vicroads

Traffic Noise Reduction Policy Review

Discussion Paper

AUGUST 2015

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State Government Victoria

Contents

Introduction 5

Public Consultation 6

Abbreviations and Definitions 7

1. Our Changing Environment 8

2. Living with Noise 11

Causes of Traffic Noise 11

Impacts of Traffic Noise 12

3. Minimising Traffic Noise – Hierarchy of Control 14

Land Use Planning 16

Land Use Planning - Reverse Sensitivity 18

Road Alignment 19

Surfacing Roads with Low Noise Pavement 19

Making Vehicles Quieter 20

Truck Engine Brake Noise 22

Speed Limits and Driver Behaviour 22

Building Siting and Design 22

Construction of Noise Barriers 25

4. Existing Approach to Managing Traffic Noise 29

5 A New Approach to Managing Traffic Noise 31

Setting a Policy Objective 32

Proposed Policy Principles 32

6..Defining Noise Criteria 35

7. Costs and Benefits of Noise Control 38

Have Your Say 43

Appendix A: Vicroads Traffic Noise Reduction Policy (2005) **45**

Appendix B: Describing Noise Levels **47**

Appendix C: Regulatory and Policy Context **50**

Transport Integration Act 2010 50
Planning Legislation 50
State Environment Protection Policies 51
Regulation of Vehicle Noise 51

Appendix D: Interstate & International Noise Policy Comparison **52**

Appendix E: Health Effects of Traffic Noise **54**

Annoyance 54
Sleep Disturbance 54
Stress hormones 54
Cardiovascular Disease 55

Appendix F: Economic Cost of Traffic Noise **56**

Health Costs of Noise 58

References **61**

Introduction

The existing VicRoads Traffic Noise Reduction Policy was written in 1989 following an investigation into traffic noise on what is now the Monash Freeway. Since then, only minor changes have been made to the policy in 1997 and 2005. Now, for the first time, VicRoads is conducting a major public review of the policy.

The environment in which VicRoads has to manage the impact of noise from the road network has changed significantly since the policy was written in 1989. At that time, the assumption was made that night-time traffic volumes were negligible compared to day time levels. This assumption is no longer valid. Today the increasing growth of night-time traffic (especially truck traffic) means that the difference between night and day time noise levels is diminishing.

In addition, more people are living near or directly abutting major roads – including in high-rise apartment towers overlooking freeways and in apartments along major arterial roads in Melbourne. This trend is expected to continue.

There is also a growing body of research, particularly in Europe, that shows that traffic noise significantly increases a number of health risks. While the magnitude of these risks is uncertain, VicRoads acknowledges that they exist.

Traffic noise will always be with us, as long as we use cars, buses, trams and even bicycles to move around and use trucks to deliver our material needs. Our challenge is to manage traffic noise in order to keep its impact to a reasonable level. For this reason, we believe that we must consider the impact of traffic noise on the health and wellbeing of Victorians, rather than as simply a matter of amenity.

This discussion paper outlines various issues associated with managing traffic noise. It seeks to provide a platform for development of a more flexible approach that can respond to both the source of the noise and to community needs.

Public Consultation

As part of the review of the current traffic noise policy, the first stage of public consultation was undertaken via an online consultation hub during March and April 2015. The hub had 2379 unique visitors of which 239 visitors to the site participated in the discussion forum and 443 visitors completed the survey. A further 49 written submissions were received. The feedback from more than 500 responses, told us that:

- The majority of respondents (69%) were concerned by traffic noise at night. Those concerned about traffic noise on freeways reported being significantly annoyed in the evening peak (63%) and early morning (63%). Those concerned about traffic noise on arterial roads reported being significantly annoyed early in the morning (59%)
- Individual noisy vehicles were by far the most mentioned source of traffic noise on arterial (92%) and local roads (99%)
- General traffic was the main source of noise for those who reported being affected by freeways (86%)
- Individual noisy trucks were the greatest source of annoyance on all road types, particularly on arterial roads (80%)
- Truck engine brakes were also reported as a major source of annoyance. Noisy motorbikes were mentioned as a particular issue on local (64%) and arterial roads (58%).

This discussion paper is informed by the community feedback and seeks to describe the key issues relating to traffic noise in Victoria as well as identify potential future options for consideration.

In this second round of consultation, VicRoads invites comments and seeks further feedback and insight from members of the public and key stakeholders such as councils, the acoustical profession, the road construction industry, builders and property developers.

A series of questions are presented at the the end of key chapters in this paper and are repeated in total on page 44. These questions are intended to be thought starters and and are not designed to restrict the scope of responses. We at VicRoads are keen to hear all community and industry views that will help us to manage traffic noise more effectively and efficiently in the future. The feedback and comments we receive throughout the two stages of community consultation will inform our thinking regarding revisions to the current policy.

Please provide your feedback, comments or ideas about the issues raised by visiting our online consultation hub at **consult.vicroads.vic.gov.au/trafficnoise**.

- Make a submission via an online form and upload any supporting documents; or
- Discuss your ideas in the online forums

Written submissions should be posted or emailed to:

Traffic Noise Policy Review
Strategy and Planning Division
VicRoads
60 Denmark St
Kew, Vic, 3101

Email: noisepolicyreview@roads.vic.gov.au

This consultation is open until 13 September 2015.

All submissions will be treated as public information unless you request otherwise. All submissions are subject to the *Freedom of Information Act 1982*.

Abbreviations and Definitions

AMI

Acute Myocardial Infarction

Arterial Road

A road declared as an arterial road under the *Road Management Act 2004*, eg Maroondah Highway Ringwood; Francis St Yarraville, Western Highway Horsham. These are shown as RDZ1 on planning maps.

DALY

Disability Adjusted Life Year (the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability) mortality and the years of productive life lost due to disability.

dB

Decibel

EPA

Environment Protection Authority Victoria

Freeway

A road declared as a freeway road under the *Road Management Act 2004*, eg Monash Freeway, EastLink. These are shown as RDZ1 on planning maps.

LA10

Noise level that is exceeded for 10% of a measurement period (usually one hour)

LA10 (12h)[1]

Average of LA10 noise levels for each hour from 6am to 6pm

LA10 (18h) [1]

Average of LA10 noise levels for each hour from 6am to midnight

LAeq

Steady noise level that is equivalent in terms of sound energy to an actual fluctuating noise level

Major Road

Freeway or Arterial Road shown as RDZ1 on planning maps

NDI

Noise Depreciation Index (a measure of how much the value of property is reduced by exposure to noise)

NEF

Noise Exposure Factor (a measure of noise cost impact that increases exponentially with noise level)

NTC

National Transport Commission

PAO

Public Aquisition Overlay (an indication on planning maps that an area of land will in the future be acquired by government for a purpose such as constructing a road

Road Authority

Authority responsible for road management eg VicRoads, Council

VPP

Victoria Planning Provisions

WHO

World Health Organisation

WTP

Willingness to Pay

Note that VicRoads currently uses the LA10 (18h) and LA10 (12h) facade noise descriptors to define noise levels. Where, for the sake of brevity, the descriptor is not explicitly mentioned in this document, the use of the LA10 (18h) or LA10 (12h) descriptor is implied, with the time period implied by the context.

[1] Note that VicRoads currently uses the LA10 (18h) and LA10 (12h) facade noise descriptors to define noise levels. Where, for the sake of brevity, the descriptor is not explicitly mentioned in this document, the use of the LA10 (18h) or LA10 (12h) descriptor is implied, with the time period implied by the context.

1. Our Changing Environment

The context in which VicRoads has to manage traffic noise has changed significantly since the organisation drafted its first noise policy in 1989. Community expectations have changed and, in addition, awareness of the health impacts of noise has grown.

A growing body of research in Europe has identified a number of health impacts of traffic noise which are described in Appendix E. In particular, a report entitled *Burden of Disease from Environmental Noise* published by the World Health Organisation provides a summary of the research on the effect of environmental noise on health (WHO, 2011). Through this research it is apparent that traffic noise can have a number of health effects related to sleep disturbance, annoyance, and stress, although the magnitude of these effects remain highly uncertain.

The impact of road traffic noise on the community is likely to increase in the future due to population and economic growth combined with more intense urban development along or near major roads including arterial roads and freeways. In particular, the volume of night-time truck traffic is expected to grow markedly in the future.

In recent years, the volume of traffic in Melbourne has grown nearly as fast as the city's population. Figure 1 shows that in the ten years to 2011, total traffic grew by 17%, while Victoria's population grew by 20%. As Melbourne grows from four million to a projected population of 6.5 million in the year 2050, personal travel is expected to grow by eight million person trips per day (State of Victoria, 2013). This represents an increase of 63% in the number of people travelling around our city. While the bulk of this growth will ideally be taken up by public transport and active travel (ie cycling, walking), the fact remains that substantial growth in private motor vehicle travel is to be expected.

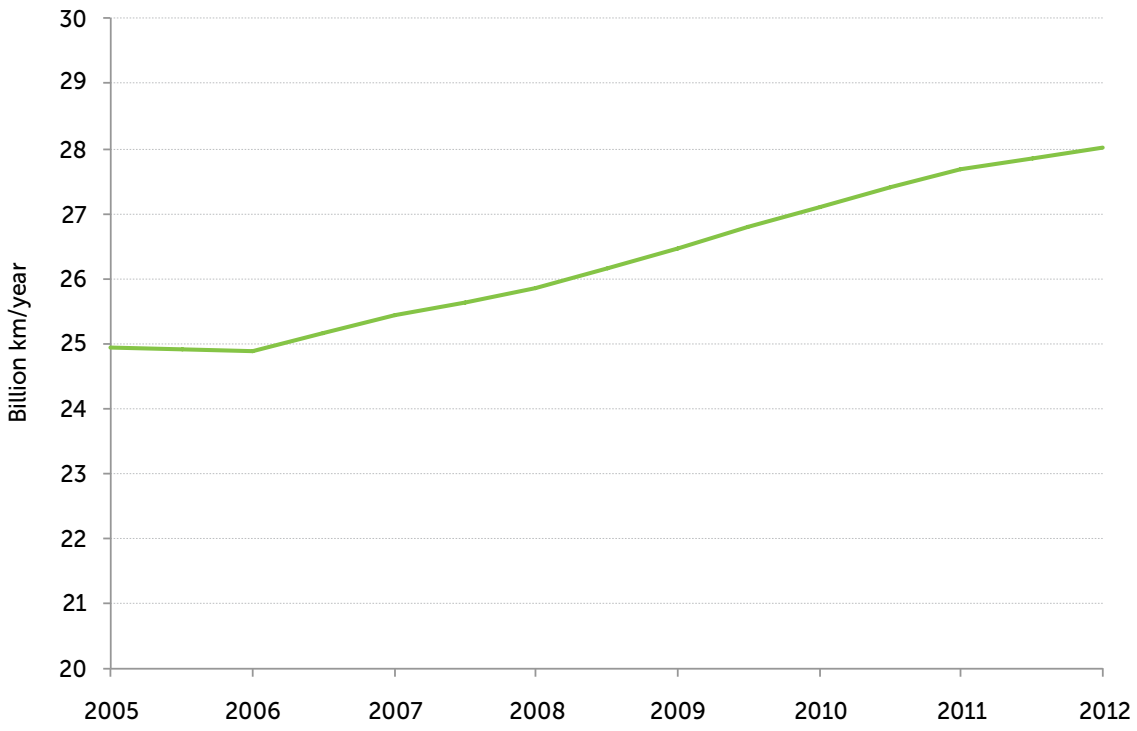

Figure 1. Total Vehicle Kilometres Travelled in Melbourne by Year (VicRoads, 2012)

The extra 2.5 million people in Melbourne will generate increased demand for goods, so major growth is also expected in freight transport (mostly by truck). Ultimately, population growth will drive traffic growth, which will create the potential for even more traffic noise in the future.

As the need to move both people and goods around Melbourne and the State develops faster than the available road space, increased traffic congestion will lead to greater night-time use of the road network, particularly by freight traffic. Figure 2 shows how the growth in Melbourne's truck traffic has changed across the 24 hour day time period. The greatest percentage growth has been during the night-time hours with truck traffic actually falling in the afternoon peak as operators try to avoid congestion.

High quality road and transport services are important not only to access employment clusters in Melbourne's suburbs but also to service Victoria's competitive advantage in freight and logistics. The transport needs of these industries are for greater orbital and east-west movement on roads that link the key industrial precincts to each other and to interstate and international gateways.

This growth means that proportionally, Melbourne's reliance on public transport will need to increase. However, it is important to note that most of our public transport trips (57%) are undertaken on the road network through trams and buses (PTV, 2013) so public transport also contributes to traffic noise.

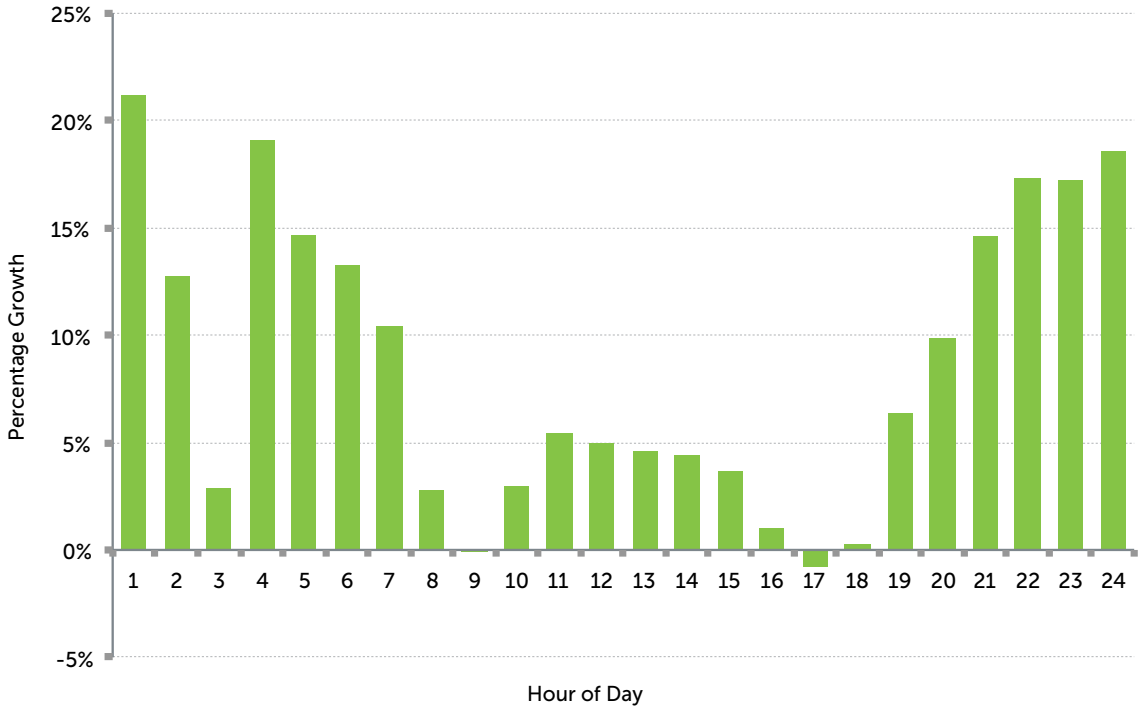

Figure 2: Truck Traffic Growth From 2007-08 to 2011-12 (VicRoads, 2012)

In addition, vehicles are not anticipated to become significantly quieter despite the fact that their technology is becoming more sophisticated. Whilst electric cars are somewhat quieter than petrol powered cars, their take-up in the foreseeable future is likely to be insufficient to significantly reduce traffic noise.

Research conducted for the Victorian Government suggested that between 14% and 30% of new vehicles sold in Victoria in the year 2020 would be electric or plug-in hybrid (AECOM, 2011). Other research, however, is less optimistic. In December 2013, the US Energy Information Administration forecast that plug-in hybrid and fully electric vehicles would make up only one percent each of new light duty vehicle sales in 2020 (EIA, 2013).

Furthermore, most traffic noise is generated by the contact of tyres and road rather than by vehicle engines, so even if the majority of vehicles on the road were electric, the noise reduction would be very limited.

Stated simply, there will be more people and hence more trams, cars, trucks, motorcycles and buses – all the transport modes that share our roads and are important for our social connectedness and our economy. As a result, traffic noise will become a larger and more complex problem on our roads and for the people who live nearby.

As the population of Melbourne and Victoria grows, planning for our future will require a flexible, ongoing and adaptable process and the way VicRoads manages traffic noise needs to reflect the same level of flexibility and adaptability.

2. Living with Noise

Noise can be described as sound that is unwanted, unpleasant or disturbing. This is a subjective definition, because what one person perceives as a pleasant sound, another may perceive as unpleasant noise. In the context of traffic noise, the focus is on high levels of sound generated by passing vehicles, from the perspective of people living adjacent to major roads.

Traffic noise is influenced by many factors, so there is no single approach that will eliminate its impact on the community. Rather, a combination of several measures is required and the management of these measures rests not only with Government but also with vehicle and tyre manufacturers, vehicle fleet operators, individual drivers and the property industry (including designers, property developers and builders).

There is considerable scope to reduce the noise problem at its source if vehicles are manufactured and maintained to be quieter in the first place. A particular challenge is addressing those individual vehicles that are exceptionally noisy, creating "noise events" which cause alarm and sleep disturbance to the community.

Causes of Traffic Noise

The majority of traffic noise is produced by the contact of vehicle tyres on the road, but vehicle engines and exhaust systems also make a significant contribution as detailed below:

- Road / Tyre Noise: When cars are travelling at a steady speed of more than approximately 30 km/h, most of the noise they produce comes from the interaction of their tyres and the road surface. In addition, some vehicles can be significantly noisier than others, just because of the type of tyres with which they are fitted. Noise can be reduced by both the use of quieter tyres and the use of quieter types of pavement.
- Engine and Exhaust Noise: If a vehicle is travelling at lower speed, or is accelerating or driving up hill at higher speeds, noise from the engine and exhaust is dominant. However, if a vehicle does not have a properly functioning muffler, the exhaust system is likely to be the dominant source of noise at any speed.
- Vehicle Maintenance: As noted above, there are a number of the cars, trucks and motorcycles on our roads which are excessively noisy because they do not have properly functioning mufflers. This may be due to inadequate maintenance by the vehicle owners, or due to deliberate tampering with the intention of increasing engine power or noise.
- Driver Behaviour: Some drivers make more noise than they need to, whether by accelerating harder than necessary, doing burnouts, spinning wheels or just by playing loud music with the windows open. The use of truck engine brakes when a truck is not undertaking a major descent is also inappropriate driver behaviour, although it is not currently illegal. Research by the Australian Bureau of Statistics has found that 35% of Australians consider noisy driving to be the most significant social disorder issue (ABS, 2013).

Traffic noise is not unique to our freeways. Whilst most of the complaints that VicRoads receives about traffic noise relate to Melbourne's urban freeways, noise levels along major arterial roads tend to be significantly higher than noise levels along freeways. Noise from trucks has a significant impact on residents in rural Victoria, particularly along major highways and in hilly areas where trucks frequently use engine brakes.

Impacts of Traffic Noise

Irrespective of the cause, the effects of traffic noise varies between individuals. Some people are extremely sensitive to traffic noise, whilst others are oblivious to it. Most people react somewhere in between.

Figure 3 shows the results of a large number of social surveys that compared people's level of annoyance from noise with the noise levels they were exposed to. It shows that louder noises are generally more annoying than quieter ones, but also that for a given noise level, there is a high variability in annoyance.

Our perception of noise is affected by characteristics such as pitch, pattern, timing and the connotation we associate with it. For example, the sound of a leaking tap can be annoying because it means the tap requires fixing. On the other hand, the sound of heavy rain on a roof, which is the same as thousands of leaking taps, is generally viewed as a positive sound, reinforcing the sense we have of being safe and secure away from the elements of the weather. In this context, it is the meaning of the sound that is important, rather than its absolute level in decibels.

For some, traffic noise is a constant reminder of a road that was constructed near their homes against their wishes; whilst for others it is a sign of a vibrant and active society.

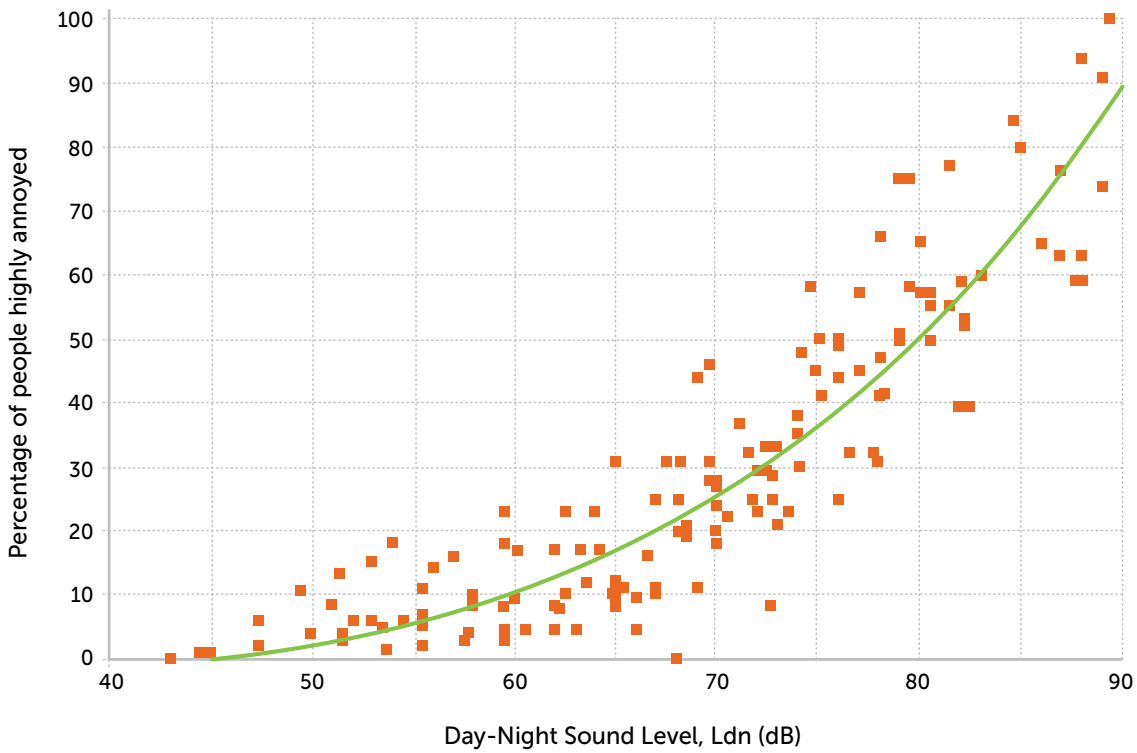

Figure 3: Noise Annoyance Scatter (Synthesis of Social Surveys on Noise Annoyance Redrawn from (Hanson, et al., 2006)

Noise of a given magnitude is more annoying during the night than during the day (Jakovljevic, et al., 2009). It is also important to consider the neighbourhood in which the noise exposure occurs. For a given noise level, annoyance is greatest in rural areas, followed, in decreasing order of annoyance, by suburban, commercial and industrial areas. The perception of traffic noise is also affected by a change in our environment. In particular, residents are usually much more annoyed by noise from a new road constructed where they live than if they have chosen to relocate to a noisier environment. Nonetheless, even with these differences, the research also highlights that some people are being disturbed by noise levels that are much lower than the limits currently described within the VicRoads *Traffic Noise Reduction Policy (2005).*

In addition to annoyance, exposure to high levels of traffic noise has a number of health impacts. European research has identified noise as a risk factor for heart disease, hypertension, diabetes, stroke and tinnitus, as well as impaired learning in school children (WHO, 2011). Noise related disease represents a cost to the community which is estimated to be in the order of $130 million per year (ARRB Transport Research, 2014).

Traffic noise will always be with us, as long as we use cars, buses, trams and even bicycles to move around, and use trucks to deliver our material needs. Our challenge is to manage traffic noise in order to keep its impact to a reasonable level.

3. Minimising Traffic Noise – Hierarchy of Control

Measures to reduce the impact of traffic noise on the community can be broadly divided into three classes – vehicle noise emission control, reducing the transmission of noise from the road to noise sensitive receptors, and making noise sensitive receptors more resistant to noise.

The first class of measures – noise emission control – seeks to limit the actual noise produced by motor vehicles and their interaction with the road surface. The actions available to government in this context consist of regulating the noise emitted by new vehicles (a Federal Government responsibility), regulating the maintenance of vehicles in service (an EPA Victoria and National Heavy Vehicle Regulator responsibility), and constructing roads with low noise surfaces (a VicRoads responsibility).

The second class of measures – reducing noise transmission – can be achieved in either of two ways. It can be achieved by land use planning that separates noisy land uses from noise sensitive land uses, or it can be achieved by construction of physical barriers such as walls that block noise, which has been the traditional approach to traffic noise management by VicRoads. Land use planning is particularly important since large reductions in noise by the use of noise barriers are not reasonable or feasible in many situations, particularly along arterial roads where residents require direct road access.

The third class of measure is to design and construct or modify noise sensitive buildings to insulate their occupants from outdoor noise levels. It is possible to achieve extremely low noise levels in this way, but only if windows and doors are kept closed and consequently, alternative forms of fresh air ventilation is often required.

As shown in Figure 4, these measures can be reflected as a hierarchy of control. Avoiding traffic noise impacts should be the first priority and this can only be achieved through firstly, appropriate zoning interfaces and secondly, land use and development planning controls.

If avoidance or elimination cannot be achieved, then the next step is to minimise the level of noise and this is best achieved through a combination of vehicle regulations (for which EPA Victoria, the Federal Government and the National Heavy Vehicle Regulator are responsible) and low noise pavements. For those locations where minimisation is not practical or feasible or insufficient, protection of sensitive receivers could possibly be achieved through implementation of appropriate building standards along the lines of those in several other States.

This hierarchy of control can be utilised to provide our community greater protection from the disturbance of traffic noise and each of these measures are discussed in more details in the following sections.

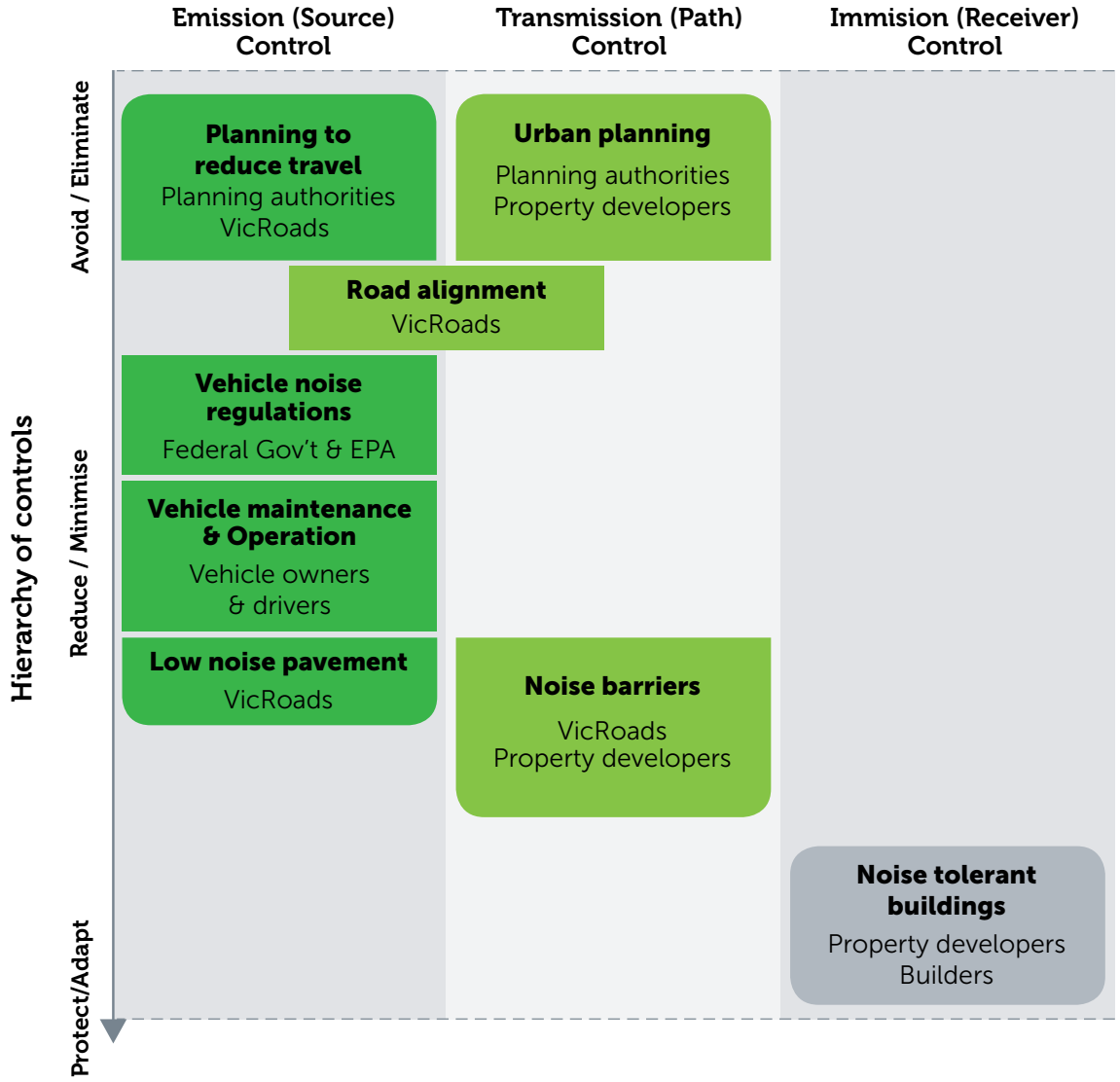

Figure 4: Hierarchy of Noise Control Measures

Land Use Planning

The impact of traffic noise on the community can be minimised through compatible zoning interfaces and by appropriate urban and site design that locates noise sensitive land uses such as homes and schools away from busy roads. It is normal practice in Europe to locate new freeways away from residential areas to the extent that is feasible, and to prohibit new residential development along existing freeways.

However, the ability to earmark large tracts of vacant land for future road development in Melbourne has become increasingly difficult over the years, as land availability becomes scarcer throughout the city. In any established urban environment it is not always possible or is seen as an efficient use of space to provide a buffer to separate residential areas from major road reserves. Consequently some noise sensitive land uses will inevitably be developed in high noise locations. (Greater potential exists in rural Victoria to separate noise sensitive land uses from major roads).

To accommodate population growth, minimise urban expansion and associated infrastructure costs, State and local planning policies – through the implementation of various zoning and control provisions - actively encourage higher density development in nominated areas including adjacent to or directly abutting major roads away from established lower density residential areas. This is partly for amenity considerations, including reducing the potential for overshadowing, loss of light, visual bulk and overlooking.

The box overleaf: *Victorian Planning Schemes* provides a summary of the key Victoria Planning Provisions that seek to ensure protection of noise sensitive uses, including residential dwellings, from traffic noise.

Strategic land use planning can also assist in limiting traffic noise by reducing traffic volumes. This can be achieved by reducing the distances that people need to travel and by reducing car dependency. The application of planning controls encouraging higher density residential growth around activity centres or hubs, provides highly accessible infrastructure including integrated public transportation links and other essential services.

Victorian Planning Schemes

The Victoria Planning Provisions (VPP) form the basis of Victorian Planning Schemes which are the key tool Responsible Authorities (usually Councils) utilise to determine what requires a planning permit and in assessing planning permit applications for various uses and/or developments. Planning Schemes, including the VPP, currently provide some limited opportunities to ensure that future residential dwellings and other sensitive uses receive some level of protection from traffic noise. Key relevant provisions are summarised below.

Environmental Risks

The objective of Noise Abatement at Clause 13.04-1 is to assist in the control of noise effects on sensitive land uses with a strategy based around building design, urban design, and land use separation. *A Guide to the Reduction of Traffic Noise (VicRoads 2003)*, which provides advice on designing buildings to protect occupants from road traffic noise. As a reference document in the Planning Scheme, its application is limited.

Subdivision (VPP Clauses 52 and 56)

Clause 52.29 of the Victoria Planning Provisions requires that a planning permit application to subdivide land adjacent to a Road Zone Category 1 or a Public Acquisition Overlay for the purpose of acquisition for a Category 1 road must be referred by the Responsible Authority to VicRoads under Clause 55 of the Planning and Environment Act (1987). The Act gives VicRoads the authority to assess any such planning permit application and amongst other considerations nominate appropriate noise mitigation measures, where required, to be included as conditions on any planning permit that the Responsible Authority may determine to issue. VicRoads routinely uses this clause to request developers to construct noise barriers for residential subdivisions abutting existing freeways, to the same acoustic standards that VicRoads would apply to barriers for a new freeway near an existing residential area or zone.

More generally, Clause 56.01-1 requires that planning permit applications for subdivisions must be accompanied by a site and context description which amongst other considerations identifies noise sources, as well as a design response to any sources identified.

Two or More Dwellings on a Lot and Residential Buildings (VPP Clause 55.04-8)

These clauses require that development of two or more dwellings on a single lot and residential buildings should be designed to limit noise in habitable rooms.

The Responsible Authority (generally Council) must consider the design response as part of their assessment in determining the amenity impacts and merits of a planning application.

Residential Development of Five or More Storeys (VPP Clause 52.35)

This clause requires that an application for a planning permit for a residential development of five or more storeys in any zone must be accompanied by an urban context report and a design response, unless this requirement is reduced or waived by the Responsible Authority. There is no specific requirement to identify noise sources however this could be a consideration with the site context identification and design response.

One dwelling on a lot (VPP Clause 54)

Clause 54.01 requires the preparation of a neighbourhood and site design context plan and design response. Noise sources must be identified and the design must respond to these, as appropriate.

A detailed design standard at Clause 54.06-2, nominates that for front fences associated with a single dwelling a maximum height of two metres for dwellings abutting a Road Zone Category 1 (RDZ1) [2] and a maximum height of 1.5 metres along other street frontages is appropriate.

Other traffic noise mitigation controls

The planning schemes of several regional Local Government Areas, including Greater Bendigo, Macedon Ranges and Strathbogie contain provisions relating to noise exposure from particular highways and freeways. Typically they require that any residential use and development or subdivision allows for sufficient set back distances of dwellings from the road reserve, to ensure traffic noise levels do not exceed 70 dB LA10 (18h), and require acoustic design of dwellings where noise exceeds 60 dB LA10 (18h). Some metropolitan Councils including Hobsons Bay and Maribyrnong have explicit noise insulation requirements in their planning provisions relating to specific developments.

Other requirements which assist with noise mitigation, include various minimum set back requirements from the RDZ1 or PAO1 including, but not limited to, in a Farm Zone, Rural Living Zone, Rural Conservation Zone. If the nominated set back distances are not satisfied, then a planning permit application is required.

[2] A two metre high solid fence can be sufficient to provide a substantial traffic noise reduction for the ground floor of a house fronting a major road.

Land Use Planning - Reverse Sensitivity

"Reverse sensitivity is the vulnerability of an established activity to objection from a sensitive land use" (NZ Transport Agency, 2013). For example, where noise from an existing road may impact on people living in homes built after the road was planned or constructed; the road has reverse sensitivity to the homes.

Good land use planning prevents or minimises reverse sensitivity in either of two ways. New noise sensitive land uses can be discouraged or prohibited in noisy locations, or can be required to incorporate protection measures against the noise source. An example is the requirement that new homes built near noisy music venues must have adequate sound insulation to protect future residents from the impact of music noise (State Government of Victoria, 2014). VicRoads takes the latter approach when residential uses are developed abutting planned or existing freeways and arterial roads. In order to facilitate the most efficient use of land near or along freeways and arterial roads, the "*agent of change*" is responsible for the implementation and cost associated with any noise protection measures, as required.

Where new residential developments or other sensitive uses are established adjacent to planned or existing freeways and arterial roads, responsibility for noise mitigation currently rests with the developer or permit applicant. At present, VicRoads agrees to accept ownership (and responsibility for maintenance) once a developer has constructed a noise barrier, provided that the developer makes a payment equal to the expected first ten years' maintenance cost.

Currently, Section 55 of the *Planning and Environment Act (1987)* requires the responsible authority (usually Local Government) to refer planning permit applications to VicRoads, where a proposal involves access being altered or created to planned or existing freeways and arterial roads or subdivision of land adjacent to planned or existing freeways and arterial roads. In these circumstances VicRoads may then require the responsible authority to include permit conditions which have appropriate noise mitigation. Many of the noise barriers along Victoria's freeway network have been built by property developers as a result of this process. Some residential developments do not require planning permits; in these cases, the provision of noise mitigation depends on the good judgement of the developer.

This arrangement is consistent with the "agent of change principle", that is, where there is a proposed land use and/or development, the new use and/or development must respond to the adjacent and surrounding existing uses and developments. As a result, under strict application of the existing *Traffic Noise Reduction Policy (2005)*, the construction of noise barriers by VicRoads is limited to noise sensitive land uses that were established prior to the construction or planning of future roads and where neither an existing Road Zone Category 1 (RDZ1) nor a Public Acquisition Overlay (PAO) for VicRoads purposes was in place. In some cases, however, VicRoads has constructed noise barriers to protect dwellings that were developed after the establishment of a PAO but prior to the construction of the road.

The practice of assigning to property developers the responsibility for both design incorporation and associated costs with noise mitigation measures is well established internationally. Other jurisdictions have already implemented a range of measures to limit reverse sensitivity to noise including:

- In New Zealand, noise sensitive land uses within twenty metres of planned or existing state highways are strongly discouraged. Noise sensitive developments within 80 metres are required to meet indoor noise level standards with certification by a qualified acoustic engineer (Chiles, 2014).
- A number of European countries avoid high traffic noise impacts by restricting noise sensitive property developments near noisy roads. For example, in Switzerland the designation and development of building zones in areas where noise levels referred to as "Planning Values" are exceeded. In the case of residential development, this means development will not be approved where day time noise levels exceed 55 dB LAeq or night time noise levels exceed 45 dB LAeq (SAEFL, 2002).
- In the United States, road authorities provide local governments with noise mapping of undeveloped land that is zoned for future residential development. It is then the responsibility of local government as the local planning authority to decide how to manage noise (FHWA, 2012). The state is not responsible for noise mitigation for noise sensitive land uses established after the "date of public knowledge" of new freeways.
- In Western Australia, developer funded noise barriers are owned by residents and are not maintained by the state.

Land Use Planning - Mixed Land Use Zones

Mixed land use zones are becoming increasingly common in Melbourne. They may include apartments, offices and shops, and attract a large amount of commercial activity. Encouraging mixed land use is seen as a way of reducing the distance that people have to travel, which is one way to reduce the total amount of noise generated by traffic. These zones are currently excluded from the scope of the VicRoads *Traffic Noise Reduction Policy* (2005).

Road Alignment

If noise is considered early enough in the planning for a new road, there is potential to minimise any impacts by selecting the best road alignment. This includes both the horizontal alignment (where the road goes) and the vertical alignment. If a horizontal alignment is chosen to be as far away as possible from dwellings, or to avoid hilly terrain, noise impacts will be reduced. If the gradient of a road is minimised, there will be less engine noise from vehicles travelling up hill and less engine braking noise from trucks descending. Also, considerable benefit can arise from roads being located below the surrounding ground level, although this can be expensive and pose challenges for the management of drainage.

Early planning of a new road makes it easier to locate it where it will have minimum adverse effect on the community. For example, a two hundred metre wide reservation for the future Outer Metropolitan Ring (OMR) transport corridor between Werribee and Kalkallo was defined in 2009 but construction is not planned to commence until after 2020. Currently, the land surrounding the OMR corridor is predominantly farmland but much of it will eventually be residential on one side. New property developments will be designed so that noise sensitive land uses are preferentially located away from noisy roads. In this situation, the road reservation is sufficiently wide to allow the final road alignment to be optimised to reduce noise.

Surfacing Roads with Low Noise Pavement

The use of low noise pavement makes a valuable difference since the majority of road traffic noise is a result of the interaction of vehicle tyres with the road surface (Muller & Moser, 2013).

Low noise pavement is quieter than standard pavement material because its surface is:

- more porous, allowing "air blasts" from tyre treads to be absorbed into the pavement rather than outward
- smoother, achieved with small aggregate, to reduce the severity of impacts of tyres on the road surface
- less rigid, typically made of asphalt rather than concrete.

In its current form, however, low noise pavement is problematic since over several years it tends to lose its noise reducing capability. This is largely because dirt fills up the cavities in the surface so they lose their porosity; and the surface must be replaced every few years. Consequently, the cost of maintaining low noise pavement is three to four times more than the cost of maintaining traditional pavement.

Due to the increased cost of low noise pavement, its use has been restricted to the urban freeway network where the noise levels are higher than those of rural freeways.

Low Noise Pavement Trial

VicRoads is currently undertaking a trial of alternative low noise pavements on the Mornington Peninsula Freeway at McCrae.

Seven types of low noise pavements were laid in early 2013 and noise testing will be conducted at regular intervals over a period of five years, with a view to identifying a longer lasting low noise pavement.

Currently, the most promising pavement consists of open graded asphalt (already known to be quieter than conventional asphalt) which has been modified by 'shaving' the surface.

Making Vehicles Quieter

The greatest reported impact of traffic noise on residents living near major roads is from individual noisy vehicles. Survey respondents were asked to identify which types noisy vehicles bothered them. As shown in Figure 5, those who mentioned noisy vehicles mainly reported trucks as the source of annoyance. The use of truck engine brakes was also a major source of concern. Many respondents identified a greater focus on enforcing regulations as the best approach to reducing traffic noise.

Noise events from individual vehicles, particularly noisy engine brakes startle people and wake them from sleep. The "hum" of vehicle tyres on the road can be substantially reduced by the use of low noise pavement or the construction of noise barriers but these measures are much less effective at addressing noise from vehicle engines and exhausts. The highest noise levels result from unroadworthy vehicles (especially trucks and motorbikes) that do not have properly functioning mufflers. With regulations and standards at State, federal or international level, regulation of vehicle noise is complex.

The Australian Design Rule *ADR 83/00 Exterior Noise* regulates noise levels for new vehicles in Australia (Govenment of Australia, 2005). It defines the maximum noise level that various types of vehicle are allowed to produce under specific test conditions. Based on the European vehicle noise regulation *ECE R51.02*, the rule limits the noise from the exhaust of new vehicles. However, this makes little difference to the noise of cruising vehicles, since tyre noise is dominant when a vehicle is not accelerating.

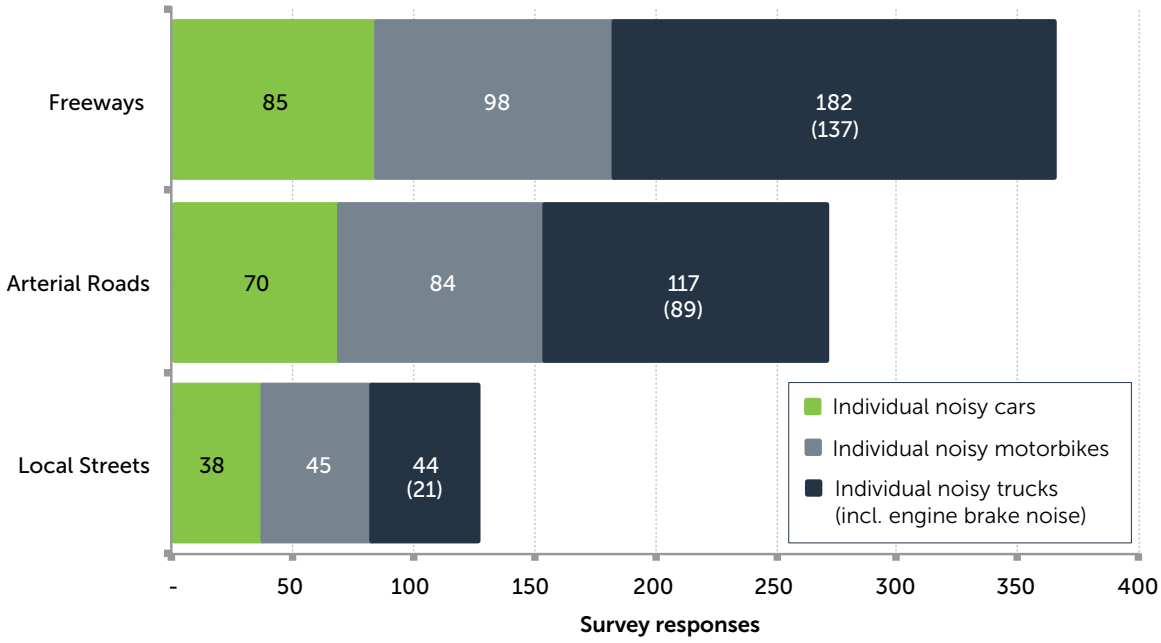

Figure 5. Source of Vehicle Noise

Regulation and Enforcement of Noisy Vehicles

Noisy vehicles are unacceptable, particularly when they have been deliberately modified for performance. Noisy vehicles can cause annoyance, sleep disturbance and other health impacts. The Environment Protection (Vehicle Emissions) Regulations 2013 aim to minimise the negative impacts on Victorians and the environment from noisy vehicles. The regulations contain standards and penalties for light vehicles (less than or equal to 4.5 tonnes gross vehicle mass) for vehicle noise and exhaust emissions. EPA Victoria enforces these regulations and all vehicles must comply with them.

EPA receives noisy vehicle reports from Victoria Police and from EPA Officers. Once reported, EPA issues a legal notice requiring the owner to have their vehicle tested by an EPA approved noise tester and make whatever repairs or modifications are needed to be within legal noise limits. Failing to comply with the notice can result in a fine for the owner and suspension of the vehicle's registration.

A member of the public can report a noisy vehicle to the traffic management unit at their local police station. If a police officer assesses the vehicle as being too noisy, the vehicle will be referred to EPA who will then issue a legal notice to the registered owner to have their vehicle tested by an EPA approved noise tester.

EPA also has an active vehicle noise enforcement campaign. EPA officers conduct roadside blitzes in known problem areas in partnership with Victoria Police. If a vehicle fails an on-the-spot noise test, enforcement action is taken and the owner or driver is also issued with a notice to comply with the noise level requirements.

In financial year 2014 / 15, EPA issued 2023 notices to vehicle owners requiring them to have EPA certified noise tests performed on their vehicles, and 56 vehicles were noise tested on the road side by EPA officers. A total of 36 fines and fifteen official warnings were issued in this time.

Fines are $738 for individuals and $1476 for a company car (2014/15).

Source: EPA Victoria

European authorities are currently developing a new noise regulation, *ECE R51.03,* which is expected to more accurately control the noise of a vehicle in normal use and be more stringent than the current regulation.

Tyre types can make a significant difference to traffic noise. Some vehicles can be up to 10 dB noisier than others just because of the type of tyres with which they are fitted. To address this issue, the European Union has introduced regulations to limit the noise from tyres as well as a labelling system for replacement tyres that indicates noise levels. As a result, European vehicle owners are able to make informed decisions when selecting tyres, to reduce noise both inside and outside their vehicles.

Tightening noise standards for vehicles and tyres has the potential to make a significant difference to traffic noise because traffic noise consists of the collection of sound from the tyres, engine, transmission, aerodynamic and braking elements. Most noise comes from the engine and exhaust if a vehicle is accelerating or is travelling at low speed, whereas tyre noise dominates for vehicles cruising at higher speeds. Therefore, work needs to be done to reduce engine and exhaust noise as well as tyre noise.

The *Environment Protection (Vehicle Emissions) Regulations (2013)* require that cars and motor bikes are maintained in order to not emit excessive noise. In addition, the *Heavy Vehicle (Vehicle Standards) National Regulation 2012* requires trucks to be maintained in order to not emit excessive noise or pollution.

Truck Engine Brake Noise

Extremely high levels of noise can result from the use of engine brakes in trucks that do not have effective mufflers. Engine brakes are intended to limit the speed of a truck when travelling downhill, avoiding impaired function of the normal brakes resulting from overheating. The function of engine brakes (or alternative retarding systems) is important to the safe operation of heavy trucks in hilly terrain.

It is anticipated that a major reduction in sleep disturbance would result if truck drivers ceased to use noisy engine brakes in residential areas at night.

Noise from truck engine brakes is currently unregulated – the existing vehicle noise regulations define limits for accelerating vehicles, not for braking vehicles. In 2007, the National Transport Commission published model rules to limit noise from engine brakes (NTC, 2007). These rules were unanimously approved by Australian Transport Ministers in November of that year. The rules were based on a measure of the recognisable character of engine brake noise, and were intended to be enforced using a camera system similar to a fixed speed camera. A review of the proposed rules by the NTC six years later identified a number of outstanding issues to be resolved prior to implementation (NTC, 2013). The New South Wales Roads and Maritime Service is conducting extensive research and development to resolve these issues (Kean, et al., 2014).

Once the issues regarding measurement of engine brake noise have been resolved, the National Heavy Vehicle Regulator will be responsible for their implementation. The intent of the enforcement program will not be to prevent the use of engine brakes but to ensure that trucks have mufflers that effectively limit noise from engine brakes.

More information on the regulatory context of traffic noise is provided in Appendix C.

Speed Limits and Driver Behaviour

Many comments in the forum suggested that noise levels could be reduced with lower speed limits. In fact, reducing vehicle speeds has only a limited impact on traffic noise levels. For example, reducing traffic speed from 100 km/h to 80 km/h reduces noise by approximately 1.5 dB, which is not noticeable when used as a single mitigation measure.

Driver behaviour, however, is a significant contributor to excessive noise. Playing loud music, spinning wheels, and excessive acceleration all contribute to annoyance. Inappropriate use of truck engine brakes (in urban areas where there is not a major descent) is also a matter of driver behaviour.

Victoria's road safety regulations prohibit driving in a manner that causes "unnecessary noise". However, this is difficult for Police to enforce due to the need to define what constitutes unnecessary noise.

Building Siting and Design

Where new residential developments and other sensitive uses and developments are not sufficiently set back from noisy roads, it is possible to provide some noise protection by appropriate site design and incorporation of acoustic building treatments. All other Australian mainland States and the Australian Capital Territory have some form of statutory regulation that requires new dwellings near railways or major roads to be designed and constructed with appropriate architectural acoustic treatments [3]. Tasmania's Department of Infrastructure, Energy and Resources encourages Councils to reflect its traffic noise mitigation guidelines in their planning schemes (DIER, 2011).

[3] New South Wales, Queensland, South Australia, Western Australia and Australian Capital Territory (NSW Planning & Environment, 2014) (Department of Housing and Public Works, 2014) (SA Building Policy Unit, DPTI, 2013) (Planning Western Australia, 2011) (Australian Capital Territory Government, 2014) (Australian Capital Territory Government, 2015)

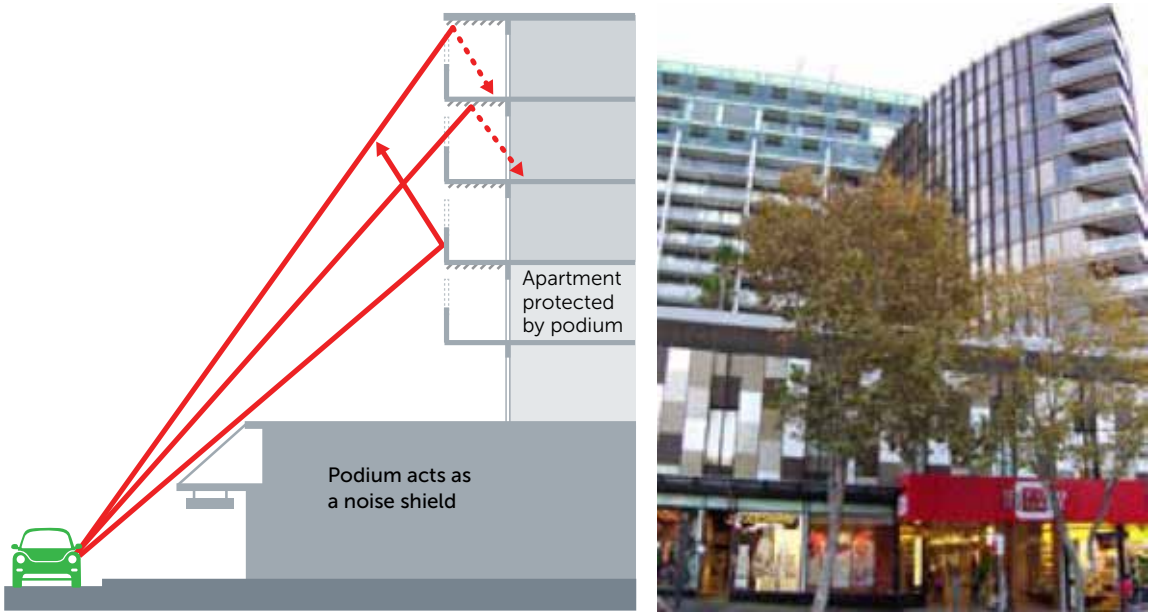

Figure 6: Building design that protects residents from noise (NSW Government Department of Planning, 2008)

Subdivisions and new land release

When considering major renewal of areas, business parks or the subdivision of land located near busy roads or rail corridors, potential noise and vibration impacts should be considered at the master planning/concept planning stage. At this stage there is more opportunity to address noise and vibration through setbacks, building orientation, layout, building height controls or noise barriers. In some cases, it might be appropriate to design open spaces adjacent to the busy road/railway corridor to set back residential uses to reduce noise exposure. These open space areas could also include appropriate bunding [earth mounds] to buffer adverse noise impacts and provide for cycle or pedestrian paths along the road/railway line to improve accessibility.

(NSW Government Department of Planning, 2008)

Appropriate design of buildings for sensitive uses such as schools, houses and apartments can minimise the impact of noise on future occupants. This can be done in several ways. Firstly, the layout of a building can be configured so that habitable rooms such as bedrooms are located furthest away from the noise source, in order to best protect residents when they are sleeping. Figure 5 shows an example of an apartment building designed to protect residents from traffic noise. Secondly, the building can be constructed with appropriate acoustic treatments. This means including design features such as sound reducing glazing, draught sealing around doors and windows, and alternative ventilation systems that provide fresh air even when the windows are closed. A secondary benefit of double-glazing and draught sealing is the reduction in energy required to heat or cool the building. Australian Standard AS 3671:1989 provides guidance on the reduction of road traffic noise intrusion in buildings in areas near major roads (Standards Australia, 1989).

It is arguable that the regulation of acoustic treatment for buildings is best placed in the National Construction Code rather than in environmental or planning policies. However, a recent regulatory impact statement prepared by the Australian Building Codes Board (ABCB, 2013) argued that the noise reduction benefit did not justify the potential impact of mandatory acoustical requirements on housing costs, partly due to the fact that other States already have regulations on external sound insulation. The regulatory impact statement instead recommended an educational approach to road traffic noise, which would make purchasers of homes more aware of the health impacts of traffic noise and encourage the housing market to demand better insulated buildings.

By way of example, the voluntary *Green Star* building rating scheme (GBCA, 2014) encourages adequate and comfortable acoustic conditions by providing reward points relating to the acoustic comfort as one of the criteria for indoor environmental quality. Within this scheme, the credit criterion for internal noise levels takes into account the noise ingress from all external sources.

Existing buildings can be modified to provide improved protection from traffic noise. This process, referred to as architectural abatement includes upgrades to glazing and the sealing of gaps. It usually requires the installation of an alternative fresh air ventilation system to allow occupants to keep the windows closed without deterioration in indoor air quality.

Construction of Noise Barriers

Noise barriers are the solution used predominantly by all road agencies, including VicRoads, to address traffic noise along freeways. They are also used on some arterial roads such as the Dingley Bypass and the Greensborough Highway. The fact that noise barriers must be continuous means that they would not be effective where driveway access is required for dwellings facing the road. Generally, noise barriers are not cost effective where dwellings are widely separated in rural settings where they would need to extend a significant distance either side of the dwelling being protected.

Noise barriers work by blocking noise coming from the road. There are two major classes of noise barrier: noise walls (Figure 7) and earth mounds (Figure 8). Where sufficient space and sufficient earth is available, earth mounds are preferred, because they are less visually intrusive and generally more effective at reducing noise for a given barrier height.

The effectiveness of barriers is limited by their height as shown in Figure 9. A barrier that only just blocks the line of sight from the road surface to the receiver (about 1.5 m to two metres high) will reduce noise by approximately five decibels which is a clearly noticeable reduction in the overall noise level. As a rule of thumb, each extra metre of noise barrier height reduces the sound at houses immediately behind the barrier by an additional 1.5 dB (FHWA, 2001). This means that a reasonable height noise barrier of five metres height will reduce noise by roughly seven to ten decibels. This is a very noticeable noise reduction, but it does not mean that absolute silence is achieved.

Figure 7: Noise Wall, Hume Freeway, Lalor

Figure 8. Earth Mound, Eastern Freeway, Doncaster East

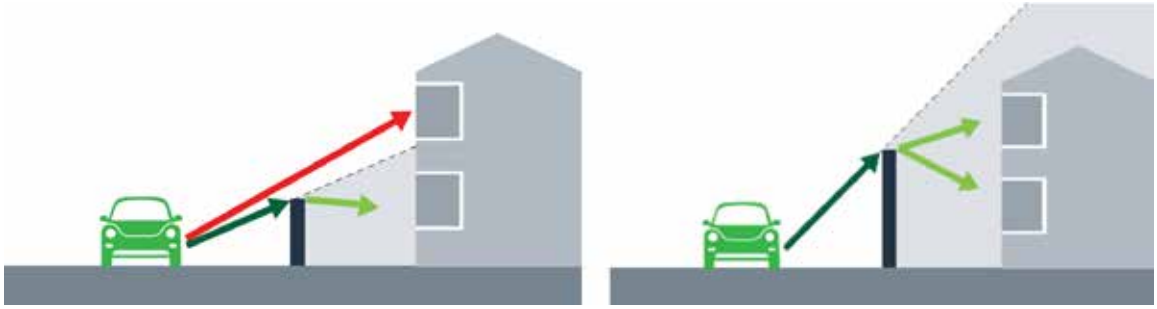

Figure 9. Effect of Barrier Height

Unfortunately the very aspect that makes noise barriers effective – their height – also contributes to their disadvantages. These disadvantages include overshadowing and visual intrusion as well as physically blocking views from the road and from residences. As a result, noise barriers are becoming the "least preferred" option to reduce noise in some parts of the world, including The Netherlands and Sweden. This does not mean that noise barriers should not be constructed; rather, other means of reducing traffic noise should be applied first if possible.

On top of this, noise barriers do not eliminate all noise. A reduction of 10 dB is quite achievable at the ground floor of a building; a 15 dB reduction is difficult to achieve and a 20 dB reduction is virtually impossible. Not surprisingly, noise barriers are significantly less effective at protecting the upper floors of high-rise buildings.

Whilst an overall reduction of noise can be achieved, the limitations of noise barriers also mean that noise from vehicle exhausts may stand out from the background noise levels.

Sound "diffracts" or bends around the top of noise barriers. The acoustic performance of a noise wall is limited by the extent to which sound can diffract or bend over the top. To halve the loudness of traffic noise, its level must be reduced by 10 dB. This requires 90% of the sound energy to be blocked, which is generally achievable.

However, reducing the loudness by three quarters (20 dB level reduction) requires 99% of the sound energy to be blocked, which is generally impossible due to the diffraction of sound over the top of the barrier unless the barrier extends over the road.

The efficiency of noise barriers is strongly dependent on the frequency of the sound and the location of its source, with lower noise reduction for low frequencies and elevated sources. As a result, noise from a high truck exhaust will be attenuated to a smaller degree than road/tyre noise and there is a risk that exhaust noise is even more noticeable.

VicRoads commonly receives complaints that noise barriers are not adequate because traffic noise is still audible and this was reflected in the on-line consultation. As noted earlier, noise barriers will not *eliminate* traffic noise; they will only reduce it.

Noise walls can also increase traffic noise at certain locations. This is because they also reflect noise and a tall noise barrier becomes an elevated source of noise as shown in Figure 10. Noise reflections are generally more significant at locations further from the road, so while a wall can be effective at reducing noise immediately behind it, there can be adverse effects elsewhere.

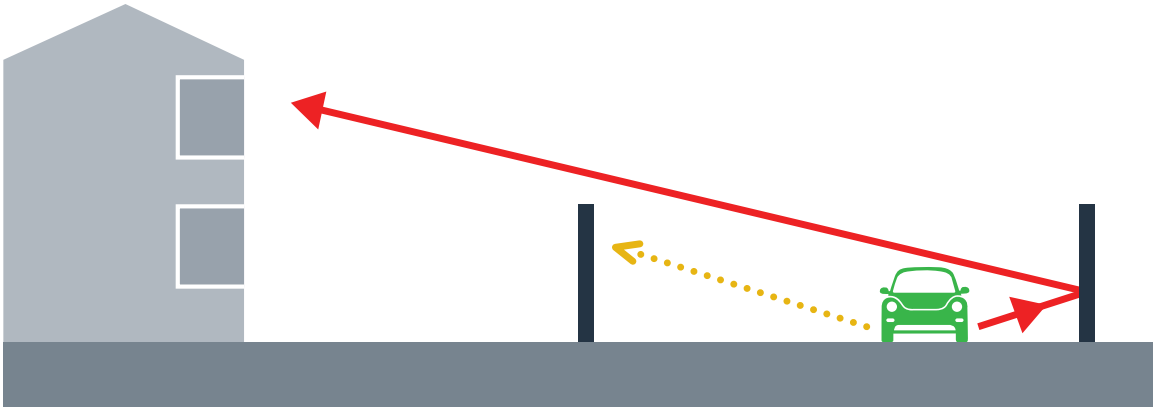

Figure 10. Noise Reflection from Wall

Other problems associated with noise barriers that are not specifically noise related include:

- The walls can attract vandalism
- The barriers cannot practically protect buildings on arterial roads where driveway access is required
- Walls may compromise road safety by blocking drivers' sight lines
- There are substantial greenhouse gas emissions resulting from barrier manufacture and installation, especially if they are constructed from concrete, steel or aluminium
- Noise walls are expensive. The total cost of new noise walls constructed in Victoria over the ten years to mid-2013 was approximately $230 million.

Some of the problems associated with noise walls can be avoided by the use of earth mounds. These can be very effective noise barriers and have greater visual appeal particularly when planted with vegetation.

However, they require large areas of land so they may not be practical in an urban setting where there is an objective to maximise the intensity of land use.

Several comments in the forum mentioned planting trees to mitigate traffic noise. To be effective as noise reducers, tree and shrub buffers need to be 15 to 30 metres wide, 4-5 metres tall and have dense foliage. Recent theoretical research in Europe has investigated optimising tree planting schemes for reducing traffic noise levels (Nilsson, et al., 2014), but with normal Australian house setbacks, it is unlikely vegetation would cause a measurable reduction in noise. Nonetheless, screening a road with trees and shrubs is an economical and effective way of improving the environment. By removing the noise source from view, planting can reduce people's awareness of traffic and also reduce the annoyance it causes.

Challenges associated with the management of Traffic Noise

The upgrading of existing roads in a dense urban environment is particularly problematic. Where new lanes are added to an existing road, it may seem obvious that noise will increase as a result of extra traffic. However, the reality is not so simple. Existing roads are generally expanded in anticipation of an increase in traffic demand, which may be driven by observed traffic congestion or forecast population growth. Had the road not been expanded and the population growth still occurred, the volume of traffic would still have increased.

The noise impact of upgrading the road is also complex. On one hand, traffic congestion would be reduced during busy periods, leading to higher speeds and a consequent increase in noise. On the other hand, high levels of traffic congestion lead to more traffic (especially trucks) travelling at night when the impact of noise on the community is greatest.

The construction of high-rise apartment buildings overlooking major roads poses an even greater challenge. Not only are elevated apartments difficult to protect from traffic noise by noise walls; but these buildings can also reflect noise.

VicRoads commonly receives complaints from residents in apartments near inner city freeways. It may be argued that people who choose to live in new apartments near long-established freeways should expect higher noise levels than people who chose to live in quieter locations. Furthermore, the property industry, namely designers, developers and builders of apartments near freeways or along arterial roads should be aware of the need to incorporate sound-proofing measures in their buildings. The Australian Building Codes Board has noted that prospective residents may be unaware of the real magnitude of noise from nearby roads and as a result, may be unlikely to gather sufficient information from an inability to interpret plans or to undertake site inspections to understand whether a new building will have adequate noise attenuation characteristics (ABCB, 2012). In any case, traffic noise levels tend to increase over time due to traffic growth, especially at night, and residents may argue that whilst noise was acceptable when they moved into a location, it has subsequently increased to an unacceptable level.

Whilst it is technically feasible to enclose freeways in tunnel structures to protect elevated apartments, it could be argued that it is not a reasonable expenditure of taxpayers' money. Irrespective, enclosing arterial roads is not feasible where adjacent land uses require direct road access. The need to provide higher density housing throughout Melbourne's suburbs and the city centre will mean more people will be exposed to high levels of traffic noise from major transport corridors, freeways and arterial roads, as well as railways.

While many of the problems caused by noise barriers could be reduced by limiting their height, this would restrict their noise reducing ability. Historically, noise barrier heights have been determined by engineering calculations that aim to achieve a particular noise level. Many jurisdictions also apply some form of limit to the height of noise barriers. For example, the height of noise barriers in South Australia is limited to five metres (DPTI, 2007).

Overall, the construction of noise barriers has been effective in reducing traffic noise. Whilst noise barriers do have their limitations as outlined above, they will continue to be an integral component of VicRoads' response to address traffic noise.

Chapter 1 (Our Changing Environment) outlined the context of population growth in Victoria and highlighted the consequent challenge of increased exposure to road traffic noise. Chapter 2 (Living with Noise) is a summary of the causes and impacts of road traffic noise.

This Chapter (3. Minimising Traffic Noise – Hierarchy of Control) introduces the various options available to manage traffic noise. It provides details on a number of control measures and presents a hierarchy that highlights the various stakeholders involved in the management of traffic noise and how measures can complement each other when used in combination.

Q1: Are there measures or tools to manage traffic noise in addition to those presented in this paper?

Q2: Does the hierarchy of control reflect your understanding of how traffic noise should be managed?

4. Existing Approach to Managing Traffic Noise

Our growing population with its demands for mobility of people and goods means Victorians' exposure to traffic noise is increasing. The diversity in individual responses to traffic noise and the increasing preference for people to live close to transport hubs means that managing traffic noise is becoming more complex and challenging. These challenges require a flexible approach.

The current VicRoads *Traffic Noise Reduction Policy (2005)* defines VicRoads' commitments to manage traffic noise in Victoria. Its approach has been to define mandatory noise limits for new and upgraded roads and to install noise barriers in order to achieve these limits. As a result of strict adherence by VicRoads to its policy, Victoria has the highest, most acoustically effective traffic noise barriers in Australia.

The current VicRoads policy applies to arterial roads built since 1979 and to all freeways[4]. The policy does not apply to local roads which are managed by local councils, some of which are designed with the intent that they will become arterial roads in the future.

Noise criteria are defined as:

- 63 dB limit for new roads and upgraded roads (defined as a road where two or more lanes are added along with buildings being removed)
- 68 dB threshold for considering noise mitigation along existing eligible roads
- consideration of limiting the increase in traffic noise to 12 dB in rural areas

The policy provides for noise mitigation for the following classes of noise sensitive building:

  - Category A – residential dwellings, homes for aged persons, hospitals, motels, caravan parks and other buildings of a residential nature
  - Category B – schools, kindergartens, libraries and other noise sensitive community buildings.

A copy of the current policy is provided in Appendix A.

The 63 dB traffic noise limit applies from 6am to midnight for Category A buildings but only from 6am to 6pm for Category B buildings.

Feedback from the consultation process identified a large degree of confusion regarding the application of the policy and in particular reflected a misconception that VicRoads has two different noise limits for new and old freeways and that this is discriminatory.

Some Comments from First Stage Consultation

"Firstly, you need to make the VicRoads Noise Reduction Policy fair & remove the current unfairness and discrimination that surrounds the dB(A) level"

"Have a consistent and fair Freeway Noise Policy - two different levels of noise measurement (i.e. 63 dB(A) vs 68 dB(A)), being applied to different sections of freeways & communities is ludicrous."

"The fact that VicRoads Policy applies a lower standard of noise suppression or attenuation to this 'old' section of freeway is – in this day an age - both absurd and unfair to all of the residential homes and their occupants"

The following section seeks to provide clarity on the issue of noise limits for new roads and new limits used for retrofitting purposes.

- New Roads
  When VicRoads constructs new freeways or new arterial roads, a noise limit of 63 dB is usually applied, however, there are two exceptions to this. If traffic noise in the area is already greater than 63 dB, then every effort is made to limit the increase in noise such that there is no measurable increase or at worst no more than two decibels. This usually means that the noise from the new road will need to be less than 63 dB.
  In rural settings where the pre-existing noise level is under 50 dB, VicRoads will consider limiting the increase in noise to 12 dB. This means for example if the pre-existing noise level is 45 dB, the noise limit would be no more than 57 dB, if feasible and practicable.

[4] The significance of the 1979 date lies in the fact that this was when noise barriers were first constructed on Victorian roads.

The use of such a low noise target for new roads in previously very quiet settings is justified by extensive research on human response to changes in traffic noise level. Essentially this research compares the level of annoyance from an existing road with the annoyance from a new road. This research indicates that the level of annoyance from a new road that produces say a 60 dB noise level is greater than the annoyance from a road that has always existed and produces a 60 dB noise level. (Griffiths & Raw, 1990) (Brown & van Kemp, 2009).

- Retrofitting Noise Mitigation

  VicRoads has a program of retrofitting noise barriers along existing freeways, subject to priorities and available funding. Retrofitting of noise barriers is considered where traffic noise levels exceed 68 dB. Once a road is in use, traffic volume tends to increase over a period of years. This usually results in an increase of about one decibel of traffic noise per ten years. Eventually the original noise limit may be exceeded and it becomes appropriate to "turn back the clock" by upgrading the noise mitigation measures. To do this requires a large investment and a substantial noise reduction is required for the benefit to be noticeable. For this reason, it has been considered appropriate to allow a five decibel increase from the original 63 dB limit before upgrading of noise mitigation is considered, which is why a criterion of 68 dB is used.

  All freeways managed by VicRoads are treated the same way; they are constructed to achieve 63 dB and are maintained to below 68 dB (subject to available funding).

  The upgraded noise mitigation is usually in the form of new noise barriers which are designed so their basic structure will last fifty years. These are usually designed to achieve a noise level of around 63 dB, so that noise levels will not reach 68 dB until fifty years has elapsed and the barriers need replacing for structural reasons.

  Unfortunately there is not always sufficient funding to upgrade all freeways that exceed 68 dB. For this reason, sites are prioritised on the basis of noise level, the number of front row residents affected and the anticipated cost of noise barrier construction.

  Some respondents to the first stage consultation suggested that the 68 dB criterion for consideration of retrofitting be reduced to 63 dB. This would not result in more noise mitigation; it would result in a longer list of candidate sites for consideration. The actual construction of upgraded noise walls would continue to be constrained by available funding.

  Since the year 2000, VicRoads has spent $36 million on noise barrier retrofitting along existing roads.

  Similar retrofitting programs are available in two other States. New South Wales has an ongoing Noise Abatement Program to address increased noise on the road network and prioritises funding to retrofit noise barriers and architectural building treatments. (RMS, 2013). Where the latter is considered, residents are required to contribute to the cost. Queensland takes a strategic approach to retrofitting noise reduction along existing roads, considering anticipated changes to traffic volumes (TMR, 2013). Other States by contrast do not generally provide traffic noise mitigation other than in locations where road upgrades are taking place (DPTI, 2007).

The current VicRoads *Traffic Noise Reduction Policy* (2005) has effectively resulted in noise walls being constructed in the locations where homes are affected by the highest levels of freeway noise. It has also guided the progressive retrofitting of noise walls along the older freeways which were constructed prior to the establishment of the policy, with priority being given to the locations with the highest noise levels.

In response to the changing nature of traffic noise on our roads and our growing understanding of how noise affects people, it is clear, however, that the current rule based policy approach has a number of limitations and does not meet community expectations.

5. A New Approach to Managing Traffic Noise

In order to address the limitations of the current policy, VicRoads is considering the option of a "principle based" policy as an alternative to the current "rule based" approach.

A principle based policy would allow VicRoads to set more stringent noise objectives in situations where this is feasible. It would also allow more innovative or site-specific measures where these are appropriate. By removing a set of "one size fits all" rules, it will be possible to achieve noise reduction in situations outside the scope of the current policy.

A principle based policy will allow flexibility when dealing with complex traffic noise issues.

This approach will still mean building noise walls where they will make a significant difference and are practical and reasonable, but it opens up the possibilities of using a range of alternative tools. Moving to a principle based policy would provide a more flexible approach, in particular:

- It would allow us to achieve lower noise levels than under the current mandatory limit policy, where reasonable and feasible.

  As discussed earlier, the actual noise level that can be achieved for sensitive uses depends on a range of factors including traffic volume, terrain, and the siting of buildings that abut the road.

  For example, a new road may produce noise at a slightly lower level than the current noise limit. Under the current policy, noise mitigation would not be considered, even though it may be possible. Under a principle based policy, the options available to mitigate the traffic noise may be considered and a reasonable effort could be made to achieve a lower noise level

  Another hypothetical example is a freeway which would produce 80 dB of noise if no mitigation was provided. Under the current policy, VicRoads would construct noise walls of whatever height is required to achieve 63 dB. These walls may be in excess of ten metres high, resulting in high costs to taxpayers as well as potential for impaired sightlines for drivers, visual bulk and overshadowing of homes and gardens.A principle based policy would allow a more flexible approach to controlling the noise, in consultation with affected parties.

  For example, VicRoads or a developer may provide a lower noise wall, combined with sound insulation improvement for the affected homes. This would achieve the same outcome with respect to sleep disturbance while reducing the visual bulk and overshadowing from the wall

  Another hypothetical example is a freeway which would produce 80 dB of noise if no mitigation was provided. Under the current policy, VicRoads would construct noise walls of whatever height is required to achieve 63 dB. These walls may be in excess of ten metres high, resulting in high costs to taxpayers as well as potential for impaired sightlines for drivers, visual bulk and overshadowing of homes and gardens. A principles based policy would allow a more flexible approach to controlling the noise, in consultation with affected parties. For example, VicRoads or a developer may provide a lower noise wall, combined with sound insulation improvement for the affected homes. This would achieve the same outcome with respect to sleep disturbance while reducing the visual bulk and overshadowing from the wall.

- It would allow a wider set of tools to be employed in addition to noise barriers. These measures would reduce the annoyance and disturbance people experience in spite of not actually changing outdoor noise levels
- It would give the flexibility to consider night-time noise in a way that has not been possible under the current policy. This is important because night- time noise levels are expected to grow faster than day-time noise levels in the future
- It would provide greater flexibility to reduce noise, taking into account community preferences as long as practicable, reasonable and cost-effective
- It would align with other Australian jurisdictions and with the intent of Victoria's *Transport Integration Act (2010)* which requires transport agencies to manage the transport system with a number of objectives including *economic prosperity* and *safety, equity, and health and wellbeing*.

This approach would need to articulate explicit principles that would inform the noise mitigation decision-making process. In addition, it would need to be underpinned by comprehensive guidelines that would ensure that decisions are made in a way that are fair, transparent and consistent within the application of the guidelines.

Setting a Policy Objective

VicRoads proposes that the objective of a principle based policy could be to *"protect the health and wellbeing of Victorians from the effects of road traffic noise"*. Under this objective, priority would be given to protection of the health and wellbeing of Victorians in their homes and to ensuring that noise sensitive community buildings (schools, libraries, places of worship, etc) are fit for purpose.

In practice, this objective would mean that priority would be given to reducing the sleep disturbance from road traffic noise and providing a reasonable level of amenity for residents in general. As funding for controlling traffic noise will always be limited, it is important that funds be directed where the maximum benefit can be obtained.

Proposed Policy Principles

In April 2013, the Victorian Government published a new *Victorian Passenger Rail Infrastructure Noise Policy* (State of Victoria, 2013). This policy established principles of *integrated early consideration, balancing objectives* and *best fit solutions* as principles to be used to determine the measures to mitigate noise from new railway infrastructure.

Given the need for integrated transport and land use considerations, VicRoads is considering similar principles as follows:

Principle 1 Integrated Early Consideration

Impacts of noise from road projects and options for noise mitigation should be considered early in the development of proposals for new projects, road duplications and/or a change in land use or proposed development. Also, an integrated approach should be taken in order to identify the options to avoid, minimise or reduce noise and its impacts.

Similarly, where there is a proposed change in land use or proposed development near major roads, the impact of noise should be considered early, at the planning and design stages. This would allow decisions about the investment to be taken in the knowledge of the full implications for all areas of government and ensure that planning and engineering solutions are costed into the project in the initial stages.

Significant opportunities exist to plan both road alignments and proposed land use and development to minimise the impact of traffic noise on the community.

This would maximise the opportunities to avoid, minimise and mitigate noise and its impacts through consideration of both planning and engineering solutions and having regard to the broader social, environmental and economic interests of the state.

Principle 2 Balancing Objectives

It is essential to balance the need to minimise the effect of traffic noise against other objectives.

There are many issues that must be considered when a new road is planned, designed and constructed. Throughout the process, some noise reduction objectives may be in conflict with other objectives. For example, in 2013, VicRoads and the local council received complaints about the construction of a noise wall in Gippsland (The Warragul & Drouin Gazette, 2013). The community believed that the wall was an inappropriate intrusion in a rural setting and compromised local amenity. Application of the "Balancing Objectives" principle, which would take into consideration the desire of the community to maintain visual amenity may have resulted in a different solution to address noise at this location.

In deciding how traffic noise should be managed, costs and benefits of possible mitigation measures and other management options need to be considered. Cost-effective options should be selected, not only in an economic context, but also taking into account social and environmental impacts. This approach would provide a wider perspective of the overall public value of mitigation.

Principle 3 Best Fit Solutions

All reasonable efforts to limit noise impacts should be made taking account of what is practicable, reasonable and cost effective, given the specific local circumstances and the broader public good.

What is "Reasonable" and "Feasible"

Many traffic noise policies contain a commitment to control noise to the extent that is reasonable and feasible.

A feasible noise mitigation measure is one that can actually be implemented in a way that is effective and without causing other problems. For example, protecting houses from freeway noise by the construction of a noise wall is usually feasible but blocking noise from an arterial road with driveway access is usually not feasible.

Not all feasible noise mitigation measures are reasonable. For example, if the cost of constructing a noise barrier was significant and the consequent noise reduction was very minimal, it would not be reasonable.

Moreover, if local residents strongly opposed the construction of a noise barrier, then a different approach to reducing noise may be appropriate.

When the Tullamarine – Calder Freeway Interchange was constructed, residents living on the west side of Essendon Airport were concerned that they would lose views if noise barriers were constructed. VicRoads negotiated an agreement with these residents to provide architectural noise treatment instead of a noise barrier. The residents agreed that they would not be entitled to a noise wall in the future.

With this example, construction of a noise barrier at this location was feasible, but to do so in the face of collective community opposition from all the directly affected parties was considered to be unreasonable.

The noise impact of road infrastructure should be addressed in relation to the local circumstances. Noises of distinct nature – for example constant and intermittent noises – may need to be dealt with by means of different mitigation options.

Examples of significant local factors that need to be considered include:

- the existing noise level in a particular location prior to construction of a new road, including the contribution from any existing road traffic
- how perceptible any reduction in noise is likely to be, as a result of improvements in road infrastructure and of the considered noise mitigation options
- the degree to which noise would have increased if a proposed road was not built or upgraded
- the extent to which there are existing or proposed residential developments in the location impacted
- whether developers or landowners/occupants in proposed or existing residential developments should have been aware of the likely noise associated with the road corridor
- the number of people exposed to noise associated with the road project or corridor and the number of people likely to benefit from any considered mitigation options
- whether there are physical or other practical constraints that limit the mitigation options available or that increase the costs of adopting any option.

For any given circumstance, a particular option may not be feasible, and as the local context changes, so do the solutions.

Principle 4 Shared Responsibility

As with road safety, responsibility for minimising the impact of traffic noise cannot rest with only one party. Many of the measures in the hierarchy of control to reduce the impact of traffic noise are outside VicRoads' domain to implement. Shared responsibility for traffic noise should include:

- Road Authorities, both VicRoads and Local Government who as the key road managers for major roads (shown as RDZ1 and RDZ2 on planning scheme maps) will specify, design, and manage roads to reduce noise impacts
- Road construction companies who design and construct roads to appropriate standards
- State and Local Government planning authorities who should consider traffic noise in strategic land use planning (including the drafting and implementation of related policies, zoning and controls) and by statutory planners in the assessment of noise sensitive uses and developments abutting major roads

- Property developers or permit applicants who should ensure that appropriate noise measures are considered, incorporated as required and costed for their developments at both the design and construction stages
- Designers, who should ensure familiarity with noise attenuation methods and understand when these should be applied
- Builders, who should construct noise sensitive buildings with appropriate architectural acoustic treatment in accordance with approved plans and applicable standards
- Federal Government, which is responsible for noise emission standards for new vehicles
- EPA Victoria and the National Heavy Vehicle Regulator, who are responsible for the enforcement of vehicle noise standards
- Tyre and vehicle manufacturers, who should manufacture tyres and vehicles with optimal noise reducing technologies (these are regulated nationally)
- Drivers, who should drive and maintain their vehicles in a manner which does not produce excessive noise.

Consideration of all the principles will provide for greater levels of protection as traffic noise grows and becomes more complex.

Chapter 4 (Existing Approach to Managing Traffic Noise) briefly summarised the current rule based VicRoads Traffic Noise Reduction Policy and discusses its limitations.

This Chapter (5. New Approach to Managing Traffic Noise) discusses the option of an alternative principle based policy rather than the current rule based approach and proposes proposed new overarching policy objective and four guiding principles.

Objective: To protect the health and wellbeing of Victorians from the effect of road traffic noise

Principle 1: Integrated Early Consideration

Principle 2: Balancing Objectives

Principle 3: Best Fit Solutions

Principle 4: Shared Responsibility

These principles would be applied to individual cases in an effort to achieve a particular target given feasibility and reasonableness. It would allow for a range of tools to address not only controlling noise itself, but controlling the effects of noise. This flexibility can result in greater protection for the community.

Q3: Do you support a principles based approach policy or believe the existing policy should be retained in some form?

Q4: Do you support the stated proposed policy objective and guiding principles?

6. Defining Noise Criteria

Many different measures are used around the world to quantify desired noise levels. These are variously described as thresholds, reference values, criteria, guidelines, objectives or limits.

Aspirational or Mandatory Limits

A fundamental challenge with the development of a traffic noise policy lies in defining how strictly the noise criteria are to be applied. In general, the stricter the application, the higher the criterion decibel level must be (I-INCE, 2009). That is, if a strict (mandatory) noise limit is to be imposed, it must be set at a sufficiently high decibel level to ensure that it can in fact be achieved with reasonable measures in all circumstances.

The current VicRoads *Traffic Noise Reduction Policy (*2005) is an example of a policy that has a mandatory noise limit. For new roads that fall within the scope of the policy, a noise level of no more than the new road limit must be achieved, except in exceptional cases, where providing affected buildings with architectural treatments to improve sound insulation is found to be a more adequate measure than erecting a noise barrier. These cases occur typically in rural settings, where houses are widely spaced and the cost to achieve the noise limit by constructing noise barriers would be several hundred thousand dollars per building, or where there is strong community opposition to the construction of a noise barrier.

By contrast, there has been a trend globally to move from strict limits to aspirational goals, along with specifying lower levels, provided that it is understood that their achievement is not always feasible and reasonable. Appendix D provides a summary of noise objectives adopted across Australian jurisdictions as well as internationally.

One example is the Noise Statement for England which articulates a vision together with aims and principles for noise management that apply to traffic noise but does not specify any particular noise levels (DEFRA, 2010). A more typical example, the *New South Wales Road Noise Policy* (DECCW, 2011), defines "noise assessment criteria" (for day and night) and states that:

> *Although it is not mandatory to achieve the noise assessment criteria in this [Road Noise Policy], proponents will need to provide justification if it is not considered feasible or reasonable to achieve them. (p5)*

The NSW Roads and Maritime Service aims to achieve the noise levels specified in the policy unless doing so is not reasonable or feasible. A defined process is used to determine reasonable and feasible noise mitigation measures (RMS, 2015) and is accompanied by a description of what is meant by reasonable and feasible. The aspirational noise assessment criteria used in NSW is effectively six decibels lower than the mandatory limit used in Victoria (see Appendix D)

A low target noise level is only feasible if the community accepts, as in other jurisdictions, that there will be circumstances under which it will not be attainable.

A third approach adopted in Western Australia (Western Australian Planning Commission, 2009) utilises both noise targets and noise limits for new roads. The targets are set at the same levels as the assessment criteria in New South Wales and the limits are roughly equivalent to the Victorian limit. New roads are designed to achieve the noise targets to the extent that they are feasible and reasonable. However, if this is not the case, then the limits apply.

Where this approach appears to offer the most flexibility there is a perceived risk that the focus of noise mitigation would be in achieving the noise limit, not the target. This is currently the case where some councils require developers to limit indoor noise in accordance to Australian / New Zealand Standard AS/NZS 2107: *2000 Acoustics – Recommended design sound levels and reverberation times for buildings interiors* (AS/NZS, 2000) [5]. This standard specifies "satisfactory" and "maximum" noise levels which are generally ten decibels higher. Developers generally apply the "maximum" levels.

[5] Note that at the time of writing, AS/NZS 2107 is under review

How to Apply "Reasonable" and "Feasible"

Jurisdictions that apply non-mandatory noise targets generally specify tests that define what interventions are feasible, and what interventions are reasonable.

For example, the following limitations on feasibility apply in NSW: (RMS, 2015)

- Inherent limitations of different techniques to reduce noise emissions
- Safety issues such as restrictions on road vision
- Road corridor site constraints such as space limitations
- Floodway and stormwater flow obstruction
- Access & Maintenance requirements
- Suitability of building conditions for architectural noise measures

The following tests of reasonableness apply in NSW:

- The magnitude of noise reduction provided and the number of people that will benefit from it
- The cost of mitigation, including the cost of noise mitigation measures as a percentage of the total project cost and the ongoing maintenance and operational costs
- Community views and wishes
- Visual impacts for the community surrounding the road project and for road users.
- Relative weighting of treatments with respect to protection of outdoor areas or only internal living spaces.

LA10, LA10 (18h) and LAeq

VicRoads currently uses the LA10 (18h) noise indicator to define traffic noise levels. LA10 (18h) is calculated by a statistical analysis of the noise occurring on a typical working day. For each hour from 6am to midnight, the higher range of noise level is determined (ie the hourly 90th percentile levels). These are the LA10 levels, which are then averaged to obtain the LA10 (18h) level.

By contrast, most jurisdictions use the LAeq indicator, which is referred to as the equivalent noise level. LAeq is determined by calculating the average energy of the fluctuating noise. It is the level that would be measured for an equivalent steady noise with the same acoustic energy.

Its calculation is complex, requiring logarithms, but suffice it to say, for one hour of busy traffic, the LAeq noise level is about three decibels less than the LA10 noise level. When measured across the daytime period (eg 6am – 10pm), the LAeq noise level for traffic noise is about 2 dB less than the LA10 (18h) noise level. See Appendix B for more information on measures of noise.

VicRoads is considering a change to the LAeq noise indicator because it is a better representation of the exposure to noise and, unlike LA10, can be used to compare noise from sources other than road traffic.

Night-Time Noise Levels

Respondents to the consultation hub reported the night-time as the greatest period of annoyance from noise. Over two thirds of all respondents (69%) were concerned by traffic noise at night.

The World Health Organisation (WHO) specifies a night-time noise guideline for Europe of 55 dB LAeq. This is a "free field" level, which accounts only for the noise travelling directly from the road to the outside of a dwelling at night (WHO, 2009).

It is normal practice in Australia to measure "facade" noise levels by locating a microphone one metre outside the window of a dwelling. This microphone measures both the noise coming from the road and the noise reflected back from the facade to the microphone. This reflection approximately doubles the sound energy and increases the noise level by three decibels as compared to the "free field" value.

This means that the WHO night-time target of 55 dB LAeq is equivalent to 58 dB LAeq in Australian terms. Due to differences in LA10 and LAeq levels and to differences between daytime and night-time traffic volume, the WHO guideline is roughly equivalent to a target value of LA10 (18h) of 65 dB.

Interstate, New South Wales and Western Australia [6] have both introduced aspirational night-time criteria of 50 dB LAeq for new roads. South Australia's Road Traffic Noise Guidelines say 50 dB LAeq "should" be achieved for new roads. All Australian States that use LAeq noise criteria have night-time levels set 5 dB below the equivalent day time criteria in recognition of the greater impact of noise at night.

This Chapter (6. Defining Noise Criteria) is a discussion around the different options available for defining noise criteria. This chapter also discusses the option of new noise criteria to address night-time noise levels and whether criteria should be aspirational or defined limits. It also proposes that any change to noise criteria could be described in terms of LAeq rather than LA10.

Q5: Do you support the introduction of a night time noise criterion?

Q6. Would you prefer a lower aspirational target or a higher defined limit?

Q7. Do you see any issues with the proposed change in metrics from LA10 to LAeq?

EastLink, CityLink and Peninsula Link

These roads are privately operated so the *VicRoads Traffic Noise Reduction Policy* does not apply to them. Instead allowable noise levels along these "commercial roads" are defined in individual legal agreements between the operators and the Victorian Government. These agreements are based on the 63 dB LA10 (18h) noise limit.

[6] WA also has noise limits which are 5dB greater than the targets.

7. Costs and Benefits of Noise Control

Common practice for the management of traffic noise is undertaken through actions that are feasible and reasonable. Selecting the most appropriate response involves a judgement regarding whether the overall noise-reduction benefits outweigh the overall adverse social, economic and environmental costs of the noise abatement measure.

Essentially this is done by evaluating two costs associated with noise; the "impact cost", which is a measure of the adverse impact of noise (annoyance, heath impacts, etc), and the "abatement cost", which is the cost of measures to reduce noise levels. A detailed explanation of how the community cost due to traffic noise is determined is provided in Appendix F. The total cost of noise is equal to the impact cost added to the abatement cost and the most cost-effective outcome for society occurs when the total of the impact cost and the abatement cost is lowest (this is known as the "sweet spot" and is represented in Figure 11).

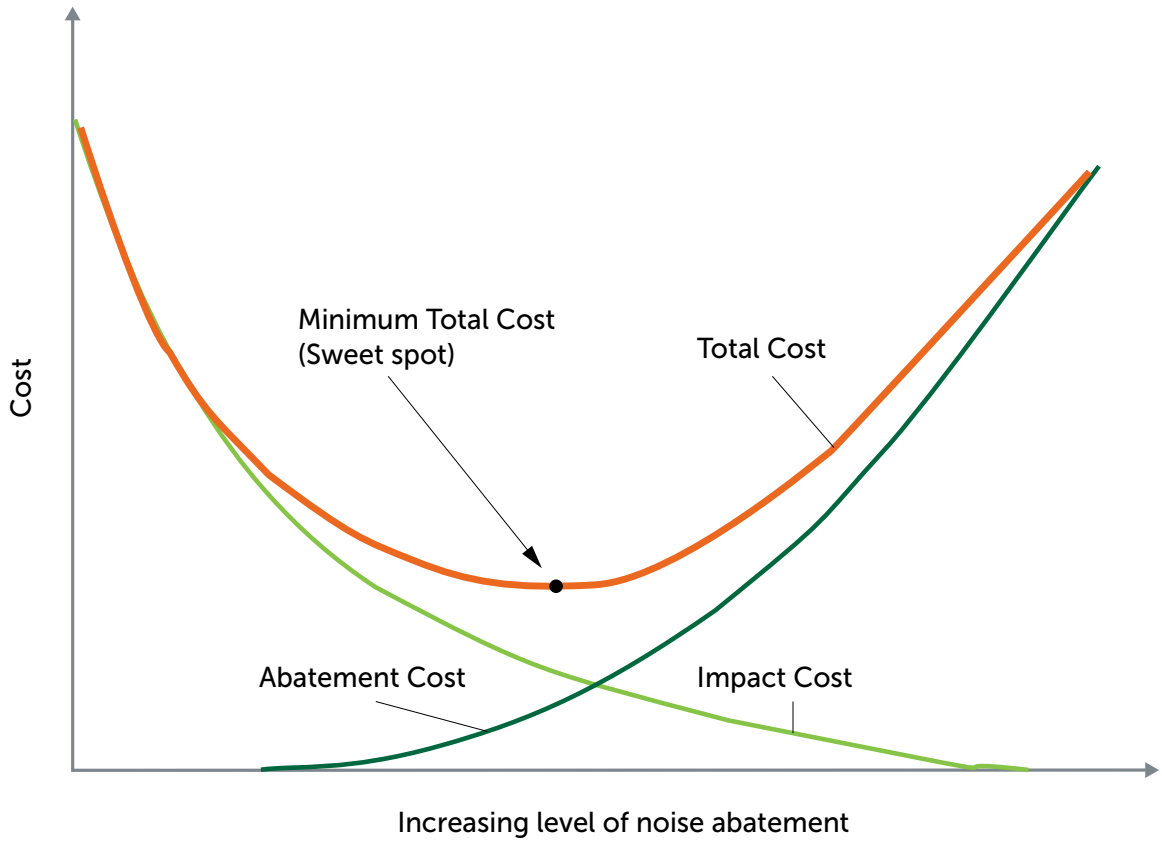

Figure 11: Noise Cost Curves

If the total cost has been minimised, then any effort to further reduce noise would not be viewed as cost-effective. If more cost-effective measures are available, then the sweet spot can be moved to achieve both lower noise levels and lower cost to taxpayers.

In practice, this means that mitigation measures (such as the height and dimensions of a noise wall) will vary taking into account:

- the physical attributes of the site, such as topography and geology; these factors will influence the structural supports required for a noise wall as well as influencing its height.
- the construction materials of the proposed noise wall; plywood noise barriers are the least expensive, typically costing approximately $400 per square metre of area. Precast concrete noise walls typically cost around $1,000 per square metre but last longer, and transparent plastic barriers are more expensive still.
- existing and projected noise levels will influence the height of a noise wall. As the effectiveness of a noise wall depends largely on its height, higher walls mean lower noise levels but higher costs.
- the effectiveness of a noise wall will also be influenced by the distance from the road to the affected houses.

Hence, selecting the optimum approach to noise mitigation will depend on the nature of the noise source, the location of noise receptors, the cost and viability of various solutions, the degree of noise mitigation required, the number of people affected and any special characteristics of the noise and individual site considerations. In many cases, this may not be limited to the construction of a noise wall.

By way of explanation, two hypothetical examples are presented overleaf that identify the cost of various noise mitigation options compared with the impact costs of noise to determine the most cost effective solution.

- Location A represents a group of suburban homes located about thirty metres from a proposed new road which would be exposed to high noise levels. Noise modelling was undertaken for the two rows of houses nearest to the road.
- Location B represents a group of ten storey apartment buildings spaced approximately one hundred metres apart that are being proposed as part of a new development. Noise modelling was undertaken for the apartments overlooking the road.

Location A Detached Housing

For each first and second row house (refer Figure 13), the community impact cost as a result of exposure to traffic noise has been calculated (based on an average of the two models presented in Appendix F), together with a range of costed mitigation measures. Note that the impact cost of noise in these calculations refers to the total cost of noise impact over a period of thirty years brought forward into the first year. This allows the impact cost and the investment required for mitigation to be compared on an equal basis.

As can be seen from Table 1, the option with the greatest benefit / cost ratio is not a noise wall but the combination of a two metre high noise wall and architectural noise abatement provided to the first row of houses only [7]. This option reduces the average impact cost of noise to the first two rows of dwellings from $140,000 to $79,000, for an investment of $36,000.

Figure 13. Location A. Detached Suburban Housing

Mitigation Option	Residual Impact Cost	Mitigation Cost	Benefit / Cost Ratio
No Noise Mitigation	$140,000	$ -	N/A
2m wall plus architectural abatement to first row houses	$79,000	$36,000	1.7
3m wall plus architectural abatement to first row houses	$67,000	$50,000	1.5
3m wall only	$81,000	$42,000	1.4
Architectural Abatement to both rows of houses	$42,000	$112,000	0.9

Table 1. Cost Analysis for Detached Suburban Housing

[7] Architectural abatement typically consists of sound proofing the houses with acoustic glazing and gap sealing, combined with fresh air ventilation to allow windows to be kept closed.

Location B Apartment Buildings

Location B has a row of ten floor apartment buildings located approximately one hundred metres apart (refer Figure 14). Each floor has two apartments on the side facing the road. Alternative mitigation measures to address noise are a noise wall, a "sound tube" which is a barrier that overhangs the road and / or architectural noise abatement. The analysis that was conducted for Location A has been repeated for Location B, and is presented in Table 2.

It is apparent from Table 2 that the option with the greatest benefit / cost ratio (a value of 2.4) is the architectural noise abatement. In this particular situation, a noise wall is not as cost effective. This is due in part to the fact that the upper floor apartments would not be protected by a reasonable height wall, and partly due to the spacing of the buildings. Given that the buildings are approximately 100m apart, roughly 100m length of noise wall would be required for each one. If the buildings were closer together, a wall would be more cost effective, but probably still not as good as architectural noise abatement.

Figure 14. Location B. Apartment Buildings

Mitigation Option	Residual Impact Cost	Mitigation Cost	Benefit / Cost Ratio
No Noise Mitigation	$89,000	$ -	N/A
2m wall plus architectural abatement to first row houses	$30,000	$39,000	1.5
3m wall plus architectural abatement to first row houses	$27,000	$45,000	1.4
3m wall only	$72,000	$24,000	0.7
Architectural abatement for apartments facing road	$32,000	$24,000	2.4
Sound tube	$7,000	$380,000	0.3

Table 2. Cost analysis for apartment buildings

This Chapter (7. Cost and Benefits of Noise Control) describes two hypothetical case studies to illustrate and compare the costs and benefits associated with different approaches that might be taken to mitigate these impacts. This chapter identifies how "reasonable" and "feasible" are applied in determining noise mitigation measures.

An aspirational limit approach can enable a cost effective solution to be provided for the net community benefit. A mandatory limit approach may result in less than optimum outcomes– eg. implementing measures costing more than justified with regards to the degree of protection provided; or conversely missing the opportunity to provide additional protection when it is cost effective to do so.

Q8: Do you support the notion of cost-effective traffic noise management? What other approaches should be considered?

Q9: What other factors do you think should be considered in applying "reasonable" and "feasible"?

Q10: How can traffic noise mitigation be made more cost effective so that greater benefits can be provided to the community?

Have Your Say

Traffic Noise Reduction Policy Review

Traffic noise can disturb people and affect their health. As traffic volumes grow and road environments become more complex, combined with development pressures to accommodate population increases, managing noise becomes an ever more challenging problem.

To meet this challenge VicRoads is reviewing its *Traffic Noise Reduction Policy* (2005), with consideration to taking a more flexible approach that can respond to both the sources of road traffic noise and to community needs.

This discussion paper forms the basis of the second stage of community consultation, presenting general principles relevant to the management of road traffic noise and its impacts to the community. It also introduces different approaches to mitigation of traffic noise.

Overview

In March and April 2015, we asked for community input on this issue. This feedback informed this discussion paper for further consultation.

We are seeking feedback from a range of participants including members of the public and key stakeholders such as councils, the acoustical profession, the road construction industry, builders and developers.

A series of questions are presented at the end of key chapters in this paper and are recalled in the following summary. These questions are intended to be 'thought starters' and are not designed to restrict the scope of responses.

We are keen to hear a diverse range of community and industry views that will help us to manage traffic noise more effectively and efficiently in the future.

Please provide your feedback, comments or ideas about the issues raised by visiting our online consultation hub at **consult.vicroads.vic.gov.au/trafficnoise** where you can:

- Make a submission via an online form or uploading a Word or PDF document; or
- Discuss your ideas in the online forums.

Written submissions can be posted or emailed to:

Traffic Noise Policy Review
Strategy and Planning Division
VicRoads
60 Denmark St
Kew, Vic, 3101

Email: noisepolicyreview@roads.vic.gov.au

This consultation is open until 13 September 2015.

All submissions will be treated as public information unless you request otherwise. All submissions are subject to the Freedom of Information Act 1982.

Summary of the Discussion Paper

The discussion paper presents some broad principles for seeking further community input regarding the management of traffic noise across Victoria's freeways and major roads.

Chapter 1 (Our Changing Environment) outlines the context of population growth in Victoria and highlights the consequent challenge of increased exposure to road traffic noise.

Chapter 2 (Living with Noise) is a summary of the causes and impacts of road traffic noise.

Chapter 3 (Minimising Traffic Noise – Hierarchy of Control) introduces the various options available to manage traffic noise. This chapter provides details on a number of control measures and presents a hierarchy that highlights the various stakeholders involved in the management of traffic noise and how measures can complement each other when used in combination.

Q1: Are there measures or tools to manage traffic noise in addition to those presented in this paper?

Q2: Does the hierarchy of control reflect your understanding of how traffic noise should be managed?

Chapter 4 (Existing Approach to Managing Traffic Noise) briefly summarises the current rule based VicRoads Traffic Noise Reduction Policy and discusses its limitations.

Chapter 5 (A New Approach to Managing Traffic Noise) discusses the option of an alternative principle based policy rather than the current rule based approach and proposes proposed new overarching policy objective and four guiding principles.

Objective: To protect the health and wellbeing of Victorians from the effect of road traffic noise

Principle 1: Integrated Early Consideration

Principle 2: Balancing Objectives

Principle 3: Best Fit Solutions

Principle 4: Shared Responsibility

These principles would be applied to individual cases in an effort to achieve a particular target given feasibility and reasonableness. It would allow for a range of tools to address not only controlling noise itself, but controlling the effects of noise. This flexibility can result in greater protection for the community.

Q3: Do you support a principles based approach policy or believe the existing policy should be retained in some form?

Q4: Do you support the stated proposed policy objective and guiding principles?

Chapter 6 (Defining Noise Criteria) is a discussion around the different options available for defining noise criteria. This chapter also discusses the option of new noise criteria to address night-time noise levels and whether criteria should be aspirational or defined limits. It also proposes that any change to noise criteria could be described in terms of LAeq rather than LA10.

Q5: Do you support the introduction of a night time noise criterion?

Q6: Would you prefer a lower aspirational target or a higher defined limit?

Q7: Do you see any issues with the proposed change in metrics from LA10 to LAeq?

Chapter 7 (Cost and Benefits of Noise Control) describes two hypothetical case studies to illustrate and compare the costs and benefits associated with different approaches that might be taken to mitigate these impacts. This chapter identifies how "reasonable" and "feasible" are applied in determining noise mitigation measures.

An aspirational limit approach can enable a cost effective solution to be provided for the net community benefit. A mandatory limit approach may result in less than optimum outcomes– eg. implementing measures costing more than justified with regards to the degree of protection provided; or conversely missing the opportunity to provide additional protection when it is cost effective to do so.

Q8: Do you support the notion of cost-effective traffic noise management? What other approaches should be considered?

Q9: What other factors do you think should be considered in applying "reasonable" and "feasible"?

Q10: How can traffic noise mitigation be made more cost effective so that greater benefits can be provided to the community?

Appendix A: VicRoads Traffic Noise Reduction Policy (2005)

The current (2005) VicRoads Traffic Noise Reduction Policy is reproduced below.

Traffic Noise Reduction Policy

Statement of Policy:

Road traffic noise is a significant environmental problem, particularly in residential areas. VicRoads is committed to taking whatever steps it can to reduce the overall level of traffic noise, and to limit the effect of traffic noise on nearby residents when new or improved roads are opened to traffic. It will achieve this by:

- seeking to reduce noise emitted by vehicles and road surfaces;
- encouraging compatible land use next to major roads;
- limiting traffic noise from new arterial roads and roads upgraded to carry significantly more traffic;
- retrofitting noise barriers on older freeways.

Detailed Requirements and Performance Standards

Reducing noise emissions at source:

VicRoads will seek to reduce noise emitted by vehicles and road surfaces by:

- supporting more stringent noise standards in Australian Design Rules for motor vehicles;
- using quieter pavement surfaces, where practicable on freeways and major arterial roads through residential areas;
- promoting and supporting measures that reduce engine brake noise.

Encouraging compatible land use:

VicRoads will encourage compatible land use next to major roads by:

- working with Planning Authorities to ensure that wherever possible, permitted land use beside busy roads is relatively insensitive to noise;
- encouraging the development of building regulations which will take into account both the noise level outside and the type of activity proposed inside the building.

Limiting noise next to new or improved roads:

Where arterial roads and freeways are built on new alignments, or where existing arterial roads or freeways are widened by two or more lanes and buildings previously protected from traffic noise are exposed by removal of buildings required for widening, the traffic noise level will be limited to the objectives set out below or the level that would have prevailed if the road improvements had not occurred, whichever is the greater.

- Category A: - For residential dwellings, aged persons homes, hospitals, motels, caravan parks and other buildings of a residential nature, the noise level objective will be 63 dB(A) L10 (18h) measured between 6 am and midnight,
- Category B: - For schools, kindergartens libraries and other noise-sensitive community buildings the noise level objective will be 63 dB(A) L10 (12h) measured between 6 am and 6 pm,
- Where the noise level adjacent to Category A or B buildings prior to road improvements is less than 50 dB(A) L10 (18h), consideration will be given to limiting the noise level increase to 12 dB(A).

VicRoads will endeavour to comply with these noise level objectives using the most cost effective technology. The approach taken to controlling noise will include but not be limited to:

- the "whole of life" attenuation performance and the practicability of the measures,
- a combination of noise barriers and other measures such as open graded asphalt, barriers on bridge parapets and crash barriers, etc.,
- off-reservation attenuation measures to be undertaken, subject to practicability testing, and agreement with key stakeholders.

In addition, VicRoads will:

- consult with Councils and affected local communities on the need for and type of protection (if necessary) for small areas of passive open space;
- implement appropriate traffic management measures, if necessary, to ensure that night time noise levels are not excessively high.

Noise abatement program - Retrofitting

The principle of this part of the Policy is that all eligible projects under the policy are to be included within the noise retrofitting program and acceptable treatment methods are to ensure that the most cost effective approach over the life cycle of the project is considered.

The following key elements to the Noise Abatement Program – Retrofitting apply:

- VicRoads will continue to retrofit barriers to freeways and arterial roads that have previously been eligible for noise attenuation works,
- The retrofitting program will apply through out Victoria,
- The trigger for considering retrofitting will be when the traffic noise levels exceed 68 dB(A) L10 (18h),
- A target noise level of less than 68 dB(A) L10 (18h) should be maintained after the attenuation works,
- When determining what measures can be employed to achieve the retrofitting target noise objective, consideration should be given to the "whole of life" attenuation performance and the practicability of the measures,
- The noise reduction may be achieved by a combination of noise barriers and other measures such as open graded asphalt, barriers on bridge parapets and crash barriers, etc.,
- Off-reservation attenuation measures may be undertaken, subject to practicability testing, and agreement with key stakeholders,
- Noise retrofitting works will be undertaken as funds permit, and will only apply to Category A and B buildings.

Exceptions to this Policy

There are a limited number of situations where expenditure of public monies on noise attenuation is not considered to be justified. Accordingly, VicRoads will not take action to protect existing or future development in the following circumstances:

- Category A or Category B buildings, as defined above, where such land use is defined as a non-conforming use in the relevant planning scheme.
- new buildings or subdivisions abutting any existing road under the control of VicRoads.
- new buildings or subdivisions abutting any road zone shown on any planning scheme for a new road or a road widening.
- buildings or subdivisions abutting any proposed road zone where the planning approval for the subdivision, was obtained after the commencement of the exhibition period to set aside land for a future road in the relevant planning scheme.

Definitions of terms used to describe traffic noise

Due to its nature traffic noise varies from instant to instant. Statistical terms have evolved to describe its level using a single number value.

dB

This is the abbreviation used for decibel which is the measure of sound pressure level.

dB(A)

The (A) denotes that the sound pressure level has been "A" weighted so that the scale approximates the response of the human ear. The ear is less sensitive to high and low frequency sounds than it is to sounds in the midrange. Most community noise is measured in "A" weighted decibels.

L10 dB(A)

This is the noise level in dB(A) exceeded for 10% of a specified time period. For a one hour period the level would be exceeded for 6 minutes but would be less for the remaining 54 minutes.

L10 (18h) dB(A)

This is the standard traffic noise descriptor used in Australia. It is the arithmetic average of the hourly L10 levels between 6 am and 12 midnight.

Key Responsibilities:

Manager - Environmental Services:

Preparation of information to advise the public of VicRoads practices with respect to traffic noise.

Ensure that VicRoads standard specifications and design practices are consistent with these guidelines.

Regional Managers and Project Managers:

Implementation of this policy

Related Technical Guidelines, Standard Specifications and Codes of Practice

Related Technical Guidelines, Standard Specifications and Codes of Practice:

The guidelines for the measurement of traffic noise are located in the Road/Road Use, Policy/ Standards Database in the Standards section. Other guidelines and works instructions are located in the Environmental Information Systems database.

Appendix B: Describing Noise Levels

Noise levels are usually measured and reported in units of decibels (dB). In the context of nose, a decibel is a measure of the sound pressure fluctuations to which the ear is exposed, converted to a logarithmic scale. The lowest noise level that can be heard by humans with good hearing is roughly zero decibels, whilst the threshold of physical pain is in the range of 120 to 140 decibels. Figure B1 shows the decibel levels of common sounds.

The smallest change in noise level that can be detected is approximately three decibels, which correspond to a just perceptible variation in loudness.

A five decibel change is clearly noticeable and an increase of ten decibels in noise level is perceived as a doubling of loudness. Traffic noise measurements are always "A weighted". This means that frequencies that are most easily heard by the human ear are given more emphasis than low or very high frequencies that are more difficult to hear.

The level of noise from traffic constantly changes in level. Figure B2 shows noise levels measured once every second for twenty four hours (LA (1sec)). It is useful to be able to describe this varying level with a single number created by statistical analysis of the actual varying noise level. Furthermore, it is useful to use separate numbers for day and night-time periods, because noise is generally more disturbing at night when people are trying to sleep.

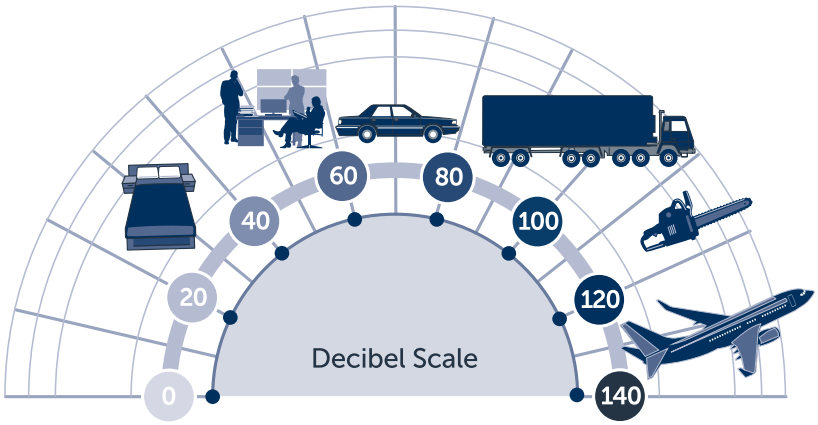

Figure B1: Decibel Scale

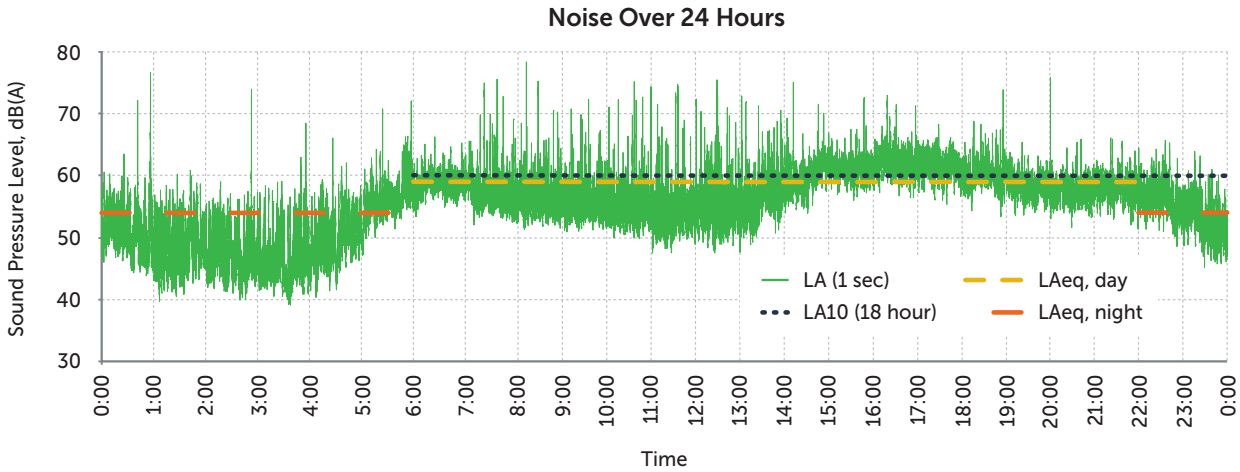

Figure B2: Noise over twenty four hours

Many different statistical indices called *noise descriptors* or *noise metrics* are used to describe traffic noise. It is not meaningful to talk about a noise level without knowing which descriptor is being used.

Table B1 lists some common noise descriptors (ARRB Group, Marshall Day Acoustics, 2005).

For road traffic noise, LA10 is a particularly good descriptor for demonstrating compliance to a strict noise limit. However, it cannot be used to meaningfully define noise levels where traffic volume is low. Neither can it be used to compare road traffic noise with noise levels from other sources such as railways.

By contrast, the noise descriptors based on LAeq are sensitive to all noise sources, but are particularly sensitive to the very loudest noises. They treat all source types equally, and can be used to account for various types of noise such as road traffic noise, railway noise or industrial noise.

Most jurisdictions now use LAeq based criteria given that they are found to be more appropriate for planning purposes.

An additional consideration is whether noise is specified for a 'free field' or at a fascia. Free field noise measurements are made in open space, and contain only noise coming directly from the source. Facade noise measurements are typically made one metre in front of a wall, and include sound reflected back from the wall. Facade noise levels are approximately 3dB higher than free field noise levels. Outside Australia, most traffic noise guidelines are specified in terms of free field levels. In Australia, facade levels are usual.

Most jurisdictions specify noise objectives in terms of annual average traffic volume. These noise levels are easy to determine with noise modelling using annual traffic volume data. However, they cannot be measured directly without conducting the measurements over an entire year. By contrast, VicRoads currently specifies traffic noise for normal working days outside school holidays. In most but not all parts of Victoria, traffic noise is higher on working days than other days because of greater traffic volume.

Descriptor	Definition	Advantages	Disadvantages	Conversion from LA10 (18h)
LA10 (1h)	Level of noise that is exceeded for six minutes in a one hour period (i.e. 90th percentile level)	LA10 (1h) is specifically sensitive to road traffic noise, provided it is at a reasonably high level. This makes it a good descriptor where testing for compliance is required.	LA10 (1h) noise levels cannot be compared with noise levels from sources other than road traffic.	N/A
LA10 (18h)	Arithmetic average of LA10 (1 hr) noise levels for each hour from 6am to midnight	Captures traffic specific noise levels from the part of the day during which most traffic occurs.	Now used in few jurisdictions. Ignores midnight to 6am period	0
LAeq (period)	Hypothetical steady noise level that has the same acoustic energy as the actual fluctuating noise. (Equivalent level.) e.g. LAeq 8h is for the period 10pm to 6am	The same measure can be used for traffic, railway, industrial and other noise sources for any time of day that is of interest. More consistent with human perception of sound.	Not specifically sensitive to traffic noise, so noise tests can be more strongly affected by extraneous noise sources.	-2 dB for day time, -7 dB for night time, -3 dB for 24 hour period
LDN	LAeq of full 24 hour day, but with a 10 dB "penalty" added for the hours from 10pm to 7am.	Allows both day and night noise levels to be assessed with a single number for convenience.	Over simplifies variation of noise level over the 24 hour day period.	+1.9 dB
LDEN	LAeq of full 24 hour day, but with a 5 dB "penalty" added for the hours from 7pm to 11pm and a 10 dB "penalty" added for the hours from 11pm to 7am.	Allows, day, evening and night noise levels to be assessed with a single number for convenience. Used as a noise criterion in Europe.	Over simplifies variation of noise level over the 24 hour day period.	+2.2 dB
LAmax	Maximum noise level. This is the level of the single loudest noise event in a particular time period.	Easy to measure with a suitably calibrated sound level meter.	Highly variable due to its sensitivity to particular noisy sources (usually defective vehicles)	N/A

Table B1: Noise Descriptors

Appendix C: Regulatory and Policy Context

There are a number of laws and regulations that are relevant to traffic noise in Victoria. These are explained in more detail below:

Transport Integration Act 2010

The *Transport Integration Act 2010* (Vic) defines the responsibilities and objectives of the Victorian Government departments and agencies in managing the state's transport system. Rather than specific outcomes that the departments and agencies must achieve, the act provides seven decision-making principles that must be applied when decisions relating to the transport system are made. These principles are:

- Integrated decision-making
- Triple-bottom-line assessment
- Equity between people
- Transport system user perspective
- Precautionary principle
- Stakeholder engagement and community participation
- Transparency.

The department and agencies must balance the objectives of these principles where they conflict. It is expected that the department and agencies be able to document their decisions and be able to explain how the principles were applied.

Whilst the act does not explicitly refer to noise, Clause 3 states that "The transport system should ... support health and wellbeing".

Planning Legislation

The *Planning and Environment Act (1987*) and the *Victoria Planning Provisions (VPP)* (Govenment of Victoria, 2014) which form the basis of Victorian Planning Schemes, require certain land use and/or development proposals to respond to already planned or existing roads. Clauses 52.35, 54.01, 55.01 and 56.01 of the VPP require that proposals for various residential development types and subdivisions consider the site context and provide responsive designs. As such, it is reasonable to expect the presence of noisy roads may be among the attributes of the environment that the development must

A more specific example in relation to noise and amenity, is at Clause 55.04-8 of the VPP. It applies to two or more dwellings on a lot, and states that:

Dwellings and residential buildings close to major roads, railway lines or industry should be designed to limit noise levels in habitable rooms.

Clause 52.29 requires a planning permit to '*create or alter access to*' or '*subdivide land adjacent to*' a road in a Road Zone Category 1 (RDZ1) or land in a Public Acquisition Overlay (PAO) if the purpose of acquisition is for a RDZ1. These applications must be referred to VicRoads in accordance with Section 55 of the Planning and Environment Act. There are limitations regarding what requires a planning permit and what must be referred to VicRoads, and not all property developments require planning permission.

Through this referral mechanism, VicRoads assesses a particular planning permit application proposal and may seek to have conditions included in planning permits. For applicable proposals, this may include that developers provide suitable noise attenuation where required. With these proposals, VicRoads requires that property developers or permit applicants provide the same level of noise mitigation for new residential development abutting an existing freeway or arterial road that VicRoads would provide if it built a new freeway or arterial road abutting an existing residential development.

State Environment Protection Policies

EPA Victoria administers two State Environment Protection Policies (SEPP) that regulate environmental noise for the Metropolitan Melbourne area. These are SEPP No. N-1 *Noise from Commerce Industry and Trade* (EPA Victoria, 1989) and SEPP No. N-2 *Control of Music Noise from Public Premises* (EPA Victoria, 1989). The additional document *Noise from Industry in Regional Victoria* (EPA Victoria, 2011) provides guidelines for industrial noise outside Melbourne. These documents exclude both construction noise and traffic noise from their scope.

Regulation of Vehicle Noise

The level of noise that may be emitted by a motor vehicle is specified by the Australian Design Rule (ADR) 83/00 – *External Noise* (Government of Australia, 2005). The ADR specifies the maximum noise level for passenger cars and trucks. The ADR also specifies a stationary noise test which can be used to check whether a vehicle still produces noise at a similar level to what it produced when new.

Within Victoria, in-service noise levels for light vehicles (under 4.5 tonnes vehicle mass) are governed by the *Environment Protection (Vehicle Emissions) Regulations 2013 (Vic)*. These regulations are based on the ADR 83/00 stationary noise test, and are enforced by EPA Victoria. Failure to comply with the regulations can result in the suspension of a vehicle's registration until any faults have been rectified. EPA Victoria actively enforces compliance with the regulations, issuing approximately 4,705 noise notices in financial year 2012 - 13 (EPA Victoria, 2013).

In-service noise levels from heavy vehicles (over 4.5 tonnes) are regulated by the *Heavy Vehicle (Vehicle Standards) National Regulation 2012*. This regulation operates similarly to the regulations for light vehicles but is administered by the National Heavy Vehicle Regulator.

Appendix D: Interstate & International Noise Policy Comparison

Summary comparisons of Australian and international traffic noise policy criteria are presented in Tables D1 and D2 respectively.

These tables represent a significant simplification as most traffic noise policies are highly complex and have many conditions on how the noise criteria are to be applied. Interested readers are encouraged to research the detailed documentation which is available on line for a more comprehensive understanding of other policies[8].

Jurisdiction (Policy owner)	Situation	Day Time Level (dB)	Night Time Level (dB) [9]	Equivalent LA10 (18h) dB [10]	Mandatory?
ACT (Planning Authority)	New	63 LA10 (18h)	N/A	63	No
	Upgrade	63 LA10 (18h)	N/A	63	No
	Existing	N/A	N/A	N/A	No
NSW (EPA)	New	55 LAeq	50 LAeq	57	No
	Upgrade	60 LAeq	55 LAeq	62	No
	Existing	65 LAeq	60 LAeq	67	No
NT (Road Authority)	New	63 LA10 (18h)	N/A	63	No
	Upgrade	68 LA10 (18h)	N/A	68	No
	Existing	N/A	N/A	N/A	N/A
Qld (Road Authority)	New	63 LA10 (18h)	N/A	63	Yes
	Upgrade	68 LA10 (18h)	N/A	68	No
	Existing	68 LA10 (18h)	N/A	68	No
SA (Road Authority)	New	55 LAeq	50 LAeq	62	Levels "should" be achieved
	Upgrade	60 LAeq	55 LAeq	67	Levels "should" be achieved
	Existing	N/A	N/A	N/A	N/A
Tas (Road Authority)	New	63 LA10 (18h)	N/A	63	No
	Upgrade	N/A	N/A	N/A	No
	Existing	68 LA10 (18h)	N/A	68	No
Vic (Road Authority)	New	63 LA10 (18h)	N/A	63	Yes
	Upgrade	63 LA10 (18h)	N/A	63	Yes
	Existing	68 LA10 (18h)	N/A	68	No
WA (Planning Authority)	New	55 LAeq	50 LAeq	57	No
	Upgrade	N/A	N/A	N/A	N/A
	Existing	N/A	N/A	N/A	N/A

Table D1: Australian Traffic Noise Policies (All values are facade noise levels)

8 See External Links at http://consult.vicroads.vic.gov.au/trafficnoise

9 N/A means that there is no noise criterion.

10 Refer to Table B1 for comparison of noise descriptors. Conversions to LA10 (18h) are approximate.

In Western Australia, it is mandatory that new roads do not exceed the criteria by more than 5 dB. For major road upgrades, practicable noise control measures should be considered but no criteria levels are specified.

In South Australia, the upgrade criteria are 3 dB lower (i.e. 57 LAeq day / 52 LAeq night) if noise walls or buildings that previously provided protection from noise are removed as part of a road upgrade.

Some countries do not have any defined acceptable or desirable noise. For example, in the United States noise barriers are designed to reduce traffic noise by between seven and ten decibels if they are constructed using Federal funds. There is no specific target noise.

Country	24 Hour LAeq	Day Time LAeq	Night Time LAeq	Lden	Equivalent LA10 (18h) Facade [11]
Austria		60 dB	50 dB	58 dB	59 dB
Denmark				58 dB	59 dB
Finland			51 dB		58 dB
France		60 dB (facade)	55 dB (facade)		62 dB
Italy		55 dB	45 dB		55 dB
Japan [12]		60 dB	55 dB		65 dB
Netherlands			52 to 55 dB		62 - 65 dB
New Zealand [13]	64 – 67 dB				64 - 67 dB
Spain		60 dB	45 dB		55 dB
Sweden	55 dB (facade)				58 dB
WHO			55 dB		65 dB

Table D2: International outdoor noise guidelines for major new roads in residential areas. (The French value is a limit, all others are guidelines. All are free field unless indicated.)

[11] Refer to Table B1 for comparison of noise descriptors. Conversions to LA10 (18h) are approximate.

[12] Japan prioritises noise mitigation where night time noise exceeds 73 dB LAeq.

[13] New Zealand guidelines are for roads with more than 75,000 vehicles per day. Lower guidelines apply to smaller roads.

Appendix E: Health Effects of Traffic Noise

The growth in traffic noise has been shown to have adverse effects on the community. European research has determined that traffic noise has significant adverse health impacts. It is well established that noise is a psychosocial stressor. Increased risks of hypertension, acute myocardial infarction (AMI) also known as heart attack, stroke, diabetes and tinnitus have been identified (Babisch, 2008) (Sorensen, et al., 2011, Sorensen, et al., 2013, WHO, 2011). The magnitude of the health impacts of traffic noise are highly uncertain, but there is little doubt that they are real. Continued research is reducing the uncertainty in the magnitude of these health impacts.

Research into the health impacts of traffic noise typically compares the health of people living near busy roads with the health of people living further away. The research seeks to separate the effect of noise from other factors such as diet, lifestyle and socio-economic factors. A particular difficulty is the fact that locations with high levels of noise also have high levels of air pollution, which is also a cause of many diseases. Traffic noise is generally not loud enough to cause hearing damage, even for road construction workers.

The main health effects attributed to traffic noise include:

- Annoyance
- Sleep disturbance
- Cardiovascular disease

Other health impacts from traffic noise have been identified including hypertension, mental illness, stroke, tinnitus and children's learning impairment.

Annoyance

Annoyance is a broad term used to describe negative reactions to noise.

Annoyance and sleep deprivation may contribute to a physiological stress response (flight or fight mode) that can modify hormone levels and the cardiovascular system in the short term. Feeling stressed is likely to further impair sleep and increase annoyance, exacerbating the effects of noise disturbance. Chronic stress may contribute to the development of mental illness and cardiovascular disease.

Sleep Disturbance

Annoyance and sleep disturbance account for the vast majority of the burden of disease due to noise (WHO, 2011). The effects of noise are strongest for those outcomes which can be classified under the "quality of life" impacts rather than physical illness, as is the case for annoyance. Researchers consider that although these effects might lack in relative severity they affect a greater number of people (Stansfeld & Matheson, 2003).

Extensive research has been conducted into the effect of environmental noise on sleep disturbance, and into the effects of sleep disturbance on health and wellbeing (WHO, 2009) (WHO, 2011). The effect of noise on sleep is complex because the amount of sleep disturbance depends not just on the noise level, but also on the nature of the noise. In particular, sleep disturbance is caused by noise events such as an individual noisy vehicle passing by. The frequency of noise events and their level are both relevant to the amount of sleep disturbance, but these are difficult to measure in a real world environment.

Effects of sleep disturbance include (WHO, 2009):

- Daytime sleepiness, resulting in cognitive problems, accidents, memory difficulties and poor job performance
- Increased mortality risk if less than six hours sleep per day
- Possible development of psychiatric conditions and increased use of medication or alcohol abuse
- Learning disability for children with long term sleep deprivation

The increased risk of sleep disturbance due to traffic noise has been quantified, and can be calculated for particular noise levels.

Stress hormones

Noise has both temporary and permanent effects on people.

Acute exposure to noise activates nervous and hormonal responses, leading to temporary increases in blood pressure, heart rate, and blood vessel constriction. Studies of people exposed to occupational or environmental noise show that exposure of sufficient intensity and duration increases heart rate and peripheral resistance, increases blood pressure, blood viscosity and levels of blood lipids, levels of adrenaline, noradrenaline and cortisol as well as shifts in electrolytes.

In addition, sudden unexpected noise evokes reflex responses. Cardiovascular disturbances are independent of sleep disturbances; noise that does not interfere with a person's sleep may still provoke autonomic responses and secretion of adrenaline, noradrenaline, and cortisol. This suggests that a person can never completely get used to night-time noise.

Cardiovascular Disease

The mechanisms by which environmental noise may cause cardiovascular disease are unclear but long term stress is thought to play a likely role.

Noise may be a risk factor for cardiovascular disease since it can trigger both endocrine and autonomic nervous system responses that affect the cardiovascular system.

The measurement of stress hormones, adrenaline, noradrenaline and cortisol has been used to study the possible increase in cardiovascular risk in people exposed to noise. Stress hormones are useful for investigating biological mechanisms where they act in the regulation of autonomic and other physiological functions affecting known established risk factors for hypertension, arteriosclerosis or myocardial infarction. (Babisch, 2003).

Extensive research has focused on the impact of traffic noise on heart attack (also called acute myocardial infarction or AMI). From epidemiological studies that provide dose-response relationships between traffic noise and cardiovascular diseases, researchers have estimated that the risk of cardiovascular disease increases for values between 65 and 70 dB of the daytime equivalent A-weighted sound pressure level (LAeq) or with acute exposure to noise levels above 80 to 85 dB. (Babisch W. et al., 1992; Babisch W. et al., 1993).

One well known German study (Babisch, 2008) plotted the increased risk of AMI against noise level using data pooled from a number of earlier studies. Figure D1 shows how the odds ratio for heart disease increases with noise level. The vertical lines with diamonds or circles indicate the 95% confidence range of the actual odds ratios. This data indicates that it is very likely that increased traffic noise causes increased risk of heart disease, although the magnitude of the increased risk is not precisely determined.

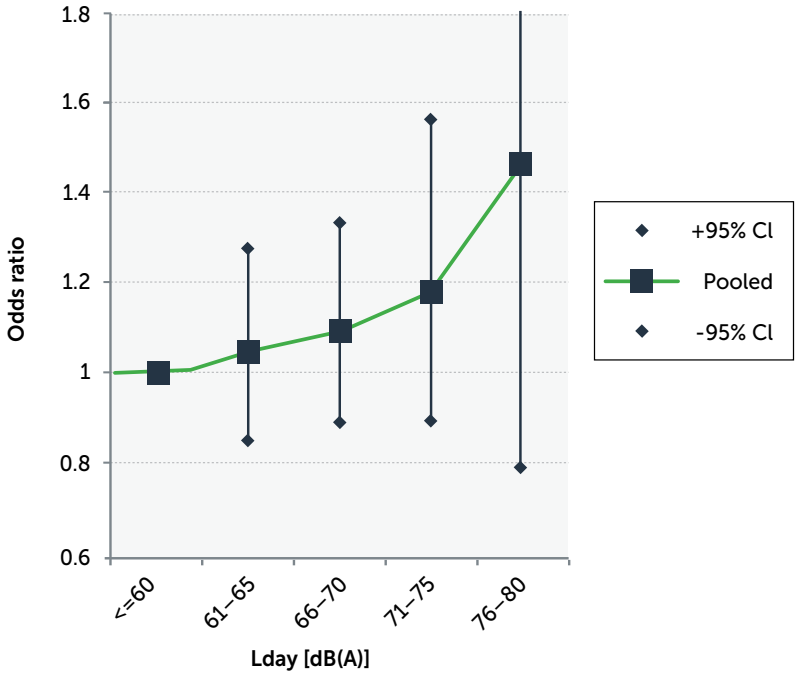

Figure E1. Odds Ratio of Myocardial Infarction (Babisch, 2008)

Appendix F: Economic Cost of Traffic Noise

To what extent is reducing traffic noise a worthwhile use of limited taxpayer's money? This depends on how we value the impact of noise on people, which is a question of economics. There are two classes of method that economists use to determine the impact cost of noise:

- "*Revealed preference methods*" which use measures of people's actual expenditure on noise avoidance to determine how much they are prepared to pay to avoid noise
- '*Stated preference methods*' based on surveys or interviews to determine how much people are prepared to pay.

Both types have advantages and disadvantages, and both have highly uncertain conclusions.

The most common revealed preference method is hedonistic pricing. This method estimates how much less people are prepared to pay to purchase a house in a noisy location based the difference in sale prices of homes in noisy and quiet locations. Hedonistic pricing aims to determine the Noise Depreciation Index (NDI) which is the percentage reduction in property value per decibel. The NDI may equally apply to property purchase price or to rent.

In Australia, it has generally been considered that residential property values are depressed by half of one percent point (0.5%) per decibel of traffic noise, once that noise is greater than around 50 or 55 dB LAeq (day time) (ARRB Transport Research, 2003). International estimates of NDIs range from as low as 0.29% per dB to as high as one percent per decibel, as shown in Table F1.

Hedonisitc pricing is sometimes criticised for three reasons. Firstly, it is difficult to separate the price difference that is due to noise from the price differences due to other factors such as air pollution, perceived safety, or simply due to the possibility that houses near busy roads may be of different quality from houses in quieter streets. Ultimately this means that the estimated hedonistic cost is uncertain, explaining some of the differences between different studies.

Secondly, hedonistic pricing depends on ability to pay – someone on a high income may value noise more highly than someone on a low income; that doesn't mean that reducing noise in wealthy neighborhoods is more worthwhile than reducing noise in poorer neighbourhoods.

Thirdly, home buyers may not be fully aware of the impacts of noise before they purchase a property. For example, they may not understand the impact of night-time freight traffic if they only inspect a property during the day time, and they may not understand that traffic growth over subsequent years will increase noise levels.

Study Name	Location	Year	NDI % / dB
CSERGE/EFTEC	UK	1994	0.67
JMP	UK	1996	0.29
Soguel	Switzerland	1994	0.91
Vainio	Helsinki	1995	0.36
Renew	Brisbane	1996	1.0
Grue	Oslo	1997	Flats – 0.24 Houses – 0.54
Palmquist	Washington State	1980 / 81	0.08 – 0.48
Nelson	USA	1982	0.40
Hall	Toronto	1982	Arterial – 0.42 Freeway – 0.52
Hidano	Tokyo	1992	0.70

Table F1: Noise Depreciation Index Studies (Navrud, 2002)

By contrast, stated preference costs for noise are determined by surveying people to determine what dollar value they place on reduction in noise levels. The most common method for determining stated preference costs for environmental impacts is the Contingent Valuation method, based on the concept of Willingness to Pay (WTP). People are asked a series of questions about how much they are ready to pay to avoid an environmental impact (or what they would need to be paid to be willing to accept it). This method is somewhat controversial due to a number of risks, such as the surveyed people who are not typical of the general population, and the possibility that respondents may modify their responses to achieve a preferred outcome (Splash, 2008).

There appears to be significantly less stated preference data on the impact cost of traffic noise than hedonistic pricing data. Examples include:

- NDI of 1.5% for houses and 0.9% for apartments in the USA (Feitelson et al, 1996)
- €6 to 14 for each exposed person per year per decibel above 65 dB LAeq (18 hour) (Bjorner, 2002) i.e. approximately $14 to $34 in 2014 Australian dollars.
- €10 for each exposed person per year per decibel (HEATCO study, 2006) ie approximately $20 in 2014 Australian dollars.

In 2003, a European Union working group determined, largely on the basis of Norwegian research (Navrud, 2002), that the apparent annual cost of noise was € 25 per decibel per household (Working Group on Health and Socio-Economic Aspects, 2003). This is equivalent to $58 in 2014 Australian dollars.

Capitalised Costs

Some costs of noise quoted in the literature are reported in terms of annual costs. For example, a Danish study introduced a 'Noise Exposure Factor" (NEF) to quantify the external costs of traffic noise (Bendtsen & Larsen, 2005). For a noise increase from 55 dB to 60 dB, the Danish NEF indicates an increased damage cost of $1,032 per household per year. This means that the effect of traffic noise on the occupants of that household is worth $1,032 for every year they are exposed to the noise.

By contrast the Noise Depreciation Index represents a capital cost. The value of a home is reduced 0.5% per decibel increase in noise (ARRB Transport Research, 2003). A $600,000 home would lose $15,000 in value if the noise level increased by five decibels. This is a one-off capital cost, not an annual cost.

In this paper, in order to compare these figures, the annual costs have been converted to capital costs by counting the total annual costs over a thirty year period, then discounting them by 3.5 % per year. This means that for an annual cost of $1,000, the second years' cost is reduced by 3.5% to get $965 and added to the first year's cost to get $1,965. The third year's cost of $1,000 is discounted by 3.5% twice to get $931, and this is added to the $1965 to get $2,896. This process is repeated thirty times to get a final capital cost of $18,400 for an annual cost of $1,000.

The discounting represents the belief that a person would rather be given a dollar today than a dollar next year, and would much rather be given a dollar today than a dollar in thirty years time.

The use of capitalised costs allows consistent comparison between different measures of noise damage costs, and comparison with the cost of noise reducing measures such as noise walls.

Health Costs of Noise

The World Health Organisation (WHO) has quantified a number of heath impacts from traffic noise using a measure of the loss of healthy life years referred to as Disability Adjusted Life Years (DALYs) (WHO, 2011). A DALY represents one year of healthy life. By detemining the fraction of a DALY for a disease that a person is subject to, it is possible to quantify the magnitude of the illness, and by assigning a monetary value to a healthy life year, it is possible to determine the economic value of health effects.

While the WHO's estimations of health impacts for different illnesses are inconsistent, the most significant one is sleep disturbance, with highly disturbed sleep being quantified at 0.07 of a DALY (WHO, 2009, p97). The WHO has defined a formula for calculating the percentage of people who are highly sleep disturbed as a function of outdoor noise levels. Determining the monetary value of a healthy life year is a matter of health economics, and is beyond VicRoads' expertise. For the purpose of analysing the health impacts of traffic noise, VicRoads has adopted the Victorian Competition and Efficiency Commissions's suggested value of a statistical life of $174,193 in 2012 dollars (VCEC, 2013). The capitalised cost of sleep disturbance is shown as a dotted line Figure F1.

The United Kingdom's Department for Environment, Food & Rural Affairs (DEFRA) has conducted an extensive investigation into the cost burden of health impacts from environmental noise. This reasearch has resulted in guidance for determining the cost burden relating to annoyance and to Acute Myocardial Infarction (AMI) (DEFRA, 2010). The AMI cost is based on the increased risk of AMI (Babisch, 2008), combined with the normal risk of AMI in the UK and with the British health burden cost of AMI. The guidance specifies the increase in cost burden of decibel by decibel increases in noise level in terms of British Pounds per household per year.

VicRoads has used these cost values to calculate an impact cost curve for AMI in terms of a captialised cost per household. Figure F1 displays this curve in a dashed line.

The total cost of noise is shown by the solid line in Figure F1. It is clear that the cost of sleep disturbance is much greater than the cost of the risk of AMI. This can be explained by the fact that the absolute increase in risk of AMI attributable to traffic noise is extremely low while sleep disturbance is very common.

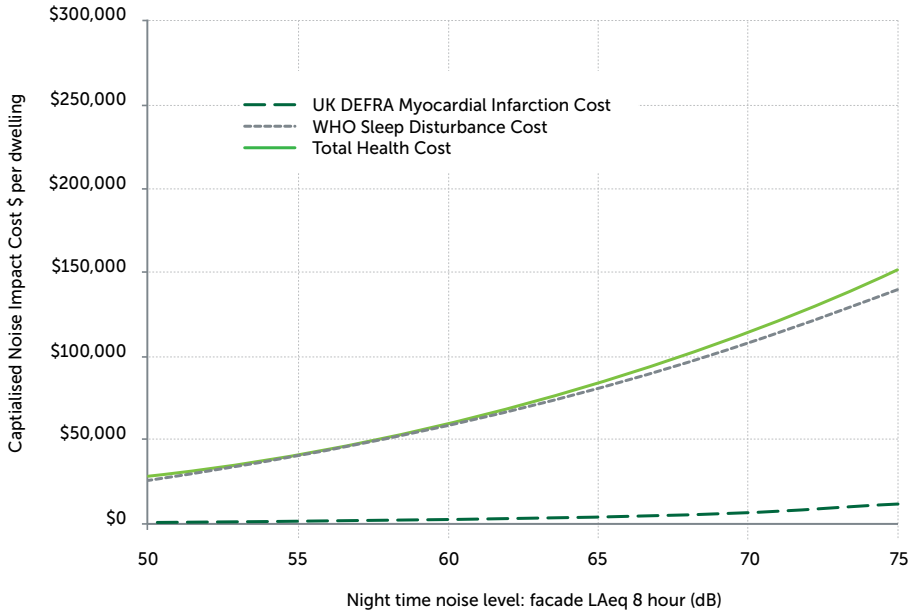

Figure F1. Health Cost of Noise

Combined Willingness to Pay and Health Costs

The health impacts of noise represent a separate economic impact to the willingness to pay for a quiet location. There is consensus amongst environmental noise specialists that the general public have a poor understanding of the health impacts of noise and are unlikely to consider health effects from noise when choosing housing or when responding to a noise impact survey (Navrud, 2002). For this reason, it is normal to consider economic health impacts of noise as being in addition to the Noise Depreciation Index or Willingness to Pay impacts of noise and determine a total impact cost.

VicRoads has adopted two approaches to quantify the impact cost of traffic noise. The first, referred to as Model 1 is to add the property devaluation cost (which is a measure of how people value the annoyance from noise, to the value of quantifiable health impacts; sleep disturbance and acute myocardial infarction. In Figure F2, the property devaluation cost is shown as a dotted line and the health cost is shown as a dashed line. The total impact cost of noise is shown by the solid line.

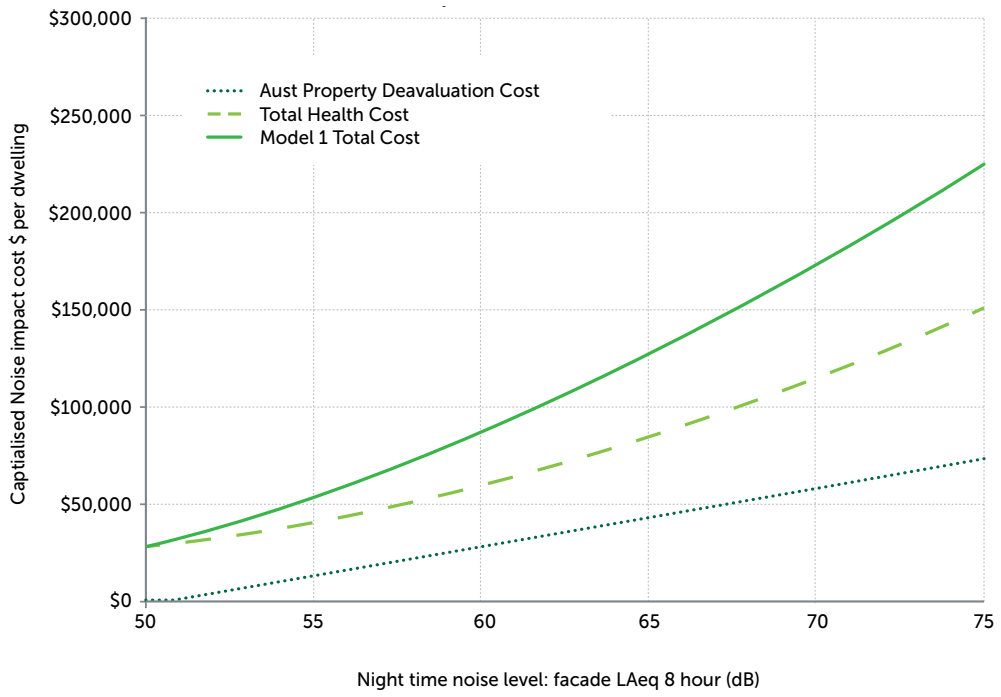

Figure F2. Impact Cost of Noise - Model 1

The second approach, referred to as Model 2, is to adopt the cost of traffic noise adopted by the Danish Road Directorate (Bendtsen & Larsen, 2005). The Danish approach is based on a calculated quantity called the Noise Exposure Factor (NEF), which is an exponential function of the 24 hour LAeq noise level. The Danish Road Directorate has determined a cost per dwelling per year based on the NEF that incorporates willingness to pay from hedonistic pricing added to a health cost based on medical costs. By converting the noise cost from Euros to 2014 Australian dollars and scaling to the average household size in Metropolitan Melbourne as compared to that in the main Danish cities, the NEF can be used as a measure of both health and amenity impacts of traffic noise. The capitalised impact cost for noise calculated on the basis of the NEF is shown by the dashed line in Figure F3 where it can be compared to the Model 1 cost (solid line).

Comparing the Model 1 and Model 2 cost curves, it is clear that the two calculation methods are similar for noise levels below about 70 dB LAeq (night time) but diverge significantly for higher noise levels. There are very few locations in Victoria where traffic noise levels exceed 70 dB LAeq (night time) so the two curves can be considered to be reasonably consistent. They indicate that in the 50 to 70 dB range, a reduction in noise level is worth a one-off expenditure of between $7,000 and $15,000 per decibel per household.

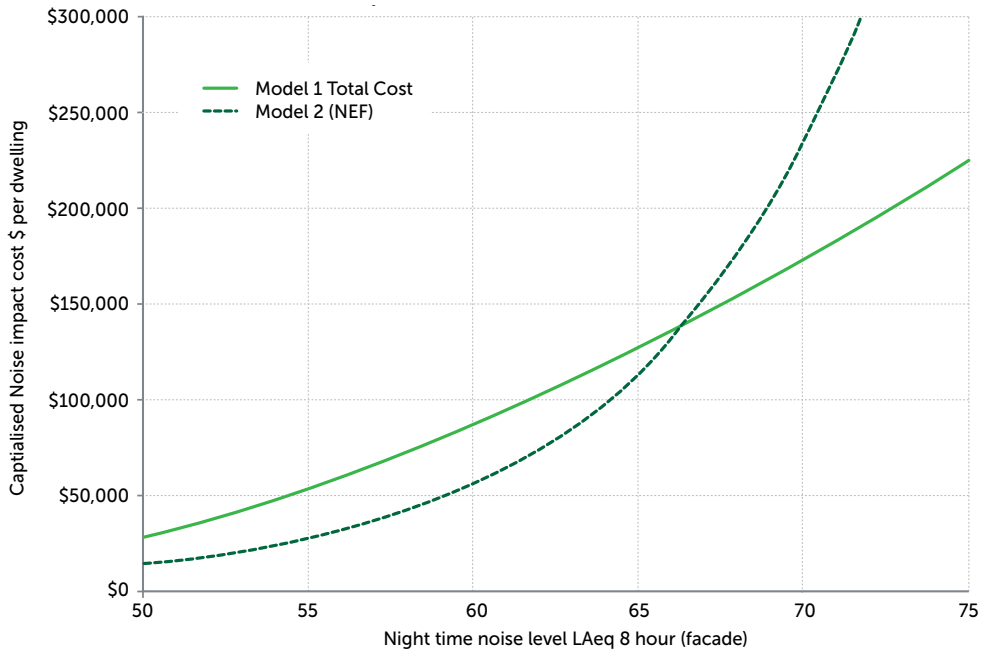

Figure F3. Noise Impact Costs - Two Models

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