in either a **rural, rural-residential or residential zone,** as defined on an LEP or other planning instrument.

Urban—an area with an acoustical environment that:

—is dominated by 'urban hum' or industrial source noise

—has through traffic with characteristically heavy and continuous traffic flows during peak periods

—is near commercial districts or industrial districts

—has any combination of the above,

where 'urban hum' means the aggregate sound of many unidentifiable, mostly traffic-related sound sources.

This area may be located in either a **rural, rural-residential or residential** zone as defined on an LEP or other planning instrument, and also includes mixed land-use zones such as mixed commercial and residential uses.

Urban/industrial interface—an area defined as for 'urban' above that is in close proximity to industrial premises and that extends out to a point where the existing industrial noise from the source has fallen by 5 dB. Beyond this region the amenity criteria for the 'urban' category applies. This category may be used only for existing situations. (See example of how this category is used in *Appendix A, Section A5*).

Commercial—an area defined as a **business** zone, except neighbourhood business zone, on an LEP.

Industrial—an area defined as an **industrial** zone on an LEP. For isolated residences within an industrial zone the industrial amenity criteria would usually apply.

7. **Time of day:**

—day: the period from 7:00 am to 6:00 pm Monday to Saturday; or 8:00 am to 6:00 pm on Sundays and public holidays

—evening: the period from 6:00 pm to 10:00 pm

—night: the remaining periods.

(These periods may be varied where appropriate, for example, see *Section 3.3.*)

8. The L_{Aeq} noise level for a specific period represents the L_{Aeq} level calculated or measured over the applicable day, evening or night period (i.e. $L_{Aeq, period}$) except where otherwise stated (for example, school classroom, hospital).

9. If existing noise levels from industrial noise sources already approach or exceed the recommended acceptable noise levels in *Table 2.1*, any increase in these levels should be strictly limited, as described in *Table 2.2*.

10. In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable L_{Aeq} noise level may be increased to 40 dB $L_{Aeq(1hr)}$.

11. The acceptable and recommended maximum L_{Aeq} noise levels can provide a guide to applying the negotiation process set out in *Section 8*. While negotiation between the proponent and the community for an agreed noise level can occur at any time, typically the proponent would negotiate with the EPA where noise-level emissions fall between the acceptable and recommended maximum. For site levels beyond the recommended maximum levels, the proponent would need to negotiate directly with the community.

2.2.2 Determining the receiver type

The selection of the type of receiver is important in determining which noise amenity criteria level should apply. In most instances the receiver category for the amenity criteria will be straightforward, but in some localities, land-use patterns or zones may be ambiguous in terms of selecting the appropriate receiver type. As a guide the following issues may be considered in deciding the land use category for a receiver:

- The primary means for identifying the type of receiver is how the receiver area is zoned in the relevant planning instrument. The standard terminology used in planning instruments is usually limited to rural, rural-residential and residential in respect of areas where dwellings would normally be located. These terms do not differentiate suburban and urban residential uses, and this is discussed in the next point.

- In deciding whether a receiver area should be allocated to the suburban or urban categories, it may be necessary to examine the predominant manner of development in the area and the prevailing noise climate. The definitions of suburban and urban provide guidance on this. For example, small communities such as villages or towns are likely to be closer in noise climate to a suburban category. Urban receivers are usually those located in densely populated areas where multi-dwelling developments such as townhouses, units, flats and apartments are the norm. Areas near noise generators (for example, roads, railways and industry) would normally be considered to be urban-receiver type for the purpose of the amenity criteria. The rural category is more representative of more isolated single dwellings on large lots (for example, 2 hectares). The population density for an area may provide a guide as to which of the residential receiver categories apply.

- In certain instances zoning for an area will allow multiple uses. For instance, some areas are classified as 'Rural' with industry-related land uses permissible, thus allowing rural uses (including a dwelling) and industries in the same area. In terms of noise the permissible uses may not be entirely compatible, and where this mix of development is permitted it may not always be possible to achieve the desirable noise criteria for receivers. In these instances the noise levels that are achievable will be defined by applying all feasible and reasonable mitigation measures. It is highly recommended that the relevant consent authority consider the need to incorporate noise mitigation measures in noise-sensitive developments where such mixed development is permitted (for example, new residences proposed near industrial or commercial areas).

- Other features of a locality that should also be considered include:

  —predominant land use, including the proportion of the different land uses within the potentially noise-affected zone

  —strategic planning objectives or plans to rezone (for example, as included in REPs, SEPs, Urban Development Program)

  —proximity of land-use to neighbouring industries and busy roads

  —any permanent existing shielding provided by natural topography or otherwise between existing noise sources and sensitive receivers

  —existing ambient noise levels in the area.

2.2.3 Assessment in areas of high traffic noise

The level of transportation noise—road traffic noise in particular—may be high enough to make noise from an industrial source effectively inaudible, even though the L_{Aeq} noise level from that industrial noise source may exceed the recommended acceptable noise level shown in *Table 2.1*. In such cases, the amenity criterion for noise from the industrial noise becomes the $L_{Aeq,\ period(traffic)}$ minus 10 dB. This criterion replaces the amenity criterion in *Tables 2.1* and *2.2* above, and is used in the same way the amenity criterion is used, that is, in conjunction with the intrusiveness criterion, to determine the limiting criterion. General and more specific case studies showing how the high traffic criterion works are included in *Appendix A. (See Section A1 and case study (c) in Section A2.)*

This criterion may be applied only if all the following apply:

1. Traffic noise is identified as the dominant noise source at the site.

2. The existing traffic noise level (determined using the procedure outlined in *Section 3.2*) is 10 dB or more above the Acceptable noise level for the area.
3. It is highly unlikely the road traffic noise levels would decrease in the future.

In all other cases the existing noise level of industrial sources may be determined by one of the methods outlined in *Section 3.2.1* for comparison with *Table 2.2* in the determination of the amenity criterion.

This method needs to be used with care for different assessment periods. For example, although this criterion may be valid in high-traffic areas for the 'day' assessment period, it may not be appropriate for the 'evening' or 'night' assessment periods because the requirement in (2) above has not been met. Where this is the case, one of the methods outlined in *Section 3.2.1* may be used for the evening and night periods.

2.2.4 Assessment in developing areas

The recommended acceptable noise level from *Tables 2.1* and *2.2* represents the ideal total level of noise from industry that should be met by a proposed development and any future, potentially noise-producing, developments in the area. In most instances where a number of industrial developments are proposed for an area, the amenity criteria, which set a cap for the cumulative noise from industry, will be more stringent than the intrusive criteria. Thus project-specific noise levels for individual developments will be derived from the amenity criteria.

Where several developments are proposed for an area, these are to be assessed as a group. This holistic approach allows project-specific noise levels to be set for a proposed industrial development, so that the total impact from all proposed and potential industrial developments does not cause amenity to deteriorate. In addition, this approach provides an equitable distribution in the burden of meeting the noise criteria.

The effectiveness of this approach depends on it being known at the time of assessment what developments will be moving into the locality, and when the various developments are proposed to commence. Generally, the approach should apply when knowledge of future developments has advanced to the point of a development application being known to the regulatory / consent authority, or where details of the proposal have been published.

Implementation of this 'holistic' approach involves the following steps in relation to impacts at the most sensitive receivers:

1. Determining the number of development proposals to be assessed.
2. Determining the amenity level according to *Tables 2.1* and *2.2*.
3. Determining the project-specific noise levels to be achieved by each development at the receiver, so that, when each is added logarithmically, the resultant total level of noise received from industry at any affected receiver will meet the amenity level identified at Step 2.

As the assessment is performed at the receiver, the level of noise received from each development depends on its distance from the receiver—with more remote developments able to emit higher noise levels at the source.

This type of approach has been applied by some forward-thinking local councils to provide an early indication to potential developers of expected noise-emission requirements, and to guarantee the noise amenity in adjacent areas. (Examples of where this approach has been used include Ingleburn industrial estate, Campbelltown; Glendenning industrial estate, Blacktown and Breamer industrial estate, Mittagong.)

2.2.5 Effects of changing land use

Land uses can change—sometimes dramatically—with an increase in industrial activities, construction of new freeways, or the development of new residential suburbs. A consequence of this is that the land-use designation of an area may change. Changes in designation occur as a result of urban-type residential subdivisions in a village or rural area with few residences, or the encroachment of industrial developments near residential areas and vice versa.

In such cases, the primary decision by planning authorities to cause or allow the development would take account of the many consequent implications. As developments introduce increased activities, they also increase environmental noise levels. Therefore, previously low ambient noise levels will not be maintained, and assessments of noise sources for control purposes should be made against the acceptable noise level relevant to the modified land use.

2.3 Using the L_{Aeq} descriptor

The $L_{Aeq,}$ descriptor applies for both the intrusiveness criterion ($L_{Aeq, 15 minute}$) and the amenity criterion ($L_{Aeq, period}$). In this policy, the equivalent continuous (energy average) level (*A-weighted*) **of the industrial source** is of interest (**not** necessarily that of the **total noise environment**). In certain circumstances other noise descriptors may be more appropriate for measurement / assessment or compliance purposes, depending on the characteristics of the noise source. For example, where the noise emissions from the source of interest are constant (e.g. fan noise) and the ambient noise level has a degree of variability (for example, due to traffic), the L_{A90} descriptor may adequately describe the noise source and be much easier to measure / assess. In these cases, it may be preferable to replace the L_{Aeq} descriptor.

If the descriptor chosen for measurement is not the L_{Aeq}, reasons for the variation should be presented in the noise assessment report.

2.4 Project-specific noise levels

After determining the relevant noise levels from the intrusive and amenity criteria, the project-specific noise levels can be assigned.

The project-specific noise levels reflect the most stringent noise level requirement from the noise levels derived from both the intrusive and amenity criteria. They set the benchmark against which noise impacts and the need for noise mitigation are assessed.

Applying the most stringent requirement as the project-specific noise levels ensures that both intrusive noise is limited and amenity is protected.

The case studies presented in *Appendix A* show definitively how project-specific noise levels are identified.

3 Determining existing noise levels

3.1 Determining background noise for the intrusiveness criterion

The background noise level is defined here as 'the underlying level of noise present in ambient noise when all unusual extraneous noise is removed'. Sound levels contributing to background levels can include sound from nearby traffic (see *Section 3.1.3*), birds, insects, animals, machinery and similar sources if these sounds are a normal feature of the location. The background noise level is considered to be represented by the $L_{A90,15\ minute}$ descriptor. In comparison, the rating background level (as defined in *Section 3.1.2*) is the single-figure background noise level derived from monitoring $L_{A90,\ 15\ minutes}$ over a representative period of time. The rating background level is used for assessment purposes.

Background noise levels need to be determined before intrusive noise can be assessed. The background noise levels to be measured are those that are present at the time of the noise assessment and without the subject development operating. Hence, for the assessment of modifications to an existing development, the noise from the existing development should be excluded from background noise measurements.

When assessing a new development, it is important to undertake sufficient monitoring of background noise to allow intrusive noise to be assessed adequately. However, when assessing noise levels in response to complaints, the background noise level during the period of the complaint is of interest, and monitoring over a shorter length of time may be appropriate.

Before embarking on a noise-monitoring program, the potential for the development / activity to cause noise annoyance, and the need for accurate noise assessment, should be considered. Two measurement regimes are presented below. The first is a definitive method to be used when assessing developments with the potential for significant noise impact. The second is a shorter method that can be used for complaint-assessment purposes.

3.1.1 Methods of determining background noise

Table 3.1 summarises the two procedures for determining background noise: the long-term method to be used at the planning and approval stage, and the short-term method for complaint and compliance assessment purposes. The long-term method involves a two-step process to determine the rating background level. The short-term method involves only one step. *Appendix B* gives a detailed description of instrumentation requirements, and procedures for measurement and analysis for each method.

The long-term method for determining background noise (summarised in *Table 3.1)* is designed to ensure that the criterion for intrusive noise will be achieved for at least 90% of the time periods over which annoyance reactions may occur (taken to be periods of 15 minutes).

Definitions and technical considerations to help users interpret and apply the methods are set down in the following sections.

3.1.2 Definitions to support methodologies

Extraneous noise—noise due to activities that are not typical of the area. These activities might include construction, changes in road, rail or air traffic due to holiday periods, and special events such as concerts or sporting events. Normal daily road traffic and other transportation noise are not considered to be extraneous noise. Where an industry in an industrial estate wishes to extend its operations, the measured background noise level may include the general hum of industries nearby, but should not include any noise from the site itself—or noise from any intrusive sources nearby that could affect the $L_{A90,15\ minute}$ value. As a reasonable guide, any extraneous noise present for at least half of a 15-minute monitoring period, and having the potential to affect the $L_{A90,15\ minute}$ value, should be excluded.

Table 3.1. Methods for determining background noise

Features	Method	
	Long-term	**Short-term**
When to use	During planning and approval stage where there is significant potential for noise impact, e.g. extractive industries and industrial developments.	During complaint assessments, compliance checks, when determining the effect of background noise on a source noise measurement and for low risk developments.
Type of monitoring	Continuous sampling accompanied by periods of operator-attended monitoring	Individual sampling—operator-attended measurements
Length of monitoring	Equivalent to one week's worth of valid data covering the days and times of operation of the development (See *Section 3.5*)	15-minute measurements covering the times of operation of the development
Conditions for monitoring	Average wind speed < 5 m/s[1], no rain, no extraneous noise (See *Sections 3.1.2 and 3.4*)	Average wind speed < 5 m/s[1], no rain, no extraneous noise (See *Sections 3.1.2 and 3.4*)
Monitoring location	Most or potentially most affected noise-sensitive location/s	Most affected noise-sensitive location and/or location of complaint
Assessment time periods	Day (0700–1800) Evening (1800–2200) Night (2200–0700) (See *Section 3.3* for exceptions)	Times when maximum impacts occur
Base measure	$L_{A90,15\ minute}$	$L_{A90,15\ minute}$
Analysis method	Determine the assessment background level for each day, evening and night by using the tenth percentile method. The rating background level is the median assessment background level over all days for each period.	The rating background level is the measured $L_{A90,15\ minute}$ value, or, where a number of measurements have been made, the lowest $L_{A90,\ 15\ minute}$ value.

Note:

1. Refers to the wind speed at the microphone height.

Special care needs to be taken when doing short-term measurements to ensure that the measurements reflect the time of maximum impact. For example, in a residential neighbourhood, short-term noise measurements should not be taken when there are other noisy activities going on (for example, lawn-mowing, idling vehicles, neighbourhood chatter). When in doubt as to whether an activity is typical of the area, it is best to exclude data affected by noise from that activity.

Noise-sensitive location(s)—residential premises, schools, hospitals, places of worship, parks and wilderness areas.

Most affected location(s)—locations that are most affected (or that will be most affected) by noise from the source under consideration as per Note 2 in *Section 2.2.1*. In determining these locations, the following need to be considered: existing background levels, noise source location / s, distance from source / s (or proposed source / s) to receiver, and any shielding (for example, building, barrier) between source and receiver. Often several locations will be affected by noise from the development. In these cases, locations that can be considered representative of the various affected areas should be monitored.

Time of maximum impact—the time during which the difference between the background noise level and the source noise is expected to be the greatest.

Assessment background level (ABL)—the single-figure background level representing each assessment period—day, evening and night (that is, three assessment background levels are determined for each 24-hour period of the monitoring period). Determination of the assessment background level is by the tenth percentile method described in *Appendix B*. **Only those days and assessment periods that are applicable to the times of operation of the proposed development are required to be assessed.**

Rating background level (RBL)—the overall single-figure background level representing each assessment period (day / evening / night) over the whole monitoring period (as opposed to over each 24-hour period used for the assessment background level). The rating background level is the level used for assessment purposes. Where the rating background level is found to be less than 30 dB(A), then it is set to 30 dB(A).

For the short-term method the rating background level is simply the measured $L_{A90,15\ minute}$ level. For the long-term method, the rating background level is defined as the median value of:

—all the day assessment background levels over the monitoring period for the day

—all the evening assessment background levels over the monitoring period for the evening, or

—all the night assessment background levels over the monitoring period for the night.

'Median' is the middle value in a number of values. For an odd number of values, the value of the median is simply the middle value in a number of values ranked in ascending or descending order. For an even number of values, the median is the arithmetic average of the two middle values.

3.1.3 Transportation noise in background noise measurements

Transportation noise (air, road and rail) may be included in background noise measurements, except when there is a reasonable expectation that flows are not representative of normal conditions (for example, traffic during school holidays). Air, road and rail traffic during these times are usually considered to be extraneous.

Where the period of measurement is limited (that is, short-term measurement), care is needed to ensure that the time at which the measurements are made reflects the period when the highest noise impacts are likely to occur. For example, where there is only intermittent traffic, the short-term noise measurement should not include transportation noise, otherwise incorrect high readings will result. However, where the traffic is constant and continuous, transportation may be included in the short-term measurement to ensure that the noise environment is adequately represented.

3.2 Determining existing noise levels for amenity criteria

Existing noise levels need to be determined for the periods during which the proposed development will operate.

In determining the existing L_{Aeq} noise level, it is important to obtain a representative level. Hence,

Table 3.2. Determining the existing L_{Aeq} noise levels

Risk of noise impact	Measurement period[1]	Definition of existing level
Low risk	One day—covering the defined day/evening/night periods relevant to the periods the proposed development would operate.	The logarithmic average[2] of individual $L_{Aeq,15\ minute}$ levels for each day/evening/night assessment period over the measurement period.
High risk	One week—covering the defined day/evening/night periods the proposed development would operate.	

Notes:

1. *It is recommended that the L_{Aeq} be measured on a 15-minute basis.*
2. *Logarithmic average = $10log_{10}((\sum_{i=1\ to\ n}10^{(LAeq,15\ min,i/10)})/n)$, where n = number of $L_{Aeq,15\ min}$ values in each assessment period over the measurement period.*

assessing the existing L_{Aeq} noise level is as defined in *Table 3.2* for assessing different noise risk developments.

3.2.1 Excluding transportation noise

The ‘existing noise levels’ described in *Table 2.2* are for industrial noise sources only. Where practicable, noise from transportation or community activities can be excluded, as the measured industry noise level will be used (*Table 2.2)* to determine the amenity level. Practical ways of excluding transportation and community noise will depend on the situation. The policy does not require transportation and community noise to be excluded when determining existing noise levels, but it may be advantageous to the proponent to minimise the effects of community and transportation noise. Possible techniques to do this include:

1. Measuring the level of transportation noise at a nearby location not affected by noise from industry, and logarithmically subtracting this measurement from the combined level at the site. This may be done by setting up two loggers (or two sound-level meters in the case of short-term measurements) to monitor simultaneously the combined noise levels at the site and the transportation noise levels at the nearby location.
2. Measuring at another location where industrial source noise levels are equivalent, but transportation noise is much lower.
3. Modelling the level of transportation noise and subtracting the result from the measured combined levels.
4. (Where it can be demonstrated that all existing noise is due to transportation-related sources) Assuming that the level of industrial noise is 10 dB below the existing combined noise levels.

When measuring existing industrial noise, take special care when determining what constitutes an industrial noise source. For example, any mobile / transportation sources that form part of the normal operations on an industrial noise source site are considered to be part of the industrial noise source and should be included when measuring existing noise levels from that industrial source.

Where dominant road traffic is over 300 m away from the site and is heard as a very distant hum, the level of traffic noise is likely to be low enough that special techniques to minimise its effects are not warranted. Exceptions to this include cases where a major road is in direct line-of-sight of the assessment position, causing traffic on it to be the dominant source of noise at the site.

3.3 Dealing with ‘shoulder’ periods

There will be situations that call for different assessment periods. For example, where early morning (5 am to 7 am) operations are proposed, it may be unduly stringent to expect such operations to be assessed against the night-time criteria—especially if existing background noise levels are steadily rising in these early morning hours. In these situations, appropriate noise level targets may be negotiated with the regulatory / consent authority on a case-by-case basis. As a rule of thumb it may be appropriate to assign a shoulder period rating background level as the mid-point value between the rating background levels of the two assessment periods that are on either side of the shoulder period.

The objective is to achieve environmental amenity in a feasible and reasonable manner. In an assessment of the likely level of noise impact, the time of day is only one of several relevant factors—such as noise level and character, and the activities affected by the noise. Noise of a lower level, and with no intrusive characteristics such as tones and impulses, can often be more acceptable over a longer period of the day than noise at a high level and / or with intrusive characteristics.

3.4 Meteorological conditions for monitoring

Wind and rain conditions

Noise monitoring should not be conducted (or the data should be excluded) when average wind speeds (over 15-minute periods or shorter) at microphone height are greater than 5 m / s, or when rainfall occurs. Exceptions to this rule are allowed, provided the proponent is able to show that the wind-induced noise on the microphone, and sound levels due to rain, are at least 10 dB below the noise levels (that is, background and / or ambient) under investigation.

Where high wind speeds are a feature of the area, monitoring may be permitted during higher wind speeds, provided the proponent is able to show that these wind speeds are a site feature and that the wind-induced noise on the microphone is at least 10 dB below the noise levels under investigation.

Wind blowing through leaves can raise the environmental noise levels, even at speeds less than 5 m / s. To avoid this effect, take care to select monitoring locations that are as far away as possible from vegetation while still being representative of the subject site.

Temperature inversions

The noise levels determined using the methods just described are considered to represent the season in which they have been monitored. For this reason, monitoring may be conducted during temperature inversion conditions to ensure that the noise environment at a site is adequately represented. However, care is needed when doing short-term measurements to ensure that the measured noise level results in an adequate assessment of impacts. For instance, measurement of short-term background noise should exclude any data collected during temperature inversions where these inversions are infrequent and are not a feature of the area. Otherwise assessment applying the intrusiveness criterion will not adequately assess the noise impact.

Seasonal variations

The EPA recognises that background noise levels may vary due to seasonal changes in weather conditions and wildlife activity (for example, insects, birds and other fauna) and also as a result of changes in operational activities on surrounding developments. As far as is practicable, these potential changes should be considered and addressed in a qualitative manner in the noise assessment report to ensure that noise impacts during other seasons are not ignored.

Such changes may be accounted for by excluding the season-related noise levels from the background noise measurements by filtering or other means (for example, in the case of seasonal operational activities, by monitoring in a similar location not affected by the development in question). In other cases these variations may be discounted on the basis of local knowledge in the area, but the discounting should still be justified in the noise assessment report.

3.5 Duration of monitoring

Screening tests may be performed before any monitoring to assess whether monitoring is required. For example, if a minimum background noise level of 30 dB(A) is assumed as the rating background level and the assessment shows no impact, then there is no need for background noise monitoring, as this represents a conservative and limiting case.

Typically, one week’s worth of valid data covering the days and times of operation of the proposed development is required to meaningfully determine the existing noise environment. However, the duration of monitoring should be determined by taking into account the circumstances of the particular situation. The cyclic or random nature of ambient noise levels can affect the duration required.

In areas where the background noise levels are affected significantly by nearby road traffic with regular daily pattern, three days' worth of valid data may be sufficient. However, care should be exercised in assuming a pattern of noise levels in an area. It is recommended that , where any doubt exists, the full week's monitoring should be performed. In those cases where there appears not to be a regular daily pattern to ambient noise, and / or the dominant ambient noise sources are some significant distance from the measurement location, one week's valid data is likely to be required. There will also be some circumstances where more than one week of valid data will be required to gain a good understanding of the variation in ambient noise (for example, where there is a wide variability in daily assessment background levels). Any variations from the specified monitoring duration in *Table 3.1* should be fully justified in the noise assessment report.

4 ‘Modifying factor’ adjustments

4.1 Introduction

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level. On the other hand, some sources may cause less annoyance where only a single event occurs for a limited duration. This section outlines the correction factors to be applied to the source noise level at the receiver before comparison with the criteria specified in *Section 2* to account for the additional annoyance caused by these modifying factors. The correction factors listed below were determined following a review of Australian and overseas practices and the relevant literature.

The modifying factor corrections should be applied having regard to:

- noise from all sources, individually and in combination, that contribute to the total noise at a site; and
- the nature of the noise source and its characteristics.

Table 4.1 sets out the corrections to be applied. The corrections specified for tonal, impulsive, intermittent and low-frequency noise are to be added to the measured or predicted noise levels at the receiver before comparison with the criteria.

4.2 Definitions to support the modifying factor corrections

Tonal noise—containing a prominent frequency and characterised by a definite pitch.

Low-frequency noise—containing major components within the low frequency range (20 Hz–250 Hz) of the frequency spectrum.

Impulsive noise—having a high peak of short duration or a sequence of such peaks.

Intermittent noise—the level suddenly drops to that of the background noise several times during the assessment period, with a noticeable change in noise level of at least 5 dB.

Adjustment for duration—applied where a single-event noise is continuous for a period of less than two and a half hours in any 24-hour period. The acceptable noise level may be increased by the adjustment shown in *Table 4.2*. This adjustment is designed to account for unusual and one-off events, and does not apply to regular high-noise levels that occur more frequently than once per day.

Maximum adjustment—the maximum correction to be applied to the criteria or the measured level where two or more modifying factors are present. The maximum adjustment is 10 dB(A) where the noise contains two or more modifying factors (excluding the duration correction).

4.3 Applying the modifying factors

The modifying factors are to be applied to the noise from the source measured / predicted at the receiver and before comparison with the criteria. The modifying factor correction is applied as follows (K_i is equal to the modifying factor correction (from *Table 4.1*)):

Criterion	Compare	
	Measured or Predicted	Criterion Value
Intrusiveness	$L_{Aeq,\ 15\ minute}$ plus K_i	Rating background level plus 5
Amenity (including high traffic criterion *Section 2.2.3*)	$L_{Aeq,\ period}$ plus K_i	Acceptable noise level

Where two or more modifying factors are present, the maximum correction is limited to 10 dB.

Table 4.1. Modifying factor corrections

(See definitions in *Section 4.2*)

Factor	Assessment/ measurement	When to apply	Correction[1]	Comments
Tonal noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: —**5 dB** or more if the centre frequency of the band containing the tone is above 400 Hz —**8 dB** or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive —**15 dB** or more if the centre frequency of the band containing the tone is below 160 Hz	5 dB[2]	Narrow-band frequency analysis may be required to precisely detect occurrence
Low frequency noise	Measurement of C-weighted and A-weighted level	Measure/assess C- and A-weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more	5 dB[2]	C-weighting is designed to be more responsive to low-frequency noise
Impulsive noise	A-weighted fast response and impulse response	If difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB	Apply difference in measured levels as the correction, up to a maximum of 5 dB.	Characterised by a short rise time of 35 milliseconds (ms) and decay time of 1.5 s
Intermittent noise	Subjectively assessed	Level varies by more than 5 dB	5 dB	Adjustment to be applied for **night-time only**.
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	One event in any 24-hour period	0 to –20 dB(A)	The acceptable noise level may be increased by an adjustment depending on duration of noise. (See *Table 4.2*)
Maximum adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10 dB(A)[2] (excluding duration correction)	

Notes:

1. *Corrections to be added to the measured or predicted levels.*
2. *Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range.*

Table 4.2. Adjustments for duration

Duration of noise (one event in any 24 hour period)	**Increase in acceptable noise level at receptor, dB(A)**	
	Daytime and evening (0700–2200 h)	**Night-time (2200–0700 h)**
1.0 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
less than 1.5 minutes	20	10

5 Meteorological conditions

5.1 Introduction

Certain meteorological conditions may increase noise levels by focusing sound-wave propagation paths at a single point. Such refraction of sound waves will occur during temperature inversions (atmospheric conditions where temperatures increase with height above ground level) and where there is a wind gradient (that is, wind velocities increasing with height) with wind direction from the source to the receiver. These meteorological effects typically increase noise levels by 5 to 10 dB, and have been known to increase noise levels by as much as 20 dB in extreme conditions, thereby causing a significant noise impact on residents living in areas prone to these effects.

Temperature inversions occurring within the lowest 50 to 100 m of atmosphere can affect noise levels measured on the ground. In the geographical areas where this policy applies, these temperature inversions are most commonly caused by radiative cooling of the ground at night leading to the cooling of the air in contact with the ground. This is especially prevalent on cloudless nights with little wind. Air that is somewhat removed from contact with the ground will not cool as much, resulting in warmer air aloft than nearer the ground.

In assessing noise impacts, the criteria are expected to apply under weather conditions that would be expected to occur at a particular site for a significant period of time. These include conditions of calm, wind and temperature inversions. As the criteria are expected to apply under weather conditions characteristic of the area, it is important at the start of a noise assessment to assess the potential for such meteorological effects occurring, thus enabling better prediction of potential noise impacts. The sections below outline the procedures for assessing temperature inversions (*Section 5.2*) and wind effects (*Section 5.3*). Essentially, there are two underlying approaches to assessing these effects: the simple and the more detailed approach.

Simple approach. With the simple approach, the proponent may forego detailed analyses of meteorological data and simply apply given default meteorological parameters to predict noise levels. This approach **assumes** that meteorological effects are present for a significant amount of time, avoiding the need to quantify these effects in detail. It is conservative, in that it is likely to predict the upper range of increases in noise levels. Actual noise levels may be less than predicted. This approach is generally used to test whether further analyses are warranted.

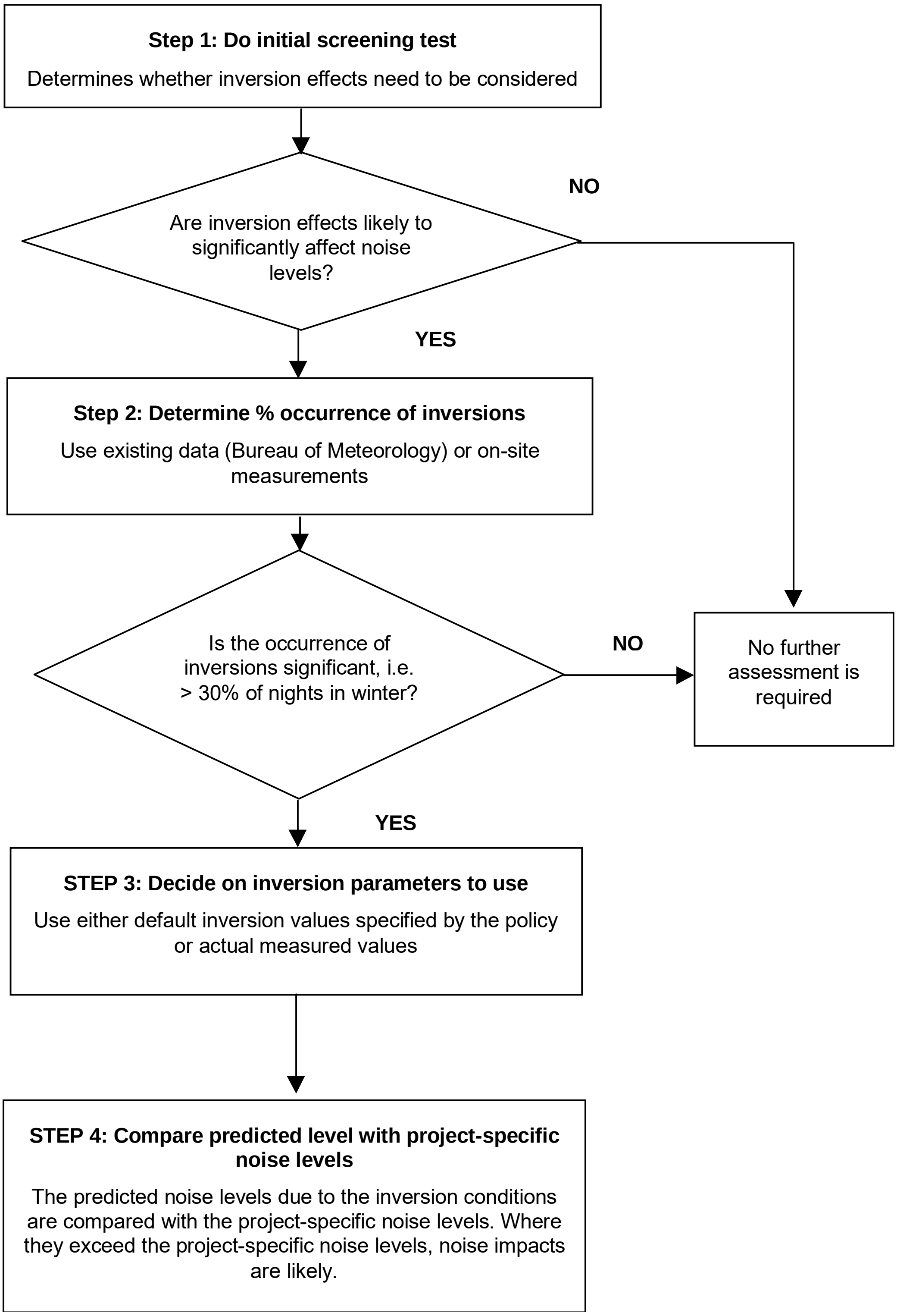
Detailed approach. The detailed approach involves analysing meteorological data to determine whether inversion and / or wind effects are significant features warranting assessment. Where assessment is warranted, default parameters are available for use in predicting noise or, where preferred, measured values may be used instead. The detailed approach gives a more accurate prediction of noise increases due to meteorological factors—as a trade-off for the additional work involved.

5.2 Temperature inversions

The 4-step procedure for assessing the amount by which noise is increased by inversion effects is summarised in *Figure 5.1*. Assessment of impacts is confined to the night noise assessment period (10 pm to 7 am), as this is the time likely to have the greatest impact—that is, when temperature inversions usually occur and disturbance to sleep is possible.

Essentially, the assessment involves a staged approach, designed to require an assessment only where initial screening tests show that inversion effects on noise are potentially significant. Where the potential is established, the next step is to analyse existing meteorological data to determine the percentage occurrence of temperature inversions. An occurrence of 30% of the total night-time during winter (June, July and August) has been selected as representing a significant noise impact warranting further assessment. As temperature inversions generally occur during the night-time and early morning periods, this percentage occurrence corresponds to about two nights per week. The night-time period for determining inversion frequency is from 1 hour before sunset to 1 hour after sunrise (taken to be 6 pm to 7 am), which is the time period during which inversions are most likely. **(This is different from the night noise assessment period over which inversions are to be assessed,**

Figure 5.1. Assessing temperature inversions



which is from 10 pm to 7 am.) Winter is selected as the appropriate season in which to determine whether temperature inversions are significant, as it represents the season with the highest frequency of occurrence of temperature inversions.

Default values for temperature inversions and drainage-flow wind speed are provided for use in assessing impacts where inversions are present for at least 30% of the total night time during winter. Alternatively, actual inversion strength and wind speed values based on on-site measurements may be used instead of the default values.

A brief description of the main components of the procedure for assessing noise increases due to inversion effects is presented below. Details of the full procedure are presented in *Appendix C*.

Step 1: Do initial screening tests

To assess the level by which noise is increased as a result of inversion effects, it is generally necessary to analyse meteorological data from the area in question. However, before doing any detailed analyses, the potential for temperature inversions to increase noise impact should be determined. Detailed analyses of meteorological data are ***not*** required where there is little or no potential for impact, as in the following cases:

- where the development in question does not operate during the night-time hours. As temperature inversions are usually prominent during night-time hours, there is no need to consider their effects for a development that does not operate at night (10 pm to 7 am)
- where, by using the default values, (see *Appendix C Table C1* for screening test default values), it can be shown that there would be no significant additional noise impacts during inversion conditions (for example, less than a 3-dB increase). In this situation, no further analysis of inversion effects is required. Situations where this could occur include:
  - —areas that experience only a slight increase in noise due to inversions
  - —areas where the most-affected premises may be located close to the development, thus negating the effects of inversions (which focus noise at relatively large distances).

Step 2: Determine the significance of temperature inversions

Where screening tests (Step 1) indicate that inversions could have a significant impact on noise, the proponent may want to do further analyses to confirm whether the occurrence of temperature inversions at the locality is significant. This would involve determining the percentage occurrence of moderate and strong inversions during winter, based on existing meteorological data and using any one of the methods outlined in *Appendix E*. (Weak inversions are not included, as they are not considered to have a significant impact on noise.) Where inversion conditions are predicted for at least 30% (or approximately 2 nights per week) of the total night time in winter, then inversion effects are considered to be significant and should be taken into account in the noise assessment.

In NSW, the Hunter region has been identified as an area often affected by temperature inversions. For this reason, the Hunter has been studied in detail, and the percentage occurrence of temperature inversions has been determined for the entire region down to a 2-km grid-square resolution. (See *Appendix F*.)

Step 3: Decide on inversion parameters to use

There are two options: use the default parameters specified, or use parameters determined by direct measurement.

A. Using default inversion parameters

Default values for inversion strength and wind speed have been specified for use in the noise assessment to avoid the need for potentially costly on-site monitoring. These default values have been chosen based on the analysis of available field data. Essentially, the following default parameters are specified for non-arid and arid areas:

Non-arid areas (annual average rainfall greater than 500 mm):

Moderate (F-class stability category) inversions

- 3 °C / 100 m temperature inversion strength for all receivers, plus a 2 m / s source-to-receiver component drainage-flow wind speed for those receivers where applicable. (See below for applicability of drainage-flow wind.) For more information see *Appendix C*.

Arid and semi-arid areas (annual average rainfall less than 500 mm):

Strong (G-class stability category) inversions

- 8°C / 100 m temperature inversion strength for all receivers, plus a 1 m / s source-to-receiver component drainage-flow wind speeds for those receivers where applicable. (See below for applicability of drainage-flow wind.)

Applicability of drainage-flow wind

The drainage-flow wind default value should generally be applied where a development is at a higher altitude than a residential receiver, with no intervening higher ground (for example, hills). In these cases, both the specified wind and temperature inversion default values should be used in the noise assessment for receivers at the lower altitude.

B. Using direct measurement

Where the proponent rejects the default values and wishes to use alternative values based on direct measurement, use the procedure outlined in *Appendix E*.

(Note: Wind data should be collected at 10 m height.)

Step 4: Assess the expected impact

The increased noise level predicted under inversion conditions is then compared with the project-specific noise levels to determine whether any noise impacts are expected. Noise impacts are likely where exceedances of the project-specific noise levels are predicted.

5.3 Wind effects

The effects of gradient wind on noise levels also need to be accounted for when assessing the impact from a planned development. Gradient wind differs from the drainage-flow wind associated with temperature inversions:

- drainage-flow wind is the localised drainage of cold air under the influence of the local topography, and travels in one direction only (direction of decreasing altitude)
- gradient wind is the regional wind determined by synoptic factors (high and low-pressure systems), and may originate from any direction.

Wind data are usually relatively easy to obtain, and wind roses are commonly used in most environmental impact assessments. Unlike temperature inversions, gradient winds may cause impacts during any assessment period (day, evening, night)—not just the night period. Hence the assessment of these effects should consider all assessment periods.

5.3.1 When do wind effects need to be assessed?

Wind effects need to be assessed where wind is a feature of the area. Wind is considered to be a feature where source-to-receiver wind speeds (at 10-m height) of 3 m / s or below occur for 30 per cent of the time or more in any assessment period (day, evening, night) in any season. This differs from the procedure used with temperature inversions, in that the 30-per-cent occurrence applies to all seasons and each assessment period—and not just the winter season and night assessment period. There are two ways to assess wind effects:

- Use a wind rose to determine whether wind is a feature based on the frequency of occurrence and wind speed. In doing this, take care to assess the source-to-receiver components of wind that are relevant.
- Simply assume that wind is a feature of the area (foregoing the need to use a wind rose) and apply a ‘maximum impact’ scenario.

5.3.2 What wind speed should be used when assessing noise impacts?

Wind is considered in two ways; the wind near the ground at the microphone position, and the wind aloft at 10 m above the ground.

When wind near the ground increases its speed it can increase ambient noise levels by rustling foliage and creating turbulence when passing over or around structures. At higher wind speeds, the noise produced by wind will drown out noise from most industrial and transportation sources. Wind can also create extraneous noise on noise-monitoring equipment; an upper limit of 5 m / s at the microphone position is commonly applied during noise measurement to reduce this effect.

Where wind speeds increase with height there is an effect that is analogous to temperature inversions but restricted to localities downwind of the noise source. This effect is represented by the wind speed and direction measured at a 10 m height above the ground. The 10-m wind may either be a drainage flow wind associated with an inversion or a gradient wind. The link between the near ground wind and the 10-m wind has been described as a power law relationship. This relationship can be complex and can depend on site factors such as the surface roughness and the stability of the atmosphere. This means that the 10-m wind cannot, as a general rule, be accurately derived from wind velocity measurements near the ground and vice versa.

In summary:

- Noise can be increased by wind.
- Wind can create high ambient noise levels.
- Wind can create extraneous noise on noise-monitoring equipment.
- The near-surface wind and the 10-m wind can cause different noise effects, so that both need to be assessed.
- The near-surface wind relates to effects on the noise monitoring equipment and noise generated through mechanical interaction with trees and other obstructions, whereas the 10-m wind relates to sound-wave refraction through the atmosphere, similar to inversions and its consequent effects on noise levels.
- A significant wind effect near the ground at microphone height does not necessarily mean that a significant wind effect will occur at 10 m (and vice versa).

A default wind speed of 3 m / s (at 10-m height) is proposed for assessing noise impacts caused by gradient winds. This wind speed can noticeably increase noise received down-wind of a noise source, but may not increase ambient noise levels to the point where they mask noise from the source and make it unnoticeable. A 10-m wind of 3m / s is also unlikely to be associated with near-surface winds of a strength able to cause increased ambient noise levels that would mask increased levels of noise from the source.

Where there is 30 per cent or more occurrence of wind speeds below 3 m / s (source-to-receiver component), then use the highest wind speed (below 3 m / s) instead of the default.

Where there is less than a 30 per cent occurrence of wind of up to 3 m / s (source-to-receiver component), wind is not included in the noise-prediction calculation.

6 Predicting noise levels & determining impacts

An important aspect of noise assessment—after determining the project-specific noise levels—is the prediction of noise levels from an industrial noise source, leading to the determination of noise impact.

This process involves:

1. Identifying all possible source, site and receiver parameters so that noise can be adequately predicted.
2. Predicting noise levels from the source at receiver locations—taking into account all important parameters identified, as well as the project-specific noise levels.
3. Comparing the predicted noise level with the project-specific noise levels to determine the noise impact.

6.1 Identifying noise parameters

The important parameters for predicting noise are listed below. These will set the boundaries of the noise prediction process. They need to be determined and clearly identified for noise impacts to be predicted adequately:

- all noise sources related to the proposed development, including vehicles that operate on site
- source noise levels, site location and effective height of the noise source. References should be provided for all source noise levels used in the assessment (for example, direct measurement, previous EIS, manufacturer's specifications)
- all stages of project development
- all nearby receivers potentially affected by the development
- weather conditions applicable to the site (from *Section 5*); noise criteria apply under existing weather conditions
- site features (including natural and constructed, development and surrounding land uses) that affect noise propagation
- operating times of the development.

6.2 Noise prediction

To quantify the noise impact, the noise levels from the source at all potentially affected receivers should be predicted, taking account of the parameters identified (*Section 6.1*).

The noise levels predicted should correspond to the noise descriptor of the project-specific noise levels applicable to the project. For example, the noise levels should be predicted in terms of:

- $L_{Aeq,period}$ if the amenity criteria establish the project-specific noise levels
- $L_{Aeq,15\ minute}$ if the intrusive criterion establishes the project-specific noise levels.

Any assumptions made when determining descriptors should be clearly validated and reported in the assessment.

For small or simple projects, the predicted noise level from the source may be calculated manually, taking into account the distance from the source to receiver and any shielding between the source and receiver.

For large or difficult projects, noise is generally predicted through the use of computer noise models. Such models generally take account of noise attenuation due to distance, atmospheric absorption, barriers, effects of intervening ground types and weather conditions. They use information about source noise levels, location of sources, topography between source and receiver and weather conditions to calculate overall noise levels at a receiver location. Strong preference will be given for the use of modelling approaches that have been the subject of peer review and that form accepted practice (for example, Environmental Noise Model (ENM) or Soundplan). Any other modelling approaches used would need to be validated before being used for a particular project. Where large numbers of people are likely to be affected by noise, a map showing predicted noise levels as noise contours surrounding the development is required.

6.3 Determining impacts

The noise impact of the development can be determined by comparing the predicted noise level at the receiver with the project-specific noise levels that have been derived for that particular location. The development is considered to cause a noise impact if the predicted noise level at the receiver exceeds the project-specific noise levels for the project. The extent of noise impact from the development is defined by the extent the predicted noise level exceeds the project-specific noise levels and the number of receivers affected.

6.3.1 Impacts under adverse weather conditions

As described in *Section 5,* adverse meteorological conditions such as temperature inversions and winds can act to increase the level of noise received from a noise source. These meteorological effects may also result in increased levels of ambient noise contributed by industry and background noise. Wind can also reduce noise levels at the receiver where it blows from the receiver towards the industry.

These effects are site specific and often complex and difficult to quantify. Extended monitoring and / or detailed modelling may be needed to capture the effects or predict what is expected to occur. The complexity and expense involved in quantifying the effect of adverse meteorological conditions on background noise levels or ambient noise levels contributed by industry preclude these detailed procedures from being a requirement in assessing noise impact. However, it is recognised that such effects do occur, and these procedures may be used to assess the effects of meteorological conditions on background noise levels and ambient noise levels in the noise assessment report.

The over-riding objective is to 'compare like with like' and to ensure that the situations where the maximum level of impact is likely to occur are identified and quantified. For example, where the impact from a proposed development is to be assessed under adverse wind conditions (for example, a 3 m / s wind blowing from source to receiver), then where a background noise level can be quantified for those same conditions it is reasonable that this background noise level should be used to assess impacts under these conditions.

In all cases the rating background level should be determined (as per *Section 3.1*) as the starting point, and any adjustments for adverse meteorological conditions can then be applied to this base value. Impact should be assessed under both adverse and non-adverse meteorological conditions to determine the maximum impact that may occur.

Quantifying the influence of temperature inversions on background noise levels can be done in a similar fashion, and the policy provides a number of methods for estimating the presence of temperature inversions.

The influence of adverse meteorology on the industry contribution to ambient L_{Aeq} noise levels may be more difficult to establish. However, where this can be quantified with a reasonable level of confidence the resultant noise levels may be used in assessing impact against the criteria.

It is emphasised that sufficient objective evidence must be supplied to support any claim for increased background noise levels or industry contribution to the ambient L_{Aeq} levels. It is not sufficient to rely solely on past experience; a site-specific analysis of the effects of meteorology must be undertaken.

7 Mitigating noise from industrial sources

7.1 Introduction

The processes described in *Sections 2* to *6* establish the project-specific noise levels and the predicted noise levels from the source. When the predicted noise level from the noise source exceeds the project-specific noise levels, mitigation measures that will reduce noise levels to meet the project-specific noise levels need to be considered. The degree of noise impact quantifies the extent of mitigation required, and points to an appropriate mix of noise control measures to be adopted as a mitigation strategy.

This policy focuses on achieving the desired environmental **outcomes**—there is no prescribed management or mitigation strategy to achieve the project-specific noise levels. In this way, the noise-source manager is given maximum flexibility in controlling noise.

The sections below provide guidance on what mitigation and management measures might be appropriate for particular types of development associated with specific noise problems.

Essentially, there are three main mitigation strategies for noise control:

1. Controlling noise at the source.

   There are two approaches: Best Management Practice (BMP) and Best Available Technology Economically Achievable (BATEA). These are described in *Section 7.2*.
2. Controlling the transmission of noise.

   There are two approaches: the use of barriers and land-use controls—which attenuate noise by increasing the distance between source and receiver. These are detailed in *Section 7.3*.
3. Controlling noise at the receiver.

   These measures are detailed in *Section 7.4*.

The overall approach to assessing appropriate strategies is outlined in *Section 7.5*.

The management of short-term exceedances for which mitigation is impractical is discussed in *Section 7.6*.

A set of generic mitigation measures that may apply to industrial development in general, plus additional measures for specific types of development, are set out in *Section 7.7*.

7.2 Controlling noise at the source

Best management practice

Best management practice (BMP) is the adoption of particular operational procedures that minimise noise while retaining productive efficiency.

When an appropriate mitigation strategy that incorporates expensive engineering solutions is being considered, the extent to which cheaper, non-engineering-oriented BMP can contribute to the required reduction of noise should be taken into account.

Application of BMP includes the following types of practice:

- in open-cut mines: restricting movement of trucks on ridgelines and exposed haul routes where their noise can propagate over a wide area, especially at night. This means restricting night-time movement of spoil to areas shielded by barriers or mounds, and reserving large-scale spoil movement for daytime
- scheduling the use of noisy equipment at the least-sensitive time of day
- siting noisy equipment behind structures that act as barriers, or at the greatest distance from the noise-sensitive area; or orienting the equipment so that noise emissions are directed away from any sensitive areas, to achieve the maximum attenuation of noise
- where there are several noisy pieces of equipment, scheduling operations so they are used separately rather than concurrently
- keeping equipment well maintained

- employing ‘quiet’ practices when operating equipment—for example, positioning idling trucks in appropriate areas

- running staff-education programs on the effects of noise and the use of quiet work practices.

Best available technology economically achievable (BATEA)

Allied with BMP is ‘best available technology economically achievable’ (BATEA). With BATEA, equipment, plant and machinery that produce noise incorporate the most advanced and affordable technology to minimise noise output. Affordability is not necessarily determined by the price of the technology alone. Increased productivity may also result from using more advanced equipment, offsetting the initial outlay—for example, ‘quieter’ equipment that can be operated over extended hours. Often old or badly designed equipment can be a major source of noise.

Where BMP fails to achieve the required noise reduction by itself, the BATEA approach should then be considered. Most of the noise-control measures listed in *Section 7.7* belong to this approach. Examples of uses of BATEA are:

- adjusting reversing alarms on heavy equipment to make them ‘smarter’, by limiting acoustic range to the immediate danger area

- using equipment with efficient muffler design

- using quieter engines, such as electric instead of internal combustion

- using efficient enclosures for noise sources

- using vibratory piling in place of impact piling

- using high-pressure hydraulic systems to split rock, instead of hydraulic or pneumatic hammers

- damping or lining metal trays or bins

- active noise control.

7.3 Controlling noise in transmission

Barriers

Barriers are more effective if they are near the source or the receiver. Their effectiveness is also determined by their height, the materials used (absorptive or reflective), and their density. The relationship of these design features to attenuation is well documented.

Barriers can take a number of forms—including free-standing walls along roads, grass or earth mounds or bunds, and trenches or cuttings within which noise sources are sited. They are employed when source and receiver control is either impractical or too costly.

Land-use planning—a strategic approach to noise mitigation

Strategic issues related to integrating transport and land-use are dealt with in detail in the *Environmental Criteria for Road Traffic Noise* (EPA 1999).

Noise impacts from industry in residential and other noise-sensitive areas stem mostly from inappropriate land-use decisions that allow industry to develop close to these areas. Once land is developed in this way, the range of available noise-control measures is restricted to better management of the industrial site, and engineering solutions. One of the most costly controls considered at this late stage, the acquisition of residences, creates a noise buffer-zone of land. These conflicts could have been avoided had appropriate land-use decisions been made at the initial stage of land-use planning.

While judicious use of land use planning techniques may often avoid noise becoming an issue it is not intended that they should be relied on as the only mitigation strategy. Noise generators are responsible for applying all feasible and reasonable noise mitigation controls at the noise source. This maximises the amount of land unaffected by noise.

Where land-use planning can be applied as a noise control tool (generally in newly developed areas), this is preferred to waiting until a specific noise impact is identified before seeking noise control measures.

Land-use planning can be used as a noise control measure at three development stages:

1. The initial planning stage.

   A greenfield (undeveloped) site offers the greatest management flexibility to zone industrial and noise-sensitive land. This is the point where compatibility of different land uses should be considered. In certain instances where land is not at a premium, buffer zones that use land for recreational or business purposes may be an option.

2. The residential subdivision planning stage.

   When a commitment has already been given to locating residential and industrial land areas close to one another, but residential development has not started, there is an opportunity to develop internal subdivision designs that allocate the least noise-sensitive land uses (for example, shopping centres, parks, sporting complexes) nearest to industry. It follows that the most sensitive land uses (for example, residential, places of worship) would then be located furthest away from industry.

3. The house-design stage.

   If subdivision development has commenced in a potential noise-impact area, and there is no opportunity for flexibility in planning land use, controls on house design—to achieve the greatest level of external to internal noise attenuation—can still be considered. This would include locating living areas of the house away from the face exposed to noise, allowing the rest of the house to act as a barrier for it.

Extractive industry by its nature has no locational flexibility. In this case, appropriate strategic land-use planning from a noise perspective could incorporate allowances for the fixed industrial site in locating noise-sensitive land uses and associated buffer zones. To be effective, planning would need to anticipate future extractive-industry land requirements—which implies knowledge of the location of mineable ore bodies—so residential development can be isolated from these areas wherever possible.

7.4 Controlling noise at the receiver

Noise controls at the receiver are expensive when many receivers require treatment, but may be attractive and cost-effective where only a few receivers would be affected by noise and the alternatives are even more expensive source controls. Cost-effectiveness is also determined by the increase in future potential receivers where residential land is being developed near the noise source.

The two major controls are insulation and double-glazing of windows. For these to be effective, the residence needs air conditioning, or a sophisticated ventilation system that does not compromise the effect of the noise insulation.

The most extreme control is property acquisition.

7.5 Noise mitigation strategies

Selecting an appropriate strategy for a proposed development or alterations to an existing development involves the following steps:

1. Determining the noise reduction required to achieve the project-specific noise levels.
2. Identifying the specific characteristics of the industry and the site that would indicate a preference for specified measures.
3. Examining the mitigation strategy chosen by similar industries on similar sites with similar requirements for noise reduction; and considering that strategy's appropriateness for the subject development.
4. Considering the range of noise-control measures available (as suggested in this chapter).
5. Considering community preferences for particular strategies. This is especially important when the community has particular sensitivities to noise.

The preference ranking (from most preferred to least preferred) for particular strategies is:

1. **Land-use controls**—a long-term strategy preferable to other measures when such strategic decisions are possible in planning land use, as it separates noise-producing industries from sensitive areas and avoids more expensive short-term measures.
2. **Control at the source—BMP and BATEA**—used in conjunction, these strategies are the best after land-use planning, as they serve to reduce the noise output of the source so that the surrounding environment is protected against noise.

3. **Control in transmission**—the next best strategy to controlling noise at the source—it serves to reduce the noise level at the receiver but not necessarily the environment surrounding the source.
4. **Receiver controls**—the least-preferred option, as it protects only the internal environment of the receiver and not the external noise environment.

Proponents will take into account the cost-effectiveness of strategies in determining how much noise reduction is affordable. A proponent's choice of a particular strategy is likely to have unique features due to the economics of the industry and site-specific technical considerations.

The above steps and the range of measures described in the chapter can be used as a guide in assessing the strength of the proponent's mitigation proposals.

Where a proposed mitigation strategy will not achieve the desired noise reduction and leaves a remaining noise impact, the problem needs to be solved by negotiation. The negotiation process is the subject of *Section 8*.

7.6 Managing short-term exceedance of approved noise levels

From time to time, managing noise at the source may require a short-term increase in noise beyond the level approved. Such situations may include:

- running-in new equipment
- abnormal operations due to unforeseen breakdown or maintenance requirements
- occasional needs to move heavy equipment to new locations on site.

Mitigation strategies are often impractical for such short-term events.

The noise-source manager should demonstrate that all alternatives to noisier operations have been considered before seeking an accommodation from the relevant regulatory / consent authority to operate in excess of the agreed noise levels. If it is judged that such an accommodation for a short-term noisier operation is warranted, the following options could be considered:

- confining noisier operations to the least-noise-sensitive part of the day—which would be when the background noise is highest
- determining an upper level for noise impact
- consulting with the community regarding the proposed events.

7.7 Generic noise control measures

Typical noise sources on industrial sites include:

- engines
- exhausts
- fans
- transport of materials, such as on conveyors and trucks
- milling and stamping (metal works)
- sawing and debarking (wood mills)
- processors such as crushing and separating
- pumps and compressors
- whistles and alarms
- material dumping and scraping
- electrical transformers and switching equipment.

The choice of noise control measures depends on both the degree of mitigation required and the undesirable characteristics of the noise source that need to be controlled. The actual measures chosen will also depend on site factors, such as the ability of the site to accommodate particular engineering measures relative to other measures and their site costs.

A generic set of noise-control measures is set out below, with additional measures shown that respond to particular developments.

Generic list of mitigation measures

Noise-source controls

- enclosing the source—the design of the enclosure and materials used to absorb sound will affect the attenuation achieved

- silencing exhausts—muffler design and noise barrier systems
- active noise control, effective on a limited range of noise sources
- times of operation.

Controls along the sound-transmission path

- noise barriers—more effective if near source or receiver; effectiveness also controlled by materials used (reflective or absorptive) and by height
- mounds, bunds and trenches
- site design to maximise the distance from the critical noise source to the receiver, and with intervening buildings to act as barriers.

Controls at noise receiver

- insulation
- double-glazing of windows and use of air conditioning
- acquisition.

Additional mitigation measures for extractive industries

On-site transport of materials

- selecting vehicles with minimum noise output—including tyre noise, exhaust and compressor / fan noise
- using rolling stock with quiet couplings and brakes
- using locomotives with components that do not emit tonal or low-frequency noise
- using trenches, cuttings, tunnels and barriers for transport routes
- restricting times for truck operations on ridgelines and in locations that are line-of-sight with receivers
- giving preference to haul routes with low grades
- using conveyor systems with low noise output, paying particular attention to rollers
- enclosing conveyors where necessary
- maintaining plant and equipment to ensure that the designers' noise-output specifications continue to be met
- using 'smart' reversing alarms.

Mine and quarry operation

- locating materials-processing in the least noise-sensitive area, or enclosing it if necessary
- dumping spoil and waste behind barriers.

Additional mitigation measures for sites with specific noise characteristics

Piling

- using piling shrouds or vibratory piling instead of impact piling to control impulsive noise.

Milling and metal works

- using efficient enclosures, where needed, to reduce the impact of impulsive noise from metal stamping
- reducing the impact or output of tonal noise from cutting equipment and saws, by using enclosures or through equipment redesign.

Pumps, transformers and machinery producing low-frequency or tonal noise

- where low-frequency noise is difficult to isolate, seeking specialist advice about machinery redesign and restricted operating times
- reducing tonal noise through machinery redesign, enclosure, or restricted operating times; or by applying active noise control.

Sites producing intermittent noise during night-time operations

- Control may be specific to the way the noise source is designed or how it fits in to the overall industrial process. Using barriers, enclosing or redesigning the source, or changing the operation to provide for a more continuous output are possible measures.

8 Negotiation process

8.1 The process leading to negotiation

This chapter deals with that part of the overall process shown in *Figure 1.1* in the box under the heading 'Decision-making process'.

Any unacceptable impacts from a development proposal that are likely to persist after noise-mitigation action has been taken can be dealt with through negotiation—either by improved mitigation or by trade-offs with benefits.

Negotiation can be:

- between the proponent and the regulator—the traditional approach
- between the proponent and the affected community (which is in the best position for evaluating the trade-offs).

In the latter case negotiation is designed to be available to those people whose amenity is potentially affected by non-achievement of the project-specific noise levels. This type of negotiation process, which leads to the determination of an achievable noise limit, is in addition to the type of direct consultation that typically occurs between the proponent and the community throughout the impact assessment process in defining the important project parameters.

8.2 Negotiation between proponent and regulator

Where proposed mitigation measures will not reduce noise levels to the project-specific noise levels, the proponent should seek to negotiate with the regulatory / consent authority to demonstrate that all feasible and reasonable mitigation measures have been applied. The regulatory / consent authority can choose to accept the level of impact proposed, or negotiate for a better level of control where this is considered achievable.

Where, in the final analysis, the level of impact would still exceed the project-specific noise levels, the economic and social benefits flowing from the proposed development to the community should be evaluated against the undesirable noise impacts.

Where it can be demonstrated by the proponent that the development offers net benefits, a regulatory / consent authority may consider these as grounds for applying the achievable noise levels, rather than the project-specific noise levels, as the statutory compliance limit.

Negotiation on what represents the best achievable level that is practicable for a development is often an iterative process involving both the proponent and regulator / consent authority and the proponent and affected community. Where the proponent is seeking to demonstrate to the regulator / consent authority that all feasible and reasonable noise mitigation measures have been applied, the proponent should include the results of their discussions with the affected community in the package of proposed noise mitigation measures. Beyond this point, the proponent might want to initiate additional community-based negotiation where there is potential for trade-offs attractive to the affected community. Typically, where the amenity criteria set the project-specific noise levels for a project, negotiations between the proponent and the regulator would occur when site noise levels are between the acceptable and recommended maximum L_{Aeq} levels presented in *Table 2.1*.

The section below outlines a checklist that can be used as a guide by EPA officers to determine an acceptable level of residual noise impacts when setting statutory noise conditions, based on the consideration of social and economic costs and benefits.

8.2.1 Residual level of impact: checklist

It is important that, as far as possible, the noise assessment quantifies any remaining or residual impacts that exceed the project-specific noise levels, after applying feasible and reasonable mitigation strategies.

The acceptability of the residual noise impacts should be evaluated by taking into consideration factors such as:

1. Characteristics of the area and receivers likely to be affected, for example:

—the extent of the areas (including existing, developing or proposed residential, health or education sites) and number of receivers (including groups that may be especially sensitive to noise, such as pre-schoolers, students, the aged, hospital and nursing home patients) likely to be affected by noise levels above the project-specific noise levels

—the daily activities of the community (in particular, effects such as sleep disturbance, speech interference, level of annoyance or effects on physical or physiological health)

—property values

—zoning of land uses affected by noise and the appropriateness of the zoning or land use

—the potential change in the ambient noise levels as a result of the proposal; cumulative noise impacts in the area; and whether parts of the area that are already moderately or badly affected by noise will be more or less affected

—the extent to which biodiversity (especially native birds and other animals) will be affected

—the likely variation between individuals in response to the noise

—the amenity of areas used for outdoor recreational activities or conservation, heritage or wilderness areas

—other industry in the area (including agriculture).

2. Characteristics of the proposal and its noise or vibrations, such as:

—the noise characteristics of the activity

—the extent to which any remaining noise impact exceeds the project-specific noise levels

—the circumstances and times when the project-specific noise levels are likely to be exceeded

—the circumstances and times when the source noise levels are likely to be below the project-specific noise levels (for example, when wind blows source noise away from the receiver)

—the accuracy with which impacts can be predicted, and the likelihood that the impacts will occur in the manner predicted

—the degree to which the character of the noise is new to an area and differs from existing noise sources

—the economic benefit and social worth of the proposal for the local area, the region or the nation.

3. The feasibility of additional mitigation or management measures:

—alternative sites or routes for the development

—the technical and economic feasibility of alternative noise controls or management procedures.

4. Equity issues in relation to:

—the costs borne by a few for the benefit of others

—the long-term cumulative increase in noise levels

—the opportunity to compensate effectively those affected.

8.3 Negotiated agreements between the proponent and the affected community

An alternative mechanism that could be applied is the more inclusive approach of a negotiated agreement between the affected community and the proponent, with traditional regulatory / consent authorities playing a supporting role. Negotiation is designed to be available to those people whose amenity is potentially affected by non-achievement of the project-specific noise levels. While negotiation on agreed noise levels between the proponent and the community can occur at any time, this should occur when site noise levels exceed the recommended maximum L_{Aeq} levels presented in *Table 2.1*.

The affected community is in the best position to know how much noise it is prepared to bear for a package of benefits that would flow from the operation of the facility creating the noise. As this approach is new, a model for the process has not been established. The process could be initiated when the proponent has demonstrated that the project-specific noise levels could not be met.

Features of a negotiated agreement process

How the process might be initiated

The process might be initiated when:

- the regulatory / consent authority is satisfied that no further reduction in noise levels can be made through a viable mitigation strategy that would seek to achieve the project-specific noise levels; and
- the proponent demonstrates that—even when using the best of their economically viable strategies—the project-specific noise levels cannot be achieved.

Who participates

The principal parties would be the proponent and the affected community, with regulatory authorities and the council participating in an advisory capacity.

There is a need to define the 'affected community': this could comprise occupiers of residences and of other noise-sensitive land uses identified as being potentially affected.

The proponent would need to employ an effective means (for example, advertising) of reaching all people who are potentially affected. Advice may include how individuals could register as 'interested and affected parties' and become participants in the negotiation process.

What is negotiated

The principal trade-off would probably be additional noise impact in return for a package of benefits. Additional noise could be defined in terms of extended times of operation, higher noise levels, and a defined time period for annoying noise characteristics to operate and for more noise to occur in the less sensitive parts of the day. Benefits could include less noise at sensitive times, treatment of residences, contributions to improve community facilities and infrastructure or acquisition of residences. The *NSW Industrial Noise Policy* could act as a framework for negotiations regarding a set of acceptable noise conditions.

The impact-assessment process may identify areas of noise-source management where concessions are practicable. The proponent may not be able to reduce noise further. In these circumstances, other benefits might be negotiated unrelated to better management of the noise source but related to material benefits for the community.

It is important for the negotiating community to understand the implications of its negotiations regarding the additional noise impacts. Either the proponent or an independent specialist should present an analysis of the impacts from the options being canvassed, in such a way that the lay community can appreciate the likely implications of their negotiations.

The community would need to be well informed, to safeguard against a position being reached where the agreed noise level represents an unreasonable impact that, ultimately, is likely to be regretted by that community.

How agreement might be negotiated

Representatives of the community could have equal status in the negotiating process with the proponent, and with any other parties (such as the EPA, councils and DUAP) acting in an advisory capacity.

Meetings could be chaired by an independent facilitator and, depending on the circumstances, the costs of the process may be borne solely by the proponent or may be shared equitably between the proponent and the community.

How agreement could be reached

'Agreement' would need to be defined for the community so that a single community view could be regarded as representative. This could mean a number of things—including a simple majority vote by the 'affected community', or a majority vote at a meeting held to reach an agreement; 'majority' could be defined to extend to a higher than 51 per cent level (for example, 60 per cent or 80 per cent). The many options would need to be evaluated. The community should determine for itself its preferred method for indicating its views when negotiating its position.

Treatment of 'affected' community members who do not support the agreement

Proponents could propose a package of assistance to be considered by these community members.

How future affected landowners would be treated

The council may act on behalf of future owners of these properties. The existence of an agreement affecting such land may be in the form of information provided on Section 149 Certificates routinely obtained by purchasers of properties.

The effect on property values of any agreement may in itself be part of the negotiations.

How the agreement could be enforced

The agreement would need to be enforced to the extent that it imposed obligations on the proponent. This could be achieved by making these obligations either development consent conditions or licence conditions. **The obligations would need to be expressed clearly and unambiguously**. The conditions may also need to specify a way of measuring clearly whether the proponent has fulfilled these obligations.

Further, the conditions must be reasonable from the point of view of existing and future landowners.

Mediation

An integral part of the process may need to be a mediation and dispute resolution process, as there is the potential for contentious issues to be raised.

Review

The consent or licence conditions could also provide for a review after a certain period. The conditions could then set out the method of review and the fact that the licence conditions may be changed as a result of that review.

The conditions could provide for the review period to be shortened where the original conditions forming the basis for negotiations had changed. Any review period should be of sufficient duration to give certainty to the proponent for the operation of the facility.

9 Consent/licence conditions

The process by which a consent authority grants development consent or regulatory authority issues licences with associated conditions is set out in *Figure 1.1*. Only where a noise impact is identified would a mitigation strategy need to be considered. Negotiation would be needed only when the proponent considered that the project-specific noise levels were not achievable.

9.1 What is included in the consent/licence

A consent agreement or licence condition arrived at through the process described in this policy will have taken the following issues into account:

- the assessed noise impact, which includes the impact of the noise source and any additional impact caused by meteorological conditions
- mitigation measures required to achieve the project-specific noise levels
- identification of a practical limit on noise control
- consideration of trade-offs
- whether the final noise level proposed is acceptable.

It is important to note that the agreed limits in the consent or licence apply under the meteorological conditions determined by the policy to be relevant to the assessment site.

Complaints about subsequent operation of the facility may arise where the project-specific noise levels are achieved, or when a higher level is negotiated, because it is not possible to protect the whole range of individual sensitivities to noise.

Complaints are also possible during extreme temperature inversions that were not covered in the assessment process because of their infrequency (see *Section 9.2*).

9.2 Specifying meteorological conditions in the consent/licence

The meteorological effect by its nature is variable. Particularly intense inversions may occur, leading to actual noise increases greater than those assessed in the policy. This is because the policy's approach is to identify levels of noise increase that occur for a significant period of time—approximately two nights a week during winter. Other, more intense events may occur for a shorter period of time. This shorter period is judged in the policy as not being significant and, therefore, not warranting the additional expense and difficulty of either a higher level of mitigation or consideration of alternative strategies to meet the greater impact.

This approach is similar in philosophy to that used with transportation noise, where an appropriate amenity level is set to protect 90 per cent of the exposed population from being 'seriously affected'. It is not practicable to protect the whole population, because the response to noise varies widely between individuals. In the case of noise increased by meteorological effects, the noise limit may allow some undesirable impacts on a proportion of the population during the short term and during unrepresentative meteorological events that increase noise to an excessive degree. As is the case with transportation noise, it is not practicable to meet the noise limit under all inversion events, hence exceedances under extreme temperature inversions are not considered to be a non-compliance with consent or licence conditions.

To ensure that the consent or licence condition applies under typical meteorological conditions relevant to the site (that is, the condition determined from *Section 5*) a consent or licence condition may be based on the following:

- For developments where F-class inversions (normally associated with non-arid areas such as the Hunter Valley and coastal areas) were found to be a feature of the area (that is, using the procedure outlined in *Section 5.2*) the following statement could accompany the noise limits in the condition:

'The noise limits apply under all meteorological conditions except

—during rain and wind speeds greater than 3 m/s; and

—from 6 pm to 7 am during intense inversions, which are indicated by cloud cover less than 40 per cent and wind speeds less than 1.0 m/s.'

Note: Wind data should be collected at 10 m height.

The latter point above excludes non-standard inversions (which are intense inversions—G-class inversions in this case), and is based on parameters specified in the Turner methodology for determining temperature inversions (described in *Appendix E*).

- For developments where G-class inversions (normally associated with arid areas such as Broken Hill and other flat inland areas) were found to be a feature of the area (using the procedure outlined in *Section 5.2*) the following statement could accompany the noise limits in the condition:

  'The noise limits apply under all meteorological conditions except during rain and wind speeds greater than 3 m/s.

  Note: Wind data should be collected at 10 m height.

  G-class represents the upper limit of inversion conditions, and no more extreme conditions are expected to occur.

10 Applying the policy to existing industrial premises

This section establishes a noise reduction program for existing industrial noise sources, based on an agreed process for assessing and managing noise. This approach is designed to allow established industries to adapt to changes in the noise expectations of the community while remaining economically viable.

The need to establish achievable noise limits and implement a noise reduction program may be triggered by actions such as:

- the site becomes the subject of serious and persistent noise complaints
- a proposal to upgrade or expand the site
- the site has no formal consent or licence conditions and management wish to clarify their position
- management chooses to initiate a noise reduction program.

This approach provides a formal structured program to reduce high existing noise levels to acceptable levels over time by applying feasible and reasonable control measures. It establishes certainty through an agreed process to achieve noise reduction, while providing flexibility in the choice of noise reduction measures.

10.1 Applying the policy to existing sites

Many existing industrial sources were designed for higher noise emission levels than the criteria outlined in this policy. In other cases industries may have been in existence before neighbouring noise-sensitive developments and even before noise-control legislation was introduced. The range of mitigation measures available for these sites may be either extremely limited or costly.

Applications for extensions to existing premises often provide an opportunity to redress issues that relate to the whole site. The need for reduced noise from existing sites must be weighed against the wider economic, social and environmental considerations. Where noise emissions from the site exceed the project-specific noise levels, the regulatory authorities and the noise-source manager need to negotiate achievable noise limits for the site. The project-specific noise levels should not be applied as mandatory noise limits. The project-specific noise levels supply the initial target levels and drive the process of assessing all feasible and reasonable control measures. Achievable noise limits result from applying all feasible and reasonable noise control measures. For sites with limited mitigation measures the achievable noise limits may sometimes be above the project-specific noise levels.

In many instances the site will be required to reduce its noise emissions progressively to achieve the specified noise limits by specified dates. This will require noise to be managed as an integral part of site upgrades. However, the development of formal operating practices to reduce noise generation often need not be linked to site upgrades, and where feasible these operating practices should be applied at the earliest opportunity. The measures required to achieve the noise limits would usually be set out in a noise reduction program, with mitigation measures staged over time. The noise reduction program would typically be attached as a licence condition. Efforts should be aimed at achieving a reduction in noise in a manner that provides the greatest benefit to residents without undue impact on the existing business. This may be accomplished by prioritising the various noise-control measures.

10.1.1 Steps in the process

This process may be triggered by a company proposal to partly upgrade its site, or by serious noise complaints. Where these occur the usual process is:

1. Measure and determine existing background and ambient noise levels.
2. Measure the noise levels produced by the source in question, having regard to meteorological effects such as wind and temperature inversion.
3. Determine project-specific noise levels from intrusive and amenity noise criteria.

4. Compare the measured noise level with the project-specific noise levels.
5. Where the project-specific noise levels are exceeded, assess feasible and reasonable noise mitigation strategies.
6. Negotiation between the regulator and the noise source manager to agree to achievable noise limits for the site. (This may involve consultation with the community.) Regulatory authorities and the noise-source manager need to consider the technical practicalities and cost of noise-reduction measures, along with the environmental consequences of exceeding the project-specific noise levels.
7. Measures to achieve the limits by specified dates may be set out in a noise reduction program.
8. Monitor compliance with the noise reduction program, and review and amend the program as required.

An example showing how this process works is contained in *Section A4* of *Appendix A*.

10.2 Noise reduction programs

The noise reduction program is reached through agreement between proponent and regulator and will typically have a statutory basis through conditions on a licence or notice. It will document the actions required to achieve the noise limits. The measures will generally be source- and site-specific, but could include the following elements:

- the aim and scope of the program
- identification of noise levels and targets for the site
- an upper limit for new equipment
- an upper limit for partial upgrades of the site
- plans to eliminate problematic characteristics that have been identified, such as tonal and low frequency noise
- a sound power limit for relevant sections of the site
- operating practices to reduce noise emissions
- training and awareness initiatives
- an ongoing monitoring program to evaluate noise-emission levels
- communicating with the affected community via one or more of a complaints handling process, liaison group, newsletters etc.

10.3 Noise-reduction strategies for existing sites

Often the range of planning instruments that can be applied to existing sites is limited. For example, planning approaches (for example, spatial separation between source and receiver and attention to noise reduction in designs for residential and industrial buildings) that could avoid impacts are generally not available at this stage. Operational procedures and immediate cost-effective measures that can minimise noise with minimal impact on the noise source should be identified and implemented.

The applicability, effectiveness and cost of particular mitigation measures often depends strongly on site variables. *Section 7* provides advice on a range of typical mitigation strategies, and is a useful guide in deciding suitable mitigation measures for a particular site.

11 Reviewing performance

Monitoring of environmental noise levels from a development to determine compliance with the consent / licence conditions is essential to proper management of noise sources. This is the responsibility of the development proponent, and should generally be performed at specific stages of a development and / or as a result of complaints from affected receivers. A good monitoring program should involve the community in reviewing the performance of a development by providing the community with:

- access to noise monitoring results
- an opportunity to discuss concerns and impacts.

An additional way to monitor the performance of a development is to establish a proponent-run complaints system. This is a beneficial management tool, allowing further involvement of the community in the performance review of a development.

The sections below outline the various methods for reviewing and managing the performance of a development.

11.1 Monitoring environmental noise

11.1.1 Options for noise monitoring

Monitoring at specific stages of a development

This involves identifying the various stages of a development where different noise outputs were predicted during the assessment process, and monitoring at each of these stages. For example, for a mine development, noise could be monitored during the first year of development and at four or five other key years in the development of the mine (for example, years 2, 5, 10, 15 and 20).

To assess the performance of the development adequately, noise monitoring should cover the full cycle of operational activity at each of the identified stages. Noise could be monitored over a full day (day, evening and night), a week, or longer—depending on the development.

It will usually be necessary to monitor noise at several sites, but these should at least include noise-sensitive locations where noise levels are likely to be the highest.

Monitoring as a result of community complaints

Another option is to monitor noise levels as a result of community complaints. This may be done in addition to noise monitoring at various stages of the development described above, or could stand alone as the sole driver for performance monitoring.

With this option, noise should be monitored at the complainant's premises. Monitoring should also be conducted to cover the time at which noise impacts were reported to occur.

11.1.2 Notes on noise monitoring

Items to be monitored

To check compliance with the consent / licence condition, the following items require monitoring:

- noise levels from the development at locations specified in the condition, or at the nearest affected receivers where no locations are specified. During monitoring the meter should be set to 'Fast' time weighting and 'A' frequency weighting and should record using the descriptor specified by the consent / licence condition (that is, $L_{Aeq,\ 15\ minute}$ or $L_{Aeq,period}$ or other)
- the wind speed and direction
- sky cloud cover, using direct observation for night measurements.

Where existing noise levels are high. When compliance is being measured it may be found that, in many cases, existing noise levels are higher than noise levels from the source, making it difficult to separate out the source noise level. When this happens, it may not be feasible to measure compliance at the specified location, and other methods will be needed. In these cases, measurements may be taken closer to the source and then calculated back to the specified location. In doing this, take care to account for the 'near field', a region in which sound pressure levels do not decrease with distance in the normal way. Definitions of the extent of this region are contained in many noise textbooks (for example, Bies & Hansen 1996). Any calculations should be done in accordance with the validation requirements set out in *Section 6.2*.

Determining the noise contribution from a development. The following techniques may be used to determine the L_{Aeq} contribution from a particular industrial source from among multiple industrial noise sources:

- measuring existing noise levels with and without the premises operating
- measuring the noise emissions from each of the premises at reference locations and then calculating the noise-emission levels back to the receiver
- using an accepted noise model calibrated for the particular locality and source.

In the case where transportation sources exist, the noise contribution from a development may be determined by isolating the transportation noise level using one of the methods outlined in *Section 3.2.1*.

11.1.3 Non-compliances with noise conditions

When is a development in non-compliance with a noise condition?

A development will be deemed to be in non-compliance with a noise consent or licence condition if the monitored noise level is more than 2 dB above the statutory noise limit specified in the consent or licence condition. This may occur for two reasons:

- The noise from the development is excessive, in which case the development is truly not complying with its consent or licence condition.
- The noise was increased by extreme, non-standard weather effects—in which case the development is not considered to be in non-compliance with its consent or licence condition. Non-standard weather effects can be considered to be present during monitoring if the cloud cover is less than 40 per cent and the wind speed (at 10 m height) is less than 1.0 m / s (represents an extremely adverse weather condition for noise)—during the period from 6 pm to 7 am in non-arid areas (see *Section 9.2*).

In this latter case, further monitoring at a later date is required to determine compliance under the meteorological conditions specified in the consent / licence condition.

Managing non-compliances

Where the noise exceedance is found to be caused by excessive noise levels from a development, the development is considered to be in non-compliance with its consent or licence condition. Strategies for mitigation of noise need to be considered and implemented, or a further negotiation process could be commenced.

When is a development in breach of a noise condition?

A development will be in breach of a noise consent or licence condition if sustained non-compliances are not addressed and rectified.

11.1.4 Items to be reported

The results of a noise monitoring test should be clearly reported and forwarded to the relevant authority (if requested), or kept on file for reference. It is recommended that they also be made readily accessible to the community.

The following items are to be included in a noise monitoring report:

- the type of monitoring test conducted (that is, the development stage or receiver complaints)
- the development noise limits on the consent / licence
- descriptions of the nearest affected receivers or, in the case of receiver complaints, description of the complainant and complaint
- the monitoring location—this should be at the most affected point at or within the receiver's boundary or, if that is more than 30 m from the receiver's premises, at the most affected point within 30 m of the premises

- the noise instrumentation used. (The instrumentation specifications required for compliance monitoring are the same as those required for background noise monitoring set out in *Appendix B.*)

- the weather instrumentation used. (The instrumentation specifications are the same as those set out in *Appendix E.*)

- the weather conditions during noise monitoring

- the time(s) and duration(s) of monitoring, including dates. In the case of receiver complaints, these should coincide with the time of the offence. In the case of development-stage monitoring, these should cover the full cycle of activity.

- the results of noise monitoring at each monitoring location, including a comparison with the development limits

- a statement outlining the development's compliance or non-compliance with the limit

- where noise exceedances are found (that is, the monitored noise level is higher than the limit), the reasons for non-compliance should be stated and strategies for management identified and stated as outlined in the previous section

- where the noise exceedance is due to excessive noise levels from the development, the strategies to be used to manage the noise exceedance should be identified and stated.

11.2 Monitoring noise complaints

Where residual noise impacts have been negotiated, it is recommended that the proponent run a complaints-monitoring system. Components of such a system could include:

- a complaint hotline to record receiver complaints regarding the development

- a system for logging complaints and dealing with them

- a database of complaints and the proponent's responses / actions. This should be readily accessible to the community and regulatory authorities

- a system for providing feedback to the community. (This could be in the form of regular meetings with affected residents, or a newsletter.)

Such a system is beneficial. It empowers the community and helps build an amicable rapport with the proponent. It also provides a useful mechanism for reviewing the performance of the development.

12 Policy evaluation and review

The NSW EPA is committed to continual review of the policy procedures and criteria, to determine how appropriate the policy is. Three areas will be evaluated:

- policy procedures—through consultation with acoustic practitioners, who collect the appropriate field data, apply the procedures and assess noise impacts—to see how practicable these procedures are
- policy framework—through consultation with proponents and noise source managers, who negotiate the noise limits and develop appropriate noise mitigation strategies—to see how well this framework helps to derive the noise levels incorporated in statutory instruments
- amenity levels—through consultation with communities affected by industrial noise sources to which the policy is applied—to help indicate whether amenity levels set in the policy are adequate and are being achieved.

A program of consultation will be developed to gauge the policy's effectiveness, once there has been sufficient time to allow the results of applying the policy to become evident. The outcome of the program will be to ascertain whether policy objectives have been fulfilled, and to suggest improvements.

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Definitions of terms

Acceptable noise level: See the fourth column of *Table 2.1*.

A-weighted: See dB(A).

Adverse weather: Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occuring more than 30% of the time in any assessment period in any season and / or temperature inversions occuring more than 30% of the nights in winter).

Ambient noise: The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.

Amenity criteria: See *Tables 2.1* and *2.2*.

Assessment period: The period in a day over which assessments are made: day (0700 to 1800 h), evening (1800 to 2200 h) or night (2200 to 0700 h).

Assessment background level (ABL): The single-figure background level representing each assessment period—day, evening and night (that is, three assessment background levels are determined for each 24-h period of the monitoring period). Its determination is by the tenth percentile method described in *Appendix B*.

Background noise: The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.

Breach: Failure to address and rectify sustained non-compliance will place a development in breach of its noise consent / licence condition.

C-weighted: C-weighting is an adjustment made to sound-level measurements which takes account of low-frequency components of noise within the audibility range of humans.

Cognitive noise: Noise in which the source is recognised as being annoying.

Community annoyance: Includes noise annoyance due to:

—characteristics of the noise (for example, sound pressure level, tonality, impulsiveness, low-frequency content)

—characteristics of the environment (for example, very quiet suburban, suburban, urban, near industry)

—miscellaneous circumstances (for example, noise avoidance possibilities, cognitive noise, unpleasant associations)

—human activity being interrupted (sleep, communicating, reading, working, listening to radio / TV, recreation).

Compliance: The process of checking that source noise levels meet with the noise limits in a statutory context.

Construction activities: Activities that are related to the establishment phase of a development and that will occur on a site for only a limited period of time.

Cumulative noise level: The total level of noise from all sources.

Day: The period from 0700 and 1800 h (Monday to Saturday) and 0800 to 1800 h (Sundays and Public Holidays).

dB: Abbreviation for decibel—a unit of sound measurement. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure.

dB(A): Unit used to measure 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.

Default parameters: In assessing meteorological enhancement of noise, refers to set values for weather parameters, such as wind speeds and temperature gradients, to be used in predicting source noise levels.

Equivalent continuous noise level: The level of noise equivalent to the energy average of noise levels occurring over a measurement period.

Evening: The period from 1800 to 2200 h.

Extraneous noise: Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.

Feasible and reasonable measures: Feasibility relates to engineering considerations and what is practical to build; reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors:

—noise mitigation benefits (amount of noise reduction provided, number of people protected)

—cost of mitigation (cost of mitigation versus benefit provided)

—community views (aesthetic impacts and community wishes)

—noise levels for affected land uses (existing and future levels, and changes in noise levels).

Greenfield site: Undeveloped land.

High traffic criterion: See *Section 2.2.3.*

Impulsive noise: Noise with a high peak of short duration, or a sequence of such peaks.

Industrial noise sources: Sources that do not generally move from place to place, for example, stationary sources. Except where other more specific guidelines apply (for example, construction activities, road or rail traffic, emergency diesel generators etc), all industrial noise sources that are scheduled under the *Protection of the Environment Operations Act 1997* are considered to be industrial sources. In general, these include:

- individual industrial sources such as:

—heating, ventilating and air conditioning (HVAC) equipment

—rotating machinery

—impacting mechanical sources

—other mechanical equipment and machinery such as conveyors

—mobile sources confined to a particular location, such as draglines and haul trucks.

- facilities, usually comprising many sources of sound,including:

—industrial premises

—extractive industries

—commercial premises

—warehousing facilities

—maintenance and repair facilities.

(In this case, the industrial source is understood to encompass all the activities taking place within the property boundary of the facility.)

Intrusive noise: Refers to noise that intrudes above the background level by more than 5 decibels. The intrusiveness criterion is set out in *Section 2.1.*

L_{A90}: The A-weighted sound pressure level that is exceeded for 90 per cent of the time over which a given sound is measured. This is considered to represent the background noise.

L_{Aeq}: The equivalent continuous noise level—the level of noise equivalent to the energy-average of noise levels occurring over a measurement period.

Low frequency: Noise containing major components in the low-frequency range (20 Hz to 250 Hz) of the frequency spectrum.

Masking: The phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street (Bies & Hansen 1996).

Maximum noise level: See the fifth column of *Table 2.1.*

Median: The middle value in a number of values sorted in ascending or descending order. Hence, for an odd number of values, the value of the median is simply the middle value. If there is an even number of values the median is the arithmetic average of the two middle values.

Meteorological conditions: Wind and temperature-inversion conditions.

Most affected location(s): Locations that experience (or will experience) the greatest noise impact from the noise source under consideration. In determining these locations, one needs to consider existing background levels, exact noise source location(s), distance from source (or proposed source) to receiver, and any shielding between source and receiver.

Negotiated agreement: An agreement involving the negotiation of an achievable noise limit in cases where the project-specific noise levels cannot be met. The agreement is negotiated between the proponent and the EPA or the proponent and the community. Such an agreement is reached through balancing the merits of a development, the feasibility and reasonableness of available mitigation measures and the noise impacts produced.

Noise criteria: The general set of non-mandatory noise level targets for protecting against intrusive noise (for example, background noise plus 5 dB) and loss of amenity (for example, noise levels for various land uses).

Noise limits: Enforceable noise levels that appear in conditions on consents and licences. The noise limits are based on achievable noise levels which the proponent has predicted can be met during the environmental assessment. Exceedance of the noise limits can result in the requirement for either the development of noise management plans or legal action.

Night: The period from 2200 to 0700 h (Monday to Saturday) and 2200 to 0800 h (Sundays and Public Holidays).

Noise-sensitive land uses: Land uses that are sensitive to noise, such as residential areas, churches, schools and recreation areas.

Non-compliance: A development is deemed to be in non-compliance with its noise consent / licence conditions if the monitored noise levels exceed its statutory noise limit by more than 2 dB.

Non-mandatory: With reference to the proposed policy, means not required by legislation. The proposed policy specifies criteria to be strived for, but the legislation does not make these criteria compulsory. However, the policy will be used as a guide to setting statutory (legally enforceable) limits for licences and consents.

Operator: Noise-source manager

Performance-based goals: Goals specified in terms of the outcomes / performance to be achieved, but not in terms of the means of achieving them.

Project-specific noise levels: Project-specific noise level are target noise levels for a particular noise generating facility. They are based on the most stringent of the intrusive criteria or amenity criteria. Which of the two criteria is the most stringent is determined by measuring the level and nature of existing noise in the area surrounding the actual or proposed noise generating facility.

Proponent: The developer of the industrial noise source.

Protection of the Environment Operations Act 1997: An Act that consolidates air, water, noise and waste requirements into a single piece of legislation. This Act repeals and replaces (among other Acts) the *Noise Control Act 1975*.

Rating background level (RBL): The overall single-figure background level representing each assessment period (day / evening / night) over the whole monitoring period (as opposed to over each 24-h period used for the assessment background level). This is the level used for assessment purposes. It is defined as the median value of:

—all the day assessment background levels over the monitoring period for the day

—all the evening assessment background levels over the monitoring period for the evening; or

—all the night assessment background levels over the monitoring period for the night.

Receiver: The noise-sensitive land use at which noise from a development can be heard

Significant period of time: In relation to temperature inversions, means at least 30 per cent of the total night-time during the winter months. In relation to wind speeds this means at least 30 per cent of the time or more in any assessment period (day, evening, night) in any season.

Sleep disturbance: Awakenings and disturbance to sleep stages

Spectral characteristics: The frequency content of noise.

Temperature inversion: An atmospheric condition in which temperature increases with height above the ground.

Temporal variation of noise: Variation in noise levels over time.

Tenth percentile method: See *Appendix B.*

Time of maximum impact: The time during which the difference between the background noise level and the source noise is expected to be greatest.

Tonality: Noise containing a prominent frequency and characterised by a definite pitch.

Transportation: Includes road, rail and air traffic.

Appendix A—Worked case studies

A1 General application case study

This case study aims to highlight the main aspects of the policy, and can be referred to in a number of different assessment situations.

Situation: New major development proposed in a high-traffic area

A major development is proposed across a major highway from a residential area. Apart from the site in question, the whole area is fully developed. There are other small industrial developments in the area. The noise impact of the proposed development needs to be assessed.

Important considerations

The proposal has the following characteristics:

- new development with existing receiver—hence, the assessment will require prediction of noise levels from the source.
- major development—the project is a major development with a potentially high noise risk due to its proximity to a residential area. Hence, long-term monitoring of existing noise levels is required to obtain an adequate measure of the existing background ($L_{A90,15\ minute}$) and ambient ($L_{Aeq,15\ minute}$) levels present in the area.
- residential area on a major highway—this fits the description of an 'urban' receiver type (*Table 2.1*), so the recommended acceptable noise level (ANL) for 'urban' areas applies. However, traffic noise levels may be high enough to make noise from stationary sources inaudible, even though it may exceed the ANL. As it is highly unlikely that traffic noise levels would decrease in future, the criterion for high traffic areas would apply in this case (*Section 2.2.3*).
- other small industrial developments present—the existing noise environment may be affected by noise from existing stationary sources.

Follow the assessment steps in *Table A1*.

Table A1. Assessment steps

1. Do a preliminary investigation	Visit site or rely on existing knowledge to determine whether traffic is the dominant source of noise and whether the existing industrial noise sources can be heard over high traffic levels for three assessment periods. Take sample measurements to determine whether the existing traffic noise level is likely to be more than 10 dB above the acceptable noise level (ANL—see *Table 2.1*) in each assessment period.
2. Determine existing noise levels	Record at least one week's worth of continuous valid data covering the period of operation of the proposed development. Monitor both the $L_{A90,15\ minute}$ and $L_{Aeq,15\ minute}$ levels. Although the measurement of $L_{A90,15\ minute}$ levels may include traffic, the measurement of existing $L_{Aeq,15\ minute}$ levels may exclude traffic and other non-industrial sources, except where traffic noise levels are more than 10 dB above the ANL. 1. Where existing traffic noise levels ≥ 10 dB above the ANL and existing stationary noise sources are inaudible due to traffic noise: • measure the $L_{Aeq,\ period(traffic)}$ 2. Where existing traffic noise levels < 10 dB above the ANL: • measure the existing $L_{Aeq,\ period}$ noise levels of industrial noise sources at the location potentially affected by noise from the new source. To isolate the industrial contributions to the noise levels from road traffic noise, measure in a different location or calculate the contribution as outlined in *Sections 3.2* and *3.2.1.* 3. Measure the background $L_{A90,15\ minute}$ levels so that the intrusiveness criterion can be determined. From the monitored data, determine single-figure values representing the background noise (RBL) and the existing $L_{Aeq,period}$ levels, using the methods outlined in *Sections 3.1* and *3.2* respectively. (Note in case (1) traffic noise levels are included in the $L_{Aeq,\ period}$, whereas in case (2) traffic noise levels may be excluded.)
4. Determine project-specific noise levels	In all cases both the intrusiveness and amenity criteria should be assessed *(Section 2*), however for case 1 (high traffic noise) the high traffic '$L_{Aeq,\ period(traffic)}$ –10 dB' criterion (*Section 2.2.3*) replaces the amenity criterion. The project-specific noise levels are the most stringent of the intrusive or amenity criteria.
5. Predict noise levels from the source	Investigate the potential for inversion effects as described in *Section 5*. Noise-level predictions should include inversion and wind conditions where the effects of these are expected to be significant. If the noise source is expected to contain annoying characteristics, apply adjustments to the predicted noise levels from the source as outlined in *Section 4*. The prediction should take the form of the descriptor used in the project- specific noise levels.
6. Compare with project- specific noise levels	If the predicted noise levels exceed the project-specific noise levels, the proposed development is likely to have a noise impact on nearby sensitive receivers.

A2 Intrusiveness, amenity and high-traffic criterion case studies

(a) New industrial development in a rural area

A new industrial development is proposed for a rural area affected by traffic noise. A noise survey of the area reveals a number of nearby residences with the following background noise levels:

- rating background levels of 33 dB(A) day, 31 dB(A) evening and 30 dB(A) night—determined using the procedure in *Section 3.1*.

The existing L_{Aeq} levels were found to be all due to traffic noise and natural sources (there being no other industrial noise sources in the area), so it was decided that the existing L_{Aeq} level from industrial noise was negligible. From *Table 2.1*, the project fits the description of a 'rural' receiver type, so the recommended acceptable noise level (ANL) for 'rural' areas applies here (that is, 50 dB(A) day, 45 dB(A) evening and 40 dB(A) night). As the existing level of noise from industrial sources is negligible, there is no need to reduce the ANL, as outlined in *Table 2.2*.

Hence, the criteria applicable to this project are as shown in *Table A2*.

From the table it can be seen that, if the intrusiveness criterion is met, the amenity criterion would automatically be met. Hence, the intrusiveness criterion is the limiting criterion and represents the project-specific noise levels to be applied to this project.

Table A2. Criteria applying to case study (a)

Period	Intrusiveness criterion[1]	Amenity criterion[2]
Day	38 dB $L_{Aeq,15\ minute}$ (33 + 5)	50 $L_{Aeq,Day}$
Evening	36 dB $L_{Aeq,15\ minute}$ (31 + 5)	45 $L_{Aeq,Even}$
Night	35 dB $L_{Aeq,15\ minute}$ (30 + 5)	40 $L_{Aeq,Night}$

Notes:

1. Intrusiveness criterion is $L_{Aeq,15\ minute} \leq$ RBL + 5 (*Section 2.1*)
2. Amenity criterion for rural areas (*Tables 2.1* and *2.2*, *Section 2.2*)

(b) New industrial development in a suburban area

A new industrial development is proposed for a suburban area. Natural sources and noise from another industry in the area dominate the existing noise levels at the site. Traffic can also be heard at the site as a very distant hum, with the main road being over 300 m away from the site and shielded by rows of houses. A noise survey of the area has determined the following existing noise levels:

- rating background levels of 51 dB(A) day, 48 dB(A) evening and 46 dB(A) night dominated by the general hum of the industry in the area and the distant traffic noise—determined using the procedure in *Section 3.1*
- existing $L_{Aeq,\ period}$ levels of 57 dB(A) day, 54 dB(A) evening and 52 dB(A) night—determined using the procedure in *Section 3.2.* Note that there was no need to eliminate traffic noise levels from the measurement, as they were considered low enough not to contribute to the levels. (See *Section 3.2.1*).

From *Table 2.1*, the project fits the description of a 'suburban' receiver type, so the recommended acceptable noise level (ANL) for 'suburban' areas applies (that is, 55 dB(A) day, 45 dB(A) evening and 40 dB(A) night). In this case, the existing industrial noise-source level exceeds the ANL, so the ANL needs to be reduced to control overall levels in the locality in order to protect amenity, as outlined in *Table 2.2*. As it is unlikely that existing noise levels will decrease in future, the criterion that applies here is 'existing level minus 10'.

Hence the criteria shown in *Table A3* apply to this project.

Table A3. Criteria applying to case study (b)

Period	Intrusiveness criterion[1]	Amenity criterion[2]
Day	56 dB $L_{Aeq,15\ minute}$ (51+ 5)	47 $L_{Aeq,Day}$
Evening	53 dB $L_{Aeq,15\ minute}$ (48 + 5)	44 $L_{Aeq,Even}$
Night	51 dB $L_{Aeq,15\ minute}$ (46 + 5)	42 $L_{Aeq,Night}$

Notes:

1. Intrusiveness criterion is $L_{Aeq,15\ minute} \leq$ RBL + 5 (*Section 2.1*)
2. Amenity criterion for suburban areas (*Tables 2.1* and *2.2*, *Section 2.2*)

In this case, the amenity criterion is the limiting criterion and represents the project-specific noise levels to be applied to this project.

(c) New industrial development in a high-traffic area

A new industrial development is proposed on a major highway. The noise environment at the nearest affected residences is dominated by traffic noise from the major highway. There are other industries in the area, but they cannot be heard above the traffic noise. A noise survey of the area has determined the following existing noise levels:

- rating background levels of 58 dB(A) day, 58 dB(A) evening and 44 dB(A) night dominated by traffic noise—determined using the procedure in *Section 3.1*
- existing $L_{Aeq,\ period}$ levels of 70 dB(A) day, 69 dB(A) evening and 66 dB(A) night—determined using the procedure in *Section 3.2*. Note that these levels were solely due to traffic.

Note: From an initial survey of the area and drawing on local knowledge, it was foreseen at the start of monitoring that existing traffic noise levels would be well over 10 dB above the ANL for the area ('urban' category—60 dB(A) day, 50 dB(A) evening, 45 dB(A) night). Hence, based on *Section 2.2.3*, there was no need to eliminate traffic noise levels from the measurement, as the high-traffic amenity criterion depends on the existing traffic noise level only. (If traffic noise levels had been less than 10 dB above the ANL, then one of the methods in *Section 3.2.1* could have been employed to exclude the traffic noise level.)

As the existing traffic noise levels are 10 dB or more above the ANL for the area, the high-traffic amenity criterion applies to this project. This is stated as '$L_{Aeq,period} \leq L_{Aeq,\ period(traffic)} - 10$' from *Section 2.2.3*.

Hence, the criteria that apply to this project are as shown in *Table A4*.

In this case the high traffic amenity criterion is the limiting criterion for the day and evening periods, and the intrusiveness criterion is the limiting criterion for the night period. The project-specific noise levels for this project comprise each of these.

Table A4. Criteria applying to case study (c)

Period	Intrusiveness criterion[1]	High traffic amenity criterion[2]
Day	63 dB $L_{Aeq,\ 15\ minute}$ (58 + 5)	**60 dB $L_{Aeq,Day}$ (70 –10)**
Evening	63 dB $L_{Aeq,\ 15\ minute}$ (58 + 5)	**59 dB $L_{Aeq,\ Even}$ (69 –10)**
Night	**49 dB $L_{Aeq,\ 15\ minute}$ 44 + 5)**	56 dB $L_{Aeq,\ Night}$ (66 –10)

Notes:

1. Intrusiveness criterion is $L_{Aeq,15\ minute} \leq$ RBL + 5 (*Section 2.1*)
2. High traffic amenity criterion (*Section 2.2.3*)

A3 Meteorological-enhancement case studies

(a) Area affected by temperature inversions

For proposed developments that operate at night, the effects of temperature inversions need to be considered. For case study (a) in the previous section, the assessment of noise enhancement (increase) caused by temperature inversions is as follows (using the procedure outlined in *Appendix C*).

Screening tests

Test 1. As the development will be operational 24 hours a day, the potential for noise increase resulting from temperature inversions warrants further investigation.

Test 2. An initial check to determine whether this increase in noise will have an impact on residents in the area is done, using default parameters in the noise prediction to estimate the upper level of impact. For a non-arid area a temperature inversion strength of 3 °C / 100 m applies, and for residents downhill from the source a drainage-wind-flow wind speed of 2 m / s also applies. (The screening test for non-arid areas assumes the presence of an F-class stability, as this category is much more likely to occur in these areas than G-class). An inspection of the area reveals that residences are located between 500 and 1000 m away from the source in a downhill direction. Using the table in *Appendix D*, the noise increase due to inversions is between 4 dB and 5 dB. Where this increase results in exceedance of the project-specific noise levels, further analysis is advisable to determine whether the actual occurrence of temperature inversions in the area is significant enough to warrant inclusion in the assessment.

Determining the extent of impact

W here further analysis is required, meteorological data need to be analysed to determine whether temperature inversions occur often enough to cause a significant noise impact. Existing weather data may be used, provided the subject area is within a radius of 30 km of the collection point and in the same topographical basin. *Table C4* in *Appendix C* outlines the methods that may be used to analyse the data, as well as the type of data and length of monitoring time (3 months in winter) required. By applying any one of the methods described in detail in *Appendix E,* one can predict both the type of inversion (in terms of a stability class) and the percentage occurrence of inversions. Where F or G-class inversions, or a combination of both, are predicted to occur for at least 30 per cent of the total night-time in winter, this is considered to be significant and warrants assessment. But if these inversions are predicted to occur for less than 30% of the total night-time, temperature inversions do not need to be included in the noise assessment. For the purposes of this case study, it is assumed that the F-class inversion occurs for more than 30 per cent of the night-time in winter and so requires assessment.

Using default or alternative parameters to predict noise

Now that it is certain that temperature inversions will be occurring for a significant amount of time, they should be included in the noise assessment. The noise assessment may use the default parameters specified (that is, 3°C / 100 m and 2 m / s), avoiding the need for on-site measurements. Otherwise on-site measurements may be conducted to determine the exact temperature inversion parameters to use in the prediction model. (See *Appendix C* for guidance on how to conduct on-site measurements.)

Assessing the impact

The predicted increase in noise level is then compared with the project-specific noise levels derived in the previous section for case (a) to determine what the noise impact will be.

(b) Area affected by gradient winds

The effects of gradient winds need to be considered in all assessments. Generally, wind-speed data need to be analysed to determine whether wind enhancement of noise warrants inclusion in the analysis. The assessment of wind effects needs to consider each season and, within those seasons, each assessment period (that is, day, evening and night).

Significant wind enhancement is deemed likely where a source-to-receiver component wind of up to 3 m / s occurs for 30 per cent of the time in any assessment period. However, this step may be bypassed by first assuming that wind is a feature of the area and then applying a default wind-speed of 3 m / s (in the direction from source to receiver) to the noise prediction to estimate the upper level of impact.

If no significant increase in noise is shown, then this should be reported, and no further analysis of the effects of gradient winds will be needed. Where impacts are significantly increased with this wind speed it is advisable to conduct a more detailed analysis of wind-speed data to confirm whether wind is a feature of the area.

Existing or measured data may be used as for temperature inversions. Wind roses offer a good visual interpretation of the occurrence of wind at a locality. These should be inspected to determine what, if any, wind speeds travel in the direction from source to receiver (or have components that travel from source to receiver); and of these, what wind speeds occur for more than 30 per cent of the total time in each season for each assessment period (day, evening, night). Where wind does not travel from source to receiver, it is not considered likely to have a significant impact and does not need to be included in the assessment. Similarly, if wind speeds up to 3 m / s do not occur for 30 per cent or more of the time in any season for any assessment period, gradient winds do not need to be included in the assessment. If a wind speed of up to 3 m / s occurs for 30 per cent of the time or more, then a default wind speed of 3 m / s can be used in the assessment. The following examples show what wind speed should be used in the assessment, when using data displayed by the wind rose.

- If the wind rose shows that a source-to-receiver component of wind up to 3 m / s occurs for at least 30 per cent of the time in any assessment period in any season, then the default wind speed of 3 m / s should be used in the assessment for the particular assessment period / s and season / s where it occurred.

- If the wind rose shows that a source-to-receiver component of wind less than 3 m / s occurs for at least 30 per cent of the time in any assessment period in any season, then the highest wind speed (below 3 m / s) may be used instead of the default.

- If the wind rose shows that there is less than 30 per cent occurrence of source-to-receiver component wind speeds up to 3 m / s, then wind is not included in the noise prediction calculation.

Assessing the impact

The parameters for wind direction and speed are then used to predict increased noise levels, which are then compared with the project-specific noise levels derived in the previous section for case (a) to determine what the noise impact will be.

A4 Existing premises case study

In dealing with noise impacts from existing premises it needs to be recognised that the means available to mitigate noise may be more limited than for new premises. For example, planning approaches that could avoid impact are generally not available at this stage (for example, spatial separation between source and receiver and attention to noise reduction in designs for residential and industrial buildings). Measures such as considering noise impacts when laying-out buildings on the industrial premises and when selecting equipment will be more limited, and may be a feasible consideration for existing premises only in the longer term.

In treating existing cases it is often necessary to take a structured approach to mitigation that starts with defining the problem, then identifies the range of feasible and reasonable controls that can be applied, then implements noise controls over time.

The following example provides a summary of how an existing premises with a noise problem can be addressed.

Example:
An existing scheduled premises is receiving complaints about noise from neighbouring residences. Currently the premises has no noise limits on its licence.

The EPA and the company have contacted complainants and it appears the complainants may have a genuine grievance.

The next step is to ascertain whether in fact there is a noise impact (that is, noise levels exceeding applicable project-specific noise levels for the site). After discussions with the residences the company agreed to the EPA's request to conduct a noise survey. The survey, conducted by an accredited acoustics practitioner, covered the following items:

- identified the most affected residences

- identified the activities on the site that caused the reported annoyance

- conducted a noise assessment without the existing premises operating, including background ($L_{A90,\ 15\ minute}$) and ambient ($L_{Aeq,\ 15\ minute}$) noise levels. (The short-term or long-term background and ambient noise methods may be used, depending on the extent of noise impact.)

- determined project-specific noise levels based on EPA noise criteria and applying the existing background and ambient noise levels

- measured noise levels from the site at the identified affected residences. (Where applicable, include adjustments to take account of any annoying characteristics of the noise.)

- compared measured noise levels (adjusted, where necessary) against the project-specific noise levels to determine the extent of impact

- discussed whether noise impacts may be increased by weather patterns (for example, winds and temperature inversions) typical to the area and estimated the extent of the increase

- discussed mitigation measures and the amount of noise reduction expected from each measure

- justified any residual impact (that is, remaining exceedances of the project-specific noise levels after feasible and reasonable mitigation measures have been applied).

The noise report showed that noise levels from the existing premises were well in excess of the applicable project-specific noise levels at nearby residences, being more than 15 decibels above the project-specific noise levels. The report outlined a range of mitigation measures that could reduce the noise levels at the site.

The mitigation measures involved re-organising schedules so that noisy activities occurred at less sensitive times; repair and ongoing maintenance to faulty bearings; fitting improved mufflers to a number of pieces of equipment; treating the building envelope by sealing some doorways and windows; erecting a small barrier; enclosing a number of pieces of equipment; and the possibility of acoustically treating a residential premises. Even with all these measures in place it was reported that there would still be minor exceedances of the project-specific noise levels. This was mainly due to the close proximity of adjoining residential properties.

Discussions between the EPA and the company ascertained that it was not economically feasible to implement all the mitigation measures at once. It was agreed to establish a timetable that covered progressive mitigation work over time that would both reduce noise levels at nearby receivers and allow the company sufficient time to achieve the required levels. (For example: re-organise schedules and repair bearing immediately, seal openings within 3 months, replace windows in 6 months and enclose generator in 12 months.)

Such a strategy and time-line was then incorporated into a pollution reduction program that formalised the proposed mitigation works.

A5 Urban/industrial interface case study

The 'urban / industrial interface' receiver category in *Table 2.1* may be applied for existing situations only where residences are close to industrial premises. The amenity levels for the 'urban / industrial interface' category are relevant for a region surrounding the industrial premises, extending out to a point where a 5-dB reduction in the source noise level from industry is reached. This takes account of how noise levels are reduced when moving away from a source.

In the existing premises example given above, the amenity criteria that would apply would be the 'urban / industrial interface' criteria if the industry were in an 'urban' area. It would apply for all residences in a region that extends out from the industrial boundary to a point where a 5-dB reduction in noise level is reached. This region may be determined by measuring the source noise level at each relevant industrial boundary and then moving back from each respective boundary until the noise level has dropped off by 5 dB. For residences beyond this point the amenity criteria for the 'urban' category would apply.

The following shows a fully worked example using the 'urban / industrial interface' category.

Example:
An existing scheduled premises is proposing to upgrade its premises. It operates 24 hours a day, seven days a week. There are residences adjoining its western boundary.

A noise survey of the area has determined the following existing noise levels at the adjoining residences:

- rating background levels of 47 dB(A) day, 45 dB(A) evening and 40 dB(A) night—determined using the procedure in *Section 3.1*
- existing $L_{Aeq, period}$ levels of 52 dB(A) day, 50 dB(A) evening and 48 dB(A) night dominated by the noise from other industry in the area—determined using the procedure in *Section 3.2*.

From *Table 2.1*, the project fits the description of an 'urban / industrial interface' receiver type, so the recommended acceptable noise level (ANL) for 'urban / industrial interface' area applies (that is, 65 dB $L_{Aeq, day}$, 55 dB $L_{Aeq, evening}$ and 50 dB $L_{Aeq, night}$). In this case the existing industrial noise in the area (not including the source in question) is within 6 dB of the ANLs for the evening and night periods, and hence the amenity criteria need to be reduced to control overall levels in the locality to protect amenity, as outlined in *Table 2.2*.

Hence the criteria in *Table A5* apply.

In this case the intrusive criterion is the limiting criterion and sets the project-specific noise level to be met by the development, including the proposed modifications, at the neighbouring residences. This project-specific noise level would be applicable to all residences in the region between the industrial premises and the point at which noise from the existing premises has decreased by 5 dB. Beyond this region the 'urban' category amenity criteria would apply. In this further region the existing background and ambient L_{Aeq} levels from industry would need to be measured at these residences and project-specific noise levels determined following the same steps as above but with the 'urban' amenity criteria.

To determine the extent of the 'interface' the instantaneous noise level of the existing industry noise can be measured at the relevant boundary (for example, in this example at the at the western boundary of the premises). Where the instantaneous noise levels varied—for example, from 48 to 52 dB(A)—the midpoint value of the range (that is, 50) may be used as the noise level representing the boundary noise level of the industry. Then instantaneous noise measurements should be taken at increasing distances away from the premises in the relevant direction (for example, to the west in this example) until the noise from the premises has fallen by 5 dB. The point at which this occurs defines the extent of the region where the 'urban / industrial interface' category applies.

Table A5. Criteria applying to urban/ industrial interface case study

Period	Intrusiveness criterion[1]	Amenity criterion[2]
Day	**52 dB $L_{Aeq,15\ minute}$ (47+ 5)**	65 $L_{Aeq,Day}$
Evening	**50 dB $L_{Aeq,15\ minute}$ (45 + 5)**	53 $L_{Aeq,Even}$
Night	**45 dB $L_{Aeq,15\ minute}$ (40 + 5)**	46 $L_{Aeq,Night}$

Notes:

1. Intrusiveness criterion is $L_{Aeq,15\ minute} \leq RBL + 5$ (*Section 2.1*)
2. Amenity criterion for urban/industrial interface areas (*Tables 2.1* and *2.2*, *Section 2.2*)

Appendix B—Applying the background noise policy

B1 Long-term background noise method

The long-term background noise measurement procedure should be used during the planning and consent stage for developments that have the potential to cause significant noise nuisance. Both the type of development and its proximity to noise-sensitive locations are important elements to be considered in deciding whether the long-term method is the most appropriate.

Some examples of developments that may present a high risk of noise impact include:

- extractive industries (for example, mines and quarries)
- industrial developments (for example, bitumen plants, coal works, crushing and grinding works, drum re-conditioning, power stations, refineries and timber mills)

Essentially, the procedure for determining long-term background noise involves two components:

1. determining a representative background noise level for each day / evening / night of the monitoring period. This level is termed the assessment background level (ABL), and is a single figure representing ***each*** day / evening / night for each monitoring site required for a particular project.
2. determining an overall level representing the day, evening and night assessment periods over the entire monitoring period. This level is termed the rating background level (RBL), and is determined based on the individual day / evening / night ABLs as outlined in *Section B1.3*.

The rating background levels are used in determining the intrusiveness criterion.

B1.1 Instrumentation requirements and siting

Background noise levels should be measured with a noise data logger that has an accuracy at least equivalent to the specifications of a Type 2 meter as stated in AS 1259. The data logger should be fitted with a windshield and should have a current laboratory calibration certificate or label in accordance with calibration requirements outlined in AS1259 and AS2659. Equipment should also be calibrated in the field in accordance with these standards.

Site the data logger(s) at the most- (or potentially most-) affected noise-sensitive location(s). If this is impractical, site the logger(s) at locations with a similar acoustical environment. Be careful to choose sites that are truly representative of the noise environment at the noise-sensitive receivers—for example, do not choose positions screened from dominant background noise sources such as road traffic if sensitive receivers are not screened from such sources. Locate the microphone 1.2 to 1.5 m above the ground and, where practicable, at least 3 to 5 m from walls, buildings and other reflecting surfaces. **Data loggers should be sited as far away from trees as practicable to avoid noise produced by wind blowing through foliage.**

During monitoring, set the meter to ‘Fast’ time weighting and ‘A’ frequency weighting.

A weather monitor that continuously monitors wind and rainfall data should be positioned within 5 m of the data logging equipment—ideally, in a place that is not shielded from the wind. The effect of weather on the instrumentation is of interest here, so the height of the monitor should correspond to that of the noise logging equipment. Where multiple monitoring sites are required for a particular project, it is best to have simultaneous weather monitoring at each noise logger location. However, weather conditions may be represented by a single weather monitor, provided this is within a 30-km radius of the site and in the same topographical basin. The weather monitor should record average wind speed (accuracy to within ± 0.5 m / s) at least once every 15 minutes (corresponding to the noise measurement interval) and record the time intervals of rainfall.

Monitoring should not be conducted (or monitoring data are to be excluded) when average wind speeds are greater than 5 m / s or during rain. Exceptions to this rule are allowed, provided the proponent is able to show that the wind-induced noise on the microphone and sound levels due to rain are at least 10 dB(A) below the background noise levels under investigation. For sites where high wind speeds are a feature of the area, monitoring may be permitted during higher wind speeds provided that the proponent is able to show that these wind speeds are a site feature and that the wind-induced noise on the microphone is at least 10 dB(A) below the noise levels under investigation.

B1.2 Measurement procedure

The steps involved in monitoring background noise levels for planning purposes are:

1. Calibrate the noise monitoring equipment in the field.
2. Monitor the background noise and meteorological conditions continuously for each day of the week the proposed development will be operating and over the proposed operating hours, using the $L_{A90,15minute}$ descriptor.
3. Note dominant and background noise sources present at the site throughout the monitoring period. Simultaneous data logging and tape-recording of noise levels and operator-attended measurements may be made at the site to support the identification and occurrence of noise sources.
4. Do a field calibration check at the end of the monitoring period in accordance with AS1259 and AS2659. Re-monitoring may be required if there is a calibration drift greater than that allowed by the standards.

B1.3 Analysis procedure

1. Remove any data that are affected by adverse weather conditions and / or extraneous noise. Check that the number and pattern of excluded $L_{A90,15\ minute}$ samples complies with the rules specified in Figure B1. If it does not, re-monitor the background noise following steps 1 to 4, but only for the affected assessment period in the corresponding day of the week. The underlying idea is to ensure that any patterns that occur are accounted for. These are often seen temporally throughout a day, diurnally, and from weekday to weekend.

   Exception: re-monitoring may not be required where monitoring contains weather-affected data if it can be ascertained that the affected samples are not within the expected 'quieter' times of an assessment period (day / evening / night)—that is, those time periods where the lowest tenth percentile background noise level might occur. In this case it should be fully justified in the noise-assessment report that the weather-affected data would not affect the lowest tenth percentile background noise level. This could be done through the clear identification of set daily noise patterns of 'quiet' periods exhibited by the measured data from the non-affected days. There should be enough non-affected data available for the assessor to be confident that any pattern identified is valid. For these cases the affected samples need **not** be removed from the data set before the tenth percentile is determined in Step 2.

Figure B1. Data exclusion rule

1. For every 4 consecutive values (-) there should be no more than 2 samples missing (x), for e.g.:

   Single invalid 15-minute samples: - - - x - - - x - - - x - - - or

   - - x - - x - - x - - x - - or

   - x - x - x - x - x - x -

   Double invalid 15-minute samples: - - x x - - x x - - x x - -
2. Where the maximum number of invalid samples (x) is greater than 8, 2 or 4 for day, evening and night respectively, then the corresponding period (day/evening/night) should be monitored again.
3. Where there are more than two consecutive invalid (x) samples, only one occurrence of the following pattern is allowed before re-monitoring is required.

   Triple invalid 15-minute samples: - - - x x x - - -

Table B1. Method for determining the tenth percentile

Step 1	Sort the $L_{A90,15\ minute}$ data in each assessment period in **ascending** order.
Step 2	Work out the tenth per cent **position** of the number of samples in the assessment period. This can be calculated by multiplying the number of $L_{A90,\ 15\ minute}$ values in the assessment period by 0.1.
Step 3	Determine the tenth percentile (essentially the lowest tenth per cent value): If the tenth per cent **position** (from Step 2) is an integer, then the tenth percentile is determined by taking the arithmetic average of the value of the $L_{A90,\ 15\ minute}$ at the tenth per cent position and the next highest value. If the tenth per cent **position** (from Step 2) is not an integer, then the tenth percentile is the next highest $L_{A90,\ 15\ minute}$ value above the value at the tenth per cent position. ***Examples:*** 1. For a data set of size 40, the tenth per cent position is 4 (i.e. 0.1 x 40). As this is an integer, the tenth percentile is the average of the values at the 4th position and the 5th position, counting from the lowest value of the sorted data (from Step 1). 2. For a data set of size 44, the tenth per cent position is 4.4 (i.e. 0.1 x 44). As this value is not an integer, the tenth percentile is the value at the 5th position counting from the lowest value of the sorted data (from Step 1).

2. Determine an assessment background level for each day (0700 to 1800), evening (1800 to 2200) and night (2200 to 0700), using the tenth percentile method (essentially represents the lower tenth percent value). The tenth percentile method may be determined automatically using a spreadsheet package, or manually by applying the method shown in *Table B1*.

3. Determine the rating background level to be used for assessment purposes. This is taken to be the median value of the corresponding day / evening / night assessment background levels. For example, for a week's worth of monitoring, the evening rating background level is the median of the seven evening assessment background levels—that is, the fourth highest (or lowest) value. Where this level is found to be less than 30 dB(A), the rating background level is set to 30 dB(A).

B2 Short-term background noise method

The short-term method is the more appropriate background noise monitoring technique for:

- establishing the difference between the background noise level and the source being measured
- checking the noise compliance of a development
- determining the effect of background noise on a source-noise measurement.

B2.1 Instrumentation requirements and siting

To measure background noise levels, use a sound-level meter that meets the specifications of a precision (Type 0 or 1) or general-purpose (Type 2) sound-level meter as stated in the AS 1259. Fit a windshield over the microphone before taking any measurements. If equipment other than a sound-level meter is used, the resulting measurement should be at least as accurate as a measurement made with a sound level meter as specified above. The equipment should have a current laboratory calibration certificate or label in accordance with the calibration requirements outlined in AS1259 and AS2659. Equipment should also be calibrated in the field in accordance with the standards. Use a portable sound-level calibrator (in current calibration) for field-checking purposes.

Wind speed during monitoring should be less than 5 m / s (equivalent to number 3 on the Beaufort wind scale—that is, leaves and small twigs in constant motion; wind extends small flag).

Take the background noise measurement at the most affected noise-sensitive location. If responding to a noise complaint, take the measurement as close as practicable to where the noise impact is alleged to occur.

Measure the background noise in the absence of both the noise under investigation and any extraneous noise not typical of the area. If it is not possible to exclude the source under investigation, then measure the background noise at a remote location judged to have a similar noise environment.

Hold the sound-level meter at arm's length or set it up on a tripod so the microphone is 1.2 to 1.5 m above the ground and at least 3 to 5 m from walls, buildings and other reflecting surfaces. During monitoring, set the meter to 'Fast' time weighting and 'A' frequency weighting. Do not take measurements when it is raining or when the average wind speed at microphone height exceeds 5 m / s.

B2.2 Measurement procedure

1. During the period of the day for which the noise source is expected to operate, determine the time when the greatest impact is likely to occur and take measurements at this time. (Note: This is often when the difference between the measured background noise and the noise level generated by the new or existing development is greatest.)
2. Field-calibrate the noise monitoring equipment.
3. Measure the background noise level continuously for 15 minutes, excluding all distinct extraneous noises. (Because of the short period over which the background noise is being measured, distinct extraneous noises, including noise from transportation, conversation, birds and insects, should be excluded from the measurements.) If extraneous noise is present, pause the meter when this noise occurs or choose another measuring time or location.

   The rating background level to be used for assessment purposes is the $L_{A90,\ 15\ minute}$ level produced by a statistical meter.
4. Check the field calibration at the end of the monitoring period in accordance with AS1259 and AS2659. Re-monitoring may be required if there is a calibration drift greater than that allowed by the standards.
5. If two or more valid measurements of background noise are recorded at the one location, adopt the lowest level as the background level.

Note: If the measured background level is less than 30 dB(A), then the rating background level is considered to be 30 dB(A).

B3 Reporting requirements

Include the following items in a report to support the determined rating background level:

B3.1 Long-term method

- details of equipment used (include latest calibration date), equipment settings and sampling rate of the logger used
- a statement justifying the choice of monitoring site, including the procedure used to choose the site, having regard to the definitions of 'noise-sensitive location(s)' and 'most-affected location(s)' described in *Section 3.1.2*
- details of the exact location of the monitoring site and a description of land uses in surrounding areas
- a brief description of where the equipment was positioned
- a description of the dominant and background noise sources at the site
- a record of periods of affected data (due to adverse weather and extraneous noise) and statement indicating the need for any re-monitoring under Step 1 in *Section B1.3*.
- day, evening and night assessment background levels for each day of the monitoring period
- the final RBL value.

B3.2 Short-term method

- details of equipment used (include latest calibration date), equipment settings and the sampling rate of the meter

- a statement justifying the choice of monitoring site and period, including the procedure used to choose the site, having regard to the definitions of 'noise- sensitive location(s)' and 'most-affected location(s)' described in *Section 3.1.2*

- a description of the dominant and background noise sources at the site

- a record of weather conditions during monitoring

- the measured background noise levels.

Appendix C Procedure for assessing noise increase due to temperature inversions

C1 Introduction

The procedure for assessing the increase in noise caused by temperature inversions involves the following main steps:

- **Do an initial screening test** to determine whether there is the potential for increased noise levels due to inversions, and whether further detailed analyses are warranted.
- **Determine the extent of impact**. Where there is the potential for inversions to increase noise levels, the actual extent of impact (in terms of percent occurrence of inversions) for the locality being assessed is to be determined. Where inversions are predicted for more than 30 per cent of the total night-time during winter, these are considered to be significant and should be taken account of in the noise assessment.
- **Predict the level of noise using default or alternative parameters** to determine the increase in noise levels expected due to inversions. Default inversion parameters are specified to avoid the need for potentially costly on-site monitoring, but, if preferred, other values based on direct measurements may be used.
- **Assess the impact** to determine whether the increased noise levels due to inversions will affect receivers in the vicinity of the development. The predicted increased noise levels are compared with the project-specific noise levels to determine if any exceedances (and hence noise impacts) are expected.

Table C1. Initial screening test procedures

Test	Procedure
1. Night-time operation	Determine whether the development in question operates at night (2200 to 0700). If the development operates at night, do screening test 2 to determine the potential for impact. If the development does not operate at night, there is no potential for noise impact due to inversions, and no further consideration of these effects is required.
2. Test for maximum possible level of impact	Do a noise-prediction assessment, assuming the following meteorological conditions to represent the upper level of impacts: **Non-arid areas (average annual rainfall 500 mm or more)** • temperature inversion strength: 3°C/100 m • source-to-receiver drainage-wind speed where applicable[1]: 2 m/s at 10 m height **Arid and semi-arid areas (average annual rainfall less than 500 mm)** • temperature inversion strength: 8°C/100 m • source-to-receiver drainage-wind speed where applicable[1]: 1 m/s at 10 m height If the predicted noise levels show an increase of less than 3 dB, meteorological effects are not considered to be an issue and no further consideration of these effects is required. If a greater than 3 dB increase is predicted, meteorological effects are an issue and further work is needed to determine the meteorological conditions applicable to the site in question. (*See Table C2.*) ***(Table D1 in Appendix D may be used as a guide to predicting the effect of inversions for this Step.)***

Note:

1. The drainage-flow wind default value should generally be applied where a development is at a higher altitude than a residential receiver, with no intervening higher ground (for example, hills).

Table C2. Procedure for assessing meteorological effects

<table>
<tr><th>Alternatives for assessment</th><th>Procedure</th></tr>
<tr><td>1. Use existing data to determine meteorological noise impact relevant to the area</td><td>Analyse site-specific meteorological data using one of the four existing data methods detailed in Table C4 to determine the percentage occurrence of atmospheric stability category F[1] or G[2] temperature inversions.

If the frequency of temperature inversions during the winter months is less than 30 per cent of the total night-time (for inversions this is from 1 hour before sunset to 1 hour after sunrise, taken to be 6 pm to 7 am), these effects are not considered significant and no additional noise predictions are needed.

If temperature inversions occur for 30 per cent of the total night-time or more during the winter months, adopt the following default values to predict noise impact:

Where rainfall ≥ 500 mm/year

F-class inversions
• inversion: 3°C/100 m
• source-to-receiver drainage-wind speed where applicable[3]: 2 m/s at 10 m height

G-class inversions
• inversion: 4°C/100 m
• source-to-receiver drainage-wind speed where applicable[3]: 3 m/s at 10 m height

Where rainfall < 500 mm/year

G-class inversion
• inversion 8°C/100 m
• source-to-receiver drainage-wind speed where applicable[3]: 1 m/s at 10 m height

Apply the above meteorological parameters to the noise prediction and determine the increased noise level.

Compare the final predicted level with the project-specific noise levels to assess the noise impact.

If the default temperature inversion and wind drift parameters are not acceptable to the developer, the actual temperature inversion strength and wind speed may be measured. (See Alternative 2 below.)</td></tr>
<tr><td>2. Use actual measurements to determine meteorological noise impact relevant to the area</td><td>Measure the actual temperature inversion strength and wind speed using the ‘Direct measurement of temperature lapse rate’ method outlined in Table C4.

Use these measurements to predict noise levels and compare the prediction with the project-specific noise levels to assess the noise impact.</td></tr>
</table>

Notes:

1. F-class stability category corresponds to moderate inversions.
2. G-class stability category corresponds to strong inversions.
3. The drainage-flow wind default value should generally be applied where a development is at a higher altitude than a residential receiver, with no intervening higher ground (for example, hills).

The sections below outline the procedure in detail.

C2 Initial screening tests

There are two tests used to determine whether the potential for an increase in noise due to temperature inversions warrants further assessment:

- **No night-time operation**. As temperature inversions are usually prominent during night-time hours there is no need to consider their effects for a development that does not operate at night.

- **No significant noise impacts**. Where inversion conditions are expected to increase noise by less than 3 decibels, no further analysis is required.

Table C1 summarises these initial screening test procedures.

C3 Determining the extent of impact

Table C2 sets out the general procedure for assessing inversion effects. The procedure involves determining the percentage occurrence of moderate and strong inversions during the winter season, based on meteorological data from the locality. (Weak inversions are not included, as they are not considered to have a significant noise impact.)

Where inversions are predicted for at least 30 per cent of the total time at night in the winter season (or approximately two nights per week), inversion effects are considered to be significant and should be taken into account in the noise assessment.

In NSW, the Hunter region has been identified as an area significantly affected by temperature inversions. For this reason, the area has been studied in detail and, as a result, a shorter procedure for determining the potential for impact in the Hunter region is outlined in *Section C4.*

C4 Identifying the extent of impact in the Hunter region

For sites located in the Hunter region, weather data do not need to be analysed, as the strength and frequency of F-class temperature inversions have already been determined for the entire region. Recent surveys have indicated that the incidence of F-class inversions are widespread in the Hunter Valley and hence, the F-class inversion category may be used as the default category for assessing inversion effects in this region as outlined in *Table C3*.

C5 Determining the potential for enhancement from temperature inversions

The procedure for assessing enhancement from temperature inversions is based on the relationship between temperature inversions and the Pasquill Stability Categories.

Table C4 summarises four different methods used to determine the strength and frequency of temperature inversions, based on atmospheric stability categories. The first three methods may be applied using existing meteorological data or simple measurement techniques to predict the frequency of a particular atmospheric stability category. The last method involves direct measurement of temperature lapse rate and wind speed. All methods rely on a minimum of three months of weather data collected during the winter season (that is, the maximum level of impact) to determine the effect of temperature inversions.

One of these alternative methods may be used to determine the significance of temperature inversions when assessing the noise impact of developments during the planning and approval phase. Note that more definitive information is provided for sites in the Hunter region. (See *Section C4.*)

Table C3. Procedure for assessing meteorological effects in the Hunter region[1]

Step	Procedure
1. Determine the exact location of the development	Identify the International Standard Grid (ISG) map grid coordinates of the area in question. Take care to identify the full extent of the area surrounding the development that is likely to be affected.
2. Determine the percent occurrence of temperature inversions	From *Table F1* in *Appendix F,* read the percentage occurrence of F-class temperature inversions corresponding to the map coordinates that cover the full extent of the area.
3. Determine the meteorological impact, based on existing data	If the frequency of temperature inversions is less than 30 per cent at this location, these effects are not considered significant and no additional noise predictions are needed. If temperature inversions occur for 30 per cent of the total night-time or more often during the winter months, adopt the following default value to predict noise impact: **F-class inversions** • inversion: 3°C/100 m • source-to-receiver drainage-wind speed where applicable[2]: 2 m/s at 10 m height Apply these inversion parameters to the noise prediction and determine the increased noise level. Compare the final predicted level with the project-specific noise levels to assess the noise impact. If the default temperature-inversion and wind-drift parameters are not acceptable to the developer, then the actual temperature inversion and wind speed may be measured as in Alternative 2, *Table C2*.

Note:

1. The proponent may elect to determine inversion frequency and strength through one of the four methods set out in *Table C4.* If a significant incidence of G-class inversions is established, then the default values for G-class inversions (set out in *Table C2*) should be applied.
2. The drainage-flow-wind default value should generally be applied where a development is at a higher altitude than a residential receiver, with no intervening higher ground (for example, hills).

Table C4. Methods for determining the strength and frequency of temperature inversions

Features	Existing/simple data methods			Direct measurement
	Pasquill-Gifford scheme	Turner scheme	Sigma-theta method	Temperature lapse rate
Type of monitoring/ parameters required	Hourly or three-hourly cloud cover, hourly or three-hourly average wind speed at 10 m height.	Hourly or three-hourly cloud cover, cloud-ceiling height, hourly or three-hourly average wind speed and direction at 10 m height.	Time of day, wind speed and direction, sigma-theta, surface roughness/ vegetation cover.	Lapse rate, hourly temperature at height intervals of 10 to 60 m.
	(For all the above, see Appendix E for full method.)			
Length of monitoring	Collect three months' data continuously during winter for night-time (6 pm to 7 am).			
Monitoring location	Collect weather data at minimum height of 10 m. Available weather data may be used to represent weather conditions within a radius of 30 km from the measurement point in the same topographical basin; otherwise data needs to be collected as it is terrain-dependent.			
Assessment time period	Night (2200 to 0700 h)			

Appendix D Estimating noise increase due to inversions

Table D1 may be used as a rough guide for predicting inversion effects at a site at the **initial screening test stage**.

The table gives an estimate of the decibel difference in noise levels predicted with and without inversion conditions representing an increase in noise levels as a result of the inversion. The levels are based on calculations performed using ENM ver. 3.06, assuming a simple flat ground and no barrier model.

Table D1. Increase in noise level due to inversions

Distance (m)	Increase in noise level, dB			
	3°C/100 m	3°C/100 m and 2 m/s	8°C/100 m	8°C/100 m and 1 m/s
100	1.0	2.0	2.0	3.0
200	1.0	3.0	3.0	4.0
300	1.0	3.0	3.0	4.0
400	1.5	3.5	3.5	5.0
500	1.5	4.0	4.0	5.5
600	1.5	4.5	4.5	6.5
700	1.5	5.0	5.0	6.5
800	1.5	5.0	5.0	6.5
900	1.5	5.0	5.0	6.5
1000	1.5	5.0	5.0	6.5
1500	1.5	4.5	5.0	6.5
2000	1.5	4.5	5.0	6.5
2500	1.5	4.5	4.5	6.5
3000	1.5	4.5	4.5	6.0
4000	1.5	4.0	4.0	6.0
5000	1.0	4.0	4.0	5.5

Notes:

The above data represent the results of single-point source calculations performed using ENM ver. 3.06 assuming a broadband noise source rounded-off to the nearest 0.5 dB. The following parameters were adopted in the calculations:

- temperature 12°C (winter), humidity 85%
- wind direction from source to receiver (270°)
- source height 3 m, receiver height 2 m
- rural, ground type: grass, rough pasture.

Appendix E Methods for determining the frequency of temperature inversions

E1 Background

An important part of the assessment of noise enhancement due to inversions involves determining whether inversions occur frequently enough to warrant inclusion in the assessment. It is considered unreasonable to expect a development to comply with noise limits under inversion conditions if inversions occur infrequently.

The frequency of occurrence of temperature inversions may be determined either by direct measurement of inversion parameters, or by using indirect methods that allow the prediction of wind and temperature profiles to within a moderately narrow range using readily available meteorological data. The direct-measurement method will result in actual temperature gradients and drainage-flow-wind speeds from which the percentage occurrence of inversions may be determined. The indirect methods, on the other hand, allow the susceptibility of an area to inversions to be determined through the use of the relationship developed by the US Atomic Energy Commission between atmospheric stability categories and inversions. The relationship shown in *Table E1* outlines the range of temperature gradients that can be expected within each stability category. Hence, if a stability category is known, then the range of possible temperature gradients may be inferred.

A positive temperature gradient signifies a temperature inversion; hence, from the table below, inversions occur during E, F and G stability categories. These three categories are considered to represent weak, moderate and strong inversions respectively. For noise-assessment purposes, only moderate and strong inversions are considered significant enough to require assessment.

Table E1. Stability categories based on DT/DZ

Stability category	Range of vertical temperature gradient (°C/100 m)
A	DT/DZ < –1.9
B	–1.9 ≤ DT/DZ < –1.7
C	–1.7 ≤DT/DZ < –1.5
D	–1.5 ≤ DT/DZ < –0.5
E	–0 .5 ≤ DT/DZ < 1.5
F	1.5 ≤ DT/DZ < 4.0
G	4.0 ≤ DT/DZ

Three basic schemes may be used to determine the occurrence of different stability classes at a particular site based on the following combinations of meteorological parameters:

1. Direct measurement of temperature lapse rate over the height interval range of 1.5 to 10 m and 50 to 60 m, and wind speed at 10 m height.
2. Cloud cover, wind speed and solar elevation (Pasquill-Gifford scheme and Turner scheme).
3. Measurements of sigma-theta (the standard deviation of wind direction), wind speed and time of day.

All methods involve analysing three months of meteorological data collected in winter—the season during which most inversions occur. Wind measurements are to comply with AS 2923, *Ambient Air—Guide for measurement of horizontal wind for air quality applications*.

E2 Direct measurement of temperature lapse rate

This method involves the measurement of temperature gradient and wind speed at hourly intervals over the three winter months. The temperature gradient measurement involves measuring temperature at two elevated levels (1.5 to 10 m and 50 to 60 m) over a 50-m height interval to determine the temperature difference. The temperature gradient is then the temperature difference (that is, the temperature at the higher elevation minus the temperature at the lower elevation) divided by the height difference. The wind speed should be measured at a height of 10 m. Care should be taken to ensure that measurement procedures comply with relevant standards.

Table E2. Step procedure for determining inversion parameters to be used in the assessment

Step	Procedure
1.	Sort the night-time (period between 1 h before sunset to 1 h after sunrise taken to be 6 pm to 7 am) temperature gradients with associated wind speed in ascending order.
2.	Convert the temperature gradients into their corresponding stability categories according to *Table E1*.
3.	If F or G stability categories occur for a period of 30 per cent of the total night-time or more, either separately or in combination, then temperature inversions are considered to be a significant feature of the area and need to be assessed.
4.	Determine the ninetieth percentile temperature gradient value from the full data set created at Step 2 (that is, the highest tenth per cent value). This may be done automatically using the percentile function available in many spreadsheet programs; or the value may be determined manually by sorting the data in ascending order by temperature gradient and choosing the highest tenth per cent value. The wind speed associated with the chosen temperature gradient is the one to be used in the assessment.

Once all data have been collected, the percentage occurrence of each stability category may be determined. From the measured data, the temperature gradient to be used in predicting increased noise levels due to inversions is the ninetieth percentile value (that is, the highest tenth per cent value) of temperature gradients that occur during the night time in winter. The wind speed to be used in the assessment is that associated with the ninetieth percentile inversion strength. A step-by-step guide to the analysis procedure is given in *Table E2*.

E3 Classifications of stability category based on cloud cover

The most widely used stability classification scheme is that developed by Pasquill (1961). This is based on observations of cloud cover, wind speed and solar elevation. This scheme has been modified by Turner (1964) to create an alternative scheme that is more amenable to application with computer-based databases. Both schemes are discussed below.

Table E3. Key to Pasquill stability categories[a]

Hourly average wind speed at 10 m (m/s)	Daytime stability categories	Stability categories based on night cloud cover[(b)] (Night = 6 pm to 7 am)	
		Thinly overcast or ≥ 4/8 low cloud	≤ 3/8 cloud
< 2	A—D	G	G
2–3		E	F
3–5		D	E
5–6		D	D
> 6		D	D

Source: Adapted from Pasquill (1961)

a. In dispersion modelling, stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme (as used in this study) there are six stability classes, A through to F. Class A relates to unstable conditions, such as might be found on a sunny day with light winds. Class F relates to stable conditions, such as those that occur when the sky is clear, the winds are light and an inversion is present. The intermediate classes B, C, D and E relate to intermediate dispersion conditions. A seventh class, G, has also been defined to accommodate extremely stable conditions such as might be found in arid rural areas.

b. The neutral category D should be used for overcast conditions regardless of wind speed.

E3.1 Pasquill-Gifford scheme

The Pasquill-Gifford scheme, outlined in *Table E3*, essentially determines Pasquill stability categories based on hourly or three-hourly wind-speed and cloud-cover measurements. Once these are known, the percentage frequency of temperature inversions over the three winter months may be predicted using the relationship in *Table E1*. The following data are required for the analysis collected over the three winter months:

- hourly or three-hourly wind speed and direction at 10 m (the wind direction is not required to determine the Pasquill Stability category but is required for the noise analysis)
- hourly or three-hourly cloud cover measurements
- times of sunrise and sunset recorded on a daily basis (these times are required to define the night-time period) or assumed to be 7 am and 6 pm, respectively.

The required data may be obtained from the Bureau of Meteorology from data collected at the closest monitoring station. The parameters needed are available from selected Bureau of Meteorology stations across NSW. Wind speeds and wind directions are subject to considerable local variation. However, cloud cover is generally not subject to such strong spatial variations and, consequently, data from a station some distance away may be acceptable. Whether or not data apply to a particular site needs to be critically assessed. For cloud cover, distance from the coast and ground elevation will have an important bearing on the cloudiness. In general, data collected from weather-monitoring stations are considered relevant for a radius of 30 km from the station, provided the surrounding area is in the same topographical basin as the station.

If representative cloud data are not available from a nearby station, it is advisable to use the sigma-theta method outlined in *Section E4* instead to determine stability categories. This is because the numerous individual observations needed to measure cloud cover for the Pasquill-Gifford method are often not feasible.

E3.1.1 Determining the frequency of occurrence of inversions

Once the stability categories have been determined for all the data collected during the period from 6 pm to 7 am, the percentage occurrence of moderate and strong inversions occurring during F and G stability categories, respectively, may then be determined. **The percentage occurrence required here is the total percentage occurrence for the night periods over the three months of winter. The Pasquill-Gifford scheme assumes that moderate and strong inversions do not occur during the daytime hours (considered here to be from 7 am to 6 pm).**

Where the sum total of F and G inversions occur for at least 30 per cent of the total night-time in winter, the project area is considered to be significantly affected by inversions warranting noise assessment. Default values to be used when assessing the impact on noise caused by temperature inversions during F and G stability conditions are presented in *Section E6*. The F-category default values are to be used in noise prediction where a combination of F- and G-category inversions is predicted. The G-category default values are to be used in noise prediction only where G-category inversions are predicted for at least 30 per cent of the total night-time in winter.

E3.2 Turner scheme

The Turner scheme recognises that stability near the ground depends mainly on net radiation and wind speed, with net radiation being a function of cloud cover and the height of the cloud ceiling. This scheme determines stability categories based on hourly or three-hourly wind measurements of cloud cover, cloud-ceiling height, wind speed and wind direction. As with the previous scheme, the percentage occurrence of temperature inversions over the three winter months may be predicted using the relationship in *Table E1*. The following data need to be collected over the three winter months for analysis:

- hourly or three-hourly wind speed and direction at 10 m (wind direction is not required to determine the Pasquill Stability category, but is required for the noise analysis)
- hourly or three-hourly cloud cover measurements

- hourly or three-hourly cloud ceiling-height measurements

- daily records of time of sunrise and sunset (needed to define the night-time period) or assumed to be 7 am and 6 pm, respectively.

Similarly, the required data may be obtained from the Bureau of Meteorology from data collected at the closest monitoring station. (See *Section E3.1* considerations relating to the applicability of data to a site.)

If representative cloud data are not available from a nearby station, it is advisable to use the sigma-theta method outlined in *Section E4* instead to determine stability categories. This is because the large number of individual observations needed to measure cloud cover for the Turner scheme may not be feasible.

Table E4 gives the stability class as a function of wind speed and net radiation. The net radiation index for the night period ranges from –1 to –2 (negative radiation is radiation directed away from the earth). **Note that the Turner scheme assumes that moderate and strong inversions do not occur during daytime hours (considered here to be the period from 7 am to 6 pm).**

Note also that, in the specifications for this scheme, cloud-cover data are assumed to be available in 1 / 10^ths^. Usually data from the Bureau of Meteorology are reported in 1 / 8^ths^, so some conversion will need to be done.

Table E4. Stability class as a function of net radiation and wind speed

Wind speed		Net radiation index		
knots	m/s	0	–1	–2
0–1	0–0.7	D	F	G
2–3	0.8–1.8	D	F	G
4–5	1.9–2.8	D	E	F
6	2.9–3.3	D	E	F
7	3.4–3.8	D	D	E
8–9	3.9–4.8	D	D	E
10	4.9–5.4	D	D	E
11	5.5–5.9	D	D	D
≥ 12	≥ 6.0	D	D	D

The net radiation index to be used in *Table E4* is:

1. If the total cloud cover is 10 / 10 and the ceiling is less than 7000 feet, use net radiation index equal to 0 (whether day or night).
2. For night-time (from 6 pm to 7 am):

   —If total cloud cover ≤ 4 / 10, use net radiation index equal to –2.

   —If total cloud cover >4 / 10, use net radiation equal to –1.

Follow the procedure outlined in *Section E3.1.1* to determine the percentage occurrence of temperature inversions once the stability-category classifications have been made.

E4 Use of sigma-theta data

The sigma-theta method, developed by the US EPA, refers to observations of sigma-theta, wind speed and time of day. With this method the Pasquill stability categories may be determined by using a relationship between stability categories and the standard deviation of the horizontal wind direction fluctuations (σ_A in degrees). The scheme is applied in one step to determine the daytime stability category and two steps to determine the night-time stability category as follows:

- the daytime (from 7 am to 6 pm) stability category may be determined directly from σ_A data using *Table E5*

- the night-time (from 6 pm to 7 am) stability category may be determined in two steps:

  —determine the stability category from σ_A data using *Table E5*.

  —modify this stability category based on prevailing wind speed using *Table E6*.

Sigma-theta data may be measured on an hourly or three-hourly basis and should be collected as specified in Australian Standard AS–2923.

Table E5. Wind flucuation criteria for estimating Pasquill-Gifford stability categories for non-arid areas in NSW[1,2]

Pasquill stability category	Standard deviation of the horizontal wind direction fluctuations[3,4] (σ_A in degrees)
A	$\sigma_A \geq 22.5°$
B	$17.5° \leq \sigma_A < 22.5°$
C	$12.5° \leq \sigma_A < 17.5°$
D	$7.5° \leq \sigma_A < 12.5°$
E	$3.8° \leq \sigma_A < 7.5°$
F	$2.1° \leq \sigma_A \leq 3.8°$
G[5]	$\sigma_A \leq 2.1°$

Adapted from: Irwin (1980) and US EPA (1987)

Notes:

1. These criteria are appropriate for steady-state conditions, a measurement height of 10 m, for level terrain, and an aerodynamic surface roughness length of 15 cm. Ensure that the wind sensor is responsive enough for use in measuring wind direction fluctuations (US EPA 1987).
2. The NSW EPA recommends that the sigma-theta method not be used for arid or semi-arid areas (US EPA 1987).
3. For areas with surface roughness different from 15 cm, the ***table*** values should be modified by multiplying by the surface roughness factor of $(z_o/15 \text{ cm})^{0.2}$, where z_o is the average surface roughness in centimetres within a radius of 1 to 3 km of the source. Note that this factor, while theoretically sound, has not been subjected to rigorous testing and may not improve the estimates in all circumstances. A table of z_o values that may be used as a guide to estimating surface roughness is given in Smedman-Hogstrom and Hogstrom (1978).
4. These criteria are from an NRC proposal (NRC 1972). It would seem reasonable to restrict the possible categories of A through D during daytime hours with a restriction that, for 10-m wind speeds above 6 m/s, conditions are neutral. Likewise, during the night-time hours, some restrictions (as in *Table E6)* are needed to preclude occurrences of categories A through C.
5. Supplemented by data from Mitchell and Timbre (1979) and US EPA (1980).

Table E6. Night-time[1] Pasquill-Gifford stability categories based on σ_A from Table E5

If the σ_A stability category is:	And the wind speed at 10 m is (m/s):	Then the Pasquill stability category is:
A	< 2.9	F
	2.9–3.6	E
	≥ 3.6	D
B	< 2.4	F
	2.4–3.0	E
	≥ 3.0	D
C	< 2.4	E
	≥ 2.4	D
D	Any	D
E	3 to 5[2]	E
F	2 to 3[2]	F
G	< 2[2]	G

Adapted from Irwin (1980) and US EPA (1987).

Notes:

1. Night-time is considered to be from 6 pm to 7 am.
2. The original Mitchell and Timbre (1979) table had no wind speed restrictions. However, the original Pasquill criteria suggest that, for wind speeds greater than or equal to 5 m/s, the D category would be appropriate; and for wind speeds between 3 m/s and 5 m/s, the E category should be used. For wind speeds between 2 m/s and 3 m/s, the F category should be used, and for wind speeds less than 2m/s, the G category should be used.

Note: *Table E5* strictly applies only when the σ_A measurements are made in an area where the surface roughness is 0.15 m. To apply the scheme using σ_A data collected in an area where the surface roughness is different, the limit in the table should be modified by multiplying it by:

$(z_o / 15 \text{ cm})^{0.2}$ where z_o = the surface roughness of the area in centimetres

For example, if the surface roughness is 0.20 m, the first limit in *Table E5* (that is, 22.5°) should be changed to 23.8° (i.e. $22.5° \times (20/15)^{0.2}$).

Table E7 shows the typical surface roughness that applies for a range of surfaces.

Table E7. Aerodynamic roughness of various surfaces

Surface	Comments	Roughness (z_o) (m)
Water	Still, open sea	0.1–10.0x10^{-5}
Sand, open desert		0.0003
Open soil		0.001–0.01
Grass	Mown lawn: 0.02–0.10 m Rough pasture: 0.25–1.0 m	0.003–0.01 0.04–0.10
Short scrub, long grass and most field crops		0.05–0.10
Forest		0.6–2
Suburban area		0.6
City		0.6–2

E5 Discussion

In summary, the above discussion outlines three independent ways that readily-available or easily-collected meteorological data can be analysed to estimate the frequency with which atmospheric stability categories of different classes occur.

It is envisaged that consultants assessing the susceptibility of an area to inversions would either accept the default meteorological parameters, or undertake their own analyses using one of the schemes outlined above.

Where the default meteorological parameters are to be replaced by the consultant's own assessment, then any one of the above schemes could be used. However, in order of preference, the schemes are:

1. Direct measurements of temperature gradient over a height interval of at least 50 m, with simultaneous measurements of wind speed and wind direction at two heights.
2. The sigma-theta method.
3. The Pasquill-Gifford scheme and Turner scheme (equally preferred).

Other methods are detailed in the US EPA's document (1987), *On-Site Meteorological Program Guidance for Regulating Modelling Applications.*

E6 Default values for the prediction of noise impacts

Once the percentage occurrence of stability categories has been determined from one of the methods described above, it is necessary to determine whether the Pasquill Stability Category occurs for ≥ 30 per cent of the time during the night-time in winter, signifying the need for further assessment.

Table E8 details the default values (temperature gradient and wind speed) to be used for the prediction of impacts where further assessment is required.

Table E8. Default values for temperature gradient and wind speed

Classification (site characteristics)	Default temperature inversion in winter	Percentage occurrence of stability categories during the winter period
All areas	Pasquill class E— 1.5°C/100 m with maximum 5 m/s wind speed at 10 m	To be excluded from the calculation, as it is not considered significant enough.
All areas	Pasquill class F— 3°C/100 m with maximum 2 m/s wind speed at 10 m	≥ 30 per cent occurrence at night during the winter period
Non-arid areas	Pasquill class G— 4°C/100 m with maximum 3 m/s wind speed at 10 m	≥ 30 per cent occurrence at night during the winter period
Arid and semi arid areas	Pasquill class G— 8°C/100 m with 1 m/s wind speed at 10 m	≥ 30 per cent occurrence at night during the winter period

E7 References

Irwin J.S. (1980), *Dispersion Estimate Suggestion #8: Estimation of Pasquill Stability Categories.* US EPA Research, Triangle Park NC. (Docket Reference Number ii-B-33).

Mitchell A.E. & Timbre K.O. (1979), *Atmospheric Stability Class from Horizontal Wind Fluctuations.* Presented at 72nd Annual Meeting of Air Pollution Control Association, Cincinnati, OH, June 24–29 (Docket Reference Number II-P-11).

NRC (1972), *Meteorological Programs in Support of Nuclear Power Plants,* Regulatory Guide (Draft). US Nuclear Regulatory Commission, Office of Standards Development, Washington DC.

Pasquill F. (1961), 'The estimation of dispersion of windborne material', *Meteorological Magazine*, vol. 90 (1063), pp. 33–49.

Smedman-Hogstrom A & Hogstrom V. (1978), 'A practical method for determining wind frequency distributions for the lowest 200 m from routine meteorological data', *Journal of Applied Meteorology*, vol 17(7), pp. 942–53.

Smith T.B. & Howard S.M. (1972), 'Methodology for treating diffusivity', MRI 72 FR-1030, Meteorological Research Incorporated, Altadena, CA. (Docket Reference Number II-P-8).

Standards Australia (1987), AS 2923–1987, *Ambient Air—Guide for Measurement of Horizontal Wind for Air Quality Applications.* Standards Australia, Sydney, ISBN 0 7262 4556 9.

Turner D.B. (1964), 'A diffusion model for an urban area', *Journal of Applied Meteorology*, vol 3(1), pp. 83–91.

US EPA (1980), *Ambient air monitoring guidelines for prevention of significant deterioration (PSD).* Publication no. EPA–450 / 4-80-012, US EPA, Research Triangle Park, NC. (NTIS Number PB 81–153231).

US EPA (1987), *On-site meteorological program guidance for regulating modelling applications.* Publication no. EPA-450 / 4-87-013, US EPA, Research Triangle Park, NC.

Appendix F Percentage occurrence of F-class temperature inversions in winter in the Hunter Valley, NSW

The Hunter Valley is a major centre for mining development, and elevated noise levels from temperature inversions have been reported as an issue for this area. For these reasons, the Hunter Valley area was used as a case study in evaluating the likely presence of F-class temperature inversions. *Table F1* presents an estimate of the occurrence of F-class temperature inversions in the Hunter Valley area. The table does not cover the incidence of G-class inversions, as these are not the predominant type of inversion in the Hunter Valley region.

This table may be used as a guide to indicate where significant inversions may occur. It would be reasonable to assume that the higher the percentage occurrence of F-class stability at a given site, the more likely it will be that noise-enhancement issues arise. It is recommended that locations that are approaching a 30 per cent occurrence level as well as those locations that either equal to or exceed the 30 per cent level be considered when assessing the effects of temperature inversions on noise levels.

In the table, atmospheric stability has been estimated using procedures developed by atmospheric scientists and formalised by the US EPA over a number of years. For a given set of parameters, for example wind speed, standard deviation of wind direction fluctuations, solar elevation and aerodynamic surface roughness, there will be only one valid stability produced for the procedure. In the current application, the derived value of stability class has been used to infer a temperature lapse rate.

In compiling this table, the Hunter Valley area was divided into 2 x 2 km square grid cells. The grid references used in the table are the standard Integrated Survey Grid (ISG) used on all topographical maps. Locations for each grid position can be determined by referring the grid reference to the appropriate topographical map.

Data from five meteorological stations in the Hunter region (located at Newcastle, Mount Thorley, Drayton, Mount Pleasant and Mount Arthur) were used to determine the occurrence of atmospheric F-class stability, which is associated with temperature-inversion conditions. The meteorological data used was that for the period 6 pm to 7 am for every winter night; that is, every night during the months of June, July and August.

The stability derived at each meteorological station has been used to interpolate stabilities at the grid of receptors. In the interpolation, the only factors that are used are the distance of the meteorological stations from each grid point (this determines the weighting that each station has at a given grid point) and the difference in elevation between the meteorological stations and the grid points (this is used to adjust the value of wind speed when it is interpolated to the grid point).

Although there are sound theoretical grounds for the relationships assumed between stability and temperature lapse rate, the relationship is not simple. Further, atmospheric temperature profiles can be very complex and cannot always be represented by a single figure specifying the gradient over a 100-m height interval. For example, a gradient of 3°C / 100 m could occur as a result of a smooth increase in temperature over the 100-m height interval, or as a jump in temperature of 3°C over a 10-m interval and no change over the remaining 95 m. The effects on noise enhancement would be quite different.

The results contained in the table are based on the best information available. However, use care in applying the tabulated values to specific situations, as specific site variables will influence the occurrence of inversions for a specific site. While the table provides a useful guide, site specific data are preferred where significant inversion effects are suspected.

Table F1. Percentage occurrence of F-class temperature inversions in winter in the Hunter Valley, NSW

East (ISG coord.)	North (ISG coord.)	% F-class
256000	1350000	15-20
258000	1350000	15-20
260000	1350000	15-20
262000	1350000	15-20
264000	1350000	15-20
266000	1350000	15-20
268000	1350000	15-20
270000	1350000	15-20
272000	1350000	20-25
274000	1350000	20-25
276000	1350000	20-25
278000	1350000	20-25
280000	1350000	20-25
282000	1350000	20-25
284000	1350000	20-25
286000	1350000	15-20
288000	1350000	20-25
290000	1350000	20-25
292000	1350000	15-20
294000	1350000	20-25
296000	1350000	20-25
298000	1350000	20-25
300000	1350000	20-25
302000	1350000	15-20
304000	1350000	15-20
306000	1350000	15-20
308000	1350000	15-20
310000	1350000	20-25
312000	1350000	20-25
314000	1350000	20-25
316000	1350000	20-25
318000	1350000	20-25
320000	1350000	15-20
322000	1350000	15-20
324000	1350000	15-20
326000	1350000	15-20
328000	1350000	15-20
330000	1350000	15-20
332000	1350000	15-20
334000	1350000	15-20
336000	1350000	15-20
338000	1350000	15-20
340000	1350000	15-20
342000	1350000	15-20
344000	1350000	15-20
346000	1350000	15-20
348000	1350000	15-20
350000	1350000	20-25
352000	1350000	20-25
354000	1350000	20-25
356000	1350000	20-25
358000	**1350000**	**25-30**
360000	1350000	20-25
362000	1350000	20-25
364000	1350000	15-20
366000	1350000	10-15
368000	1350000	20-25
370000	**1350000**	**55-60**
372000	**1350000**	**55-60**
374000	**1350000**	**55-60**
376000	**1350000**	**55-60**
378000	**1350000**	**55-60**
380000	**1350000**	**55-60**
382000	**1350000**	**50-55**
384000	**1350000**	**50-55**
386000	**1350000**	**50-55**
388000	**1350000**	**50-55**
390000	**1350000**	**50-55**
392000	**1350000**	**45-50**
394000	**1350000**	**45-50**
256000	1352000	15-20
258000	1352000	15-20
260000	1352000	15-20
262000	1352000	15-20
264000	1352000	15-20
266000	1352000	15-20
268000	1352000	20-25
270000	1352000	20-25
272000	1352000	20-25
274000	1352000	20-25
276000	1352000	20-25
278000	1352000	20-25
280000	1352000	20-25
282000	1352000	20-25
284000	1352000	20-25
286000	1352000	20-25
288000	1352000	20-25
290000	1352000	20-25
292000	1352000	15-20
294000	1352000	15-20
296000	1352000	15-20
298000	1352000	20-25
300000	1352000	15-20
302000	1352000	15-20
304000	1352000	20-25
306000	1352000	15-20
308000	1352000	20-25
310000	1352000	20-25
312000	1352000	20-25
314000	1352000	20-25
316000	1352000	20-25
318000	1352000	20-25
320000	1352000	15-20
322000	1352000	15-20
324000	1352000	15-20
326000	1352000	20-25
328000	1352000	15-20
330000	1352000	15-20
332000	1352000	15-20
334000	1352000	15-20
336000	1352000	15-20
338000	1352000	15-20
340000	1352000	15-20
342000	1352000	15-20
344000	1352000	20-25
346000	1352000	15-20
348000	1352000	15-20
350000	1352000	20-25
352000	**1352000**	**25-30**
354000	1352000	20-25
356000	1352000	20-25
358000	1352000	20-25
360000	1352000	15-20
362000	1352000	20-25
364000	1352000	15-20
366000	1352000	10-15
368000	1352000	15-20
370000	**1352000**	**30-35**
372000	**1352000**	**60-65**
374000	**1352000**	**60-65**
376000	**1352000**	**55-60**
378000	**1352000**	**55-60**
380000	**1352000**	**55-60**
382000	**1352000**	**50-55**
384000	**1352000**	**50-55**
386000	**1352000**	**50-55**
388000	**1352000**	**45-50**
390000	**1352000**	**45-50**
392000	**1352000**	**45-50**
394000	**1352000**	**50-55**
256000	1354000	15-20
258000	1354000	15-20
260000	1354000	15-20
262000	1354000	15-20
264000	1354000	15-20
266000	1354000	15-20
268000	1354000	15-20
270000	1354000	15-20
272000	1354000	20-25
274000	1354000	20-25
276000	1354000	20-25
278000	1354000	20-25
280000	1354000	20-25

282000	1354000	20-25
284000	1354000	20-25
286000	1354000	15-20
288000	1354000	15-20
290000	1354000	15-20
292000	1354000	15-20
294000	1354000	15-20
296000	1354000	15-20
298000	1354000	20-25
300000	1354000	15-20
302000	1354000	20-25
304000	1354000	20-25
306000	1354000	15-20
308000	1354000	20-25
310000	1354000	20-25
312000	1354000	20-25
314000	1354000	20-25
316000	1354000	20-25
318000	1354000	15-20
320000	1354000	15-20
322000	1354000	15-20
324000	1354000	20-25
326000	1354000	20-25
328000	1354000	20-25
330000	1354000	20-25
332000	1354000	20-25
334000	1354000	15-20
336000	1354000	15-20
338000	1354000	15-20
340000	1354000	20-25
342000	1354000	20-25
344000	1354000	20-25
346000	1354000	15-20
348000	1354000	15-20
350000	1354000	20-25
352000	**1354000**	**25-30**
354000	**1354000**	**25-30**
356000	**1354000**	**25-30**
358000	**1354000**	**30-35**
360000	**1354000**	**25-30**
362000	1354000	15-20
364000	1354000	15-20
366000	1354000	20-25
368000	1354000	20-25
370000	**1354000**	**25-30**
372000	**1354000**	**30-35**
374000	**1354000**	**55-60**
376000	**1354000**	**55-60**
378000	**1354000**	**55-60**
380000	**1354000**	**50-55**
382000	**1354000**	**50-55**
384000	**1354000**	**50-55**
386000	**1354000**	**50-55**
388000	**1354000**	**50-55**
390000	**1354000**	**50-55**
392000	**1354000**	**45-50**
394000	**1354000**	**50-55**
256000	1356000	15-20
258000	1356000	15-20
260000	1356000	15-20
262000	1356000	15-20
264000	1356000	15-20
266000	1356000	15-20
268000	1356000	15-20
270000	1356000	20-25
272000	1356000	20-25
274000	1356000	20-25
276000	1356000	20-25
278000	1356000	20-25
280000	1356000	20-25
282000	1356000	20-25
284000	1356000	20-25
286000	1356000	15-20
288000	1356000	15-20
290000	1356000	15-20
292000	1356000	15-20
294000	1356000	15-20
296000	1356000	20-25
298000	1356000	20-25
300000	1356000	20-25
302000	1356000	15-20
304000	1356000	15-20
306000	1356000	20-25
308000	1356000	20-25
310000	1356000	20-25
312000	1356000	20-25
314000	1356000	20-25
316000	1356000	20-25
318000	1356000	15-20
320000	1356000	15-20
322000	1356000	20-25
324000	1356000	20-25
326000	1356000	20-25
328000	1356000	20-25
330000	1356000	20-25
332000	1356000	20-25
334000	1356000	20-25
336000	1356000	20-25
338000	1356000	15-20
340000	1356000	20-25
342000	1356000	20-25
344000	1356000	20-25
346000	1356000	15-20
348000	1356000	15-20
350000	1356000	20-25
352000	1356000	20-25
354000	**1356000**	**25-30**
356000	1356000	20-25
358000	**1356000**	**25-30**
360000	1356000	20-25
362000	1356000	20-25
364000	1356000	15-20
366000	1356000	20-25
368000	**1356000**	**30-35**
370000	**1356000**	**40-45**
372000	**1356000**	**35-40**
374000	**1356000**	**45-50**
376000	**1356000**	**55-60**
378000	**1356000**	**55-60**
380000	**1356000**	**55-60**
382000	**1356000**	**50-55**
384000	**1356000**	**50-55**
386000	**1356000**	**50-55**
388000	**1356000**	**50-55**
390000	**1356000**	**50-55**
392000	**1356000**	**45-50**
394000	**1356000**	**45-50**
256000	1358000	15-20
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