Technical Report 15

Assessment of Traffic Noise Effects

NZ TRANSPORT AGENCY
WAKA KOTAHI

1 MacKays to Peka Peka Expressway

Revision History

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-	Siiri Wilkening (Marshall Day Acoustics)	For internal review by Marshall Day Acoustics	15 August 2011
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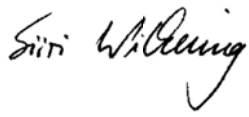
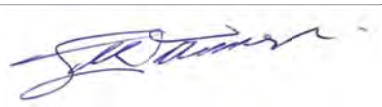
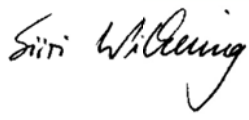
Document Acceptance

Action	Name	Signed	Date
Prepared by	Siiri Wilkening (Marshall Day Acoustics)		15 August 2011
Reviewed by	Graham Warren (Marshall Day Acoustics)		20 September 2011
Approved by	Siiri Wilkening		25 January 2012
on behalf of	Marshall Day Acoustics		

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1. Executive summary

This report provides an assessment of operational noise effects for the MacKays to Peka Peka Expressway Project.

It contains a review of relevant traffic noise criteria, a discussion of appropriate criteria and methodologies of assessment, and a detailed discussion of the determination of the "best practicable option" for traffic noise management and mitigation measures for each Sector of the Project.

Traffic noise has been assessed in accordance with NZS6806:2010 "Acoustics – Road-traffic noise – New and altered roads". Preferred mitigation options have been determined by the Project team[1] through the application of the best practicable option approach.

Mitigation measures proposed include noise barriers and bunds, and the installation of low-noise generating road surface material, such as Open Graded Porous Asphalt.

Detailed plans show the location, height and length of barriers where these are the selected mitigation options, and tables list the predicted noise levels for individual dwellings assessed for each sector, for each mitigation option considered.

The Project can be designed and operated to achieve compliance with relevant criteria, and the best practicable option approach to mitigation determination and design, involving the wider Project team, provides a balanced result for the implementation of mitigation measures.

2. Introduction

The purpose of this report is to provide an assessment of the NZTA's MacKays to Peka Peka Expressway Project in relation to traffic noise effects associated with the Project. Where this assessment identifies potential adverse traffic noise effects on the environment, the report provides measures to avoid, remedy or mitigate these effects. Where there is uncertainty regarding the likely effects or the significance of effects, the report recommends monitoring and, where appropriate, subsequent response.

This noise report relates closely to other reports pertaining to construction noise and construction and operational vibration. It is based on information provided in the traffic report[2] for the Project,

[1] This Technical Report refers to the Project team as carrying out works on behalf of and as contracted by the NZTA. The NZTA is the requiring authority and the consent holder.

[2] Technical Report 32, Volume 3, Assessment of Transport Effects

specifically current and future traffic volumes on local roads and State highways, and provides input to other Project reports, such as the visual[3] and social impact assessments[4]. The results of the traffic noise assessment, specifically the management and mitigation measures, form part of the Project's Environmental Management Plans (Appendix F of the CEMP, Volume 4).

The proposed Expressway has been assessed in four sectors as shown and described in Part D, Chapter 7, Volume 2 of the AEE, with Sector 1 extending from just south of Poplar Avenue to Raumati Road, Sector 2 from Raumati Road to Mazengarb Road, Sector 3 from Mazengarb Road to north of Te Moana Road and Sector 4 from Te Moana Road to Peka Peka. This assessment report refers to those sectors throughout.

A glossary of technical terms is contained in Appendix 15.A.

3. Project description

A full Project description is contained in Part D, Chapter 7, Volume 2 of the AEE. The following sections contain a brief overview of each Project sector in relation to features that may affect noise generation.

3.1. Sector 1 – MacKays Crossing to Raumati Road

Sector 1 is extended from south of Poplar Avenue to the north of Raumati Road (Chainage 900 to 4500).

Following is an overview of the proposed Expressway Alignment, bridges, interchange and local road connections as they may have an effect on traffic noise generation:

- The proposed Expressway crosses over Poplar Avenue. Poplar Avenue itself will remain at grade but will be realigned to the north at its existing location.
- A partial interchange will be located at Poplar Avenue with on and off ramps.
- The proposed Expressway crosses the eastern end of Leinster Avenue. Leinster Avenue will be closed at this location to form a cul-de-sac. A separate accessway will be provided for properties north of Leinster Avenue.
- The Expessway will cross over Raumati Road (with twin bridges). Raumati Road will remain at grade.

[3] Technical Report 7, Volume 3, Assessment of Landscape and Visual Effects

[4] Technical Report 20, Volume 3, Assessment of Social Effects

Traffic noise attenuation will be provided in several locations throughout this Sector. Details of the dimensions and location of these noise attenuation measures are provided in Appendix 15.B[5] of this report.

3.2. Sector 2 – Raumati Road to Mazengarb Road

Sector 2 commences north of Raumati Road and extends to north of Mazengarb Road.

Following is a general overview of the proposed Expressway Alignment, bridges, interchange and local road connections as they may affect traffic noise generation:

- The proposed Expressway will cross over Kāpiti Road (twin bridges).
- A full diamond interchange will be constructed at Kāpiti Road. This will consist of north and south facing on and off ramps connecting to Kāpiti Road.
- Kāpiti Road will remain at grade with improvements made to the local road to allow the network to manage the Expressway traffic. These improvements will generally include widening Kāpiti Road to 6 lanes and generally two traffic lanes in each direction. In addition, the intersection of the on and off ramps will be signalised to control traffic exiting the Expressway onto Kāpiti Road and vice versa.
- The proposed Expressway will cross over Mazengarb Road on twin bridges. Mazengarb Road will be slightly lowered to reduce the height of the proposed Expressway.

Traffic noise attenuation will be provided in several locations throughout this Sector. Details of the dimensions and location of these noise attenuation measures are provided in Appendix 15.B of this report.

3.3. Sector 3 – Mazengarb Road to North of Te Moana Interchange

Sector 3 extends from north of Mazengarb Road to the north of Te Moana Road.

The following paragraphs provide a general overview of the proposed Expressway Alignment, bridges, interchange and local road connections as they may affect traffic noise generation:

- The proposed Expressway will cross over Otaihanga Road. Otaihanga Road will remain at grade in its current location. A new accessway will be provided for those properties on the eastern side of the proposed Expressway to the north of Otaihanga Road.
- The proposed Expressway will cross over the Waikanae River and a new access road to the Waikanae Christian Holiday Camp (El Rancho).

[5] Appendix 15.B is contained in Technical Report Appendices, Report 15, Volume 5

- The proposed Expressway will cross over Te Moana Road. A full diamond interchange will be located at Te Moana Road consisting of north and south facing on and off ramps connecting to Te Moana Road.
- Two roundabouts on Te Moana Road will be built to the east and the west of the proposed Expressway to provide access onto and off the proposed Expressway, without the need for signals.
- Near the bridge, Te Moana Road will need to be widened. Te Moana Road will remain at grade in its current location.

Traffic noise attenuation will be provided in several locations throughout this Sector. Details of the dimensions and location of these noise attenuation measures are provided in Appendix 15.B of this report.

3.4. Sector 4 – North of Te Moana Interchange to Peka Peka Road

Sector 4 commences north of Te Moana Road and ends to the north of Peka Peka Road.

A general overview of the proposed Expressway Alignment, bridges, interchange and local road connections, as they affect traffic noise generation, is provided below:

- The proposed Expressway passes under Ngarara Road. Ngarara Road will be bridged over the proposed Expressway and requires a minor realignment.
- A new local road will be bridged over the proposed Expressway to provide access to properties currently serviced by Smithfield Road and the Nga Manu nature reserve on the eastern side of the Expressway Alignment.
- On the western side of the proposed Expressway, existing Smithfield Road will be retained up to the edge of the proposed Designation boundary. On the eastern side of the proposed Expressway, existing Smithfield Road will be retained up to the edge of the proposed Designation boundary and a local road connection made between the new Smithfield Road and the existing Smithfield Road for the purposes of continued access to properties.
- A partial interchange will be located at Peka Peka Road with on and off ramps.
- A local connection from existing SH1 heading north passes over the proposed Expressway south of Peka Peka Road and connects to a roundabout at grade at Peka Peka Road. A new roundabout will provide a local connection onto Peka Peka Road, a local connection northward as well as a northern on ramp to the proposed Expressway.

Traffic noise attenuation will be provided in several locations throughout this Sector. Details of the dimensions and location of the noise attenuation measures are provided in Appendix 15.B of this report.

4. Existing noise environment

The existing noise environment of the area through which the proposed Expressway traverses provides a base for assessing noise effects in terms of the RMA, independent from compliance with the criteria of NZS6806.

Assessment is possible through an understanding of the potential change in noise level due to the implementation of the Project. (refer Section 6.5 for further explanation)

For this reason, the existing noise environment in the vicinity of the Project has been investigated extensively by means of noise level surveys.

4.1. Noise level survey methodology

Technical Report 17, Volume 3 (Pre Construction Noise Level Survey) contains extensive information relating to the ambient noise level surveys. This section contains a summary of that report.

Noise level surveys were undertaken along the Alignment of the proposed Expressway in April and May 2011. Of the 39 locations surveyed, eight consisted of long duration noise level surveys and 31 of short duration daytime noise level measurements.

Tablesof the noise survey locations are contained in Appendix 17.C of the Technical Report 17, Volume 3, and figures showing these locations are contained in Appendix 15.C[6] of this report.

4.1.1.Long duration surveys

Eight representative measurement sites were selected for continuous long term measurements using unattended noise loggers over periods of five to seven days each. The measurement positions were selected as being representative of a group of houses potentially affected by noise from the proposed Expressway.

The daily 24-hour variations of noise levels for each long duration survey are shown in Appendix 17.D of Technical Report 17, Volume 3. Ambient noise data from the loggers was converted to $L_{Aeq(24hr)}$ sound levels. Appendix 17.D shows the long term noise levels for each location, together with the 24-hour variation in sound level and a photo of the survey site.

[6] Appendix C is contained in Technical Report Appendices, Report 15, Volume 5

4.1.2. Short duration surveys

Short duration attended noise level surveys were undertaken along the entire Expressway Alignment in order to gain extensive and covering knowledge of the existing ambient noise environment. Surveys were undertaken for 15 to 30 minutes at each position during daytime.

While the resultant noise levels provide only a level for the duration of measurement, they provide an indication of average daily noise levels in the area when examined in the context of the long duration noise level surveys.

4.2. Summary of existing noise environments

The proposed Expressway has been assessed within each of the four Sectors identified in Section 2 above. The existing noise environments for each Sector are discussed below.

4.2.1. Sector 1

The noise environment in Sector 1 varies from relatively elevated in areas close to the existing SH1 (e.g. at Leinster Avenue) to relatively quiet in areas removed from local main roads (e.g. towards Raumati Road).

Noise levels were measured at 12 locations, including two long duration noise level surveys. Noise levels varied from 42 to 68 dB $L_{Aeq(24h)}$.

4.2.2. Sector 2

Sector 2 includes densely populated residential areas between Kāpiti and Mazengarb Roads, with further scattered residential developments north of Raumati Road and south of Kāpiti Road.

Apart from areas immediately adjacent to the local main roads (Kāpiti, Mazengarb and Raumati Roads) the ambient noise environment is considered to be low for a suburban area.

Noise levels were measured at 19 locations, including two long duration surveys. Noise levels varied from 42 to 55 dB $L_{Aeq(24h)}$.

4.2.3. Sector 3

The character of Sector 3 is becoming increasingly rural, with a few dwellings spread along the Alignment. Areas of denser residential activity include the Kauri/Puriri Road area and Te Moana Road. Ambient noise levels are relatively low for most of the survey locations.

Noise levels were measured at nine locations including three long duration noise level surveys. Noise levels varied from 42 to 53 dB $L_{Aeq(24h)}$.

4.2.4.Sector 4

Sector 4 traverses rural areas only, with the proposed Expressway connecting with the existing SH1 at Peka Peka. Dwellings are located sparsely along the Alignment with a more densely populated area at Peka Peka.

Noise levels were measured at seven locations, including one long duration survey. Noise levels varied from 44 to 55 dB $L_{Aeq(24h)}$. Dwellings at Peka Peka are some distance from the existing SH1, and closer houses would be removed for the proposed Expressway Alignment, therefore, ambient noise levels at the closest potentially affected houses are lower than in Sector 1.

Overall, ambient noise levels along the proposed Expressway Alignment are relatively low due to the absence of major local roads or industry in the vicinity.

5. Noise performance standards

The prediction, assessment, and control of road-traffic noise impacts from the Project can be undertaken in accordance with various methodologies, including national policy instruments, relevant New Zealand standards and legislative controls.

Potentially relevant Noise Assessment methodologies and standards include:

- New Zealand Standard NZS6806 “Acoustics – Road-traffic noise – New and altered roads” (the Standard)
- NZTA (Transit New Zealand) Guidelines for the Management of Road Traffic Noise – State highway Improvements (Noise Guidelines) – superseded by NZS6806
- NZTA Environmental Plan (June 2008)

Refer to Appendix 15.A for a definition of technical terms.

Further discussion of each of these is provided in the following sections.

5.1. New Zealand Standard NZS6806:2010

A Standard for the assessment and control of road-traffic noise (NZS6806:2010 “Acoustics – Road-traffic noise – New and altered roads”) has recently been developed and issued as a full New Zealand

Standard in April 2010. It is considered appropriate that the assessment of this Project be based on the provisions of this Standard. This is the first New Zealand road-traffic noise standard and was developed by an independent multidisciplinary committee of Standards New Zealand. The committee consisted of representatives of the following nominating organisations:

- Department of Building and Housing
- IGENIUM (an organisation representing engineers who look after public assets such as roads)
- Local Government NZ
- Ministry of Health
- Ministry of Transport
- New Zealand Acoustical Society
- New Zealand Institute of Environmental Health Inc.
- NZ Transport Agency
- Road Controlling Authorities New Zealand Inc.
- Road New Zealand.

The Standard is intended for all road-traffic noise assessments both from State highways, and local roads in circumstances where the traffic is within the thresholds of the Standard. The NZTA has adopted this Standard for assessment of road-traffic noise from new and altered State highways.

The Standard is an extensive and complex document; therefore, it is only practicable to present the key concepts for the purposes of this report.

The Standard retains some of the methodologies previously used in the NZTA Noise Guidelines (discussed in Section 5.2 below), such as the noise measurement index ($L_{Aeq(24h)}$) and the concept of a “design year” (the year for which the assessment is undertaken) at least ten years after opening of a project.

5.1.1. Assessment positions

The Standard specifies a list of types of protected premises and facilities (PPFs), which are assessed in accordance with the provisions of the Standard. In addition to premises that were protected under the NZTA Noise Guidelines (refer Section 5.2 below), such as dwellings and educational facilities, NZS6806 extends its protection to other premises such as marae, hospitals which contain in-patient facilities, motels and hotels in residential zones and playgrounds within 20 metres of educational facilities.

The assessment position for existing buildings is at the façade (i.e. an ‘incident’ noise level) rather than one metre in front of the façade (as was previously the case under the NZTA Noise Guidelines), thus a facade correction is no longer included.

Commercial and business uses are not considered to be PPFs and are therefore excluded from the assessment as they are not considered to be noise sensitive.

NZS 6806 stipulates that, in an urban area, all protected premises and facilities within 100 metres of the Alignment shall be assessed, and excludes locations outside this area. The noise assessment

for the Project has generally been undertaken in accordance with this limitation. However, where appropriate in unusual circumstances, additional buildings have been included in the assessment. Where this has been undertaken, it is noted in this report.

5.1.2.Noise criteria

The noise criteria of the Standard are not based on existing ambient noise levels, but are dependent on traffic volume and distinguish between new and altered roads. There are three levels of criteria (A, B and C) as set out in the table below.

Table 5-1: Noise criteria

Category	Altered Roads dB $L_{Aeq(24h)}$	New Roads with a predicted traffic volume >75,000 AADT at the design year dB $L_{Aeq(24h)}$	New Roads with a predicted traffic volume of 2,000 to 75,000 AADT at the design year dB $L_{Aeq(24h)}$
A (primary external noise criterion)	64	64	57
B (secondary external noise criterion)	67	67	64
C (internal noise criterion)	40	40	40

The relevant columns for this Project are shaded in the table.

This Project constitutes a new road with traffic volumes between 2,000 and 75,000 vehicles per day. This means that the applicable criteria are as follows: the “A” (or primary external) noise criterion is 57 dB $L_{Aeq(24h)}$, the “B” (or secondary external) noise criterion is 64 dB $L_{Aeq(24h)}$ and the “C” (or internal) noise criterion is 40 dB $L_{Aeq(24h)}$.

However, the Standard states that “special cases” may apply for areas such as intersections, tie-ins or mergers.[7] For these, case-by-case assessments are required. It has been assumed, for these special circumstances, that the criteria be chosen partially based on existing noise levels, i.e. where

[7] NZS6806:2010, Section 6.2.1

existing noise levels are elevated due to local roads in the vicinity, the altered road criteria should apply. This is considered to be in line with the RMA which addresses effects from an activity. Where existing noise levels are elevated, the introduction of a new noise source such as the proposed Expressway would result in less noise level increase than for areas where the existing noise levels are low.

Where the proposed Expressway crosses local roads such as Kāpiti, Mazengarb, Otaihanga or Raumati Road, the ambient noise levels are only slightly higher than in areas removed from the roads. This is due to the relatively low traffic flows on the roads which means that noise levels reduce quickly once locations become more removed from the roads. Therefore, the 'new road' criteria have been used where the proposed Expressway crosses local roads.

However, where the proposed Expressway joins the existing State Highway 1, ambient noise levels are elevated due to the relatively high traffic volumes on SH1, and some road widening is required on SH1. Therefore, for these areas, the Project has been assessed as an altered road. This means that the applicable criteria are as follows: the "A" (or primary external) noise criterion is 64 dB $L_{Aeq(24h)}$, the "B" (or secondary external) noise criterion is 67 dB $L_{Aeq(24h)}$ and the "C" (or internal) noise criterion is 40 dB $L_{Aeq(24h)}$.

The criteria to be used depend on the application of the best practicable option (BPO) test, with the A criterion being met or bettered if this is consistent with the BPO, the B criterion being met or bettered if criterion A is not achievable with the BPO, and criterion C being achieved with the adoption of the BPO, if criterion B is not achievable with the BPO.

The Category C criterion is an internal design criterion for habitable rooms; however, while not specifically stated in NZS6806, it is assumed that the internal criterion applies to all noise sensitive rooms in protected premises and facilities, including teaching areas and in-patient care rooms where patients sleep.

The 40 dB $L_{Aeq(24h)}$ criterion is required to be achieved by the adoption of the BPO, for habitable rooms which would otherwise receive internal noise levels greater than 45 dB $L_{Aeq(24h)}$, i.e. a minimum noise level reduction of five decibels is required to be achieved.

5.1.3. Noise assessment scenarios

For new roads, NZS6806 provides for several operational scenarios to be assessed and compared. These include:

- The existing noise environment which, for altered roads, consists of the current road layout and traffic volume, and, for new roads, consists of the current ambient noise level;
- A future Do-Minimum scenario, which represents circumstances at the design year where a Project has been implemented without any specific noise mitigation. This means that the choice

of road surface material is independent from its noise generating characteristics and the only barriers included are solid safety barriers, which are required for reasons other than noise mitigation. Local roads that are not proposed to be altered by the NZTA in conjunction with the proposed Expressway Project, are not included in the assessment as they are not part of this Project. In addition, these roads are outside the Designation;

- Several future mitigation options, which consist of scenarios whereby mitigation is designed specifically to reduce noise levels in order to achieve compliance with the relevant noise criteria and fulfil the BPO test.

5.1.4. Mitigation options

The fundamental basis of compliance with NZS6806 is the determination of the BPO for mitigation measures.

In order to ensure that the BPO is identified, NZS6806 requires that several mitigation options be developed and compared, not only in terms of noise level reductions but also in relation to other considerations such as urban design, safety, cost, technical feasibility and others. For large projects, such as the proposed Expressway, the Standard recommends that up to four mitigation options should be developed and a selected option chosen. However, some parts of the proposed Expressway traverse lightly populated areas where a lower number of mitigation options (up to two) is recommended by the Standard.

The process of comparing mitigation options is interactive, and often additional mitigation options are developed from the collaboration of several disciplines. Therefore, the assessment result generally consists of a number of options, and a selected option developed by the entire Project team. For that reason, the mitigation option chosen as the selected option may not be providing the greatest noise level reduction, but is considered optimal and practicable on balance, when evaluated by the team against relevant criteria. For further explanation of the process of determining the selected mitigation option, refer to Section 6.3.5 below.

5.1.5. Structural noise mitigation requirements

One aspect of the BPO is the noise level reduction achieved by structural noise mitigation. Structural noise mitigation includes low noise road surface materials and barriers of any type, if these are chosen specifically for their noise reducing characteristics.

Barriers, while often effective for noise reduction purposes, can cause adverse effects, such as shading or safety issues. While these are outside the area of expertise of the acoustic consultant, and are dealt with by other disciplines through the BPO process described in Section 5.1.4 above, any structural noise mitigation measures need to be designed so that they result in worthwhile noise level reductions.

Therefore, NZS6806 includes a criterion for the effectiveness of structural mitigation measures. In areas of high residential density, such as the Raumati, Paraparaumu and Waikanae residential areas, structural mitigation *"should only be implemented if the combination for the structural mitigation measures used would achieve … an average reduction of at least 3 dB $L_{Aeq(24h)}$"*[8]. In areas of lower residential density, such as areas of rural character with houses sporadically located along the Alignment, structural mitigation should achieve *"a minimum reduction of 5 dB $L_{Aeq(24h)}$ at any assessment position(s)"*.[9]

The circumstances of the proposed Expressway require the application of a common sense approach whereby assessment locations that are likely to receive noise mitigation from the same barrier should be grouped in order to achieve a practicable outcome. This means that all receiver clusters must be on the same side of the road and geographically close. The Standard defines a cluster of assessment positions to be at least three PPFs that are on the same side of the road and to be within 100 metres of each other.[10]

The reason for the minimum requirement that an average of 3 decibels mitigation should be achieved is that in an urban situation many receivers are in close proximity to each other, and a barrier would benefit more than just one or two PPFs. The noise level reductions for individual assessment positions would vary, from significant for positions located immediately behind a barrier, to lesser reductions for those at the ends or further removed from a barrier.

In rural areas, barriers would generally provide noise level reductions for individual dwellings only due to the large distance from one dwelling to the next, and therefore a significant noise level reduction should be achieved to justify the installation of any mitigation measure.

It is noted that the criteria contained in NZS6806 have been developed with the intention that they are "*reasonable criteria for the road-traffic noise from new or altered roads taking into account adverse health effects associated with noise; the effects of relative changes in noise levels on people and communities; and the potential benefits of new and altered roads to people and communities*"[11].

[8] NZS6806 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.2(a), page 41.

[9] NZS6806 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.2(b), page 41.

[10] NZS6806 Acoustics – Road-traffic noise – New and altered roads, Section 2.2, page 22.

[11] NZS6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 1.1.3, page 15.

5.2. NZTA (Transit) Noise Guidelines

Prior to the development of NZS6806, the NZTA (formerly Transit New Zealand) had developed 'Transit New Zealand's Guidelines for the Management of Road Traffic Noise – State highway Improvements' (Noise Guidelines). The NZTA, while fully adopting the provisions of NZS6806, requires an assessment in accordance with the Noise Guidelines during the first two years of adoption of NZS6806 in order to gain an understanding of the implications of the new Standard.

The Noise Guidelines assessed the predicted future traffic noise level for a design year 10 years from the construction of a highway with respect to the existing ambient noise levels and provided traffic noise design levels to be met for State highway projects.

Although the NZTA Noise Guidelines did not have statutory status, they had been widely adopted up until recently as a de-facto traffic noise standard for most major roading developments.

The assessment of road traffic noise in accordance with the Noise Guidelines, while generally similar to the assessment methodology prescribed in NZS6806, differs in some fundamental aspects from the Standard. These differences include specifically:

- The criteria, which are based on ambient noise levels rather than the type of roading project
- The assessment position, which is at 1 metre from the facade rather than at the facade thus including a 2.5 decibel facade adjustment and
- The inclusion of a maximum noise criterion (the Single Event Noise Design Criterion L_{Amax})

It is therefore not practicable to directly compare the Noise Guidelines outcomes with those determined through NZS6806. However, the noise assessment includes reference to the Noise Guidelines, generally, as one of the mitigation options discussed in Section 7 below.

5.3. NZTA Environmental Plan

The NZTA has developed an 'Environmental Plan' (Version 2, June 2008). The Environmental Plan is intended to support the NZTA's responsibilities for environmental sustainability under the Land Transport Management Act 2003 and contains sections on several issues, including noise.

The Implementation Plan for Noise within the Environmental Plan discusses a number of approaches designed to reduce noise effects on sensitive receiver positions, including land use planning opportunities, requirements of new developments adjacent to State highways to provide noise mitigation, reduction of heavy vehicle noise and a revision of the NZTA Noise Guidelines.

The Environmental Plan also states that noise assessments should be undertaken and Designation conditions sought recognising reasonable noise limits for new or altered designations in areas likely to be affected by road-traffic noise. In accordance with the Environmental Plan, NZTA has contributed to and now adopted NZS6806. Therefore, this current assessment focuses on the

achievement of compliance with the provisions of NZS6806 and is also consistent with the Environmental Plan.

5.4. District Plan

The proposed Expressway traverses the jurisdictional area of the Kāpiti Coast District Council. The District Plan of the Council contains the following rules that may be applicable to this Project:

"D.1 Residential Zone Standards

(ii) Transportation Noise

b) Predicted Future Excessive Noise Routes

The only future road predicted, at this stage, to become an excessive noise route is the Sandhills Arterial, the route and extent of which is shown by the designation in the planning maps. No dwelling shall be erected within 80 metres of the boundary of the Sandhills Arterial designation except where the following standards can be satisfied:

- *An external $L_{10(18\,h)}$ level of 60 dBA required at a point 1 metres from the façade of the buildings.*
- *An internal $L_{10(18\,h)}$ level of 40 dBA in all internal rooms with the windows closed.*

An acoustic design certificate to be provided to show how this level can be met using approved noise abatement measures.

Transportation noise levels shall be measured in accordance with NZS6801:1991 "Measurement of Sound"."

This rule does not constitute a noise performance standard for this Project, but relates to the design of buildings adjacent to the existing WLR designation. Therefore, it is not relevant to this road construction Project.

The existing WLR designation is not proposed to be retained, therefore, the above rule is not applicable to the proposed Expressway Project and has not been taken into consideration further in this report.

However, if this rule was to apply to the Designation sought for the proposed Expressway, then new dwellings within 80 metres of the proposed Expressway Designation would be required to be sited so that the external noise level at 1 metre from the façade is no more than 60 dB $L_{A10(18h)}$ and designed so that they meet the internal noise criterion of 40 dB $L_{A10(18h)}$.

These criteria are similar to the criteria of NZS6806 (57 dB $L_{Aeq(24h)}$ external and 40 dB $L_{Aeq(24h)}$ internal).

A further rule states the following:

"D.2 Rural Zone Controlled Activity Standards

New Roads

Traffic Noise From New Roads

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 ambient sound levels by more than the limits specified in the following table:

Ambient Noise Levels (dBA) $L_{eq(24\ hour)}$	*Noise Limit (dBA)* $L_{eq(24\ hour)}$
Less than 43	*55*
43 – 50	*Ambient + 12*
50 – 59	*62*
59 – 67	*Ambient + 3*
67 – 70	*70*
More than 70	*Ambient"*

The criteria set out in this rule are based on the now historic Noise Guidelines from 1990 (refer Section 5.2 above), as stated in the District Plan Section C.14-2.

Since the publication of the Kāpiti Coast District Plan in 1999, the New Zealand Road Traffic Noise Standard NZS6806 has been published. The District Plan is currently being reviewed, and it is likely that a variation in noise rules relating to road traffic noise would be incorporated into the District Plan, in line with the available Standards in New Zealand.

5.5. Discussion and conclusion on noise performance standards

Utilisation of NZS6806 "Acoustics – Road-traffic noise – New and altered roads" to assess the Project's road-traffic noise impacts will result in reasonable noise levels for all affected residents in the vicinity of the Project. The Standard also provides a suitable methodology for predicting the potential noise impacts from the Project on future development in the vicinity.

The methodologies for noise level measurement, prediction and assessment set out in the Standard ensure an equitable management of noise effects for all assessment positions in the vicinity of the proposed Expressway.

The Standard is based on the best practicable option approach, which aligns with RMA requirements. It is therefore considered that for this Project the utilisation of NZS6806 is appropriate.

6. Assessment methodology

6.1. Existing noise environment

Traffic noise has been assessed in accordance with the New Zealand Standard NZS6806. Noise level criteria in the Standard are not based on existing ambient noise levels and are chosen depending on the type of road, traffic volume and the application of the best practicable option for mitigation.

Nevertheless it is important to gain an understanding of the existing noise environment (refer Section 3) to enable an accurate assessment of noise effects due to changes to noise levels as a result of the Project.

Existing ambient noise level information was obtained by measurement (refer Technical Report 32, Volume 3 and Section 3 above) and was subsequently used in the effects assessment for all identified receiver positions. Surveys of the existing noise environment were carried out in potentially affected areas in the vicinity of noise sensitive activities between 6 April and 20 May 2011.

Ambient noise measurements showed a range of noise levels from 40 dB to 68 dB $L_{Aeq(24h)}$ (refer Section 3) demonstrating the varying effect of relative proximity to existing roads, with noise levels at the lower end representing positions located away from the existing roading network and at the higher end representing positions close to existing major roads (such as the existing SH1, Kāpiti and Te Moana Roads).

The existing ambient noise level for most of the Alignment is not controlled by current road traffic noise. Therefore, it is not possible to realistically model the existing noise environment for large sections of the Alignment. Therefore, ambient noise level survey results have been used to determine the existing noise levels in the vicinity of the proposed Alignment, and no computer noise modelling was undertaken for the existing (pre-Expressway) circumstance. This is further discussed in Section 6.4 below.

6.2. Road parameters

The traffic noise prediction method most commonly used in New Zealand is the UK Department of Transportation, Welsh Office “Calculation of Road Traffic Noise”, adjusted for New Zealand conditions, specifically the road surfaces, in accordance with LTNZ Report No. 326.

This calculation methodology takes into consideration multiple factors which affect the road noise level. These include, amongst others, the traffic volume, vehicle speed, road gradient, angle of view, percentage of heavy vehicles and road surface material. The calculation methodology also takes into account limited meteorological conditions, namely for slightly enhancing weather conditions with an average wind speed of approximately 2 m/s and a wind direction of no less than 45 degrees from the road, i.e. downwind.[12]

6.2.1. Design year

The year 2026 has been selected as the design year for this Project and aligns with the traffic modelling of the Project. The anticipated opening year for the road is 2016. NZS6806 requires the assessment of traffic noise at least 10 years after the opening of a new or altered road making the 2026 design year appropriate.

6.2.2. Road surface material

The selection of road paving has a significant effect on traffic noise generation as road tyre interaction is the major source of traffic noise at open road speeds (40 km/h and above). This has been shown in numerous studies and is described in detail by Prof. Ulf Sandberg in the Tyre/Road Noise Reference Book[13]. The following table is an excerpt from that book, describing the cross-over speed at which the road/tyre interaction becomes the controlling noise source over engine noise.

Table 6-1: Road/Tyre Noise

"Table 5.1 Crossover speeds for various cases, i.e. the speed above which tyre/road noise is more important than power unit noise.		
Vehicle type	*Cruising*	*Accelerating*
Cars made 1985-95	*30-35 km/h*	*45-50 km/h*
Cars made 1996-	*15-25 km/h*	*30-45 km/h*
Heavies made 1985-95	*40-50 km/h*	*50-55 km/h*
Heavies made 1996-	*30-35 km/h*	*45-50 km/h"*

Appendix D of NZS6806 contains extensive discussion of the application of low noise road surfaces. It confirms that "open graded porous asphalt" (OGPA), a porous and smooth layered asphalt surface, can reduce noise levels by around six decibels when compared with "chip seal", the noisiest surface. This is a noticeable difference. However, in order for this reduction in noise

[12] Department of Transport, Welsh Office: Calculation of Road Traffic Noise, Sections 4 and 39.2

[13] Ulf Sandberg, Jerzy A. Ejsmont: Tyre/Road Noise Reference Book, Informex 2002, ISBN 91-631-2610-9

level to be achieved and maintained, OGPA must be laid to a sufficient depth, properly drained and regularly cleaned.

It is understood that, for non-acoustic reasons, the proposed Expressway Alignment will be paved with OGPA from its southern termination to the new Smithfield Road bridge. From this point to the northern end of the Project, chip seal road surface is proposed.

6.2.3. Traffic volume and speed

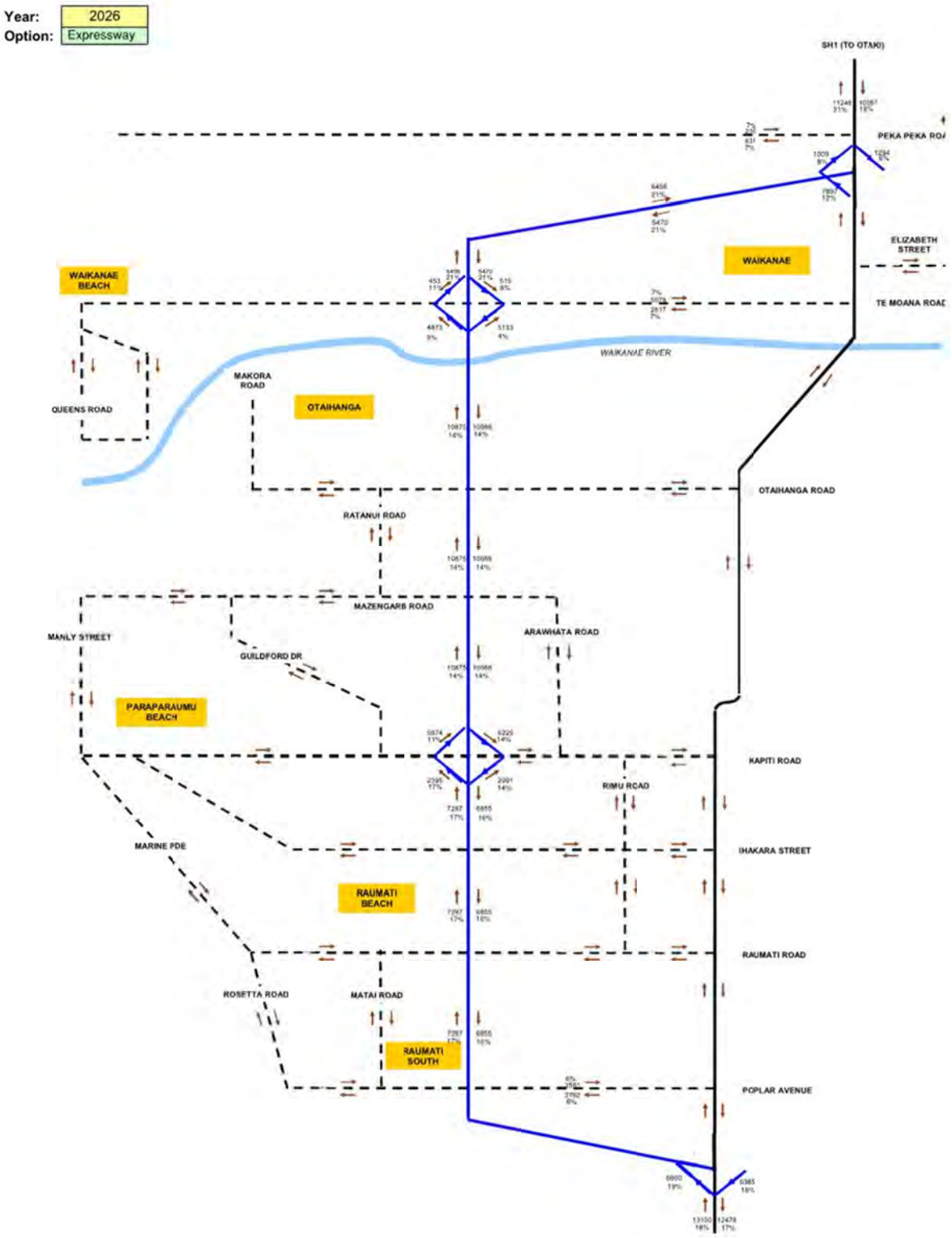
The speed and volume of traffic on a road are key factors in determining the level of traffic noise generated. Traffic flows generally increase with time. The proposed Expressway is intended to have a posted speed of 100 km/h. This speed has been used in the computer noise modelling. On ramp speed has been modelled at 70 km/h and off ramp speed as 60 km/h, taking account of the acceleration and reduction in speed respectively.

In this circumstance, the operation of the proposed Expressway would also result in decreased traffic flows on the existing SH1. This will provide a beneficial reduction in noise level for most residences adjacent to SH1, e.g. traffic volumes are predicted to reduce by approximately 50% which equates to a three decibel noise level reduction. (refer Section 6.5 below)

Noise level predictions for the Design Year 2026 were based on traffic flow figures provided by Beca for the proposed Expressway and its associated ramps and parts of local roads that are proposed to be changed due to the Project, but excluding all other local roads, in accordance with the requirements of NZS6806.[14]

The figure below shows the traffic volumes used in the modelling, including the percentage of heavy vehicles, for the Design Year 2026.

[14] Refer to Technical Report 34, Volume 3 for detailed traffic volumes


Year: 2026
Option: Expressway
SH1 (TO OTAKI)
PEKA PEKA ROA
ELIZABETH STREET
WAIKANAE
WAIKANAE BEACH
TE MOANA ROAD
WAIKANAE RIVER
MAKORA ROAD
QUEENS ROAD
OTAIHANGA
OTAIHANGA ROAD
RATANUI ROAD
MAZENGARB ROAD
ARAWHATA ROAD
MANLY STREET
GUILDFORD DR
PARAPARAUMU BEACH
KAPITI ROAD
RIMU ROAD
MARINE PDE
IHAKARA STREET
RAUMATI BEACH
RAUMATI ROAD
ROSETTA ROAD
MATAI ROAD
RAUMATI SOUTH
POPLAR AVENUE

6.2.4. Safety barriers

For safety requirements, any bridges along the proposed Expressway will include edge safety barriers. Where these barriers provide acoustically effective shielding to sensitive receiver locations, solid concrete edge barriers of 1100 mm in height on both sides have been considered in the assessment.

In addition to the solid road edge safety barriers, which also fulfil the role of noise mitigation, specifically designed noise barriers are required for several sectors of the proposed Expressway. These are discussed in Section 6.3 below.

6.3. Traffic noise mitigation measures

There are three general methods for the control of the generation and propagation of traffic noise in the circumstances under consideration. These are:

- selection of an appropriate road surface (refer Section 6.2.3 above)
- construction of traffic noise barriers and
- upgrade of building envelopes to provide mitigation of internal noise levels, including improvements to wall and ceiling insulation, upgrade of external windows and doors and installation of ventilation.

Other management measures are set out in NZS6806 in Appendix B, including the choise of vehicle speed, which is discussed further in Section 6.3.5.

6.3.1. Road surface

The choice of road surface material for the proposed Expressway has already been discussed in Section 6.2.3 above.

Open Graded Porous Asphalt (OGPA) is the most common low-noise road surface used on the New Zealand S

tate highway network in areas characterised as urban. OGPA is proposed to be used for the proposed Expressway from the southern termination at MacKays Crossing to the end of Sector 3, just north of the Te Moana Interchange. In addition, OGPA is proposed to be used as a mitigation measure for parts of Sector 4, as described in Section 7.6.2 below. The use of this material will represent an effective noise mitigation measure for the proposed Expressway Project.

Chip seal is generally used for roads in lightly populated areas as it is durable and cost effective. Coarse chip seal is proposed to be used for Sector 4 of the Project, from north of Te Moana interchange to Peka Peka Road.

For some areas where increased shear resistance for the pavement is required, e.g. for areas where vehicles brake, accelerate or turn, a more substantial structural road surface material is required. This includes the proposed Expressway ramps. In these instances, Stone Mastic Asphalt (SMA) or similar may be utilised. This material, while also smooth and therefore generating less noise than chip seal, is non-porous. Therefore, noise levels are slightly higher than those for OGPA.

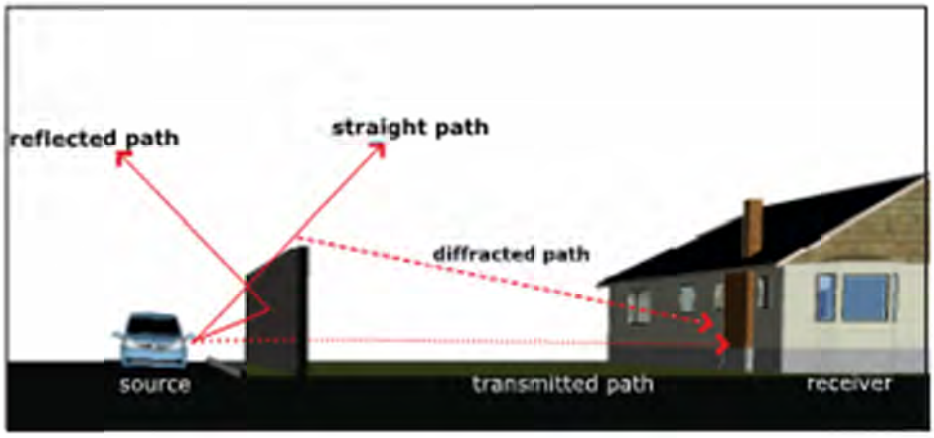
6.3.2. Traffic noise barriers and bunds

Traffic noise barriers can take a variety of forms such as:

- Earth bunds (if space is available)
- Solid barrier walls: Concrete; fibre cement; bio barriers (planted walls)
- Transparent barriers: Acrylic; polycarbonate; glass
- Tunnels: Below ground; above ground (full enclosure); trenches/cuts: fully open or partially covered (i.e. trench tunnel combination)

Mitigation by means of barriers functions by breaking acoustic line-of-sight from the noise source to the receiver. In order to provide the most effective noise level reduction, an acoustic barrier must be of solid material (i.e. have no gaps) and have a minimum surface weight of 10 to 12 kg/m^2 (e.g. 20 mm timber, 9 mm fibre cement, concrete etc).

The figure below shows how traffic noise barriers mitigate noise by reducing its transmission through the barrier to a negligible level so that the main contribution of received noise is due to bending of sound waves over and around the barrier.



(Source: NZTA State Highway Noise Barrier Design Guide Version 1.0/August 2010)

As discussed in Section 5.1.4 above, NZS6806 requires that several mitigation options be developed. This process involves input from all design disciplines, including urban design. Therefore, the final form of the preferred barriers has been derived through an iterative process with relevant members of the Project team. The process used for this Project to determine the best practicable option (BPO) is described in Section 7 below.

For the proposed Expressway Project, due to the availability of peat in the area, peat bunds have been proposed where practicable. This avoids the requirement of transporting the peat off site thus reducing emissions and the use of fill areas outside the proposed Expressway Alignment.

6.3.3. Building envelope improvements

The NZTA will use noise mitigation within the road corridor if practicable. As discussed above, such mitigation will normally comprise low-noise road surfaces and/or barriers. However, dwellings and other protected premises and facilities, where the relevant external noise criteria cannot be achieved with structural mitigation in the road corridor, may require further attention if the Category C criterion is triggered (for an explanation regarding the criteria categories of NZS6806 refer Section 5.1 above).

The Category C assessment is triggered if the noise level inside habitable rooms would be 45 dB $L_{Aeq(24h)}$ or more, with the implementation of the selected structural mitigation measures (refer Sections 6.3.1 and 6.3.2 above). In that instance, at least a five decibel noise level reduction is required to achieve an internal noise level of no more than 40 dB $L_{Aeq(24h)}$.

The improvements required would vary from building to building. While some buildings have already been designed to achieve suitable internal noise environments, with the choice of heavy building materials, improved glazing and insulation, and well fitting doors and windows, other building structures may not provide sufficient attenuation.

Therefore, a case-by-case assessment is required for those buildings identified to fall within Category C.

The assessment and implementation of building modification mitigation would require several steps to be undertaken in order to allow for a practicable and suitable result to be achieved. These would involve:

i. Identification of buildings which would fall within Category C, e.g. which are predicted to receive external noise levels above 64 dB $L_{Aeq(24h)}$ following the implementation of the selected mitigation option(s). This would be facilitated through computer noise modelling and calculation once the selected mitigation option(s) are finalised through detailed design.

ii. Notifying the owner of a property identified in Step 1 above and requesting to visit the property and enter the building in order to undertake a noise level survey to determine the building envelope noise reduction performance. At this stage, information about the building envelope can be gathered, including details relating to joinery and glazing, wall and ceiling construction, insulation or the lack thereof etc.

iii. Following the site visit and noise survey, determination of whether the building meets the requirements of NZS6806, i.e. if the internal noise level in habitable rooms, following the implementation of the selected mitigation option, would be 45 dB $L_{Aeq(24h)}$ or higher, and, if practicable, an internal noise level in habitable rooms of 40 dB $L_{Aeq(24h)}$ can be achieved with the use of building modification mitigation. Several building modification mitigation options may be developed, e.g. a combination of glazing and ventilation or insulation and ventilation or different types of glazing and joinery.

iv. The building modification mitigation options would then be provided to the building owner, and discussions held between the NZTA and the building owner to determine a satisfactory outcome and reach agreement as to the choice of mitigation option, if any.

v. Finally, the NZTA would ensure that the agreed building modification mitigation option would be implemented at an agreed time. This may be prior to, during or following construction of the Project, in discussion with the building owner. From an acoustic view, it would be preferable to provide building modification mitigation as early as practicable during construction in order to obtain the greatest noise mitigation benefit possible during noisy construction activities.

Often, improvements to glazing and joinery may be sufficient to achieve the required internal noise levels, or simply provision of mechanical ventilation so windows can remain closed.

Any insulation or other building envelope improvements have to be implemented concurrently with the achievement of the requirements of Clause G4 of the New Zealand Building Code, which governs the ventilation requirements for buildings. Therefore, in many instances an alternative mechanical ventilation system would be required in order to ensure sufficient ventilation is provided while maintaining suitable internal noise levels to comply with the NZS6806 Category C requirements.

6.3.4. Maintenance of mitigation measures

The acoustic performance of noise mitigation measures, i.e. the effectiveness and amount of noise level reduction, needs to be maintained over time. NZS6806 states that “structural mitigation measures should be designed in such a way that they retain the same noise-reduction properties up to the design year”.[15]

This means that the barriers proposed for the proposed Expressway should not develop gaps or other openings, and porous road surface materials should be maintained to retain their porosity, in order to achieve the same noise reducing qualities as following initial installation, for the ten year design period, i.e. the year 2026 for the Project.

[15] NZS6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.5, page 42

In relation to barriers, this means that any damage, vandalism, or material failure resulting in openings in the barrier or between the barrier and the ground, will need to be repaired or remedied.

Road surface materials would require maintenance in the event of cracks or settlement resulting in uneven surfaces, which would result in increased noise level generation. Porous road surfaces, including OGPA, rely to some extent on their porosity to absorb sound. Therefore, porosity needs to be retained at a high level in order to achieve the noise reduction performance assumed in the noise level predictions (refer Section 6.4 below). Porosity of road surfaces can be retained for extended duration through high pressure water cleaning and regular resurfacing, should the material deteriorate excessively.

Maintenance of structural mitigation measures to the performance standards of NZS6806 should be undertaken for the proposed Expressway in order to achieve the noise level reductions on which the noise level predictions are based.

6.3.5. Traffic speed

NZS6806 provides a list of potential noise management and mitigation measures in Table B1 in Appendix B, such as Traffic Management, which also includes a potential reduction in vehicle speed. The Standard states that *"Although it is theoretically possible to manage noise elvels by changing posted speed limits, in New Zealand such changes must be made in accordance with the Land Transport Rule: Setting of Speed Limits and its amendments. The rule is administered by the NZTA and is primarily focused on the safety and efficiency of road networks."*[16]

The proposed Expressway has been designed to operate at a speed of 100 km/h as required by the NZTA 'Roads of National Significance design standards and guidelines'. A reduction in traffic speed from 100 km/h to 80 km/h is predictced to result in a noise level reduction of 1 decibel, an unnoticeable difference. From discussion with the Project traffic engineer, it is understood that such speed reduction would have implications for the effective operation of the proposed Expressway, e.g. the time saving achieved would be reduced considerably, Therefore, this is not considered to be a practicable option for the proposed Expressway.

6.3.6. Determination of selected mitigation option

In accordance with NZS6806, a number of mitigation options should be developed and evaluated by the Project team. This generally involves the following steps, which have been followed for the proposed Expressway Project:

[16] NZS6806:2010 Acoustics – Road-traffic noise – New and altered roads, Table B1, page 107

vi. Several mitigation options were developed for each individual assessment area. Assessment areas were determined by Sector and further divided into coherent clusters of dwellings. These clusters would involve buildings that would, to varying degree, benefit from the same mitigation measure, e.g. a barrier. Therefore, the dwellings within a cluster would be on the same side of the proposed Expressway, e.g. those located north of Kāpiti Road and west of the proposed Expressway.

vii. The mitigation options, together with noise level spreadsheets, benefit-cost predictions, figures showing the barrier locations and heights and evaluation matrices for each assessment cluster, were provided to the Project team for pre-evaluation.

viii. A workshop was held during which the Project team met and determined the selected mitigation option for each assessment area. Each discipline (e.g. urban design, visual impact, engineering and stormwater) provided feedback on the options and a round table discussion enabled fine tuning of the initial mitigation options. In some instances, further mitigation options were developed following the feedback at the workshop, and included in the assessment matrix.

The workshop was attended by representatives of the following disciplines:

- NZTA Project staff
- MacKays to Peka Peka Project team: planning, social, roading, structures, visual/landscape, urban design, construction, ecology, cultural, hydrology/stormwater, property, financial
- Sub-consultant team: acoustics
- Council: Kāpiti Coast District Council
- NZTA national office: acoustics.

The Project documentation associated with this process is contained in Appendix 15.C of this report.

6.4. Computer modelling process

6.4.1. Overview

Computer modelling of noise generated by road-traffic is a vital tool in the prediction of traffic noise impact on areas in the vicinity of major roads and for the determination of mitigation measures. Modelling enables a comprehensive and overall picture of future noise impacts to be produced. For this Project 'SoundPLAN' software has been utilised which is an internationally recognised computer noise modelling programme.

In summary, SoundPLAN uses a digital topographical terrain map of the area as its base. A three dimensional topographical terrain map was provided by the Project team and included the following:

- Elevation lines representing the proposed Expressway Alignment, and including important aspects of the proposed road (e.g. edge of seal, median, traffic lane markings, bridges and solid safety edge barriers);
- Elevation lines for the area surrounding the proposed Expressway at vertical distances of 1 metre;
- Elevation lines extending between 160 metres and 1.2 kilometres from either side of the proposed Expressway edge.

In addition, all existing buildings and structures, including auxiliary buildings, within approximately 120 metres of the edge of the proposed Expressway were digitised off recent aerial photographs. The heights of these buildings were determined through site visits and entered into the model.

Each noise source (motorway lane) was located in the map and the software then calculates traffic noise generation for multiple directions, allowing for terrain, topography, shielding, and meteorological conditions.

The SoundPLAN model uses the calculation algorithms of the "Calculation of Road Traffic Noise" methodology referred to in Section 6.2 above. The adjustments for New Zealand conditions, specifically road surface types, are included in the model by including correction factors in the input of the traffic characteristics, thus allowing the resulting output to be utilised without further adjustment.

Further modelling inputs are set out in Section 6.2 above.

6.4.2. Model verification

NZS6806 states, in Section 5.3.4, that *"modelling of existing ambient sound levels should be compared with measured levels for model calibration purposes where practicable"*. In this instance, the existing ambient noise level for most of the new proposed Expressway Alignment traverses rural areas with little or no "man made" noise sources that could be entered into a computer noise model. Only small extents of the proposed Expressway Alignment, where it would be close to existing roads, would be able to be modelled to then be compared with a measured level.

The assessment of effects has been solely based on the noise level surveys set out in Technical Report 17, Volume 3 with measured levels being applied to receiver locations in the vicinity. The modelled noise levels of the proposed Expressway are based on the factors described in Section 6.2 above and cannot be verified against surveys as the proposed Expressway is not in existence. Currently existing roads do not form part of the model, as NZS6806 does not apply to existing roads, and therefore the predicted levels cannot be compared with the survey results.

It is noted that NZS6806, in Section 5.3.2(c), states that *"noise modelling software used should"* […] *"have an accuracy based on field tests demonstrating that the predicted level does not vary from*

the measured level by more than ±2 dB". SoundPLAN is ISO9001:2008 certified. Relevant documentation for the current year is attached in Appendix 15.E.

In summary, SoundPLAN calculations are tested to provide results within 0.2 dB of the relevant Standard calculation methodology, in this instance the "Calculation of Road Traffic Noise", and therefore fulfil the accuracy requirement of NZS6806.

6.4.3. Individual receiver noise levels

Noise levels received at individual dwellings and other noise sensitive positions, for the design year 2026, are contained in the tables in Appendix 15.C(i) to 15.C(iv). The locations of these dwellings are shown on the plans in the same Appendix.

These levels have been calculated for all floor levels of each dwelling within 100 metres of the Project as required by NZS6806. In most circumstances, the highest floor is the most affected floor which controls the mitigation measures to be implemented. However, it is noted that other floors at lower levels would generally benefit to a greater extent from the proposed mitigation measures and therefore, receive lower noise levels. The design of appropriate noise mitigation measures has been based on the compliance with the relevant criteria being complied with at all affected floors.

Individual receiver noise levels have been shown as a graphic representation by colouring the buildings with the colour scale showing NZS6806 Category A buildings in green, Category B buildings in yellow and Category C buildings in red. Those buildings shown in grey on the figures are outside the assessment area of 100 metres from the Expressway Alignment or are not Protected Premises and Facilities (PPFs) (refer Section 5.1.1 above), e.g. garages, sheds, business premises etc.

6.4.4. Noise contour plans

Noise contour plans for the entire Project area, generally extending further than the 100 metre assessment area, are included in Appendix 15.D.[17] These plans show indicative free-field noise level bands at 5 decibel intervals.

6.5. Subjective perception of noise level changes

Noise is measured on a logarithmic scale and the subjective impression of changes in noise can generally be correlated with the numerical change in noise level. While every individual reacts differently to noise level changes, research[18] has shown a general correlation between noise level

[17] Appendix 15.D is contained in Technical Report Appendices, Report 15, Volume 5

[18] For instance, LTNZ Research Report No. 292: Road traffic noise: determining the influence of New Zealand Road surfaces on noise levels and community annoyance, Table 18

changes and subjective responses. The table below shows indicative values to aid comprehension of the noise level assessment contained in this report.

It is noted that each column, i.e. increase in traffic volume and change in distance, are independent from one another. The noise level change described is based on either one of these factors. In the event of both changes occurring, e.g. doubling of traffic and halving of distance, the noise level increase would be 6 decibels rather than 3 decibels.

The perception of these noise level changes generally applies to immediate changes in noise level, as would be the case for a new road such as the proposed Expressway. Therefore, the changes are likely to be perceived by residents adjacent to the proposed Expressway as set out in the table.

Table 6-2: Noise level change compared with subjective perception, traffic volume change and distance to road

Noise Level Increase	General Subjective Perception	Traffic Volume Increase (example to a base of 10,000 vehicles per day)	Distance to Road (Example to a base of 100 metres from the road)	Impact/ RMA Effect
1 – 2 decibels	Insignificant change	Less than double (15,000 vpd)	More than half (60 m from the road)	Negligible/Less than minor
3 – 4 decibels	Perceptible change	Approximately double (20,000 vpd)	Approximately half (50 m from the road)	Slight/Minor
5 – 8 decibels	Appreciable change	Approximately 6 times increase (60,000 vpd)	Approximately one fifth (20 m from the road)	Moderate
9 – 11 decibels	Doubling of loudness	Approximately 10 times increase (100,000 vpd)	One tenth (10 m from the road)	Significant/ Substantial
> 11 decibels	More than doubling of loudness	More than 10 times increase (> 150,000 vpd)	Less than one tenth (< 6 m from the road)	Severe

7. Assessment of traffic noise levels

7.1. Methodology

The implementation of the Project will result in varying effects throughout the area affected by the proposed Expressway. Each sector will have individual effects and issues to be managed which are set out in the sections below.

For each sector, the existing situation has been assessed by means of noise level surveys. The existing situation (refer Section 5.1.3) is compared with the Do-minimum scenario to determine the potential noise level change due to the Project implementation. For the proposed Expressway, the noise level change due to the Project implementation is predicted to be considerable in some areas,

with changes ranging in the most affected instances from 10 to 21decibels. The Do-minimum scenario serves as the base for the assessment of noise mitigation options.

NZS 6806 requires that several mitigation options be considered in order to ensure that the BPO determination is effective. Therefore, each sector assessment set out below contains a summary of all mitigation options considered and a detailed description of the selected mitigation option.[19]

The determination of the selected mitigation options was undertaken by means of a workshop. Prior to the workshop, noise mitigation options were circulated to the Project team, and an assessment matrix for each receiving environment[20] was filled in by relevant team members. Discussion during the workshop served to refine the pre-circulated mitigation options. For this Project, the planner, having received input from all team members, was responsible for determining the selected mitigation options that, in the team's opinion, constituted the BPO. The matrices containing the information used to identify the selected mitigation options are attached in Appendix 15.C.

The selected mitigation options for all receiving environments were then re-modelled in the computer noise model for the final calculation of noise levels.

7.2. Receiving environments

Mitigation measures for each sector have been developed based on the receiving environment, i.e. those assessment positions that would benefit from a specific mitigation measure or barrier. Therefore, each sector contains several mitigation options for each receiving environment or assessment area.

For example, Sector 4 from Te Moana Interchange to Peka Peka Road contains four distinct receiving environments, one each east and west of the proposed Expressway at Ngarara Road and Peka Peka Road Interchange. Mitigation has been designed individually for these receiving environments, and a selected option selected for each. Once this choice has been made, the selected mitigation options for the entire Sector 4 have been entered into the final computer noise model to constitute "the selected mitigation option" for Sector 4.

Each receiving environment is briefly described, including existing noise environment, Do-minimum scenario, mitigation options and the selected mitigation option. In addition to the discussion of

[19] This process has been described in Section 6.3.5 of this report.

[20] A receiving environment constitutes a cluster of dwellings, in accordance with NZS6806 Section 2.2, within 100 metres of each other that are located on the same side of the proposed Expressway and therefore would benefit from the same mitigation option, albeit to varying degree depending on the location of the dwelling in relation to the mitigation option. Therefore, each Sector contains a number of receiving environments.

compliance in accordance with the provisions of NZS6806, an assessment of noise effects is also included.

7.3. Sector 1 – MacKays Crossing to Raumati Road

The remaining Alignment of the proposed Expressway constitutes a “new” road in terms of NZS6806.

Sector 1 contains five receiving environments that are addressed separately below: west of the proposed Expressway – Leinster Avenue area, west and east of the proposed Expressway – Raumati South area and west and east of the proposed Expressway – Kāpiti Road area. All of these environments are residential areas of generally suburban character. A number of dwellings in the Leinster Avenue area are proposed to be removed as they would be inside the construction corridor. Others are within the Designation but may be retained for future use. These dwellings have been assessed also in terms of noise effects as NZS6806 because it is based only on the use of a building, i.e. if the building is used for noise sensitive activities.

7.3.1. West of proposed Expressway – Leinster Avenue area

The area around Leinster Avenue west of the proposed Expressway is relatively densely populated. The terrain gradually elevates towards the west, away from SH1 and the proposed Expressway. A number of dwellings adjacent to SH1 will be removed to allow for the proposed Expressway construction and Alignment, thus reducing shielding for remaining dwellings.

The proposed Expressway will cross Poplar Avenue on a bridge and quickly revert back to existing ground level, before reaching Leinster Avenue. The Alignment will remain generally at grade in the vicinity of the 21 PPFs assessed.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(i).

a. Existing noise environment

The existing noise environment has been measured to be between 55 and 58 dB $L_{Aeq(24hr)}$, depending on the distance to, and elevation above, the existing SH1.

b. Do-minimum scenario

The Do-minimum scenario includes low noise road surface material (OGPA) and concrete edge barriers on the bridge over Poplar Avenue. The Do-minimum scenario shows that the operation of the proposed Expressway would have a negligible to moderate effect on dwellings within 100 metres of the Alignment, with noise levels remaining similar to existing levels for some dwellings while others would experience a noise level increase of up to 9 decibels.[21]

About half of all PPFs would be within Category A (up to 57 dB $L_{Aeq(24hr)}$), with the other half being within Category B (between 57 and 64 dB $L_{Aeq(24hr)}$).

c. Mitigation option 1

Mitigation option 1 involves the construction of a 2 metre high bund extending from chainage 2920 to 3500, with a 3 metre barrier on top of the bund. In addition, a 2 metre boundary fence would be installed at 107 Leinster Avenue.

The barriers are predicted to achieve noise level reductions of between one and ten decibels, with an average structural mitigation of 5 decibels, above the 3 decibels required by NZS6806.

This mitigation option, while achieving a good level of noise level reduction, was not perceived by the Project team to be the selected option due to the potential visual impact of the five metre high overall bund/barrier combination.

d. Mitigation option 2

Mitigation option 2 is similar to Mitigation option 1, with a 4 metre barrier towards the northern end of the bund/barrier combination. This would reduce the number of PPFs within Category B to only one, while achieving average structural mitigation of 6 decibels.

However, similarly to Mitigation option 1, the visual impact of such a high barrier was seen by the Project team to not represent the most appropriate form of mitigation.

[21] Refer Section 6.5 for an explanation of subjective responses to changes in noise level.

e. Mitigation option 3

Mitigation option 3 involved the design of noise mitigation which would fulfil the requirements of the now superseded Noise Guidelines.22 The Noise Guidelines criteria would be less stringent than those of Category A and more stringent than those of Category B of NZS6806.

A barrier much reduced in length (only 190 metres compared with 514 metres for Option 2) and height (only 1 metre compared with 3 metres) would be required to be installed on top of the 2 metre bund proposed as per Mitigation options 1 and 2.

While the visual impact from this option is considerably less than that of the previously tested options, the noise level reduction achieved by the 1 metre barrier in addition to the bund (refer Section 7.3.1f below) is negligible, less than 2 decibels for two PPFs, and even less for the remaining 19 PPFs assessed.

f. Mitigation option 4

During the workshop, a fourth mitigation option was discussed which provided for the 2 metre high bund only with no barrier on top. This option achieves an average structural mitigation of 4 decibels and results in 15 positions within Category A and six positions within Category B. Noise levels would range from 52 to 61dB $L_{Aeq(24hr)}$.

g. Selected mitigation option

The Project team selected Mitigation option 4. The resulting noise levels are generally comparable to those currently experienced, with only four positions predicted to receive a noise level increase of more than 3 decibels.

The overall noise level reduction from the bund only is above the required average mitigation of 3 decibels (NZS6806) and provides up to 5 decibels noise level reduction for some dwellings.

h. Assessment of effects

With mitigation option 4 in place, the traffic noise effects from the proposed Expressway would range from negligible for those locations not experiencing a noise level change, to moderate for the two positions which are predicted to receive a noise level increase of 5 and 6 decibels.

The following table shows the predicted change in noise level for the 21 PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

[22] Refer Section 5.2.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	10	49 %
1 – 2 decibels	7	33 %
3 – 4 decibels	2	9 %
5 – 8 decibels	2	9 %
9 – 11 decibels	0	n/a
> 11 decibels	0	n/a

7.3.2.West of proposed Expressway – Raumati South area

The area around Raumati Road is generally residential, but not densely populated. Twelve dwellings, which are generally slightly elevated above the road, are located west of the proposed Expressway.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(i).

a. Existing noise environment

The existing noise environment in this area is relatively low, in the mid-40 dB LAeq(24hr). This means that compliance with the most stringent Category A (up to 57 dB) would still result in a significant noise effect.

b. Do-minimum scenario

The Do-minimum scenario includes low noise road surface (OGPA) and 1.1 metre high concrete edge barriers on the proposed Expressway bridge crossing Raumati Road. With the proposed Expressway operational, noise levels are predicted to be between 49 and 62 dB $L_{Aeq(24h)}$. This constitutes a noise level increase of between 3 and 15 decibels. Three PPFs are predicted to be within Category B, with noise levels above 57 dB $L_{Aeq(24h)}$, with the remaining PPFs in Category A.

c. Mitigation option 1

Mitigation option 1 replaces the 1.1 metre concrete edge barrier on the bridge with a slightly higher 1.5 metre high barrier, in order to test if a slight change in barrier height, which is not considered visually intrusive, would result in a noise level reduction.

The three dwellings in Category B are predicted to receive a 1 to 2 decibel noise level reduction due to the increase in barrier height. However, this is a generally unnoticeable difference (refer Section 6.5 above). Therefore, the Project team did not consider this option to constitute the BPO.

d. Mitigation option 2

Mitigation option 2 involves a 2 metre barrier on the bridge edge. This option also fulfils the requirements of the Noise Guidelines.

The noise levels at the Category B dwellings were further reduced by up to 3 decibels, with only two dwellings remaining in Category B (88 and 92 Raumati Road). While this option provides a just noticeable noise level reduction at two dwellings, it does not fulfil the requirements of NZS6806 that mitigation measures should reduce noise levels by an average of 3 decibels for any three or more houses, or 5 decibels for individual houses (refer Section 5.1.5 above).

Therefore, the Project team did not consider this option to constitute the BPO.

e. Selected mitigation option

Following discussions at the workshop, and taking into consideration the minimal noise level reductions and adverse visual effects of barriers on the bridge over Raumati Road, the Project team chose the Do-minimum option as the selected option for the receiving environment west of the proposed Expressway and south of Raumati Road.

The selected option includes low-noise road surface and a 1.1 metre high concrete edge safety barrier on the bridge and results in nine PPFs being in Category A and the remaining three in Category B.

f. Assessment of effects

As discussed in Section b above, the introduction of the proposed Expressway into a currently very quiet noise environment is predicted to have a significant effect for some dwellings that will be close to the new road. Noise level increases of between 3 and 15 decibels are predicted. However, the predicted noise environment for all dwellings is considered to be suitable for residential use, despite the predicted increase in noise level.

The following table shows the predicted change in noise level for the 12 PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	0	n/a
3 – 4 decibels	2	17 %
5 – 8 decibels	5	41 %
9 – 11 decibels	3	25 %
> 11 decibels	2	17 %

7.3.3.East of proposed Expressway – Raumati South area

South of Raumati Road and east of the proposed Expressway is the Conifer Court residential area. Eleven PPFs fall within the assessment area. The dwellings are generally somewhat removed from the road and the most southern dwellings are somewhat elevated above the proposed Expressway.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(i).

a. Existing noise environment

The existing noise environment is considered low, with noise levels around 46 to 47 dB $L_{Aeq(24hr)}$, as dwellings are unaffected by noise from major roads or industry. This means that even with the achievement of the most stringent Category A criterion of 57 dB $L_{Aeq(24hr)}$ a significant increase in noise level would occur.

b. Do-minimum scenario

The Do-minimum scenario involves the use of low noise road surface (OGPA) and 1.1 m high concrete edge barriers on the proposed Expressway bridge over Raumati Road. Noise levels are predicted to be between 48 and 63 dB $L_{Aeq(24hr)}$, a noise level increase above existing levels by between 2 and 16 decibels. Of the 11 PPFs assessed, two would be within Category B with the remaining dwellings within Category A.

c. Mitigation option 1

Mitigation option 1 provides for a 2 metre high barrier along the eastern side of the proposed Expressway from chainage 4080 to the edge of the bridge. In addition, barriers of up to 3 metres are included adjacent to 110 Raumati Road.

This barrier arrangement would result in all PPFs being within Category A. Noise level reductions range from 1 to 6 decibels, with an average structural mitigation of 3 decibels.

d. Mitigation option 2

In order to avoid the high barrier on the property boundary at 110 Raumati Road, a further mitigation option was assessed which involved a longer 2 metre barrier along the proposed Expressway and no barrier at the property boundary.

This option, while achieving slightly less mitigation at 110 and 114 Raumati Road (by 2 decibels), retains all PPFs within Category A and achieves an average mitigation of 3 decibels in accordance with NZS6806.

This option also achieves compliance with the Noise Guidelines criteria.

e. Selected mitigation option

Mitigation option 2 was selected by the Project team. The reduced visual impact was the main factor for this decision. In terms of noise mitigation, the difference between options 1 and 2 is

negligible. All PPFs are predicted to receive noise levels within Category A, i.e. up to 57 dB $L_{Aeq(24hr)}$.

f. Assessment of effects

At all dwellings, noise levels within Category A are predicted to be achieved, i.e. noise levels will be up to 57 dB L_{Aeq}(24h). These levels are well suited for residential use and are not considered to result in health or other adverse effects on residents. However, even with the achievement of Category A noise levels at all dwellings, the increase in noise level due to the proposed Expressway will be significant, with increases up to 11 decibels because of the low existing ambient noise levels.

The following table shows the predicted change in noise level for the 11 PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	1	10 %
3 – 4 decibels	3	27 %
5 – 8 decibels	5	45 %
9 – 11 decibels	2	18 %
> 11 decibels	0	n/a

7.3.4. Summary of assessed mitigation options – Sector 1

Table 7-1: Summary of assessed mitigation options and selected option

Area	Option	Selected	Mitigation measures
West of proposed Expressway – Leinster Avenue	Do-minimum		OGPA
	1		OGPA, 2m bund (580m), 3m barrier (560m), 2m barrier (60m)
	2		OGPA, 2m bund (580m), 3m barrier (575m), 4m barrier (76m), 2m barrier (60m)
	3*		OGPA, 2m bund (580m), 1m barrier (190m)
	4	Selected	OGPA, 2m bund (580m)

Area	Option	Selected	Mitigation measures
West of proposed Expressway – Raumati South	Do-minimum	Selected	OGPA
	1		OGPA, 1.5m barrier (165m)
	2*		OGPA, 2m barrier (165m)
East of proposed Expressway – Raumati South	Do-minimum		OGPA
	1		OGPA, 2m barrier (300m), 3m bund (80m)
	2*	Selected	OGPA, 2m barrier (335m)

* - this mitigation option fulfils the requirements of the Noise Guidelines (refer Section 5.2)

7.3.5. Selected mitigation options – Sector 1

Through the workshop process, in order to determine the BPO in the opinion of the Project team, the selected mitigation options for Sector 1 are:

- West of proposed Expressway, Leinster Avenue area – Mitigation option 4
- West of proposed Expressway, Raumati Road area – Do-minimum scenario
- East of proposed Expressway, Raumati Road area – Mitigation option 2.

Noise level predictions for Sector 1 for the selected mitigation options and figures showing the barrier lengths and heights are contained in Appendix 15.B.

7.4. Sector 2 – Raumati Road to Mazengarb Road

Sector 2 includes the Kāpiti Road Interchange and the proposed Expressway bridge over Mazengarb Road. This sector is densely populated, particularly between Kāpiti and Mazengarb Roads and immediately south west of Kāpiti Road. Smaller residential areas are located in Raumati South on either side of the proposed Expressway Alignment.

The noise environment in Sector 2 varies from relatively low for areas removed from major roads (e.g. at Rata Road) to elevated in the vicinity of Kāpiti Road.

The proposed Expressway generally remains within the existing WLR designation in this sector, therefore, some dwellings will be in close proximity to the road.

Receiving environments assessed in Sector 2 include those east and west of the proposed Expressway at Raumati and Rata Roads, west of the proposed Expressway and south of Kāpiti Road, east of the proposed Expressway between Kāpiti and Mazengarb Roads and west of the proposed Expressway at Cheltenham Drive. These areas are discussed in detail below.

7.4.1. West of proposed Expressway – Raumati Road

The area north of Raumati Road and west of the proposed Expressway is of rural/suburban character, without any major existing noise sources. Only four dwellings are located in the receiving environment. They are generally a significant distance from the proposed Expressway Alignment, between 50 and 90 metres. The proposed Expressway will be elevated by approximately 5 metres in the vicinity of these dwellings.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(ii).

a. Existing noise environment

The existing noise environment is typical of a suburban environment with minor influence by road traffic noise from local roads. Ambient noise levels were measured to be around 52 dB $L_{Aeq(24hr)}$. This level is 5 decibels below the Category A criterion of 57 dB $L_{Aeq(24hr)}$, therefore just meeting the Category A noise criterion would result in a noticeable increase in noise level.

b. Do-minimum scenario

The Do-minimum scenario provides for low noise road surface material (OGPA) and 1.1 metre concrete edge barriers on the proposed Expressway bridge over Raumati Road.

The noise levels predicted for the four PPFs range from 57 to 59 dB $L_{Aeq(24h)}$. Two PPFs would be within Category A and two within Category B. Noise levels are predicted to increase by between 5 and 7 decibels, a noticeable change.

The Do-minimum scenario would fulfil the requirements of the Noise Guidelines, and therefore, no specific mitigation option was developed for this circumstance.

c. Mitigation option 1

Mitigation option 1 includes a 2 metre high barrier along the western side of the proposed Expressway, extending from chainage 4520 to chainage 4780. Predicted noise levels for this option show that all PPFs would be within Category A, with noise levels of 52 and 53 dB $L_{Aeq(24hr)}$, i.e. similar to existing noise levels.

No further mitigation option for noise control purposes was developed as the barriers of Mitigation option 1 were considered to be suitable and practicable from an acoustic point of view.

d. Selected mitigation option

The Project team agreed that the 2 metre barrier as per Mitigation option 1 is the selected option as it achieves a good degree of noise level reduction (between 4 and 6 decibels) thus fulfilling the requirements of NZS6806, with all PPFs achieving the Category A criterion. In addition, the proposed barrier would be visually unobtrusive.

e. Assessment of effects

As set out above, with the installation of the selected noise mitigation option, i.e. a 2 metre high barrier along the proposed Expressway, the noise level at all four PPFs assessed is predicted to remain virtually unchanged. The predicted 1 decibel increase at three dwellings is considered to be likely to be not discernible (refer Section 6.5).

The following table shows the predicted change in noise level for the four PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	1	25 %
1 – 2 decibels	3	75 %
3 – 4 decibels	0	n/a
5 – 8 decibels	0	n/a
9 – 11 decibels	0	n/a
> 11 decibels	0	n/a

7.4.2.East of proposed Expressway – Rata Road

Four dwellings fall within the assessment area at Rata Road, east of the proposed Expressway and north of Raumati Road. These dwellings are somewhat removed from the Expressway Alignment (between 60 and 95 metres) and the road is elevated above the dwellings due to its crossing of Raumati Road on a bridge.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(ii).

a. Existing noise environment

Similarly to the Raumati Road area discussed in Section 7.4.1 above, the existing noise environment is typical of a suburban environment with minor influence by road traffic noise from local roads. Ambient noise levels were measured to be around 52 dB $L_{Aeq(24hr)}$. This level is 5 decibels below the Category A criterion of 57 dB $L_{Aeq(24hr);}$ so that just meeting the Category A noise criterion would mean a noticeable increase in noise level.

b. Do-minimum scenario

The Do-minimum scenario provides for low-noise road surface material (OGPA) and 1.1 metre concrete edge barriers on the proposed Expressway bridge over Raumati Road.

The noise levels predicted for the four PPFs range from 51 to 59 dB $L_{Aeq(24h)}$. Two PPFs would be within Category A and two within Category B. Noise levels are predicted to remain similar to existing for one PPF, and increase by between 5 and 7 decibels at the other dwellings, a noticeable change.

The Do-minimum scenario would fulfil the requirements of the Noise Guidelines, therefore, no specific mitigation option was developed for this circumstance.

c. Mitigation option 1

Mitigation option 1 includes a 2 metre high barrier along the western side of the proposed Expressway, extending from chainage 4800 to chainage 5150. Predicted noise levels for this option show that all PPFs would be within Category A, with noise levels between 50 and 55 dB $L_{Aeq(24hr)}$, i.e. up to 3 decibels above existing noise levels, a just perceptible difference.

An average noise level reduction of 3 decibels is achieved by the structural mitigation, which fulfils the requirements of NZS6806.

d. Selected mitigation option

No further mitigation option for noise reduction purposes was developed as the barrier acoustic point of view.

However, in discussion the Project team decided that the visual impact of Mitigation option 1 (a 2 metre high barrier along the east of the proposed Expressway) would be intrusive due to its height in relation to the dwellings.

Therefore, the Do-minimum scenario was the selected option for this receiving environment.

e. Assessment of effects

As noted in Section 7.4.2b above, noise levels are predicted to remain similar to those currently existing for one PPF, and increase by between 5 and 7 decibels at the other PPFs, a noticeable change. Nevertheless, the predicted noise levels are suitable for residential use.

The following table shows the predicted change in noise level for the four PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	1	25 %
1 – 2 decibels	1	25 %
3 – 4 decibels	2	50 %
5 – 8 decibels	0	n/a
9 – 11 decibels	0	n/a
> 11 decibels	0	n/a

7.4.3.West of proposed Expressway – South of Kāpiti Road

A residential area is located south of Kāpiti Road, with the 35 dwellings assessed being in Milne Drive, Observation Place and Quadrant Heights. A number of dwellings are double storey. Some dwellings are in close proximity to the proposed Expressway Alignment, within 20 metres.

The dwellings are generally elevated above the proposed Expressway thus further reducing natural shielding through terrain or potential barriers.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(ii).

a. Existing noise environment

The existing noise environment in this area is relatively low for a suburban area, with ambient noise levels measured to be between 43 and 44 dB $L_{Aeq(24hr)}$. This is generally due to the absence of

major roads in the vicinity. Kāpiti Road is somewhat shielded from this receiving environment and therefore has little effect on the ambient noise level.

b. Do-minimum scenario

The Do-minimum scenario includes the use of low noise road surface (OGPA) on the proposed Expressway and dense asphalt on the Kāpiti Interchange ramps, and 1.1 m high concrete edge barriers on the proposed Expressway bridge over Kāpiti Road.

As the ambient noise level is low, the introduction of the proposed Expressway will result in a significant increase in noise level, by up to 22 decibels, with an average noise level increase of 12 decibels. This would be perceived as a doubling in noise, compared with the existing noise environment.

Two PPFs would be within Category C, i.e. would receive an external noise level of more than 64 dB $L_{Aeq(24hr)}$. A further ten PPFs would be within Category B, and the remaining 23 in Category A. Dwellings in Milne Drive immediately adjacent to the Kāpiti Road northbound off ramp and double storey dwellings overlooking the proposed Expressway Alignment will be affected, and mitigation options have focussed on these dwellings in particular.

c. Mitigation option 1

Mitigation option 1 involves a 2 to 3 metre high barrier along the common Designation and residential property boundary, in addition to an extended 1.1 metre concrete edge barrier from the bridge extending towards the south where the ramp exits the proposed Expressway.

This barrier arrangement would result in a moderate reduction in noise level for the most affected PPFs, between 2 and 9 decibels. However, the double storey dwelling at 21 Observation Place is predicted to remain in Category C due to the upper floor receiving an external noise level of 65 dB $L_{Aeq(24hr)}$.

The average mitigation achieved by this mitigation option is 3 decibels, as required by NZS6806.

d. Mitigation option 2

Mitigation option 2 was intended to achieve compliance with Category A for all PPFs to the greatest degree possible. This involved a combination of barriers along the common Designation and property boundaries of between 2 and 3 metres in height, and along the proposed western Expressway and Kāpiti Road off ramp edge, of 2.5 metres height. In addition, a dip in the sand dunes would be filled in to form an uninterrupted bund, which would then form an effective barrier for dwellings in Quadrant Heights. The concrete edge barrier on the bridge over Kāpiti Road has been increased in height from 1.1 metres to 2 metres.

The combined effect of these barriers results in a considerable reduction in noise level of up to 11 decibels for the most affected dwellings, and with an average mitigation of 5 decibels.

All PPFs but one are predicted to be within Category A. The double storey dwelling at 21 Observation Place is predicted to remain within Category B, with an external noise level of 63 dB $L_{Aeq(24hr)}$.

e. Mitigation option 3

This mitigation option was developed that would fulfil the Noise Guidelines requirements. Mitigation option 3 is similar to option 2, but with considerably higher barriers along the property boundaries. These would have to be increased in height from 2 metres to 4 metres, and from 3 metres up to 6 metres. This is not considered a viable option, considering that these barriers would have to be placed immediately along the residential property boundaries and therefore have adverse effects in terms of visual impact and light.

f. Mitigation option 4 and 4a

During the workshop, a further mitigation option was developed which involved 2 metre high barriers along the common property boundaries, the proposed dune fill-in at the southern end of this receiving environment and a 3 metre barrier along the proposed Expressway and ramp. A 2 metre high barrier is located along the proposed Expressway towards the bridge over Kāpiti Road. This barrier arrangement means that high barriers along the property boundary can be avoided. This would reduce the visual impact of the barriers in close proximity to dwellings.

The combination of these barriers is predicted to achieve a similar reduction in noise level to that of Mitigation option 3, with all PPFs but one in Category A. Structural mitigation achieves noise level reductions of between 2 and 9 decibels, with an average of 4 decibels.

Mitigation option 4a shows the same barrier arrangement, with the 2 metre high property boundary only where required to achieve Category A at all PPFs but one (21 Observation Place). This option represents the minimum requirements in terms of property boundary barriers to achieve the same result as Mitigation option 4.

g. Selected mitigation option

Mitigation option 4/4a was seen as the selected option. The noise level reductions achieved are significant and fulfil the requirements of NZS6806. All PPFs but one would be within Category A.

Several barriers are combined to provide the most effective shielding for residences in close proximity to the proposed Expressway. In order to avoid high barriers adjacent to residences, higher barriers have been placed away from the property boundary. A representative cross section is shown below.

h. Assessment of effects

Despite the extensive mitigation options proposed, the introduction of a major road into a currently quiet environment will have significant noise effects. For the residential area south of Kāpiti Road and west of the proposed Expressway, with the implementation of Mitigation option 2, noise levels are predicted to increase by up to 20 decibels at one PPF (the upper floor of 21 Observation Place) and up to 14 decibels for other PPFs. The average increase in noise level for all dwellings is predicted to be 10 decibels, perceived as a doubling in loudness when compared with the current ambient noise environment.

Nevertheless, the predicted noise levels for all PPFs remain appropriate for residential use, particularly as all dwellings will be within Category A, with external noise levels of up to 57 dB $L_{Aeq(24hr)}$. The upper floor at 21 Observation Place is the only position that would receive a noise level above the Category A criterion, but is still within the Category B criterion.

The following table shows the predicted change in noise level for the 35 PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	0	n/a
3 – 4 decibels	3	9 %
5 – 8 decibels	11	31 %
9 – 11 decibels	12	35 %
> 11 decibels	9	25 %

7.4.4.East of proposed Expressway – Kāpiti Road to Mazengarb Road area

The section of the proposed Expressway Alignment from Kāpiti to Mazengarb Roads is the most densely populated area along the entire route. The existing WLR designation has been in place in this area for a considerable time, and residential development has aligned itself with the existing WLR designation boundary. Therefore, the residential property boundaries from Kāpiti to Mazengarb Roads form virtually a straight line.

Sand dunes within the Designation provide shielding to dwellings in varying areas, while other dwellings would be exposed to the proposed Expressway. The proposed Expressway height varies in relation to the dwellings. It is elevated at either end of this section, where the proposed Expressway crosses over Kāpiti and Mazengarb Roads by bridge, level in some areas and up to 5 metres below the neighbouring houses in other areas.

A total of 147 PPFs fall within the assessment area between Kāpiti and Mazengarb Roads. This includes ten double storey dwellings along the Alignment.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(ii).

a. Existing noise environment

The existing noise environment in this area is relatively low for the majority of dwellings due to the absence of any major roads or other noise sources, with noise levels measured between 42 and 44 dB $L_{Aeq(24h)}$. Dwellings at either end of this receiving environment, in close proximity to Kāpiti and Mazengarb Roads, experience slightly higher noise levels of approximately 49 dB $L_{Aeq(24hr)}$. Nevertheless, all PPFs would receive a considerable increase in noise level from the proposed Expressway while meeting the most stringent Category A criterion of 57 dB $L_{Aeq(24hr)}$.

b. Do-minimum scenario

The Do-minimum scenario includes low noise road surface (OGPA) on the proposed Expressway and dense asphalt on the ramps of the Kāpiti Interchange. In addition, 1.1 metre concrete edge barriers are positioned on the proposed Expressway bridge edges across Kāpiti Road.

With these measures in place, noise levels are predicted to range from 48 to 66 dB $L_{Aeq(24hr)}$. Of the 147 PPFs assessed, 100 would fall within Category A, 42 within Category B and 5 within Category C.

Noise levels are predicted to increase by between 2 and 23 decibels, with an average increase of 11 decibels. This is a significant increase for the majority of PPFs.

c. Mitigation option 1

Mitigation option 1 is designed to work with the natural terrain formation of the sand dunes, filling in the gaps between the dunes with barriers in the most appropriate location, while keeping barriers in scale with residential sites. Therefore, 2 metre high barriers are located either along the property boundary or adjacent to the proposed Expressway.

Mitigation of up to 6 decibels can be achieved, with an average noise level reduction of 3 decibels. Noise levels are predicted to increase by up to 19 decibels, with an average increase of 10 decibels.

Mitigation option 1 would ensure that no PPFs would be within Category C, with only 25 PPFs remaining in Category B and the remaining 122 PPFs being in Category A.

d. Mitigation option 2

Mitigation option 2 is intended to determine if it is possible to achieve Category A for all PPFs with barriers that can still be considered to be in scale with residential use of the neighbouring sites. Therefore, barriers are located in similar positions as for Mitigation option 1 and increased in height to 3 metres where considered appropriate, with the remaining barrier retaining the 2 metre height of the previous mitigation option. In addition, the 1.1 metre bridge edge barrier at Kāpiti Road is extended by 250 metres to provide additional shielding of the elevated proposed Expressway to the dwellings below.

This mitigation option moves a further number of PPFs into Category A, with only 7 PPFs remaining in Category B. The mitigation achieves an average noise level reduction of 4 decibels, with individual PPFs receiving up to 10 decibels mitigation.

e. Mitigation option 3

Mitigation option 3 has been developed to determine what barriers would be required to achieve compliance with the Noise Guidelines. As the ambient noise level is relatively low, the design criterion of the Noise Guidelines is lower than that of NZS6806, by up to 3 decibels.

Barriers of heights varying from 2 to 5 metres are located in similar positions as for the previous mitigation options. Only two PPFs remain in Category B, with noise levels of 58 dB $L_{Aeq(24hr)}$, only just above the 57 dB Category A criterion.

Average mitigation of 5 decibels is predicted to be achieved, with individual PPFs receiving up to 13 decibels noise level reduction. However, the barrier heights on the property boundaries of up to 5 metres are out of scale with residential use and would likely lead to adverse effects in terms of visual intrusiveness and shading. Therefore, this option has not been developed further.

f. Mitigation option 4

During the workshop, this section of Sector 2 was extensively discussed due to the sensitivities of the receiving environment and the large number of residents in the vicinity. Visual effects require strong consideration as many dwellings are in close proximity to the proposed Expressway.

Therefore, extensive mitigation options were discussed, including a full “dune replacement”, consisting of the excavation of all existing dunes between the proposed Expressway and the property boundaries, and the formation of a new continuous dune to provide consistent and effective shielding for all dwellings along the proposed Expressway.

This dune would vary in height from 2 metres to 6.5 metres above road level. This variation in height is similar to that currently experienced, i.e. a dune of 6 metres height above road level would not be imposing or out of place in this environment as existing dunes are of similar heights, though not continuous. It is understood that peat excavated at other parts of the proposed Expressway Alignment could be used to form this bund thus reducing transportation effects.

In the vicinity of the Kāpiti Interchange, adjacent to the southbound off ramp, barrier heights would be limited to 2 to 3 metres due to space restrictions.

An average noise level reduction of 3 decibels can be achieved by this mitigation, with individual PPFs receiving up to 9 decibels reduction. Six PPFs would remain in Category B, with 141 PPFs in Category A.

Similarly to Mitigation option 2, PPFs could receive an average noise level increase of 9 decibels, with the most affected PPFs receiving an increase of up to 18 decibels when compared with current ambient noise levels.

g. Mitigation option 5

A further mitigation option developed throughout, and following, the workshop involves a hybrid of Mitigation option 2, whereby barriers would be moved away from the property boundaries in order to avoid adverse shading and visual effects and provide noise level reductions similar to those achieved with Mitigation option 2. This would enable the use of higher barriers.

Barriers between 2 and 3 metres are placed along the eastern side of the proposed Expressway along the southern half of this section of road, with bunds filling in gaps in the dunes along the northern half of this section of road. The infill bunds would have heights up to 7 metres, matching the dunes already existing between the proposed Expressway and the residential sites.

This arrangement would result in an average noise level reduction of 3 decibels thus fulfilling the requirements of NZS6806. Of the 147 PPFs assessed, 137 would be within Category A and the remaining 10 within Category B.

Notwithstanding the above, noise levels are predicted to increase by up to 18 decibels, with an average noise level increase of 9 decibels. This is a significant increase.

However, the resulting noise levels are considered to be appropriate for residential use and similar to other suburban areas throughout New Zealand.

h. Mitigation option 6

Further extensive discussions were held with the urban design team in order to determine if a reduction of barrier heights is possible in the vicinity of the Kāpiti Road Interchange, specifically in the vicinity of Greenwood Place. In addition, the bund at Mazengarb Road would be moved closer to the proposed Expressway.

Therefore, a further mitigation option was developed, with only a 1.1 metre high concrete safety barrier along the southbound off ramp and the proposed Expressway edge.

Noise level reductions of up to 7 decibels are achieved by this mitigation option. Moving the bund closer to the proposed Expressway at Mazengarb Road will result in similar outcomes to those predicted for the other mitigation options above.

i. Selected mitigation option

The selected mitigation option is Mitigation option 6. While a reasonable degree of noise level reduction is achieved with the barriers and bunds proposed, visual impacts are reduced, specifically shading, for properties close to Kāpiti Road. The input by the urban design team had a strong influence on the choice of selected mitigation option for this area.

The use of a full bund which is similar to the existing sand dunes will result in good noise mitigation for the dwellings along this section of the proposed Expressway. A representative cross section is shown below.

j. Assessment of effects

Irrespective of the mitigation option chosen, the introduction of the proposed Expressway into the currently quiet ambient noise environment between Kāpiti and Mazengarb Roads will result in a major adverse effect on adjacent residents. Noise levels are predicted to increase on average by around 10 decibels, which would be perceived as a doubling in loudness. A few individual PPFs would receive even higher noise level increases up to 18 decibels.

While the effects of this change in noise level are considered to be significant, the resultant noise environment is considered to be appropriate for residential use and similar to many suburban residential environments.

The following table shows the predicted change in noise level for the 147 PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	3	2 %
3 – 4 decibels	4	3 %
5 – 8 decibels	70	48 %
9 – 11 decibels	52	35 %
> 11 decibels	18	12 %

7.4.5.West of proposed Expressway – Cheltenham Drive area

Just south of Mazengarb Road, a retirement village is located west of the proposed Expressway. Dwellings are single storey and at a ground level similar to the road. The Designation boundary coincides with the property boundary for this receiving environment.

Forty two dwellings would be in the assessment area within 100 metres of the edge of the proposed Expressway.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(ii).

a. Existing noise environment

The existing noise environment has been measured to be around 45 dB $L_{Aeq(24hr)}$, a low noise environment for a suburban area. This is generally due to the absence of major roads in the vicinity and the reduced traffic on local roads in the retirement village.

The most stringent noise criterion of NZS6806 is 57 dB $L_{Aeq(24h)}$, or 12 decibels above the existing noise environment.

b. Do-minimum scenario

The Do-minimum scenario includes the use of low noise road surface (OGPA) on the proposed Expressway and 1.1 m high concrete edge barriers on the proposed Expressway bridge over Mazengarb Road.

Noise levels are predicted to range from 49 to 63 dB $L_{Aeq(24hr)}$, an increase between 4 and 18 decibels depending on the location of the dwellings in relation to the proposed Expressway.

Two thirds of all PPFs assessed would be within Category A, with the remaining 14 PPFs predicted to be in Category B.

c. Mitigation option 1

Mitigation option 1 involves a 4 metre high bund extending from chainage 7200 to chainage 7700. This bund was initially proposed by the Project team and achieves a good degree of mitigation (an average of 3 decibels) and moves all PPFs assessed into Category A.

However, following redesign of the stormwater systems, the area between the proposed Expressway and the retirement village will not be available for space intensive mitigation measures such as the proposed bund. Therefore, this option has not been assessed further.

d. Mitigation option 2

In order to enable mitigation to be provided for the retirement village without encroaching into the area between the proposed Expressway and the retirement village, a barrier is located immediately west of the proposed Expressway. As this barrier is sufficiently removed from the residential property boundary, the height could be increased to 2.5 metres without impinging on the residential sites through visual or shading effects.

The resultant noise levels are similar to those achieved by the 4 metre high bund of Mitigation option 1 above, with all dwellings being within Category A. This mitigation option would also fulfil the requirements of the Noise Guidelines.

The barrier is predicted to achieve an average noise level reduction of 3 decibels, and up to 6 decibels for the most affected PPFs. Noise levels would range from 48 to 57 dB $L_{Aeq(24hr)}$, between 3 and 12 decibels above the existing ambient noise levels. On average, noise levels in this receiving environment would increase by 8 decibels, a significant change.

However, the resultant noise levels are considered to be appropriate for residential use and similar to comparable suburban areas in other parts of New Zealand.

e. Mitigation options 3 and 4

Further discussions with the urban design team resulted in additional mitigation options 3 and 4 being developed. These options involve a split barrier/bund and lower barrier along the proposed Expressway respectively. While the split barrier/bund option would result in similar noise levels to Mitigation option 2 above, the use of a lower 2 metre barrier along the proposed Expressway would result in a number of PPFs falling within Category B. Therefore, Mitigation option 4 has not been developed further.

f. Selected mitigation option

The Project team determined that Mitigation option 3 is selected, due the good degree of noise level reduction and avoidance of adverse visual and shading effects on residential properties, while using bunding where possible to provide natural shielding.

g. Assessment of effects

Noise levels are predicted to increase by between 3 and 12 decibels, with an average increase of 8 decibels. These are significant changes, with increases around 10 decibels generally being perceived as being twice as loud compared with existing levels.

However, these effects are due to the fact that existing ambient noise levels are unusually low for residential areas, and the introduction of any activity would result in a significant increase in noise level. The resultant levels are suitable for residential use and comparable to many other residential areas in New Zealand, all being below 60 dB $L_{Aeq(24hr)}$.

The following table shows the predicted change in noise level for the 42 PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	0	n/a
3 – 4 decibels	5	12 %
5 – 8 decibels	18	43 %
9 – 11 decibels	15	36 %
> 11 decibels	4	9 %

7.4.6. Summary of assessed mitigation options – Sector 2

Table 7-2: Summary of assessed mitigation options and selected option

Area	Option	Selected	Mitigation measures
West of proposed Expressway – Raumati Road	Do-minimum*		OGPA
	1	Selected	OGPA, 2m barrier (240m)
East of proposed Expressway – Rata Road	Do-minimum*	Selected	OGPA
	1		OGPA, 2m barrier (330m)

Area	Option	Selected	Mitigation measures
West of proposed Expressway – South of Kāpiti	Do-minimum		OGPA
	1		OGPA, 1.1m barrier (240m), 2-3m barrier (325m)
	2		OGPA, 1.1m barrier (275m), 3m barrier (260m), 2.5m barrier (270m), 2m barrier (140m), 1-7m bund (100m)
	3*		OGPA, 1.1m barrier (275m), 3m barrier (260m), 2.5m barrier (270m), 4m barrier (190m), 1-7m bund (100m)
	4/4a	Selected	OGPA, 1.1m barrier (275m), 2m barrier (530m or 200m), 3m barrier (210m), 1-7m bund (100m)
East of proposed Expressway – Kāpiti Road to Mazengarb Road	Do-minimum		OGPA
	1		OGPA, 1.1m barrier (30m), 2m barrier (1265m)
	2		OGPA, 1.1m barrier (250m), 2m barrier (660m), 3m barrier (660m)
	3*		OGPA, 1.5m barrier (250m), 2m barrier (130m), 3m barrier/bund (325m), 4m barrier/bund (985m), 5m bund (130m)
	4		OGPA, 1.1m barrier (250m)
	5		OGPA, 1.1m barrier (305m), 2m barrier (490m), 3m barrier (390m), 4.5m barrier (120m), 5m barrier (185m)
	6	Selected	OGPA, 1.1m barrier (625m), 2m barrier (155m), 3m barrier (55m), 4m bund (1015m)
West of proposed Expressway – Cheltenham Drive	Do-minimum*		OGPA
	1		OGPA, 4m bund (500m)
	2		OGPA, 2.5m barrier (500m)
	3	Selected	OGPA, 4m bund (225m), 2.5m barrier (295m)
	4		OGPA, 2m barrier (500m)

* - this mitigation option fulfils the requirements of the Noise Guidelines (refer Section 5.2).

Sector 2 – selected mitigation options

Through the workshop process to determine the BPO in the opinion of the Project team, the selected mitigation options for Sector 2 are:

- West of proposed Expressway, Raumati Road – Mitigation option 1
- East of proposed Expressway, Rata Road – Do-minimum scenario
- West of proposed Expressway, South of Kāpiti Road – Mitigation option 4/4a
- South of proposed Expressway, Kāpiti Road to Mazengarb Road – Mitigation option 6
- West of proposed Expressway, Cheltenham Drive – Mitigation option 3.

Noise level predictions for Sector 2 for the selected mitigation options and figures showing the barrier lengths and heights are contained in Appendix 15.B.

7.5. Sector 3 – Mazengarb Road to North of Te Moana Interchange

Sector 3 extends from Mazengarb Road to just north of the Te Moana Interchange, including the northbound on- and southbound off-ramp. The area is generally sparsely populated and has a rural residential character. Small pockets of residential use are generally located around the local roads crossed by the proposed Expressway, including Mazengarb, Otaihanga and Te Moana Roads, and the residential area at Puriri Road.

This sector also includes the crossing of the Waikanae River and borders the Takamore Urupa and Maketu Tree.

Sector 3 includes six receiving environments, namely residential areas east and west of the proposed Expressway and north of Mazengarb Road, dwellings at Otaihanga and Puriri Roads and areas east of the proposed Expressway and north and south of Te Moana Road. These areas are discussed in detail below.

7.5.1. West of proposed Expressway – Mazengarb Road area

A small number of dwellings are located within 100 metres of the western edge of the proposed Expressway immediately north of Mazengarb Road. Dwellings are generally well below the proposed Expressway Alignment, by up to 9 metres, therefore, the road surface would be well shielded from the dwellings to a large extent.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iii).

a. Existing noise environment

The existing noise environment has been measured to be around 45 dB $L_{Aeq(24hr)}$ in this receiving environment. This relatively low noise level is due to the absence of major roads in the vicinity and the small number of dwellings.

b. Do-minimum scenario

The Do-minimum scenario includes the use of low noise road surface material (OGPA) on the proposed Expressway and 1.1 metre high concrete edge barriers on the proposed Expressway bridge over Mazengarb Road.

Even with these measures in place, the introduction of the proposed Expressway into the currently unaffected and quiet noise environment results in a significant increase in noise level by between 11 and 17 decibels. Noise levels at the eight PPFs assessed are predicted to range from 56 to 62 dB $L_{Aeq(24hr)}$.

c. Mitigation option 1

Mitigation option 1 has been developed to determine the mitigation requirement to achieve Category A at all PPFs west of the proposed Expressway. This can be achieved by means of a 2 metre high barrier immediately adjacent to the proposed Expressway, extending from the bridge across Mazengarb Road to chainage 8420.

Noise reductions between 3 and 6 decibels are predicted to be achieved at all PPFs assessed, with an average mitigation of 4 decibels. Noise levels are predicted to vary from 52 to 56 dB $L_{Aeq(24hr)}$ which is an appropriate noise environment for residential use.

d. Mitigation option 2

A further mitigation option has been developed to determine what barriers would be required to achieve compliance with the Noise Guidelines. A shorter 2 metre barrier would be required, although two of the PPFs assessed would still fall within Category B and experience noise level increases of up to 14 decibels, a significant effect. Therefore, this option was not considered further.

e. Selected mitigation option

The Project team discussed the visual and urban design implications of a 2 metre barrier as per Mitigation option 1 and decided that the noise level reductions achieved would outweigh any potential adverse effects unrelated to acoustics.

Therefore, Mitigation option 1 was the selected option.

f. Assessment of effects

As noted above, the existing noise environment is relatively low and therefore, the introduction of the proposed Expressway into this environment is predicted to result in noise level increases of between 7 and 11 decibels, with an average noise level increase of 9 decibels. This would be perceived as being about a doubling of loudness compared with current levels. However, the predicted noise levels are in the low to mid-50 decibels and therefore suitable for residential use, being within the (ideal) noise criteria set out by the World Health Organisation.

The following table shows the predicted change in noise level for the eight PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	0	n/a
3 – 4 decibels	0	n/a
5 – 8 decibels	2	25 %
9 – 11 decibels	6	75 %
> 11 decibels	0	n/a

7.5.2.East of proposed Expressway – Mazengarb Road area

Two dwellings are located within 100 metres of the eastern edge of the proposed Expressway immediately north of Mazengarb Road. These dwellings are approximately at the same terrain level as the proposed Expressway Alignment and are therefore not shielded by intervening terrain.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iii).

a. Existing noise environment

The existing noise environment has been measured at around 45 dB $L_{Aeq(24hr)}$. This relatively low noise level is due to the absence of major roads in the vicinity and the small number of dwellings.

b. Do-minimum scenario

The Do-minimum scenario includes the use of low noise road surface material (OGPA) on the proposed Expressway and 1.1 metre high concrete edge barriers on the proposed Expressway bridge over Mazengarb Road.

Even with these measures in place, the introduction of the proposed Expressway into the currently unaffected and quiet noise environment results in a significant increase in noise level by 15 and 18 decibels respectively. Noise levels at the two PPFs assessed are predicted to range from 60 to 63 dB $L_{Aeq(24hr)}$.

c. Mitigation option 1

Mitigation option 1 involves a 2 metre barrier extending from the bridge over Mazengarb Road past the dwellings.

Noise reductions of 5 decibels are predicted to be achieved at both PPFs assessed. Noise levels are predicted to vary from 56 to 59 dB $L_{Aeq(24hr)}$, suitable for residential use.

d. Mitigation option 2

Mitigation option 2 provides for an extension of the 1.1 metre bridge edge barrier from Sector 2 into Sector 3 past the PPFs, as the dwellings have line of sight to the proposed Expressway south of the bridge. This option also fulfils the requirements of the Noise Guidelines.

This mitigation option achieves 4 decibels average noise level reduction and noise levels are predicted to be 57 and 59 dB $L_{Aeq(24hr)}$ at the PPFs. One dwelling would be in Category A and the other in Category B, similar to the result of Mitigation option 1.

e. Selected mitigation option

The Project team discussed the visual and urban design implications of a 2 metre barrier as per Mitigation option 1 and decided that the noise level reductions achieved would outweigh any potential adverse effects unrelated to acoustics.

Therefore, Mitigation option 1 was the selected option.

f. Assessment of effects

The existing noise environment is relatively low and therefore, the introduction of the proposed Expressway into this environment is predicted to result in noise level increases of between 7 and 11 decibels, with an average noise level increase of 9 decibels. This would be perceived as being about a doubling of loudness compared with current levels. However, the predicted noise levels are in the low to mid-50 decibels and therefore suitable for residential use, being within the (ideal) noise criteria set out by the World Health Organisation.

The following table shows the predicted change in noise level for the two PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	0	n/a
3 – 4 decibels	0	n/a
5 – 8 decibels	0	n/a
9 – 11 decibels	1	50 %
> 11 decibels	1	50 %

7.5.3. Otaihanga Road area

The area around Otaihanga road is of rural character with very few dwellings in the vicinity. Only four dwellings fall within the assessment area, two on both the eastern and western sides of the proposed Expressway. Due to the low number of PPFs, one assessment matrix was developed for both sides of the road.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iii).

a. Existing noise environment

The existing noise environment in this area is relatively low, with a measured noise level of 47 dB $L_{Aeq(24hr)}$. This is due to the absence of major local roads or other noise sources in the vicinity.

b. Do-minimum scenario

The introduction of the proposed Expressway into the existing low noise environment is predicted to result in a noise level increase of between 12 and 15 decibels, with an average noise level increase of 13 decibels.

For the Do-minimum circumstance, this includes the use of low noise road surface material (OGPA) and 1.1 m high concrete edge barriers on the proposed Expressway bridge across Otaihanga Road.

c. Mitigation option 1

A mitigation option has been developed to achieve compliance with Category A at all PPFs. Due to the large distances between dwellings, mitigation measures also have to be extensive and therefore would not benefit several dwellings at the same time. This means that the mitigation achieved for each dwelling should be a minimum 5 decibels in accordance with NZS6806.[23]

Mitigation option 1 involves an extension of the 1.1 m western bridge edge barrier by 430 metres in order to provide shielding to 150 and 155 Otaihanga Road. This would achieve noise level reductions of 3 decibels for both houses.

In addition, a 2 metre high, and about 590 metre long, barrier was proposed for the eastern proposed Expressway edge in order to shield 20 Grand Poppa Way and 121 Otaihanga Road. This barrier would achieve noise level reductions of 4 and 5 decibels respectively.

Noise levels are predicted to range from 55 to 57 dB $L_{Aeq(24hr)}$, with all PPFs being within Category A.

d. Mitigation option 2

A second mitigation option has been developed to determine what mitigation may be required to achieve compliance with the Noise Guidelines.

Only the dwelling at 121 Otaihanga Road is predicted to exceed the Noise Guidelines criteria thus requiring mitigation. A 2 metre high barrier extending for 360 metres along the edge of the proposed Expressway would suffice to achieve compliance at this location. However, the noise level reduction achieved would be 4 decibels for this one PPF only, with no benefit to other PPF.

Therefore, this mitigation option does not fulfil the requirements of NZS6806 whereby mitigation for individual PPFs should achieve at least 5 decibels noise level reduction.

[23] Refer NZS6806, Section 8.2.2(b)

e. Mitigation option 3

Mitigation option 1 has been extensively discussed during the workshop and provisionally selected. However, the 2 metre eastern barrier is not seen to be acceptable for urban design and visual reasons. The extension of the 1.1 metre bridge barrier is considered to be practicable and could be designed to blend into the rural environment.

Therefore, mitigation option 3 has been developed which incorporated the Project team feedback.

f. Selected mitigation option

Mitigation option 3 has been chosen by the Project team to be selected as it provides some noise mitigation while blending into the natural environment.

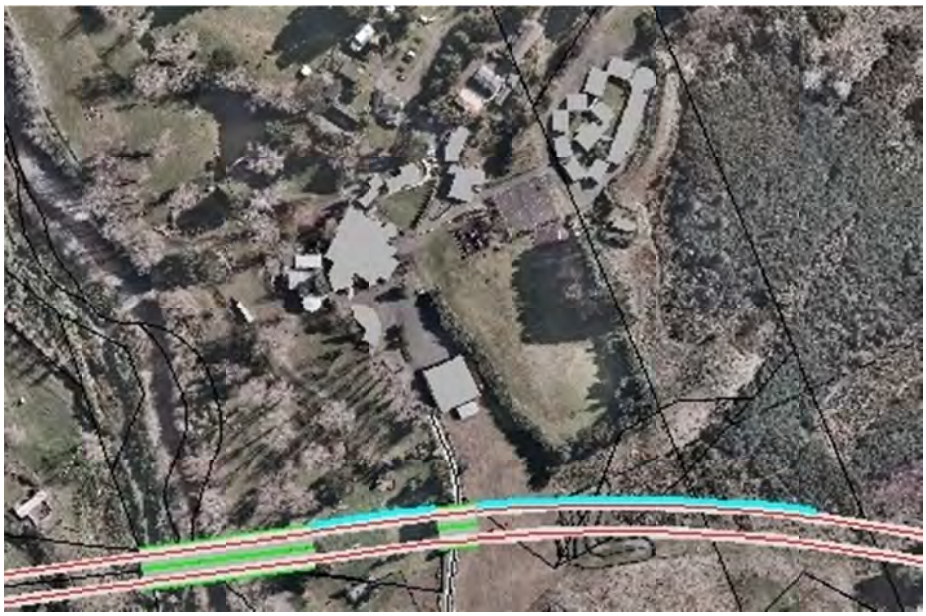
g. Assessment of effects

The operation of the proposed Expressway in this currently quiet environment would result in noise level increases of between 9 and 15 decibels, a significant change. However, noise levels at all dwellings but one are predicted to be below 60 dB $L_{Aeq(24h)}$ and therefore well suitable for residential use. The dwelling at 121 Otaihanga Road is predicted to receive a noise level of 62 dB $L_{Aeq(24h)}$, an acceptable noise level for residential use.

The following table shows the predicted change in noise level for the four PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	0	n/a
3 – 4 decibels	0	n/a
5 – 8 decibels	0	n/a
9 – 11 decibels	3	75 %
> 11 decibels	1	25 %

7.5.4.El Rancho



El Rancho is a Christian holiday camp east of the proposed Expressway and north of the Waikanae River. The camp is remote from existing local roads. It consists of a hall/church, several administrative/meeting buildings and cabins.

While the camp is outside the 100 metre assessment area set out in NZS6806, it has been included in this report due to the special nature of the activity, including sleeping facilities. NZS6806 defines PPFs based on their sensitive nature in relation to road traffic noise, e.g. sleeping facilities.

Despite having been included in this assessment, it is noted that the camp is outside the assessment area and therefore not strictly required to be assessed.

a. Existing noise environment

The existing noise environment in the camp is relatively low, with noise levels measured to be approximately 40 dB $L_{Aeq(24h)}$. This is due to the absence of noise sources such as local roads or industry.

b. Do-minimum scenario

With the establishment of the proposed Expressway, the noise levels at the El Rancho buildings are predicted to be range from 48 to 56 dB $L_{Aeq(24h)}$, i.e. all buildings will be within Category A, the most stringent of NZS6806.

The proposed Expressway is proposed to be surfaced with low noise road surface material (OGPA) and would have a 1.1 metre concrete edge barrier on the western edge of the proposed Expressway extending from the southern end of the Waikanae River bridge to approximately

chainage 11000. This barrier will have a significant shielding effect on the elevated proposed Expressway for the El Rancho facilities. A representative cross section is shown below.

If the camp would be required to be assessed in accordance with NZS6806, all buildings would be within Category A and no specific noise mitigation would be required.

c. Assessment of effects

All buildings are predicted to be within Category A and therefore receive noise levels below 57 dB $L_{Aeq(24h)}$. Nevertheless, the increase in noise level from the existing low noise environment will be considerable with noise levels predicted to increase by between 8 and 16 decibels.

However, resultant noise levels are appropriate for residential and similar noise sensitive uses, and no further mitigation is proposed.

7.5.5. East of proposed Expressway – Kauri Road area

A small residential enclave is located south of Te Moana Road at Kauri and Puriri Roads. Although of suburban character, no major local roads traverse this area which borders onto the Takamore Urupa and El Rancho sites.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iii).

a. Existing noise environment

The existing noise environment in the Kauri Road area is relatively low, with noise levels measured to vary from 40 to 50 dB $L_{Aeq(24h)}$ depending on the location in relation to Te Moana Road. Those dwellings closest to the proposed Expressway Alignment currently experience the lowest noise levels as they are located in dead end streets without any through traffic.

b. Do-minimum scenario

The proposed Expressway in the vicinity of the Kauri Road area would utilise low noise road surface material (OGPA). Noise levels are predicted to range from 51 to 60 dB $L_{Aeq(24h)}$ without the use of further mitigation measures. Only one of the six PPFs assessed would receive noise levels above the Category A criterion of 57 dB $L_{Aeq(24h)}$.

c. Mitigation option 1

A mitigation option has been developed that provides for all dwellings to fall within Category A. A 2 metre high barrier is proposed along the eastern proposed Expressway edge. Noise level reductions of between 2 and 3 decibels are predicted to be achieved at three of the six PPFs assessed. This is a small noise level reduction, less than recommended by NZS6806 which states that mitigation should achieve an average of 3 decibels noise level reduction.

d. Mitigation option 2

A further mitigation option has been developed that would achieve compliance with the Noise Guidelines criteria and provide for a higher degree of mitigation. A 3 metre high bund extending for approximately 280 metres along the eastern side of the proposed Expressway is proposed. This bund would achieve noise level reductions of 1 to 6 decibels, with the most affected PPFs receiving on average a 5 decibel noise level reduction.

Resultant noise levels would be between 50 and 54 dB $L_{Aeq(24h)}$.

e. Selected mitigation option

The Project team decided that Mitigation option 2 is the selected option due to the significant reductions in noise level achieved and the possible use of a bund rather than a barrier, thus reducing the visual impact on the surrounding environment.

f. Assessment of effects

Due to the very low ambient noise level environment in the Kauri Road area, particularly at the dwellings at some distance from Te Moana Road and closest to the proposed Expressway Alignment, noise levels are predicted to increase between 7 and 12 decibels. However, with the

proposed selected mitigation option the resultant noise levels are well below 57 dB $L_{Aeq(24h)}$ and therefore within the most stringent noise criteria Category A. These noise levels are well suited and appropriate for residential use.

The following table shows the predicted change in noise level for the six PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	0	n/a
3 – 4 decibels	0	n/a
5 – 8 decibels	2	33 %
9 – 11 decibels	4	66 %
> 11 decibels	0	n/a

7.5.6.West of proposed Expressway – South of Te Moana Road

The area around Te Moana Road Interchange is of rural residential character. Te Moana Road is main road providing a local connection from SH1 to the Kāpiti Coast. Existing dwellings do not generally have solid or acoustically effective fences fronting Te Moana Road.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iii).

a. Existing noise environment

The existing noise environment in this area is controlled by traffic on Te Moana Road. Ambient noise levels have been measured to be between 51 and 53 dB $L_{Aeq(24h)}$. These levels are slightly below the most stringent noise level Category A criterion of 57 dB $L_{Aeq(24h)}$.

b. Do-minimum scenario

The proposed Expressway is proposed to be surfaced with low noise road surface material (OGPA) on the main road and asphaltic concrete on the ramps of the full diamond interchange. In addition, a 1.1 metre high concrete edge safety barrier will be installed on the proposed Expressway bridge over Te Moana Road. This barrier is predicted to result in effective acoustic shielding of traffic noise from the proposed Expressway due to the height difference between the vehicles and the dwellings below.

The introduction of the proposed Expressway into this environment is predicted to result in a noticeable to significant increase in noise level by between 2 and 11 decibels. Of the seven PPFs assessed, three would be within Category A. For the remaining four PPFs, noise levels are predicted to remain within Category B (up to 64 dB $L_{Aeq(24h)}$) without the implementation of additional mitigation.

c. Mitigation option 1

Mitigation option 1 includes the use of a higher, 1.5 metre edge barrier on the proposed Expressway bridge and the road sections leading up to the bridge. Such small increase in barrier height would not have adverse visual effects and potentially provide additional shielding for elevated traffic.

However, no noticeable noise level reduction could be achieved by this option and it has not been developed further.

d. Mitigation options 2 and 3

The controlling noise source for the PPFs in Te Moana Road is traffic on Te Moana Road, not traffic on the proposed Expressway. Te Moana Road will be slightly realigned and widened to allow for connection with the proposed Expressway ramps.

It is not considered practicable to provide property fences as the barriers would need to allow access to sites thus either requiring tightly closing gates, or have a diminished noise mitigation effect. Therefore, this was not further considered.

Alternatively, traffic noise from Te Moana Road can be reduced by using a low-noise road surface. Mitigation options 2 and 3 are based on the use of dense asphalt and open graded porous asphalt respectively.

Both these options provide noticeable reductions in noise level of between 3 and 6 decibels. The use of OGPA is preferable as it achieves better noise reductions of up to 6 decibels for the most affected dwellings. Mitigation option 3 also provides for general compliance with the Transit Guidelines.

Both mitigation options result in no dwellings being within Category C. Mitigation option 3 results in six of the seven PPFs being in Category A, while Mitigation option 2 would have six PPFs in Category B.

e. Selected mitigation option

Mitigation option 3 has been selected by the Project team. It provides a significant noise level reduction of 6 decibels for most PPFs and results in only one PPF being in Category B with the remaining PPFs being in category A.

f. Assessment of effects

The proposed Expressway, while being some distance from the dwellings in Te Moana Road, would have a noticeable effect on the ambient noise environment. Noise level increases are predicted to range from 2 to 8 decibels, with an average increase of 3 decibels. This area will be less affected than many others in the vicinity of the proposed Expressway due to the ambient noise level already being affected by Te Moana Road.

Resulting noise levels with the implementation of mitigation are appropriate for residential use, being between 55 and 61 dB $L_{Aeq(24h)}$.

The following table shows the predicted change in noise level for the seven PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	4	57 %
3 – 4 decibels	2	29 %
5 – 8 decibels	1	14 %
9 – 11 decibels	0	n/a
> 11 decibels	0	n/a

7.5.7. West of proposed Expressway – North of Te Moana Road

Dwellings north of Te Moana Road are similarly situated to those south of Te Moana Road (refer Section 7.5.6). Te Moana Road is about level with the residences, and sections are not generally fenced on the road boundary.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iii).

a. Existing noise environment

The existing noise environment is the same as that for the area south of Te Moana Road described in Section 7.5.6a above. Noise levels are generally between 51 and 53 dB $L_{Aeq(24h)}$.

b. Do-minimum scenario

The proposed Expressway is proposed to be surfaced with low-noise road surface material (OGPA) on the main road and asphaltic concrete on the ramps of the full diamond interchange. In addition, a 1.1 metre high concrete edge safety barrier will be installed on the proposed Expressway bridge over Te Moana Road. This barrier is predicted to result in effective acoustic shielding of traffic noise from the proposed Expressway due to the height difference between the vehicles and the dwellings below.

The introduction of the proposed Expressway into this environment is predicted to result in a significant increase in noise level by up to 14 decibels for PPFs not fronting Te Moana Road. Of the 17 PPFs assessed, nine would be within Category A, four within Category B and four within Category C.

c. Mitigation option 1

All mitigation options are the same as for the area south of Te Moana Road discussed in Section 7.5.6 above. This is because the dwellings will be affected by the same mitigation measures.

Mitigation option 1 includes the use of a higher 1.5 metre high edge barrier on the proposed Expressway bridge and the road sections leading up to the bridge. No noticeable noise level reduction could be achieved by this option and it has not been developed further.

d. Mitigation options 2 and 3

The most effective mitigation was found to be that addressing noise from Te Moana Road by using low-noise road surface. Mitigation options 2 and 3 are based on the use of dense asphalt and OGPA respectively.

Both these options provide noticeable reductions in noise level between 3 and 6 decibels. Using OGPA is preferable as it achieves greater noise reductions of up to 6 decibels for the most affected PPFs. Mitigation option 3 also provides for general compliance with the Transit Guidelines.

Both mitigation options result in no PPF being within Category C and for nine PPFs being within Category A.

e. Selected mitigation option

Mitigation option 3 has been selected by the Project team. It provides for significantly higher noise level reductions. In addition, since the receiving environments north and south of Te Moana Road are closely related, the selected mitigation option selected needs to be the same for both receiving areas.

f. Assessment of effects

The operation of the proposed Expressway in the vicinity of the PPFs north of Te Moana Road will result in a noticeable increase in noise level, of 5 to 7 decibels, for those PPFs not fronting Te Moana Road as they are currently in a low noise environment.

For PPFs fronting Te Moana Road, the noise level is predicted to remain largely unchanged as the proposed mitigation will reduce traffic noise levels from Te Moana Road which will counteract the potential increase in noise level from the proposed Expressway.

The following table shows the predicted change in noise level for the 16 PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	8	50 %
1 – 2 decibels	0	n/a
3 – 4 decibels	1	6 %
5 – 8 decibels	7	44 %
9 – 11 decibels	0	n/a
> 11 decibels	0	n/a

7.5.8. Summary of assessed mitigation options – Sector 3

Table 7-3: Summary of assessed mitigation options and selected option

Area	Option	Selected	Mitigation measures
West of proposed Expressway – Mazengarb Road	Do-minimum		OGPA
	1	Selected	OGPA, 2m barrier (475m)
	2*		OGPA, 2m barrier (150m)
East of proposed Expressway – Mazengarb Road	Do-minimum		OGPA
	1	Selected	OGPA, 2m barrier (70m)
	2*		OGPA, 1.1m barrier (70m)
Otaihanga Road area	Do-minimum		OGPA
	1		OGPA, 1.1m barrier (430m), 2m barrier (590m)
	2*		OGPA, 2m barrier (360m)
	3	Selected	OGPA, 1.1m barrier (430m)

Area	Option	Selected	Mitigation measures
El Rancho	Do-minimum	Selected	OGPA , (1.1m safety barrier on bridge, not specific mitigation)
East of proposed Expressway – Kauri Road area	Do-minimum		OGPA
	1		OGPA, 2m barrier (165m)
	2*	Selected	OGPA, 3m barrier (95m)
West of proposed Expressway – South of Te Moana Road	Do-minimum		OGPA
	1		OGPA, 1.5m barrier (140m)
	2		OGPA, asphalt on Te Moana Road
	3*	Selected	OGPA, OGPA on Te Moana Road
West of proposed Expressway – North of Te Moana Road	Do-minimum		OGPA
	1		OGPA, 1.5m barrier (125m)
	2		OGPA, asphalt on Te Moana Road
	3*	Selected	OGPA, OGPA on Te Moana Road

* - this mitigation option fulfils the requirements of the Noise Guidelines (refer Section 5.2)

7.5.9.Sector 3 – selected mitigation options

Through the workshop process to determine the BPO in the opinion of the Project team, the selected mitigation options for Sector 3 are:

- West of proposed Expressway, Mazengarb Road area: Mitigation option 1
- East of proposed Expressway, Mazengarb Road area: Mitigation option 1
- Otaihanga Road Area: Mitigation option 3
- East of proposed Expressway, Kauri Road area: Mitigation option 2
- West of proposed Expressway, South of Te Moana Road: Mitigation option 3
- West of proposed Expressway, North of Te Moana Road: Mitigation option 3.

Noise level predictions for Sector 3 for the selected mitigation options and figures showing the barrier lengths and heights are contained in Appendix 15.B.

7.6. Sector 4 – North of Te Moana Interchange to Peka Peka Road

Sector 4 extends from just north of Te Moana Road to the northern termination of the Project. This sector is the most rural in character, with few dwellings within 100 metres of the proposed Expressway Alignment.

Only three receiving environments have been identified for this Sector, being the dwellings in End Farm Road and dwellings to the east and west of the proposed Expressway at Peka Peka. These assessment areas are described in detail below.

7.6.1. East of proposed Expressway – End Farm Road

As noted, there is only a very small number of dwellings within 100 metres of the proposed Expressway. Two of these are in End Farm Road. These dwellings are in a remote area with no immediate neighbours or major local roads in the vicinity.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iv).

a. Existing noise environment

As noted above, the PPFs are in a remote area with virtually no man made noise sources in the vicinity. The ambient noise levels are relatively low and have been measured to be 46 dB $L_{Aeq(24h)}$.

b. Do-minimum scenario

The proposed Expressway would introduce a major new road into the area. The road surface material north of the new Smithfield Road bridge is proposed to be chip seal. Resulting noise levels for the Do-minimum scenario are predicted to be 65 and 66 dB $L_{Aeq(24h)}$, 20 decibels above the existing noise levels.

Both PPFs would be within Category C.

c. Mitigation option 1

Due to the small number of dwellings affected by, and the distance of the dwellings from, the proposed Expressway, the design of adequate mitigation is problematic. Barrier mitigation has been developed involving a 5 metre high and 530 metre long barrier along the eastern proposed Expressway boundary.

Noise levels are predicted to be reduced slightly only, by 2 to 4 decibels. However, the barrier would result in both PPFs being within Category B. Nevertheless, the urban design and visual implications are understood to be of concern as a 5 metre high barrier would look out of place in the rural environment and there would be insufficient space for a bund. Therefore, this option has not been developed further.

d. Mitigation option 2

The most effective external traffic noise mitigation measure would be the selection of low-noise road surface. Mitigation option 2 involves the use of OGPA, continuing on from the new Smithfield Road bridge to approximately chainage 15400.

Noise levels would be reduced by 4 to 5 decibels to 61 dB $L_{Aeq(24h)}$ at both PPFs. This is considered to be an acceptable noise level for residential use.

e. Mitigation option 3

Mitigation option 3 acknowledges that only two PPFs fall within the assessment area of the proposed Expressway in the vicinity of End Farm Road. The cost of the mitigation proposed is relatively high compared with the benefit received. NZS6806 includes some guidance in terms of effectiveness of mitigation measures, specifically that mitigation for individual receivers (as is the case in End Farm Road) should receive at least 5 decibels of mitigation.

Therefore, if no structural mitigation was implemented, i.e. no improvement of road surface material or barriers, building envelope improvements could be used to achieve a suitable internal noise environment for the two dwellings. This is detailed as Mitigation option 3.

The Standard states that building modification mitigation is required for dwellings where the internal noise level in habitable spaces would be 45 dB $L_{Aeq(24h)}$ or more with the implementation of the Project. If this trigger level is exceeded, then internal noise levels shall be reduced to an internal noise level of no more than 40 dB $L_{Aeq(24h)}$ in those habitable spaces. However, this criterion may not in fact be triggered.

As noted above, the current ambient noise environment in the vicinity of End Farm Road is low. Therefore, providing protection to habitable spaces inside dwellings will not reduce the effects on the outdoor living areas for these PPFs, which is the selected form of mitigation.

Therefore, the Project team decided that this mitigation option is not selected in this instance.

f. Mitigation option 4

Mitigation option 4 is intended to fulfil the requirements of the Transit Guidelines. As the existing ambient noise level is low, the criterion is also relatively stringent. Mitigation is provided in the form of OGPA and the installation of a 5 metre barrier, and constitutes a combination of Mitigation options 1 and 2.

Resultant noise levels are 7 to 12 decibels lower than the Do-minimum scenario. However, the cost of mitigation in relation to the achieved benefit is high and the Project team decided that this option was therefore not the BPO.

g. Selected mitigation option

Mitigation option 2 was the selected mitigation option by the Project team. The use of OGPA not only provides a reasonable outcome for the existing dwellings but also provides mitigation for the wider area. OGPA also does not cause adverse visual effects in a rural landscape, unlike the high barriers potentially required to achieve a similar outcome.

Noise levels are predicted to be 61 dB $L_{Aeq(24h)}$ for both PPFs. An average noise mitigation of 5 decibels is achieved for both PPFs, a noticeable reduction in noise level when compared with the Do-minimum scenario.

h. Assessment of effects

As noted in Section 7.6.1b above, the existing low noise level means that the introduction of a major noise source into the area will cause a significant effect. Noise levels are predicted to increase by 15 decibels for both PPFs assessed. However, the predicted noise level of 61 dB $L_{Aeq(24h)}$ is considered acceptable for residential use and is therefore considered reasonable.

The following table shows the predicted change in noise level for the two PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	0	n/a
3 – 4 decibels	0	n/a
5 – 8 decibels	0	n/a
9 – 11 decibels	0	n/a
> 11 decibels	2	100 %

7.6.2.West of proposed Expressway – Peka Peka Road

A small residential enclave is located west of the proposed Expressway Alignment at Peka Peka Road. The dwellings are generally elevated above the proposed Expressway and existing SH1 alignment and currently have an unobstructed view to SH1. This area is within 100 metres of the existing State Highway 1 and therefore this part of the proposed Expressway Project is assessed as an altered road in accordance with NZS6806.

The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iv).

a. Existing noise environment

The existing noise environment for the dwellings in this assessment area is already impacted by noise from SH1. Ambient noise levels have been measured to be 58 dB $L_{Aeq(24h)}$. This would place all receivers within altered road Category A (up to 64 dB $L_{Aeq(24h)}$) in accordance with NZS6806.

b. Do-minimum scenario

The proposed Expressway is proposed to be surfaced using chip seal in the vicinity of Peka Peka Road. Based on this layout, the do-minimum noise level is predicted to vary from 56 to 70 dB

$L_{Aeq(24h)}$, depending on the location of the dwelling in relation to the road and the shielding provided by the raised Peka Peka ramps. Five positions are predicted to be within Category A, with one of the remaining two positions being in Categories B and C each.

c. Mitigation option 1

The most effective way of mitigating road traffic noise is the use of low noise road surface material such as OGPA. This has been assumed for Mitigation option 1.

The resultant noise levels are predicted to vary from 52 to 67 dB $L_{Aeq(24h)}$, with one PPF remaining within Category B (9 Te Kowhai Road). All other PPFs are in Category A. Mitigation in the order of 3 decibels can be achieved by this option.

d. Mitigation option 2

An alternative mitigation option has been developed that involved the use of a 162 metre long and 2.5 metre high barrier along the Designation boundary at 20 Peka Peka Road, and 246 metre long and 5 metre high bund along the Designation boundary at 9 Te Kowhai Road. Noise mitigation of 2 decibels for both PPFs is achieved, which is not satisfactory or practicable for such extensive mitigation measure, and has therefore not been assessed further.

e. Mitigation option 3

In order to meet the Noise Guidelines, a combination of Mitigation options 1 and 2 has been assessed as Mitigation option 3. This involves the use of OGPA and the barriers as described in Section 7.6.2d above.

Noise level reductions between 2 and 7 decibels are predicted to be achieved with this mitigation option and all PPFs would be within Category A.

f. Mitigation option 4

A final mitigation option was developed following mitigation option 3, whereby the OGPA road surface was retained and the 5 metre high bund in the vicinity of 9 Te Kowhai Road. This option achieves a similar noise level reduction of between 2 and 7 decibels with an average reduction of 4 decibels.

All PPFs but one (20 Peka Peka Road) would be within Category A. Predicted noise levels range from 55 to 65 dB $L_{Aeq(24h)}$.

g. Selected mitigation option

Mitigation option 1 has been the selected option by the Project team. It achieves a good level of noise reduction and is predicted to retain all dwellings but one within Category A. In addition, the

use of OGPA benefits the wider community, i.e. also dwellings outside the 100 metre assessment area. One dwelling, 9 Te Kowhai Road, is predicted to receive noise levels within Category B.

h. Assessment of effects

For the selected mitigation option 1, the predicted noise levels are similar to those currently experienced in the area, with the exception of 9 Te Kowhai Road and 20 Peka Peka Road, where noise levels are predicted to increase by 9 and 6 decibels respectively.

This is generally due to the fact that the existing ambient noise environment is impacted by traffic noise on SH1 and traffic flows are being redistributed onto the proposed Expressway and existing SH1, with little additional effect resulting from increased traffic volumes.

The two dwellings most affected would experience a noticeable noise level increase due to the proposed Expressway moving traffic closer to the buildings.

The following table shows the predicted change in noise level for the seven PPFs in this area. These changes can be related to the descriptions in Table 6-2 in Section 6.5 above.

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	4	58 %
1 – 2 decibels	1	14 %^
3 – 4 decibels	0	n/a
5 – 8 decibels	1	14 %
9 – 11 decibels	1	14 %
> 11 decibels	0	n/a

7.6.3.East of proposed Expressway – Hadfield Road

The northern termination of the Project is located between Peka Peka Road and Te Kowhai Road. In this area, the proposed Expressway rejoins the existing SH1. Therefore, this section of the Project is considered to constitute an “altered road” in accordance with NZS6806 and the altered road criteria would apply.

An individual dwelling is located within 100 metres east of the proposed Expressway (and existing SH1) in Hadfield Road. The assessment matrices, individual receiver calculations and figures showing predicted noise levels for this receiving environment are contained in Appendix 15.C(iv).

a. Existing noise environment

The existing noise level at Hadfield Road is already impacted to some degree by the existing SH1. Ambient noise levels have been determined to be 58 dB $L_{Aeq(24h)}$. The Category A criterion for an altered road is 64 dB $L_{Aeq(24h)}$.

b. Do-minimum scenario

The proposed Expressway is proposed to be surfaced using chip seal in the vicinity of Peka Peka Road. Based on this layout, the do-minimum noise level is predicted to be 63 dB $L_{Aeq(24h)}$. This means that the Category A criterion can be complied with without the need for mitigation, and no further mitigation options have been assessed for this PPF.

c. Selected mitigation option

As no mitigation is required to achieve compliance with the most stringent Category A criterion for an altered road, the Do-minimum scenario has been selected as being appropriate for the dwelling at Hatfield Road.

However, it is noted that the selected Mitigation option 1 for the residential area west of the proposed Expressway (Peka Peka Road area, refer Section 7.6.2 above) involves the use of OGPA. This will also benefit the dwelling at Hatfield Road, and predicted noise levels would be some 5 decibels lower than currently predicted, i.e. 58 dB $L_{Aeq(24h)}$, only marginally above the Category A criterion of 57 dB $L_{Aeq(24h)}$.

d. Assessment of effects

Due to the selection of OGPA for dwellings in Peka Peka Road, noise levels at the Hatfield Road dwelling are predicted remain unchanged to current noise levels, and therefore, the Project would not cause an effect.

The noise level change for the one PPF is predicted to be 2 decibels, a just noticeable change. (Refer Table 6-2 in Section 6.5 above)

Change in Noise Level	Number of PPF	Percentage of total number of PPF in this area
Less than 1 decibel change	0	n/a
1 – 2 decibels	1	100 %
3 – 4 decibels	0	n/a
5 – 8 decibels	0	n/a
9 – 11 decibels	0	n/a
> 11 decibels	0	n/a

7.6.4. Summary of assessed mitigation options – Sector 4

Table 7-4: Summary of assessed mitigation options and selected option

Area	Option	Selected	Mitigation measures
East of proposed Expressway – End Farm Road	Do-minimum		Chip seal
	1		5m barrier/bund (530m)
	2	Selected	OGPA
	3		Building modification mitigation for both PPFs
	4*		OGPA, 5m barrier/bund (530m)
West of proposed Expressway – Peka Peka Road	Do-minimum		Chip seal
	1	Selected	OGPA
	2		2.5m barrier (160m), 5m bund (245m), Building modification mitigation (2PPFs)
	3*		OGPA, 2.5m barrier (160m), 5m bund (245m)
	4		OGPA, 5m bund (245m)
East of proposed Expressway – Hadfield Road	Do-minimum	Selected	Chip seal

* - this mitigation option fulfils the requirements of the Noise Guidelines (refer Section 5.2)

7.6.5. Sector 4 – selected mitigation options

Through the workshop process to determine the BPO in the opinion of the Project team, the selected mitigation options for Sector 4 are:

- End Farm Road – Mitigation option 2
- West of proposed Expressway, Peka Peka Road – Mitigation option 1
- East of proposed Expressway, Hadfield Road – Do-minimum.

Noise level predictions for Sector 4 for the selected mitigation options and figures showing the barrier lengths and heights are contained in Appendix 15.B.

8. Summary and Conclusions

An extensive and detailed assessment of operational noise effects for the proposed MacKays to Peka Peka Expressway Project has been undertaken. Each Project sector (1 to 4) has been assessed separately, and a variety of mitigation options examined.

The assessment of traffic noise effects is based on New Zealand Standard NZS6806:2010 'Acoustics – Road-traffic noise - New and altered roads', and in some instances consideration given to the (Transit) Noise Guidelines.

The assessment is based on a combination of measurement of existing noise levels and prediction of future noise levels undertaken by computer noise modelling. Extensive noise level surveys were conducted in early 2011 and have been used as the basis for the assessment of noise effects. Traffic volumes for the years 2011 and 2026 (the design year) have been utilised to predict future noise levels, with and without the Project in place.

Detailed assessments of effects and development of numerous mitigation options has been undertaken for residential and other noise sensitive sites in each Sector. This process is in accordance with the requirements of NZS6806 and is based on the best practicable option (BPO) approach of the Resource Management Act.

The mitigation options have been presented to, and assessed with, the full Project team. The resultant extensive feedback and input provided has resulted in further mitigation options being developed and refined. For all sectors, mitigation options have been selected and presented in this report, together with a description of the processes by which decisions were made.

Noise mitigation proposed for this Project includes various types of measures such as low-noise road surface material, road-side barriers, higher and longer edge safety barriers, combination of bunds and barriers where necessary and appropriate. The most effective placement of barriers has been determined for each sector in order to fulfil the requirements of NZS6806 that structural noise mitigation achieves a minimum noise reduction performance to be considered practicable.

It is considered that the principle of the best practicable option has been applied consistently throughout this assessment, and resulting selected mitigation options are practicable and achieve appropriate noise level reductions.

Selected mitigation Options for each of the relevant sectors are:

- Sector 1
  - West of proposed Expressway, Leinster Avenue area – Mitigation option 4
  - West of proposed Expressway, Raumati Road area – Do-minimum scenario
  - East of proposed Expressway, Raumati Road area – Mitigation option 2.
- Sector 2
  - West of proposed Expressway, Raumati Road – Mitigation option 1
  - East of proposed Expressway, Rata Road – Do-minimum scenario
  - West of proposed Expressway, South of Kāpiti Road – Mitigation option 4/4a
  - South of proposed Expressway, Kāpiti Road to Mazengarb Road – Mitigation option 6
  - West of proposed Expressway, Cheltenham Drive – Mitigation option 3
- Sector 3
  - West of proposed Expressway, Mazengarb Road area: Mitigation option 1
  - East of proposed Expressway, Mazengarb Road area: Mitigation option 1
  - Otaihanga Road Area: Mitigation option 3
  - East of proposed Expressway, Kauri Road area: Mitigation option 2
  - West of proposed Expressway, South of Te Moana Road: Mitigation option 3
  - West of proposed Expressway, North of Te Moana Road: Mitigation option 3
- Sector 4
  - End Farm Road – Mitigation option 2
  - West of proposed Expressway, Peka Peka Road – Mitigation option 1
  - East of proposed Expressway, Hadfield Road – Do-minimum.

As this assessment is based on a detailed process to determine the BPO, it is not possible to then apply a retrospective performance specification (i.e. a numerical limit) to define that outcome. Any Designation conditions should instead specify the actual physical mitigation measures determined by this assessment to be implemented.

Overall, it is considered that the proposed MacKays to Peka Peka Expressway Project can be constructed to operate such that unacceptable traffic noise effects can generally be avoided, remedied or mitigated by utilising the best practicable option approach to achieve compliance with the relevant criteria of NZS6806.

References

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Appendix 15.A – Glossary of Technical Terms

Frequency	The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).
Hertz (Hz)	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).
Noise	A sound that is unwanted by, or distracting to, the receiver.
Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 μPa i.e. dB = 20 x log(P/Pr)
dBA	The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
$L_{Aeq\ (t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (24 h) would represent a period of 24 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
NZS 6801:2008	New Zealand Standard NZS 6801:2008 *"Acoustics – Measurement of*

Appendix 15.A

Glossary of Technical Terms

	environmental sound"
NZS 6802:2008	New Zealand Standard NZS 6802:2008 *"Acoustics – Environmental Noise"*
NZS 6806:2010	New Zealand Standard NZS 6806:2010 *"Acoustics - Road-traffic noise - New and altered roads"*

Appendix 15.B

Selected Mitigation Options

Refer to drawings EN-NV-001 – EN-NV-016, Technical Report Appendices, Report 15, Volume 5

Appendix 15.B – Selected Mitigation Options

Refer Drawings EV-NV-001 to EV-NV-016, Technical Report Appendices, Report 15, Volume 5

Drawing Legend

Appendix 15.C

Best Practicable Option Assessment Documentation

Refer to tables and drawings EN-NV-020 – EN-NV-094,

Technical Report Appendices, Report 15, Volume 5

Appendix 15.C – Best Practicable Option Assessment Documentation

Refer Matrices, Spreadsheets and Drawings EV-NV-020 to EV-NV-094, Technical Report Appendices, Report 15, Volume 5

Appendix 15.C(i) – Sector 1

Appendix 15.C(ii) – Sector 2

Appendix 15.C(iii) – Sector 3

Appendix 15.C(iv) – Sector 4

Drawing Legend

Appendix 15.D

Noise Level Contours

Refer to drawings EN-NV-100 – EN-NV-117, Technical Report Appendices, Report 15, Volume 5

Appendix 15.D – Noise Level Contours

Refer Drawings EV-NV-100 to EV-NV-117, Technical Report Appendices, Report 15, Volume 5

Do-minimum scenario and selected mitigation options

Appendix 15.E

SoundPLAN ISO9001 and Accuracy Certification

Appendix 15.E – SoundPLAN ISO9001 and Accuracy Certification

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

TÜV SÜD Management Service

CERTIFICATE

The Certification Body
of TÜV SÜD Management Service GmbH
certifies that

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has established and applies
a Quality Management System for

**Development and distribution of
software as well as consultancy work for
environmental noise control,
structural sound insulation and air pollution control**

An audit was performed, Report No. **70719876**
Proof has been furnished that the requirements
according to

ISO 9001:2008

are fulfilled. The certificate is valid until **2013-02-22**
Certificate Registration No. **12 100 30762 TMS**

Munich, 2010-03-24

GMS-TGA-ZM-07-82

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SoundPLAN International LLC

Software Designers and Consulting Engineers for
Noise Control • Air Pollution • Environmental Protection

Sound PLAN
designing a sound environment

1 January 2012

To Whom It May Concern,

SoundPLAN is a standards based software. Braunstein + Berndt GmbH (SoundPLAN software development office) tests that SoundPLAN is within 0.2dB of the standards. When available, they use the author's or overseeing agency's test questions for the standards for testing. However, not all authors or organizations provide test cases to benchmark results. When no test questions are available, Braunstein & Berndt or a SoundPLAN trading partner generate questions and test to ensure accuracy. Results from the hand calculations are compared with the results from SoundPLAN using our Excel test database. SoundPLAN is tested until deviations from the hand calculations do not exceed 0.2 dB.

Please note that all noise prediction models are statistical approximations of the real world. Deviation in measurement can occur. Every standard has a number of uncertainties such as metrological conditions, the source input data and geometry. SoundPLAN only processes the input data with the algorithm provided in the standards themselves. SoundPLAN is not inventing or developing new propagation methodologies, nor improving on the equations inherent in the standards. Braunstein & Berndt GmbH and SoundPLAN International LLC (SoundPLAN international sales office) only guaranty the accuracy of the standard implementation in the SoundPLAN software.

Quality Assurance (QA) is of vital importance to Braunstein & Berndt GmbH and SoundPLAN International LLC. Every new SoundPLAN release is benchmarked with the test cases from the previous version to ensure results are the same. Our QA testing is an ongoing process so results remain accurate to the requirements of the standards, and routines are compatible in all versions.

Furthermore, Braunstein & Berndt GmbH has been awarded the ISO 9001: 2000 certificate. The certification body of TUV SUD Management Service GmbH certifies that "Braunstein + Berndt GmbH has established and applies a quality management system for development and distribution of software as well as consultancy work for environmental noise control, structural sound insulation and air pollution control."

Braunstein + Berndt GmbH implements new standards as they are published. All changes are incorporated in SoundPLAN updates available at www.soundplan.com for customers with warranty or update and maintenance contracts.

The following page lists the standards implemented and tested in SoundPLAN.

Sincerely,

Elizabeth Berndt

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