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Environment, Climate Change & Water

NSW Road Noise Policy

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1 Introduction

The state's road system contributes to the economic and social wellbeing of the people of NSW. At the same time, road traffic noise can have a significant impact on the community. A balance, therefore, needs to be reached between providing efficient road transport infrastructure and minimising the adverse environmental effects of road use.

Motor vehicle ownership in NSW has increased substantially over the last four decades, from 246 vehicles per 1,000 people in 1960 to 538 vehicles per 1,000 people in 1990 and 634 vehicles per 1,000 people in 2007 (Australian Bureau of Statistics 1961, 1992, 2007). As at June 2009, there were over 5.3 million vehicles registered in NSW (NSW Roads and Traffic Authority 2009).

Overseas research into road traffic noise levels in developed countries has shown that while there have been significant reductions in the level of noise emitted by motor vehicles over the last 30 years, the growth in vehicle numbers has meant some areas have experienced a rise in traffic noise levels and those higher levels have occurred over longer periods of the day.

Vehicle use is increasing. The total number of vehicle kilometres travelled in Australia rose by an average of 2.2% each year from 2002 to a 2006 level of 209,405 million kilometres. Haulage of freight by road in Australia is also increasing, with total tonne-kilometres travelled rising by an average of 4.5% per annum in 2002–06, with 95% of goods hauled by rigid and articulated trucks. Heavy vehicles accounted for 3.75% of the national vehicle fleet in 2006 (Australian Bureau of Statistics 2007).

General levels of road traffic noise throughout NSW have increased significantly. As part of the review of the Protection of the Environment Operations (POEO) (Noise Control) Regulation 2000, the then Department of Environment and Conservation commissioned a community survey of neighbourhood noise issues in NSW in 2004 (Department of Environment and Conservation 2004). The results showed that 46% of respondents considered that road traffic noise was a problem in their neighbourhood. Road traffic noise was identified as the main issue affecting neighbourhood amenity.

A study by Brown and Bullen (2003), conducted in several capital cities in Australia, indicated that in Sydney about 20% of the population were exposed to levels of road traffic noise that were well above those recommended by the World Health Organisation for reducing annoyance and sleep disturbance (World Health Organisation 1999). The NSW Department of Health's Population Health Survey in 2009 also found 46% of respondents were exposed to road traffic noise (NSW Department of Health 2010). These results are further discussed in **Section 5.5**.

The growth in motor vehicle numbers, persistent undesirable levels of road traffic noise, and the community response to road traffic noise confirm the need to continue to develop programs to minimise the impact of such noise. Gains anticipated from tougher noise emission limits from individual motor vehicles through Australian Design Rules are likely to be limited to a few decibels. More significant gains may come from:

- reducing noise from tyres
- the take-up of electric vehicles with their quieter electric motors
- strategies that reduce motor vehicle use
- programs that enforce existing laws and standards for maintaining the condition of vehicles and modifying noisy vehicles.

However, the most significant benefits are expected to come from the effective environmental impact assessment of road projects and traffic-generating developments adjacent to roads (see **Section 1.1**).

In 1999, the Environment Protection Authority published *Environmental criteria for road traffic noise* to introduce a comprehensive and effective approach for managing road traffic noise in NSW. This policy was widely adopted by determining authorities, regulators, project proponents and acoustic practitioners and supported by the *Environmental noise management manual* (NSW Roads and Traffic Authority 2001). Its use resulted in successful noise outcomes on projects such as the:

- City West Link (urban design of noise walls)
- Westlink M7 Motorway (provision of effective noise treatment)
- Pacific Highway upgrade, Raymond Terrace (use of pre-cast concrete noise barriers).

The NSW Government has approved this *NSW road noise policy* (RNP), to replace the *Environmental criteria for road traffic noise* with effect from 1 July 2011. This new policy outlines the range of measures needed to minimise road traffic noise and its impacts. It is intended for use by:

- road project proponents
- determining authorities and regulators involved in the approval and construction of road projects and land use developments that generate additional traffic on existing roads
- city and transport planners and policymakers dealing with issues such as route corridors, heavy vehicle transport and building codes
- acoustic specialists.

The RNP will help the above individuals and agencies to assess and mitigate the impacts of traffic noise from new and redeveloped road projects, and traffic-generating developments on residential and other sensitive lands.

The RNP links with other NSW Government policies and plans to ensure that where road traffic exists, its noise impacts are appropriately identified and addressed (see **Section 1.3**).

1.1 Aim of the RNP

The RNP aims to identify the strategies that address the issue of road traffic noise from:

- existing roads
- new road projects
- road redevelopment projects
- new traffic-generating developments.

The RNP also defines criteria to be used in assessing the impact of such noise. To achieve this aim, the RNP needs to address several critical areas, as described in **Sections 1.1.1–1.1.4**.

1.1.1 Land use and development planning

Land use planning offers the greatest potential for minimising conflict between road noise and sensitive land uses, followed closely by the development of appropriately designed and noise insulated buildings.

The *State environmental planning policy (Infrastructure) 2007* (Infrastructure SEPP) (Department of Planning 2007) sets internal noise criteria which must be met by new developments along some of the busiest transport corridors in NSW. This is a major initiative to ensure that sustainable higher density living can occur along major transport routes whilst maintaining an acceptable level of amenity for residents. Developers and councils should consider the recommended approaches outlined in the accompanying *Development near rail corridors and busy roads – interim guideline* (Department of Planning 2008). See **Appendix C10** for more details.

The provision of quiet spaces for respite has been shown in research literature to be beneficial for health and wellbeing (see **Section 5.7**). Ideally, such spaces should be provided in residences – preferably accompanied by openable windows facing away from traffic – and outside but within easy reach of residences, in the form of parks and reserves.

1.1.2 Road and transport planning

The primary need for the development of new roads is to improve access and safety, and reduce travel times. While the road network must be updated to cope with future demands, the network's environmental footprint should be kept to a minimum. Development of new roads affords opportunities to reduce exposure to road traffic noise through techniques such as town bypasses. It is therefore important that during the early stages of road planning, noise minimisation is considered during route selection processes for new roads or major realignments.

Buffer zones can be used to separate noisy roads from residential areas. Photo: DECCW

Road network planners must consider limiting the noise exposure of existing receivers and minimise the number of any new receivers exposed to road traffic noise. The adoption of prudent and effective route selection processes will avoid the sterilisation of large tracts of land adjoining road corridors.

The noise impacts of statewide transportation strategies, such as those for bulk freight movement, should be taken into account to ensure their compatibility with surrounding land uses.

1.1.3 Noise source control

Incorporating technologies that address the sources of road traffic noise is very effective. In particular, road network managers, planners and pavement engineers must look at incorporating advances in the development of low noise road pavement surfaces. The quality of the pavement surface finish can affect the amount of road traffic noise generated. However, the choice of road pavement surfaces and textures must meet a number of criteria including skid resistance, water shedding and design life as well as potential noise generating characteristics. The road pavement surface's noise performance throughout its duration and the need to maintain that performance when the pavement is replaced are also important considerations.

Motor vehicle standards such as Australian Design Rules reduce noise from motor vehicle engines and transmissions. New standards for motor vehicle tyre noise are being developed in Europe and are expected to be the next major step in reducing motor vehicle noise. Reducing vehicle tyre noise while not compromising safety with respect to factors such as tyre skid resistance and aquaplaning is an ongoing challenge for tyre manufacturers.

Noise limits for modified vehicles used on roads are enforced by the Department of Environment, Climate Change and Water (DECCW) and the NSW Police to deal with the relatively few excessively noisy vehicles that can cause disturbance over large areas. Limiting noise emissions from new vehicles via Australian Design Rules and identifying heavy vehicles with excessively noisy engine brakes will also benefit the community.

1.1.4 Transmission path control

Although the strategies in **Sections 1.1.1–1.1.3** benefit the entire area potentially affected by a proposed project, there may be instances where the use of engineering-type noise mitigation measures such as barriers and at-property treatments is effective and appropriate. Transmission path controls should be considered in combination with the above strategies rather than in isolation.

A noise barrier only protects a limited area and its noise reduction effectiveness depends on its design, dimensions and location relative to the source of the noise and the locations it seeks to protect. The use of noise barriers must also be balanced against considerations such as safety, visual amenity, security and cost.

Homes can be protected from traffic noise by noise barriers. Photo: DECCW

Similarly, treatments to the façade of a building such as thick laminated glass or double glazing of windows only provide noise reduction in internal spaces, so do not benefit outdoor areas around it. The use of façade treatments can also prevent building occupants from opening windows, which in turn often necessitates the installation of mechanical ventilation systems to provide adequate indoor air quality and air conditioning.

1.2 Scope and application of this policy

Noise from road related activities includes construction of new freeways, noise from heavy vehicles and the noise from individual vehicles fitted with modified exhaust systems. The manner and location of the noise emission will determine what noise controls are available and ways in which the noise should be assessed. The primary purpose of this document is to provide assessment criteria for road traffic noise based on protecting amenity and wellbeing.

Although it is not mandatory to achieve the noise assessment criteria in this RNP, proponents will need to provide justification if it is not considered feasible or reasonable to achieve them. The policy must be used during the environmental assessment of road proposals to develop feasible and reasonable noise mitigation measures. Considering the assessment criteria will mean all noise control options are analysed before any approval is granted for a proposed project to proceed. The assessment criteria:

- allow for the careful planning and design of new projects, or of roads that are being significantly realigned or upgraded
- can be used to determine conditions of planning approval and conditions in environment protection licences for traffic-generating developments
- form the basis for target levels used in considering noise abatement from existing roads not subject to redevelopment.

In most instances, achieving the road traffic noise assessment criteria will require a range of short and long term strategies administered by several agencies. Some measures should be adopted across the board; others will need to be adopted for individual road projects.

Where it can be justifiably demonstrated that the assessment criteria cannot be feasibly or reasonably achieved within the project planning, design and implementation stages, the criteria should be adhered to as closely as possible, with the aim of adopting broader supporting strategies in the longer term.

Road-related activities covered by other policies, guidelines and regulations include:

- construction and road maintenance activities (see **Appendix C1**)
- noise from existing roads (see **Appendix C2**)
- operational vibration (see **Appendix C3**)
- private haul roads (see **Appendix C4**)
- excessive noise from new and modified vehicles (see **Appendix C5**)
- noise from stationary vehicles and heavy vehicle refrigeration units (see **Appendix C6**)
- heavy vehicle engine brake noise (see **Appendix C7**)
- service stations and other roadside facilities (see **Appendix C8**)
- traffic calming devices and profiled line marking (see **Appendix C9)**
- new residential and other sensitive developments affected by noise from existing roads (see **Appendix C10**).

Some works that are either minor or required to improve safety are not covered by this RNP.

1.3 Planning strategies to reduce road traffic noise

Strategies that are currently being implemented to reduce road traffic noise include local council requirements to include noise mitigation in new dwellings, metropolitan plans to increase the use of public transport, statewide plans for upgrades of major transport routes, and national initiatives to reduce heavy vehicle engine brake noise and road freight haulage. Some initiatives are being promoted by the Australian or NSW governments, some by industry associations or representatives, some by industry itself and some by individuals looking to reduce the impact of road noise on the environment.

These strategies aim to:

- manage the demand for travel
- influence the location of new urban development and urban renewal
- increase travel choices by expanding and improving the quality of public transport networks, and expanding and increasing the use of facilities for pedestrians and cyclists
- maximise the proportion of freight transported by rail
- review parking policies with a view to reducing the provision of car parking.

Some measures for reducing road traffic noise result in immediate and perceptible improvements, while others result in small but cumulatively important changes. Some measures, such as the NSW BikePlan, involve reducing or avoiding the generation of road traffic noise at the source while others limit the impact of road noise through the strategic design and location of noise sensitive buildings and land uses.

Many strategies to reduce the impact of road traffic noise have other environmental benefits such as reducing greenhouse gas emissions and improving air quality. The key strategies being employed in NSW are briefly discussed in **Sections 1.3.1–1.3.5** below.

1.3.1 NSW State Plan

Investing in a better future: NSW State Plan (NSW Government 2010a) is the NSW Government's long-term plan to deliver the best possible services to the people of NSW. It sets tough, realistic targets for service improvement across the public sector and provides an open and transparent way to measure performance.

In 2009, the NSW Government held an extensive statewide consultation with the community, business, local government and stakeholder groups, to assist in developing the State Plan and to make sure it reflected the needs and vision of the NSW community. More than 3,500 groups and individuals provided their views and local knowledge.

The State Plan aims to ensure:

- the economy grows stronger, supporting jobs and attracting business investment
- the transport network is world-class – safe, reliable and accessible
- NSW is the Clever State – children are better educated, people are more skilled, and the state is known for its research and innovation
- the health system provides the highest quality care, accessible by all
- NSW is the Green State – energy is clean, the natural environment is protected and NSW is a leader in tackling climate change
- the most disadvantaged communities are strengthened and the most vulnerable citizens are supported
- the police and justice system keep people safe.

Further information on the State Plan may be found on www.stateplan.nsw.gov.au.

1.3.2 Metropolitan Plan

In December 2010, the NSW Government released *Metropolitan Plan for Sydney 2036* (The Metropolitan Plan) (NSW Government 2010b). This is a strategic plan aimed to guide Sydney's growth and change over the next 25 years. It outlines the government's commitment to delivering transport that matches Sydney's population and employment needs.

The Metropolitan Plan contains a number of actions to reduce private car use, by integrating transport and land use planning; adopting the compact city model; and identifying the need to:

- avoid locating new sensitive development, including residential development, beside major roads to prevent noise, and to protect air quality and human health
- increase the proportion of freight transported by rail
- place jobs and homes near existing and planned transport.

It also identifies long-term urban renewal and freight corridors to be further investigated.

1.3.3 Freight strategy

An increased proportion of freight on rail is one of the NSW Government's key priorities. In December 2004, the NSW Government announced a target of transporting 40% of container traffic by rail into and out of Port Botany, Sydney. There is broad support for measures to develop a network of intermodal terminals and associated improvements in infrastructure. This rail mode share target is a core component of the NSW Freight Strategy being developed by Transport NSW.

Initiatives such as those for Port Botany are expected to result in reduced noise from heavy vehicle freight on roads in many areas and a corresponding reduction in high noise level events from road traffic. Additional benefits of rail freight include improved air quality and reduced greenhouse gas emissions.

1.3.4 NSW Growth Centres Commission Development Code

The *NSW growth centres development code* (NSW Growth Centres Commission 2006) sets out the approach to precinct planning and provides the broad protocols and processes to be followed. The Code defines a process which includes an early planning stage, referred to as the 'indicative layout plan', where noise is considered along with other fundamental development concepts. Noise issues in a precinct should be a guiding factor in planning considerations ranging from the layout of residential lots to the location of land uses such as those for education and employment.

1.3.5 Draft interim guidelines on transport management and accessibility plans

The *Draft interim guidelines on transport management and accessibility plans* (NSW Ministry of Transport 2001) provide a framework for developing plans which comprehensively assess the transport impacts of major site development or redevelopment proposals. These guidelines also identify appropriate transport measures to help manage the demand for travel to and from a proposed development, especially by private cars and commercial vehicles.

The guidelines provide for the integrated planning and design of land use, urban form and transport facilities and services, as well as providing the required transport infrastructure and services in line with development to meet the needs of residents and users of the site.

1.4 Responsible organisations

The strategies listed in **Table 1** are considered to be areas of high priority for reducing road traffic noise. It is important to recognise the shared responsibility for strategies between a number of organisations and encourage a broad approach to the management of road traffic noise.

Table 1 General traffic noise management strategies and responsible organisations

Management strategy – responsible organisations
Land use and transport planning development control – **Department of Planning**, Transport NSW, NSW Roads and Traffic Authority[1], DECCW, councils • Consider traffic noise impacts from existing and future roads at the land use and transportation planning stage, through state environmental planning policies, local environmental plans and planning guidelines. • Ensure that new development and redevelopment activities include road traffic noise as a consideration through instruments such as *AMCORD – A national resource document for residential development* (Commonwealth of Australia 1995) and *Development near rail corridors and busy roads – interim guideline* (Department of Planning 2008).
Heavy vehicle noise control – **NSW Roads and Traffic Authority, National Transport Commission**, DECCW, councils, NSW Police[2] • Regulate heavy vehicle engine brake noise. • Periodically inspect heavy vehicle exhaust systems for defects. • Develop and implement Australian Design Rules. • Identify and police heavy vehicle preferred routes.
In-service enforcement – **DECCW, NSW Police, approved Noise Testing Stations, NSW Roads and Traffic Authority** • Monitor and regulate excessively noisy vehicles through in-service enforcement. • Regulate against modifications to motor vehicle noise control equipment that increase noise emissions. • Promote strategies to encourage responsible driving.
Community and industry noise education – **NSW Roads and Traffic Authority, Department of Planning, DECCW, Transport NSW**, councils • Develop education campaigns targeted at vehicle repairers, vehicle users, the housing industry and councils. • Encourage the community to cycle and use public transport, and increase the numbers of passengers travelling per vehicle.
Noise Abatement Program – **NSW Roads and Traffic Authority** • A program to address acute levels of road traffic noise on state and federal roads where no road development is occurring. The program has limited funding and provides noise mitigation measures on a priority basis linked to the level of noise exposure and other factors (see **Section 4.4**).

Note: Organisations holding prime responsibility for the strategies are shown in bold.

1. The NSW Roads and Traffic Authority comes under the umbrella of Transport NSW.
2. NSW Police comes under the umbrella of Police and Emergency Services NSW.

2 Assessment criteria

Impacts from road traffic noise on public roads, as with other sources of environmental pollution, are assessed in the RNP through criteria that are transparent, equitable and consistent both on an individual project and on a statewide basis.

The criteria aim to provide protection primarily inside and immediately around permanent residences, and at schools, hospitals and other sensitive land uses, rather than at all points in a given locality, which would not be practical or possible.

A review of external (outdoor) noise assessment criteria in other countries (see **Appendix A1** for more information) shows that a planning level of 45–55 dB(A) L_{Aeq} appears to be the most widely used night-time criterion, with a day-time criterion set 5–10 dB above this. In many countries, variations in the criteria allow higher noise levels on existing roads, and lower noise levels on roads in quiet areas or near noise-sensitive land uses such as hospitals.

The noise assessment criteria presented in this section are consistent with current international practice for managing traffic noise impacts. However, achieving the noise assessment criteria would not guarantee that all people would find the resulting level of traffic noise acceptable. There can be a wide variation in individual reaction to noise. In this context, the criteria have been set approximately at the point at which 90% of residents are not highly annoyed by the noise.

The criteria for various road categories and land uses presented in **Section 2.3** identify noise levels that provide for a degree of amenity appropriate for the land use and road category. The specified noise levels are based on well-documented social surveys defining a dose–response relationship between noise level and its effects, such as annoyance and disturbance to listening, talking, relaxing and studying (see **Section 5.1**). These levels are supported by comparison with overseas criteria.

2.1 Factors considered in setting the assessment criteria

The following factors have been considered in the development of the assessment criteria:

- whether the road project is in a new or existing road corridor
- the existing level of noise exposure
- whether the road project involves the construction of a new road or substantial changes to the alignment or design of an existing road
- whether the volume or composition of traffic flows would substantially change.

There are generally more opportunities to minimise noise impacts from new roads and road corridors, especially those in greenfield locations, through judicious road design and land use planning. The scope to reduce noise impacts from existing roads and corridors is more limited.

There are also generally fewer opportunities to reduce the noise impacts from new land use developments generating additional traffic on existing roads.

2.2 Road categories

2.2.1 NSW Roads and Traffic Authority's functional categories of roads and management responsibility

In Table 2.1 of the *Network and corridor planning practice notes* (NSW Roads and Traffic Authority 2008a), roads are functionally classified by a range of factors, including their role in facilitating traffic movement; their relationship to other road categories; and whether they support through or local traffic, access to adjacent land uses and applicable traffic management options. The functional categories for roads, together with the management responsibility for their care and control, are laid out in **Table 2**.

Table 2 Road categories and management responsibility

Road category	Functional role	Examples	Management responsibility
Freeways or motorways/ arterial roads	Support major regional and inter-regional traffic movement. Freeways and motorways usually feature strict access controls via grade separated interchanges.	• Pacific Highway, Taree • M4 Motorway, Eastern Creek • Princes Highway, Arncliffe	State government
Sub-arterial roads[1]	Provide connection between arterial roads and local roads. May support arterial roads during peak periods. May have been designed as local streets but can serve major traffic-generating developments or support non-local traffic.	• Bourke Street, Surry Hills • Cook Street, Baulkham Hills • Forest Road, Lugarno	Local councils
Local roads	Provide vehicular access to abutting property and surrounding streets. Provide a network for the movement of pedestrians and cyclists, and enable social interaction in a neighbourhood. Should connect, where practicable, only to sub-arterial roads.	• Prince Street, Randwick • Pell Street, Howlong • Killarney Drive, Killarney Heights	Local councils

1. Previously designated as 'collector' roads in *Environmental criteria for road traffic noise* (Environment Protection Authority 1999)

The three road categories. Left to right: freeway, sub-arterial road and local road. All photos: DECCW.

2.2.2 Principal haulage routes along public roads

Some industries such as mines and extractive industries are, by necessity, in locations that are often not served by arterial roads. Heavy vehicles must be able to access these often more remote sites and this may mean travelling on local public roads. Good planning practice acknowledges this type of road use and develops ways of managing any associated adverse noise impacts. Principal haulage routes are distinct from private haul roads – further guidance on private haul roads is provided in **Appendix C4**.

Where local authorities identify a 'principal haulage route', the noise criteria for the route should match those for arterial/sub-arterial roads, recognising that they carry a different level and mix of traffic to local roads.

2.3 Noise assessment criteria

2.3.1 Noise assessment criteria – residential land uses

Table 3 sets out the assessment criteria for residences to be applied to particular types of project, road category and land use. These criteria are for assessment against façade-corrected noise levels when measured in front of a building façade as recommended in **Table 7**. In **Table 3,** freeways, arterial roads and sub-arterial roads are grouped together and attract the same criteria.

Table 3 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from **new** freeway/arterial/sub-arterial road corridors	$L_{Aeq, (15 hour)}$ 55 (external)	$L_{Aeq, (9 hour)}$ 50 (external)
	2. Existing residences affected by noise from **redevelopment** of existing freeway/arterial/sub-arterial roads 3. Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq, (15 hour)}$ 60 (external)	$L_{Aeq, (9 hour)}$ 55 (external)
Local roads	4. Existing residences affected by noise from **new** local road corridors 5. Existing residences affected by noise from **redevelopment** of existing local roads 6. Existing residences affected by **additional traffic** on existing local roads generated by land use developments	$L_{Aeq, (1 hour)}$ 55 (external)	$L_{Aeq, (1 hour)}$ 50 (external)

Note: Land use developers must meet internal noise goals in the Infrastructure SEPP (Department of Planning NSW 2007) for sensitive developments near busy roads (see **Appendix C10**).

2.3.2 Noise assessment criteria – other non-residential land uses

In some cases there will be existing land uses that are sensitive to noise (e.g. hospitals and schools) where more stringent standards are expected, and there are other land uses where different criteria than those specified for residential land use are more appropriate. For existing schools, child care facilities, hospitals, places of worship and recreation, specific criteria have been set so the characteristic activities for each of these land uses will not be unduly disturbed.

The noise assessment criteria in **Table 4** must be applied for assessing the impact and determining mitigation measures in the following situations:

- when there is a new road or road redevelopment
- when there is a land use development with the potential to generate additional traffic on local, sub-arterial or arterial roads.

The external criteria are for assessment against façade-corrected noise levels when measured in front of a building façade as recommended in **Table 7**.

Table 4 Road traffic noise assessment criteria for non-residential land uses affected by proposed road projects and traffic generating developments

<table>
<tr><th rowspan="2">Existing sensitive land use</th><th colspan="2">Assessment criteria – dB(A)</th><th rowspan="2">Additional considerations</th></tr>
<tr><th>Day (7 a.m.–10 p.m.)</th><th>Night (10 p.m.–7 a.m.)</th></tr>
<tr><td>1. School classrooms</td><td>$L_{Aeq,\,(1\ hour)}$ 40 (internal) when in use</td><td>–</td><td rowspan="2">In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the ‘maximum’ levels shown in Australian Standard 2107:2000 (Standards Australia 2000).</td></tr>
<tr><td>2. Hospital wards</td><td>$L_{Aeq,\,(1\ hour)}$ 35 (internal)</td><td>$L_{Aeq,\,(1\ hour)}$ 35 (internal)</td></tr>
<tr><td>3. Places of worship</td><td>$L_{Aeq,\,(1\ hour)}$ 40 (internal)</td><td>$L_{Aeq,\,(1\ hour)}$ 40 (internal)</td><td>The criteria are internal, i.e. the inside of a church. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established what in these areas may be affected by road traffic noise.
For example, if there is a church car park between a church and the road, compliance with the internal criteria inside the church may be sufficient. If, however, there are areas between the church and the road where outdoor services may take place such as weddings and funerals, external criteria for these areas are appropriate. As issues such as speech intelligibility may be a consideration in these cases, the passive recreation criteria (see point 5) may be applied.</td></tr>
</table>

Existing sensitive land use	Assessment criteria – dB(A)		Additional considerations
	Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)	
4. Open space (active use)	$L_{Aeq, (15\ hour)}$ 60 (external) when in use	–	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion. Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading. In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.
5. Open space (passive use)	$L_{Aeq, (15\ hour)}$ 55 (external) when in use	–	
6. Isolated residences in commercial or industrial zones	–	–	For isolated residences in industrial or commercial zones, the external ambient noise levels can be higher than those in residential areas. Internal noise levels in such residences are likely to be more appropriate in assessing any road traffic noise impacts, and the proponent should determine suitable internal noise level targets, taking guidance from Australian Standard 2107:2000 (Standards Australia 2000).
7. Mixed use development	–	–	Each component of use in a mixed use development should be considered separately. For example, in a mixed use development containing residences and a childcare facility, the residential component should be assessed against the appropriate criteria for residences in **Table 3**, and the childcare component should be assessed against point 8 below.
8. Childcare facilities	Sleeping rooms $L_{Aeq, (1\ hour)}$ 35 (internal) Indoor play areas $L_{Aeq, (1\ hour)}$ 40 internal) Outdoor play areas $L_{Aeq, (1\ hour)}$ 55 (external)	–	Multi-purpose spaces, e.g. shared indoor play/sleeping rooms should meet the lower of the respective criteria. Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility.
9. Aged care facilities	–	–	Residential land use noise assessment criteria should be applied to these facilities (see **Table 3**).

Note: Land use developers must meet internal noise goals in the Infrastructure SEPP (Department of Planning NSW 2007) for sensitive developments near busy roads. See **Appendix C10** for details.

2.3.3 Transitway noise assessment criteria

Table 5 sets out the assessment criteria to be applied to off-road and on-road bus transitways. The criteria for bus transitways aim to assist future public transport proposals and ensure that any adverse amenity effects that might be associated with increased public transport use are properly assessed and minimised to the greatest extent possible.

The criteria for an on-road transitway are incorporated into the criteria from **Table 3** as appropriate for the road use. The residential criteria for off-road bus transitways given in **Table 5** stem from criteria developed for light rail, which can have similarities such as carrying 'heavy' vehicles used exclusively for public transport and operating to a timetable. These criteria are for assessment against façade-corrected noise levels when measured in front of a building façade as recommended in **Table 7**.

Dedicated on-road transitway. Photo: DECCW

Table 5 Transitway noise assessment criteria for existing residential land uses

Transitway type	Assessment criteria – dB(A)		Additional considerations
	Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)	
Off-road transitway	$L_{Aeq, (15 hour)}$ 60 (external)	$L_{Aeq, (9 hour)}$ 50 (external)	The total noise level from the transitway is to be assessed against the criteria.
On-road transitway	The noise assessment criteria in **Table 3** apply as appropriate to the existing road classification, e.g. freeway/arterial/sub-arterial or local road classification.		The total combined noise level from the road including the transitway and other traffic is to be assessed against the criteria.

2.4 Relative increase criteria

In addition to the assessment criteria outlined in **Tables 3–5**, any increase in the total traffic noise level at a location due to a proposed project or traffic-generating development must be considered. Residences experiencing increases in total traffic noise level above the relative increase criteria in **Table 6** should also be considered for mitigation as described in **Section 3.4**. For other existing sensitive land uses as outlined in **Table 4**, the relative increase criteria should be applied to the respective $L_{Aeq, (period)}$ for that land use type, except for open space. For road projects where the main subject road is a local road, the relative increase criterion does not apply.

Table 6 Relative increase criteria for residential land uses

Road category	Type of project/development	Total traffic noise level increase – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.– 7 a.m.)
Freeway/arterial/ sub-arterial roads and transitways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing traffic $L_{Aeq, (15 hour)}$ + 12 dB (external)	Existing traffic $L_{Aeq, (9 hour)}$ + 12 dB (external)

In **Table 6** above, the 'existing' traffic noise level refers to the level from all road categories which would occur for the relevant 'no build' option as described in **Section 2.5.3**. Where the existing $L_{Aeq, (period)}$ road traffic noise level is found to be less than 30 dB(A), it is deemed to be 30 dB(A).

A relative increase of 12 dB represents slightly more than an approximate doubling of perceived loudness (AS2659.1–1988) and is likely to trigger community reaction, particularly in environments where there is a low existing level of traffic noise.

The relative increase criteria are primarily intended to protect existing quiet areas from excessive changes in amenity due to noise from a road project. A similar approach is adopted in both the United States Federal Highway Administration's Noise Abatement Criteria (United States Department of Transportation 1982) and the VicRoads Traffic Noise Reduction Policy (VicRoads 2005).

2.5 Technical notes

Details of the approaches to take when measuring and predicting noise are set out in **Appendix B**, but it is worthwhile to note here the key points in interpreting the specified noise levels from a technical perspective.

2.5.1 Noise sources included in the criteria

Specified noise assessment criteria refer to noise from traffic on roads, road bridges and freeways, and do not include ambient noise from other sources.

2.5.2 Application of descriptors

The 'A' frequency weighted L_{Aeq} noise level descriptor has been chosen for use with the criteria, and is designed to measure a level of annoyance reaction caused by road traffic noise. As discussed in **Section 5.1**, social surveys indicate that for existing road traffic noise, a daytime level of L_{Aeq} 55 dB(A) equates to about 10% of an exposed population being highly annoyed by the noise.

Annoyance due to a noise source is perceived differently by each individual and depends on acoustic factors such as volume, tone and frequency, as well as non-acoustic factors such as the listener's opinion of the noise source. Noise criteria therefore aim to stop 90% of the community from becoming highly annoyed.

Freeways, transitways, arterial and sub-arterial roads handle high volumes of through-traffic over extended periods of time; hence the need for a noise descriptor that measures noise exposure for the full day and night. Local roads in metropolitan areas, by contrast, handle only intermittent local traffic and require a shorter measurement period. More information on calculating the descriptors below is given in **Appendix B**.

- $L_{Aeq, (15\ hour)}$ represents the L_{Aeq} noise level for the period 7 a.m.–10 p.m.
- $L_{Aeq, (9\ hour)}$ represents the L_{Aeq} noise level for the period 10 p.m.–7 a.m.
- $L_{Aeq, (1\ hour)}$ is the L_{Aeq} noise level for a specific one-hour period.

2.5.3 Assessment criteria timeframe

For new road projects and road redevelopment projects, the road traffic noise level should be evaluated at the following two points in time:

New road project

- timeframe 1: within one year of opening
- timeframe 2: for a design year (typically ten years) after opening

Road redevelopment project

- timeframe 1: within one year of changed traffic conditions
- timeframe 2: for a design year (typically ten years) after changed traffic conditions.

For each timeframe above, a comparison should be made between:

- the road traffic noise levels if the project proceeds (termed the 'build option'), and
- the corresponding road traffic noise levels, due to general traffic growth, that would have occurred if the project had not proceeded (termed the 'no build option').

The comparison for timeframe 1 above will indicate the potential for any noise issues at the commencement of the project, such as community reaction to significant changes in noise levels from a new road. The comparison for timeframe 2 above will indicate the potential for noise impacts in the longer term once the project is well established and the surrounding road network has stabilised.

2.5.4 Locations where noise assessment criteria apply

The nominated locations for assessment against the criteria are described in **Table 7**.

Table 7 Assessment locations for existing land uses

Assessment type	Assessment location
External noise levels at residences	The noise level should be assessed at 1 metre from the façade and at a height of 1.5 metres from the floor. Separate noise criteria should be set and assessments carried out for each façade of a residence, except in straightforward situations where the residential façade most affected by road traffic noise can be readily identified. The residential noise level criterion includes an allowance for noise reflected from the façade ('façade correction'). Therefore, when taking a measurement in the free field where reflection during measurement is unlikely (as, for instance, when measuring on open land before a residence is built), an appropriate correction – generally 2.5 dB – should be added to the measured value. The 'façade correction' should not be added to measurements taken 1 metre from the façade of an existing building. Free field measurements should be taken at least 15 metres from any wall, building or other reflecting pavement surfaces on the opposite side of the roadway, and at least 3.5 metres from any wall, building or other pavement surface, behind or at the sides of the measurement point which would reflect the sound.
Noise levels at multi-level residential buildings	The external points of reference for measurement are the two floors of the building that are most exposed to traffic noise. On other floors, the internal noise level should be at least 10 dB less than the relevant external noise level on the basis of openable windows being opened sufficiently to provide adequate ventilation (Refer to the Building Code of Australia (Australian Building Codes Board 2010) for additional information).
Internal noise levels	Internal noise levels refer to the noise level at the centre of the habitable room that is most exposed to the traffic noise with openable windows being opened sufficiently to provide adequate ventilation (Refer to the Building Code of Australia (Australian Building Codes Board 2010) for additional information).
Open space – passive or active use	The noise level is to be assessed at the time(s) and location(s) regularly attended by people using the space. In this regard, 'regular' attendance at a location means at least once a week.

For residential dwellings, the assessment point is one metre from the façade. This position has been adopted to provide a relatively accessible measurement location, and will protect the acoustic amenity of both the internal spaces in the dwelling and external spaces near the respective façade.

Meeting the assessment criteria at one metre from the façade does not mean that noise levels over the entire property will also meet the assessment criteria.

The provision of a good acoustic environment for external spaces around a building (e.g. a courtyard or backyard of a residence) should be considered, although there are no specific criteria relating to these spaces. Guidance on how to improve such environments may be found in *Development near rail corridors and busy roads – interim guideline* (Department of Planning NSW 2008).

2.5.5 Dealing with 'shoulder periods'

At times, it may be reasonable to vary the standard time periods applied to the day and night. For example, the noise levels in an area may begin to rise sharply earlier than 7 a.m. (the standard time day begins) due to normal early morning activity from the community. In these situations, it is reasonable to consider varying the standard day-time and night-time periods.

Appropriate noise level targets where night-time noise levels rise quickly to day-time noise levels (often termed 'shoulder periods') may be negotiated with the determining or regulatory authority on a case-by-case basis.

2.5.6 Commercial and industrial premises

For commercial and industrial premises, information on desirable internal noise levels is contained in Australian Standard 2107:2000 (Standards Australia 2000).

3 Applying the noise assessment criteria

3.1 Assessing noise impacts

Noise measurement and assessment methods are an integral part of implementing any set of noise criteria. Noise measurement procedures are described in **Appendix B**, with a step-by-step methodology for assessing the noise impacts from road traffic.

3.2 Use of the criteria by approval and regulatory bodies

Although the assessment criteria are non-mandatory, they provide the basis for establishing appropriate noise levels that can be incorporated into:

- conditions in planning approvals issued by authorities such as local councils and the Department of Planning
- licences issued by the Environment Protection Authority, such as those for traffic-generating developments.

Noise level conditions are set by applying the noise assessment criteria as the targets and then applying all feasible and reasonable measures. Noise levels higher than the criteria may need to be applied as a condition of consent where it is demonstrated that the criteria cannot be met by applying all feasible and reasonable mitigation measures. The concepts of feasibility and reasonableness are described in more detail in **Section 3.3**.

3.3 Feasible and reasonable mitigation

3.3.1 Feasible mitigation

A noise abatement measure is feasible if it can be engineered and is practical to build, given project constraints such as safety and maintenance requirements.

Control of transport noise at the source often involves modifying existing technology or practices that result in small but cumulatively significant reductions in generated noise. Examples of such modifications include the use of low noise pavement surfaces or reductions in vehicle speed. Control of noise at the source is always the preferred method as it reduces the impact on the entire surrounding area. Noise path control or mitigation at the receiver end usually requires adopting measures such as barriers or at-property treatments that block the transmission of noise. As the benefit from these measures would only apply to a limited area, they should generally only be applied after endeavouring to control noise at the source.

3.3.2 Reasonable mitigation

Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the abatement measure. To make such a judgement, consideration may be given to:

- noise impacts:
  - existing and future levels of noise, and projected changes in noise levels
  - the level of amenity before a road or land use project was initiated, e.g. number of people affected or annoyed
  - any noise criteria for associated land use development e.g. internal noise goals for certain rooms
  - the amount by which the criteria are exceeded
- noise mitigation benefits:
  - the amount of noise reduction expected including the cumulative effect of proposed abatement measures; ideally, a noise wall/mound should be able to reduce noise levels by at least 5 decibels
  - the potential ability of the abatement measure to reduce noise during both construction and operational stages of the project
  - the number of people protected

Several noise mitigation techniques have been used on the Northern Distributor including good road design, a low noise pavement and judicious use of noise barriers. Photo: DECCW

- cost effectiveness of noise mitigation:
  - the total cost of mitigation measures, taking into account the physical attributes of the site, e.g. topography, geology, and the cost variation to the project given the expected benefit
  - noise mitigation costs compared with total project costs, taking into account capital and maintenance costs
  - operational and maintenance costs borne by the community, e.g. running air conditioners or mechanical ventilation
- community views:
  - engagement with affected land users when deciding about urban design and aesthetic considerations and other impacts of noise abatement measures
  - the views of all affected land users, not just those making complaints, determined through early community consultation
  - measures with the most support from the affected community.

The above considerations should also be taken into account when determining which locations should be mitigated first.

Practices to assess the feasibility and reasonableness of mitigation measures are contained in Practice Note 4: 'Selecting and designing feasible and reasonable treatment options for road traffic noise from new and redeveloped roads affecting residential land uses' of the *Environmental noise management manual* (NSW Roads and Traffic Authority 2001). A review of the practices is under way and revised practice notes will be published once the review is finalised.

3.4 Applying the assessment and relative increase criteria

The process for applying the criteria involves firstly defining a study area. This helps ensure that noise is assessed and any necessary mitigation applied at those locations most affected. The *UK Design Manual for Roads and Bridges* (United Kingdom Highways Agency 2008) adopts a distance of 600 metres from a project as being adequate for this purpose.

Where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. A secondary objective is to protect against excessive decreases in amenity as the result of a project by applying the relative increase criteria.

In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

Section 3.4.1 provides a step-by-step procedure for applying the noise criteria to each type of project and development covered by the RNP.

The relative increase criteria aim to prevent excessive road traffic noise increases in quiet areas.
Photo: DECCW

3.4.1 Process for applying the criteria

Steps should be taken in the following order to apply the assessment and relative increase criteria:

Step 1

Identify a study area comprising assessment locations within a distance of 600 metres from the centre line of the outermost traffic lane on each side of the subject road.

Step 2

i. For each assessment location in the study area, identify where the project results in an increase in total (existing and projected) traffic noise levels that exceed the relative increase criteria in **Table 6**.

ii. For each assessment location in the study area, identify where:

- for existing residences and other sensitive land uses affected by noise from **new road corridors**, the traffic noise level contribution from the new road project exceeds the 'new road corridor' criterion for residences in **Table 3** or the criteria for non-residential land uses in **Table 4**. The contribution from the new road project refers to the noise from the new road project alone and not the total level of road traffic noise.

- for existing residences and other sensitive land uses affected by noise from **redevelopment of existing roads**, the total traffic noise level from existing roads and the road redevelopment project exceeds the 'redevelopment of existing road' criterion for residences in **Table 3** or the criteria for non-residential land uses in **Table 4**.
- for existing residences and other sensitive land uses affected by **additional traffic on existing roads generated by land use developments**, the total traffic noise level from existing roads and the traffic generating development exceed the 'traffic generating development' criterion for residences in **Table 3** or the criteria for non-residential land uses in **Table 4.**

For assessment locations where both conditions i and ii above are met, identify the greater exceedance. This will be the controlling criterion.

The above should be determined for both day-time and night-time periods, and the more stringent of the day-time and night-time criteria should be adopted.

When assessing a change in noise level, the result should be reported to one decimal place. For example, where a noise level changes from 63.2 dB(A) to 64.7 dB(A) the change should be reported as 1.5 dB. Rounding is discussed in **Appendix B2.**

In cases where non-traffic noise constitutes an important part of the ambient noise in an area, monitoring needs to be supplemented by calculation of the traffic noise component, as described in **Appendix B1**.

Step 3

For each assessment location in the study area where exceedances are identified in Step 2, identify feasible and reasonable mitigation measures in the following order of priority:

i. road design and traffic management
ii. quieter pavement surfaces
iii. in-corridor noise barriers/mounds
iv. at-property treatments or localised barriers/mounds

to achieve the controlling criteria in Step 2 for both day-time and night-time periods.

Assessment locations exceeding the external noise criteria in Step 2 that already incorporate at-property treatment should identify feasible and reasonable mitigation measures in the priority order of (i) to (iii) above to address those external exceedances.

Step 4

For each assessment location in the study area, if the controlling criteria identified in Step 2 are not achievable in Step 3, justification should be provided that all feasible and reasonable mitigation has been applied.

For existing residences and other sensitive land uses affected by **additional traffic on existing roads generated by land use developments**, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'.

3.5 Cumulative impacts from traffic-generating developments

Land use developments could generate additional traffic and affect existing residential or other noise-sensitive land uses.

The assessment criteria aim to limit any additional traffic noise impacts as far as practicable. Their application would need to take into account the prevailing circumstances.

For example, a proponent will not be able to gain approval for multiple increases in the overall level of traffic noise simply by dividing a large development into small segments. However, where a single development covers a large area and separate changes are expected to increase traffic noise to two widely separated areas around the site (so as not to have any cumulative noise impacts on sensitive receivers in those areas), an increase may be allowed for each area. This, of course, would need to be assessed on a case-by-case basis by the relevant approval or regulatory authorities.

Strategic planning policies should address the cumulative impacts of transport and land use development to minimise exposure to unacceptable noise levels.

3.6 Setting assessment criteria where the road category is unclear

3.6.1 Functional road categories

The functional categories described in the *Network and corridor planning practice notes* (NSW Roads and Traffic Authority 2008a) may not be sufficiently definitive in some cases to allow the relevant noise criteria in **Table 3** to be identified.

When this is the case, the physical characteristics of the road should be assessed first and, where there is still doubt about the appropriate category, the acoustic characteristics of the road should be assessed.

Where existing traffic flows and road design are not sufficiently conclusive to identify a road category, the primary determinant for assigning appropriate noise criteria is the existing level of road traffic noise. For example, where the existing level of road traffic noise falls within the local road criteria, the local road noise criteria should be applied.

3.6.2 Transitions between road categories

Where different road and transitway categories along a proposed road are well separated, the criteria for each category apply as in **Table 3, Table 5** and **Table 6** and no transition between categories is necessary.

There will be instances, however, where a transition occurs between the differing road and transitway categories presented in this policy. A road development may encompass two or more road categories where, because of receiver distribution, application of the criteria in **Table 3, Table 5** and **Table 6** would result in criteria change boundaries running through residential areas. Similarly, an off-road transitway may transition into an on-road transitway, leading to differing criteria levels.

To manage the transition zone between two road categories (one having a lower criterion and the other having a higher criterion) in an equitable way for both the project proponent and the community, the following approach should be applied:

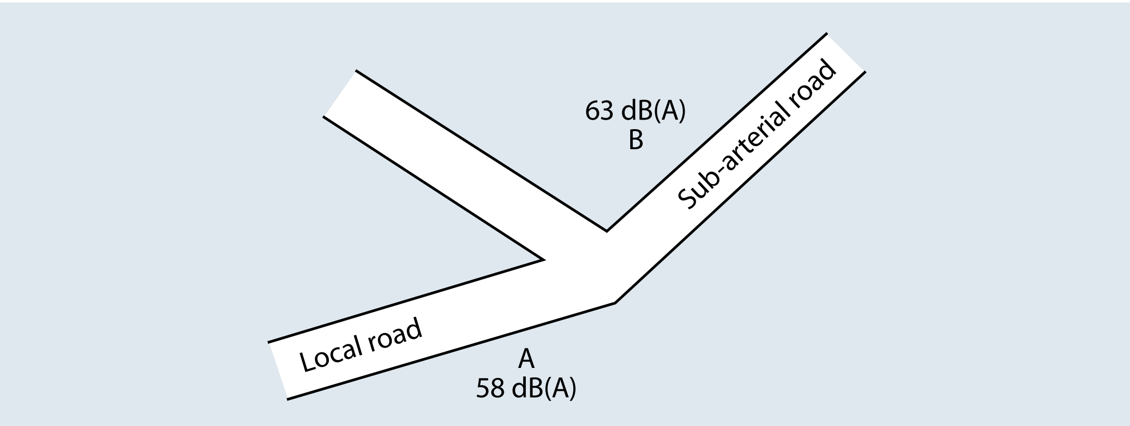
- where the existing noise levels are between the lower criteria and the higher criteria, the existing noise levels are the target
- where the existing noise levels exceed the higher criterion, the higher criterion is the target.

Any feasible and reasonable mitigation measures in a transition zone should be designed with reference to these revised target levels.

To illustrate this approach, consider an example where a new residential development will increase traffic along an existing local road that feeds into a sub-arterial road. As a result, both roads will be widened. In **Figure 1** below, residential premises are indicated as A and B.

The appropriate daytime criteria for the redevelopment of existing local and sub-arterial roads are $L_{Aeq, (1 hour)}$ 55 dB(A) and $L_{Aeq, (15 hour)}$ 60 dB(A) respectively. The current noise level measured at residence A is $L_{Aeq, (1 hour)}$ 58 dB(A) and at residence B is $L_{Aeq, (15 hour)}$ 63 dB(A). Therefore the target at residence A is to maintain the existing level of $L_{Aeq, (1 hour)}$ 58 dB(A) and the target at residence B is $L_{Aeq, (15 hour)}$ 60 dB(A).

Figure 1 Transition zones



4 Mitigation and management of road traffic noise

4.1 Strategies for new road projects

New road projects, especially those in greenfield areas, generally offer more opportunities to ensure that noise impacts are minimised and criteria are met. Road location and layout are more readily adjusted in greenfield areas than in built-up areas, and in many cases subsequent land use developments can be planned with regard to their sensitivity to noise.

The design process for new roads consists of several stages:

- **Stage 1: Strategic planning** – this stage establishes the objectives and the need for the proposed development. During this phase, land use and transport plans are considered as well as environmental factors.
- **Stage 2: Option evaluation** – an evaluation of a number of preliminary studies is undertaken to identify the need for the development and to select a preferred option. These studies may include an economic analysis, a route selection study, a value management or other option study and a preliminary environmental assessment – this assessment may include information on the potential noise impacts of the options, and identify broad noise mitigation strategies and requirements.
- **Stage 3: Concept design** –the preferred option is examined in more detail along with the likely environmental impacts and proposed safeguards. To assist the process, specialist reports will be prepared where required and may include a detailed noise assessment. Environmental impact assessment documentation will be produced, and the decision to approve a proposed development is generally made at this point.
- **Stage 4: Detailed design** –the approved concept design is further refined and the outputs generally inform the project's construction.

In stage 1, land use planning can be used to avoid future conflicts between noise-sensitive buildings and roads. Appropriate planning is a preventative measure that is often less costly and more effective for noise control, and should always be considered first. When development near a road corridor is planned, subdivision design and house/building design can also reduce noise impacts. For more information on the benefits of appropriate urban planning, see **Section 5.7**.

Transport planning is also considered at this stage. Traffic management strategies include the use of dedicated truck routes, enforcement of quiet zones and restricted access in residential areas during sleeping hours. At a broader level, encouragement to cycle, use public transport, increase the occupancy rates in private vehicles and encourage freight transport modes other than road transport, such as rail, can reduce the impact of traffic noise.

In stage 2, for some transport corridors both the noise assessment criteria and the relative increase criteria would be readily met through judicious road corridor selection and road design. For more difficult situations, existing uses in and around the transport corridor may prevent the selection of a corridor that avoids noise impacts. In particular, there may be practical problems incorporating appropriate engineering solutions for road projects into areas with existing development such as dwellings. In these cases, the proponent would be expected to collaborate with land use authorities, and to identify the additional strategies needed to achieve both the noise assessment criteria and the relative increase criteria.

Stage 3 should involve considering all mitigation measures. Examples include a minimum impact road alignment, low noise road pavement surfaces, noise barriers and at-property treatments. Engineering solutions such as noise barriers and at-property treatments are not necessarily the most cost effective or efficient methods of reducing road traffic noise. Any real gain will generally depend on a combination of strategies rather than just one strategy.

During stage 4, details such as exact barrier heights and the extent and nature of at-property treatments should be considered.

Generally, where existing noise levels can be reduced through feasible and reasonable measures, the primary objective is to reduce noise levels to meet the assessment criteria. Any contributed traffic noise from the new road and any relative increases in total traffic noise levels should be addressed as outlined in **Section 3.4**. The best combination of short-term and long-term measures should be applied.

Short-term strategies typically involve mitigation measures, while longer-term strategies encompass measures such as improved planning, design and construction of sensitive land use developments; lower vehicle emission standards; more public transport use, and modal changes in freight transportation. These longer-term strategies apply equally to addressing internal and external noise levels. Further long-term strategies are outlined in **Section 5.8**.

It is important to ensure the adequate and appropriate involvement of stakeholders, including local government and the community, in evaluating and selecting noise mitigation strategies and measures. Involving stakeholders as early as possible in the planning process, with effective communication and transparent decision-making, will assist in reflecting the perspective of those affected by noise from the project and foster improved acceptance of new road projects.

Information on maximum noise levels can be used to assess the relative impacts on sleep of different options for new roadway developments, and to rank maximum noise level impacts on residences so noise control measures can be prioritised (see NSW Roads and Traffic Authority 2008a for further guidance).

As the impact of noise on sleep relates to noise levels experienced in the home, approaches used to prevent sleep disturbance can be different from those used to address annoyance.

The best strategies for limiting maximum noise levels are discussed in **Section 5.1**.

4.2 Strategies for road redevelopments

There are opportunities to reduce road traffic noise levels when an existing road is redeveloped. The appropriate criteria to trigger the assessment process for mitigation are in **Tables 3** and **4**.

The redevelopment of existing road corridors offers a more limited range of noise control measures because of likely limitations to using corridor route adjustment, the proximity of residents to the road and limited road re-design options.

Upgrading of roads not designed to increase road traffic should not generate significant noise impacts and should aim to reduce current noise impacts, where possible.

In calculating the level of traffic noise generated by a road project, a technical and economic assessment would normally be done to establish feasible and reasonable options for noise mitigation. Such an assessment would include traffic noise criteria as the primary consideration; other factors are outlined in **Section 3.3**.

Road redevelopment project. Photo: DECCW

Where noise barriers are identified as the primary means of noise mitigation, visual considerations such as the protection of views, shadowing, and the appearance of the noise barriers should also be taken into account.

Road managers who assess the impacts of road developments and have the relevant expertise in noise mitigation works, develop the assessment process for feasible and reasonable noise mitigation works for road developments. Such a process needs to provide the community with early involvement and a transparent decision-making process, and to address what can be done where the chosen works do not meet the noise criteria.

As is the case for new road projects, implementing an effective communication strategy ensures that stakeholders and the community are aware of:

- the noise criteria for the project
- efforts being made to mitigate noise impacts
- who is responsible for noise management both on-site and in government, during construction and when the project has been completed.

Where a reduction of existing noise levels is possible, the primary objective for redeveloped roads is to reduce noise levels to meet the noise assessment criteria. Any relative impacts due to an increase in noise levels must be addressed as outlined in **Section 3.4**. Short-term and long-term strategies for achieving these reductions are outlined in **Section 1.4**.

4.3 Strategies for traffic-generating developments on existing roads

New industrial, commercial or residential developments that generate additional traffic on existing roads are likely to provide limited potential for noise control, because these developments are not usually linked to road improvements. However, strategies to minimise noise from traffic associated with the development should be applied. Mitigation that is implemented should be applied to the location along the public road from the development to the location where road traffic noise levels from the development are contained within the existing road traffic noise levels.

Examples of applicable strategies include the appropriate location of private access roads, regulating times of use, clustering vehicle movements, using 'quiet' vehicles and using barriers and acoustic treatments. Strategies should be appropriate to the type of development. For example, it is not appropriate or possible to control vehicle types and movements for residential developments but it may be possible when traffic is being generated from an industrial site.

Traffic-generating development. Photo: DECCW

4.4 Noise abatement for existing roads not subject to redevelopment

For existing roads where no redevelopment is taking place, the primary role of the RNP is to provide a basis for measuring and defining the extent of any existing traffic noise impacts. The target levels in **Table 8** are provided as a guide to assessing impacts rather than as achievable targets.

Table 8 Target noise abatement levels for existing roads not subject to redevelopment

Existing road category	Target noise level – dB(A)	
	Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)
Freeway/arterial/sub-arterial road	$L_{Aeq,\ (15\ hour)}$ 60 (external)	$L_{Aeq,\ (9\ hour)}$ 55 (external)
Local road	$L_{Aeq,\ (1\ hour)}$ 55 (external)	$L_{Aeq,\ (1\ hour)}$ 50 (external)

Resources are generally limited for noise control on existing roads and strategies need to take into account what is feasible and reasonable.

The retrofitting of engineering-type noise controls to existing roads where no upgrade or redevelopment is occurring should be limited to situations where there are noise impacts that require prompt attention.

A Noise Abatement Program has been developed and implemented by the NSW Roads and Traffic Authority on a priority basis for state and federal roads as a response to acute existing traffic noise impacts. This program directs resources to receivers experiencing the highest road traffic noise impacts. Access to the program's waiting list depends on a number of factors such as being exposed to traffic noise levels above $L_{Aeq,\ (15\ hour)}$ 65 or $L_{Aeq,\ (9\ hour)}$ 60, length of residence and whether any treatment of noise would be cost-effective and practical (see **Appendix C2**).

In 2009–10, the Roads and Traffic Authority spent $2.6 million treating 57 dwellings exposed to high levels of road traffic noise under this program. Architectural noise treatments included sealing around doors and windows, installing mechanical ventilation and replacing doors and windows with acoustically rated units.

The preferred approach to addressing existing and potential traffic noise impacts is through statewide or region-wide strategies, such as:

- progressive reduction of vehicle noise emissions (see **Appendix C5**)
- in-service inspections to ensure vehicle exhaust systems are well maintained (see **Appendix C5**)
- driver education
- traffic management, including limited access areas for heavy vehicles
- regulation of heavy vehicle engine brakes (see **Appendix C7**)
- the integration of transportation and land use planning (see **Sections 1.3.1** and **1.3.2** and **Appendix C10**)
- design and construction of new housing alongside transport corridors that minimises noise impacts (see **Appendix C10**).

These strategies address overall existing and potential noise impacts, rather than relying on piecemeal approaches such as the erection of noise barriers.

5 Other road traffic noise issues

5.1 Reaction to noise

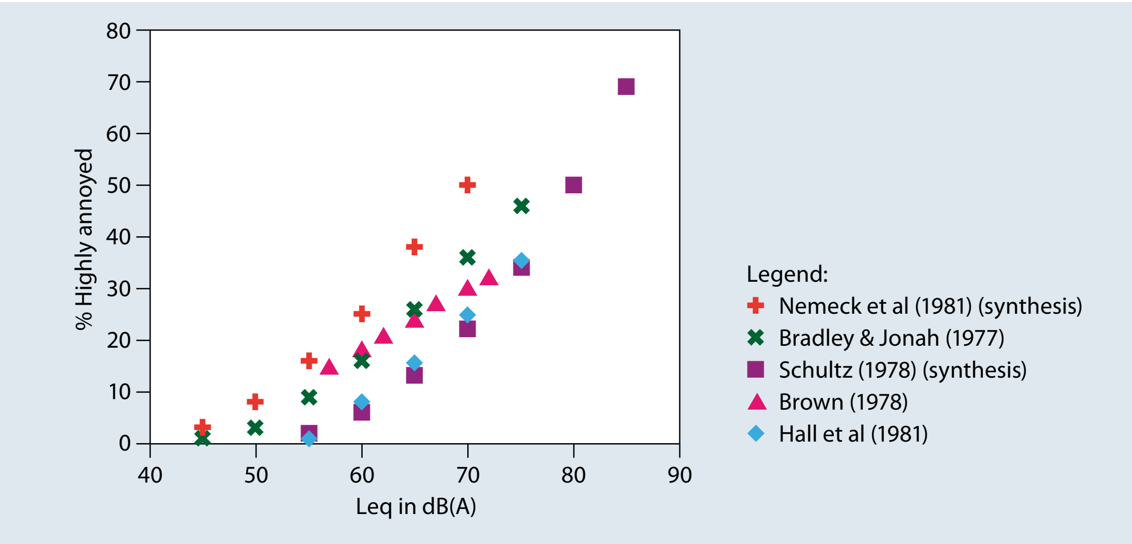
Most people's reaction to noise can be described as 'annoyance', but for some people other responses are evoked. For example, people may choose words related to annoyance to describe their reaction such as 'annoyed', 'irritated' or 'bothered', or words related to fear ('nervous', 'scared', 'edgy') or anger ('cranky', 'angry').

The individual level of reaction to noise varies widely and can be linked to a person's perceptions of the activity that produces the noise. In this regard, the results of social surveys are not a good tool for estimating an individual level of reaction to noise. However, for a group of people the average reaction, or the proportion of people showing a high level of reaction, can be predicted relatively accurately from social surveys. One useful measure of noise reaction is the proportion of people in a group who are 'highly annoyed' by the noise. This term may have a specific meaning in the context of a particular survey, but in general it is used to describe people who would choose the designation 'highly annoyed' from a list of categories to describe their feelings.

The proportion of residents found to be seriously and moderately affected by road traffic noise is shown in **Figure 2**, plotted against noise exposure as measured by the day-time equivalent (L_{Aeq}) noise level. Data in this figure are drawn from a number of international studies, including one conducted in Brisbane, Sydney and Melbourne (Brown 1978).

From **Figure 2**, 55 dB(A) L_{Aeq} corresponds to approximately 10% of residents who were highly annoyed, and 60 dB(A) L_{Aeq} corresponds to approximately 18% of residents who were highly annoyed.

Figure 2 Percentage of people highly annoyed by road traffic noise



Based on research findings, environmental objectives for transportation-related noise sources are set approximately at the point at which 10% of residents are highly annoyed by the noise. This is the case, for example, with aircraft noise, where the 20 Australian Noise Exposure Forecast (ANEF) noise contour (below which the construction of new residences is considered 'acceptable') represents approximately the point at which 10% of residents are highly annoyed.

The use of L_{Aeq} based descriptors for determining the degree of annoyance from road traffic noise remains as the preferred approach, based on recent research results (Sato et al 1999; Versfeld & Vos 2001).

There is growing evidence, however, that maximum noise levels from noisy vehicles in a traffic stream, such as noises from loud trucks, buses, cars and motorcycles, are also a key factor in determining annoyance (Bjorkman 1988, 1991; Sato et al 1999). The exact nature of the relationship between such noises and their degree of annoyance remains unclear at this stage.

It is therefore beneficial to implement, where possible, strategies to reduce the maximum noise levels from noisy vehicles in a traffic stream. Such strategies include:

- more stringent standards for new vehicles
- enforcement for in-service vehicles
- traffic management
- separating sensitive land uses from roadways where maximum noise levels from vehicles are unavoidable
- installing noise mitigation measures in new dwellings to reduce the effects of highly noisy events on sleep.

5.2 Noise habituation

Research supports the view that annoyance reactions to moderate levels of traffic noise generally decrease with length of residence. At relatively high traffic noise levels, however, (e.g. more than 74 dB(A)) the reverse occurs with longer periods of exposure leading to an increase in annoyance (Vallet et al 1978). One study found the behaviour of residents who are exposed to 80 dB(A) can be observed to change radically: they tend to become aggressive and less helpful (Tanczos et al 2006).

In relation to sleep, research (Kuroiwa et al 2001, Kawada et al 2000) based on measuring physiological reactions suggests that no habituation to noise takes place. Increased physiological effects occur with increasing noise levels even though self-reports of sleep study subjects indicate a degree of habituation to noise. More information on the effects of road traffic noise on sleep can be found in **Section 5.4**.

Research on the subject of habituation to noise during both waking and sleeping hours is inconclusive at this point and further work is required before any clear inferences can be drawn.

5.3 Response to a change in noise level

The data presented in **Section 5.1** are based on the responses of people living in residences that have been exposed to road traffic noise for some time. However, the level of reaction to a newly introduced noise may not be directly predictable from these results. While people may express a certain tolerance for their existing noise environment, they may feel strongly about increases in noise.

There is evidence to suggest that reaction to a newly introduced noise source is considerably higher than reaction to a source that has been present for some time. One study conducted in Japan (reported in Schultz 1979), compared the reaction to noise near a newly-opened Shinkansen (fast train) line with the reaction near a line that had been open for eight years. For the same noise level, reaction was higher near the newly opened line. The difference in reported annoyance was equivalent to a difference of approximately 8 dB in noise exposure (L_{Aeq}). The difference in reported awakenings from sleep was equivalent to a difference of 7 dB in maximum noise levels.

An Australian study (Brown 1987) considered reactions to a sudden increase in road traffic noise levels. It was found that while the reported reaction to traffic noise was consistent with other studies before the change in exposure, after the change it was higher than would have been predicted from studies performed under conditions of constant exposure. The difference was equivalent to a difference of between 3 and 15 dB in noise exposure. This variation reflects the uncertainty in predicting reactions to a given exposure under steady conditions.

In addition, one study (Geoplan Resource Planning 1992) investigated reactions to traffic noise in residents living near the newly opened F3 freeway. The level of reaction was compared to that of residents living near the Pacific Highway, before the opening of the freeway, who were exposed to similar noise levels. The reaction of residents near the F3 freeway was found to be higher than that of residents near the Pacific Highway for the same noise level, the difference being equivalent to a difference of approximately 9 dB in noise level.

The results of these studies are consistent and indicate that where noise exposure is suddenly and substantially increased, reaction is higher than would be predicted from studies of steady conditions. It is for this reason that the relative increase criteria have been introduced into this policy.

Converse findings have been reported for reactions to a sudden decrease in exposure, that is, the reaction to the altered situation is less than would have been predicted from the reaction to steady conditions.

5.4 Sleep disturbance

The disruption of a person's normal sleep patterns, or sleep disturbance, due to road traffic noise, has been the subject of numerous research studies conducted over the last 30 years. Despite intensive research, the triggers for and effects of sleep disturbance have not yet been conclusively determined. Sleep disturbance occurs through changes in sleep state and awakenings. Awakenings are better correlated to subjective assessments of sleep quality than are changes in sleep state, which generally require objective measurement.

Both subjective and measured physiological responses have been observed following exposure to road traffic noise and low frequency noise during sleep. Subjective responses include a negative mood, reduced task performance, irritation, tiredness, less social orientation, anxiety and tension (Waye 2004). Measured differences include an increased length of time to accomplish the transition from full wakefulness to sleep, reduced duration of deep (slow-wave) sleep, corresponding increases in rapid eye movement sleep and nocturnal awakening, and a variation in cortisol levels during sleep and after awakening in the morning, indicating a potential disruption of the body's circadian rhythm (Waye et al 2002, 2004; Waye 2004).

Individuals describing themselves as sensitive to noise tend to be more affected by it. The potential for sleep disturbance of shift workers who typically sleep during day-time periods was just as great as for night-time sleepers. It is also apparent that sleep disturbance due to noise is not diminished over time and some cumulative negative effects may occur (Ohrstrom et al 1988).

A summary of the current literature concerning sleep disturbance due to noise indicates that the main noise characteristics that influence sleep disturbance are the number of noisy events heard distinctly above the background level, the emergence of these events and the highest noise level.

The L_{Aeq}, which is the energy average level of the noise signal, accounts for the number and level of the louder events in a signal, due to the high amount of energy such events carry. However, the consensus is that L_{Aeq} by itself is an inadequate predictor of the potential of a varying noise to disturb sleep. For continuous traffic flow, L_{Aeq} appears to be acceptably correlated with sleep disturbance, since under these conditions there are few emergent noise events above the main hum of the traffic. However, for intermittent traffic flow, which often occurs at night, some other measure that takes into account the emergence, described by measures such as (L_{AFmax}–L_{Aeq}) or (L_{AFmax}–L_{AF90}), the highest level of noise and the number events may be needed to obtain a better correlation with sleep disturbance.

The World Health Organisation guidelines (World Health Organisation 1999) recommended that:

> 'where noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided'.

Further studies by the enHealth Council (2004) and the guidelines published by the World Health Organisation (1999) were reviewed and analysed in terms of the guidance on noise exposure and sleep disturbance. The enHealth report states that:

> 'as a rule for planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dB(A) $L_{A, (Max)}$ more than 10 or 15 times per night'.

The *Night noise guidelines for Europe* (World Health Organisation 2009) comprehensively reviewed policy and research on:

- methods and criteria for measuring night-time noise
- the relationship between sleep and health
- the effects of night-time noise on sleep
- the effects of night-time noise on health and wellbeing.

Long-term effects, such as cardiovascular disorders, are more correlated with noise indicators summarising the situation over a long period, such as $L_{Anight,outside}$ whereas instantaneous effects such as sleep disturbance are better linked to the maximum noise level per event (L_{Amax}).

The NSW Roads and Traffic Authority is tackling the issue of engine brake noise. Photo: DECCW

The World Health Organisation report (2009) uses $L_{Anight,outside}$ as a primary measure of night-time noise. This is the yearly average of outside façade noise levels during the night-time period, and roughly equivalent to the $L_{Aeq9hour}$ night-time descriptor.

Groups vulnerable to night noise exposure include the elderly and shift workers; children tend to be less sensitive. The report concluded that, although individual responses may vary:

- at $L_{Anight,outside}$ levels of <30 dB(A), no substantial biological effects are observed
- at $L_{Anight,outside}$ levels between 30 dB(A) and 40 dB(A), a number of effects are observed, but their impact is modest
- at $L_{Anight,outside}$ levels between 40 dB(A) and 55 dB(A), adverse health effects are observed, with many people needing to adapt their lives to cope; vulnerable groups are more severely affected
- at $L_{Anight,outside}$ levels above 55 dB(A), adverse health effects occur frequently, and a sizeable proportion of the population is highly annoyed and sleep disturbed. Cardiovascular disease risk rises, and public health is also threatened.

The report recommends a long-term $L_{Anight,outside}$ noise guideline level of 40 dB(A), with an interim $L_{Anight,outside}$ target level of 55 dB(A). The interim target is only intended as an intermediate step in localised situations as health impacts, particularly on vulnerable groups, are apparent at this noise level.

From the research on sleep disturbance to date it can be concluded that:

- maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep
- one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.

The *Environmental criteria for road traffic noise* (Environment Protection Authority NSW 1999) discussed a guideline aimed at limiting the level of sleep disturbance due to environmental noise – that the $L_{AF1,\ 1\ minute}$ level of any noise should not exceed the ambient L_{AF90} noise level by more than 15 dB. This guideline takes into account the emergence of noise events, but does not directly limit the number of such events or their highest level, which are also found to affect sleep disturbance.

Triggers for, and effects of sleep disturbance from, exposure to intermittent noise such as noise from road traffic are still being studied. There appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise. The NSW Roads and Traffic Authority's Practice Note 3 (NSW Roads and Traffic Authority 2008a) outlines a protocol for assessing and reporting on maximum noise levels and the potential for sleep disturbance.

DECCW will continue to review research on sleep disturbance as it becomes available.

5.5 Health effects

Recent research literature (Bluhm et al 2007, Grazuleviciene et al 2004, Muzet 2007, van Kempen et al 2002) has supported earlier research findings (Carter 1996, Ohrstrom & Bjorkman 1988) that the shorter-term health effects of sleep disturbance due to excessive noise exposure can affect quality of life during the subsequent waking hours. Symptoms include fatigue, moodiness, irritability, headaches, stomach upsets, lack of concentration and reduced work ability. These shorter-term effects do not appear to be reduced through repeated exposure.

Longer-term effects on health are more difficult to quantify, although tentative links have been drawn between noise exposure and heart rate, immune response, hypertension, blood pressure, occurrence of ischaemic heart disease, cardiovascular disease and myocardial infarction. The above links are often difficult to identify and quantify due to the presence of other environmental and lifestyle factors.

There is also evidence that noise has an effect on child cognition (enHealth Council 2004). Children exposed to high levels of environmental noise may display sustained and visual attention deficits, difficulty concentrating, reduced auditory discrimination and speech perception, poorer memory, and reduced reading ability and school performance on national standardised tests. Further research is required to define noise threshold levels triggering the onset of these effects.

The NSW Department of Health's New South Wales Population Health Survey 2009 (HOIST) asked questions for the first time about exposure to road traffic noise and its impacts on health. A total of 10,719 interviews were conducted with adults aged 16 years or over, from various area health services in urban and rural locations in NSW. The methodology of the 2009 NSW Population Health Survey can be found at http://www.health.nsw.gov.au/publichealth/surveys/hsa/09.asp. Some results were:

- 46% of respondents considered themselves exposed to road traffic noise. The highest levels of exposure were reported by those in the 25–34 age group, the most socio-economically disadvantaged and those living in urban areas, particularly western Sydney.
- 14% of respondents affected by road traffic noise considered it loud, 50% considered it moderate and 36% said it was quiet. Loud traffic noise was most common in Sydney's south-west (20%) and was reported least in western NSW (8%). Quiet road traffic noise was most commonly reported in southern NSW (30%).
- Cars (45%) and trucks (31%) were the most common sources of road traffic noise, with noisy cars and motorbikes cumulatively accounting for a further 20% of noise. Around 53% of respondents were affected primarily by noise from cars in south-eastern Sydney and the Illawarra, compared with 39% on the NSW north coast. The opposite was true for truck noise, with only 21% of respondents in south-eastern Sydney and the Illawarra being affected primarily by truck noise, compared with 40% on the north coast and 43% in the western regions of NSW.
- The most frequently reported adverse effects of road traffic noise exposure were annoyance (27%) and disturbed sleep (19%). Around 67% of respondents indicated no disturbance from their exposure to traffic noise.
- 55% of respondents identified traffic on local roads as being their main source of road traffic noise, 35% of respondents identified the source as main road traffic, and 9% identified freeways/motorways or major arterial road traffic as the source. Freeways, motorways and major arterial roads were the main source of traffic noise in the NSW north coast and greater southern regions, and also in western Sydney.
- 48% of respondents estimated their homes were within 10 metres of a road, 37% of homes were between 11 metres and 100 metres from a road, and 15% were more than 100 metres from a road.

5.6 Response to traffic noise in rural areas

Existing research on the response to noise of people living in areas with differing background noise levels (Hawkins & Large 1983) has shown that the response to a particular level of road traffic noise does not depend on background noise levels.

This suggests that noise assessment criteria for areas of higher existing background noise typical of urban/suburban settings, and areas of lower existing background noise typical of rural settings, should remain consistent.

Changes in road traffic noise level in rural areas due to the introduction of new roads or the upgrading of existing roads are addressed in **Section 2.4**.

5.7 Access to quiet areas

The importance of access to quiet areas, both within and outside a residence, has been recognised in research literature (Gidlof-Gunnarsson & Ohrstrom 2007, Ohrstrom et al. 2006). There is evidence that access to such areas results in reduced annoyance, adverse health effects and disturbance to sleep; and increased wellbeing.

The availability of openable windows on the quiet side of dwellings, oriented away from dominant traffic noise sources, facilitates the enjoyment of quiet indoor spaces for sleep, rest and relaxation. Dwelling layouts incorporating such features have been shown to reduce annoyance from road traffic noise compared to dwellings where openable windows are available only on the façade facing dominant road traffic noise sources (Rylander & Bjorkman 2002).

Access from residences to nearby quiet green areas, such as parks and reserves, has also been demonstrated to reduce traffic noise annoyance and stress-related psychological symptoms. The benefits provided by such areas are additional to those gained through providing indoor and outdoor quiet areas in dwellings (Gidlof-Gunnarsson & Ohrstrom 2007).

The above findings reinforce the importance of judicious planning when dealing with development on a broader scale. Nevertheless, reducing traffic noise levels in the community remains important as it has been shown that the effectiveness of the above measures is decreased when moderate to high ambient noise levels remain in these respite areas (Klaeboe 2007).

Further guidance on avoiding adverse noise and vibration impacts through good design is provided in *Development near rail corridors and busy roads – interim guideline* (Department of Planning NSW 2008).

5.8 Long-term strategies

Longer term strategies to address road traffic noise include but are not limited to:

- investigating changes to transportation, for example, shifting freight transport to rail from road
- encouraging the use of distribution centres for road freight to reduce the need for multiple heavy vehicle deliveries to one location
- promoting the use of low noise pavement surfaces and further researching these
- developing hybrid and electric light and heavy vehicles with lower noise emissions
- improving the quality of public transport services and expanding public transport networks
- developing travel demand management measures
- expanding cycle and pedestrian facilities and increasing their attractiveness
- reviewing parking policies to reduce the provision of parking
- ideally locating residential development away from major roads
- locating centres and main streets on streets branching off or parallel to major roads for improved amenity.

Appendices

Appendix A1 – Overseas criteria

In considering appropriate guidelines for road traffic noise, it is important to look at the criteria used in other countries, as shown in **Table 9**. Additional criteria have also been obtained for Canada, Denmark, Sweden, Austria, Hong Kong and the European Union. Most countries have a variety of criteria, depending on the zoning of the area receiving noise.

The noise descriptors used by most countries to define noise criteria are L_{Aeq}, L_{AF10} or L_{AF50}. For continuous high volume traffic, L_{Aeq} and L_{AF10} are strongly correlated when assessed over the same period, L_{AF10} being approximately 3 dB higher than L_{Aeq}.

Day-time noise criteria range from 40 to 75 dB(A) L_{Aeq}, while night-time criteria range from 30 to 70 dB(A) L_{Aeq}. Many countries place a more stringent limit on the night-time L_{Aeq} level from road traffic noise than on the day-time level. L_{Aeq} is measured or calculated over a variety of periods, from 24 hours to an $L_{Aeq,\ (1\ hour)}$, with some countries, including Denmark, Hong Kong and the USA, assuming that a single criterion will assure that both day-time and night-time noise levels will be satisfactory. The period over which the night-time L_{Aeq} is calculated also varies considerably from country to country, and sometimes between regions in one country. This may partly be explained by a difference in normal sleeping hours from one country to the next.

Since the publication of the *Environmental criteria for road traffic noise* (Environment Protection Authority 1999), noise management in the European Union has undergone review. In 2002, a European Union directive (2002/49/EC) outlining a common approach to noise assessment and management was issued, as the situation in the different member states was diverse and difficult to compare. A European Union survey (European Commission 2000) showed that the L_{Aeq} 58 to 62 dB(A) day-time limit and L_{Aeq} 48 to 55 dB(A) night-time limit seem to be the ranges of basic limits applied to zones bordering new roads in residential areas. Differences of 5 to 10 dB are observed between the limits applied to new developments and those for the management of existing situations.

The European Union directive introduced L_{den} as the indicator of annoyance due to road traffic noise. L_{den} is a noise assessment indicator that represents the sound pressure level corrected according to the period of the day. L stands for 'level', d for 'day', e for 'evening', and n for 'night'. The L_{den} (Day Evening Night Sound Pressure Level) or CNEL (Community Noise Equivalent Level) is the energy averaged sound pressure level over a 24-hour period, with a penalty of 5 dB added for the evening hours of 7 p.m. to 10 p.m., and a penalty of 10 dB added for the night-time hours of 10 p.m. to 7 a.m. These periods can be slightly changed for a better match with lifestyle habits in different countries or states. Other levels can be defined, covering the 24-hour period with different penalties depending on the time. An additional assessment indicator, L_{dn} (day–night 7 a.m. to 10 p.m. and night–day 10 p.m. to 7 a.m.) with just a penalty of 10 dB added for the night-time hours, is also noted in the directive.

Another aspect of the European Union directive is noise mapping: a requirement for large cities with major roads that carry more than six million passengers per year to produce noise contour maps. These will eventually cover all major routes including railways. Some member countries have completed these maps and they form an important part of setting limits and measures for environmental noise. The noise maps also form part of country action plans which must be submitted to the European Union and are reviewed every five years.

It is estimated that approximately 32% of the European Union population is exposed to road noise levels above 55 dB L_{dn} in front of their homes.

Table 9 Residential traffic noise criteria by country

Country	Day-time criteria	Night-time criteria	Instrument	Comments
Austria	60 dB(A) L_{eq} Planned roads in quiet areas 55 dB(A) L_{eq}	50 dB(A) L_{eq} Planned roads in quiet areas 45 dB(A) L_{eq}	*Instruction for noise control on federal roads.*	For the purpose of these criteria, quiet areas are where the extraneous noise level, excluding rail and aircraft noise, is less than 50 dB during the day and 40 dB at night.
Canada	Outdoor 55 dB(A) $L_{Aeq, (16 hr)}$ Indoor 40–45 dB(A) $L_{Aeq, (16 hr)}$	Outdoor 50 dB(A) $L_{Aeq, (8 hr)}$ Indoor 40–45dB(A) $L_{Aeq, (8 hr)}$	*Noise assessment criteria in land use planning*	Criteria given are for roads. Noise descriptor for freeways is $L_{Aeq, (24 hr)}$.
Denmark	50–65 dB(A) $L_{Aeq, (24 hr)}$ dependent on land use		*Noise from traffic in residential areas*	
France	60–65 dB(A) $L_{Aeq, (16 hr)}$ (6 a.m.–10 p.m.)	55–60 dB(A) $L_{Aeq, (8 hr)}$ (10 p.m.– 6 a.m.)	1995 law against noise	Noise criteria now part of national law against noise.
Germany	64 dB(A) $L_{Aeq, (16 hr)}$ (6 a.m.–10 p.m.)	54 dB(A) $L_{Aeq, (8 hr)}$ (10 p.m.–6 a.m.)	Federal Immission Protection Act	Federal law, but may change due to introduction of European Commission directive.
Greece	Residences 70 dB(A) $L_{A10, (18 hour)}$ Also 67 dB(A) L_{Aeq} (8 a.m.–8 p.m.)		National law	Criteria on traffic noise being developed, in accordance with European Union legislation, require use of L_{den} and L_{night}. Sensitive land uses 60 dB(A) $L_{A10, (18 hour)}$.
Hong Kong	70 dB(A) $L_{A10, (1 hr)}$ dwellings		Hong Kong planning standards and guidelines	Measured during peak hour of traffic. 65 dB(A) educational institutions and places of worship. 55 dB(A) hospitals and clinics.
Italy	65 dB(A) $L_{Aeq, (16 hr)}$	55 dB(A) $L_{Aeq, (8 hr)}$	*Sustainable mobility in urban areas*	National law
Japan	50–60 dB(A) $L_{Aeq, (16 hr)}$	40–50 dB(A)$L_{Aeq, (8 hr)}$	*Environmental quality standards for noise*	Criteria increase if more than one road is nearby.

Country	Day-time criteria	Night-time criteria	Instrument	Comments
Member States of the European Union	L_{Aeq}58–62 dB(A)	L_{Aeq}48–55 dB(A)		Some Nordic countries use $L_{Aeq, (24\ hour)}$. The 2002 European Commission directive on environmental noise management uses Lden as a measurement of night-time noise.
Spain	Proposed criteria of 55–75 dB(A) L_{eq}	Proposed criteria of 45–65 dB(A) L_{eq}		No fixed laws – looking to implement the Lden noise descriptor recommended in the European Commission directive.
Sweden	<30 dB(A) L_{eq} equivalent level indoors <55 dB(A) L_{eq} equivalent level outdoors at façade <70 dB(A) $L_{A, (Max)}$	<45 dB(A) $L_{A, (Max)}$ maximum level indoors at night		Swedish Government and Swedish Parliament have defined guidelines for residential areas and schools and hospitals. Transport Policy for Sustainable Development Bill.
Switzerland	60 dB(A) $L_{Aeq, (15\ hr)}$ reference level	50 dB(A) $L_{Aeq, (9\ hr)}$ reference level	Noise Abatement Ordinance	Planning levels 5 dB below these criteria.
The Netherlands	48–58 dB(A) $L_{den(7\ a.m.–7\ p.m.,\ 7\ p.m.–11\ p.m.,\ 11\ p.m.–7\ a.m.)}$ (new motorways) 53–68 dB(A) $L_{den(7\ a.m.–7\ p.m.,\ 7\ p.m.–11\ p.m.,\ 11\ p.m.–7\ a.m.)}$ (modification of existing motorways)		Fourth national environment policy plan	60 criteria to choose from, depending on zoning and stage of construction of road and residences.
UK	55–72 dB(A) L_{Aeq} (7 a.m.–11 p.m.)	45–66 dB(A) L_{Aeq} (11 p.m.–7 a.m.)	*Town and Country Planning Act 1990* *Planning Policy Guidance PPG24: Planning and noise*	Different criteria depending on dwelling category.
United States of America	52 dB(A) (interior), 67 dB(A) (exterior) $L_{Aeq, (1\ hr)}$ or 55 dB(A) (interior), 70 dB(A) (exterior) L_{A10} Noise impact where predicted traffic noise levels 'substantially exceed' existing levels, set by individual state highway agencies and typically around 10 dB.		Code of Federal Regulations Part 772	Noise level criteria are dependent on land use. Criteria for residences are shown here.

Sources

Austria: Federal Ministry of Environment, Youth and Family Affairs, Economic Affairs 1995, *National environmental plan (NUP) instruction for noise control on federal roads*

Canada: Ontario Ministry of Environment 1997, *Noise assessment criteria in land use planning*, LU-131

Denmark: Danish Environment Protection Authority 1984, *Environmental guideline no. 3/1984, Noise from traffic in residential areas*

European Union: European Commission 2000b, *Position paper on EU noise indicators*, a report produced for the European Commission, Environment Directorate-General

France: 1995 Law Against Noise

Germany: Federal Minister for Environment, *Federal Immission Protection Act – 16 BImSchV 1990*

Greece: National Law 17252/92, Official Journal of the Hellenic Parliament, 395 B/19-6-92

Hong Kong: Environment Protection Department, The Government of the Hong Kong Special Administrative Region 1985, *Hong Kong planning standards and guidelines*, Chapter 9

Italy: Ministry of Environment 1998, *Sustainable mobility in urban areas*

Japan: Ministry of the Environment, Government of Japan 1998, *Environmental quality standards for noise*, Environment Agency Notification No 64

Spain: Jefatura del Estado, Ley 37/2003 Del Ruido

Sweden: Swedish Government Bill 1997/98:56: Transport Policy for Sustainable Development

Switzerland: Swiss Federal Council Noise Abatement Ordinance of 15 December 1986 (NAO) 814.41

The Netherlands: Ministry for Housing, Spatial Planning and the Environment (VROM), 2001, *Fourth national environment policy plan*

UK: *Town and Country Planning Act 1990* and *Planning Policy Guidance PPG24: Planning and Noise*

USA: FHWA, Title 23 of the United States Code of Federal Regulations Part 772 (23 CFR 772), 1982 (United States Department of Transportation 1982)

Appendix A2 –Criteria for other Australian states and territories

Information on noise criteria used in other Australian states and territories is shown in **Table 10**. Most jurisdictions have a variety of criteria, depending on the zoning of the area receiving noise and the type of road project under consideration (new road or upgrade/ redevelopment of an existing road).

Day-time noise criteria range from 63 to 68 dB(A) measured as a L_{AF10} or 55 to 65 dB(A) measured as a $L_{Aeq.}$ (For continuous high volume traffic, L_{Aeq} and L_{AF10} are strongly correlated when assessed over the same period, L_{AF10} being approximately 3 dB higher than L_{Aeq}). Night-time criteria range from 50–60 dB(A) measured as a L_{Aeq}. South Australia and Western Australia place more stringent limits on the night-time L_{Aeq} levels from road traffic noise than on the day-time levels. Jurisdictions with no day–night split set the measuring period to 6 a.m.–midnight with the assumption that the criteria will ensure that both day-time and night-time levels will be satisfactory. Jurisdictions with a day–night split measure the day as the period between 6 a.m. or 7 a.m. to 10 p.m. and the night between 10 p.m. to 6 a.m. or 7 a.m.

Table 10 Comparison of interstate residential traffic noise criteria

State	Day-time criteria	Night-time criteria	Instrument	Comments
South Australia	Outdoor target: 55 dB(A) $L_{Aeq,(15\ hour)}$ (7 a.m.–10 p.m.) if existing traffic noise level is < 53 dB(A). Target is existing level plus 2 dB if existing level is < 63 dB(A). Target is 65 dB(A) if existing level is > 63 dB(A).	Outdoor target: 50 dB(A) $L_{Aeq,(9\ hour)}$ (10 p.m.–7 a.m.) if existing traffic noise level is < 50 dB(A) Target is existing level plus 2 dB if existing level is < 58 dB(A) Target is 60 dB(A) if existing level is > 58 dB(A).	Department for Transport, Energy and Infrastructure 2007, *Road traffic noise guidelines.*	Lower target used for residences not currently exposed to traffic noise, or infrastructure projects in low ambient noise environment. For high existing exposure, use higher target. Only applies to infrastructure projects, not to the network where no works are being undertaken.
Western Australia	Outdoor target: 55 dB(A) $L_{Aeq,\ (16\ hr)}$ (6 a.m.–10 p.m.) Outdoor limit: 60 dB(A) $L_{Aeq,\ (16\ hr)}$ (6a.m.–10p.m.)	Outdoor target: 50 dB(A) $L_{Aeq,\ (8\ hr)}$ (10 p.m.–6 a.m.) Outdoor limit: 55 dB(A) $L_{Aeq,\ (8\ hr)}$ (10p.m.–6a.m.)	Western Australian Planning Commission, *Statement of planning policy 5.4: Road and rail transport noise and freight considerations in land use planning*	For new roads, criteria apply at 1 metre from the façade on the ground floor level. Criteria also apply to new noise-sensitive development. Proponent should achieve limit, and consider measures to achieve target. For major road upgrades, criteria are established by negotiation between agencies.

State	Day-time criteria	Night-time criteria	Instrument	Comments
Northern Territory	Existing road – unplanned significant development: outdoor target – 68dB(A) $L_{A10\,(18\,hr)}$ (6 a.m.–midnight), where there is a predicted increase in noise levels of > 5dB and the predicted noise level is > 68db(A) $L_{A10\,(18\,hr)}$ (6 a.m.–midnight) Future road – not currently planned: outdoor 63 dB(A) $L_{A10\,(18\,hr)}$ (6 am-midnight), where there is a predicted increase in noise levels of > 5dB and the predicted noise level is > 63dB(A) $L_{A10\,(18\,hr)}$ (6 a.m.–midnight)		Department of Lands and Planning, Road Network Division, *Policy – road traffic noise on NT Government controlled roads*	Existing noise-sensitive land uses are 5 dB lower than these values. Noise mitigation for future residential development is the responsibility of the proponent.
Queensland	New access controlled road: outdoor 63 dB(A) $L_{A10\,(18\,hr)}$ (6 a.m.–midnight) and an increase of 3 dB or more above a pre-construction level of > 55 dB(A); or outdoor 60 dB(A) $L_{A10\,(18\,hr)}$ (6 a.m.–midnight) and an increase of 6 dB or more above a pre-construction level of ≤ 55 dB(A) Upgrade of existing road: outdoor 68 dB(A) $L_{A10\,(18\,hr)}$ (6 a.m.–midnight) Existing road with no roadworks: outdoor 68 dB(A) $L_{A10\,(18\,hr)}$ (6 a.m.–midnight)		Department of Main Roads 2007, *Road traffic noise management: code of practice*	A policy for development on land affected by environmental emissions from transport and transport infrastructure is being developed for new developments contiguous with state-controlled roads. For 'existing roads with no roadworks', special consideration for treatment is required where there is a sudden increase in traffic volume or a high (> 20%) percentage of heavy vehicles, particularly at night. Outdoor levels are façade corrected.
Tasmania	No specific criteria for traffic noise		Department of Primary Industries, Parks, Water and the Environment 2009, *Environment Protection Policy (Noise) 2009*, Part 4	A transport noise strategy is being developed by the Department of Infrastructure, Energy and Resources in accordance with Part 4 of the *Environment Protection Policy (Noise) 2009.*

State	Day-time criteria	Night-time criteria	Instrument	Comments
Victoria	New or upgraded road: Category A: outdoor 63 dB(A) $L_{A10\ (18\ hr)}$ (6 a.m.–midnight) Category B: outdoor 63 dB(A) $L_{A10\ (12\ hr)}$ (6 a.m.–6 p.m.) Where noise level before road construction is < 50 dB(A) $L_{A10,\ (18\ hr),}$ consider limiting noise level increase to **12 dB.** Where pre-existing noise levels are > 63 dB(A), an increase of 2 dB in total noise level may be tolerated, provided it is demonstrated that a zero dB increase cannot feasibly be achieved. Otherwise it must be zero. In **exceptional** circumstances it is acceptable to supplement outdoor noise mitigation with at-property treatments where 63 dB(A) cannot be achieved. Otherwise, the targets are regarded as mandatory. Existing road: Where outdoor levels > 68 dB (A) $L_{A10\ (18\ hr)}$ for Cat A or 68 dB(A) $L_{A10\ (12\ hr)}$ for Cat B, noise mitigation will be provided **subject to available funding.**		Vic Roads 2005, *Traffic noise reduction policy*	Category A comprises residential dwellings, aged persons homes, hospitals, motels, caravan parks and other residential buildings. Category B comprises educational institutions, childcare centres and places of worship. Road upgrade is defined as adding two or more lanes **and** removing buildings that previously provided screening from traffic noise.
Australian Capital Territory	Current practice is to apply the criteria in the former 'Draft noise management guidelines'. These are: New development on existing road or new road in new area: outdoor 63 dB(A) $L_{A10\ (18\ hr)}$ (6 a.m.–midnight). Upgrade existing road in existing area: If the existing outdoor level is > 63 dB(A) $L_{A10\ (18\ hr)}$ (6 a.m.–midnight), equal to existing level. If the existing outdoor level is 58-63 dB(A) $L_{A10\ (18\ hr)}$ (6 a.m.–midnight), equal to 63 dB(A). If the existing outdoor level is < 58 dB(A) $L_{A10\ (18\ hr)}$ (6 a.m.–midnight), equal to the existing level plus 5 dB. The criterion applicable to noise-sensitive land uses (principally residential uses, but also educational establishments, hospitals) established before 23 March 1996 is that applied by the former National Capital Development Commission (i.e. $L_{A10\ (18\ hour)}$ not to exceed 65 dB (A) at 1 m in front of the wall of a building adjacent to a road which is the source of traffic noise).		ACT Planning Authority's 'Draft noise management guidelines' were repealed on 31 March 2008	A transportation noise code is being developed by the Department of Territory and Municipal Services in consultation with the ACT Planning and Land Authority.

Appendix B – Measurements and preparing a noise assessment report

This appendix gives detailed guidance on measuring and predicting traffic noise levels and preparing a noise assessment report for new road projects, road redevelopments and land uses generating additional traffic on existing roads.

Details are also given of the procedures required for monitoring existing noise levels, and of specific requirements for calculating noise.

B1 Traffic noise assessment and reporting

The process below provides guidance on carrying out and reporting traffic noise assessments.

1. Determine land use types, as set out in **Tables 2 and 3** in **Section 2** of this document, within the study area along the length of the new or affected section(s) of road.
2. Determine noise assessment criteria for each section of the road, using the levels given in **Tables 2 and 3** for each land use.
3. Conduct noise monitoring to determine existing traffic noise levels at representative potentially affected locations. Measurement procedures are described in **Appendix B3**. In cases where non-traffic noise constitutes an important part of the ambient noise in an area, monitoring needs to be supplemented by calculation of the traffic noise component, carried out as described in **Appendix B4**.

   Note that all noise descriptors that will be used in the assessment should be monitored. This may include $L_{Aeq, (1 hour)}$, $L_{Aeq, (15 hour)}$, $L_{Aeq, (9 hour)}$ and maximum noise levels, depending on the area classification and types of land use involved.

   Note that any change in traffic volume or composition on existing roads, resulting from the road project, would also need to be taken into account.
4. Identify every potentially affected receiver along the length of the proposed road, and assign both assessment criteria and relative increase criteria (based on the existing level of traffic noise) for each one (see **Section 3.4.1**). Select the lower of the assessment criteria and the relative increase criteria to be the controlling criterion at each identified receiver.
5. Obtain accurate data on:
   - the alignment of the proposed road or redeveloped road, including gradient and heights of cuttings and fill
   - the pavement surface type
   - posted traffic speed limits
   - projected traffic volumes and heavy vehicle proportion for both assessment timeframes under the 'build option'. Break this down at least into the periods 7 a.m.–10 p.m. and 10 p.m.–7 a.m., and specify the proportion of heavy vehicles on the road in each period. Preferably, obtain projected volumes for each hour and use average weekday volumes
   - existing traffic in the case of a redeveloped road or land use development creating additional traffic, with a similar level of detail to that above, to allow the calculation of the total existing level of traffic noise on the road.

6. Calculate an initial noise level, expressed in terms of the required descriptors, for each receiver, as described in **Appendix B4**, assuming no noise mitigation measures are introduced.
   - For new roads, calculated levels should include noise from traffic on the new road to assess its contribution. Traffic noise from any other roads which may influence the total traffic noise level at the receiver should be included when assessing the relative increase.
   - For redeveloped roads or land use developments creating additional traffic, calculations may be based on measured existing noise levels with any necessary corrections for the variation in traffic conditions.
7. Where the initial calculated noise level exceeds the relevant assessment criteria for any receiver, investigate feasible and reasonable mitigation measures (see **Section 3.3**) such as those in the priority order below, with the aim of achieving the assessment criteria:
   - alternative road alignments (such a measure is typically considered during the option evaluation stage, as outlined in **Section 4.1**)
   - use of alternative transport modes or other ways of avoiding the need for the proposal (such a measure is typically considered during the strategic planning stage, as outlined in **Section 4.1**)
   - control of traffic (for example, limiting times of access or speed limitations)
   - use of a low-noise road pavement surface
   - use of in-corridor noise barriers, bunds or cuttings
   - for non-residential buildings or residential buildings where the night-time criteria are the major concern, treatment of the façade to reduce internal noise levels or localised barriers/mounds.
8. If appropriate, recalculate noise levels to include the effect of the proposed mitigation measures. If noise levels still exceed the assessment criteria and further reasonable mitigation measures are available, repeat step 7.
9. Include the following details in the acoustic report:
   - diagrams showing the road alignment, land uses along the proposed road and noise measurement locations – these should be to a scale large enough to delineate individual residential lots
   - details of the noise assessment criteria at each potentially affected receiver
   - details of noise monitoring procedures and calculations of existing noise levels – these should include raw measurement data from each site, and assumptions made in calculations, including assumed traffic volumes and proportions of heavy vehicles, as well as details of the calculation procedure
   - details of assumed data for the new road, redeveloped road or new road use, including traffic volumes and proportion of heavy vehicles by time of day; and details of the calculation process, including assumed noise source heights of vehicles
   - details of any modelling uncertainties and their effect on predicted noise levels
   - posted traffic speed limit(s) and road pavement surface type
   - if required, a description of the mitigation measures considered, reasons for inclusion or exclusion, and procedures for calculating noise levels, including mitigation measures

- a diagram showing noise level contours (this may not be required for new traffic generating developments that are not predicted to show a significant impact), or other methods of determining the calculated noise level at each receiver, both with and without mitigation measures
- details of any relative increases in noise levels, both with and without mitigation measures
- if necessary, discussion of any potential problems associated with the proposed mitigation measures, such as overshadowing effects
- where the noise assessment criteria set out in **Tables 2– 4** and relative increase criteria set out in **Table 6** have not been met, an assessment of feasible and reasonable considerations on noise mitigation measures.

B2 Rounding

Noise reports should usually present:

- noise levels rounded to the nearest integer
- differences between two noise levels rounded to a single decimal place.

In both of the above instances, symmetric arithmetic rounding should be used. The above rounding methods should only be applied to the final result of a calculation – intermediate rounding steps should be avoided.

B3 Noise monitoring procedures

This section describes the procedures used to gather the noise information needed to apply this RNP. This section is not intended to describe in detail the procedures required to undertake a comprehensive noise-monitoring program. These procedures are documented elsewhere, and are a part of general acoustic practice.

To measure the range of noise levels specified in this document, any noise monitoring program must be carefully designed. Select sites to cover the range of traffic noise conditions encountered in the area of interest. Avoid locations with significant sources of noise other than road traffic. If this is not possible, document these other sources and estimate their contribution to the measured noise level. Remember that in applying this RNP, only levels of road traffic noise are important.

L_{Aeq} noise levels can be measured with noise monitors or appropriate sound level meters, using conventional techniques. Measuring systems may be attended or unattended, depending on the requirements of the specific project.

- $L_{Aeq,\,(15\ hour)}$ is the L_{Aeq} noise level for the period 7 a.m.–10 p.m. It is recommended that the L_{Aeq} be measured on a 15-minute basis. The equation is $L_{Aeq,\,(15\ hour)}$ = logarithmic average of all the individual $L_{Aeq,\,(15\ minute)}$ values from 7 a.m. to 10 p.m., with the first reading taken at 7:15 a.m. and the last at 10 p.m., for the entire measurement period (for example, one week). In this case:

$$\text{Logarithmic average} = 10 \times \log_{10}\left(\frac{\sum_{i=1}^{n} 10^{\left(\frac{L_{Aeq,\,(15\ minute),\,i}}{10}\right)}}{n}\right)$$

where n = number of $L_{Aeq,\,(15\ minute)}$ values in each assessment period over the measurement period.

- $L_{Aeq, (9 hour)}$ is the L_{Aeq} noise level for the period 10 p.m.–7 a.m. It is recommended that the L_{Aeq} be measured on a 15-minute basis. The equation is $L_{Aeq, (9 hour)}$ = logarithmic average of all the individual $L_{Aeq, (15 minute)}$ values from 10 p.m. to 7 a.m., with the first reading taken at 10:15 p.m. and the last at 7 a.m., for the entire measurement period (for example, one week). In this case:

$$\text{Logarithmic average} = 10 \times \log_{10}\left(\frac{\sum_{i=1}^{n} 10^{\left(\frac{L_{Aeq,\,(15\,minute),\,i}}{10}\right)}}{n}\right)$$

  where n = number of $L_{Aeq, (15 minute)}$ values in each assessment period over the measurement period.

- $L_{Aeq, (1 hour)}$ is the noise level representing the 'average maximum' one-hour noise level. It is recommended that the L_{Aeq} be measured on a 15-minute basis, and the $L_{Aeq, (1 hour)}$ for any specific hour be calculated as the logarithmic average of the four $L_{Aeq, (15 minute)}$ levels in that specific hour.

- The L_{Aeq} for the entire monitoring period (a minimum of seven consecutive days is preferred) is calculated as follows:

  1. A 'daily' $L_{Aeq, (1 hour)}$ is calculated as the $L_{Aeq, (1 hour)}$ noise level during the period 7 a.m.–10 p.m. (or the period 10 p.m.–7 a.m. for night-time, as relevant) that is exceeded for 10% of the time. Or, if the $L_{Aeq, (1 hour)}$ that is exceeded for 10% of the time cannot be accurately defined, the 'daily' $L_{Aeq, (1 hour)}$ is taken as the $L_{Aeq, (1 hour)}$ noise level for the noisiest hour, i.e. the maximum $L_{Aeq, (1 hour)}$.
  2. Then the overall $L_{Aeq, (1 hour)}$ noise level for the total duration of the monitoring period is calculated as the median of the 'daily' $L_{Aeq, (1 hour)}$ noise levels. The overall $L_{Aeq, (1 hour)}$ noise level is then taken to apply for any hour during the relevant period (7 a.m.–10 p.m. or 10 p.m.–7 a.m.). In this case:

$$\text{Logarithmic average} = 10 \times \log_{10}\left(\frac{\sum_{i=1}^{n} 10^{\left(\frac{L_{Aeq,\,i}}{10}\right)}}{n}\right)$$

  where n = number of L_{Aeq} values in the sample for which the average is being calculated.

Maximum noise levels during the night-time period (10 p.m.–7 a.m.) should be assessed to analyse possible effects on sleep. The assessment should encompass the likely maximum noise levels due to road traffic, the extent to which these maximum noise levels exceed ambient noise levels, and the number of noise events from road traffic during the night on an hourly basis for a 'typical' night.

The most appropriate currently available methods of determining maximum noise levels as required for this RNP are:

- electronic storage of instantaneous sound pressure levels at intervals of at least 1/4 second, or
- the use of a chart recorder.

In either case, 'fast' time weighting should be used. Storage of longer-period noise levels, such as 1-second L_{Aeq} levels, may be appropriate, but should be justified on the basis that shorter-term fluctuations in noise levels are unlikely in the circumstances involved.

For unattended monitoring, the arrangement of instruments would normally involve a standard noise logger with a signal output to a storage device. Sound level meters with data storage capabilities may also be used, typically during operator-attended monitoring sessions.

Noise levels that are attributable to sources other than road traffic, including sirens on emergency vehicles, should be discarded.

When describing the measurement and analysis procedures used in any monitoring program, give details of the method used to determine maximum noise levels.

B4 Noise modelling methods

The calculation of traffic noise levels may be based on one or more modelling methods, each of which has its advantages and disadvantages. The three models generally used in Australia, and which have been validated under specific Australian conditions, are:

- Calculation of Road Traffic Noise – the CoRTN model. This has the advantage of having been specifically validated under Australian conditions, and specific corrections can be included to account for the results of this validation study, conducted by the NAASRA Working Group (Saunders, Samuels, Leach & Hall 1983). It is also relatively simple to use, and for this reason may be the most appropriate method for relatively small projects. However, the method provides only relatively simplistic corrections for the percentage of heavy vehicles and the distance from the roadway. In addition, results are in terms of $L_{AF10, (18\ hour)}$ and $L_{AF10, (1\ hour)}$ and require corrections to give predicted levels for other noise descriptors. For example, a commonly applied correction for continuous traffic is $L_{Aeq} = L_{AF10} - 3$ dB. It should also be noted that the algorithms are not valid for low traffic volumes.

Source of model: UK Department of Transport or UK Department of Environment.

- Federal Highway Administration Model – the FHWA (STAMINA 2.0) model. This has the advantage of allowing direct calculation of L_{Aeq} noise levels, based on stated assumptions regarding the noise emission levels of various classes of vehicles. Where the noise emission levels differ from those assumed, adjustment to the model is relatively easy. Furthermore, the calculation algorithms are generally considered to be mathematically more rigorous than those of the CoRTN method, leading to greater accuracy and a wider range of validity at low traffic flows.

Source of model: US Federal Highway Administration/US Department of Transport.

- Federal Highway Administration Model 2004 – the FHWA (TNM 2.5) model. In addition to the FHWA STAMINA model, it provides for changes in noise emissions around features such as traffic lights and toll booths, pavement surface corrections, and user defined vehicle types. The calculations also calculate frequency-related effects in octave bands, and propagation effects via sophisticated (but cumbersome) algorithms. TNM 2.5 contains improved acoustical algorithms compared with previous versions of the model (TNM 1.0 to 2.1).

Source of model: US Federal Highway Administration/US Department of Transport.

For more information on the models see the following references: Brown (1989), Hede (1995), United Kingdom Department of Transport (1988) and US Department of Transport (2004).

Other models in use internationally include:

- Nord2000 (Scandinavia)
- NMPB (France)
- RLS 90 (Germany)
- RMV II (Netherlands)
- Harmonoise (European Union).

The use of one or more of the above models, or any other procedure, should be justified according to the circumstances of the particular project.

A point that should be taken into account in any traffic noise calculation is the effective vehicle height. This can be crucial in determining the predicted attenuation from barriers. The effective height of light vehicles is generally taken as 0.5 metres, and this appears to give acceptable results. However, for heavy vehicles there are often three distinct sources, representing the tyres, engine and the exhaust, with different noise emission levels and different heights. The recommended practice is to model heavy vehicles as three sources, calculating the barrier attenuation for each and adding the final result. The procedure used in any specific case should be documented and justified in the report.

A number of software packages which implement various suites of calculation methods are available, including:

- SoundPLAN – Braunstein + Berndt
- CadnaA – Datakustik
- Type 7810 Predictor – Bruel and Kjaer
- Traffic Noise Model – US Federal Highway Administration.

The above software packages can accurately implement calculation methods as specified by their developer. This is not an exhaustive list, and there are other effective software packages.

It is important to note that any model used must be validated with representative in-field measurements so noise predictions reflect the actual situation as closely as possible and any differences between the model output and measured values are known.

Other modelling factors to be aware of are the effects of meteorology on road traffic noise levels, barrier heights, pavement surface, vehicle speeds and vehicle volumes. Meteorological conditions should be accounted for by noting any wind or temperature inversion conditions characteristic of the area and discussing their effects on traffic noise from the project. Noise criteria for the project do not need to be met under adverse meteorological conditions.

B5 Maximum noise level calculations

The prediction of maximum noise levels during the night-time period involves considering the likely sources of these levels. They will generally be due to heavy vehicle movements, and in most cases the number of these movements will be sufficiently low that noise events can be identified with the passing of a single vehicle.

Because the maximum noise levels from individual heavy vehicles vary, the distribution of these noise levels may need to be taken into account to determine the representative values for maximum noise levels; the extent to which the maximum noise levels exceed the ambient noise levels; and the number of noise events. The decision as to the level of detail to be adopted in calculations will depend on the size and potential impact of specific projects, and on the level of detail needed for noise mitigation design requirements.

Where there are many heavy vehicle movements at night, it may become difficult or impractical to identify the maximum noise level with the passing of a single heavy vehicle. However, in these cases, experience indicates that the difference between maximum and L_{Aeq} noise levels is such that the design of noise control measures will generally be governed by the night-time L_{Aeq} criterion.

Of the models described above, only Nord2000 can most accurately predict maximum noise levels from an individual source. However, the algorithm used in the FHWA method can be adapted to do this and other methods may be available.

Appendix C – Road related activities outside this policy

C1 Construction and maintenance activities

Advice on the management of construction noise impacts from all types of road development in NSW is given in *NSW interim construction noise guideline* (Department of Environment and Climate Change 2009).

Guidance on dealing with noise emissions from the maintenance and renewal of existing roads is also provided in the above guideline.

The NSW Roads and Traffic Authority provides practical guidance on noise and vibration from its activities in *Environmental noise management manual* (NSW Roads and Traffic Authority 2001).

C2 Noise from existing roads

This policy does not establish mandatory noise criteria that existing roads must meet. However, it does establish noise criteria that provide the basis for measuring and assessing the extent of any existing impacts.

The NSW Roads and Traffic Authority provides limited funding to a Noise Abatement Program which is a retrofit program to mitigate the impacts of road traffic noise from existing roads that are not subject to redevelopment. Mitigation measures such as barriers and acoustic treatment of buildings to abate road traffic noise are provided on a priority basis according to levels of road traffic noise and other factors. Access to the program is available to noise sensitive receivers such as residences that meet a number of criteria including noise levels that are above $L_{Aeq,\ (15\ hour)}$ 65 dB(A) (7 a.m.–10 p.m.) or $L_{Aeq,\ (9\ hour)}$ 60 dB(A) (10 p.m.–7 a.m.) at the property. Access also depends on the duration of home ownership.

More information on the Noise Abatement Program is available on www.rta.nsw.gov.au/environment.

C3 Operational vibration

Vehicles operating on a roadway are unlikely to cause a perceptible level of vibration unless there are significant road irregularities, particularly if the affected receiver is more than 20 metres from the roadway. Often, vibration of lightweight building elements such as windows is wrongly thought to be caused by ground borne traffic vibration travelling up into the building via the building's foundations. However, this phenomenon is often due to airborne low frequency noise emissions, typically from heavy vehicles and buses, that cause lightweight building elements to vibrate.

Complaints regarding vibration are recorded by the NSW Roads and Traffic Authority on its Noise Abatement Program database for further assessment.

Assessing vibration: a technical guideline (Department of Environment and Conservation 2006) provides guidance on the assessment of operational vibration.

C4 Private haul roads

Noise from vehicles travelling on private roads associated with an industrial activity, such as a mine or quarry, is to be assessed as an industrial noise source under the NSW Industrial Noise Policy (Environment Protection Authority 2000). Further guidance on this approach is provided in the 'Application Notes' to the policy.

C5 Excessive noise from new and modified vehicles

Australian Design Rules (ADRs) have set drive-by test noise levels for new vehicles to be used on public roads. In NSW, Schedule 1 of the Protection of the Environment Operations (Noise Control) Regulation has provided the in-service stationary exhaust noise test levels for different classes of vehicles manufactured during certain years.

In 2003, the Australian Transport and Environment Ministers agreed to adopt Australian Design Rule 83/00 which is based on the European regulatory framework. As well as incorporating a drive-by test level, this design rule incorporates a model-specific in-service stationary exhaust noise test ('signature') level determined when the vehicle model is certified. The drive-by levels for all vehicles certified to Australian Design Rule 83/00 are 2–3 decibels lower than previous Australian Design Rules. The in-service signature level may be higher or lower than the Schedule 1 level and a 5 dB allowance for wear and tear and variations between vehicles is applied to the signature level.

Different classes of vehicles have been certified to Australian Design Rule 83/00 progressively since 1 January 2005. The Federal Department of Infrastructure, Transport, Regional Development and Local Government, which administers application of the Australian Design Rule 83/00 drive-by levels and assigning of the in-service signature levels, is progressively providing the signature levels on websites. To align NSW with these national vehicle design requirements, the Protection of the Environment Operations (Noise Control) Regulation 2008 is phasing in the Australian Design Rule 83/00 in-service signature levels until 1 September 2011. The in-service levels in Schedule 1 of the Regulation remain in force for vehicles not certified to Australian Design Rule 83/00.

Enforcement of the relevant in-service Schedule 1 and Australian Design Rule 83/00 signature levels is undertaken by NSW Police and DECCW through both joint roadside operations at known trouble spots and identifying individual vehicles on NSW roads. To facilitate the clearing of defect notices issued during these operations and effective enforcement of individual vehicles by police officers, DECCW launched the Noise Testing and Anti-Tampering Inspection Scheme in 2007. Under the scheme, DECCW approves mechanics and inspection stations to undertake noise tests on vehicles directed to a station through police and DECCW enforcement activities. Approved inspection stations have been established in Sydney at Granville, Campbelltown and East Roseville. Stations have also been established at Albion Park Rail near Wollongong, Redhead near Newcastle, Dubbo, Wagga Wagga and Coffs Harbour.

Additionally, under the NSW Road Rules 2008, administered by NSW Police, Road Rule 291 states that the driver of a vehicle that is stationary must switch off the vehicle's engine as often as necessary to prevent noise. Also, Clause 16 of the Protection of the Environment Operations (Noise Control) Regulation 2008 states that a person must not use a vehicle sound system in such a way that it emits offensive noise.

C6 Noise from stationary vehicles and heavy vehicle refrigeration units

The Road Transport (Safety and Traffic Management) (Road Rules) Regulation 1999 requires the driver of a motor vehicle, when it is stationary, to stop the engine as often as necessary to prevent noise. Restrictions on the use of refrigeration units on motor vehicles are provided in the Protection of the Environment Operations (Noise Control) Regulation 2008.

C7 Heavy vehicle engine brake noise

Engine brake noise from heavy vehicles is a major source of community noise, and impacts can occur during both the day and night. It can be a source of sleep disturbance in both rural and metropolitan areas. Likely locations for noise impacts from engine braking include traffic intersections, change of road grades and directions and change of speed limits (for example, from 100 km per hour to 60 km per hour). Heavy vehicles with noisy engine brakes can be fitted with mufflers designed to minimise engine brake noise. The National Transport Commission has reported that excessive noise from the use of engine brakes reflects the use of degraded mufflers, the replacement of standard mufflers with inadequate after-market mufflers or straight pipes, the fitting of curved tail pipes to vertical exhausts and engine brake use with a horizontal exhaust outlet (Close 2001).

The noise characteristics of engine braking, when not fitted with appropriate and well-maintained mufflers, can include an impulsive 'bark' and a low frequency tone. The use of engine brakes is largely an economic issue, saving wear and tear on service brakes. The exceptions to this situation are roads with very steep grades (for example, Bulli Pass, Wollongong) where the use of auxiliary braking systems (including engine brakes) is a safety issue. Engine braking noise is not a large problem in Europe as auxiliary braking systems other than compression engine brakes for heavy vehicles predominate. Controls on the use of engine brakes have been introduced by local authorities in various locations in the USA and more recently have been banned in urban areas in New Zealand (I-INCE 2001).

The specific issue of engine brake noise and the particular characteristics of this type of noise have been investigated by the National Transport Commission. In November 2007, the Australian Transport Council unanimously accepted the National Transport Commission's proposal (National Transport Commission 2007) to produce model national legislation limiting engine brake noise emissions to root mean square 3.0 through amendments to Australian Vehicle Standards Rules and Vehicle Standards Regulations. Based on an in-service test, measurement of the modulated root mean square of the acoustic signal can be used to identify the application of excessively annoying heavy vehicle engine brakes. Transport and Environment Ministers also agreed in late 2007 to adopt a national standard of root mean square 3.0.

A new system of measuring and identifying offensive noise from engine brakes has been developed and is being trialled by various state road authorities in conjunction with a 'noise camera' to record and identify noisy vehicles. Measurements can be undertaken by the 'noise camera' that records both an audio and video file of the offending vehicle for possible further action. The NSW Roads and Traffic Authority has two engine brake noise camera sites at Mount Ousley and Woolgoolga in NSW. Trials of fixed engine brake camera technology have been successfully completed.

The NSW Roads and Traffic Authority has promoted driver education at its Mount Ousley site to reduce the incidence of engine braking, and is developing appropriate legislation to enforce the standard in NSW.

Further information on heavy vehicle engine brake noise may be found on the National Transport Commission's and NSW Roads and Traffic Authority's websites.

C8 Service stations and other roadside facilities

Noise emissions from permanent facilities that support the road network are assessed against criteria established in *NSW industrial noise policy* (Environment Protection Authority 2000).

C9 Traffic calming devices and profiled line marking

Noise emissions from traffic calming devices, such as speed humps, typically installed on suburban roads, are the responsibility of local councils.

Noise emissions from vehicles travelling over various forms of profiled line marking, including roadside ripple strips, must be balanced against their operational and safety aspects. Further guidance on profiled line marking is available in *RTA Delineation Technical Manual* (NSW Roads and Traffic Authority 2008b).

C10 New residential and other sensitive developments affected by noise from existing roads

Gazetted in late 2007, the Infrastructure SEPP (Department of Planning NSW 2007) is an important planning instrument which facilitates the development of state significant projects. Of particular importance is that for the first time, internal noise levels (based on World Health Organisation guidelines) have been established for new sensitive developments along major road and rail corridors. The Infrastructure SEPP recognises that judicious land use planning, architectural design, building orientation and good internal layout can achieve acceptable acoustic amenity near busy transport corridors.

Supporting guidelines (Department of Planning 2008) have been published which guide development adjacent to railway lines and along motorways, tollways, freeways, transitways and other 'busy' roads. For new residential developments, internal noise levels of 35 dB(A) have been set for bedrooms during the night-time period and 40 dB(A) for other habitable rooms.

While application of the Infrastructure SEPP requirements is mandatory only for residential developments near specific highly trafficked roads as listed in the guidelines, the design advice offered in the SEPP may be useful when designing such a development near other high traffic roads. The NSW Road and Traffic Authority's website provides traffic volume maps that identify where the Infrastructure SEPP requirements are mandatory, at www.rta.nsw. gov.au/publicationsstatisticsforms/downloads/traffic_volume_maps/traffic_vol_maps_dl1.htm.

For new sensitive land use developments around existing busy roads in NSW, such as educational institutions, child care facilities, places of worship and hospitals, both suggested internal acoustic performance requirements and design principles are provided in **Section 3.6.1** of the interim guideline.

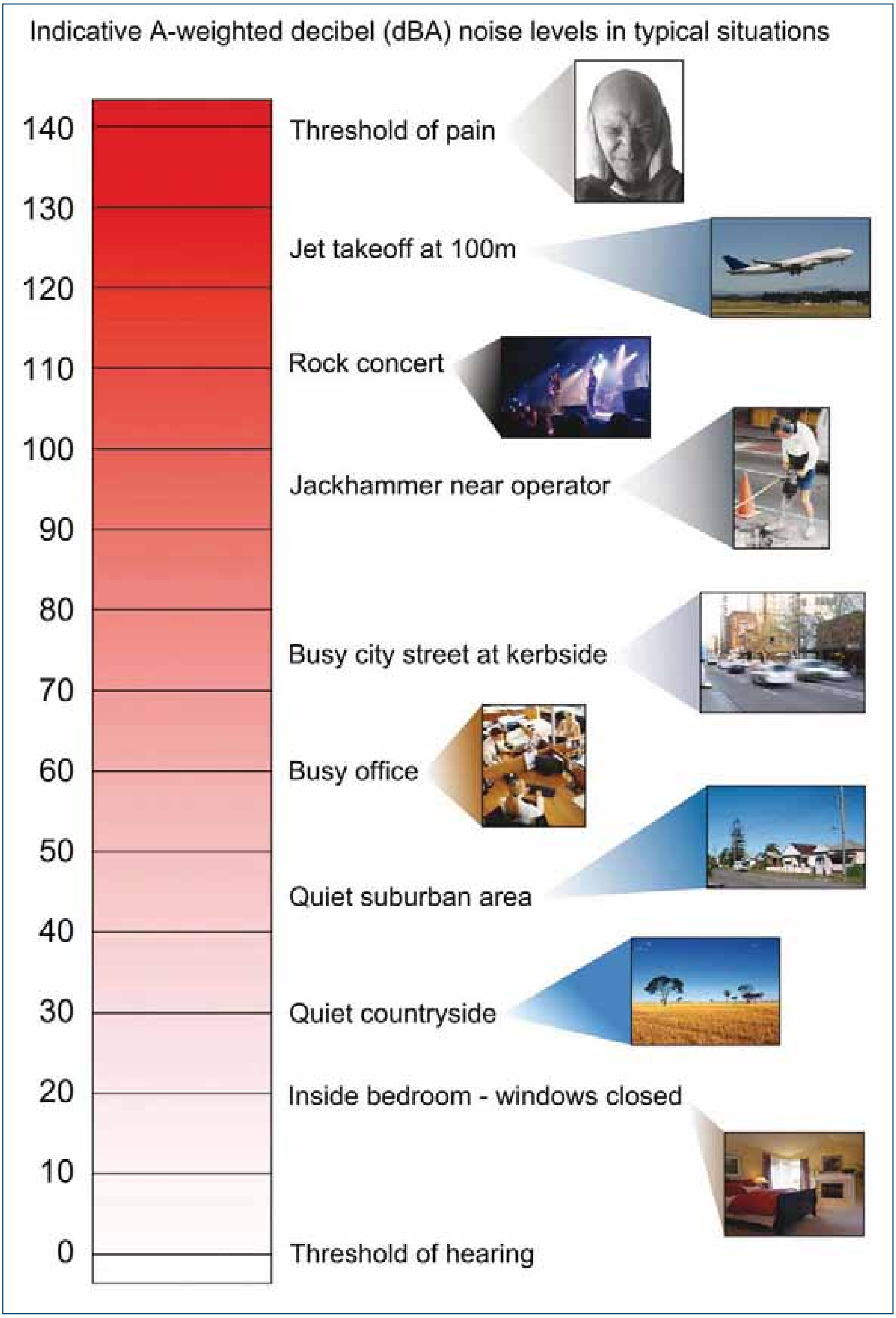
The acoustic design advice in the guideline may be considered when designing such a development near any type of road.

In certain circumstances, the Infrastructure SEPP imposes a requirement on councils to consider these guidelines before determining development applications for noise sensitive developments.

Further information on the Infrastructure SEPP and the interim guideline may be found on www.planning.nsw.gov.au.

C11 Common sources of noise

Figure 3 Some common sounds and their typical noise level



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Glossary

ambient noise	The general environmental noise at any specific location, being a composite of sounds from many near-field and far-field sources.
ANEF	*Australian Noise Exposure Forecast*
annoyance	The most common type of reaction felt by residents towards traffic noise. The degree of annoyance felt by an individual may be assessed using social survey techniques.
A–frequency weighting	An adjustment made to sound level measurement, by means of an electronic filter, in line with international standards. This approximates the response of the human ear at lower sound pressure levels.
buffer	An area of land between a roadway and a noise-sensitive land use, used as open space or for some other noise-tolerant land use.
dB	Decibel, which is 20 times the logarithm (base 10) of the ratio of a given sound pressure to a reference pressure; used as a measure of sound.
dB(A)	Used as a measure of A–frequency weighted sound levels.
DEC	Department of Environment and Conservation (now DECCW)
DECC	Department of Environment and Climate Change (now DECCW)
DECCW	Department of Environment, Climate Change and Water
development with potential to generate additional traffic on existing roads	Land use development that increases the magnitude of the traffic flow or leads to increases in the number of heavy vehicles by more than 10%. Includes new land use developments or significant alterations to existing land use developments, which may not involve any road construction. This category does not cover minor changes that are not subject to either development consent or amendment to an EPA licence.
EPA	Environment Protection Authority NSW
free field	a sound field where the effects of boundaries are negligible throughout the region of interest (Australian Standard 2659.1-1988).
freeway/arterial	Includes sub-arterial roads and refers to roads handling through-traffic, with characteristically heavy and continuous traffic flows during peak periods.
freeway/arterial/ sub-arterial road (new)	A freeway, arterial or sub-arterial road that is proposed on a 'corridor' that has not previously been a freeway, arterial or sub-arterial road; or an existing freeway, arterial or sub-arterial road that is being substantially realigned.
freeway/arterial/ sub-arterial road (redeveloped)	An existing freeway, arterial or sub-arterial road corridor where it is proposed to increase traffic-carrying capacity, increase the number of heavy vehicles by more than 50% (eg. from 10% HV to 15% HV) or change the road alignment through design or engineering changes. Redevelopment does not cover minor road works designed to improve safety, such as straightening curves, installing traffic control devices or making minor road alignments. This category may apply to proposals outside an existing road corridor, as described in the NSW Road and Traffic Authority's *Environmental noise management manual* (NSW Roads and Traffic Authority 2001).
grade (road)	The line or slope of a road – that is, the angle of a road to the horizontal plane, expressed as a percentage.
greenfield site	Site without existing roads.
habitable room	Any room other than a garage, storage area, bathroom, laundry, toilet or pantry.

heavy vehicle	A truck, transport or other vehicle with a gross vehicle weight greater than 4.5 tonnes.
highly annoyed	An individual is generally referred to as being 'highly annoyed' by a specific type of noise if in a social survey they choose 'highly annoyed' from a list of possible descriptions of their reaction (such as 'highly, moderately, slightly, or not at all annoyed'), or if they rate their annoyance as at least eight on a ten point scale.
isolated residences in a commercial or industrial area	An individual dwelling or cluster of residences on commercial or industrial zoned land, typically surrounded by commercial or industrial land uses and usually flagged for future commercial or industrial use in a Local Environmental Plan or similar instrument.
$L_{AF1, T}$	The A-frequency weighted 'fast' time weighted sound pressure level that is exceeded for 1% of the time (T) for which the given sound is measured.
$L_{AF10, T}$	The A-frequency weighted 'fast' time weighted sound pressure level that is exceeded for 10% of the time (T) for which the given sound is measured.
$L_{AF10\ (1hour)}$	The A-frequency weighted 'fast' time response L_{10} level measured over a one-hour period.
$L_{AF10(18hour)}$	The arithmetic average of the $L_{AF10(1hour)}$ levels for the 18-hour period 6 a.m.–12 a.m. on a normal working day.
L_{Aeq}	Equivalent sound pressure level – the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Aeq(15hour)}$	The L_{Aeq} noise level for 7 a.m.–10 p.m.
$L_{Aeq\ (9hour)}$	The L_{Aeq} noise level for 10 p.m.–7 a.m.
$L_{Aeq(1hour)}$	The noise level representing the 'average maximum' one-hour noise level (see **Appendix B3** for a description of how to calculate the $L_{Aeq, (1\ hour)}$).
$L_{Aeq(1hour), daily}$	The $L_{Aeq, (1\ hour)}$ for each day (as in 24-hour period), calculated as described in **Appendix B3**.
$L_{Aeq(1hour), assessment}$	The overall $L_{Aeq, (1\ hour)}$ noise level for the total duration of the monitoring period, calculated as described in **Appendix B3**.
local road	A road handling local traffic and characteristically having low or intermittent traffic flows.
local road (new)	A local road that is proposed on a 'corridor' that has not previously been a local road; or an existing local road that is being substantially realigned.
local road (redeveloped)	An existing local road corridor where it is proposed to increase traffic-carrying capacity, increase the number of heavy vehicles by more than 50% (eg. from 10% HV to 15% HV) or change the road alignment through design or engineering changes. Redevelopment does not cover minor road works designed to improve safety, such as straightening curves, installing traffic control devices or making minor road alignments. It should be noted that this category may apply to proposals outside an existing road corridor, as described in the *Environmental noise management manual* (NSW Roads and Traffic Authority 2001).
maximum noise level ($L_{AFmax, T}$)	Maximum A-frequency weighted 'fast' time weighted sound pressure level, measured at a given location over a specified time period (T).

mound	A type of noise control barrier consisting of an artificial earthen embankment or knoll constructed between a roadway and a noise receptor area.
noise barrier	Any natural or artificial physical barrier to the propagation of noise (from a roadway), but generally referring to acoustically reflective or absorbent fences, walls or mounds (or combinations thereof) constructed beside a roadway.
noise impact statement	A document setting out the existing noise impacts at a specific location, and, generally, the expected change in noise impacts that would result from a proposed development, including strategies and controls to mitigate noise impacts.
noise level (target)	A noise level that should be adopted for planning purposes as the highest acceptable noise level for the specific area, land use and time of day.
noise reaction	The response evoked in a listener by a noise. For traffic noise, this can usually be described as 'annoyance', but may also include fear, anger and other reactions.
road corridor	As defined in *State environmental planning policy (Infrastructure) 2007* (Department of Planning NSW 2007).
set-back	The distance between the building alignment or face and the corresponding land boundaries of a property, which are controlled through planning regulation.
sound pressure level	The level of noise, usually expressed in dB(A), as measured by a standard sound level meter with a pressure microphone. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
sub-arterial road	A road that collects local traffic leaving a locality and connects to another local road, freeway or arterial or sub-arterial road.
threshold	The lowest sound pressure level that produces a detectable response (in an instrument/person).
through traffic	Traffic passing through a locality bound for another locality.
traffic noise	The total noise resulting from road traffic, including both light and heavy vehicles, steady and intermittent traffic flow and specific events such as the use of engine brakes.
transitway (dedicated-off-road)	Is separate from existing roads and occurs within a defined reserve that is not used by general road traffic.
transitway (on-road)	Is on or adjoining an existing public road reserve and includes situations where the road reserve is widened to accommodate an additional dedicated transitway lane(s).