

**IN THE MATTER** of the Resource Management Act 1991 ("**RMA**")

**AND**

**IN THE MATTER** of submissions by NZ Transport Agency Waka Kotahi (submitter 143) on the Noise Chapter of the Timaru Proposed District Plan

**STATEMENT OF EVIDENCE OF STEPHEN CHILES  
ON BEHALF OF NZ TRANSPORT AGENCY WAKA KOTAHI**

**ROAD-TRAFFIC NOISE**

**16 April 2025**

## **1. INTRODUCTION**

- 1.1 My full name is Dr Stephen Gordon Chiles. I have the qualifications of Doctor of Philosophy in Acoustics from the University of Bath and Bachelor of Engineering in Electroacoustics from the University of Salford, UK. I am a Chartered Professional Engineer and Fellow of the UK Institute of Acoustics.
- 1.2 I am self-employed as an acoustician through my company Chiles Ltd. I have been employed in acoustics since 1996, as a research officer at the University of Bath, a principal environmental specialist for NZ Transport Agency Waka Kotahi ("**NZTA**"), and a consultant for Arup, WSP, URS, Marshall Day Acoustics and Fleming & Barron. I am contracted as the principal advisor to provide the Environmental Noise Analysis and Advice Service to the Ministry of Health and Te Whatu Ora.
- 1.3 I have been involved in many situations relating to noise effects on new or altered sensitive activities around existing infrastructure. I was an Independent Commissioner for plan changes for Queenstown and Wanaka Airports and a plan variation for Port Nelson, which dealt particularly with noise effects. I have previously been engaged to advise NZTA and Auckland Transport (roads), KiwiRail (railways), Christchurch City Council (airport) and Environment Canterbury (port) on reverse sensitivity noise issues. I previously drafted potential environmental noise provisions for Clause G6 of the New Zealand Building Code for the Ministry of Business, Innovation and Employment.
- 1.4 I am convenor of the New Zealand reference group for "ISO" acoustics standards and a member of the joint Australian and New Zealand committees responsible for acoustics standards. I was Chair of the 2012 New Zealand acoustics standards review, Chair for the 2010 wind farm noise standard, and a member for the 2008 general environmental noise standards.

### **Code of Conduct**

- 1.5 I confirm that I have read the Code of Conduct for Expert Witnesses set out in the Environment Court's Practice Note 2023. I have complied with the Code of Conduct in preparing this evidence and will continue to comply with it while giving oral evidence at the hearing. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

### **Scope of evidence**

- 1.6 My statement relates to the noise chapter of the Timaru Proposed District Plan (Proposed District Plan, "**PDP**"), and primarily to NOISE-R9, NOISE-S3 and NOISE-S4. I have prepared this statement on behalf of NZTA in relation to its function as the state highway network operator.
- 1.7 I have also been engaged by KiwiRail with respect to its submissions on the PDP and will be providing separate evidence on rail noise and vibration. There is some overlap with common issues between road and rail noise.
- 1.8 NZTA submitted on the PDP seeking amendment to provisions to manage adverse effects caused by new buildings containing sensitive activities establishing near existing state highway corridors. The purpose of these provisions is to protect the health and amenity of occupants of those buildings.
- 1.9 My evidence will address:
- (a) noise effects arising from roads;
  - (b) methods to manage effects on new buildings containing sensitive activities near existing roads;
  - (c) the appropriateness of the relief sought by NZTA, from an acoustics and public health perspective; and
  - (d) the Section 42A report prepared by Liz White, including acoustics advice from Malcolm Hunt, dated 24 March 2025, in relation to recommendations on the relief sought by NZTA.
- 1.10 I understand NZTA is not pursuing performance standards for road-traffic vibration and noise in outdoor living spaces, so I will not address those matters in my evidence.

## **2. NOISE EFFECTS FROM ROADS**

- 2.1 Sound from road networks has the potential to cause adverse health effects on people living nearby. This has been documented by authoritative bodies such as the World Health Organisation ("**WHO**"),<sup>1</sup> including a 2018 publication by WHO Europe ("**2018 WHO Guidelines**"), which sets out guidelines for

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<sup>1</sup> World Health Organisation, Guidelines for community noise, 1999; World Health Organisation, Burden of disease from environmental noise, 2011.

managing environmental noise.<sup>2</sup> These WHO publications are underpinned by extensive research. I am not aware of any fundamental disagreement in the acoustics profession with the information published by WHO regarding road noise effects.

- 2.2 Research published in 2024, and previous research published in 2019, specifically addressed the applicability of international data on road noise annoyance to New Zealand.<sup>3,4</sup> This research included surveys of people living in the vicinity of state highways, using the same methodology as most international studies. The research found that international noise annoyance response curves are generally applicable for the New Zealand population, although there is some indication that the New Zealand population might have greater sensitivity to road noise. Broader adverse health effects from road noise in New Zealand were also investigated in separate research published in 2024.<sup>5</sup>
- 2.3 From preceding studies, the 2018 WHO Guidelines found evidence that road noise causes adverse health effects in that they increase the risk of ischaemic heart disease, hypertension, annoyance and sleep disturbance in the population. Various other potential health effects were examined but evidence was not available to determine a relationship with road noise. Based on the information available the 2018 WHO Guidelines made ‘strong’ recommendations that external road sound levels should be reduced below guideline values. The relief sought by NZTA on the PDP is consistent with this direction, as an integral part of its broader noise management activities. I describe below some of the steps and actions that NZTA implements as part of this management approach.

### **3. METHODS TO MANAGE ADVERSE EFFECTS**

- 3.1 I have been involved in numerous different activities undertaken by NZTA to manage and reduce sound from state highways where practicable. These include development of quieter road surfaces, investigation into engine braking noise and installation of noise barriers. For new or altered roads, NZTA seeks to apply NZ 6806,<sup>6</sup> which provides guidance on the assessment of noise, recommended noise criteria and potential mitigation measures. However,

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<sup>2</sup> World Health Organisation, Environmental noise guidelines for the European region, 2018.

<sup>3</sup> Humpheson D. and Magill K., 2024. Community response to transport noise exposure in New Zealand, Waka Kotahi Research Report 727. <https://nzta.govt.nz/resources/research/reports/727/>

<sup>4</sup> Humpheson D. and Wareing R., 2019. Evidential basis for community response to land transport noise, Waka Kotahi Research Report 656. <https://nzta.govt.nz/resources/research/reports/656/>

<sup>5</sup> Evans L. et al, 2024. Health cost of land transport noise exposure in New Zealand, Waka Kotahi Research Report 715. <https://nzta.govt.nz/resources/research/reports/715/>

<sup>6</sup> New Zealand Standard NZS 6806:2010 Acoustics – Road-traffic noise – new and altered roads

practicable improvements are often constrained, and operation of the state highway network results in noise effects that cannot be internalised.

- 3.2 As these effects cannot be completely internalised within the corridor, in my opinion there must be appropriate land use controls in place to manage sensitive development near these road corridors. Land use controls to avoid or manage noise effects on new sensitive activities or alterations to such activities are critical in protecting sensitive activities from adverse health impacts.
- 3.3 For new buildings being constructed, or existing buildings being altered, near to state highways, it is relatively straight-forward to control internal sound through the building location, design and systems (like acoustic insulation and mechanical ventilation). Thus, with careful design of building location, orientation and materials, future occupants of the building can be protected from the most significant adverse effects associated with state highway noise.
- 3.4 Rules in other district plans commonly control the location and design of sensitive activities, where such activities seek to locate near existing sound sources such as roads, railways, airports, ports, quarries, industrial sites, industrial and business zones, gun clubs and motorsport facilities. The notified PDP includes such controls for road noise in NOISE-R9, NOISE-S3 and NOISE-S4.

#### **4. RELIEF SOUGHT**

- 4.1 NZTA submitted that NOISE-R9 should apply over a slightly wider corridor for parts of State Highway 1 (SH1) where the speed limit is above 50 km/h. The notified provisions apply controls within 80 m of SH1, and NZTA submitted that this should be increased to 100 m, where the speed limit is above 50 km/h.
- 4.2 The NZTA submission also referred to an alternative mapped overlay to be provided in further submissions. While I was involved in preparing that mapped overlay, it was not included in the further submissions, and therefore the relief sought is limited to increasing the distance for application of NOISE-R9 from 80 m to 100 m around SH1 where the speed limit is above 50 km/h.
- 4.3 NZTA also submitted to amend NOISE-R9 to remove the reference to sound insulation standards for road noise, consistent with the NZTA submission on NOISE-S3, as I will discuss below.
- 4.4 The notified version of NOISE-R9 includes a compliance pathway based on a combination of notional noise screening and separation. NZTA submitted that

for this pathway to be adequate the separation element should be increased to 50 m.

- 4.5 NZTA submitted that for road noise NOISE-S3 should be amended so that rather than specifying fixed sound insulation an indoor noise criterion should be used. An indoor criterion means that acceptable internal conditions can be achieved in the most efficient manner for each building depending on the specific site and building layout and design.
- 4.6 NZTA submitted for ventilation requirements in NOISE-S4 to apply to all habitable rooms and to include a maximum temperature. Without an adequate ventilation and cooling system windows might need to be opened for occupants to be comfortable, which would compromise the sound insulation and could result in excessive indoor noise.
- 4.7 NZTA made a further submission opposing relief sought by Rooney Holdings Limited that would exclude alterations to existing buildings from NOISE-R9.

## **5. RESPONSE TO SECTION 42A REPORT**

### Distance for application of controls

- 5.1 Ms White notes that an alternative mapped overlay has not been provided. She also recommends rejecting the NZTA submission that the notified 80 m distance for application of NOISE-R9 should be increased to 100 m from SH1 where the speed limit is above 50 km/h.
- 5.2 Mr Hunt refers to having made a check on noise from SH1. NZTA has previously commissioned nationwide mapping of noise from all highways and the resulting contours are available online.<sup>7</sup> These contours provide spatial data of noise from SH1 throughout the Timaru District. For other districts, NZTA has adopted a standard method to process these contours to form mapped overlays as set out in Appendix A to my evidence. This method includes an essential allowance for uncertainty in the predictions. While a mapped overlay is no longer proposed, as stated by Mr Pearson in paragraph 3.3 of his evidence, I have checked the contours and overlay that was prepared for the Timaru District. This shows that for most of SH1 in the Timaru District, controls are warranted up to and beyond 100 m. In my opinion, the evidence of noise exposure from this detailed mapping demonstrates that a distance of 100 m from SH1 is warranted where the speed limit is above 50 km/h.

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<sup>7</sup> <https://www.arcgis.com/home/item.html%3Fid%3D7fd0c57e57e274e579b05c27c66e2a4fa>

#### Alternative compliance pathways

- 5.3 Ms White recommends rejecting the NZTA submission to require a 50 m separation distance in addition to noise screening, as an alternative compliance pathway in NOISE-R9. Mr Hunt cites a lack of evidence for a 50 m distance.
- 5.4 This compliance pathway has been used in numerous other districts with noise screening and a 50 m separation distance. This pathway avoids having to make a site-specific assessment of internal noise. The exact outcome achieved by screening will be highly variable and therefore this pathway is designed to be slightly conservative. In my opinion this compliance pathway must not be based on an optimistic assumption about there being significant screening in all instances, because the wording of the rule only requires nominal line-of-sight screening. In practice, from modelling of numerous noise barriers, noise screening often only results in two or three decibels reduction at houses. Even the blunt rule-of-thumb for line-of-sight screening is only for a 5 dB reduction. At a distance of 20 m, road noise levels could be in the order of 7 dB higher than at 100m, so even with screening this does not provide equivalent protection. At 50 m the noise level could be 3 dB less than 100 m, so in combination with realistic screening the same outcome will be achieved in most instances.
- 5.5 If an individual site does have highly effective screening, a site-specific assessment can be still be used to show the external levels are below the specified thresholds so that no further treatment or assessment is required.

#### Indoor noise criterion

- 5.6 Based on Mr Hunt's advice, Ms White recommends rejecting the NZTA submission to use an indoor road noise criterion in NOISE-R9 and NOISE-S3, instead maintaining a fixed sound insulation requirement.
- 5.7 Mr Hunt makes reference to various standards related to sound insulation requirements. I disagree with Mr Hunt that a fixed sound insulation requirement is better supported by New Zealand or International Standards. Standards provide methods for either approach. I also disagree with Mr Hunt that specifying an indoor noise criterion creates significant issues for the regulatory authority. This is apparent from the Christchurch District Plan, which previously allowed for either fixed sound insulation or an internal road noise criterion. On detailed review of the controls for Plan Change 5E it was found that in most cases site-specific assessment of indoor noise was

selected by developers rather than fixed sound insulation. This was presumably as the site-specific assessment provided a more efficient solution. The plan was changed to now only use an indoor criterion for road noise.

- 5.8 Using an indoor noise criterion requires a site-by-site assessment and tailored mitigation for each development, whereas fixed sound insulation requires the same mitigation for all developments. Fixed sound insulation requirements result in excess treatment in many cases and potentially inadequate treatment for those developments most exposed. Setting indoor noise limits is the most efficient and effective approach.

#### Alterations to existing buildings

- 5.9 While Mr Hunt agrees that NOISE-R9 should apply to alterations to existing buildings (noting they "provide a practical opportunity to cost-effectively incorporate the necessary acoustic insulation and ventilation"), he considers the requirements should only apply to "significant alterations". He conceives significant alterations as being where the floor area in a habitable room within an existing building is increased by 20% or more. I agree with the principle that controls should not be triggered by routine repairs and maintenance to homes. However, in terms of noise effects I disagree that it is appropriate to set an arbitrary threshold based on floor area increases.

#### Ventilation

- 5.10 Based on Mr Hunt's advice, Ms White does not consider it is necessary to apply the ventilation requirements in NOISE-S4 to all types of habitable rooms, or to set a maximum temperature.
- 5.11 In terms of noise effects, activities involving relaxation and concentration routinely occur in all habitable rooms. I disagree with Mr Hunt, and in my opinion there is no basis to differentiate ventilation controls between habitable rooms. In all cases, occupants should have a genuine choice to leave windows closed as necessary to achieve healthy indoor noise environments. From previous investigations I have commissioned, I understand the New Zealand Building Code ventilation requirements are not set at a level needed to achieve thermal comfort and are not adequate for this purpose.<sup>8</sup>
- 5.12 Mr Hunt has quoted part of a 2014 report by Beca regarding geographic applicability of system specifications.<sup>9</sup> Following the passage Mr Hunt quotes,

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<sup>8</sup> Acoustics Engineering Services, *NZTA Ventilation Specification Review*, 30 June 2020.

<sup>9</sup> Beca, *Ventilation Systems Installed for Road-traffic Noise Mitigation*, 26 June 2014



the report provides specific examples of geographic regions with Christchurch requiring cooling but Southland not requiring cooling. I understand that Christchurch and Timaru are in the same climate zone and that Timaru can experience extremely hot summer days.<sup>10</sup> Hence, temperature controls should be required based on the Beca report.

## **6. CONCLUSION**

- 6.1 Noise from state highways can give rise to adverse health effects on occupiers of noise sensitive activities located nearby. The research and guidelines relating to these effects are widely accepted internationally and applied in New Zealand.
- 6.2 NZTA continuously works to reduce existing sound exposure and to manage the effects of its operations on existing sensitive activities. However, due to the nature of its operations, NZTA (as with many large infrastructure providers) is unable to internalise all noise effects.
- 6.3 Adverse effects on buildings for sensitive activities can be avoided and managed through well understood controls in district plans. NZTA submitted on PDP for such controls in the notified version to be amended to address identified deficiencies. I consider the relief sought by NZTA appropriate to address these issues.

Stephen Chiles  
**16 April 2025**

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<sup>10</sup> NIWA, *Climate & Weather, Eastern South Island*, <https://niwa.co.nz/climate-and-weather/map-e-south>

## Appendix A

# Chiles Ltd

## MEMORANDUM

From: Stephen Chiles  
To: Mike Wood, Waka Kotahi  
Date: 23 March 2023  
Subject: State highway noise control boundary overlay

### Introduction

This memorandum sets out details of how Waka Kotahi has prepared a draft noise control boundary overlay for the national state highway network based on noise modelling, and the checks and amendments required before implementation of that overlay in each district. Comments are also made on the limitations of using such as overlay based on modelling.

### Calculation of noise contours

The proposed noise control boundary overlays are based on national road-traffic noise modelling by AECOM. That modelling work was undertaken as part of a broader research project "*Social cost (health) of land transport noise exposure*". In this formal research programme, the work was subject to internal review, steering group review and independent peer review. At the time of preparing this memorandum the final research report from that project has not been published but is understood to be complete and undergoing final editorial review. The research report will be available on the Waka Kotahi website once finalised/published.

The following table sets out the modelling details understood to have been used by AECOM. These details should be confirmed in the research report although there might be some minor variations.

Table 1 – AECOM noise modelling details (subject to confirmation by research report)

Primary modeller	Lee Evans, AECOM
Software	SoundPLAN v8.2
Calculation algorithm	UK Calculation of Road Traffic Noise
Calculation area	600 metres either side of all highway and arterial centrelines
Parameter	$L_{Aeq(24h)}$ (taken as $L_{A10(18h)} - 3$ dB)
Sound contour grid	Free-field, 10 m spacing, 1.5 m high
Ground absorption	Urban environments – 0.6 Rural environments – 1
Date of input datasets	2021 (generally reflecting 2020/21 conditions)
Road centrelines	CoreLogic National Road Centreline dataset (x/y) DEM (z)
Traffic volumes (AADT)	CoreLogic National Road Centreline dataset 24h traffic data entered in CRTN as 18h traffic
Heavy vehicles (%HV)	CoreLogic National Road Centreline dataset
Speed	CoreLogic National Road Centreline dataset Posted speed limit

Road surface	Surface types as recorded in Waka Kotahi RAMM database Surface corrections in accordance with Waka Kotahi <i>Guide to state highway road surface noise</i> , including a -2 dB correction from CRTN to a reference AC-10 surface.
Bridge locations	CoreLogic National Road Centreline dataset Height interpolated from start and end points
Terrain	LIDAR where available NZ School of Surveying 15 m nationwide DEM in other areas Data combined in GIS to produce 1 m×1 m DEM for noise model
Building footprints	LINZ NZ Building Outlines dataset
Building heights	Where available, calculated from DSM median height minus DEM median height, otherwise: 6 m residential / 8 m commercial
Noise barriers	None modelled

Of note in this table is that the modelling was for highways and other arterial roads in a combined dataset. This has resulted in 'stubs' and other artefacts in the proposed overlay where there are noise contours due to other arterial roads (not highways) in proximity to a highway (within 100 m).

From the AECOM noise modelling the 54 and 55 dB  $L_{Aeq(24h)}$  contours (polygons extending around highways and other arterial roads) have been used for subsequent GIS processing. The distance of the contours (and subsequent overlay) from a highway depends on numerous factors included in the modelling, with key parameters being:

- Traffic volume
- Traffic composition (percentage of heavy vehicles)
- Traffic speed
- Road surface
- Road geometry
- Screening by terrain or buildings
- Relative height of highway and surrounding land

These parameters are constantly changing, which results in the contours being at a variable distance from a highway along its length. Notably, the contours are generally smaller around highways with lower traffic volumes, although that effect is often partly offset by differences in road surfaces with lower volume highways more likely to have noisier chipseal surfaces. For busier highways the contours are often further than 100 metres from the road, but the extent of the noise overlay has been capped at 100 metres by the GIS processing.

### GIS processing of noise contours

The proposed noise control boundary overlay has been developed based on the modelled noise contours with some additional GIS processing. This additional processing is to make some allowance for uncertainty in the modelling and to reduce the influence of artefacts due to the modelling method and limitations of input data. At a national level the GIS processing summarised in Table 2 has been undertaken by Waka Kotahi.

Table 2 – national GIS processing details

Primary operator	Stewie He, Waka Kotahi
Software	ArcGIS
Base noise contour	54 dB $L_{Aeq(24h)}$ (representing 57dB with 3 dB allowance)
Smoothing	PAEK method - 50m tolerance - one-sided barrier of 55 dB $L_{Aeq(24h)}$ contour
Overlay limits	- no closer than 25m to a centreline (approximating 20m to an edgeline) - no further than 105m from a centreline (approximating 100m from an edgeline)
Holes	All holes in contour less than 5000m <sup>2</sup> filled
Islands	All islands outside contour less than 1000m <sup>2</sup> removed

The 3 dB allowance made by using the 54 dB  $L_{Aeq(24h)}$  contour provides a relatively small degree of tolerance for factors including:

- Inherent modelling uncertainty associated with the calculation algorithm
- Uncertainty associated with input datasets and national modelling without detailed ground truthing and checking at a localised level
- Normal changes in road and traffic conditions such as from routine resurfacing and traffic growth or composition change

In reality, the uncertainty from these factors far exceeds 3 dB, but that has been adopted as a compromise value. For example, just the first factor of calculation method uncertainty is around +/- 2dB close to the road and say double that at greater distances. Without adequate allowance for uncertainty, many buildings that might theoretically comply with the internal noise criterion but would actually exceed it immediately on construction, and many other buildings would exceed the criterion over following years.

It is noted that the allowance for uncertainty in preparing the overlay needs to be consistent with the corresponding rules applying within the overlay (otherwise neither function effectively).

The limitation for the overlay not to extend further than 100 metres from highways is a policy position that Waka Kotahi has adopted since it first standardised its approach to this issue in 2007. Technically there are noise effects that warrant control beyond 100 metres near busier highways, but the limitation has been made as a compromise to address the most significant effects without applying controls over an extended land area.

Following the national processing, the draft overlay is subject to additional verification by Waka Kotahi planning and environmental staff before potential use in each district. Currently, this has been completed for a small number of districts and others are in process. Manual alterations are made to the overlay for each district by the Waka Kotahi GIS team as required. The following matters are checked by desk-top inspection of the overlay along all highways in a district and are corrected as required:

- The overlay is extended around any sections of highway where it is absent from the modelling, generally at a fixed distance of 105 m from the centreline. This can occur

because the highway did not exist at the time of the modelling or because of missing road or traffic data in the modelling.

- Any large anomalies caused by contours around other arterial roads are removed.
- The overlay is removed from any highways that have been revoked or are in the process of being revoked.
- The overlay is extended around any unimplemented highway designations, generally at a fixed distance of 100 metres from the designation boundary.
- If the extent of the overlay is limited by the scope of a particular RMA process then it is restricted to the relevant spatial limits. For example, the overlay might only apply to certain zones or the furthest distance the overlay extends from highways might be capped at a value less than 100 metres.

Once processed the noise control boundary overlay for a district is made available initially on a web map. Access required to the web map (i.e. specific parties or public) is to be determined by the relevant Waka Kotahi planner. When required a GIS file will be provided for inclusion in the district plan maps. Waka Kotahi will also maintain a collated map of the final overlays adopted in each district.

### **Limitations of an overlay based on noise modelling**

There are numerous intricacies associated with noise modelling that could be relevant to use of a noise contour as the basis for an overlay. However, the following points have particular impact on the use of model outputs in this context:

- Widescale national noise modelling is constrained by the quality and availability of input data in a suitable format for terrain, buildings and roads. This is different to modelling for a discrete roading project over say 10 to 20 kilometres, where it is practical to spend time checking and adjusting data, such as through ground truthing. Also, for individual projects, specific high resolution terrain data can be obtained if it does not already exist. It is not practical to apply the same processes to modelling 11,000 kilometres of the national state highway network. Therefore, while applying the same calculation algorithms, because the input data is constrained, national modelling is subject to greater uncertainties and inaccuracies than discrete project modelling.
- Modelling includes noise screening by buildings in the available dataset at that point in time. This is beneficial for land use controls as it means that if a site is screened from state highway noise by buildings on other sites the contour would be smaller and it might exclude that site such that it would not be subject to the controls. However, this approach does not account for changes to buildings post-modelling. For example, screening by an existing building on a site might result in noise contours excluding most of the site, including in the footprint of that building. If the existing building is removed, then new buildings on the site might be outside the relevant contour even though they may have high noise exposure warranting building treatment.

- The modelling is only for a single height above ground level (1.5 metres), intended for single storey buildings. Noise exposure is often higher at higher elevations due to a reduction in screening by other buildings or the terrain.
- As for buildings, the modelling is based on road and traffic conditions at a certain point in time (2020/2021). These parameters commonly change (e.g. resurfacing as part of routine maintenance) and can increase the extent of noise exposure. However, an overlay based on modelling would be fixed to the previous conditions so land use controls might exclude sites with noise exposure warranting building treatment at the time of development.

Waka Kotahi has proposed using an overlay based on noise contours as it can reduce the area over which land use controls apply and thus avoids a requirement for compliance assessment on some sites, which are likely to have lower noise exposure but would otherwise have been captured within a fixed distance. However, the above limitations of this approach mean that it will also exclude many sites where controls are warranted, particularly in urban areas where screening effects and higher buildings are more likely.