Transport for NSW

Road Noise Mitigation Guideline

April 2025

NSW GOVERNMENT

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Transport
for NSW

Acknowledgement of Country

Transport for NSW acknowledges the traditional custodians of the land on which we work and live.

We pay our respects to Elders past and present and celebrate the diversity of Aboriginal people and their ongoing cultures and connections to the lands and waters of NSW.

Many of the transport routes we use today – from rail lines, to roads, to water crossings – follow the traditional Songlines, trade routes and ceremonial paths in Country that our nation's First Peoples followed for tens of thousands of years.

Transport for NSW is committed to honouring Aboriginal peoples' cultural and spiritual connections to the land, waters and seas and their rich contribution to society.

Document control

Document owner	Senior Specialist Noise
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Branch / division	Environment and Sustainability / Safety, Policy, Environment and Regulation
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Superseded documents	RMS 14.584 Noise Mitigation Guideline Practice Note (iv), (iv-a) and (iv-c) of the Transport for NSW Environmental Noise Management Manual (2001)

Versions

Version	Date	Amendment notes
1.0	Oct 2016	Original Roads & Maritime document
1.1	Jun 2022	Rebranded from a Roads & Maritime document to Transport for NSW
1.2	Jul 2023	Minor updates
1.3	June 2024	Clarification of assessment process when using quieter pavements
1.4	Oct 2024	Documentation of current practice in relation to assessment of at-property treatment for non-residential noise sensitive receivers during early and detailed design phases
1.5	Apr 2025	Documentation and other modifications primarily to existing and new noise barrier optimisation process. Also, inclusion of related definitions. Changes are to minimise different interpretations, to ensure better outcomes and to facilitate consistency, including in terms of reporting terminology.

Related policy and supporting information

- Transport Environment and Sustainability Policy
- Environment & Sustainability Management Framework
- EPA's NSW Road Noise Policy 2011 (RNP)
- Transport EMF-NV-GD-0025 Road Noise Criteria Guideline
- Transport EMF-NV-GD-0026 Road Noise Model Validation Guideline
- Transport EMF-NV-GD-0058 At-Receiver Road Noise Treatment Guideline

Contacts and further information

Email: environoiseandvibration@transport.nsw.gov.au

Internal Transport users: ESMF Noise and vibration (sharepoint.com)

Contents

1. Overview

1.1 Why is this guideline required?

This guideline outlines the approach Transport for NSW (Transport) takes to the evaluation, selection and design of feasible and reasonable noise mitigation measures.

This policy should be read in conjunction with the:

- EMF-NV-GD-0025 Road Noise Criteria Guideline (Transport for NSW)
- EMF-NV-GD-0026 Road Noise Model Validation Guideline (Transport for NSW)
- EMF-NV-GD-0058 At-Receiver Road Noise Treatment Guideline (Transport for NSW)
- Noise Wall Design Guideline (Transport for NSW Centre for Urban Design)
- EPA's NSW Road Noise Policy 2011 (RNP)
- Transport's Project Pack (information provided on a project-specific basis)
- Transport's QA Specification R271 - Design and Construction of Noise Walls

1.2 Policy statement

Transport is committed to effectively managing impacts from its activities in an environmentally-responsible manner. Transport is committed to avoiding or minimising noise and vibration impacts from road traffic on all roads and traffic systems under our control.

Transport recognises that considering noise at the outset of a project can minimise or avoid noise impacts and the cost of mitigating them.

Transport will assess and provide feasible and reasonable noise mitigation measures for:

- Road projects in accordance with the NSW Government's Road Noise Policy (RNP)
- Existing roads in accordance with the Transport Noise Abatement Program (NAP)

Transport prefers noise and vibration mitigation measures to be applied within the road corridor wherever practicable. Measures that need to be applied outside the road corridor such as at-property treatment of building facades will be limited to the circumstances described in this guideline.

1.3 Context

Policies such as the RNP and the NAP call for the application of a feasible and reasonable approach to mitigate noise.

This document provides guidance to feasible and reasonable noise mitigation measures for road projects and to existing roads with an acute level of traffic noise.

This guideline will need to be considered for all road projects.

Noise impacts and mitigation measures need to be evaluated at various stages of a road project to inform the approval and design process. The evaluated outcomes reported during these processes also provide the required reference to assess post construction operational compliance.

When identifying feasible and reasonable noise mitigation, the total noise level from all roads is always used including when assessing against new road criteria. This is because it is not reasonable to provide noise mitigation unless it provides a reduction in noise level. This differs from the 2011 edition of the RNP where only contributed noise levels are considered. This ensures that noise mitigation provides a benefit by reducing noise levels at a receiver rather than just noise levels coming from the new road. It also ensures that the noise from the new road cannot unreasonably increase noise levels at a receiver without the receiver qualifying for noise mitigation.

1.4 Scope

This guideline provides a consistent approach to the evaluation, selection and design of the most appropriate mix of these further noise control options. This guideline is most relevant for:

- Project development managers.
- Environmental staff.
- Project implementation managers.
- NAP managers.
- Acoustic consultants.

This guideline will apply for:

- All new and redeveloped road projects managed by Transport:
- In the final stages of project concept design development and in the environmental impact assessment (including any REF).
- During the project's detailed design.
- Following post-construction operational compliance noise monitoring and assessment if re-evaluation of the project's noise treatments is considered necessary.
- Minor works where noise levels increase by more than 2.0dBA (2.1dBA or more).
- NAP noise mitigation measures.

This guideline does not apply to:

- Ancillary facilities such as truck rest areas, bus layovers or heavy vehicle inspection stations. In these cases, the EPA's Noise Policy for Industry (2017) is the applicable guideline.
- Road traffic on private roads.

2. Policy

This guideline describes the principles to be applied when reviewing if noise mitigation is feasible and reasonable. It also describes procedures to assist in reviewing noise mitigation.

The approach is staged giving preference to reducing noise during corridor planning and road design rather than through use of specific noise mitigation measures. The basis for this staged approach is given in the RNP.

The intention in all situations is to meet the following principles. Should circumstances arise where the procedures in this document do not appear to meet the principles below, then the procedure may be varied through consultation with Transport noise specialists. Note that the use of the procedures in this guideline does not guarantee that the principles will always be met and in cases where there is doubt then it is the principles rather than the procedures that are paramount.

The principles are:

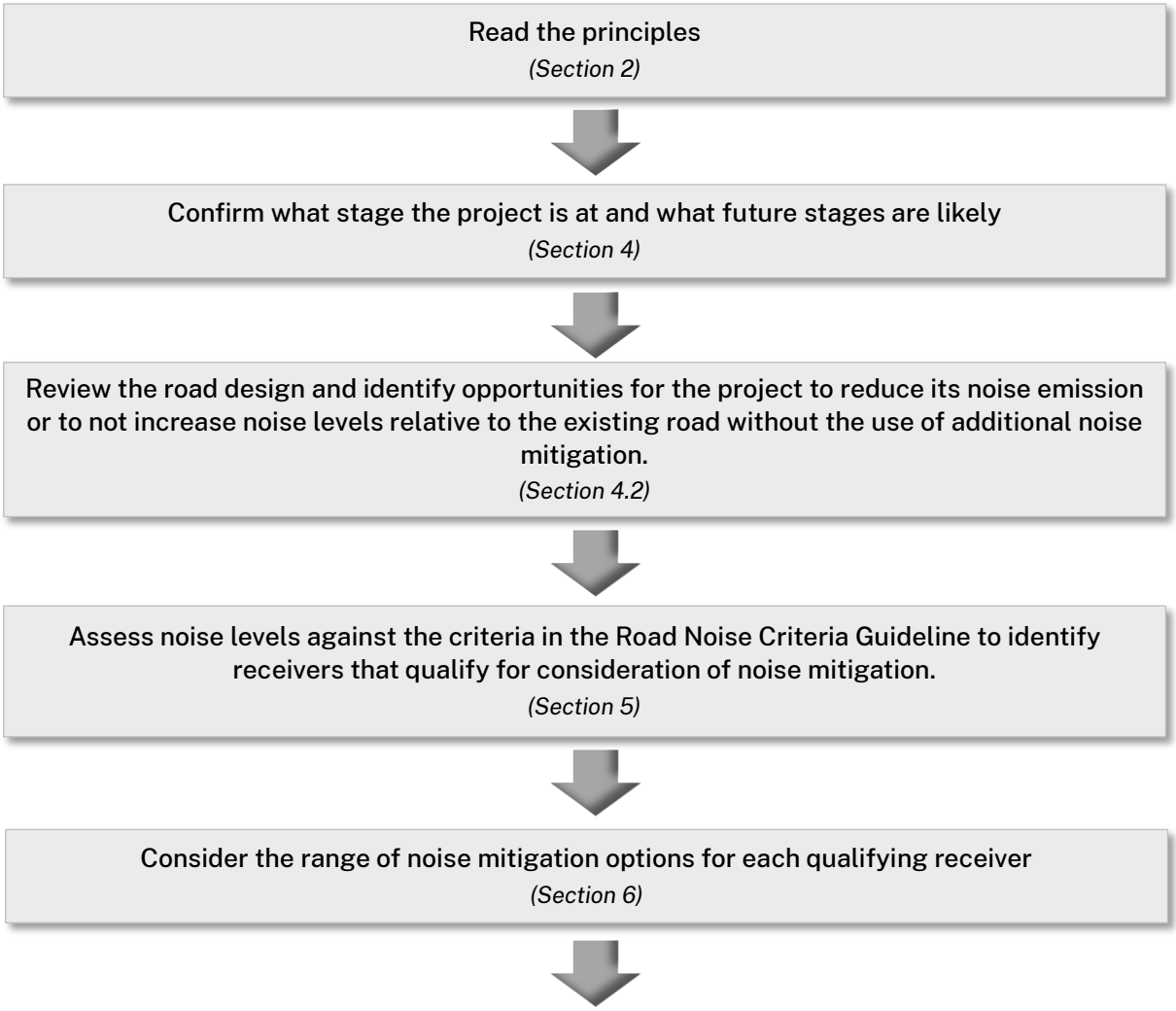
- Communities should receive reasonable and equitable outcomes.
- Noise mitigation should be designed to reduce noise levels to the criteria at qualifying receivers.
- Priority should be first given to reducing noise during corridor planning and road design where there may be greater opportunity to provide cost effective and integrated outcomes with better urban design.
- Following corridor and road design residual exceedances of noise criteria may be addressed at qualifying receivers using in order of preference (RNP Section 3.4.1); quieter road surfaces, barriers and at-property treatments.
- Incidental benefits from the noise mitigation designed for qualifying receivers should be recognised at all receivers within a community where noise levels exceed WHO guidelines[1].
- Noise barrier evaluation processes must:
  - give preference to reducing outdoor noise levels and the number of at-property treatments
  - provide efficient barrier heights and extents without disregarding lengths of effective noise barrier in front of eligible groups of receivers
- Noise mitigation shall be evaluated and installed where feasible and reasonable.

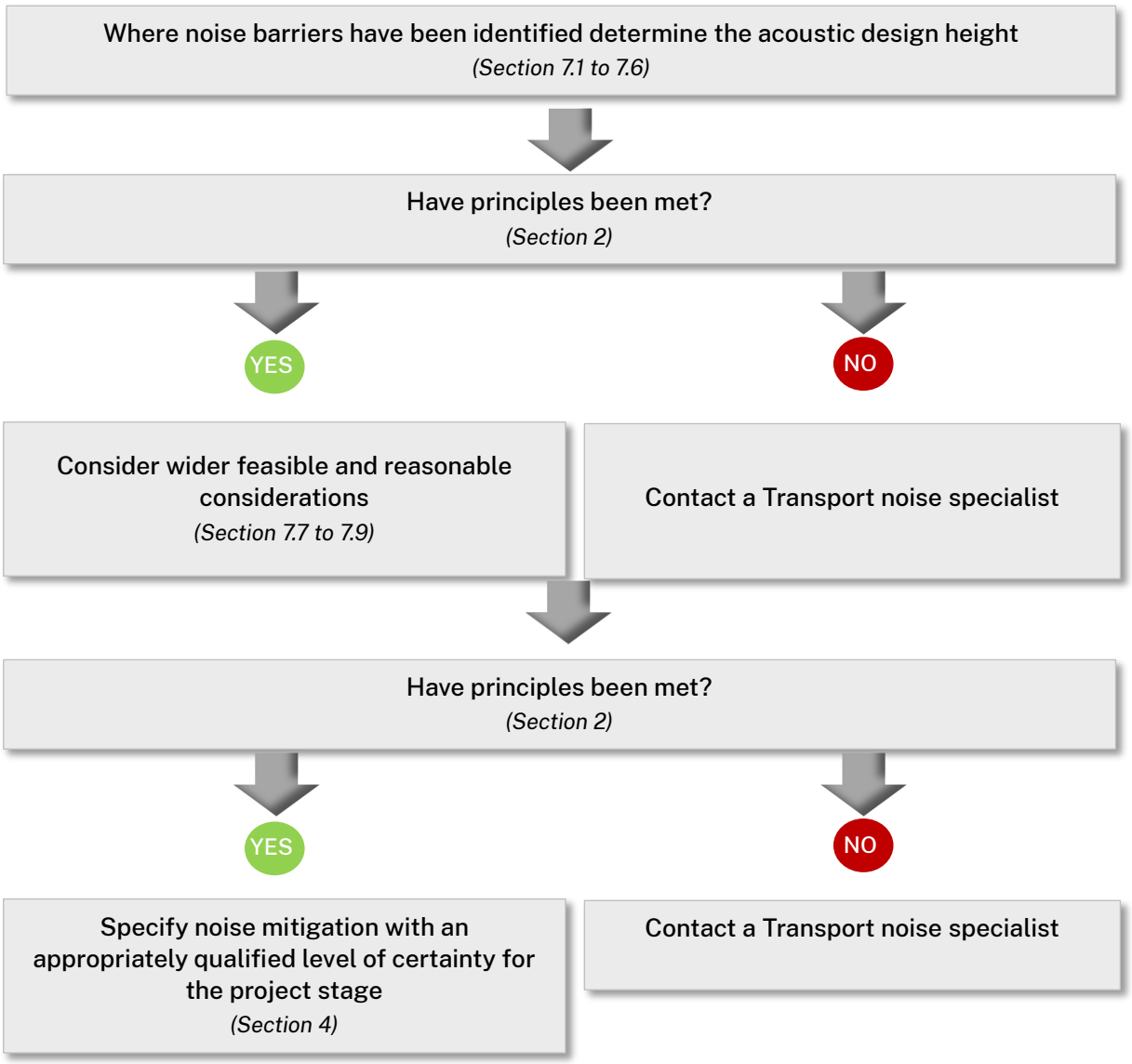
Note[1]: Facade noise levels of 50 dBA day and 45 dBA night are considered representative of the World Health Organisation (WHO) Guidelines for Community Noise (1999) for outdoor areas and the WHO Night Noise Guidelines for Europe (2009) threshold levels.

3. How do I use this guideline?

The following flow chart provides an overview of how to use this guideline. Key aspects to note are that the guideline principles must be met and that each step in the flow chart is applicable at each project stage.

Figure 3-1: Overall approach for noise mitigation assessment




Where noise barriers have been identified determine the acoustic design height
(Section 7.1 to 7.6)
Have principles been met?
(Section 2)
YES
NO
Consider wider feasible and reasonable considerations
(Section 7.7 to 7.9)
Contact a Transport noise specialist
Have principles been met?
(Section 2)
YES
NO
Specify noise mitigation with an appropriately qualified level of certainty for the project stage
(Section 4)
Contact a Transport noise specialist

4. Project stages

4.1 Designing to reduce and mitigate noise

When reviewing project noise, the first consideration should be at what stage is the project and what the likely future stages are. The project stages are detailed in Sections 4.4 to 4.6.

The project stage and any subsequent stages determine the level of detail that is available and the certainty in which final mitigation measures may be specified.

For example, depending on the scale of the project, there may be one design stage which is used for the environmental assessment or further design refinements at different stages after the environmental approval. More complex projects may also have a route-options analysis completed prior to the environmental assessment.

4.2 Integrated noise reduction measures

Each of the project stages (Sections 4.4 to 4.5) provides a review point at which opportunities to integrate noise reduction into decisions, corridor planning and fundamental design processes are available. This may require coordination of multiple design and planning disciplines at each stage and throughout the duration of the project.

The following road design features should be considered integral to corridor planning and road design. They may also provide greater benefits than just mitigation of noise:

- Adjustments to vertical and horizontal alignments.
- Road gradient modifications.
- Traffic management.
- Utilisation of airspace above roads for acoustically designed land use developments
- Cost effective use of won project spoil to provide landscape mounds where there is suitable site footprint.

Integrated noise reduction measures should exclude the use of quieter surfaces during road design except for where they are used for another primary purpose.

As the stages progress towards the ‘for construction’ design the opportunities to integrate noise reduction measures into the design may reduce with increased reliance on specific noise mitigation measures to meet the criteria established for the project using the Road Noise Criteria Guideline (RNCG).

4.3 Specific noise mitigation measures

Specific noise mitigation measures to meet the RNCG criteria at qualifying receivers (Section 5) should only be included after opportunities for integrated measures have been investigated. Specific noise mitigation measures should be identified (Section 6) with an appropriately qualified level of certainty for each project stage.

Guidance on how to evaluate the most feasible and reasonable mix of noise mitigation is in Sections 6 and 7. Detailed discussion of noise mitigation performance for pavements, barriers and property treatments are proposed to be contained in separate guidelines.

These specific measures should be reviewed at each stage of the project below (Sections 4.4 to 4.6).

4.4 Route options

During an options assessment various routes are investigated. Each route may have different opportunities to integrate noise reduction, different noise specific mitigation measures and a different potential noise impact.

An important aspect in planning a new road and road corridor is to provide a buffer. This buffer aligns the road corridor away from sensitive receivers and also provides sufficient space for noise mitigation in the road corridor. This underlies the premise in the RNP that for a new road there is a greater potential opportunity to have lower noise levels than a redeveloped road.

4.5 Design

Each of the following steps represents an increase in the level of design detail:

- Environmental impact assessment (EIA).
- Environmental impact assessment review for scope of works or performance requirement documentation provided to contractor.
- Tender design.
- Detailed design stages (e.g.,15, 80 and 100 per cent and 'for construction').

This improved level of detail (e.g., road location, topography) increases the level of certainty in modelling results and allows for refinement of mitigation measures. Where the level of certainty increases this may permit the modelling allowance to be adjusted.

Common examples of information, that is refined as a project progresses, include ground geology and ground height contours near the road and at receivers. These both influence vertical and horizontal road alignment and the corresponding noise propagation.

In all instances, any allowance added to predicted noise levels to address less than ideal information, should be applied after the difference between the 'build' and 'no-build' noise levels have been calculated or to both the 'build' and 'no-build' noise levels. This ensures that the allowance does not artificially increase the noise level difference. The effect of the allowance should be to only increase the number of receivers that are identified above the criteria.

Potential mitigation identified at all stages of assessment, particularly during the EIA phase should clearly state:

- If it is being presented as an option only subject to feasible and reasonable considerations or future design refinement.
- If there are any uncertainties that may result in changes to the noise mitigation.

When recommending mitigation during the EIA stage it should be confirmed whether there is to be a detail design stage. If there are to be no further design stages, then the level of detail in survey information used to prepare the EIA technical noise report should be appropriate for construction purposes.

For example, if there are no further design stages then input parameters such as ground height contour resolution should be confirmed to provide sufficient accuracy. Typically, 1 metre contours inside 300 metres. For distances beyond 300 metres then two (preferred) to five (upper limit) metre contours are sufficient.

Any limitations and modelling uncertainty in the EIA reports should be documented in the technical report.

4.6 Post-construction operational compliance

Please see Section 6 of the Road Noise Model Validation Guideline (RNMVG) and additional clarification by Transport. Note that where the outcome of the compliance report is that further noise mitigation should be considered, the processes in this guideline should be followed.

5. When should additional mitigation be considered?

Once noise has been minimised by feasible and reasonable methods during the corridor planning and road design stages receivers with residual exceedances of RNCG criteria can be assessed to determine if they qualify for noise mitigation.

The eligibility of receivers for consideration of additional noise mitigation is established for the base case where certain noise triggers are exceeded (refer to Definition in Section 8), **prior** to any additional noise mitigation being implemented (e.g. quieter pavement, noise barriers, etc). Where feasible and reasonable, additional mitigation is then progressively applied at these same established receivers, with the objective of ultimately meeting the relevant RNCG noise criteria. Where this initial objective is not feasible or reasonable and/or there are residual exceedances of the RNCG criteria after additional in-corridor mitigation such as quieter pavement and/or noise barriers, then at-property treatments are considered to address the residual impacts.

Eligibility for consideration of noise mitigation should be determined for each affected property and the exceedance above relevant RNCG criteria assessed at each façade.

The noise model used to determine mitigation considerations should be prepared and validated with reference to the RNMVG. In all instances, any modelling allowance added to predicted noise levels should be applied so that it does not affect the difference between the 'build' and 'no-build' noise levels.

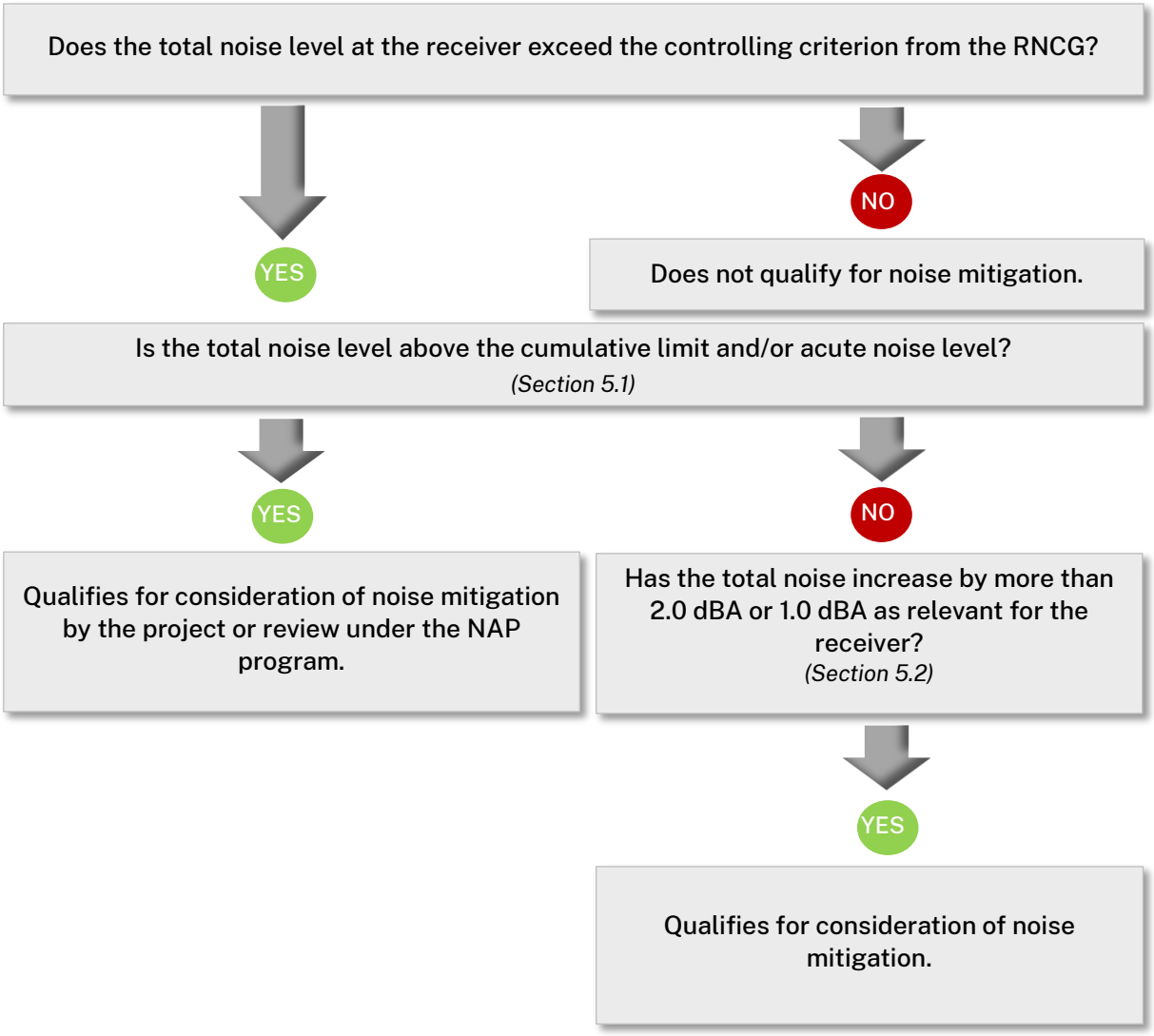
When evaluating if a receiver qualifies for consideration of noise mitigation Transport considers how far above the criterion the noise level is and also how much the noise level has increased by. These two considerations are detailed further below and provide for a feasible and reasonable approach to identifying qualifying receivers and managing small noise increases.

A receiver may qualify for consideration of noise mitigation under the situations outlined in Sections 5.1 to 5.4.

It is noted that a proposed noise-sensitive development is assessed as an existing noise sensitive receiver for the purpose of noise impact assessment, where the proposed noise-sensitive development has an approved development consent, or a complying development certificate for the erection of a building on vacant, that has been issued before a road development proposal has been approved. As such it may be considered for noise mitigation, where feasible and reasonable. In this circumstance, if architectural treatment of individual dwellings is deemed appropriate, but at the time of project completion a noise-sensitive development has not yet been built to a stage that would allow the installation of the architectural treatment, then it is not feasible or reasonable for Transport to provide this noise mitigation and additional at-property mitigation becomes the responsibility of the developer. The developer is responsible for the noise mitigation of noise sensitive developments approved or constructed following the approval of the road infrastructure project. The design of the development must then take into consideration the noise emission of the road infrastructure and where appropriate, the internal noise level requirements of the Department of Planning and Environment's (DPE) Transport and Infrastructure SEPP (T&I SEPP), as a minimum. The T&I SEPP outlines relevant criteria under which compliance is mandatory. The DPE's Development near Rail Corridors and Busy Roads – Interim Guideline (2008) provides some guidance on noise mitigation considerations for noise sensitive developments, in support of the SEPP.

A summary of the process by which a receiver may qualify for consideration of noise mitigation is shown in Figure 5-1 below.

Figure 5-1: Summary of qualifying process for a receiver



5.1 Cumulative limit and acute noise level

When the total noise level in the build year is 5dBA or more above the RNCG criterion it is considered to have exceeded the cumulative limit. Receivers where the exceedance occurs qualify for consideration of noise mitigation with the objective of reducing noise levels to the RNCG criteria, where feasible and reasonable.

The purpose of the cumulative limit is to prevent a receiver with an existing high noise level from remaining well above the criterion if the noise level did not increase significantly relative to the 'no-build' year. This meets the intention of the RNP where criteria have no allowance for high existing noise levels and still provides for a feasible and reasonable approach. Refer Appendix A for an example of a new and redeveloped road with a transition zone.

The cumulative limit does not apply if most of the noise causing the cumulative limit to be exceeded comes from a road that is not assessed as part of the project. This is defined as where the contribution from the road project at the affected facade adds less than 2.0dBA to the total noise level in the build year. Instead consideration should be given to whether the noise levels are acute at the receiver.

A receiver with noise levels at or above 65dBA $L_{Aeq(15hour)}$ day or 60dBA $L_{Aeq(9hour)}$ night may be referred to as acute. If the contribution from the road project is acute then the receiver qualifies for consideration of noise mitigation. The objective is to reduce noise levels to the RNCG criteria, subject to feasible and reasonable considerations.

Note, typically, for a given redevelopment project, the numbers of residential receivers that are triggered for consideration of treatment under the cumulative noise and acute noise categories are generally similar, but not necessarily the same.

5.2 New roads, redeveloped roads, transitways and transit zones

Where the total noise level for the build year exceeds the controlling criterion established using the RNCG, and there is an increase of more than 2.0dBA (i.e. 2.1dBA or greater), relative to the no-build year, then a receiver qualifies for consideration of noise mitigation. This includes the situation where the no-build noise level is marginally below the criterion value.

A receiver may also qualify for consideration of noise mitigation where the RNCG criterion is exceeded with the project and the noise increase from the project is less than 2.0dBA. This may occur where there is potential for a noise reduction from the upgraded design moving traffic further away from receivers and this is not realised because of the introduction of a noisier pavement than the existing road surface. The two specific examples to be considered where road design may provide noise reduction benefits are shown in Figure 5-2 and Figure 5-3.

In the situations in Figure 5-2 and Figure 5-3, a receiver qualifies for consideration of noise mitigation where the total noise level for the 'build' year exceeds the criterion and there is an increase of more than 1.0dBA (i.e., 1.1dBA or greater) relative to the 'no-build' year. This meets the intention in the RNP which places greater emphasis on reducing noise levels during corridor planning and road design.

Mitigation should also be considered when the mitigation measures are relatively inexpensive. For example, a minor adjustment to the length of barriers or to a length of pavement treatment that has already planned may improve equity at receivers adjacent to qualifying receivers. Another example is the use of small Jersey barriers that are relatively inexpensive to install.

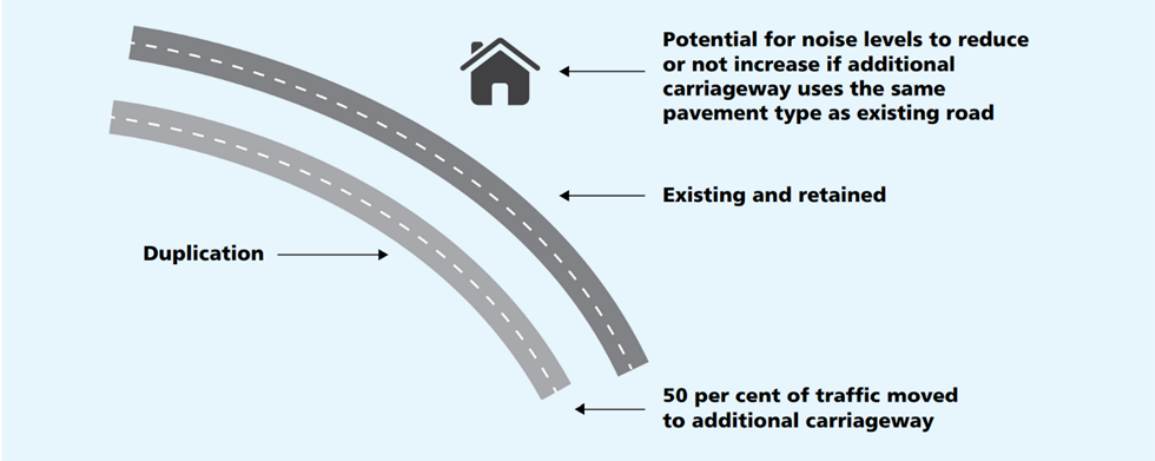


Figure 5-2: Duplication with additional carriageway further away from receivers

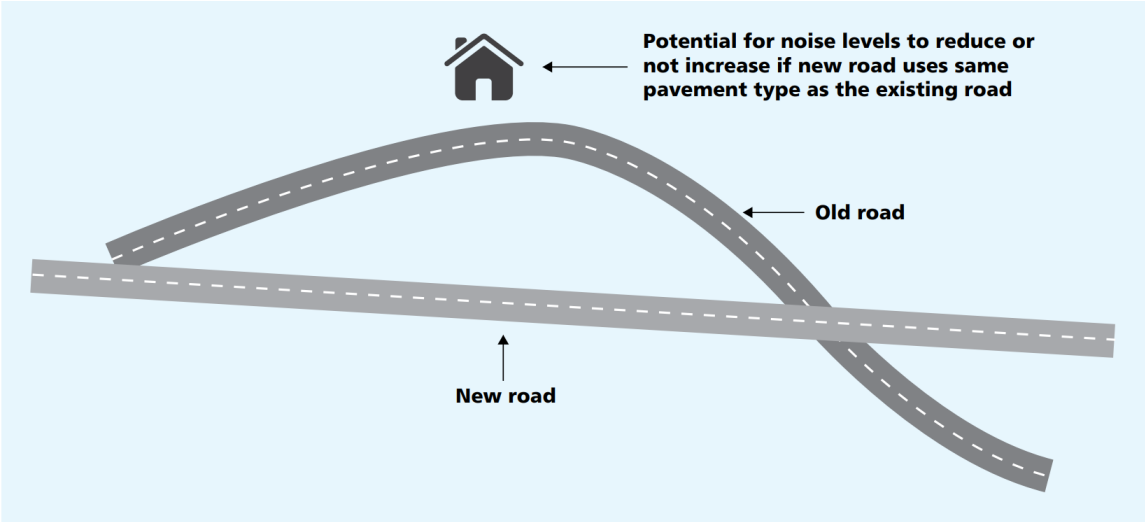


Figure 5-3: New road further away from receiver

5.3 Minor works

For minor works, Transport applies the criteria from the RNCG if noise levels increase by more than 2.0dBA at the worst affected receiver.

When this is demonstrated, all sensitive receivers must be assessed where the noise levels exceed the controlling criterion within the minor works study area (RNCG). Where the total noise level for the build year on project opening exceeds the criterion and there is an increase of more than 2.0dBA (i.e. 2.1dBA), relative to the no-build year on project opening, then the receiver qualifies for consideration of noise mitigation. This includes the situation where the initial no-build noise level is marginally below the criterion value(s).

5.4 Noise abatement program

If a receiver has been identified as being acute under the NAP then it qualifies for consideration of noise mitigation under the procedures in Section 6 and 7 of this document and in accordance with the NAP.

6. Identify the noise mitigation measures

For receivers that qualify for consideration of additional noise mitigation measures, identify potential noise mitigation measures from the list below. Options for noise mitigation measures are listed below in the order of preference for application given in the RNP:

1. Quieter pavement surfaces
2. Noise mounds
3. Noise walls
4. At-property treatments.

Community views should be considered when evaluating and selecting noise treatments as should the wider community benefits arising from noise mitigation of the proposed road or road redevelopment. Community views may be identified through a range of community engagement activities including visits to individual affected receivers.

For it to be considered reasonable to provide quieter pavement surfaces, noise mounds and noise walls there needs to be four or more closely spaced receivers that benefit. Where there are four or more closely spaced receivers the specific combination of noise mitigation measures is subject to further evaluation.

The catchment of receivers triggered (refer to Definition in Section 8) for consideration of noise mitigation measures should be established using the initial baseline pavement surface proposed by the project. This is undertaken prior to consideration of in-corridor noise mitigation treatments such as quieter pavement surfaces and noise barriers. These same receivers are then held through the mitigation and barrier optimisation process until the RNCG noise criteria applicable at the affected properties are achieved. Where this is not feasible or reasonable and there are residual impacts after the noise barrier optimisation process, then residual impacts are addressed by way of at-property treatments. This is consistent with the RNP's preferred hierarchy of treatment starting within the road corridor.

In summary, during the detailed design phase, unless the proposed pavement type has changed to a quieter pavement for reasons other than noise mitigation (i.e. for reasons of safety, maintenance, etc), then the catchment of receivers for consideration of additional noise mitigation should be based on the same pavement surface assumed in the relevant environmental assessment for the project.

6.1 Quieter pavement

Where feasible and reasonable, a quieter pavement surface (refer Section 8, Definitions) is the preferred form of noise mitigation as it reduces source noise levels. This provides protection to both outside recreational areas and internal noise levels and has the least visual impact.

For traffic generally, road tyre noise appears to dominate at around 70 km/h. This means that in areas with posted speeds of 70 km/h or more, the reduction of road tyre noise can be a useful noise reduction treatment.

A quieter pavement surface should be considered where there are groups of four or more receivers that exceed the criteria and before the use of noise barriers.

It is noted that the noise reduction provided by quieter pavements is generally in the order of a few dBA, therefore, other noise mitigation measures such as noise barriers and at-property treatments need to be considered where exceedances are relatively large.

6.2 Noise barriers

6.2.1 Noise mounds and noise walls

A noise mound or noise wall provides similar benefits to those provided by a quieter pavement surface in terms of reducing both external and internal levels of noise. It is noted that the potential noise reduction that can be provided by a noise barrier is however much higher (up to around 15dBA-18dBA in real world terms)

than that provided by a quieter pavement (typically less than 3dBA and generally not exceeding approximately 5dBA at best).

In terms of visual impact, a noise wall has a higher visual impact than a quieter pavement or noise mound under most situations. However, a noise wall is often more feasible than a mound as the site footprint can be much smaller.

Often barriers comprise a mound with a wall on top. Combinations with both mounds and walls may be visually more appealing than a wall alone and cost less than a wall of equivalent total height. A detailed guideline on how to identify noise barrier height is described in Section 7.

Noise barriers should be considered where there are four or more closely-spaced receivers.

6.2.2 Projects with existing noise barriers

The benefit provided by existing noise barriers (walls and mounds) must be taken into account when determining if a residence qualifies for consideration of treatment. Where road widening has expanded over the existing noise barrier footprint then the top of barrier height should be moved to an adjacent and suitable new barrier location as part of the build scenario.

If four or more closely spaced noise sensitive receivers behind the existing noise barrier trigger (refer to Definition in Section 8) for consideration of noise mitigation treatment, then noise barrier design as per Section 7, should be completed assuming that the existing barrier does not exist.

If, however, the existing noise barrier is long and the four or more triggered receivers behind the existing noise barrier are clustered in a specific area, then a review of a smaller section of the overall noise barrier may be reasonable and justifiable. Where this is the case, then subject to feasibility considerations, the length of this smaller section of the barrier to be assessed should be such that any flanking noise from around the fixed sections of existing noise barrier at each end should not control the noise levels at any of the initial triggered receivers behind the existing noise barrier. This would otherwise compromise the acoustic performance of the section of noise barrier being reviewed and optimised. Accordingly, the objective should be that the length of the assessed section of barrier should obstruct the view of the receiver to the road by an angle of at least 160 degrees (refer Noise wall design guideline), where feasible. Another way to put this is that the angle subtended from any outermost receiver behind the barrier to the nearest barrier end should be at least 80 degrees, when measured from the perpendicular line extending from the receiver to the road. This approximately equates to the noise barrier extending past any outermost receiver at least 4 times the distance of that receiver to the road. This is similar to the process that would be undertaken if this section of noise barrier were being designed and optimised in isolation, i.e. without the fixed sections at either end (refer Section 7.1).

Where receivers qualify for consideration of treatment, the aim is to conduct a full barrier design assessment with height ranges between 0 metre and the maximum height, assuming that the existing barrier does not exist. From an initial barrier optimisation perspective, this avoids situations where consideration is only given to incremental benefits from extending the height of the existing barrier. Please note that where it is required to review the adequacy of the acoustic performance of existing noise barriers, at-property treatments are only considered reasonable to implement where there are **residual exceedances of the relevant RNCG criteria** at the initially triggered properties behind the existing noise barrier. Refer to Definitions as per Section 8.

If the outcome of the assessment is a barrier height greater than the existing barrier then the additional noise reduction provided needs to be evaluated. If the barrier has been relocated due to widening, then the higher barrier should be recommended. Otherwise, where the additional noise reduction is greater than 2.0dBA then an increase in barrier height may be considered reasonable as it achieves a noticeable reduction in noise level.

Any replacement or augmented barrier must as a minimum provide the same noise reduction for L_{Aeq} and L_{Amax} noise sources as the existing barrier.

Where higher barriers are identified as feasible and reasonable then supplementing the existing barrier heights should be examined and considered before the removal and replacement of the existing barriers. Issues such as wind loading, suitability of footings and visual aspects are important considerations to the possibility of supplementing existing barriers. Reuse and recycling of existing material is encouraged.

6.3 At property treatment in place of barriers

At-property noise mitigation measures such as facade treatments and localised screens may replace at-road mitigation, subject to a reasonable and feasible assessment, only in the following circumstances:

- Isolated single residences or isolated groups of closely spaced residences.
- Where the affected community expresses a preference for at-property treatment and the cost is less than a combination of a barrier and at-property treatment.
- Where noise barriers cannot achieve the level of noise mitigation (insertion loss) required.
- Where the only applicable noise criteria are internal (e.g. places of worship, hospitals or schools and child care facilities where play areas meet external criteria).
- Where other noise mitigation measures have been shown not to be feasible or reasonable.

These treatments are generally limited to acoustic treatment of the building elements and the installation of acoustic screens close to the receiver where they also protect outdoor living spaces.

The RNCG external noise level targets are the initial design guide for the level of noise reduction by external screen walls.

Building element treatments are more effective when they are applied to masonry structures than lightly clad timber frame structures. Caution should be exercised before providing treatments for buildings in a poor state of repair, as they may be less effective in these cases and may not provide any appreciable noise reduction benefit. As such, treatment would not be cost-effective and therefore not reasonable to implement. The acoustic treatments provided by Transport are outlined in the At-Receiver Road Noise Treatment Guideline and are limited to the following where feasible and reasonable:

- The installation of courtyard screens.
- Fresh air ventilation systems that facilitates windows and doors to be shut by the occupant while providing ventilation (Note: where adverse climate conditions prevail, air conditioning that includes fresh air intake may also be considered).
- Upgraded windows and glazing and solid core doors on the exposed facades of substantial structures only (e.g., masonry or insulated weather board cladding with sealed underfloor). These techniques would be unlikely to produce any noticeable benefit for light frame structures with no acoustic insulation in the walls.
- Upgrading window and door seals and appropriately treating sub-floor ventilation.
- The sealing of wall vents.
- The sealing of the underfloor below the bearers.
- The sealing of eaves.

Upgraded windows and doors must have a minimum sound reduction index (Rw) of 30 based on the performance of the entire door or window set. Higher performance may be required in some instances and consideration given to traffic spectrum corrections to the sound reduction index.

In most cases $30,000, is the limit of funding per residence currently provided by Transport for courtyard screen walls and/or building treatments for individual dwellings.

Additional funding may be provided but only where exceptional site-specific circumstances exist to justify a variation.

Where a property is in a significant state of disrepair such that at-property noise treatment packages provided by Transport cannot be acoustically effective, then it is not reasonable for Transport to provide treatment. This would represent poor use of funding for little or no acoustic benefit. It would be the owner's responsibility to address the initial state of disrepair to be eligible to be considered for treatment.

Due care must be taken in the design and selection of acoustic treatments for which funding is provided. In particular, gaps around window and door frames must be properly sealed to prevent significant degradation in performance of doors and windows. Accordingly, any post treatment assessment is limited to ensuring that the construction meets relevant building standards and industry best practices. It is recommended that inspection of the installation occur before the fitting of architraves or weather strips to ensure adequate sealing. Photographs of the installation before the fitting of architraves or weather strips are required. No post-treatment noise monitoring of internal noise levels is done. Financial compensation is not provided in lieu of treatments.

6.4 At property treatment at non-residential, noise sensitive receivers

In support of the EPA's RNP, Transport's RNCG identifies noise criteria for noise sensitive receivers. For residential noise sensitive receivers, noise criteria are externally based in order to also consider the external acoustic amenity. In the case of several nominated non-residential noise sensitive receivers however, noise criteria are internally based, therefore some assessment of noise intrusion is required.

Table 6-1 outlines indicative external to internal noise reductions for various construction types. The table demonstrates the range of noise reductions that may occur for different types of building construction.

Table 6-1: Indicative building noise reduction (adapted from FHWA 1995)

Building type	Window	Internal noise reduction
All	Open	10 dBA
Light frame	Single glazed, closed	20 dBA
Masonry	Single glazed, closed	25 dBA
Masonry	Double glazed, closed	35 dBA

During the early environmental assessment phases of a project, it is generally not practicable to determine the acoustic performance of the building façade to assess internal noise levels. Accordingly, an indicative screening assessment is undertaken in the early phases of assessment with the intent of confirming the need and extent of feasible and reasonable noise mitigation treatment during the detailed design phase of the project. This would likely comprise an inspection of the facility and field assessment of the representative noise reduction performance of the building to external traffic noise intrusion.

In some cases, the design of the development may incorporate fixed, unopenable glazing, with alternative ventilation provisions. This may be for various reasons, including as a means of addressing high levels of external noise (road traffic, rail traffic, aircraft or industrial noise sources). In this circumstance, no fresh air ventilation would be provided as part of the mitigation package.

Transport targets consideration of noise mitigation treatment to the most sensitive spaces within non-residential noise sensitive receivers, where feasible and reasonable. Specifically, these are internal teaching/study areas in educational facilities such as schools, hospital wards and internal prayer areas within buildings designed and constructed for worship, such as church, synagogue or mosque.

6.5 Noise abatement program

The NAP implements noise mitigation measures at noise sensitive receivers adjacent to Transport roads, where road noise levels have been identified as being acute and where there are no road projects adjacent to the residence proposed in the short term that will influence noise levels.

In the absence of a road project, noise mitigation is generally limited to what is feasible within the constraints of the existing road corridor (no additional land acquisition). This generally includes:

- Noise barriers.

- At-property treatments (within nominated habitable/sensitive spaces).

Heights of noise barriers are identified using Section 7 in the same way as for road projects.

Feasible and reasonable noise barrier construction under the NAP is more constrained than for noise mitigation measures provided during road projects. Additional feasible and reasonable considerations include:

- Local government planning objectives.
- Cost of relocating services already within the existing road corridor such as gas, electricity, communications, water and sewerage.

7. Assessment of barrier height

7.1 Overview

The process in this section is to be used to design noise barriers for receivers that have been identified as qualifying for consideration of noise mitigation under Section 7. The process aims to meet the following policy principles during barrier design:

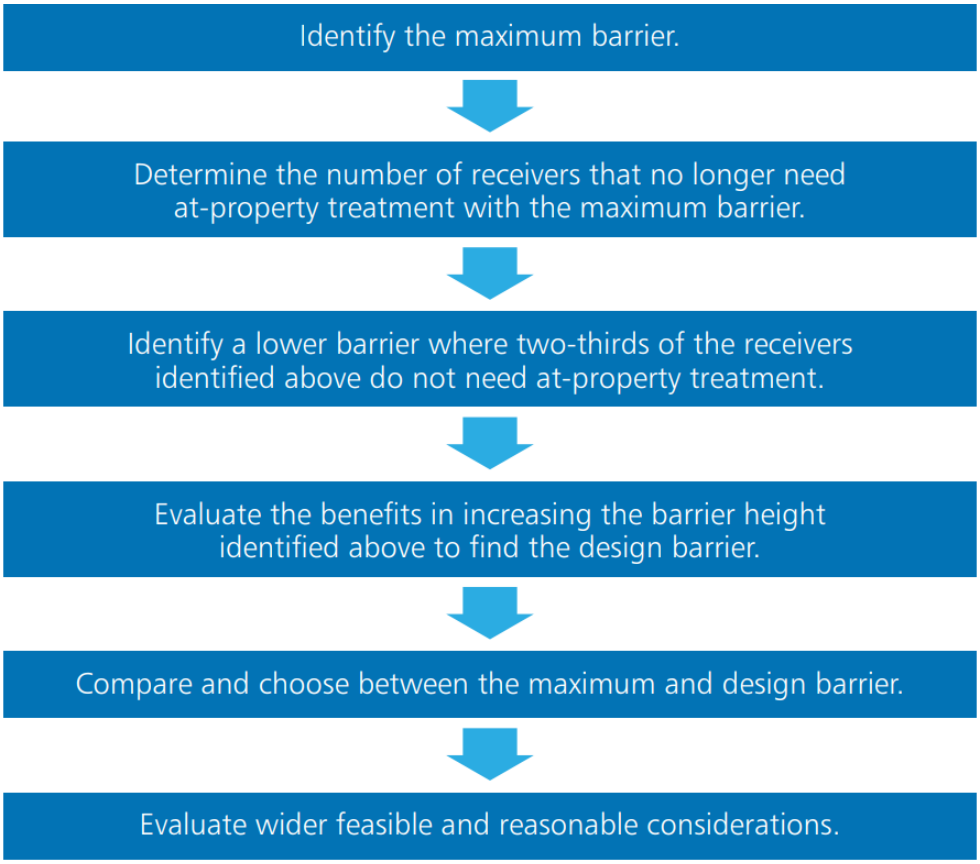
1. Communities should receive reasonable and equitable outcomes.
2. Noise mitigation should be designed to reduce noise levels to the criteria.
3. Incidental benefits from the noise mitigation designed for qualifying receivers should be recognised at all receivers within a community where noise levels exceed WHO guidelines[1].

Noise barrier evaluation processes must:

4. Give preference to reducing outdoor noise levels and the number of at-property treatments.
5. Provide efficient barrier heights and extents without disregarding lengths of effective noise barrier in front of eligible groups of receivers.
6. Noise mitigation shall be evaluated and installed where feasible and reasonable.

Note[1]: World Health Organisation (WHO) Guidelines for Community Noise (1999) for outdoor areas and the WHO Night Noise Guidelines for Europe (2009) threshold levels.

Figure 7-1: Overall barrier design process



Noise barrier designs can vary in height along the barrier length, subject to urban design and community views. However, if a barrier is to vary in height along its length it must be demonstrated that it achieves a better noise outcome for the community than a constant height noise barrier.

Before assessing barrier height, the location of the barrier should be reviewed to ensure it provides the best opportunity to use the topography and road geometry to maximise shielding. Consideration should also be given to future road widening and maintenance access. For example, where additional lanes are planned at a future date to accommodate traffic growth then the location of the noise barrier and the size of footings should be made to allow the noise barrier to be added to in the future where this is likely to be more cost effective than replacing the barrier with a new one when additional lanes are added.

Please note that noise barrier siting and design should be consistent with the Noise wall design guideline and QA Specification R271 - Design and Construction of Noise Walls. This includes the recommended minimum 160 degrees subtended angle of view (refer to the Noise wall design guideline) from any receiver behind the noise barrier to the road, to ensure that acoustic flanking around the ends of the noise barrier will not compromise the optimum height and therefore acoustic performance of the noise barrier. Put another way, the angle subtended from any outermost receiver behind the barrier to the nearest barrier end should be at least 80 degrees, when measured from the perpendicular line from the receiver to the roadway. This approximately equates to the noise barrier extending past any outermost receiver at least 4 times the distance of that receiver to the road. It should be noted that the angle of view will impact on the overall length of the noise barrier and therefore may be subject to feasibility constraints. It should be reviewed initially near the start of the barrier optimisation process, to establish the noise barrier length and footprint prior to barrier height optimisation.

7.2 Maximum barrier height

The **maximum barrier height** provides the ideal outcome in which relevant RNCG noise criteria are met at all receivers. However, other factors need to be considered before a final barrier height can be identified such as, impact on visual amenity, shading of properties, engineering constraints and available resources. Additionally, barrier heights above eight metres will not be considered.

Sometimes it will not be feasible to meet the noise criteria with a noise barrier at all receivers because the length of the barrier cannot be increased or because of road traffic noise from other roads coming from different directions. In this situation the maximum barrier height is the height that will result in the lowest noise level that can be feasibly achieved, taking account of limitations to barrier length or traffic noise from other roads which are not part of the proposed road project.

No further investigation of barrier height and at-property treatment is necessary where it is considered reasonable to construct a maximum barrier with acceptable visual impact and where community views have been taken into consideration. However, it may also be reasonable to investigate the benefits from a combination of barrier height and at-property treatment. This process is described below.

Note, if the maximum barrier height is assessed as needing to be greater than eight metres then use a height of eight metres for the maximum barrier height when evaluating combinations of barrier height and at-property treatment. Analysis must also ensure that the maximum barrier height is not greater than eight metres due to limitations in barrier length or traffic noise from other roads.

During the assessment and design process, there may be limitations to the barrier height identified, for example due to urban design or constructability constraints. In this situation, the maximum height complying with these constraints would then dictate the maximum allowable barrier height.

7.3 Combination of noise barrier and at-property treatment

A combination of noise barrier and at-property treatment can provide the most reasonable overall noise reduction for an affected community when consideration is given to cost, urban design, shadowing and engineering constraints with the maximum barrier. The process of deriving the most effective combination of noise barrier height and at-property treatment considers:

- The additional benefit of noise barriers in reducing external noise levels.
- Noise reductions that occur to the broader community beyond only those receivers affected by traffic noise above the RNCG noise criteria.

The preference for reducing outdoor noise levels is achieved by the relative point weighting given to barriers compared to at-property treatments. Benefits to the broader community are accounted for by including any residences that receive noise reductions of more than 2dBA (benefiting residence) from the presence of the noise barrier.

The process starts by incrementally reducing the height or area of the maximum barrier and identifying how this influences noise levels across the community behind the barrier as a whole.

To account for incidental benefits to the broader community noise reductions are counted at all benefiting residences until the noise levels are reduced to the lower of 50dBA daytime and 45dBA night time[1].

Exceptions to these lower limits are where:

- It can be demonstrated that noise levels from other traffic sources that are not being assessed as part of the road project are greater than 50dBA daytime or 45dBA night time[1].
- Under this situation the noise level from other traffic sources becomes the lower limit where benefits are assessed.
- The relative increase criteria from the RNCG is more stringent. Under this situation the relative increase criteria becomes the lower limit for where benefits are assessed.

7.4 How to identify the design barrier height

The noise barrier design should be undertaken for the day or night period, whichever represents the greatest exceedance of the relevant design criteria.

The **design barrier** is the final barrier height that is proposed with or without at-property treatment to give the most reasonable noise benefits after the barrier optimisation process. The **initial design barrier height** may be described as the identified height at which two thirds of affected receivers that could meet the criteria with the maximum barrier relative to the no barrier scenario, no longer need at-property treatment. This sets the initial design barrier height, which also represents the minimum design barrier height. The process to obtain the initial noise barrier height is fully outlined in Step 2 below. A value of two-thirds is utilised to determine the initial barrier height as further increases in height typically have diminishing benefits per increase in height increment. This is investigated further in the next step for the remaining one third of receivers. Weightings are then applied which consider cost and the benefits the barrier provides to the wider community. A low point in the weighting curve between the maximum barrier and in the initial design barrier height corresponds to the most reasonable barrier height.

The steps to identify the design barrier height are:

1. Identify and plot the number of receivers (up to two for a two-storey building[1]) that would be eligible for consideration for at-property treatment at each height increment (usually 0.5 metre or 0.6 metre) of noise barrier. Start at the maximum barrier height and reduce to 0 metre (Figure 7-2). Note that for a stepped noise barrier, the average height may be used. Receiver floors that are classified as eligible for at-property treatment consideration during the barrier optimisation process are limited to those that initially trigger with a 0 metre height barrier and then where there are continuing residual exceedances of the RNCG criterion at each increment of barrier height above 0 metre. The initial noise level triggers prior to the noise barrier (i.e. zero metre height barrier) are where:
   - The RNCG criteria are exceeded and the build vs no build increase is more than 2dBA (or 1dBA if appropriate for receiver),
   - The cumulative limit (where noise from the project road is significant, refer Section 5.1) is exceeded.
   - The contribution from the road project equals or exceeds the acute limit.
   - The RIC is exceeded.
2. Identify the number of receivers at the maximum barrier height for which there are still residual exceedances of the relevant RNCG noise criteria. These would therefore still be eligible for consideration of at-property treatment. Subtract this number from the number of “triggered” receivers in Step 1 (with zero height barrier), also eligible for at-property treatment. This identifies the maximum number of receivers, that could meet noise criteria using only a noise barrier, that being the maximum height barrier.
   - Of this maximum number of receivers, identify the corresponding barrier height where two thirds could meet the noise criteria, therefore not requiring at-property treatments. Subject to further feasible and reasonable considerations this is the initial design barrier height, which also represents the minimum design barrier height.
3. At each incremented barrier height, calculate the total points[1] for the following:
   - The corresponding barrier area (height x length).
   - The number of at-property treatments (i.e. where there are residual exceedances of the relevant noise criteria from the initial catchment of triggered receivers determined without a barrier).
   - Exceedances of 50dBA day or 45dBA night.

   For reasons including reasonableness, consistency and repeatability, only include **benefiting receivers** (refer Section 8, Definitions) behind the barrier. This is defined as those receivers where a 2.1dBA or higher noise reduction is achieved at maximum barrier height compared to the zero height barrier scenario. The points are:
   - 1 point per square metre of wall or vertical cross section for mounds (outdoor noise reduction).

- 40 points for each at-property treatment where criteria are exceeded by less than 10dBA (internal noise reduction only).
- 120 points for each at-property treatment where criteria are exceeded by greater than or equal to 10dBA (internal noise reduction only).
- 4 points per dBA exceedance of 50 dBA[2] day or 45 dBA[2] night at each residence behind the barrier (note that where the barrier does not provide at least 2dBA of noise reduction then the number of points is the same as without the barrier).

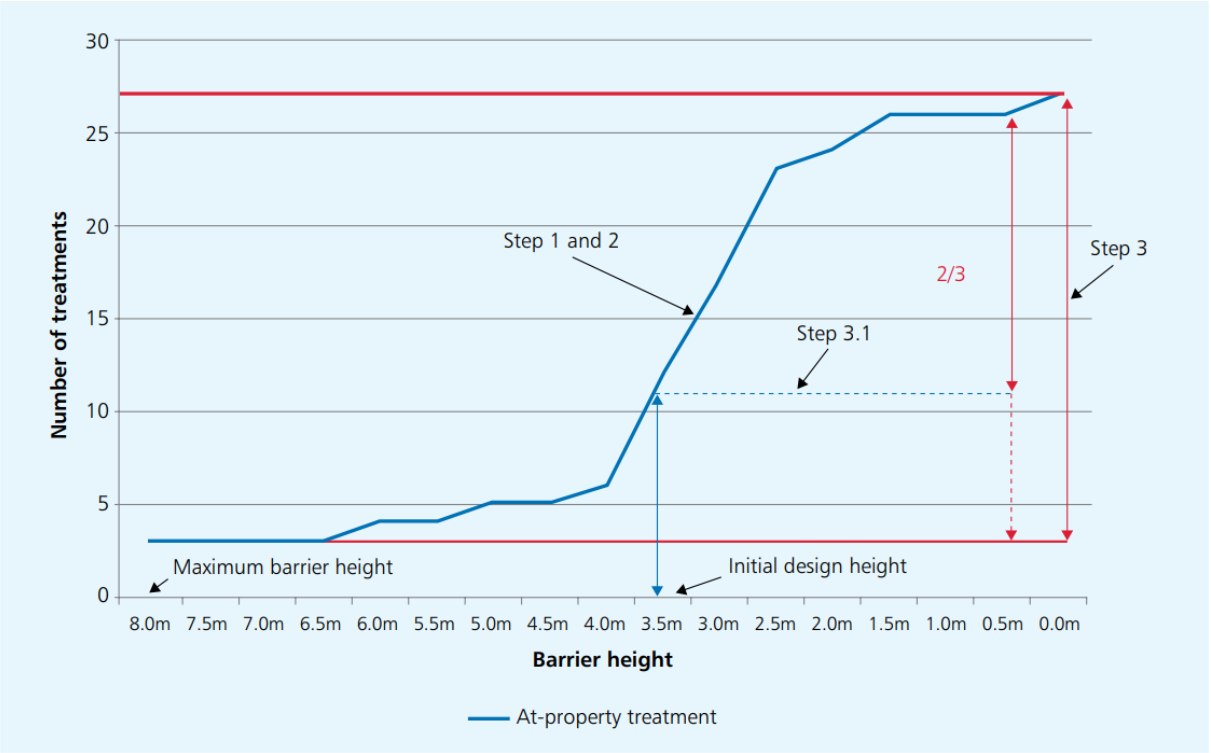
4. Plot the total number of points for each barrier height (Figure 7-3) increment.
5. Dips in the points curve highlight designs with potentially higher overall community benefit and reduced weighted cost. Identify the barrier height with the lowest total points between the maximum barrier height and the initial design barrier height from 2 above. Subject to further feasible and reasonable considerations this is the design barrier height (Figure 7-3).

Examples of these steps are shown in Figures 7-2 and 7-3 using total height for a barrier with constant height along its length. Detailed examples including calculation and plotting of points may be found in Appendix B.

Note[1]: Points are calculated at the first two floors of a receiver only. The calculation point is fixed throughout the entire assessment at the worst affected facade of each floor when the barrier is zero metres in height.

Note[2]: Facade noise levels of 50 dBA day and 45 dBA night are considered representative of the World Health Organisation (WHO) Guidelines for Community Noise (1999) for outdoor areas and the WHO Night Noise Guidelines for Europe (2009) threshold levels.

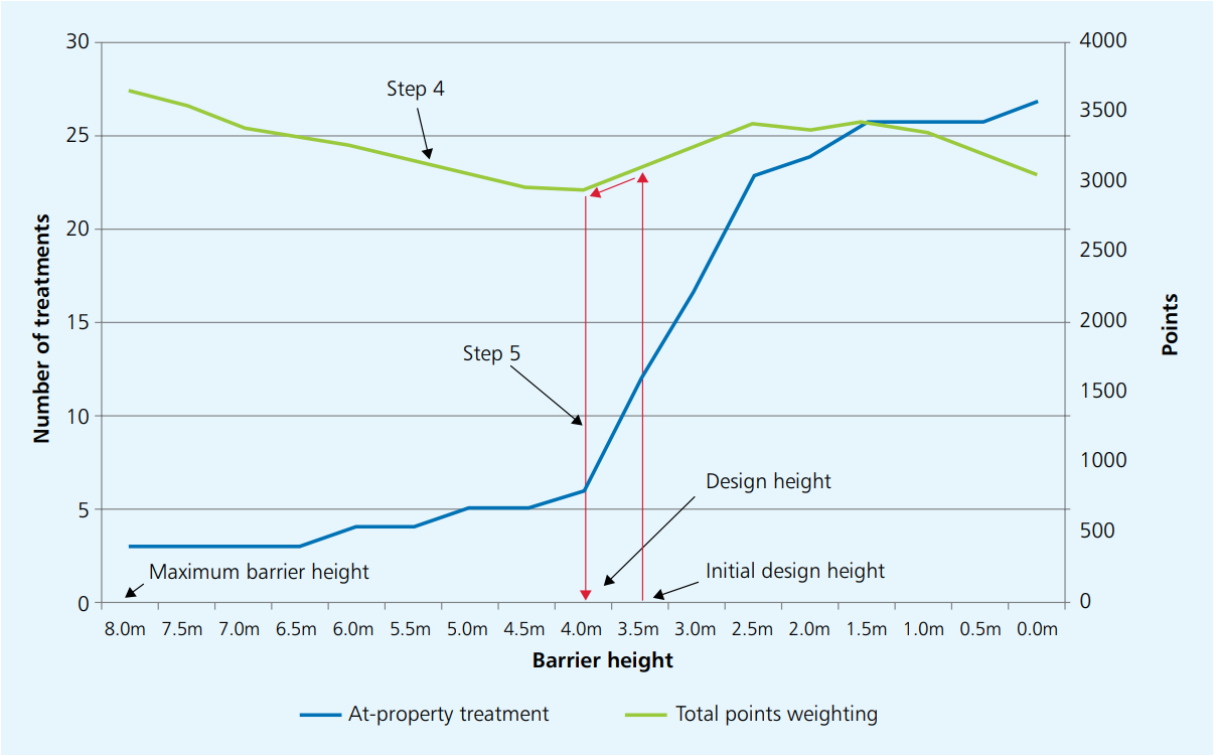
Figure 7-2: Initial design barrier height



For Step 3: There are 27 receivers that qualify for consideration of noise mitigation for a wall height of 0 metres. 27 minus the 3 receivers remaining at the maximum barrier height = 24 additional receivers that could potentially meet the noise criteria with the maximum barrier height of 8.0 metres.

For Step 3.1: Two thirds of 24 is 16.27 minus 16 = 11 receivers. The wall height where 11 receivers still require at-property treatment is 3.5 metres. The initial design barrier has a height of 3.5 metres.

Figure 7-3: Design barrier height from points weighting curve



For Step 5: The initial design barrier height is 3.5 metres. There is a low point at 4.0 metres in the total weighting curve between the initial design height and the maximum barrier height. The design barrier height in this case is therefore 4.0 metres.

7.5 Notes on optimisation

Advanced optimisation processes including the use of software may be helpful when designing barriers with varying height along their length and reduce the need for breaking the corridor up into arbitrary adjacent noise catchments. This may produce a number of different design options that may be plotted against height and the number of points.

Before recommending noise barriers that vary in height in front of a group of receivers, or between groups of receivers, consultation will be required with urban design and the wider project team.

Note however that care should be taken to avoid situations where the software provides less than ideal outcomes at some receivers. An example would be where a low-density area of housing lies between two high density areas of housing. It is possible that an optimisation process may give a barrier height of 0 metres to the low-density area and assign all barrier material to the high-density areas. This may not align with the barrier height assigned if the low-density area was assessed separately. Thus, barrier optimisations that result in parts of a barrier being assigned a height of 0 metres must be rejected and closer analysis undertaken.

7.6 Selecting the design barrier height or maximum barrier design

If the maximum barrier design has a height of less than eight metres apply the following process to identify the preferred barrier height.

Where the difference in life cycle cost is not significant (i.e., cost for the maximum barrier is within 125 percent of the design barrier cost) the maximum barrier design is preferred if it gives a noise reduction of at least 2.0dBA above the design barrier. Otherwise, the design barrier is to be preferred.

Life cycle costs should as a minimum consider:

- Combinations of a noise wall and mound or mounds instead of noise walls.
- Cost effective use of excess or additionally won project fill and temporary stockpiles.
- Maintenance.
- Provision for height augmentation if future road upgrades are considered likely.
- Provide a detailed breakdown of the costs.

7.7 Consideration of community views

Sometimes an outcome of community consultation is that the community deems the preferred noise barrier height to be too high. In deciding the height of the noise barrier consideration should be given to:

- Community views and wishes. These are typically gathered at a number of stages including route selection, following concept design, the period of community consultation following the noise assessment and post opening in the operational noise report.
- Visual impacts for the community surrounding the road project and for road users. These are typically identified in the Environmental Impact Assessment.

When considering community views reference should be made to the Transport for NSW Stakeholder Engagement Manual which details the Transport for NSW policies on effective communication and engagement and provides guidance on how this can be achieved.

7.8 Barrier design aesthetic impacts

It is important that noise barrier design recognises the character of the road corridor, its environment and the views to and from the road. These issues are addressed in the Noise wall design guideline.

Some care needs to be exercised in the process of barrier design in respect of added costs. In particular, aesthetic requirements from the noise affected community, such as requests for transparent barriers should be separated from aesthetic requirements applied by Transport for NSW to improve the experience of road users. This is to allow the cost of noise mitigation measures assigned to the community impacted by road traffic to be identified separately from the cost of aesthetics for road users. Both of these are important aspects of providing noise barriers, however in terms of identifying the cost of noise mitigation only the aesthetic requirements that derive from the noise affected community are to be included. If this is not done there is a risk that the cost of noise barriers may be increased to improve aesthetics for road users to an extent that they are not economic.

Local councils and projects may also have planning guidelines relating to visual amenity and urban design.

7.9 Consider further if the barrier is feasible and reasonable

7.9.1 Noise barrier benefit

As a guide noise walls or mounds are considered to be a reasonable noise mitigation option where they are capable of providing an insertion loss of:

- 5dBA at representative receivers for heights up to five metres high.
- 10dBA at representative receivers for heights above five metres and up to eight metres high.

Where a location exceeds the noise criteria by less than 5dBA this can lead to designing to achieve an insertion loss of less than 5dBA. Under these circumstances where two thirds of the residences no longer require at-property treatment a noise barrier would not be abandoned because it did not provide 5dBA insertion loss.

Where noise barriers greater than five metres do not provide 10dBA of noise reduction additional consideration needs to be given to the number of receivers that benefit, any unusual topography and whether

the barrier placement could be improved. If it is not reasonable to provide a barrier with height above five metres, then lower heights should be considered.

These insertion loss requirements are applicable to noise reduction provided by the full barrier height and should not be used to discount incremental changes in height to existing noise barriers.

7.9.2 Additional feasible and reasonable consideration for barriers

Consideration also needs to be given to engineering considerations (what can be practically built) about noise walls and mounds. These engineering considerations may include:

- Safety issues such as restrictions on road vision.
- Road corridor site constraints such as space limitations.
- Floodway and stormwater flow obstruction.
- Access requirements for maintenance.
- Maintenance requirements including ongoing costs.
- Wind loading and ground conditions.
- Shadowing.
- Driveway access from residences to the noisy road.

Where issues of feasibility are identified that would prevent installation of a noise mitigation measure that had been identified for consideration, it is important to provide a well-supported and objective case to support the feasibility issues cited.

Expert opinion in each particular area is helpful and for contentious locations the views of an independent expert are highly recommended. Quantitative information such as wind loading calculations, diagrams of site access, soil conditions, etc. are needed to provide an objective basis.

If there is insufficient detail available at this point to present a quantified and definitive case, then the issues and extent of information known should be presented together with a clear commitment to provide the missing information once the detailed design of the project is known.

It should also be clearly stated that it will only be at that stage (i.e., post detailed design) that a decision on what noise mitigation measures can be applied can be made.

The consideration of what is reasonable typically means looking at cost and equity considerations. There is no set monetary limit for noise mitigation provided for a road project however, there are some guiding principles to gauge whether costs are reasonable and equitable, and the following points should be considered:

- Cost of mitigation measure.
- Total cost of noise mitigation for the project.
- Cost of mitigation measure and total cost of noise mitigation measures as percentages of total project cost.
- Whether comparable noise mitigation measures have been provided at other locations in the project or for other similar projects and surrounding network.

Use this and other salient information that may be available to guide considerations as to whether the mitigation measure is reasonable or not.

Where feasible and reasonable considerations rule out the design barrier height then an alternative barrier height should be considered. The underlying principle in this document is to give preference to at-road noise mitigation measures over at-property measures. Except where isolated groups of dwellings occur in close groupings of three or less, there is no provision to select at-property noise mitigation measures over at-road noise mitigation measures based solely on cost.

8. Definitions

Term	Definition
A–frequency weighting	A frequency-based adjustment made to sound level measurement, by means of an electronic filter, in line with international standards. This approximates the frequency response of the human ear and accounts for reduced sensitivity at low frequency.
Acute noise level	A level of road traffic noise of 65 dBA or more for the day period of 7am to 10pm or 60 dBA or more for the night period of 10pm to 7am and measured as an equivalent continuous noise level (L_{Aeq}) 1 metre from the building facade.
At-property treatments	Includes building treatments and courtyard walls. Building treatments may include but are not limited to ventilation, glazing, window and door seals, sealing of vents and underfloor areas.
Benefitting receiver (noise barrier optimisation)	Receiver where there is a 2.1dBA or higher noise reduction when the noise barrier is at maximum height (refer to corresponding definition), as part of the barrier optimisation process
Build and No Build project options	Build option – assumes the project proceeds No Build option – assumes the project does not proceed
Closely spaced group of residences	Residences are generally considered closely spaced where the facades are separated by less than 20 metres.
Controlling criterion	Whichever of the day or night time L_{Aeq} criteria (Road Noise Criteria Guideline) is exceeded by the greatest amount.
Cumulative limit	A total noise level that is 5 dBA or more above the Transport for NSW Road Noise Criteria Guideline criteria in the build year. See Section 7.1 for further clarification.
Decibel (dB)	A measure of sound level. The decibel is a logarithmic way of describing a ratio. The ratio may be power, sound pressure, voltage, intensity or other parameters. In the case of sound pressure, it is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure squared to a reference sound pressure squared.
Decibel (A-weighted; dBA)	Unit used to measure 'A-weighted' sound pressure levels. A-weighting is a frequency-based adjustment made to sound-level measurement to approximate the response of the human ear.
Design barrier	The design barrier is the barrier height that is used with or without at-property treatment to give the most reasonable noise benefits following the barrier optimisation process. See Section 7.4.
Design year	Typically, 10 years after project opening (refer to EPA's NSW Road Noise Policy)
Equitable	Receivers and communities exposed to road project noise receive consistent outcomes.
Feasibility	Relates to engineering considerations (what can be practically built). These engineering considerations may include: • The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources • Safety issues such as restrictions on road vision • Road corridor site constraints such as space limitations • Floodway and stormwater flow obstruction • Access requirements • Maintenance requirements The suitability of building conditions for at-property treatments.
Frequency	The number of times that a vibration or periodic function occurs or repeats itself in one second, measured in Hertz (Hz).

Initial barrier height	The identified barrier height at which two thirds of affected receivers that could meet the criteria at the maximum height barrier, relative to the no barrier scenario, no longer need at-property treatment. This also represents the minimum design barrier height. Refer to Section 7,4, Step 2 for the full process to determine the initial barrier height.
Isolated single residences and isolated groups of closely-spaced residences	Single residences or closely spaced groups of residences in numbers of three or less are considered isolated where they are separated from other residences by more than 100 metres. Where residences are separated by between 20 metres and 100 metres, they may be considered isolated, but this depends on examining surrounding development more broadly. If for example, the low-density development comprises regular placement of residences at 20 metres to 100 metres separation, then the residences are not considered isolated.
L_{Aeq}	Energy average A-weighted sound level – the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Aeq(15hour)}$	The L_{Aeq} noise level between the period of 7am–10pm
$L_{Aeq(9hour)}$	The L_{Aeq} noise level between the period of 10pm–7am
L_{Amax}	The "Maximum Noise Level" for an event, used in the assessment of potential sleep disturbance during night-time periods. The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (i.e., A-weighted). "Fast" time constant is used for this measurement.
Low noise pavement	Low noise pavement, as opposed to quieter pavement, is pavement that has an emission level 2dBA or more, lower than a reference pavement of dense graded asphalt
Maximum barrier height	Ideally, the barrier height where there are no receivers behind the barrier that need at-property noise treatment other than those that are influenced by barrier end effects or noise from other non-project roads. Where a barrier higher than 8m is required to meet RNCG criteria, then the maximum barrier height is limited to 8m from a feasibility and reasonability perspective. Other non-acoustic reasonability factors also need to be considered including visual amenity, shading of properties, engineering constraints, urban design constraints, security issues and available resources. Consideration of all the above establishes the final maximum barrier height for assessment purposes.
Modelling allowance	A decibel amount added to predicted noise levels to artificially increase them. This may be used to provide conservatism to predictions where there is uncertainty in modelling input parameters. In engineering design this is commonly referred to as a safety factor. Further guidance on the above may be found in Transport's Road Noise Model Validation Guideline.
NAP	Noise Abatement Program
Quieter Pavement	A potential alternative pavement which has a noise emission level that is lower than the baseline design pavement proposed by the project or a reference pavement.
Reasonable	Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits provide significant social, economic or environmental benefits. The factors to be considered are: • The noise reduction provided and the overall number of people that benefit from the mitigation. • Existing and future noise levels, including changes in noise levels in the build and design year and the extent of any exceedance of the noise criteria. • Potential for a mitigation measure to reduce noise during construction as well as from road traffic after the project is complete.

	• 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 (typically gathered at a number of stages including route selection, following concept design, community consultation process following the noise assessment and post opening in the operational noise report). • Visual impacts for the community surrounding the road project and for road users. These are typically identified in the environmental impact assessment. • The wider community benefits arising from noise mitigation of the proposed road or road redevelopment. Relative weighting of treatments with respect to protection of outdoor areas or only internal living spaces.
Residual exceedance	An exceedance of the RCNG noise criterion at a previously triggered receiver (refer to "triggered receiver" definition below) after noise mitigation has been proposed. Note that the terminology "residual exceedance" does NOT apply to exceedance of noise trigger levels.
RNP	EPA's NSW Road Noise Policy 2011 (RNP)
Triggered receiver	Receivers at which noise levels at the start of the mitigation review process meet nominated noise level trigger thresholds. Noise level triggers include where: • The RNCG criteria are exceeded and the build vs no build increase is more than 2dBA (or 1dBA if appropriate for receiver), • The cumulative limit (where noise from the project road is significant, refer Section 5.1) is exceeded. • The contribution from the road project equals or exceeds the acute limit. • The RIC is exceeded. Where feasible and reasonable noise mitigation options are considered to reduce noise levels at triggered receivers down to the relevant RNCG criteria. Triggered receivers are established based upon the initial base case/design at the start of the mitigation review process. As mitigation measures are progressively applied to triggered receivers to reduce noise levels, any remaining exceedances of the relevant RNCG criteria are then termed "residual exceedances" (see definition "residual exceedance" above).

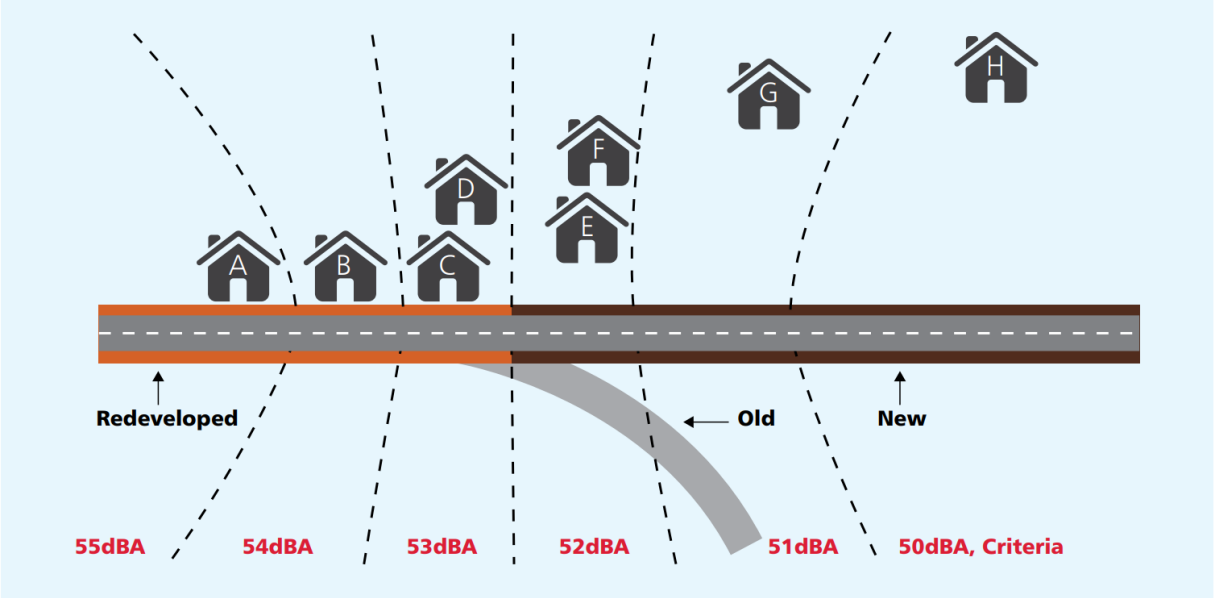
Appendix A: Example of cumulative limit in a transition zone

The cumulative limit provides a process that limits total noise level after applying a reasonable process to less than 5dBA above the criteria. Without the cumulative limit receivers with high existing noise levels and small noise increases may not qualify for consideration of noise mitigation unless they are acute which may be up to 10dBA above criteria.

The example below for a transition zone at night time shows how the cumulative limit is applied so that receivers either meet criteria or are less than 5dBA above criteria (RNCG) following consideration of feasible and reasonable mitigation. Comparison is also made to outcomes at each receiver without the cumulative limit.

The cumulative limit realises the intention of a transition zone in providing a smooth change in criteria and corresponding noise levels between different road categories where transition zones are close to existing roads with high noise levels. The cumulative limit also meets the intention of the RNP more closely where no allowance is given for high existing noise levels when setting criteria.

Figure A1: Example transition zone



Example noise levels and outcomes are shown below and discussed in the following text.

Table A1: Night-time noise levels with and without the cumulative limit (CL)

Receiver	A	B	C	D	E	F	G	H
Criteria Type	Redeveloped		Transition zone				New	
Criteria	55	54	53	53	52	52	51	50
Noise Level, $L_{Aeq, 9hr}$ dBA								
Existing	63	62	60	59	58	57	55	52
Build	63.1	62.2	60.2	59.4	58.8	58	56.2	54.2
Increase	0.1	0.2	0.2	0.4	0.8	1	1.2	2.2
Build without CL and with mitigation	55	54	53	59.4	58.8	58	56.2	50
Exceedance without CL and with mitigation	0	0	0	6.4	6.8	6.0	5.2	0
Build with CL and with mitigation	55	54	53	53	52	52	51	50
Exceedance with CL and with mitigation	0	0	0	0	0	0	0	0

Appendix B1: Example of barrier design

Example 1

The following example shows the steps to identify the design barrier height for five receivers behind a 100 metres long noise wall. Receiver D has a ground floor and also a second storey. The night time criterion is 55dBA. The maximum barrier height is taken to be eight metres as noise levels are still exceeded at eight metres.

Step 1: Example 1

The noise levels are presented below. Noise levels highlighted in orange require double glazing and receivers in green exceed the criteria by less than 10dBA.

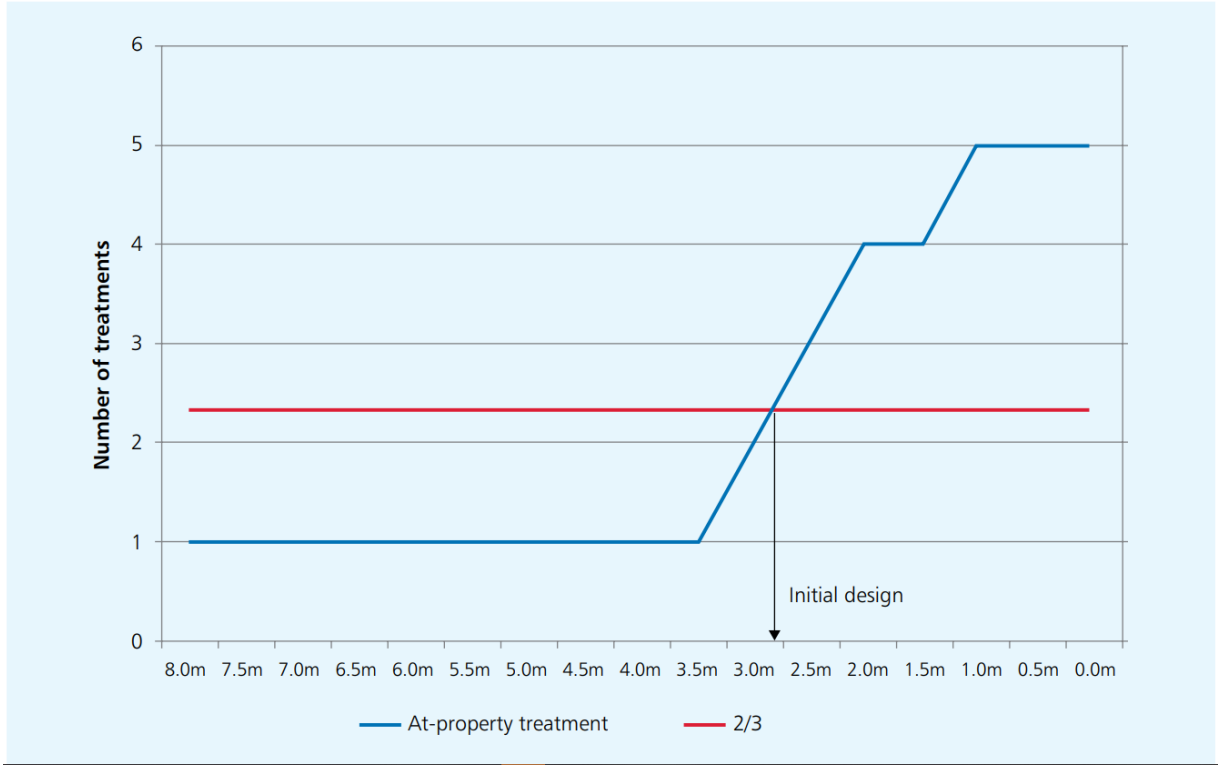
Table B1: Noise levels and number of at-residence treatments

Receiver	Wall height																
	8.0m	7.5m	7.0m	6.5m	6.0m	5.5m	5.0m	4.5m	4.0m	3.5m	3.0m	2.5m	2.0m	1.5m	1.0m	0.5m	0.0m
A	49	50	52	52	53	54	54.1	54.2	54.4	54.6	54.9	55.5	55.6	55.9	56.2	58	59
B	57	58	59	60	61	62.9	63	63.2	63.4	63.8	65	65.2	65.3	65.6	66.1	66.6	68
C	45	47	48	49	50	50.9	51.1	51.4	51.8	52.2	52.7	53.3	54	54.8	55.6	57	58
D Ground	50	50	51	52	52	53.3	53.5	53.7	54	54.2	54.6	54.8	55.5	56.2	57	58.2	59.5
D 2nd Storey	48	49	50	52	53	54	54.2	54.4	54.6	54.7	55.5	56	56.7	57.4	58.1	58.8	59.4
E	40	41	42	44	44	45.3	45.5	45.7	46	46.2	46.6	46.9	47.2	47.5	47.8	48	48.1
At-residences treatments																	
More than 10dBA above criteria (double glazing required)	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Exceed criteria by less than 10dBA (sealing of windows and vents etc)	1	1	1	1	1	1	1	1	1	1	1	2	3	3	4	4	4
Total At Resident Treatments	1	1	1	1	1	1	1	1	1	1	2	3	4	4	5	5	5

Step 2 and 3: Example 1

The figure below shows the number of at-property at each wall height and the wall height where two-thirds of receivers no longer need at-property treatment. The initial barrier design height is three metres.

Figure B1: Number of at-property treatments



Step 4: Example 1

The weightings at each wall height need to be calculated. First of all this requires the calculation of how much the noise levels exceed 45dBA night at each of the residences. This is shown in Table B2.

The exceedences in the cells highlighted in orange are within 2dBA of the exceedences with a wall height of 0 metres. Therefore, the wall is not providing a significant benefit at receivers that exceed 45dBA night.

Table B2: Exceedance of 45dBA night

Receiver	Wall height																
	8.0m	7.5m	7.0m	6.5m	6.0m	5.5m	5.0m	4.5m	4.0m	3.5m	3.0m	2.5m	2.0m	1.5m	1.0m	0.5m	0.0m
A	4.0	5.0	7.0	7.0	8.0	9.0	9.1	9.2	9.4	9.6	9.9	10.5	10.6	10.9	11.2	13.0	14.0
B	12.0	13.0	14.0	15.0	16.0	17.9	18.0	18.2	18.4	18.8	20.0	20.2	20.3	20.6	21.1	21.6	23.0
C	0.0	2.0	3.0	4.0	5.0	5.9	6.1	6.4	6.8	7.2	7.7	8.3	9.0	9.8	10.6	12.0	13.0
D Ground	5.0	5.0	6.0	7.0	7.0	8.3	8.5	8.7	9.0	9.2	9.6	9.8	10.5	11.2	12.0	13.2	14.5
D 2nd Storey	3.0	4.0	5.0	7.0	8.0	9.0	9.2	9.4	9.6	9.7	10.5	11.0	11.7	12.4	13.1	13.8	14.4
E	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.7	1.0	1.2	1.6	1.9	2.2	2.5	2.8	3.0	3.1

The total weightings at each height are then obtained by multiplying results in Table B1 and B2 by the following factors in Table B3.

Table B3: Weighting

Weighting points	
1	per m^2 of barrier
40	per receiver with exceedance NCG criterion less than 10dBA
120	per receiver with exceedance of NCG criterion greater than or equal to 10dBA
4[1]	per dBA exceedance of 50dBA day or 45dBA at each receiver

Note: Where the barrier does not provide at least 2dBA of noise reduction then the number of points is the same as without the barrier at height 0.0 metre.

Step 4 continued: Example 1

Table B4 below summarises the points for the wall and each receiver by multiplying the data in Tables B1 and B2 by the points in B3. The points at each receiver include the points for the barrier, at-property treatment and also for exceedance of 45dBA night. Note that the points for the cells in orange use the 45dBA night exceedance for a wall height of 0.0 metres in Table B2. This is because the wall does not provide a significant benefit of 2dBA or more at the heights with orange cells.

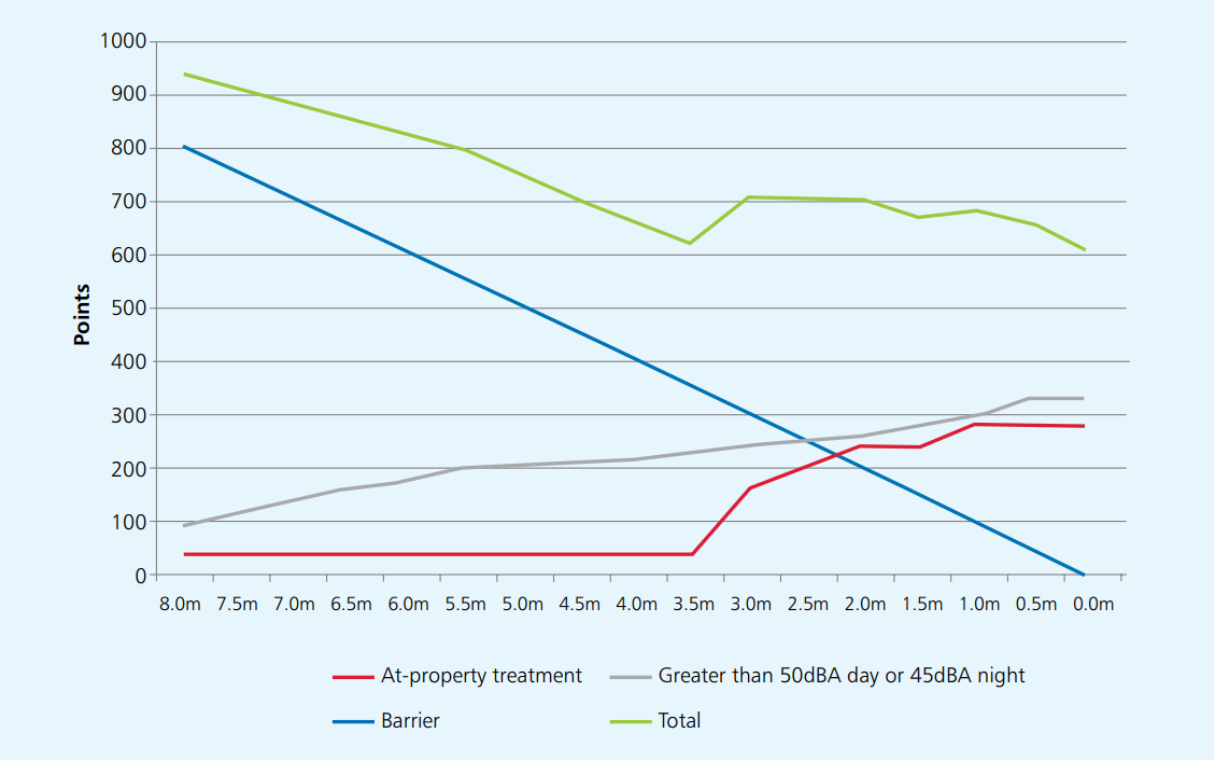
Table B4: Weighted points

Item/Receiver	Points																
	8.0m	7.5m	7.0m	6.5m	6.0m	5.5m	5.0m	4.5m	4.0m	3.5m	3.0m	2.5m	2.0m	1.5m	1.0m	0.5m	0.0m
Wall	800	750	700	650	600	550	500	450	400	350	300	250	200	150	100	50	0
A	16	20	28	28	32	36	36	37	38	38	40	82	82	84	85	96	96
B	88	92	96	100	104	112	112	113	114	115	200	201	201	202	212	212	212
C	0	8	12	16	20	24	24	26	27	29	31	33	36	39	82	92	92
D Ground	20	20	24	28	28	33	34	35	36	37	38	39	82	85	88	98	98
D 2nd Storey	12	16	20	28	32	36	37	38	38	39	82	84	87	98	98	98	98
E	0	0	0	0	0	1	2	3	4	12	12	12	12	12	12	12	12
Total Points	936	906	880	850	816	792	746	700	657	620	703	702	701	670	677	658	608

Step 5: Example 1

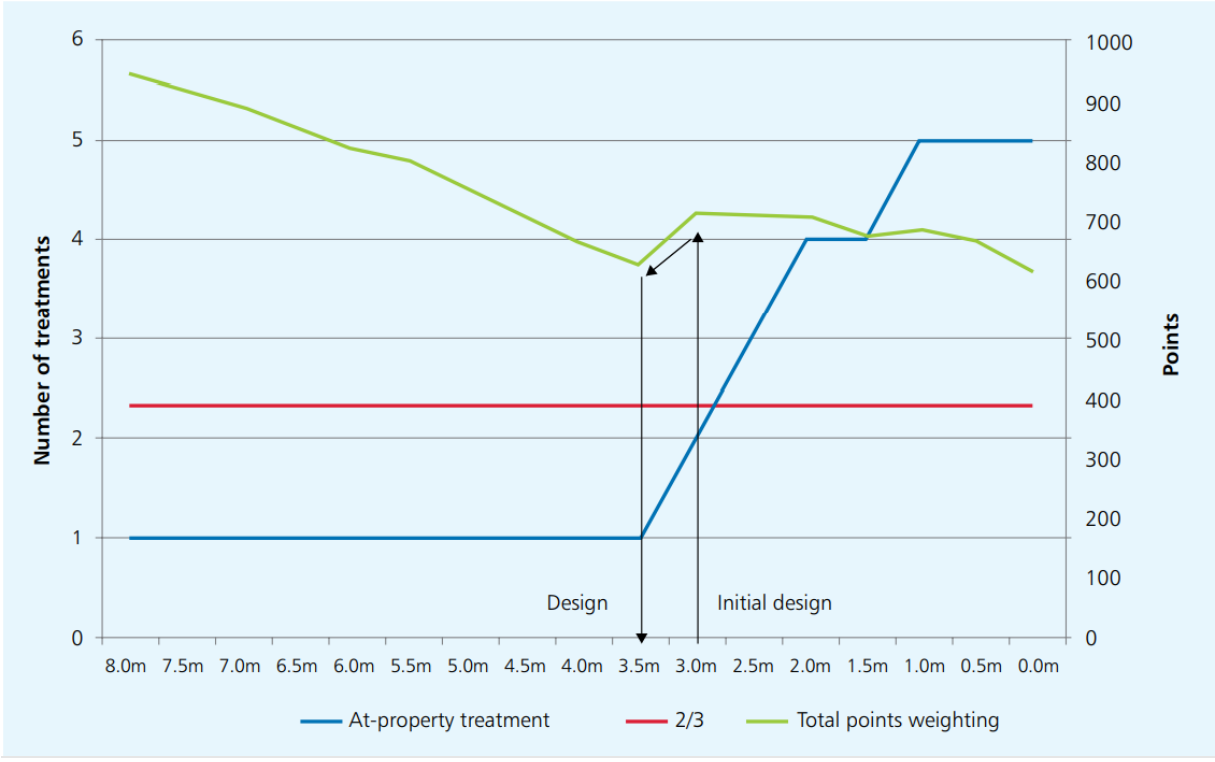
The figure below shows how the points for the property treatments and exceedences of 50dBA day or 45dBA night increase as the wall height reduces from 8 metres to 0 metre. In contrast the points for the wall decrease as the wall height reduces. The conflicting trends combine to give a low value in the Total Points curve at 3.5 metres.

Figure B2: Number of at-property treatments and total weighting curve



There is a minimum in the total points weighting curve between the initial design barrier height of 3.0 metres and the maximum barrier height of 8.0 metres. The minimum occurs at a wall height of 3.5 metres. The design barrier height is 3.5 metres.

Figure B3: Number of at-property treatments and total weighting curve



Appendix B2: Example of barrier design with longer wall and reduced urban density

Example 2

This example is similar to Example 1 (in Appendix B1), except that the barrier is 300 metres long rather than 100 metres. Table B4 has been updated below for a longer barrier length. Note that the weighted points for the cells in orange use the 45dBA night exceedance for a wall height of 0.0 metre in Table B2. This is because the wall does not provide a greater than 2dBA benefit at these heights.

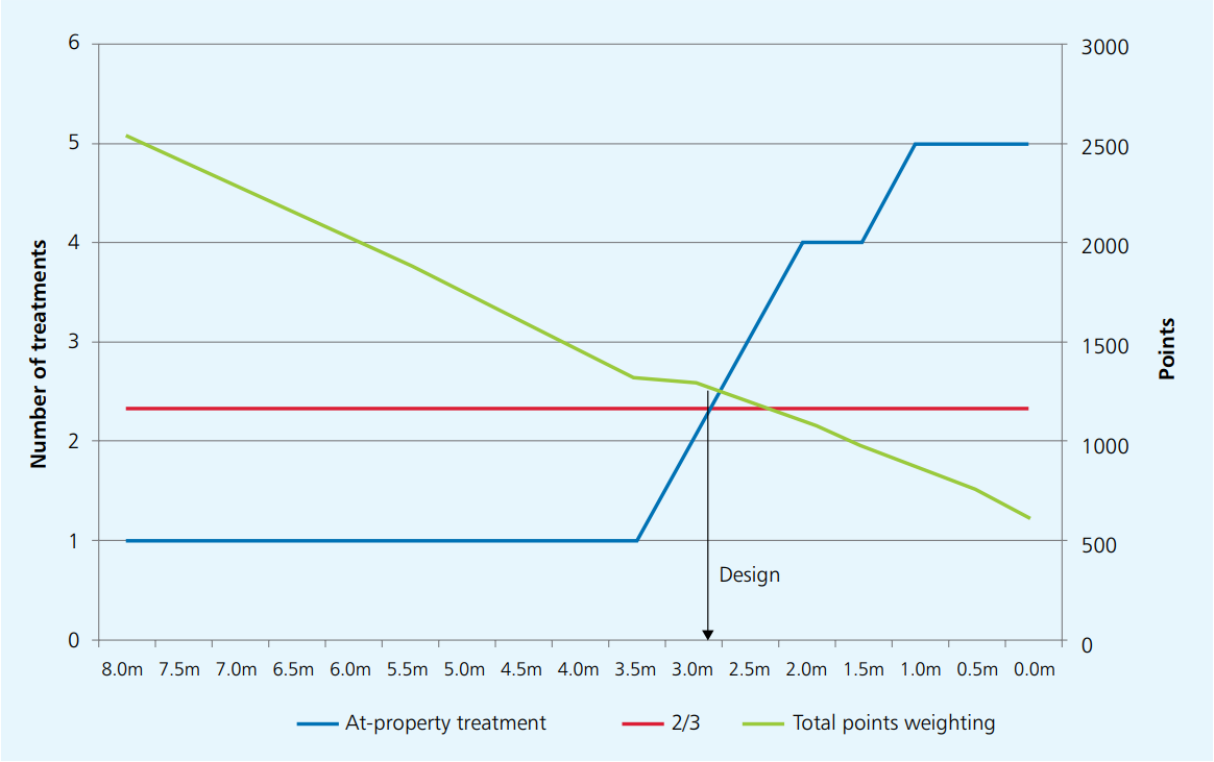
Table B5: Weighted points

Item/Receiver	Points																
	8.0m	7.5m	7.0m	6.5m	6.0m	5.5m	5.0m	4.5m	4.0m	3.5m	3.0m	2.5m	2.0m	1.5m	1.0m	0.5m	0.0m
Wall	2400	2250	2100	1950	1800	1650	1500	1350	1200	1050	900	750	600	450	300	150	0
A	16	20	28	28	32	36	36	37	38	38	40	82	82	84	85	96	96
B	88	92	96	100	104	112	112	113	114	115	200	201	201	202	212	212	212
C	0	8	12	16	20	24	24	26	27	29	31	33	36	39	82	92	92
D Ground	20	20	24	28	28	33	34	35	36	37	38	39	82	85	88	98	98
D 2nd Storey	12	16	20	28	32	36	37	38	38	39	82	84	87	98	98	98	98
E	0	0	0	0	0	1	2	3	4	12	12	12	12	12	12	12	12
Total Points	2536	2406	2280	2150	2016	1892	1746	1600	1457	1320	1303	1202	1101	970	877	758	608

Step 5: Example 2

There is no minimum in the total points weighting between the initial design barrier height of 3.0 metres and the maximum barrier height of 8.0 metres. The initial design barrier height of 3.0 metres is the design barrier height. This is because compared with Example 1 there are less receivers that benefit per metre length of wall.

Figure B4: Number of at-property treatments and total weighting curve



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