Operational noise and vibration assessment

Peka Peka to North Ōtaki Expressway Project

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Prepared for

NZ Transport Agency

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H	12 February 2013	Minor editorial changes

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Abbreviations

Abbreviation	Description
AADT	Annual average daily traffic
AC	Asphaltic concrete
AEE	Assessment of environmental effects
BCR	Benefit-cost ratio
BPO	Best practicable option
CRTN	Calculation of road traffic noise
dB	Decibels
EPA	Environmental Protection Authority
GIS	Geographic information system
HV	Heavy vehicle
Hz	Hertz
km	Kilometre
km/h	Kilometres per hour
NIMT	North Island main trunk
NoR	Notice of requirement
NS	Norwegian Standard
NZS	New Zealand Standard
NZS 6806	NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads
NZTA	NZ Transport Agency
OGPA	Open graded porous asphalt
PA-10	Porous asphalt (10 mm nominal chip size)
PPF	Protected premises and facilities
PPM	NZTA Planning Policy Manual – for Integrated Planning and Development of State Highway
RoNS	Road of national significance
RMA	Resource Management Act 1991
SAR	Scheme assessment report
SARA	Scheme assessment report addendum
SH1	State Highway 1
ULDF	Urban and landscape design framework
vpd	Vehicles per day

Abbreviations

Term	Definition
Alignment	The horizontal or vertical geometric form of the centre line of the carriageway.
Annual average daily traffic	The total volume of traffic passing a roadside observation point over the period of a calendar year, divided by the number of days in that year (365 or 366 days). Measured in vehicles per day.
Benefit-cost ratio	The ratio that compares the benefits accruing to land transport users and the wider community from implementing a project or providing a service, with that project's or service's costs.
Carriageway	That portion of the road devoted particularly to the use of travelling vehicles, including shoulders.
Centreline	The basic line, at or near the centre or axis of a road or other work, from which measurements for setting out or constructing the work can conveniently be made.
Chip seal	A wearing course consisting of a layer or layers of chips originally spread onto the pavement over a film of freshly sprayed binder and subsequently rolled into place.
Designation	Defined in section 166 of the RMA as: "a provision made in a district plan to give effect to a requirement made by a requiring authority under section 168 or section 168A or clause 4 of schedule 1."
Design speed	A speed fixed for the design of minimum geometric features of a road.
Expressway	A road mainly for through traffic, usually dual carriageway, with full or partial control of access. Intersections are generally grade separated.
Free-field (Noise)	Description of a location which is at least 3.5 metres from any significant sound reflecting surface other than the ground.
$L_{Aeq(24h)}$	Time-average sound level over a twenty-four hour period, measured in dB.
Local road	A road (other than a State highway) in the district, and under the control, of a territorial authority, as defined in Section 5 of the Land Transport Management Act 2003.
Notice of requirement	A notice given to a territorial authority (under section 168 of the RMA) or by a territorial authority (under section 168A of the RMA) of a requirement for land, water, subsoil or airspace to be designated.
Outline plan	A plan of the public work, project, or work to be constructed on designated land provided to a territorial authority, pursuant to section 176A of the RMA, prior to the work being undertaken.
Road reserve	A legally described area within which facilities such as roads, footpaths and associated features may be constructed and maintained for public travel.
Traffic volume	The number of vehicles flowing in both directions past a particular point in a given time (e.g. vehicles per hour, vehicles per day).
Vehicles per day	The number of vehicles observed passing a point on a road in both directions for 24 hours.

Executive Summary

Introduction

This report documents the assessment of operational noise and vibration from road and rail traffic for the Peka Peka to North Ōtaki Expressway Project ('Expressway' and/or 'Project'). For road-traffic, this assessment includes the Expressway, the new local arterial, and other local roads which are either being built or altered to accommodate the Expressway. For rail-traffic the assessment is for the section of the North Island Main Trunk Line being realigned in Ōtaki to make room for the Expressway. This report provides details of the criteria adopted, an assessment of existing and future conditions, proposed mitigation where appropriate, and an assessment of the actual and potential noise and vibration effects.

Criteria

NZS 6806 contains an assessment process including guideline levels for road-traffic noise, which is adopted for the Project as representing good practice. Following the process in NZS 6806 should result in road-traffic noise within reasonable levels. Road-traffic noise is assessed at noise sensitive locations, which are described by NZS 6806 as Protected Premises and Facilities (PPFs).

The operative Kāpiti Coast District Plan includes noise limits, based on the NZTA's previous internal policy ('Transit Guidelines'), for new roads as controlled activities in rural zones. Those noise limits do not apply to the proposed designation, but have been used as a reference.

Rail noise and vibration criteria have been proposed based on KiwiRail's reverse sensitivity guidelines. These include reference to Norwegian Standard NS 8176 for vibration criteria.

Existing environment

The Expressway route closely follows the existing State highway and rail line through both rural and urban areas. A number of PPFs affected by this Project are already subject to high levels of road-traffic noise. A noise survey has been performed to quantify this existing exposure, and provide the baseline that would be required to determine noise limits from the District Plan if they were applicable. Rail noise and vibration measurements have also been undertaken.

Modelling

Road-traffic acoustics computer modelling has been conducted using an assessment year of 2031. The modelling includes the existing situation, the future scenario without the Project (do-nothing), the scenario with the Project (do-minimum), and various noise mitigation options.

Rail noise and vibration levels have been modelled using reference source levels, which have been verified by noise and vibration measurements.

Design and mitigation

An extensive road-traffic noise mitigation options assessment has been undertaken in accordance with the method set by NZS 6806. For each area of the Project, a number of options have been developed and assessed by all relevant members of the project team to determine the best practicable option (BPO) for noise mitigation. This process involved the circulation of options and a workshop to review each team member's assessment. The mitigation was also reviewed following public open days and feedback in July 2012.

Executive Summary

This report outlines the proposed noise mitigation, which includes one kilometre of open graded porous asphalt (PA-10) on the Expressway through Ōtaki, and investigation of one PPF for acoustic treatment. Two additional PPFs will be investigated for acoustic treatment to mitigate rail noise.

Rail vibration from the realigned track is predicted to comply with the appropriate criteria without the need for specific mitigation.

Assessment of noise effects

The PPFs for the Project are currently exposed to road-traffic noise from the existing State highway and rail noise from the existing alignment of the North Island Main Trunk Line. In many instances, there will be a reduction in sound levels due to the Project, and there will be a significant reduction in the number of heavy vehicles using the Ōtaki Main Highway. In other instances there will be a slight increase in road-traffic noise levels. With the mitigation proposed the road-traffic noise levels will be at a reasonable level defined by NZS 6806, and rail noise will be within reasonable noise levels determined from KiwiRail's reverse sensitivity guidelines. The existing environment is already affected by road and rail traffic noise, and the increases in levels are modest. Given that the resulting levels are also within reasonable absolute levels, they are considered acceptable.

Assessment of rail vibration effects

The existing rail alignment through Ōtaki passes close to several PPFs, in which rail vibration can currently be felt. With the removal of some properties and the realignment of the rail, the nearest PPFs are further from the rail, and overall exposure to rail vibration will be reduced. While two PPFs on the west of the rail become closer to the realigned rail, they remain further than PPFs to the east are from the existing alignment. Rail vibration may be perceptible in the nearest PPFs, but at a level that will not interfere with domestic activities.

Conclusions

The Project has potential to cause adverse rail and road-traffic noise and vibration effects. These potential effects have been investigated. Due to the proximity to the existing State highway, in many instances there will be a reduction in noise due to the Project. Noise mitigation has been proposed where required, and with these measures all noise and vibration should be restricted to within reasonable levels and effects are considered acceptable.

A summary of potential effects resulting from the Project is shown in the following table.

Item	Evaluation	Mitigation
Road-traffic noise	Increases in noise level at properties east of Expressway Decrease in noise level at PPFs west of SH1 in Te Horo Improvement in character throughout Otaki	Low-noise road surface throughout Otaki Potential building modification at one PPF
Rail noise	Increase in noise level at two PPFs Decrease in noise level at all nearby other PPFs Removal of level crossing will reduce use of train horns	Potential building modification or noise barriers at two PPFs
Rail vibration	Decrease in vibration generated by new track Increased levels at 2 PPFs due to reduction in distance, however Class C criteria still to be achieved	N/A

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Introduction

1.1 Project overview

The NZ Transport Agency (the NZTA) is lodging a Notice of Requirement (NoR) and applications for resource consents for the construction, operation and maintenance of the Expressway. The Project would require the re-alignment of approximately 1.2 kilometres of the North Island Main Trunk (NIMT) through Ōtaki, and KiwiRail is lodging an NoR for that purpose. In this application, the Project refers to:

- construction of the main road alignment;
- realignment of part of the NIMT; and
- associated local road connections.

1.2 Project description

1.2.1 Main alignment

The Wellington Northern Corridor RoNS runs from Wellington Airport to Levin. The Project is one of eight sections of the Wellington Northern Corridor RoNS. The location of the Project in the overall scheme of this corridor is illustrated in Figure 1-1.

The NZTA proposes in this application to designate land and obtain the resource consents necessary to construct, operate and maintain the Expressway. The Project extends from Te Kowhai Road in the south to Taylors Road just north of Ōtaki, an approximate distance of 13 kilometres.

The Expressway will provide two lanes of traffic in each direction. Connections to existing local roads, new local roads and access points over the Expressway to maintain safe connectivity between the western and eastern sides of the Expressway are also proposed as part of the Project. There is a new crossing of the Ōtaki River proposed as part of the Project, along with crossings of other watercourses.

On completion, it is proposed that the Expressway become State Highway 1 (SH1) and that the existing SH1 between Peka Peka and North Ōtaki will become a local arterial road, allowing for the separation of local and through traffic. The NZTA has a State highway revocation policy[1], however it is noted that the power to declare roads to be State highways or revoke status resides with the Chief Executive of the Ministry of Transport.

1.2.2 North Island Main Trunk

KiwiRail proposes to designate land in the Kāpiti Coast District Plan for the construction, operation and maintenance of a re-aligned section of the NIMT through Ōtaki. The realignment of the NIMT is to facilitate the Expressway, however at the same time the realignment yields other benefits including the removal of a level crossing.

[1] http://www.nzta.govt.nz/planning/process/doc/state-highway-revocation-policy.pdf, accessed 1 October 2012

1 Introduction

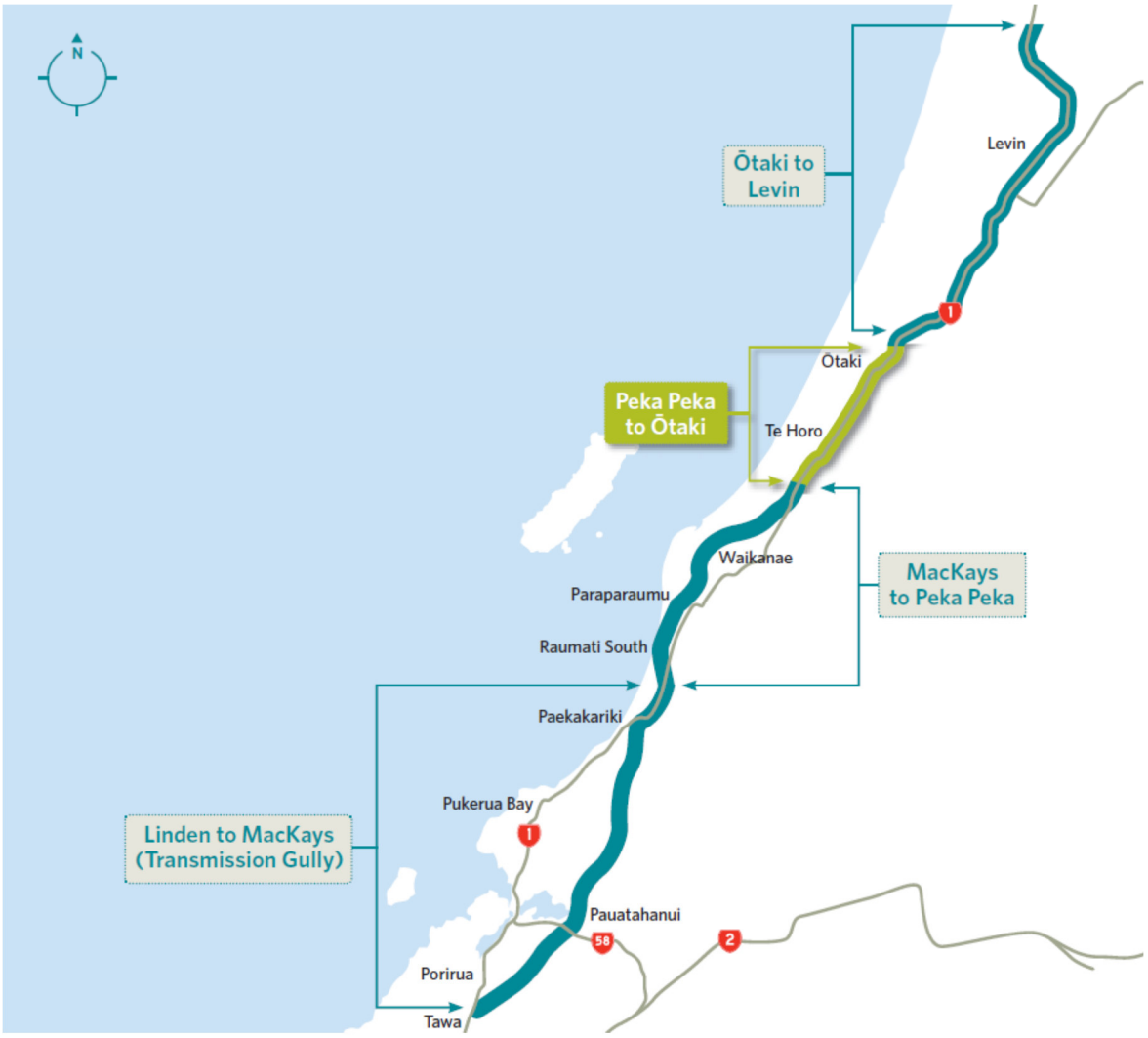

Figure 1-1 Project location

The Project route can be seen in drawings N-001 to N-008.

1.3 Noise assessment

1.3.1 2002 Scheme Assessment Report (SAR)

A scheme assessment report was prepared in 2002. Malcolm Hunt Associates prepared the acoustics assessment as part of the 2002 SAR. In 2003, an addendum to the scheme assessment report was prepared to consider the western 'Te Waka alignment' favoured by submitters during consultation. The assessment concluded that this alignment was less favourable than the board preferred alignment that has since been developed.

1.3.2 2011 Scheme Assessment Report Addendum (SARA)

The Project was further developed as part of the Roads of National Significance programme, and a scheme assessment report addendum was prepared in 2011. More detailed work on interchange design and east-west linkages along the route was conducted. The consideration of all alignment and interchange options involved multi-criteria analyses including potential noise and vibration effects.

1 Introduction

URS conducted the acoustics assessment for the 2011 SARA[2]. The SARA acoustics report provided an indication of the road-traffic noise mitigation measures likely to be required.

1.3.3 Assessment of Environmental Effects (AEE)

A noise and vibration assessment for the Project was conducted by URS between July 2010 and August 2012 as part of the environmental assessment of the Project. The purpose of the noise assessment (including components performed during the SARA) was to:

- measure existing noise and vibration levels;
- predict and assess future rail and road-traffic noise and vibration levels; and
- determine measures required to avoid, remedy or mitigate potential operational noise and vibration effects.

The results of the study are presented in this report. A separate report has been prepared to assess potential construction noise and vibration effects.

1.3.4 Road-traffic vibration

Vibration from road-traffic has the potential to cause perceptible ('feelable') vibration inside buildings in close proximity to the road (typically buildings closer than 10 metres to the traffic lane). This is predominantly from heavy vehicles interacting with defects in the road surface such as potholes, corrugations and surface joints that can be present in poorly maintained or disturbed roads. Even for buildings close to roads there is negligible risk of building damage from road-traffic vibration.

Vibration from road traffic has not historically been assessed on road projects in New Zealand, however it has recently been assessed for the Waterview Connection[3], Transmission Gully[4], and MacKays to Peka Peka[5] Projects. In all three cases, the results confirmed that a vibration assessment was not actually warranted.

For the Expressway the new road formation will be uniformly compacted and hence will not be subject to surface and pavement irregularities that exist in some roads that have developed and altered over time. The surface of the Expressway will not be disturbed for utilities, and there will be no utilities running along the corridor under the road. Installation of future utilities crossing the road will either use pre-installed ducts or use horizontal drilling / micro-tunnelling, without disturbing the road surface. Therefore, the Expressway will be inherently less prone to vibration generation than many other existing roads. Furthermore, the nearest PPF to the Expressway is 18 metres away, and most other PPFs are at least 50 metres away. Road-traffic vibration effects would not be present at these distances.

While road-traffic vibration may be perceptible in close proximity to the proposed Expressway, it will be at a low level that does not represent a potential adverse effect. Vibration will not interfere with any normal domestic activities in PPFs. For these reasons, a quantitative assessment has not been conducted.

[2] URS Report 42176987/001/C dated 30 November 2011
[3] Marshall Day Acoustics, Western Ring Route – Waterview Connection, Assessment of Vibration Effects. Technical report 19. July 2010
[4] URS, Acoustics Assessment, Transmission Gully Project, Technical Report 12. Revision H, 26/07/2011
[5] Marshall Day Acoustics, MacKays to Peka Peka Expressway, Assessment of vibration effects. Technical report 18, Revision 2, 17/02/2012

1.4 Report structure

This report is structured with following sections:

- Section 2 introduces the New Zealand Standard for road-traffic noise (NZS 6806) and explains why it has been adopted for the Project. Criteria for rail noise and vibration are also proposed.
- Section 3 describes the existing environment, including the results of a noise survey performed as part of the Project, and noise modelling performed with the existing roads and traffic.
- Section 4 provides detail on the computer acoustics model used for the Project, including the model settings, assumptions and source data. A table of predicted noise levels is provided which covers the existing (2010) environment, and future (2031) prediction with and without the Project, including the proposed mitigation.
- Section 5 describes the mitigation options considered, and the multi-disciplinary assessment process undertaken in accordance with the NZS 6806 process. The reasons for the selection of the best practicable option for noise mitigation are provided.
- Section 6 provides an assessment of noise and vibration effects, which is a qualitative assessment extending beyond simple application of the criteria, drawing from the existing environment, predicted noise level, and the change in character of the area due to the Project. Positive effects from the Project are also identified in this section.
- Section 7 provides recommendations on what should be covered in the designation conditions, and a discussion on how these need to be consistent with the NZS 6806 framework.
- Section 8 provides conclusions on the assessment process and the noise effects.

2

Criteria

2.1 Overview

There is no National Environmental Standard for road-traffic noise, and most district plans exclude road-traffic noise from zone noise limits and do not provide alternate criteria. In the absence of other criteria, virtually all significant State highway projects prior to 2010 were subject to noise assessment under NZTA (Transit) Guidelines[6]. The Kāpiti Coast District Plan adopts the criteria from the Transit Guidelines as the controlled activity standard. As a designation the Project will not be authorised as a controlled activity, so those criteria are not applicable, although they have been used as a reference.

In 2010 a New Zealand Standard for road-traffic noise NZS 6806[7] was released, and the NZTA has adopted it as an assessment standard in place of the Transit Guidelines. Criteria are proposed by NZS 6806 to protect from sleep disturbance and provide a reasonable level of residential amenity. Unlike the Transit Guidelines, criteria are not based on the existing noise environment. However, a qualitative assessment of changes in noise levels is made in this report in addition to the quantitative assessment under NZS 6806. While the assessment primarily is of the effects of the Expressway, the effects of the Expressway and existing road and rail network have been considered cumulatively.

Criteria for rail noise and vibration are proposed based on KiwiRail's internal guidance for reverse sensitivity effects.

A qualitative assessment of the effects from individual vehicle noise has been performed.

2.2 NZTA (Transit) Guidelines

The Transit Guidelines were an internal document produced by Transit New Zealand (now the NZTA). They were widely accepted and were used for over a decade almost as if they were a National Environmental Standard. In the Transit Guidelines there is an average noise design criterion. For each location by a road, the average noise design level relates to the existing ambient noise level using the relationship shown in Table 2-1.

Table 2-1 Transit Guidelines noise criteria

Noise Area	Ambient Noise Level*	Average Noise Design Level*
Low	Less than 40.5 dB $L_{Aeq(24h)}$	52.5 dB $L_{Aeq(24h)}$
	40.5 - 47.5 dB $L_{Aeq(24h)}$	Ambient + 12 dB
Medium	47.5 - 56.5 dB $L_{Aeq(24h)}$	59.5 dB $L_{Aeq(24h)}$
High	56.5 - 64.5 dB $L_{Aeq(24h)}$	Ambient + 3 dB
	64.5 - 67.5 dB $L_{Aeq(24h)}$	67.5 dB $L_{Aeq(24h)}$
	More than 67.5 dB $L_{Aeq(24h)}$	Ambient

*Levels adjusted to free-field levels for consistency with NZS 6806. Original façade levels are 2.5 dB higher.

[6] NZTA (1999)' Appendix 6: Guidelines for the management of road traffic noise - state highway improvements' in Planning policy manual
[7] NZS 6806:2010, Acoustics - Road-traffic noise - New and altered roads

The extensive use of the Transit Guidelines revealed four key challenges, in the way they were applied in many cases:

- They did not encourage integrated design. For example, in some projects the required performance of a noise barrier would take precedence over the adverse visual effects it might create.
- There was no requirement to mitigate unreasonable existing noise levels when altering a State highway. For example, if the levels were already 80 dB $L_{Aeq(24)}$ prior to a project then they could remain at that level under the Transit Guidelines.
- The criteria for new roads could be prohibitive.
- Mitigation was sometimes interpreted as being required to meet the noise limit even though the reduction achieved by the mitigation was imperceptible.

2.3 Kāpiti Coast District Plan

The operative Kāpiti Coast District Plan (the District Plan) contains a series of objectives, policies and rules detailing the requirement to manage the effects of road-traffic noise on noise-sensitive activities in areas zoned rural in the District Plan. An extract from the district plan maps is shown in Figure 2-1. This zoning is different to the Statistics New Zealand areas shown in Figure 2-2. The majority of the PPFs for the Project are in rural zoned areas in the District Plan, with the exception being the residential and commercial zones in Ōtaki.

Controlled Activity Standard D.2.2.2 for the Rural Zone states that new roads with a traffic volume exceeding 5,000 vehicles per day (AADT) shall be designed and constructed so that traffic noise levels at 10 years following opening of the route shall not exceed specified noise limits. While Transit Guidelines are not referenced in the District Plan, the limits presented are identical. The values in the District Plan are presented as façade levels which are 2.5 dB higher than the free field levels shown in Table 2-1, consistent with Transit Guidelines.

The Project will not be authorised as a controlled activity, even for the connecting local roads, therefore these criteria are not applicable. Nevertheless, the criteria serve as a guide in the qualitative assessment of noise effects.

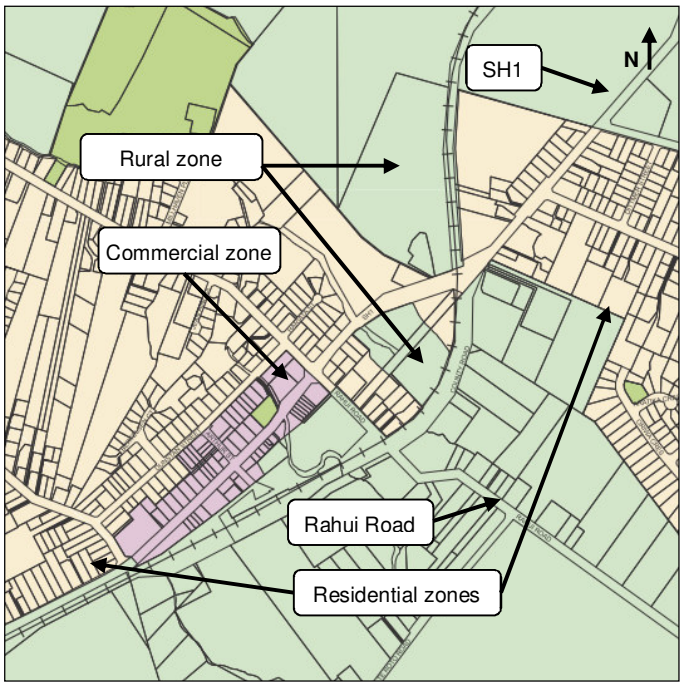

Figure 2-1 District plan zones around Otaki

2.4 NZS 6806

2.4.1 Background

To address some of the weaknesses in the Transit Guidelines, the NZTA opted to participate in an independent process initiated by the Ministry of Transport and run by Standards New Zealand to create a new national standard for road-traffic noise.

To develop a Standard, Standards New Zealand appoints experts to a technical committee from organisations which should include representatives of all stakeholders. In the case of NZS 6806, the organisations were: Department of Building and Housing, INGENIUM, Local Government New Zealand, Ministry of Health, Ministry of Transport, New Zealand Acoustical Society, New Zealand Institute of Environmental Health, New Zealand Transport Agency, Road Controlling Authorities New Zealand and Roading New Zealand.

2.4.2 Criteria

New Zealand Standard 6806 provides criteria and an assessment method for road-traffic noise. The method provides performance targets and requires assessment of a number of different options for noise mitigation (often including barriers and low-noise road surfaces). These options are subject to an integrated design process in which the costs and benefits are considered, amongst other factors. The performance targets in NZS 6806 are set to be reasonable taking into account adverse health effects associated with noise on people and communities, the effects of relative changes in noise levels, and the potential benefits of new and altered roads. For the Project, the noise criteria in Table 2-2 are applicable.

2 Criteria

Table 2-2 NZS 6806 noise criteria

Category	Criterion	Altered roads	New road
A	Primary	64 dB $L_{Aeq(24h)}$	57 dB $L_{Aeq(24h)}$
B	Secondary	67 dB $L_{Aeq(24h)}$	64 dB $L_{Aeq(24h)}$
C	Internal	40 dB $L_{Aeq(24h)}$	40 dB $L_{Aeq(24h)}$

Noise mitigation options are to be assessed and, if practicable, the Category A (primary) criterion should be achieved. If this is not practicable, then mitigation should be assessed against Category B. However, if it is still not practicable to comply with categories A or B, then mitigation should be implemented to ensure the internal criterion in Category C is achieved. Depending on the specific building, mitigation in Category C could include ventilation and/or sound insulation improvements ranging from upgraded glazing through to new wall and ceiling linings. In Category C there is no protection of outdoor amenity.

For example, if the predicted do-minimum noise level was 70 dB, a 6 metre high barrier may be required to achieve the Category A criterion. This may not be practicable, or the project team may determine that adverse visual effects would be unacceptable. A 4 metre high barrier may provide sufficient attenuation to achieve the Category B criterion and may be visually acceptable. If mitigation within the road corridor is not practicable to achieve the Category B criterion, acoustics treatment for the PPFs would be investigated to achieve the Category C criterion internally.

NZS 6806 provides a procedure for assessing the benefits and costs of mitigation options to help determine the Best Practicable Option.

The criteria apply to a design year 10 to 20 years after the completion of the new or altered road. In this case, the opening year has been taken as 2017, and all noise predictions in this report relate to predicted traffic volumes in 2031.

2.4.3 Protected premises and facilities

This assessment has considered all noise sensitive locations within set distances from the Expressway. In accordance with NZS 6806 these are known as Protected Premises and Facilities (PPFs) and include existing houses, schools, marae and various other locations defined in the Standard. In accordance with NZS 6806, future (unbuilt) PPFs are not considered in this assessment, unless they have building consent. As at 24 August 2012, there were no known sites where there is building consent for a new PPF, near the Project within the following distances.

The distance from the road within which PPFs are considered is set in NZS 6806 according to Statistics New Zealand definitions of urban and rural areas as:

- urban areas - 100 metres from the edge of the nearside traffic lane; and
- rural areas - 200 metres from the edge of the nearside traffic lane.

Outside of these areas, PPFs do not require assessment under NZS 6806. The standard distances provide practical criteria to ensure the assessment is made at the most relevant receivers. Potential noise effects are still controlled at receivers further away by virtue of noise criteria applying at receivers nearest to the road. However, for the purposes of the Project, all PPFs where the predicted Project noise level is greater than 57 dB have also been considered in the qualitative assessment of effects. All PPFs considered are listed in Table 4-5.

2 Criteria

Figure 2-2 shows the Ōtaki and Te Horo urban areas as defined by Statistics New Zealand[8] from the 2006 census.

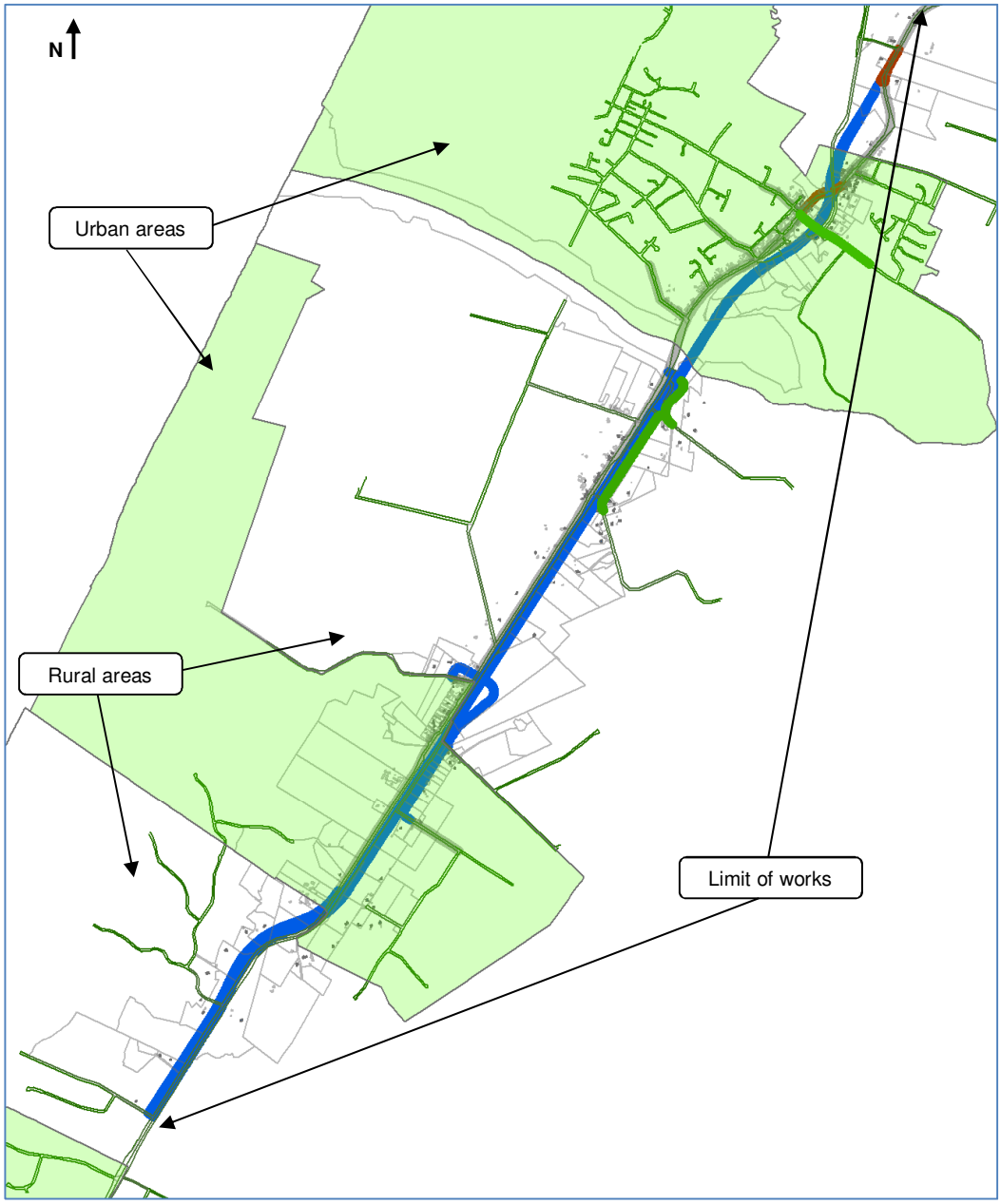

Figure 2-2 Statistical areas

2.4.4 Special case

The Project does not fit cleanly within the NZS 6806 definitions of new and altered roads, which determine the noise criteria discussed above. NZS 6806 defines a new road as any road which is to be constructed where no previously formed legal road existed. The Expressway fits this definition and is therefore a new road for the purposes of NZS 6806, other than at tie-ins with existing roads. However, new roads are typically formed in greenfield areas, where the existing environment is not dominated by significant road-traffic noise and hence are subject to relatively stringent criteria. On the

[8] New Zealand: An urban/rural profile, Statistics New Zealand

2 Criteria

other hand, the duplication of an existing road would be considered an alteration to the road, and as the area would already be subject to road-traffic noise, more lenient criteria apply. In some respects a duplication is more representative of the Project than a new road.

Section 6.2.1c of NZS 6806 states that for any PPFs which are significantly affected by noise from another existing road in the vicinity, it may be appropriate to apply different criteria. This clause is applicable in this instance to PPFs near the existing State highway, and in these cases the altered road criteria are appropriate, even though the Expressway is a new road. The following have been applied to identify PPFs where the altered road criterion is applied:

- within 100 metres of the existing State highway in Ōtaki which is being altered as part of the Project; and
- where the existing road-traffic noise level is assessed as 64 dB or greater at the PPF.

The Expressway running parallel to the new local arterial also requires special attention for noise mitigation design. Section 6.2.2 of NZS 6806 states that:

> *"Where PPFs are affected by noise from an existing road, mitigation is only required for road-traffic noise generated on the new or altered road"*

In many cases, placing a noise barrier immediately adjacent to the Expressway, between the main alignment and the railway/new local arterial, would not prove effective as PPFs remain exposed to the noise from traffic on the existing road. For this reason, during the mitigation design, noise from the new local arterial (existing State highway) has been included for the purposes of determining the best practicable option. However, in accordance with NZS 6806, the noise level results in Section 4.3 only includes the new and altered roads. For completeness, Table 4-5 also includes a column showing the total road-traffic noise including both the Expressway and new local arterial.

Figures 2-3 to 2-7, indicate the status of new and altered roads along the route, and PPFs where the altered road criteria have been applied. The figures show roads colour coded as:

- Blue - new road;
- Red - altered road;
- Grey - existing road; and
- Green - new road with AADT less than 2000 vpd (not modelled).

PPFs are colour coded:

- Blue - NZS 6806 new road criteria applied;
- Red - NZS 6806 altered road criteria applied; and
- Grey - beyond the 100/200 m distance from the road for consideration under NZS 6806, or a building which is not a PPF (e.g., commercial property or shed).

2 Criteria

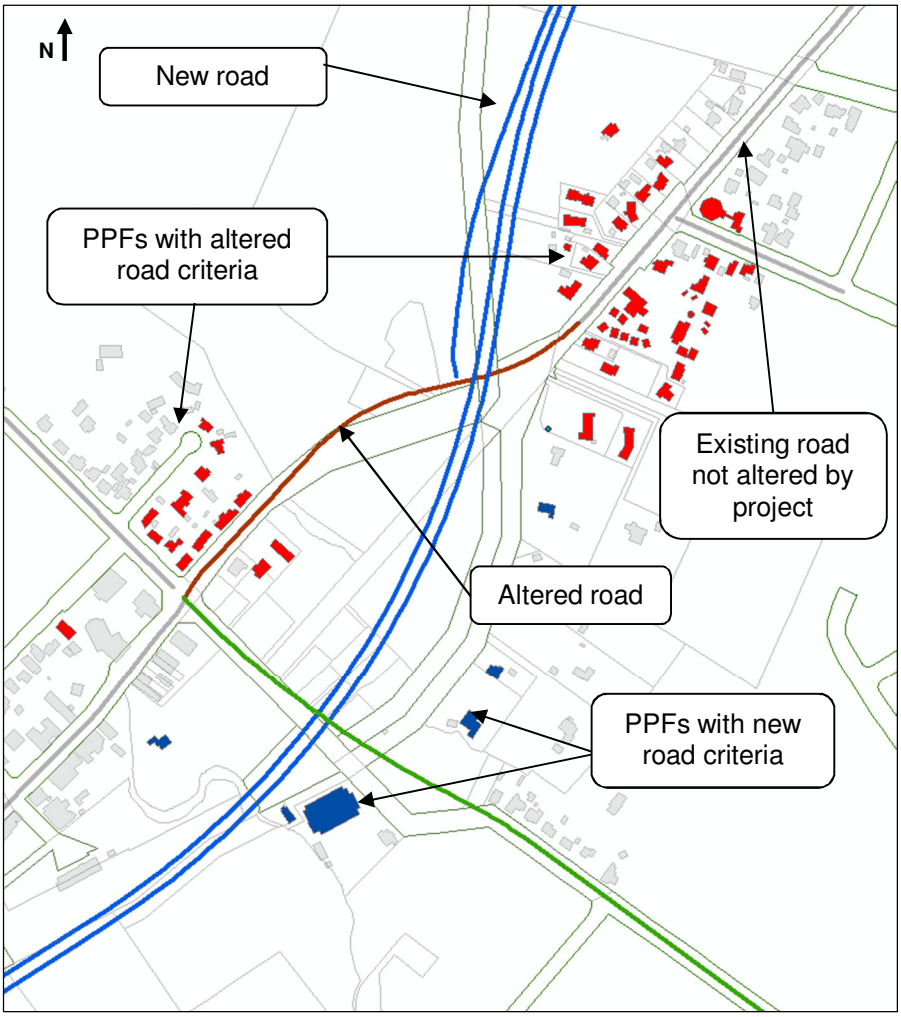

Figure 2-3 New and altered roads - Ōtaki Township

2 Criteria

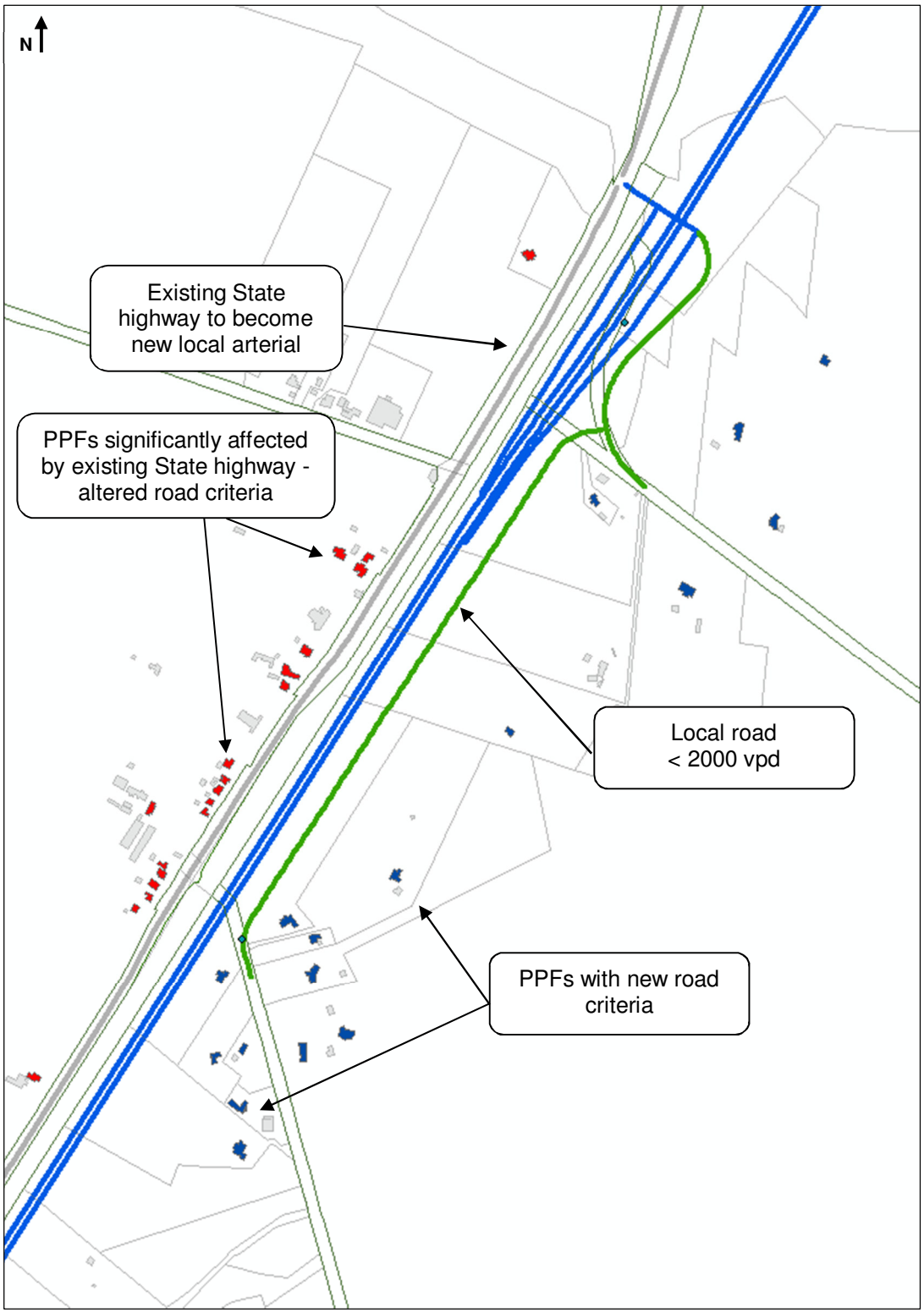

Figure 2-4 New and altered roads - Otaki Gorge Road

2 Criteria

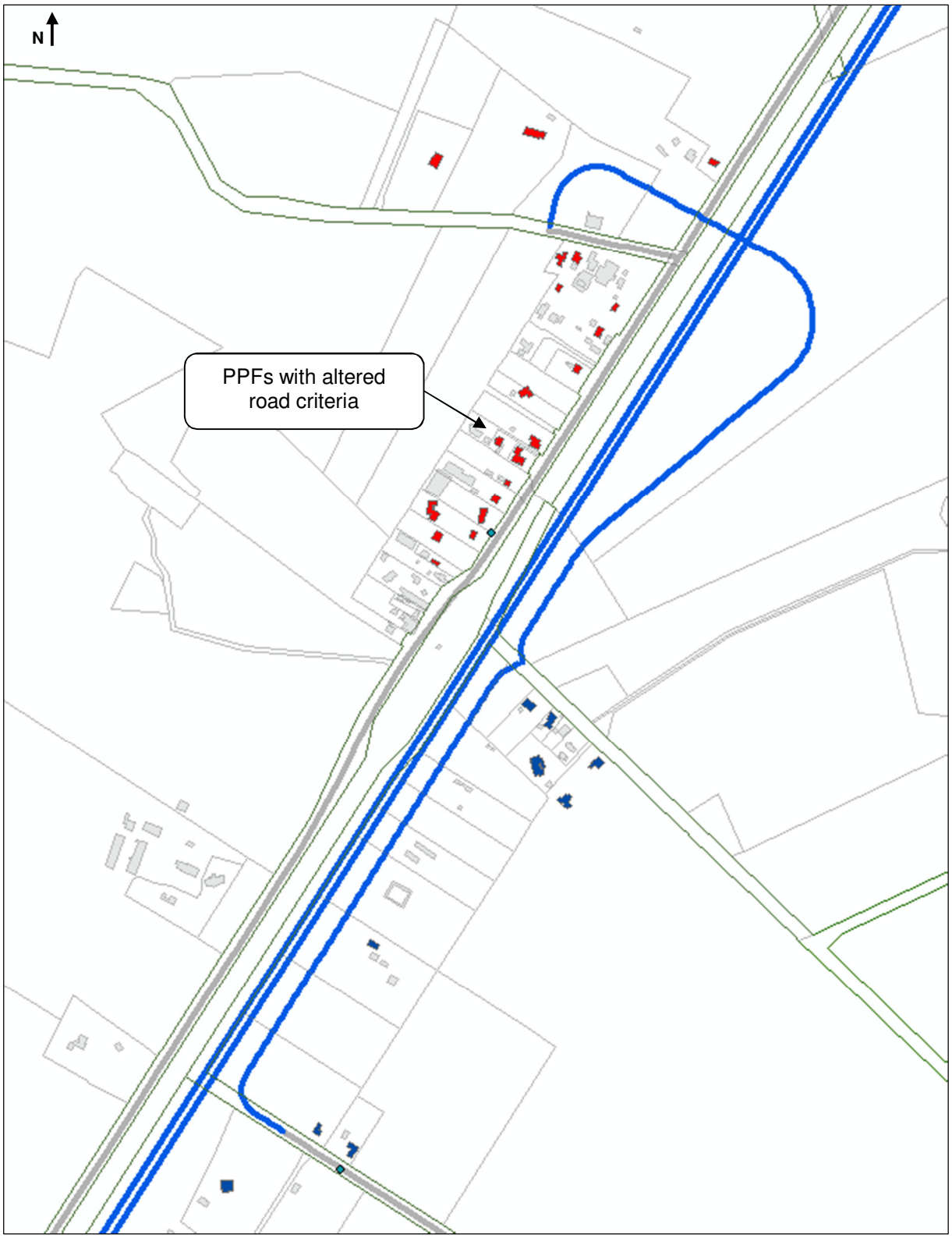

Figure 2-5 New and altered roads - Te Horo

2 Criteria

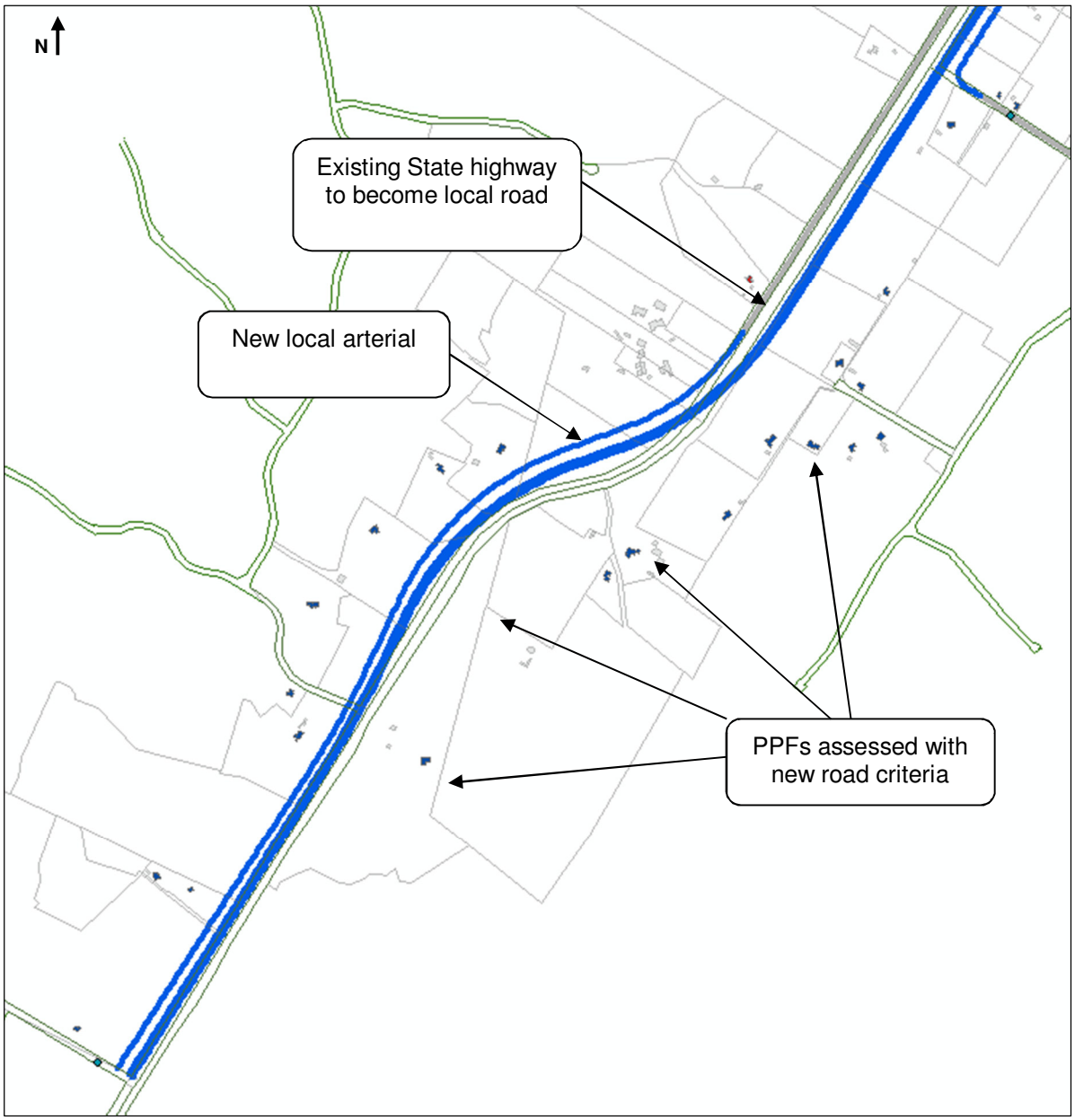

Figure 2-6 New and altered roads - South of Gear Road

2.4.5 Waterview Connection and Transmission Gully Projects

The Boards of Inquiry for the NZTA Waterview Connection Project (2011) and Transmission Gully Project (2012) both made extensive comment on NZS 6806, and raised several issues. Two key issues that arise from those decisions which require consideration for the Expressway are:

- The Boards considered that criteria in NZS 6806 should not be applied rigidly as the sole basis for operational road-traffic noise assessment. For the Project, the assessment of potential noise effects has occurred over a long period, including being part of the multi-criteria analysis at different stages of the scheme development. In the current stage, NZS 6806 has formed a framework for considering the potential effects and mitigation options. The criteria have informed this process, but there has also been an overarching qualitative assessment of the resulting noise effects as presented in Section 6. A key issue raised in relation to the Transmission Gully Project was the

provision of adequate information to allow the Board to see changes in noise levels, which is addressed in this report by the inclusion of Table 4-5.

- For both the Waterview Connection and Transmission Gully Projects, there were sections of the routes relatively remote from existing road-traffic noise where the new roads caused a significant change in acoustics amenity. In those areas, the Boards determined that the NZTA should treat individual PPFs if required to achieve the indoor noise criterion. This issue is discussed further in Section 5.3, but the situation is fundamentally different for the Project in that the alignment closely follows the route of an existing State highway. Therefore, in this instance, the surrounding areas are already influenced by road-traffic noise and there is not such a significant change in acoustics amenity.

2.5 Rail noise and vibration

Unlike road-traffic noise, there are no standardised criteria for noise and vibration from rail lines in New Zealand. In 2009, Marshall Day Acoustics Ltd prepared a report[9] for KiwiRail (Ontrack) advising appropriate criteria for reverse sensitivity guidelines. The resultant guidelines have criteria for new houses near rail designations that can be inserted in district plans, aimed at avoiding potential reverse sensitivity complaints against KiwiRail's operations. The criteria in Table 2-3 are proposed by the guidelines for rail noise and vibration.

While these reverse sensitivity guidelines were not intended to apply to new and altered railways, the criteria do provide a useful reference. The guidelines do not assess the effects for specific sites, but rather highlight areas where further assessment is required, through the use of a 40 metre 'buffer' zone and 80 metre 'effects' zone.

Table 2-3 Rail noise and vibration criteria

Criteria	Value
Outdoor areas	60 dB $L_{Aeq(1h)}$
Indoor areas - bedrooms	35 dB $L_{Aeq(1h)}$
Indoor areas - other habitable spaces	40 dB $L_{Aeq(1h)}$
Vibration	0.3 mm/s $v_{w,95}$ Class C limits from NS 8176E:2005[10]

The rail vibration criterion is based on the Norwegian Standard NS 8176. It contains classes of vibration based on the degree of annoyance or disturbance at various magnitudes of vibration and applies to bedrooms and living rooms in a residential building. Class C corresponds to the recommended upper limit of vibration in residential buildings in connection with the construction of a new railway. The vibration levels in each class are presented in terms of the statistical maximum weighted velocity or acceleration.

For the Project, the assessment is of the vibration effects on existing dwellings from the re-alignment of the existing railway line. Vibration effects may currently be present at a number of dwellings located near to the existing alignment.

[9] Marshall Day Acoustics Ltd (2009), *Ontrack Rail Noise Criteria, Reverse Sensitivity Guidelines.* Rp 2009031c Ontr
[10] Norwegian Standard NS 8176E:2005 *Measurement of vibration in buildings from landbased transport and guidance to evaluation of its effects on human beings*

2 Criteria

This assessment report does not consider any change in volumes or composition of rail traffic which may occur in the future, but rather just the direct effects of relocation of the railway to accommodate the Expressway.

3

Existing environment

3.1 Overview

Unlike previous standards, the criteria in NZS 6806 to assess road-traffic noise are not dependent on the existing noise levels. Measurements of existing levels are therefore not required for the main part of this assessment. However, an appreciation of the existing environment is required to understand and describe the potential noise effects, regardless of compliance with any particular criteria. Therefore, the existing environment has been assessed in detail through both modelling and measurements.

The Expressway closely follows the existing State highway and rail line, with the environments ranging from rural to urban. A noise survey has included measurements at two locations over a week to capture temporal variations, and spot measurements at six other locations to capture spatial variations.

For the existing State highway, computer modelling has been used to predict existing road-traffic noise levels to supplement measurements. This also forms the basis for comparisons with modelling of the Project.

The North Island Main Trunk Line runs parallel to the State highway from Peka Peka through to Ōtaki, before diverging. A noise survey has included measurements of rail noise from different trains at a fixed distance.

3.2 Road-traffic noise

3.2.1 Procedure

Two noise loggers were used over a period of one week. Loggers were configured to continuously make consecutive fifteen minute measurements. A portable sound analyser was used to conduct 'spot' fifteen minute daytime measurements at additional positions. During these times observations were made to identify dominant noise sources. All measurement locations were selected to be free-field. Measurement locations are listed in Table 3-1. Measurements were performed in general accordance with NZS 6801[11] and assessed using NZS 6806. As discussed in following sections, local weather data was not obtained, and therefore measurements may have been performed outside of the meteorological window prescribed by NZS 6801. This limitation is not expected to have a material effect on the results. Measurements were otherwise in accordance with NZS 6801. Full measurement details are held on file by URS and are available on request.

[11] NZS 6801:2008, Acoustics - Measurement of environmental sound

3 Existing environment

Table 3-1 Noise measurement locations

Noise loggers			Spot measurements		
Dates	**Address**	**Notes**	**Date/time**	**Address**	**Notes**
10-18/2/11	50 County Road, Ōtaki	Steady level from distant traffic	10/2/11 1415h	20 Peka Peka Road	Combination of distant and local traffic noise
10-18/2/11	903 SH1, Te Horo	Partially shielded by fences	10/2/11 1445h	9 Te Kowhai Road	SH1 dominant
			10/2/11 1645h	50 County Road	SH1 dominant
			11/2/11 0745h	15 Otaki Gorge Road	SH1 dominant
			11/2/11 0830h	9 Old Hautere Road	SH1 dominant
			11/2/11 0910h	97 Gear Road	SH1 dominant

Equipment

The following instrumentation was used for the survey:

- Acoustical Research Laboratories Type EL316 noise logger;
- Acoustical Research Laboratories Type Ngara noise logger;
- Brüel & Kjær Type 2250 sound level analyser; and
- Brüel & Kjær Type 4231 calibrator.

Meteorological conditions

During the survey, meteorological data was obtained from the nearest weather station at Paraparaumu Airport. This is some distance from the Project location, although no significant adverse weather conditions (high wind or rainfall) were encountered which would require exclusion of data. There has been no apparent influence of insect noise on the measurements (e.g. cicadas).

3 Existing environment

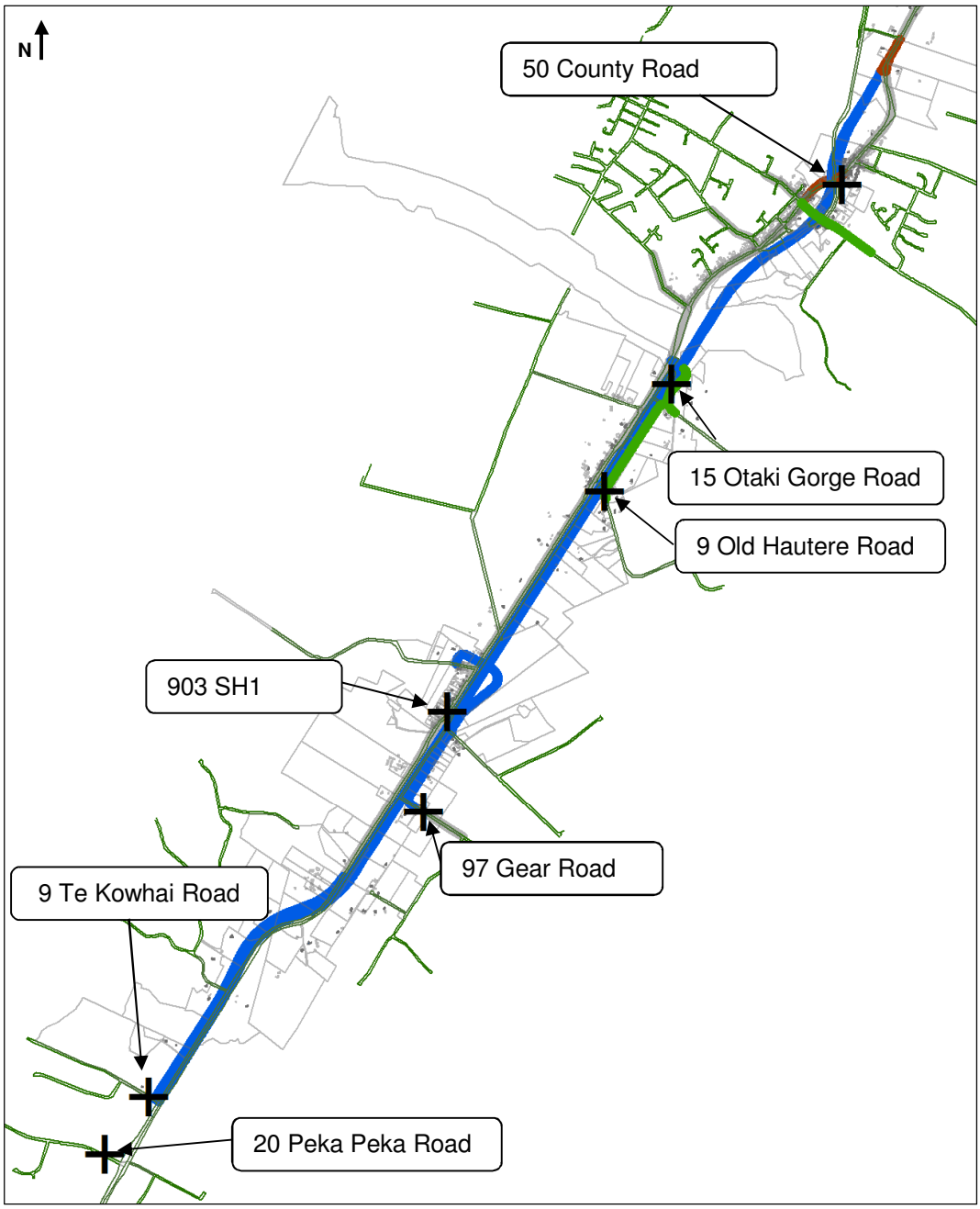

Figure 3-1 Measurement locations

Traffic data

For measurements dominated by road-traffic noise from existing SH1, the results have been adjusted to account for the actual traffic flow during the survey in comparison to the daily average. This has been done by using the daily traffic counts from the nearest permanent count station and adjusting the noise measurements to correspond to the 2010 Average Annual Daily Traffic (AADT).

Analysis

All data from each noise logger location has been averaged to obtain the $L_{Aeq(24h)}$ noise level at that location. For spot measurements, the daily variations in noise levels at the nearest noise logger location have been used to estimate the $L_{Aeq(24h)}$ noise level.

3 Existing environment

3.2.2 Results

Table 3-2 shows the measurement results and gives the modelled existing noise level for the same positions. According to NZS 6806 these should be within 2 dB, and where this is not the case the reasons are given in the table. In all cases, the modelled noise level is greater than the measured level, which indicates the conservatism of the calculation method.

Table 3-2 Measurement results

Dates	Address	Type	$L_{Aeq(24h)}$	Modelled	Comment
10-18/2/11	50 County Road, Ōtaki	Logger	54 dB	58 dB	Two rows of trees provides slight shielding from State highway
10-18/2/11	903 SH1, Te Horo	Logger	65 dB	65 dB	-
10/2/11 1415h	20 Peka Peka Road	Spot	59 dB	56 dB	Traffic from Peka Peka Road was not modelled, and the modelled section of SH1 did not extend south of Te Kowhai Road
10/2/11 1445h	9 Te Kowhai Road	Spot	55 dB	60 dB	Measurement position was partially shielded from State highway
10/2/11 1645h	50 County Road	Spot	53 dB	58 dB	Significant variation in daily pattern
11/2/11 0745h	15 Otaki Gorge Road	Spot	58 dB	60 dB	-
11/2/11 0830h	9 Old Hautere Road	Spot	55 dB	58 dB	Significant variation in daily pattern
11/2/11 0910h	97 Gear Road	Spot	47 dB	53 dB	Measurement position did not have full field of view of State highway

3.2.3 Uncertainty

By performing a measurement, the true value of a parameter is only known to within a measurement uncertainty. An uncertainty budget is presented in Table 3-3 for the noise measurements performed at 50 County Road, based on the methodology proposed by Craven and Kerry[12]. This budget is generally representative of other measurements.

[12] N.J. Craven and G. Kerry. *A good practice guide on the sources and magnitude of uncertainty arising in the practical measurement of environmental noise.* University of Salford. 2001.

Table 3-3 Measurement uncertainty budget (road-traffic noise)

Source of uncertainty	Value (half width)	Conversion	Distribution	Standard uncertainty
Source				
Traffic flow	1000 in 22000 vpd	0.2 dB	Rectangular	0.11 dB
% HGV and Mean speed	5% at 90km/hr to 15% at 110km/hr	3.1 dB	Rectangular	1.8 dB
Transmission path				
Weather	3.0 dB	3.0 dB	Rectangular	1.7 dB
Ground	-	-	-	-
Topography	-	-	-	-
Receiver				
Position	2 m in 100 m	0.1 dB	Rectangular	0.50 dB
Instrumentation	1.9 dB	1.9 dB	Rectangular	1.1 dB
Background	< 0.1 dB	-	-	-
Reflective surfaces	1.0 dB	1.0 dB	Rectangular	0.58 dB
Combined uncertainty				2.8 dB
Expanded uncertainty (95% confidence)				5.7 dB

3.3 Rail noise

3.3.1 Procedure

Rail noise measurements to determine train characteristics were performed at a single location, which was chosen to minimise noise from other sources and also to avoid terrain screening. The chosen location was at Taylors Road, north of Ōtaki. Measurements were taken approximately 16 metres from the railway. The measurements were conducted in accordance with NZS 6801, which defines good practice for noise measurements. The measurement commenced when the train was able to be seen or heard. The measurement duration at night was longer due to the lower background noise levels.

No measurements of rail noise were performed at PPFs. This was due to the infrequent number of train movements, and the need to obtain a positive measurement above the ambient sound levels.

Equipment

The following instrumentation was used for the survey:

- Brüel & Kjær Type 2250 sound level analyser; and
- Brüel & Kjær Type 4231 calibrator.

3.3.2 Results

The results of the rail noise measurements are presented in Table 3-4. The results are in terms of the sound exposure level (L_{AE}) and a 1-hour time-average noise level ($L_{Aeq(1h)}$), assuming only a single rail movement.

3 Existing environment

Table 3-4 Rail noise measurement results

Location	Distance to track	Date	L_{AE}	$L_{Aeq(1h)}$
The Overlander (south bound)	16 m	10/02/2011 1800h	95 dB	59 dB
Capital Connection (north bound)	16 m	10/02/2011 1840h	100 dB	65 dB
Freight train (south bound)	16 m	10/02/2011 2150h	102 dB	66 dB

The KiwiRail reverse sensitivity guidelines (Section 2.4.5) state that a reference train noise can be deemed to be 70 dB $L_{Aeq(1h)}$ at 12 metres from the closest rail track. This is consistent with the measurements taken in Ōtaki at 16 metres, assuming there are two freight movements in an hour or multiple passenger train movements.

Train noise levels have been predicted at four different distances, as shown in Table 3-5. This assumes a train noise level of 70 dB $L_{Aeq(1hr)}$ at 12 metres and 3 dB per doubling of distance up to 30 metres from the track, and 6 dB per doubling thereafter.

Table 3-5 Predicted rail noise levels

Distance from track edge	Indicative rail noise level, $L_{Aeq(1h)}$
40 metres	64 dB
60 metres	60 dB
80 metres	58 dB
100 metres	56 dB

3.3.3 Uncertainty

Unlike the road-traffic noise measurements, the rail measurements are of discrete events, which would often lead to the use of statistical techniques to determine variances, however in this instance the small sample size (4 events) would not provide meaningful results. An uncertainty budget for rail noise measurements is presented in Table 3-6 using the same format as road-traffic noise. Due to the smaller distances between source and receiver, propagation uncertainties are lower.

Table 3-6 Measurement uncertainty budget (rail noise)

Source of uncertainty	Value (half width)	Conversion	Distribution	Standard uncertainty
Source				
Mean speed	5 km/hr in 70 km/hr	0.3 dB	Rectangular	0.19 dB
Wheel roughness	1.5 dB	1.5 dB	Rectangular	0.87 dB
Transmission path				
Weather	1 dB	1.0 dB	Rectangular	0.58 dB
Receiver				
Position	1 m in 12 m	0.3 dB	Rectangular	0.20 dB
Instrumentation	1.9	1.9 dB	Rectangular	1.10 dB
Combined uncertainty				1.54 dB
Expanded uncertainty (95% confidence)				3.07 dB

3.4 Rail vibration

3.4.1 Procedure

Vibration measurements were conducted in accordance with the requirements of NS 8176, adjacent to Ōtaki Station. A tri-axial array of accelerometers was located at a free-field position approximately 60 metres from the existing railway, chosen to represent the distance of the realigned railway to nearest receivers. Acceleration data was recorded from each of the passing trains for subsequent analysis. The data recording was started before the arrival of the train and stopped after the train had passed, to ensure the complete vibration record was obtained. The passenger trains (Capital Connection) stopped at Ōtaki Station and therefore the measurements for these trains included deceleration, stationary and accelerating elements of the passby.

Equipment

The following instrumentation was used for the survey:

- Svantek 958 sound and vibration analyser; and
- Svantek 207A building vibration accelerometer (tri-axial).

3 Existing environment

The trains measured are described in Table 3-7.

Table 3-7 Trains measured

Date	Time	Type	Direction	Stop at station?	Configuration
11-Jun	16:49	Freight	South	No	2 locos, 20 wagons
11-Jun	18:23	Passenger	North	Yes	1 loco, 7 coaches,1 guards vehicle
11-Jun	20:06	Freight	North	No	3 locos, hoppers and flats
13-Jun	20:30	Freight	North	No	2 locos, 40 wagons
13-Jun	21:30	Freight	South	No	3 locos, 35 wagons
14-Jun	05:50	Freight	South	No	North-bound train stopped in passing loop
14-Jun	07:10	Passenger	South	Yes	1 loco, 7 coaches,1 guards vehicle
14-Jun	09:45	Freight	South	No	2 loco, ~40 wagons

Analysis

NS 8176 specifies a minimum of fifteen train passbys, with at least 30% of the train type that gives the highest levels of weighted vibration. Due to the infrequent trains at this location, eight events were measured. 75% of these events were from the freight trains which produced the highest levels of weighted vibration. Further measurements, to increase the number of trains up to fifteen, is not expected to change the results significantly. The highest levels of vibration were measured in vertical and transverse directions relative to the railway line.

Analysis of the acceleration data was as follows:

1. For each passby, the maximum weighted acceleration was calculated according to NS 8176.
2. The maximum weighted velocity was obtained from the maximum weighted acceleration using the relationship given in NS 8176 (Section 5.2, Equation 1).
3. The maximum weighted velocities (representing a free-field location) were converted to the levels expected on the floor of a single storey building using the following empirical factors[13]:
    a. free-field to foundation for single storey residential x 1 (max);
    b. foundation to floor x 0.79;
    c. wooden floor resonance x 2;
    d. total for concrete floor = 1 x 0.79 = 0.79; and
    e. total for wooden floor = 1 x 0.79 x 2 = 1.58.
4. The mean, standard deviation, statistical maximum and coefficient of variation were calculated from the maximum weighted velocities for concrete and for wooden floors.

3.4.2 Results

The results of the analysis are presented in Table 3-8, where exceedance of the proposed design criterion is shown, particularly in buildings with wooden floors. It should be noted that there are a

[13] US DOT/Transportation Systems Center (1982) *Handbook of Urban Rail Noise and Vibration Control*, report UMTA-MA-06-0099-82-2

3 Existing environment

number of houses on Rahui and County Roads, which are closer than 60 metres and higher levels of vibration will be currently experienced. NS 8176E provides a Class D criterion of 0.6 mm/s, which should be achieved for existing buildings, and vibration at this level correlates to about 25% of people being disturbed by vibration in dwellings from new infrastructure.

Table 3-8 Analysis results

Parameter	Value		Criterion
	Concrete floor	Wooden floor	
Distance from railway	60 m		-
Average velocity	0.30 mm/s	0.59 mm/s	
Standard deviation	0.09 mm/s	0.18 mm/s	
Coefficient of variation	0.303	0.303	<1.0
Statistical maximum weighted velocity	0.46 mm/s	0.91 mm/s	0.3 mm/s (Class C)

3.4.3 Uncertainty

The reported vibration parameter ($v_{w,95}$) is determined statistically from the mean and standard deviation of the eight samples, and therefore considers uncertainty when considering the 95th percentile. There are other uncertainties associated with equipment and transducer mounting, which have the potential to cause a constant offset which is not identified by the statistical assessment. A vibration uncertainty budget is presented in Table 3-9.

Table 3-9 Uncertainty budget (rail vibration)

Source of uncertainty	Value (half width)	Conversion	Distribution	Standard uncertainty
Source				
N/A - variations considered by multiple measurements				
Transmission path				
Transducer mounting	3 dB	3.0 dB	Rectangular	1.73 dB
Receiver				
Position	5 m in 60 m	0.3 dB	Rectangular	0.20 dB
Instrumentation / calibration	2.5 dB	2.5 dB	Rectangular	1.44 dB
Combined uncertainty				2.26 dB
Expanded uncertainty (95% confidence)				4.53 dB

4

Modelling

4.1 Procedures

Modelling of road-traffic noise provides an objective basis to consider future activity. The modelling techniques used are well established in New Zealand.

In addition to the existing scenario, two scenarios modelled were:

- do-nothing - the Project not constructed; the existing roads with 2031 traffic; and
- do-minimum - the Project constructed; 2031 traffic; no specific noise mitigation.

Comparison of do-nothing and do-minimum noise levels shows that the Project meets the threshold criteria to be considered as both a new and altered road in accordance with NZS 6806. After identifying all PPFs which were in NZS 6806 categories B and C in the do-minimum scenario, the Project was split into seven assessment areas labelled Areas A to G. The locations of the assessment areas are shown in Figure 4-1.

4 Modelling

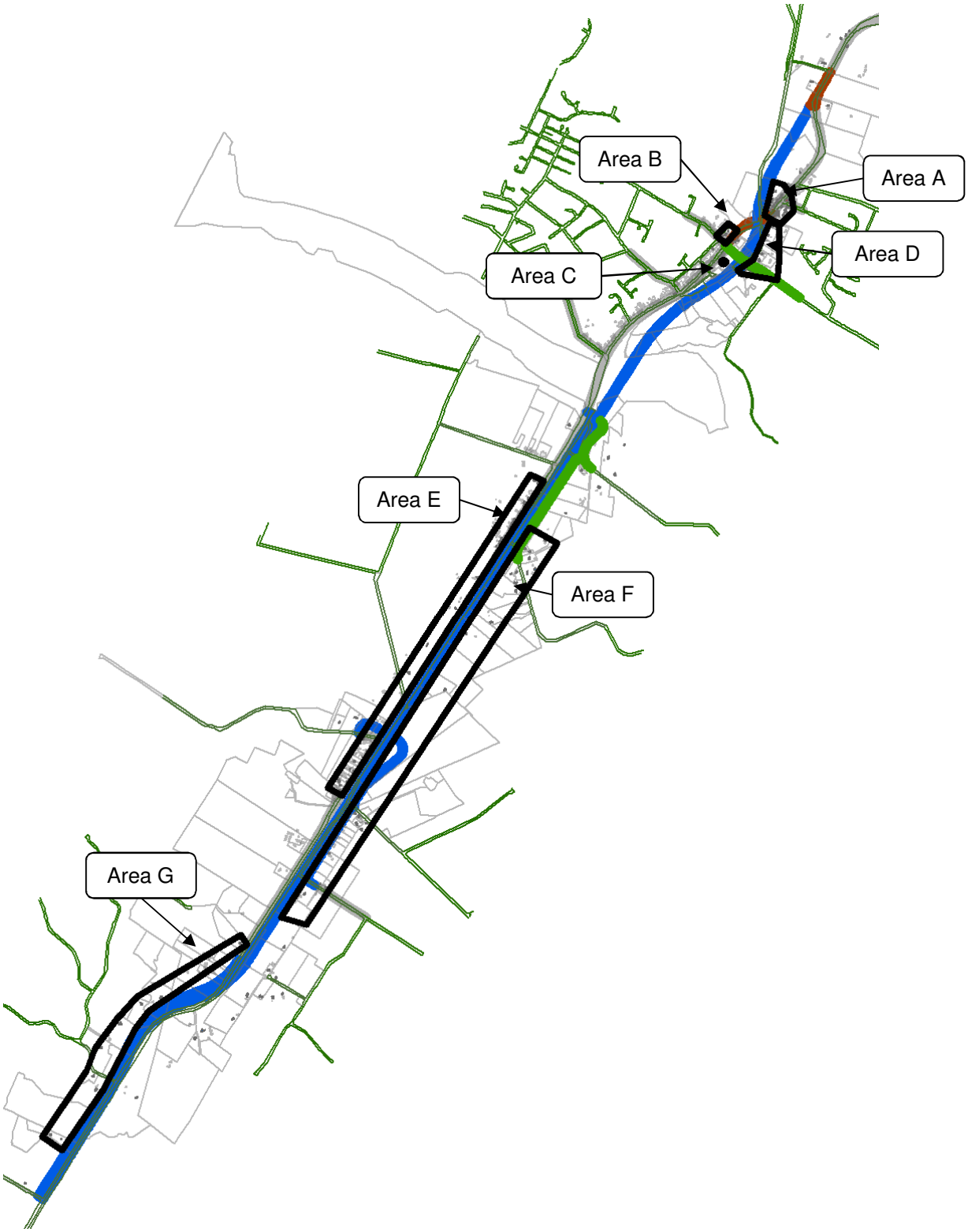

Figure 4-1 Noise assessment areas

The noise mitigation options considered for each area are detailed in Table 4-1 and a summary matrix of all the assessment scenarios considered is provided in

4 Modelling

Table 4-2. Where no mitigation options are listed it is because all PPFs are in NZS 6806 Category A in the do-minimum scenario. For each option modelled predictions were made at all individual receivers. Table 4-3 lists the key model settings.

Table 4-1 Noise mitigation options

Area	Project section	Noise mitigation options
A	North of Ōtaki Ramp	3 m high barrier roadside of Expressway
		5 m high barrier roadside of Expressway
		Open graded porous asphalt surface to Expressway
		Open graded porous asphalt surface to Expressway and 3 m high barriers
B	Main Highway, Ōtaki	2 m high barrier on property boundary
		Asphaltic concrete surface to local arterial
C	230 Main Highway, Ōtaki	5 m high barrier railside
		3 m high barrier roadside of Expressway
		Open graded porous asphalt surface to Expressway
D	East Ōtaki	3 m high barrier roadside of Expressway
		Open graded porous asphalt surface to Expressway
		Open graded porous asphalt surface to Expressway, asphaltic concrete to Rahui Road and 3 m high barriers
E	Otaki Gorge to Te Horo (West)	3 m high barriers roadside of Expressway
		5 m high roadside of local road
		Open graded porous asphalt surface to Expressway
		Open graded porous asphalt surface to Expressway and new local arterial
F	Otaki Gorge to Te Horo (East)	3 m high barriers roadside of Expressway
		5 m high barriers outside of swale
		Open graded porous asphalt surface to Expressway
		Building modification to Category C PPFs
		Combination of 3, 4 and 5 metre high barriers roadside of Expressway to meet Transit Guidelines
G	South of Mary Crest	3 m high barriers roadside of Expressway
		5 m high barriers roadside of Expressway
		Open graded porous asphalt surface to Expressway
		3 m high barriers roadside of Expressway to meet Transit Guidelines

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Table 4-2 Assessment scenarios

Scenario	Year	Assessment Area						
		A	B	C	D	E	F	G
Existing	2010	✓	✓	✓	✓	✓	✓	✓
Do-nothing	2026	✓	✓	✓	✓	✓	✓	✓
Do-minimum	2026	✓	✓	✓	✓	✓	✓	✓
Mitigation Option 1	2026	✓	✓	✓	✓	✓	✓	✓
Mitigation Option 2	2026	✓	✓	✓	✓	✓	✓	✓
Mitigation Option 3	2026	✓		✓	✓	✓	✓	✓
Mitigation Option 4	2026	✓				✓	✓	✓
Mitigation Option 5	2026						✓	

Changes in model

At the end of the assessment of mitigation options, the selected options were combined and the entire scheme was remodelled as the final 'BPO scenario'. Following the options assessment, some details of the model were refined and the calculations for the existing, do-nothing and do-minimum were also updated. The BPO mitigation was reviewed to confirm that this remodelling did not alter the basis for any of the options selected. The updates to the modelling were:

- The traffic modelling used during the scheme assessment (2026) has been replaced with design year (2031) values based on an updated traffic model;
- Basic 2010 traffic data based on count stations has been replaced by the results of the network model with traffic volumes for each network link;
- Building heights have been adjusted where two-story buildings have been identified during site visits;
- A PPF has been removed where the building was confirmed to be a farm shed during a site visit, and another PPF has been added where it was confirmed to be used as a residence;
- Road surface assumptions have been refined using the most recent NZTA data. A section of PA-10 has been included on the existing State highway in Te Horo where is was previously modelled as chip seal;
- PPFs on Rahui Road have been removed from the model as the traffic volume has reduced below 2000 vpd. These PPFs are now greater than 100 metres from the nearest modelled road;
- The earthworks have been updated to reflect the raising of the Expressway by Gear Road due to stormwater issues, the lowering of the Expressway between School Road and Old Hautere Road, the addition of landscaping bunds, and various other developments to the Project; and
- 0.5 m resolution terrain contours have been used to more accurately model the screening of the existing State highway provided by the rail embankment adjacent to Old Hautere and Gear Roads. Previously 1m contours were used.

Table 4-3 lists the key model settings.

The modelling was carried out by John McKirdy of URS.

Table 4-3 Model settings

Parameter	Setting/source
Software	Cadna/A v4.2
Algorithm	CRTN[14]
Reflection model	CRTN
Parameter	$L_{Aeq(24h)}$
Ground absorption	1.0
Receiver height	1.5 m (4.5 m upper floors) - most exposed façade
Noise contour grid	1.5 m height, 10 m resolution
Receivers and grid position	free-field

The CRTN algorithm gives results in terms of the $L_{A10(18h)}$. To convert this to $L_{Aeq(24h)}$ a -3 dB adjustment has been made. This adjustment has been implemented in the software in conjunction with the road surface adjustment detailed below.

4.2 Input data

Most data used in the noise model has been obtained directly from the Project GIS data. However, in some instances additional data such as traffic flow have required manual entry direct into the noise model.

Contours

Topographic contours have been imported directly from the Project GIS. The contour resolution was with 0.5 metre. Road gradients and screening have been determined from the topographic contours.

Two sets of topographic contours have been used:

- do-nothing contours of the existing landform without the Project, and
- do-minimum contours of the new landform with the Project.

All of the mitigation options and final BPO scenario are based on the do-minimum topographic contours.

Buildings

The footprints for all buildings and all other structures within 200 metres of the roads have been imported into the noise model from building outlines received from KCDC. All buildings have been modelled as 5 metres uniform height for single storey buildings and 7.5 metres uniform height for known two-storey buildings which were identified during site visits and using Google StreetView. Predictions were made at all façades of individual buildings, with the noise levels stated being the highest of any facade.

[14] Calculation of Road Traffic Noise (CRTN). UK Department of Transport and the Welsh Office. ISBN 0115508473. 1988

4 Modelling

Road alignments

Road alignments have been imported from the Project GIS as centrelines and road widths. Each two-lane carriageway has been modelled as a separate road. Gradients have been calculated by the noise software. Where there is a third lane (e.g. exit lane) this has been modelled as a separate road. Local roads with one lane in each direction have each been modelled as a single road.

Road surfaces

Surfaces of existing roads in the do-nothing scenario have been modelled as the current surfaces recorded in the NZTA database. In the do-minimum scenario the Expressway has been assumed to have a grade 2/4 chip seal surface. In investigating mitigation options alternative surfaces have been tested in the noise model for some sections.

The procedure used to incorporate different road surfaces in the model is as follows:

- in accordance with Transit Research Report 28[15], a -2 dB adjustment has been made for a reference asphaltic concrete road surface compared to CRTN;
- surface corrections relative to asphaltic concrete have been in accordance with LTNZ Research Report 326[16]. The combination of surface corrections for cars and heavy vehicles have been made using the equation on the NZTA Transport Noise website[17]; and
- the combined correction has been entered in the modelling software as a road surface correction. This has also included the adjustment from $L_{A10(18h)}$ to $L_{Aeq(24h)}$.

Safety barriers

Solid (e.g. concrete) safety barriers have been manually entered in the noise model as 0.8 m high barriers for the do-minimum scenario. The only safety barriers modelled are on the bridges.

Bridges

Bridges have been configured to be 'self-screening' roads, which blocks the noise of that road passing through them. Where there are no safety barriers, to represent the kerb and channel on bridges, a 150 mm high vertical barrier has been modelled along the edges of the bridges.

Traffic data

Traffic data has been provided for all roads as the Annual Average Daily Traffic (AADT), percentage of heavy vehicles and speed, as shown in Table 4-4. This has been provided separately for each carriageway. All traffic data has been provided for the design year of 2031, which is 13 years after the assumed opening year of 2018.

The CRTN model has been developed based on 18-hour traffic. However, this has been entered as the 24-hour daily traffic (AADT), which results in modelling in the order of +0.2 dB conservative.

[15] Research Report 28. Traffic noise from uninterrupted traffic flows, Transit, 1994
[16] Research Report 326: Road surface effects on traffic noise: Stage 3 - Selected bituminous mixes. Land Transport New Zealand, 2007
[17] NZTA Transport Noise website, www.acoustics.nzta.govt.nz, accessed 24 August 2012

4 Modelling

Table 4-4 Road surface and traffic parameters

Section	Existing (2010)				Do-nothing (2031)				Do-minimum (2031)			
	Surface	Speed (km/h)	AADT (vpd)	HV (%)	Surface	Speed (km/h)	AADT (vpd)	HV (%)	Surface	Speed (km/h)	AADT (vpd)	HV (%)
Expressway (one way)												
North of Taylors Road (two way)	Grade 2/4	100	12,518	10	Grade 2/4	100	14,730	18	Grade 2/4	100	14,852	18
Otaki on-ramp NB									Grade 2/4	70	2,788	22
Otaki off-ramp SB									Grade 2/4	70	2,766	22
North of Otaki on-ramp NB									Grade 2/4	70	7,782	18
North of Otaki on-ramp SB									Grade 2/4	70	4,495	14
North of Otaki Gorge Road NB									Grade 2/4	100	4,993	16
North of Otaki Gorge Road SB									Grade 2/4	100	4,495	14
Otaki Gorge off-ramp NB									Grade 2/4	70	3,930	33
Otaki Gorge on-ramp SB									Grade 2/4	70	3,705	32
North of Peka Peka Road NB									Grade 2/4	100	8,923	23
North of Peka Peka Road SB									Grade 2/4	100	8,200	22
Existing SH1 / new local arterial (two way)												
South of Te Manuao Rd	AC-10 / PA-10	50	12,499	10	Grade 2/4	50	16,679	17	Grade 2/4	50	5,172	16
North of Mill Road	AC-10	50	13,935	10	AC-10	50	16,679	17	AC-10	50	7,266	19
North of Riverbank Road	AC-10 / BBM	50-70	10,808	11	AC-10 / BBM	50-70	14,799	19	AC-10 / BBM	50-70	6,862	24
North of Otaki Gorge Road	AC-10	100	15,095	11	AC-10	100	19,285	22	AC-10	100	9,762	29
North of School Road	Grade 2/4	100	15,521	11	Grade 2/4	100	19,951	22	Grade 2/4	100	2,699	18
Te Horo	PA-10	70	16,453	11	PA-10	70	21,119	22	PA-10	70	3,822	20
Mary Crest	Grade 2/4	80	16,453	11	Grade 2/4	80	21,119	22	Grade 2/4	80	3,822	20
North of Peka Peka Road	Grade 2/4	100	16,453	11	Grade 2/4	100	21,119	22	Grade 2/4	100	4,249	19
Local roads (two way)												
Overbridge at Otaki Gorge Rd									Grade 2/4	50	4,370	6
Gear Rd	Grade 2/4	50	2363	10	Grade 2/4	50	3079	17	Grade 2/4	50	2,723	19
Overbridge at School Rd									Grade 2/4	50	4,194	17

4.3 Results

Predicted road-traffic noise levels at all PPFs are shown in Table 4-5. For the do-minimum and BPO scenarios, the cells are colour coded according to the NZS 6806 category: Category A - green, Category B - orange and Category C - red. An additional column is provided with the predicted noise levels at PPFs with the scheme road and existing roads with over 2000 vehicles per day.

A set of plans with building references and noise contours are presented in drawings N-001 to N-008.

The development of the BPO shown in Table 4-5 is detailed in Section 5. Area 'X' receivers have not been specifically considered for noise mitigation because they either meet Category A in the do-minimum scenario, or they exceed the 100/200 m PPF catchment distance. While NZS 6806 does not require these to be assessed, all PPFs with a predicted noise level of greater than 57 dB are listed in this table and have been considered in the qualitative assessment of noise effects.

Table 4-5 Predicted noise levels, dB $L_{Aeq(24h)}$

ID	Area	Address	Type	Predicted noise level, $L_{Aeq(24h)}$				
				All roads		Scheme roads only		All roads
				Existing	Do-nothing	Do min	BPO	BPO
R009	A	291A Main Hwy	Altered	53 dB	51 dB	55 dB	53 dB	53 dB
R010	A	291 Main Hwy	Altered	50 dB	48 dB	59 dB	56 dB	56 dB
R011	A	287 Main Hwy	Altered	61 dB	60 dB	52 dB	49 dB	54 dB
R012	A	285 Main Hwy	Altered	64 dB	63 dB	55 dB	55 dB	58 dB
R013	A	283 Main Hwy	Altered	62 dB	61 dB	56 dB	56 dB	58 dB
R014	A	277A Main Hwy	Altered	50 dB	49 dB	65 dB	61 dB	61 dB
R015	A	286 Main Hwy	Altered	66 dB	65 dB	56 dB	55 dB	63 dB
R016	A	281 Main Hwy	Altered	63 dB	62 dB	59 dB	59 dB	60 dB
R017	A	275A Main Hwy	Altered	52 dB	51 dB	65 dB	61 dB	61 dB
R018	A	277 Main Hwy	Altered	63 dB	62 dB	59 dB	59 dB	60 dB
R019	A	271 Main Hwy	Altered	55 dB	53 dB	63 dB	60 dB	60 dB
R020	A	275 Main Hwy	Altered	65 dB	64 dB	61 dB	61 dB	61 dB
R021	A	273 Main Hwy	Altered	64 dB	63 dB	61 dB	60 dB	60 dB
R022	A	3A Te Manuao Rd	Altered	58 dB	59 dB	50 dB	48 dB	59 dB
R023	A	276 Main Hwy	Altered	67 dB	65 dB	63 dB	63 dB	63 dB
R024	A	5 Te Manuao Rd	Altered	62 dB	63 dB	47 dB	45 dB	63 dB
R025	A	3B Te Manuao Rd	Altered	60 dB	61 dB	48 dB	46 dB	61 dB
R026	A	3C Te Manuao Rd	Altered	53 dB	52 dB	51 dB	50 dB	51 dB
R027	A	269 Main Hwy	Altered	63 dB	62 dB	63 dB	60 dB	60 dB
R028	A	270A Main Hwy bld1	Altered	68 dB	67 dB	65 dB	65 dB	65 dB
R029	A	270A Main Hwy bld2	Altered	67 dB	66 dB	64 dB	64 dB	64 dB
R030	A	270A Main Hwy bld3	Altered	57 dB	56 dB	55 dB	55 dB	55 dB

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ID	Area	Address	Type	Predicted noise level, $L_{Aeq(24h)}$				
				All roads		Scheme roads only		All roads
				Existing	Do-nothing	Do min	BPO	BPO
R031	A	270A Main Hwy bld5	Altered	67 dB	65 dB	64 dB	63 dB	63 dB
R032	A	270A Main Hwy bld4	Altered	51 dB	50 dB	51 dB	49 dB	50 dB
R033	A	272 Main Hwy	Altered	51 dB	50 dB	52 dB	50 dB	51 dB
R034	A	270A Main Hwy bld6	Altered	57 dB	56 dB	55 dB	54 dB	54 dB
R035	A	270A Main Hwy bld7	Altered	53 dB	52 dB	52 dB	50 dB	51 dB
R036	A	270A Main Hwy bld8	Altered	52 dB	50 dB	50 dB	49 dB	50 dB
R037	A	268 Main Hwy	Altered	68 dB	67 dB	66 dB	65 dB	65 dB
R038	A	270A Main Hwy bld9	Altered	50 dB	49 dB	50 dB	48 dB	49 dB
R039	A	266 Main Hwy	Altered	58 dB	56 dB	57 dB	56 dB	56 dB
R040	A	270B Main Hwy	Altered	52 dB	50 dB	51 dB	50 dB	50 dB
R041	A	270 Main Hwy	Altered	53 dB	51 dB	52 dB	51 dB	51 dB
R042	B	17 Hariata St	Altered	52 dB	50 dB	50 dB	49 dB	49 dB
R045	B	15 Hariata St	Altered	57 dB	55 dB	55 dB	53 dB	53 dB
R046	B	9 Mill Rd	Altered	57 dB	55 dB	56 dB	54 dB	55 dB
R047	B	294-296 Mill Rd	Altered	66 dB	64 dB	62 dB	62 dB	62 dB
R048	B	5 Hariata St	Altered	52 dB	50 dB	51 dB	50 dB	50 dB
R050	B	1 Hariata St	Altered	59 dB	59 dB	49 dB	46 dB	59 dB
R051	B	290-292 Mill Rd	Altered	68 dB	66 dB	63 dB	63 dB	63 dB
R052	B	280 Mill Rd	Altered	61 dB	61 dB	50 dB	48 dB	61 dB
R053	B	288 Mill Rd	Altered	67 dB	65 dB	62 dB	62 dB	62 dB
R054	B	282 Mill Rd	Altered	60 dB	60 dB	53 dB	52 dB	60 dB
R056	B	286 Mill Rd	Altered	69 dB	67 dB	64 dB	64 dB	64 dB
R062	C	230 Main Hwy	New	54 dB	53 dB	58 dB	55 dB	55 dB
R043	D	50 County Rd	Altered	58 dB	56 dB	57 dB	55 dB	55 dB
R044	D	52 County Rd	Altered	51 dB	49 dB	53 dB	51 dB	51 dB
R049	D	46 County Rd	New	56 dB	54 dB	62 dB	58 dB	58 dB
R059	D	22 County Rd	New	49 dB	48 dB	57 dB	52 dB	52 dB
R060	D	12 County Rd	New	50 dB	48 dB	58 dB	54 dB	54 dB
R066	D	Former Rahui Milk Treatment Station	New	51 dB	50 dB	66 dB	61 dB	61 dB
R068	D	Former Rahui Factory Social Hall	New	49 dB	48 dB	67 dB	63 dB	63 dB
R080	E	1217 SH1	Altered	57 dB	58 dB	54 dB	54 dB	55 dB
R081	E	1215 SH1	Altered	66 dB	67 dB	57 dB	57 dB	61 dB
R082	E	1209 SH1	Altered	66 dB	68 dB	57 dB	57 dB	61 dB

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ID	Area	Address	Type	Predicted noise level, $L_{Aeq(24h)}$				
				All roads		Scheme roads only		All roads
				Existing	Do-nothing	Do min	BPO	BPO
R084	E	1195 SH1	Altered	67 dB	68 dB	59 dB	59 dB	62 dB
R085	E	1191 SH1	Altered	68 dB	70 dB	59 dB	59 dB	63 dB
R086	E	1189 SH1	Altered	67 dB	69 dB	59 dB	59 dB	62 dB
R088	E	1173 SH1	Altered	66 dB	67 dB	58 dB	58 dB	61 dB
R089	E	1171 SH1	Altered	69 dB	70 dB	59 dB	59 dB	63 dB
R090	E	1169 SH1	Altered	68 dB	70 dB	59 dB	59 dB	63 dB
R091	E	1167 SH1	Altered	68 dB	69 dB	59 dB	59 dB	63 dB
R092	E	1155 SH1	Altered	57 dB	58 dB	55 dB	55 dB	56 dB
R093	E	1165 SH1	Altered	69 dB	71 dB	59 dB	59 dB	64 dB
R094	E	1153 SH1	Altered	66 dB	67 dB	58 dB	58 dB	61 dB
R095	E	1149 SH1	Altered	68 dB	69 dB	60 dB	60 dB	63 dB
R097	E	1149 SH1	Altered	68 dB	69 dB	60 dB	60 dB	63 dB
R098	E	1147 SH1	Altered	68 dB	70 dB	60 dB	60 dB	63 dB
R099	E	1127 SH1	Altered	66 dB	67 dB	60 dB	60 dB	62 dB
R108	E	1115 SH1	Altered	67 dB	69 dB	61 dB	61 dB	64 dB
R111	E	1081 SH1	Altered	56 dB	58 dB	56 dB	56 dB	56 dB
R112	E	1081 SH1	Altered	64 dB	65 dB	60 dB	60 dB	62 dB
R115	E	1039 SH1	Altered	60 dB	62 dB	59 dB	59 dB	60 dB
R116	E	12 Te Waka Rd	Altered	61 dB	62 dB	59 dB	59 dB	60 dB
R120	E	961 SH1	Altered	68 dB	69 dB	63 dB	63 dB	65 dB
R121	E	13 Te Horo Beach Rd	Altered	51 dB	51 dB	57 dB	57 dB	61 dB
R122	E	11 Te Horo Beach Rd	Altered	52 dB	53 dB	57 dB	57 dB	62 dB
R123	E	3 Te Horo Beach Rd (bld2)	Altered	53 dB	51 dB	56 dB	56 dB	56 dB
R124	E	3 Te Horo Beach Rd (bld1)	Altered	65 dB	62 dB	62 dB	62 dB	62 dB
R125	E	941 SH1	Altered	64 dB	62 dB	61 dB	61 dB	62 dB
R126	E	939 SH1	Altered	63 dB	61 dB	60 dB	60 dB	60 dB
R127	E	931 SH1	Altered	66 dB	63 dB	62 dB	62 dB	63 dB
R128	E	921 SH1	Altered	59 dB	56 dB	59 dB	59 dB	59 dB
R129	E	915A SH1	Altered	57 dB	54 dB	57 dB	57 dB	57 dB
R130	E	915 SH1	Altered	68 dB	66 dB	63 dB	63 dB	64 dB
R131	E	913 SH1	Altered	66 dB	64 dB	62 dB	62 dB	62 dB
R132	E	909 SH1	Altered	69 dB	67 dB	64 dB	64 dB	65 dB
R133	E	907 SH1	Altered	67 dB	64 dB	62 dB	62 dB	63 dB
R134	E	901A SH1	Altered	56 dB	55 dB	56 dB	56 dB	57 dB

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ID	Area	Address	Type	Predicted noise level, $L_{Aeq(24h)}$				
				All roads		Scheme roads only		All roads
				Existing	Do-nothing	Do min	BPO	BPO
R135	E	903 SH1	Altered	66 dB	63 dB	61 dB	61 dB	62 dB
R136	E	901 SH1	Altered	66 dB	64 dB	61 dB	61 dB	62 dB
R137	E	895 SH1	Altered	59 dB	57 dB	58 dB	58 dB	58 dB
R138	E	893 SH1	Altered	61 dB	59 dB	58 dB	58 dB	59 dB
R096	F	11 Old Hautere Rd	New	53 dB	54 dB	54 dB	54 dB	55 dB
R100	F	9 Old Hautere Rd	New	56 dB	58 dB	60 dB	60 dB	60 dB
R101	F	15 Old Hautere Rd	New	53 dB	55 dB	56 dB	56 dB	56 dB
R102	F	19 Old Hautere Rd	New	53 dB	55 dB	56 dB	56 dB	56 dB
R103	F	14 Old Hautere Rd	New	59 dB	60 dB	66 dB	66 dB	66 dB
R104	F	23 Old Hautere Rd	New	51 dB	52 dB	52 dB	52 dB	53 dB
R105	F	26 Old Hautere Rd	New	55 dB	56 dB	58 dB	58 dB	58 dB
R106	F	33 Old Hautere Rd	New	52 dB	54 dB	55 dB	55 dB	55 dB
R107	F	22 Old Hautere Rd	New	55 dB	57 dB	59 dB	59 dB	60 dB
R109	F	36 Old Hautere Rd	New	54 dB	55 dB	57 dB	57 dB	57 dB
R110	F	46 Old Hautere Rd	New	53 dB	54 dB	55 dB	55 dB	56 dB
R113	F	56 Old Hautere Rd	New	54 dB	55 dB	57 dB	57 dB	57 dB
R114	F	1070 SH1	New	56 dB	58 dB	62 dB	62 dB	62 dB
R117	F	990B SH1	New	54 dB	55 dB	58 dB	58 dB	58 dB
R139	F	32 School Rd	New	56 dB	56 dB	63 dB	63 dB	63 dB
R140	F	34 School Rd	New	55 dB	55 dB	60 dB	60 dB	60 dB
R141	F	42A School Rd	New	52 dB	53 dB	56 dB	56 dB	56 dB
R142	F	40 School Rd	New	53 dB	54 dB	58 dB	58 dB	58 dB
R143	F	42B School Rd	New	53 dB	53 dB	56 dB	56 dB	56 dB
R144	F	45 Gear Rd	New	58 dB	59 dB	63 dB	63 dB	64 dB
R145	F	91 Gear Rd	New	56 dB	57 dB	60 dB	60 dB	64 dB
R146	F	97 Gear Rd	New	53 dB	55 dB	56 dB	56 dB	64 dB
R147	F	82 Gear Rd	New	57 dB	59 dB	61 dB	61 dB	61 dB
R148	G	737 SH1	Altered	63 dB	65 dB	60 dB	60 dB	62 dB
R156	G	635 SH1	New	48 dB	50 dB	52 dB	52 dB	52 dB
R157	G	633 SH1	New	47 dB	48 dB	50 dB	50 dB	50 dB
R159	G	12 Derham Rd	New	57 dB	58 dB	61 dB	61 dB	61 dB
R162	G	36 Te Hapu Rd	New	55 dB	56 dB	57 dB	57 dB	57 dB
R006	X	85 State Hwy	Altered	60 dB	60 dB	61 dB	61 dB	61 dB
R007	X	82 State Hwy	Altered	58 dB	57 dB	58 dB	58 dB	58 dB
R008	X	299 State Hwy	Altered	62 dB	59 dB	48 dB	46 dB	53 dB

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ID	Area	Address	Type	Predicted noise level, $L_{Aeq(24h)}$				
				All roads		Scheme roads only		All roads
				Existing	Do-nothing	Do min	BPO	BPO
R055	X	260 Main Highway (Otaki Motel)	Altered	63 dB	61 dB	59 dB	59 dB	59 dB
R057	X	260 Main Highway (Otaki Motel bld2)	Altered	61 dB	59 dB	57 dB	57 dB	57 dB
R058	X	12 Dunstan St	Altered	52 dB	50 dB	48 dB	45 dB	49 dB
R073	X	151-153 Main Hwy	Altered	67 dB	66 dB	58 dB	58 dB	64 dB
R074	X	1277 SH1	Altered	62 dB	63 dB	55 dB	55 dB	58 dB
R075	X	69 Otaki Gorge Rd	New	51 dB	52 dB	53 dB	53 dB	54 dB
R076	X	53 Otaki Gorge Rd	New	51 dB	52 dB	52 dB	52 dB	53 dB
R077	X	34 Otaki Gorge Rd	New	52 dB	53 dB	53 dB	53 dB	54 dB
R078	X	32 Otaki Gorge Rd	New	55 dB	56 dB	55 dB	55 dB	56 dB
R079	X	65 Otaki Gorge Rd	New	50 dB	51 dB	50 dB	50 dB	51 dB
R083	X	44 Otaki Gorge Rd	New	50 dB	52 dB	51 dB	51 dB	52 dB
R087	X	38 Otaki Gorge Rd	New	52 dB	54 dB	53 dB	53 dB	54 dB
R118	X	12 Te Horo Beach Rd	Altered	52 dB	53 dB	59 dB	59 dB	59 dB
R119	X	40 Te Horo Beach Rd	Altered	50 dB	50 dB	54 dB	54 dB	55 dB
R149	X	36 Sutton Rd	New	55 dB	56 dB	58 dB	58 dB	59 dB
R150	X	38 Sutton Rd	New	54 dB	56 dB	58 dB	58 dB	58 dB
R151	X	17 Sutton Rd	New	53 dB	54 dB	56 dB	56 dB	56 dB
R152	X	31 Sutton Rd	New	51 dB	52 dB	54 dB	54 dB	54 dB
R153	X	35 Sutton Rd	New	57 dB	58 dB	59 dB	59 dB	59 dB
R154	X	42A School Rd	New	54 dB	56 dB	57 dB	57 dB	57 dB
R155	X	31A Sutton Rd	New	52 dB	53 dB	55 dB	55 dB	55 dB
R158	X	33 Sutton Rd	New	55 dB	56 dB	57 dB	57 dB	57 dB
R160	X	670 SH1	New	57 dB	58 dB	57 dB	57 dB	57 dB
R161	X	664 SH1	New	56 dB	57 dB	55 dB	55 dB	55 dB

4 Modelling

4.4 Rail noise and vibration

4.4.1 Noise

In this assessment, only two properties have been identified that will become closer to railway due to the Project. These two properties are the Ōtaki Motel and 230 Main Highway. In addition to the change in distance between the railway and properties, the effects of change in speed to an increased curve radius have been investigated. The current rail geometry in Ōtaki limits train speed to 70 km/h, however the general KiwiRail line design speed is 100-110 km/h, with freight trains limited to 80 km/h.

The following passenger trains service this line:

- the Overlander, which runs twice a day, does not stop in Ōtaki and could therefore reach the line design speed; and
- the Capital Connection, which also runs twice a day, stops in Ōtaki and therefore is unlikely to increase in speed over the current situation.

Above 50 km/h the predominant source of train noise is wheel/rail rolling noise. Therefore, the character of the noise will not change significantly with increased speed despite an increase in noise level. At these speeds, the noise emitted is proportional to 20 x $\log_{10}$ (velocity).

The increase in noise due to speed is therefore:

- freight trains (from 70 km/h to 80 km/h): 1.2 dB; and
- passenger trains (from 70 km/h to 110 km/h): 3.9 dB.

For each of the nearest receivers, the change in noise level has been predicted due to the change in distance from the railway as well as the increased speed. As shown in the following table, the noise level at each of the receivers which move further away remains lower than the existing level. No significant effects at other locations are anticipated due to the potential increase in train speed.

Table 4-6 Changes in rail noise due to distance and speed

Location	Decrease in distance between receiver and railway	Increase in noise level for freight trains	Increase in noise level for passenger trains
230 Main Highway	25 m (3.3 dB)	4.4 dB	7.2 dB
Ōtaki Motel	110 m (9.0 dB)	10.2 dB	13.0 dB
12 County Road	-100 m (-9.0 dB)	-7.8 dB	-5.1 dB
22 County Road	-110 m (-10.7 dB)	-9.6 dB	-6.8 dB
46 County Road	-99 m (-10.4 dB)	-9.2 dB	-6.5 dB
50 County Road	-74 m (-5.1 dB)	-4.0 dB	-1.2 dB

The assessment above is based on the relative change of distance and train speed. The absolute level of noise will depend on these factors plus the train type, and condition of the train and track.

In addition to the change in permitted maximum speed, the realigned railway will have a slight increase in gradient compared to the previous alignment, due to the height change from the Ōtaki station to North Ōtaki being gained over a shorter horizontal distance. A preliminary rail alignment has been designed by the project team, and the maximum gradient will increase from 1.05% to 1.30%

In terms of the noise produced by freight trains as they climb these gradients, this will depend upon the vertical alignments, the operating conditions of the locomotives, the tractive power of the locomotives and the mass of the wagons. For the small change in gradient discussed above it is

expected that the freight trains will produce negligible additional external noise on the new alignment as the locomotives are currently 'on power' as they climb the existing alignment and the change in traction required on the new gradient will not be significant.

The removal of the level crossing at Rahui Road will result in the warning bells being removed, as well as the train horn not being used. Noise levels from these two sources have not been determined, however it is the character which is more important than the level. This change in character is a significant benefit from the Project in this area.

An assessment of absolute rail noise has been performed using a design level of 70 dB $L_{Aeq(1h)}$ at 12 metres, as recommended by the draft KiwiRail guideline. Rail noise measurements performed as part of the Project where on a straight length of track north of Ōtaki. These measurements were consistent with the design level, assuming two movements per hour, which is considered representative of current operations.

Table 4-7 Predicted rail noise levels

Location	Distance from track edge	Predicted rail noise level, $L_{Aeq(1h)}$
Otaki Motel	80 metres	58 dB
230 Main Highway	60 metres	60 dB

4.4.2 Vibration

The measurements of vibration from the railway on its existing alignment and in its current condition indicate that the proposed criterion might be exceeded at PPFs 60 metres or less from the track. With the re-alignment of the track, a new track will be constructed and the vertical alignment and ballast condition will be improved compared to the existing. It is therefore predicted that the levels of vibration will be lower than the existing railway.

The vibration generated by the railway, and observed at the nearest PPFs, is influenced by a number of factors, including:

- vehicle characteristics (e.g. unsprung wheelset mass, suspension parameters);
- track characteristics (e.g. vertical alignment, rail joints, condition of the ballast);
- ground propagation characteristics; and
- building/foundation construction.

The amount of vibration generated is highly dependent on the vertical geometry (irregularities in the vertical alignment of wavelengths less than approximately 5 m). A reduction of up to 15 dB (equivalent to a factor of 5.6) is anticipated from the improved vertical geometry of the new track, where no significant irregularities or defects will be present. The exact reduction depends on the difference between the current and the new geometry. Further reductions can be expected with improved resilient performance of new ballast.

It is predicted that the new alignment will meet the Class C vibration criterion (0.3 mm/s) without the need for additional mitigation in the track structure.

5

Design and mitigation

5.1 Mitigation options

The road-traffic noise assessment areas and mitigation options evaluated are detailed in Section 4.1. For any areas where the NZS 6806 Category A criteria was exceeded (Table 2-2), a number of mitigation options were tested. For each mitigation option tested, URS ran the computer model to predict road-traffic noise levels at each PPF.

The mitigation options for each area were assessed by URS on the basis of:

- compliance with NZS 6806 criteria;
- attenuation provided by structural (barriers and low noise surfaces) mitigation;
- requirement for building-modification measures;
- effect of changes to the existing noise environment; and
- value-for-money (using the benefit-cost ratio (BCR) calculation from NZS 6806).

The options were documented with each one described and presented graphically as illustrated in Figure 5-1. The options were then circulated to the project team for other factors to be assessed. An assessment matrix was compiled for each area. For each option the following issues were considered by the appropriate project team members:

- consistency with NZ urban design protocol, Project Objectives and project specific ULDF;
- potential effects on known heritage or cultural values;
- potential effects on areas of significant indigenous vegetation and significant habitats of indigenous fauna;
- potential effects on known heritage or cultural values;
- road users' views to the surrounding landscape and key features/ locations in particular;
- maintenance or enhancement of visual amenity for surrounding residents;
- availability of sufficient land for construction and maintenance and the extent to which NZTA would need to acquire land, or interests in land;
- constructability/technical feasibility; and
- compliance with relevant safety standards and guidelines.

Each discipline rated these assessment criteria using a seven point scale (+++, ++, +, o, -, --, ---), and where required provided commentary explaining the rating. The completed options matrices (Appendix A) were then circulated to the project team and considered at a noise mitigation workshop.

5 Design and mitigation

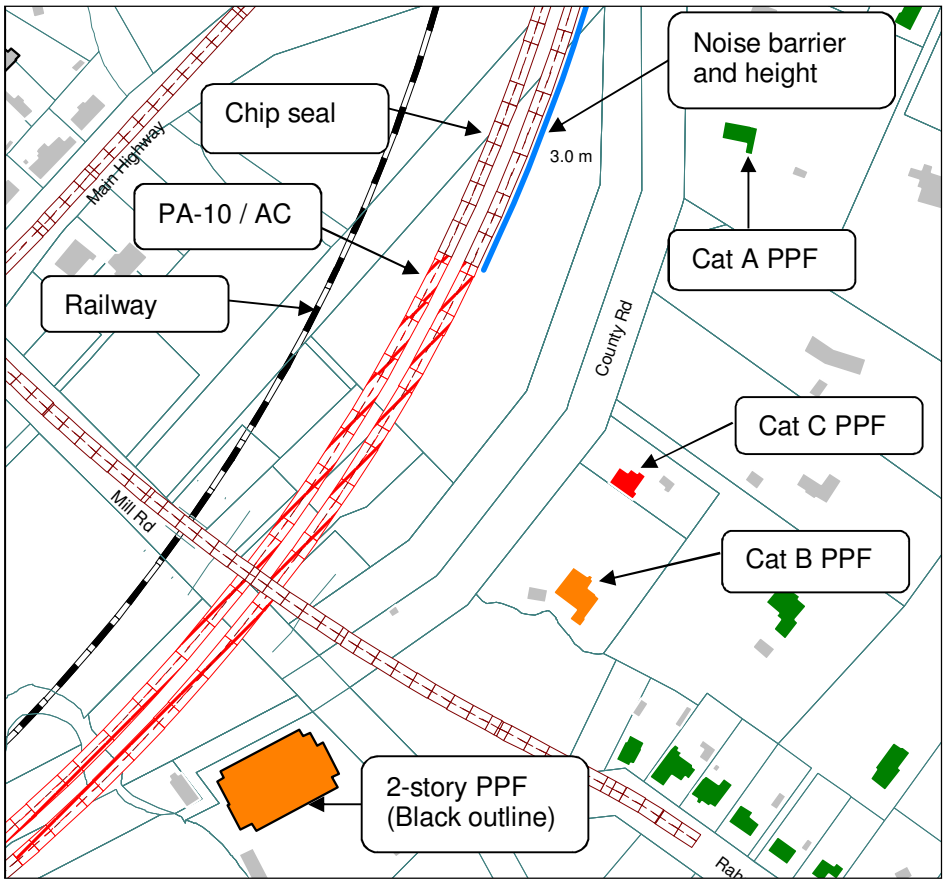

Figure 5-1 Mitigation option figures key

Workshop

The noise mitigation workshop was held in Wellington on 2 February 2012. The following people contributed to the workshop:

- Stephen Chiles, URS, acoustics / facilitator;
- Tony Coulman, Opus, project team leader;
- David McKenzie, Opus, landscape / urban design;
- Mark Edwards, Opus, roading / construction;
- Michael Smith, URS, acoustics;
- Dean Ingoe, NZTA, regional planner;
- David Randal, Buddle Findlay, legal;
- Rob Hannaby, NZTA, national office acoustics;
- Lucie Desrosiers, NZTA, national office urban design;
- Sara Bell, KCDC, landscape architect;
- Glynn Jones, KCDC, acoustics;
- Pam Butler, KiwiRail; and
- Vince Dravitzki, Opus, acoustics peer review.

Each of the noise assessment areas and the options matrices completed by all disciplines were reviewed at the workshop. In each case an option was selected as representing the BPO. In some instances this was subject to confirmation following further investigation by the project team and the NZTA. In all cases there was consensus achieved at the workshop as to the BPO.

Following the workshop, URS visited owners of PPFs that may require acoustic treatment and also attended Project open days in June 2012. Further public feedback was received after the open days. The BPO was reviewed in several areas where comments had been made by the public, as set out in the following sections.

The following provides a brief commentary on the design issues for each noise assessment area and gives the reasons for the selected options.

5.2 Ōtaki township

Area A - North Ōtaki

In this area, the main alignment passes under Bridge 2 where the local arterial follows the alignment of the existing State highway. Properties are subject to noise from both the Expressway and the local arterial.

Options considered include roadside noise barriers along the Expressway, a barrier on the median strip, and the use of low-noise road surfaces. The Expressway is in cut relative to the nearest properties, reducing the effect of roadside noise barriers. The position of houses at the top of the cut prevents barriers in that location.

At the workshop, the consequences of using a low-noise road surface such as open graded porous asphalt (OGPA/PA-10) were discussed in detail. A significant reduction in noise is obtained for cars and light vehicles, however there is minimal effect on heavy vehicles, where engine and exhaust noise is more prominent. PA-10 also requires a different maintenance regime to chip seal, and short sections can prove to be impractical.

Nevertheless the mitigation option chosen for this location is the use of low-noise road surface (OGPA/PA-10). The reasons were:

- all PPFs will be Category A (altered road) with the exception of two properties which front the local arterial; and
- the barriers tested do not provide efficient mitigation due to the topography.

The use of noise barriers for Area D immediately to the south is not effective, and therefore the continuation of low-noise road surface from Area D into Area A has practical benefits.

There were no significant changes to the assessment in this area following feedback or remodelling.

5 Design and mitigation

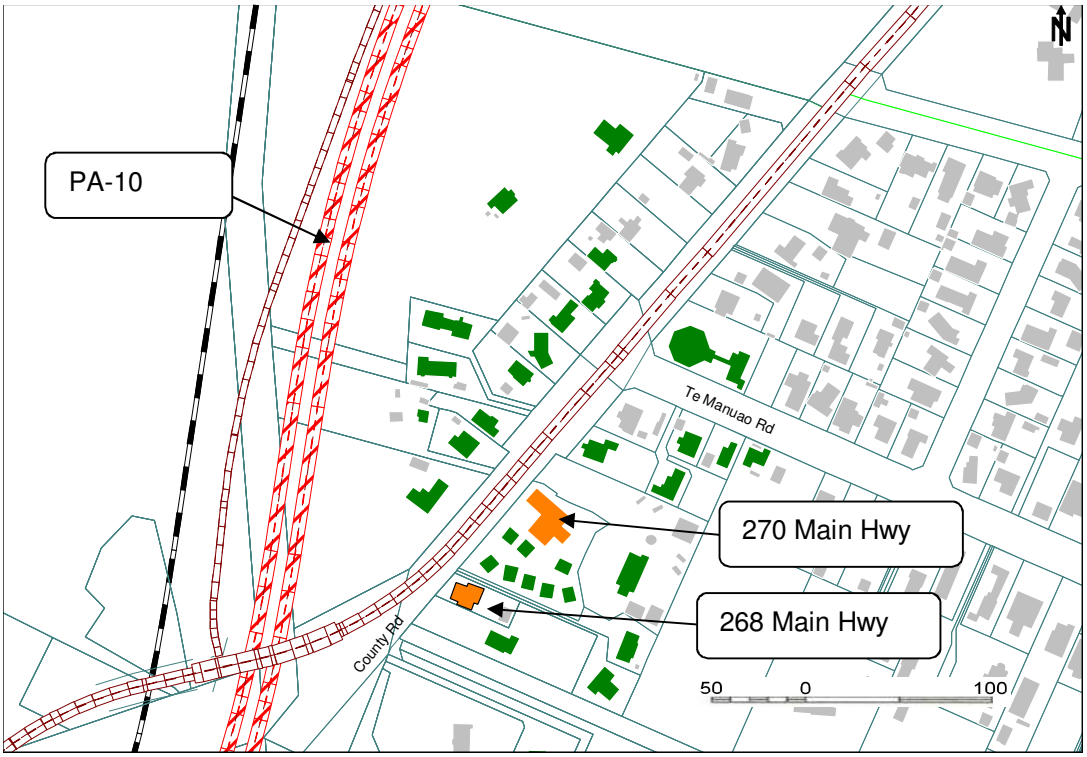

Figure 5-2 Area A - North Ōtaki - selected option

Area B - Main Highway

The extent of work for the Project includes Main Highway in Ōtaki to just north of Mill Road. This is currently SH1 but becomes the local arterial. For the SARA the road surface was incorrectly modelled as chip seal, with four properties to the west of Main Highway identified as Category B with that surface. It was subsequently established that the surface is currently asphaltic concrete, which was previously listed as a mitigation option. The selected mitigation is to maintain the asphaltic concrete surface (do-minimum), which results in all PPFs in Category A.

There were no significant changes to the assessment in this area following feedback or remodelling.

Area C - 230 Main Highway

Where mitigation is considered for a PPF in isolation, NZS 6806 requires a minimum 5 dB of attenuation. This threshold is used to avoid detailed consideration of mitigation where the benefit is limited, with a likely low benefit-cost ratio. In other locations, a small reduction in noise level to a large number of PPFs can often have sufficient benefit. Roadside and railside barriers considered do not provide the required 5 dB of attenuation. If this PPF was considered in isolation, the do-minimum would be maintained.

This PPF will benefit from the selection of a low-noise road surface (OGPA/PA-10) for Area D, and becomes category A. This PPF will be investigated for treatment to protect from rail noise, which will also reduce the amount of road-traffic noise.

There were no significant changes to the assessment in this area following feedback or remodelling.

5 Design and mitigation

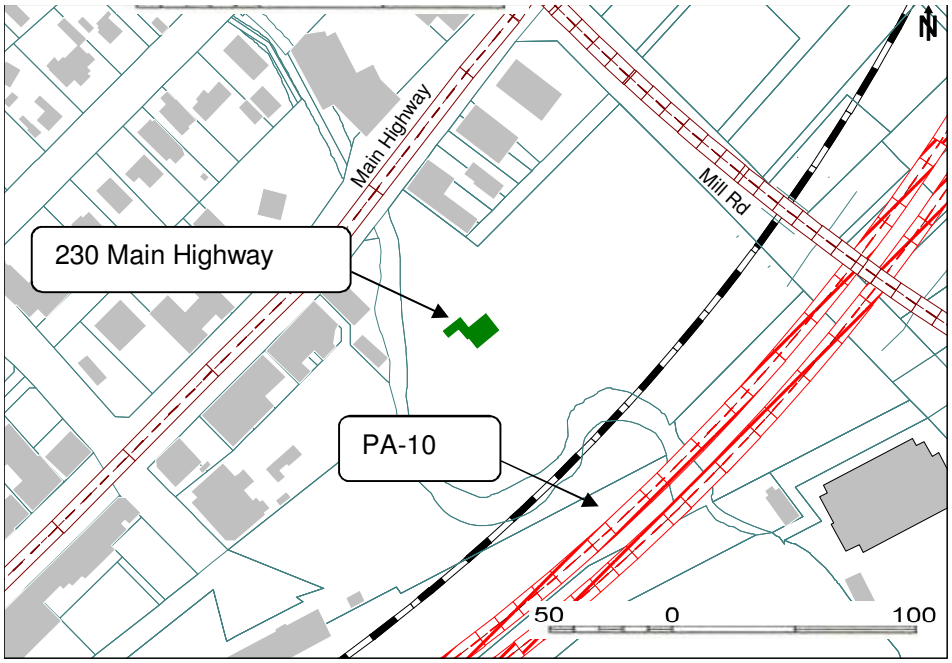

Figure 5-3 Area C - 230 Main Highway - selected option

Area D - East Ōtaki

The properties along County and Rahui Roads, including the former Rahui Milk Treatment Station, have been considered as a single assessment area. In our initial review of mitigation, traffic on Rahui Road was modelled, which significantly affected the predicted levels for properties for the on Rahui Road properties. However, the revised traffic modelling has 2031 traffic volumes for Rahui Road of less than 2000 vpd and Rahui Road has therefore been removed from the model. A number of previously identified associated PPFs have also been removed from the model because they are now more than 100 metres from the nearest road that has been modelled.

Noise barriers immediately adjacent to the Expressway have been considered along with low-noise road surfaces. The selected mitigation option is low-noise road surface (PA-10) along this section of the Expressway because:

- barriers do not effectively screen both carriageways, as a number of the receivers are elevated;
- all PPFs will be categories A and B; and
- the use of PA-10 allows a continuous solution through areas A and D.

During the workshop, it was discussed that the former Rahui Factory Social Club building to the west is occupied and may be noise sensitive. In addition, it was noted that 12 County Road was incorrectly modelled as a single story building. The model was revised after the workshop to address both of these issues.

The most exposed façade of the former Rahui Milk Treatment Station is currently the northern façade, which fronts onto Rahui Road. The western façade is shielded from Rahui Road, however will be most exposed to the Expressway. Therefore the change in character will be greater at the western façade than the northern façade, however it is noted that the bedrooms on the western façade are shielded by a concrete parapet and the incident noise levels will be lower than predicted.

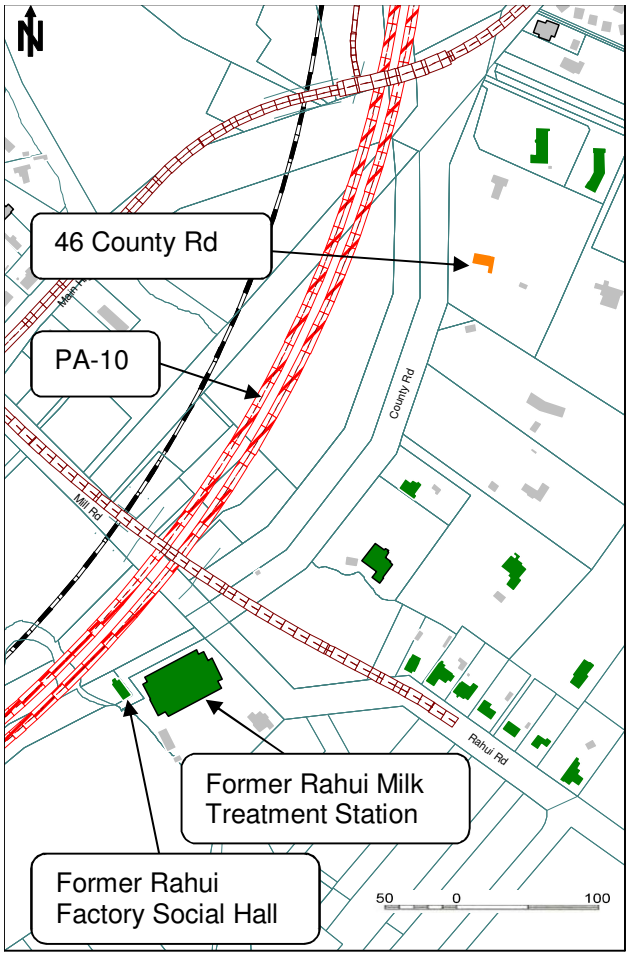

Figure 5-4 Area D - East Ōtaki - selected option

Summary

During the workshop the project team also considered that there would be community expectation for a low-noise road surface throughout Ōtaki. The BCR for a low-noise surface is 1.4, and supports the selected mitigation detailed above for Areas A and D. The use of noise barriers would not provide better acoustics performance, and would have adverse visual and urban design effects.

5.3 Ōtaki River to Te Horo

This area comprises two separate groups of PPFs: those to the west of the existing State highway which are currently subject to relatively high levels of road-traffic noise, and those to the east which generally have larger setbacks and a lower existing noise level. As discussed in Section 2.4.4 the altered and new road criteria will be applied to these groups respectively.

The NIMT runs east of the State highway and rail noise forms part of the existing environment. There will be no changes to the rail alignment in this area.

Area E - West

With the application of the altered road criteria, the majority of PPFs fall within Category A, including contributions from the local arterial. In developing the mitigation options, noise barriers of different heights were tested between the Expressway and local arterial and also to the west of the local

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arterial. The application of a low-noise road surface to the Expressway alone and also in combination with the local arterial was investigated. If a low-noise surface was selected for the existing SH1 it would need to be maintained by the Council after State highway status is revoked.

Area F - East

Most PPFs to the east are Category B assuming new road criteria, however would be Category A assuming altered road criteria. Therefore the need for mitigation in this area is not clear, but has been investigated on the basis of new road criteria. A discussion on the change in noise level at PPFs in this area is provided in Section 6.6.

Noise barriers close to the road, and larger barriers on bunds set further back were tested, but did not prove to be efficient. If there was surplus fill available due to earthworks, bunding would be investigated further, but at the workshop this was dismissed as fill was not readily available.

Mitigation in this area was revisited after analysing comments by many residents at the open days, and also the review of the proposed landscaping. 2 metre high landscape bunds were modelled at several locations between the Expressway and local access roads (Old Hautere Road, School Road and Gear Road). No reduction in noise level is predicted with these bunds, due to the distance between the bund and the Expressway. Nevertheless these bunds do perform as mitigation, as people are often less sensitive to noise from sources that they cannot see.

During the open day, residents questioned whether the rail embankment was providing any screening from the existing State highway, and hence the modelling was understating the change with the Expressway. An investigation was performed with a 1m high bund modelled for the railway embankment, and the result was no discernible changes in predicted noise levels. Nevertheless, higher resolution (0.5 m) terrain contours were sourced for this area and included in the final noise model.

Since the scheme assessment there have been a number of changes to the vertical alignment to accommodate the necessary flood protection. Where the Expressway was previously in a slight cutting adjacent to Gear road, it has now been elevated by approximately 1 metre from the previous alignment. North of School Road the Expressway remains elevated however this level has been reduced by incorporating a flood retention bund on the upstream side.

There is one Category C PPF for the do-minimum scenario (14 Old Hautere Road), which may require building-modification mitigation, unless other mitigation is implemented. URS has met with the owner of this PPF to discuss the potential for building modification. A site visit to another building by Gear Road that had been thought to be a Category C PPF revealed that it was a farm shed.

Combined Areas E and F

The use of a low-noise road surface (PA-10) results in a benefit to PPFs both east and west of the Expressway. The BCR in accordance with NZS 6806 considering the benefit to both sides is 0.49, which indicates poor value-for-money. During the workshop no other benefits to the use of a low-noise surface were identified and it was decided to maintain the do-minimum as the selected option. The single Category C PPF will need to be investigated for treatment.

Several comments at the open day related to the choice of road surface, and requests were made for a low noise type. Given this feedback the project team reviewed the surface decision, considering other potential benefits of using porous asphalt for example. Without a compelling noise benefit, it was determined that there still is not sufficient justification for a low noise surface in this area.

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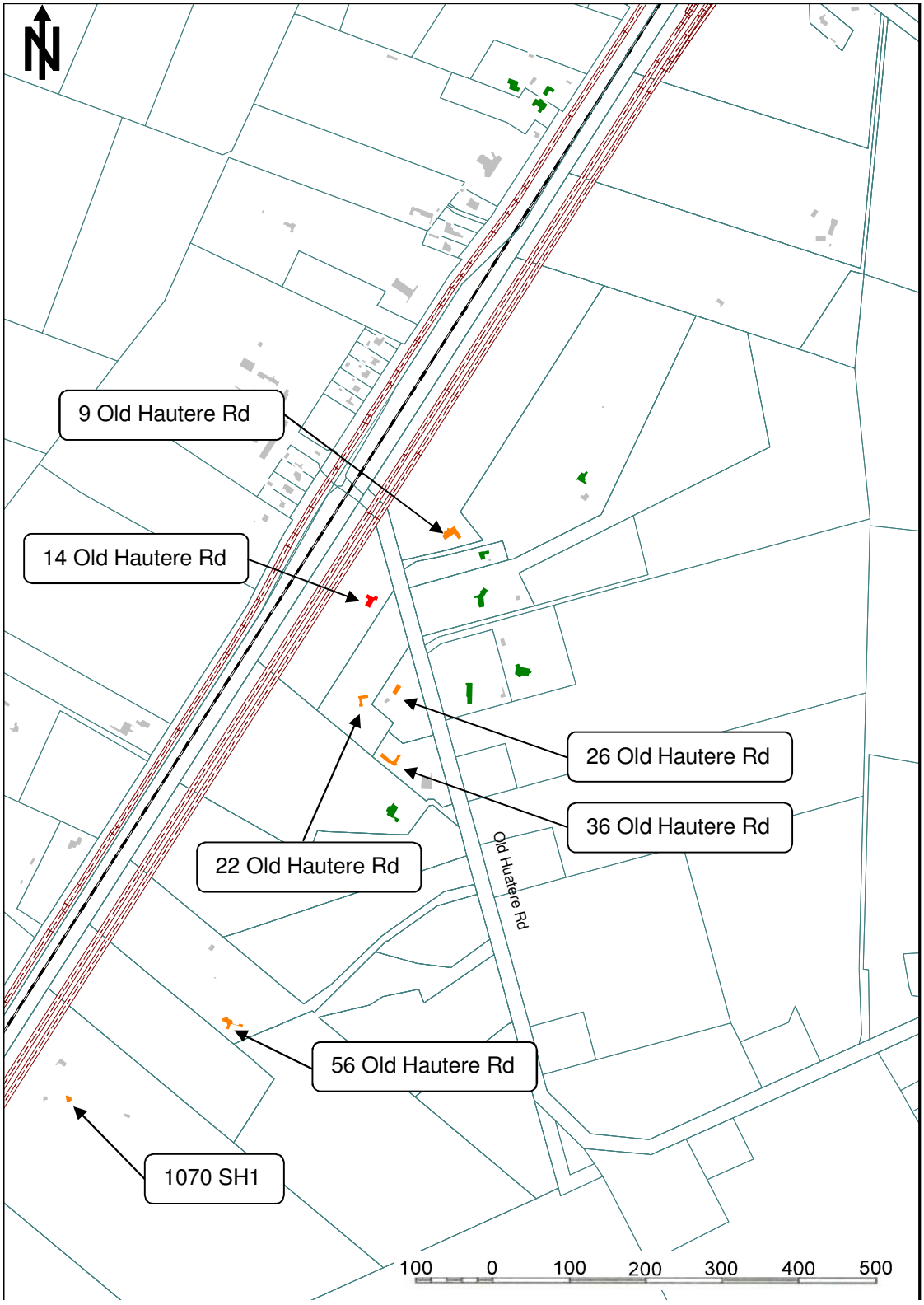

Figure 5-5 Areas E and F – north of Te Horo – selected option

5 Design and mitigation

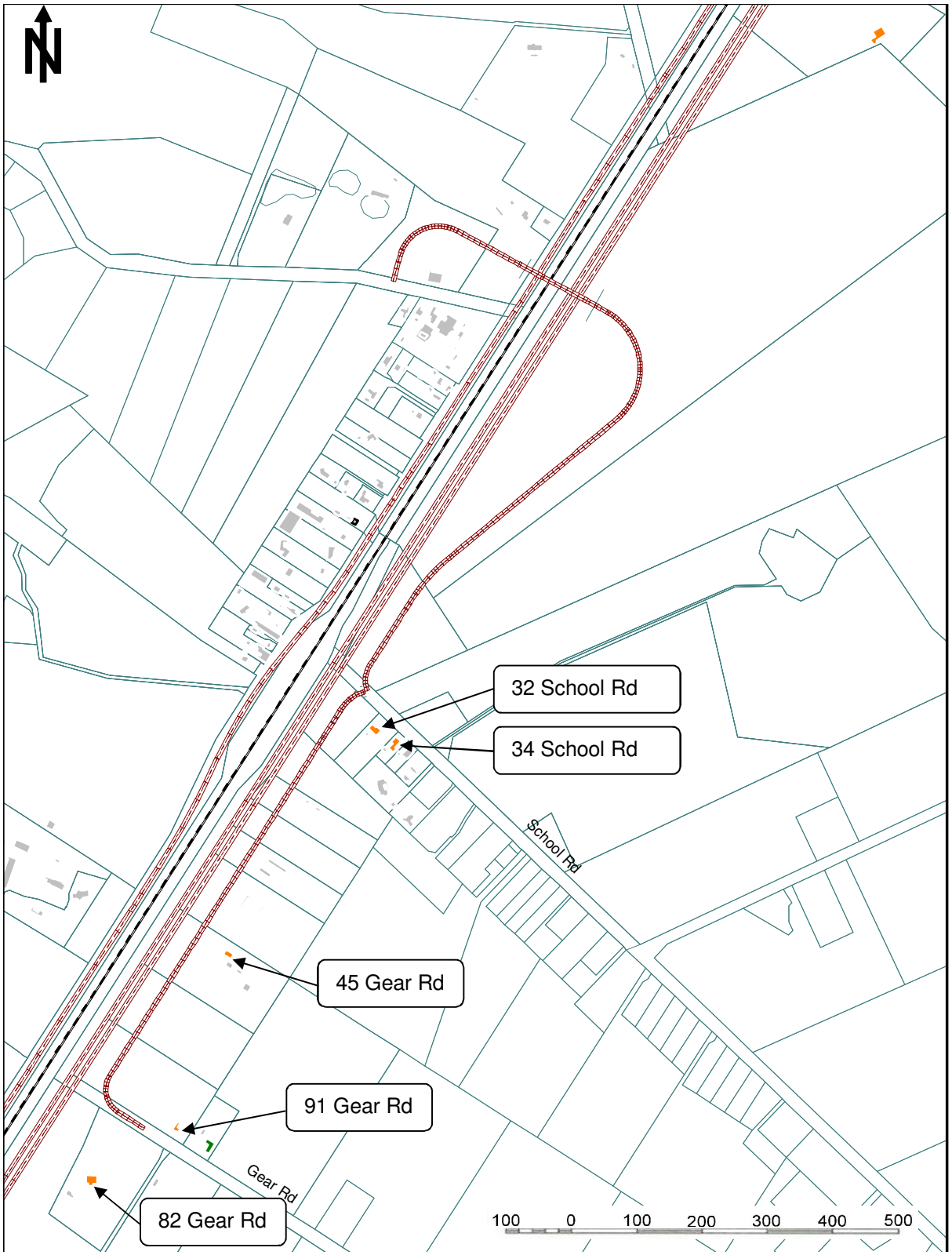

Figure 5-6 Area E and F – Te Horo – selected option

5.4 South of Mary Crest

This area comprises a number of scattered properties generally remote from the local arterial and main alignment. None of the PPFs form a cluster. The dwellings to the west are generally raised and in some instances do not have line of sight to the Project.

These PPFs are currently exposed to noise from the State highway, and the NIMT which runs parallel to the highway on the eastern side.

The option selected at the noise mitigation workshop is to maintain the do-minimum of grade 2/4 chip seal and no noise barriers, as:

- all PPFs are in NZS 6806 categories A and B;
- a barrier has limited effectiveness due to the topography; and
- low-noise road surfaces have limited effectiveness unless extended over a significant length of the Expressway and local arterial.

There were no significant changes to the assessment in this area following feedback or remodelling.

5 Design and mitigation

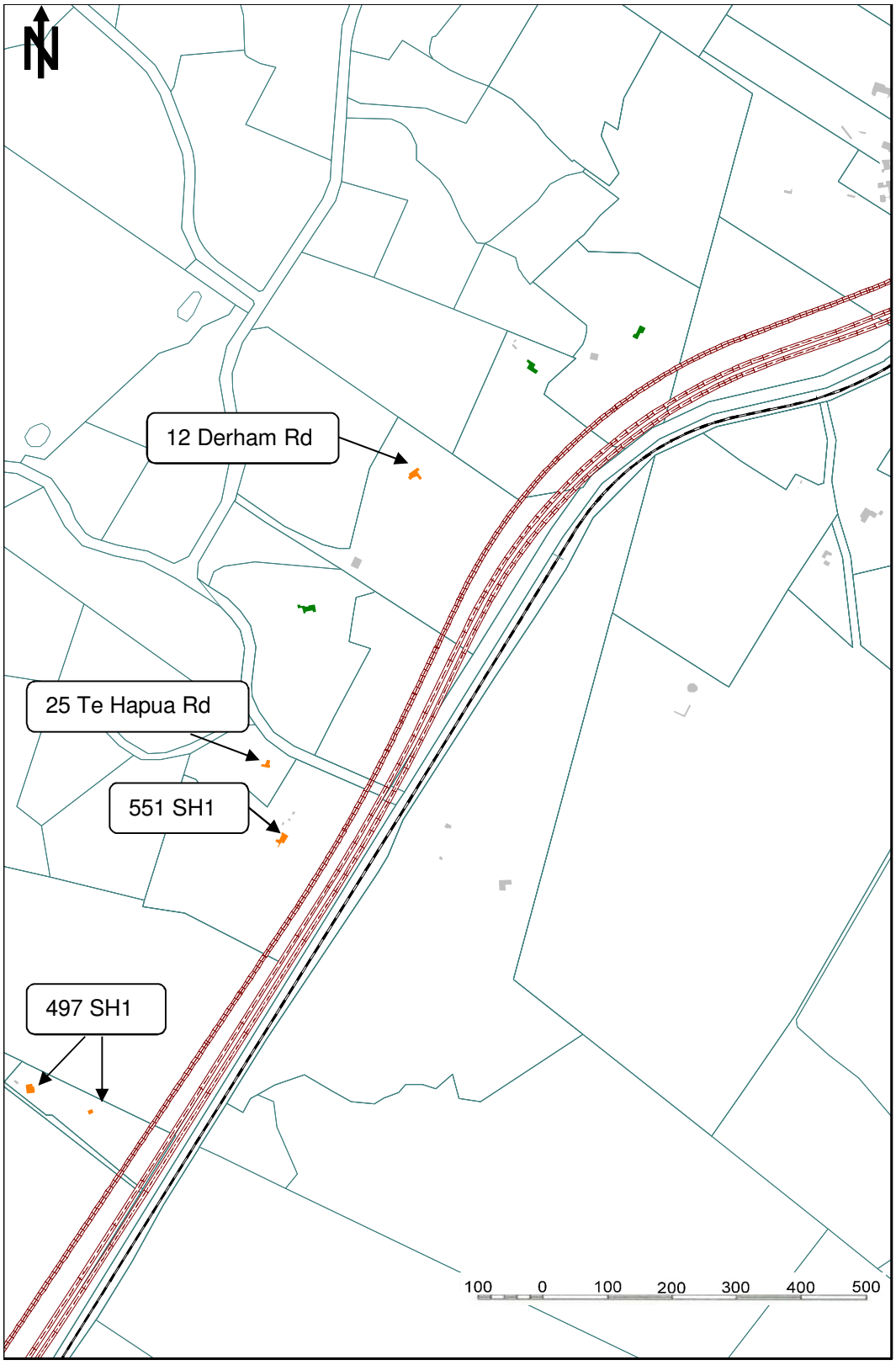

Figure 5-7 Area G - South of Mary Crest - selected option

5.5 Road noise mitigation summary

The mitigation detailed for each of the selected options is summarised in Table 5-1 for road surfaces and Table 5-2 for building-modification mitigation to be offered to residents. It should be noted that there would be a delay between the base chip seal surface being installed and the final open graded porous asphalt being laid, as setting is required to occur to prevent unnecessary wearing. It is common for roads to be open for up to one year prior to the final surface being laid.

Table 5-1 Selected options - road surfaces

Location	Surface	Length
Ōtaki Township (01300-02350)	Open graded porous asphalt (PA-10)	1050 m

Table 5-2 Selected options - building-modification mitigation

PPF
14 Old Hautere Road

With the structural mitigation detailed in Table 5-1 and Table 5-2, the total numbers of PPFs in each of the NZS 6806 categories are shown in Table 5-3.

Table 5-3 Number of PPFs in NZS 6806 categories

Category A	Category B	Category C
132 PPFs	15 PPFs	1 PPFs

5.6 Rail noise and vibration

To accommodate the Expressway, the rail alignment will move west in Ōtaki, and rail noise and vibration levels will increase at some PPFs. Only three PPFs fall within the 80 metre buffer zone used by KiwiRail's reverse sensitivity policy, and are identified in Figure 5-8. The PPF to the east of the railway will become further away from the railway, and are not considered further. The noise mitigation implemented at remaining two PPFs is discussed separately below.

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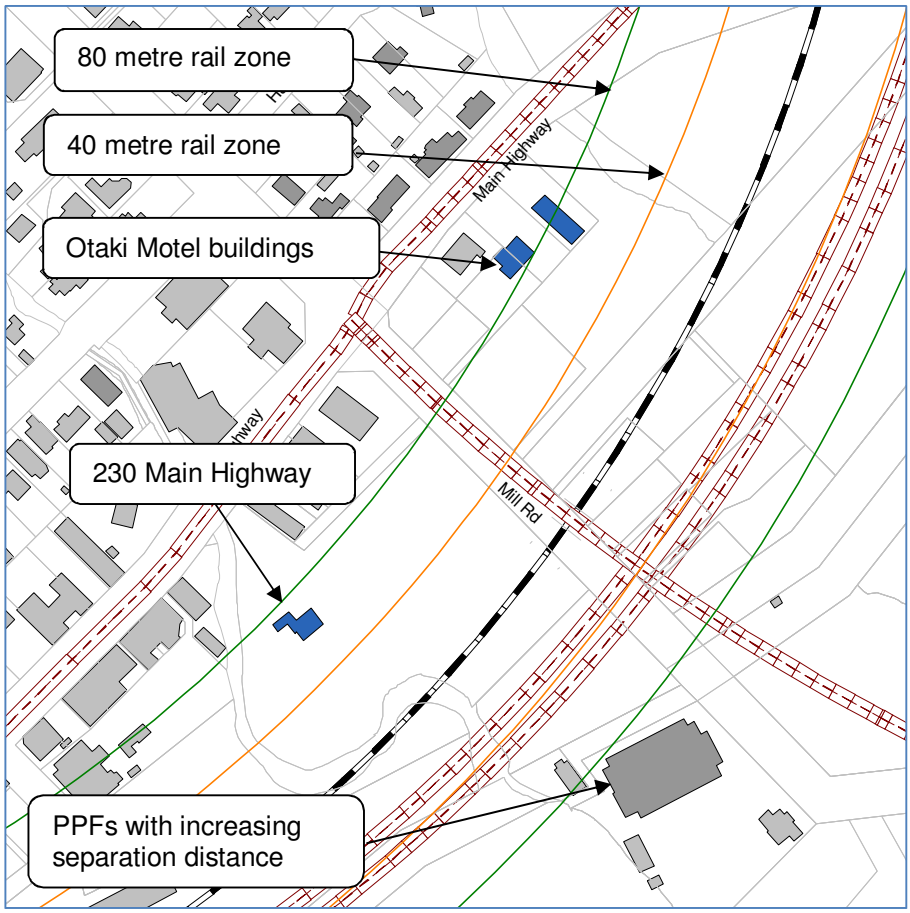

Figure 5-8 Railway area

5.6.1 Noise

Ōtaki Motel

The nearest facades of the two motel buildings are 70 to 80 metres from the rail corridor, which are the main accommodation building and the manager's house. The outdoor amenity criteria will be achieved without mitigation. A preliminary site inspection in May 2012 has confirmed that the internal noise criteria are unlikely to be achieved without mitigation. To achieve the internal criteria, it is anticipated that building-modification mitigation such as mechanical ventilation, and potentially updated glazing, would be subject to detailed design and agreement with the landowner. There is some scope for providing a noise barrier (fence) to shield the east and northeast façade. This is unlikely to be desirable to the main motel building, however may be acceptable for the manager's house, and the noise barrier would have the appearance of a standard property boundary fence.

230 Main Highway

This building is approximately 60 metres from the rail reserve, and outdoor noise levels will be similar to the amenity criteria. A preliminary site inspection in May 2012 has confirmed that the internal noise criteria may not be achieved without mitigation. While barrier options were considered to mitigate noise from the Expressway, which also would mitigate rail noise, there is no obvious location for a noise barrier. The potential for treating the building was discussed the landowner, however further

investigations will be required. It is understood there are heritage issues with this property which must be considered.

5.6.2 Vibration

As discussed in Section 4.4.2, vibration generation will decrease from the existing track due to the new track and ballast, however this will be partly offset by the railway being closer to two PPFs. Rail vibration is predicted to achieve the nominated criterion in Section 2.5, therefore no specific mitigation is required for rail vibration.

6

Assessment of noise and vibration effects

6.1 Existing environment

The proposed route closely follows the existing State highway, with most PPFs currently exposed to road-traffic noise from the State highway and rail noise and vibration from the NIMT. If the Project is not built, traffic growth is still anticipated with an increase in 2031 of approximately 30% of total vehicles, with a greater proportion of heavy vehicles. Road-traffic noise from the existing State highway is expected to increase by 2-3 dB in most locations.

A number of PPFs are in close proximity to the railway, and rail noise can be heard intermittently throughout the area.

Measurements have indicated that the current levels of vibration from the railway are likely to be perceptible in properties close to the existing alignment, although, depending on the building structure, these effects may be masked by the airborne noise from the railway.

6.2 NZS 6806

NZS 6806 sets reasonable criteria for road-traffic noise levels, taking into account health issues associated with noise and other matters. On this basis, it is considered that road-traffic noise levels in compliance with NZS 6806 Category A should generally result in acceptable noise effects. As the existing environment is heavily influenced by road-traffic noise, compliance with Category B may also represent acceptable noise levels. This is particularly so for the new road criteria where Category B is the same road-traffic noise level as Category A for altered roads.

In addition to compliance with the NZS 6806 noise levels, actual and potential noise effects have been explicitly considered during the options assessment in Section 5 and a further qualitative assessment is made below. Comparison with existing and do-nothing noise levels forms part of this assessment.

6.3 Transit Guidelines

Adverse effects were considered under the Transit Guidelines (and under the District Plan for controlled activities) using relative rather than absolute criteria. Where the environment was quiet, an increase of up to 12 dB was permitted, recognising that it is not practicable to maintain low ambient noise levels adjacent to State highways. At higher noise levels, typical for most of the Project, an increase of up to 3 dB over the existing noise level is permitted. The full methodology for determining noise limits under Transit Guidelines is described in Section 2.4.2.

Transit Guidelines fail to consider the significant traffic growth, which is predicted, even without the Project, as the criteria are solely based on the existing noise levels.

6.4 Individual vehicle noise

The control of noise from individual vehicles is beyond the control of the NZTA other than the prescribed emission limits in the Land Transport Rule[18]. Adverse effects from individual vehicles is predominantly from exhaust noise, engine braking, rattling of body panels or surface defects.

The Transit Guidelines included a 75 dB L_{AFmax} single event noise design level, and state that this will generally be achieved at receivers greater than 12 metres from the road edge. There are no receivers within this distance from the Project, and the road surfaces will be free of discontinuities and other

[18] NZTA (2004), Land Transport Rule: Vehicle Equipment

surface defects. The introduction of the Expressway will decrease the number of heavy vehicles using the section of road (currently State highway) north of the Mill Road roundabout.

Effects from individual vehicle noise are expected to reduce with the Project.

6.5 Ōtaki Township

Area A - North Ōtaki

The PPFs in this area front onto the existing State highway and are exposed to road-traffic noise, although several are set back further from the highway. The Expressway will divert a significant proportion of this traffic away from the existing State highway, resulting in a decrease in levels of road-traffic noise from the existing State highway.

The western-most PPFs (275A and 277A Main Highway), which are partially shielded from the existing State highway, will become exposed to road-traffic noise from the Expressway. The western facades of these buildings are currently not exposed to road-traffic noise. With the selected mitigation of PA-10 on the Expressway, road-traffic noise levels will increase by 10-11 dB at these two PPFs. This increase will be clearly noticeable, but the resulting levels of 61 dB should not unduly interfere with normal domestic activities.

Only two PPFs will remain in Category B with the proposed low-noise road surface, however noise levels at these PPFs are dominated by the existing State highway/new local arterial. There is a reduction in noise level from the existing and do-nothing scenario for these PPFs, therefore there are no adverse noise effects from the Project on these PPFs.

During holiday periods there is currently extensive queuing throughout Ōtaki, and without the Project, queuing will become more pronounced. Due to the proposed Waitohu River bridge (Bridge 1) only being single lane each way, a pinch point will remain and some slowing of traffic is predicted for north-bound traffic during peak holiday conditions, however not to the extent as present.

Noise levels at the PPFs in this area remain within reasonable levels, and while the change in noise level for individual facades will be noticeable, overall the noise effects are considered acceptable.

Area B - Main Highway

There will be a significant change in character for PPFs on Main Highway, with reductions in traffic volumes with through traffic using the Expressway. Noise from heavy vehicles accelerating from the roundabout up the ramp, and braking on the descent south currently is clearly audible over general traffic noise. With the Project, the number of heavy vehicles using Main Highway in 2031 is predicted to be approximately half the number if the Project is not built.

There are no adverse effects from road-traffic noise in this area from the Project.

Area C - 230 Main Highway

This PPF is currently exposed to road-traffic noise from Main Highway through Ōtaki, and to rail noise.

With the selected PA-10 on the Expressway, this PPF achieves the Category A criterion and the predicted road-traffic noise level decreases from the do-nothing scenario. The PPF will be exposed to increased levels of road-traffic noise on the eastern façade which will result in a change in character.

The realignment of the railway will bring the tracks approximately 20 metres closer to this PPF, resulting in a predicted increase in rail noise of 2 dB, which is not significant, particularly for transient

events. While the increase in noise level is not significant, mitigation is proposed to achieve the KiwiRail guidelines.

For the above reasons, the noise effects from the Project at 230 Main Highway are considered acceptable.

Area D - East Ōtaki

All PPFs in this assessment area have been considered against the new road criteria. For the purpose of this assessment road-traffic noise from Rahui Road has been excluded as the 2031 traffic volume is predicted to be less than 2000 vehicles per day.

PPFs on County Road will experience an increase in noise level as the Expressway shifts the traffic further east. With the selected mitigation of a low-noise road surface (PA-10), this increase is limited to 5 dB over the do-nothing level at these locations. The facades most exposed to the existing State highway will remain the most exposed to the Expressway. The increase in noise level will be noticeable, however the predicted levels of 52-57 dB remain within Category A and compliance would be achieved with the Transit Guidelines. Effects from road-traffic noise at these PPFs are considered acceptable.

The former Rahui Milk Treatment Station and former Rahui Factory Social Club have predicted road-traffic noise levels of 61 and 63 dB respectively. A site visit was performed in May 2012 with the building owners present. The treatment station has been converted into an events centre, with visitor accommodation. On the second floor, balconies to bedrooms facing the Expressway and railway have a high concrete parapet. The buildings are currently exposed to distant traffic noise from the State highway and transient noise from vehicle movements on Rahui Road. The noise effects of the Project at these two PPFs are also considered acceptable.

A reduction in noise from rail activities will be observed at all PPFs in this area, from increased separation and the removal of the level crossing.

There will be a period of up to one year after the opening of the Expressway before the final open graded porous asphalt can be installed over the chip seal base. This is required to ensure that the basecourse is appropriately settled, to avoid accelerated wearing. During this period noise levels will be 2-4 dB higher, however will remain at an acceptable level.

6.6 Ōtaki River to Te Horo

Area E - West

The PPFs immediately to the west of the existing State highway are currently subject to high levels of road-traffic noise due to the minimal setback. PPFs are also approximately 50 m from the NIMT. The Expressway will result in a decrease in road-traffic noise at these PPFs. The resulting environment will remain controlled by road-traffic noise, and there are no adverse noise effects from the Project at these PPFs.

Area F - East

The PPFs in this area are currently exposed to a moderate level of road-traffic noise from the existing SH1 and the NIMT, with predicted do-nothing levels of 55-60 dB from road-traffic. There is a small degree of screening provided by the existing rail embankment, which is 50 m from the closest PPFs.

The majority of PPFs in this area are well within Category A, with considerable setbacks between the road and PPFs remaining. Increases in noise level are often limited to 2 dB which is not significant. There is not expected to be a significant change in character of noise, and road-traffic noise is not expected to interfere with domestic activities.

At Old Hautere Road, the predicted road-traffic noise levels at PPFs are generally 52-59 dB, however there is one PPF which is exposed to 65 dB. This PPF is in Category C and the NZTA will investigate building modification options to achieve 40 dB $L_{Aeq(24h)}$ internally. The designation conditions proposed in the AEE specify how this process will occur.

Two PPFs are classified Category B, with noise levels of 59 dB, which is only 2 dB above the Category A criterion. The increase over the do-nothing noise level at these properties is limited to 4 dB. Compliance is achieved with the Transit Guidelines criteria. Landscaping treatment is proposed between the Expressway and Old Hautere Road, and while this will not reduce the measured sound level, this screening is likely reduce the perception of noise from the Expressway.

Two PPFs on School Road will be Category B. The most exposed PPF will be subject to a noise level of 63 dB, which is an 8 dB increase over the do-nothing scenario. This increase will be clearly noticeable. Compliance would not be achieved with the Transit Guidelines. The second PPF is subject to 59 dB from the Expressway, which is a 5 dB increase over the do-nothing. While they are indicated as Category B (new road), they would all be Category A under the altered road criteria (less than 64 dB). As discussed in Section 2.4.2, the numeric criteria only provide guidance for mitigation and therefore the selection is not critical, rather just another point of reference.

There are four PPFs on Gear Road, three of which are Category B. Noise levels range from 56 to 63 dB. Increases in noise level over the do-nothing scenario are 4-6 dB. They would all be Category A (altered road) however two PPFs exceed the Transit Guideline criteria. In the scheme assessment, this section of Expressway was in a slight cut, however this been raised for flood protection reasons. Landscaping treatment will be applied between the Expressway and the Gear Road extensions and, as with Old Hautere Road, this screening should reduce the perception of noise from the Expressway.

All PPFs in this area are currently exposed to road-traffic noise, and the character of the noise is not expected to change significantly because of the Project. This is in contrast to sections of the Transmission Gully and Waterview Connection Projects, where the roads were to be built in greenfield areas with no significant transportation noise. For the Project area, increases are 3-7 dB. There will be increased road-traffic noise, however these remain within reasonable absolute levels. Compliance with Category A and B is designed to achieve reasonable amenity both indoors and outdoors, and road-traffic noise at these levels is not expected to interfere with normal domestic activities. There will be no significant change in noise character, and the resultant effects are considered acceptable.

Noise from the existing State highway and the NIMT will contribute to the noise experienced by these PPFs, however the Expressway will be the dominant source due to its proximity, and the fact that a large portion of the traffic that would have been on the State highway will shift to the Expressway.

6.7 South of Mary Crest

The increase in road-traffic noise due to the Project in this area is no more than 3 dB. All PPFs are currently exposed to some level of road-traffic noise from the existing State highway, and for most PPFs in this area under the Transit Guidelines the noise criteria would be set at 3 dB above the existing ambient noise level. In this instance, this increase is noise level considered reasonable. All PPFs would achieve Category A if the altered road criteria applied.

The road-traffic noise effects in this area are considered acceptable.

6.8 Other areas

Where PPFs have not been assigned an assessment area, the predicted noise level places them into Category A. Where there is an increase in noise due to the Project, the increase is generally limited to 2-4 dB. In many instances there is a reduction in noise level. Noise effects at these properties are considered to be acceptable and no significant change in noise character/amenity is anticipated.

6.9 Rail noise and vibration

6.9.1 Noise

The railway in Ōtaki is in close proximity to a number of PPFs. Rail noise may currently disturb a number of occupants, however people adapt and are less affected over time. The railway will move closer to two PPFs and mitigation is proposed to minimise any adverse effects. Rail movements are irregular and the minimal increase in noise level at all other PPFs is such that no change in amenity is expected. With mitigation, no increase in sleep disturbance is likely. Consequently, with this mitigation, noise effects are considered acceptable.

The grade separation of Rahui Road will result in the elimination of the level crossing, and therefore there will be no crossing bells and trains will not need to use their horn to signal their approach to the intersection. The change in character will be more significant than the change in absolute noise level In addition, there will be no discontinuities which are present at level crossings and give rise to noise.

6.9.2 Vibration

Measurements of vibration from the railway on its existing alignment and in its current condition indicate that the proposed criterion might be exceeded at houses 60 metres or less from the track. There are currently a number of existing houses on County Road within this distance. Due to improved vertical alignment and new ballast (Section 4.4.2), vibration levels for a given distance are predicted to be lower with the realigned railway. Compliance with the proposed criterion is predicted at the two PPFs which will become closer to the realigned railway.

At times vibration from rail movements may be perceptible, however it is unlikely to be disturbing. For these reasons, vibration effects from the realigned railway are considered acceptable.

6.10 Positive effects

Positive effects have been discussed above and the following provides a summary.

The most significant positive noise effect will be the significant reduction in the amount of through-traffic on Ōtaki Main Highway, particularly heavy vehicles. This will result in free-flowing traffic on the Expressway, with fewer stationary vehicles queuing at the roundabout on Main Highway. There is currently a significant amount of engine noise from trucks while driving north up the ‘ramp’, which is clearly audible over the general traffic noise. Heavy vehicles on the Expressway will not exhibit the same characteristics as they will not be accelerating from a roundabout. The Expressway will also be a smooth surface free of discontinuities which will minimise body slap on trucks.

The removal of level crossing and Rahui Road will result in warning bells no longer being necessary and trains will not need to use their horn as they approach Rahui Road.

Properties directly west of the State highway in Te Horo are currently exposed to high levels of road-traffic noise and will experience a significant improvement with the Expressway.

6.11 Summary

The majority of PPFs along this route are exposed to moderate levels of road-traffic noise from the existing State highway. The introduction of the Expressway and local arterial will increase noise levels at some locations, and decrease at others, but will not significantly change the aural character of the environment. The changes are not substantial at any location, with the average increase 3-7 dB where the road is moving closer to PPFs. A summary of the changes in noise level in each assessment area is presented in Table 6-1, along with commentary on the compliance with Transit Guidelines. With the adoption of the mitigation options detailed in Section 5.5, it is considered the noise effects from this Project to be acceptable and the resulting noise levels reasonable.

Table 6-1 Summary of changes in road-traffic noise

Area	Project section	Change in noise level	Compliance with Transit Guidelines
A	North of Ōtaki Ramp	Decrease in noise level at most locations	2x exceedances where PPFs are distant from existing SH1 and near proposed Expressway
B	Main Highway, Ōtaki	Decrease in noise at all locations	Complies at all locations
C	230 Main Highway, Ōtaki	Decrease in noise	Complies
D	East Ōtaki	Minor increases in noise at PPFs on County Road. More significant increase in noise at 2 PPFs	2x exceedances
E	Otaki Gorge to Te Horo (West)	Decrease in noise level at all PPFs, often significant	Complies at all locations
F	Otaki Gorge to Te Horo (East)	Moderate increase in noise level at all PPFs, with greater levels of increase at particular PPFs close to the Expressway	6x exceedances
G	South of Mary Crest	Moderate increase in noise level at some PPFs,	1x exceedence

Rail noise effects will be limited to two PPFs, which are currently exposed to a degree of rail noise. Mitigation is proposed to minimise any noise effects, and with this mitigation noise effects will be acceptable.

The vibration emitted into the ground under the track of the re-aligned railway is predicted to be less than the current levels of vibration due to improved vertical track alignment and ballast condition. This reduction will be partially offset by the decrease in distance between the railway and buildings at two PPFs. Vibration at these PPFs is predicted to achieve the Class C criterion, and will be of similar level to vibration experienced at PPFs on County Road. For these reasons, adverse effects from rail vibration are considered acceptable.

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Conditions

The new assessment method from NZS 6806, which has been used in this Project, has changed the way in which noise mitigation measures are designed. While the criteria proposed by the Transit Guidelines are generally appropriate, in any instances rigid adherence to specific noise limits, regardless of practicality or adverse effects such as shading by barriers, has resulted in poor outcomes. NZS 6806 promotes an integrated design process to establish the best practicable option.

NZS 6806 requires significantly more design work during the noise assessment, and consequently the noise mitigation is more refined at this stage in the Project.

It is not possible to assign a simplistic performance standard such as a noise limit to the NZS 6806 process or the results of the process. The BPO is determined by following the correct process and not by achieving an absolute limit.

To support the introduction of NZS 6806, the NZTA has commissioned its legal panel to prepare designation conditions that encapsulate the NZS 6806 process. The conditions aim to provide certainty in the noise mitigation outcome to be provided, while allowing for development during normal detailed design processes. It is recommended that this form of conditions should be used for road-traffic noise. These conditions are listed in the AEE for the Project. Despite the concerns of the Boards of Inquiry for the Waterview and Transmission Gully projects (discussed in Section 2.4.5), the conditions adopted were consistent with the approach outlined in NZS 6806.

The designation boundaries constrain the possibility for significant increases in noise due to alignment changes during design development.

No conditions are proposed for rail vibration, as the new alignment will meet the vibration criteria without the need for mitigation.

Conditions should be based on the following mitigation in Tables 7-1 and 7-2, subject to design in accordance with NZS 6806.

Table 7-1 Selected options - road surfaces

Location	Surface	Length
Ōtaki Township (01300-02350)	Open graded porous asphalt (PA-10)	1050 m

The open graded porous asphalt surface is to be installed within 1 year of the Expressway opening, as the underlying structure is required to settle.

Table 7-2 Selected options - building-modification mitigation

PPF
14 Old Hautere Road
Otaki Motel
230 Main Highway

The proposed conditions for this Project are detailed in Volume 2 of the AEE.

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Conclusions

The Expressway has been assessed in accordance with NZS 6806, and actual and potential noise effects considered. For each area where there are Protected Premises and Facilities (PPFs) near the road, the BPO for noise mitigation has been determined through an integrated assessment process. Rail noise and vibration has been assessed against the criteria recommended by KiwiRail's reverse sensitivity guidelines.

Road-traffic noise levels will remain at reasonable levels throughout the route, and mitigation has been selected in some locations to reduce potential effects. Open-graded porous asphalt (PA-10) has been selected by the project team for the road surface through Ōtaki, as the appropriate form of noise mitigation. Building treatment has been identified as being appropriate at one PPF near Te Horo to protect from road-traffic noise, and two PPFs in Ōtaki to protect from rail noise. For the remainder of the Project, no specific noise mitigation is proposed.

The route closely follows the existing State highway, and no significant change in character of noise at most nearby PPFs is expected. There will be a significant improvement in the acoustical amenity within the Ōtaki township with the reduction in through traffic, and in particular heavy vehicles. There will also be a significant reduction in noise for those properties directly accessing the State highway in Te Horo.

There will be increases in noise levels primarily at PPFs to the east of the Expressway. Predicted noise levels provide a reasonable level of amenity in outdoor areas and protection from sleep disturbance in indoor areas. Based on the existing environment, and the limited change in noise level as well as character, potential noise effects from this Project are considered acceptable.

Limitations

URS New Zealand Limited (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the NZ Transport Agency connection with the designation of Expressway and the local roads. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Acoustics Scope dated July 2010.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between February 2012 and January 2013 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.