19 Noise and Vibration

Overview

The assessment of noise and vibration effects has been undertaken for both the construction and operation of the Project.

Noise from the construction of the Project will generally fall within the construction noise criteria contained within the construction noise standard with some exceptions. The intention is to meet the criteria as far as practicable, although given the scale of the works and the nature of construction activities, alternative management will need to be implemented in some parts of the alignment: alternative options for management are described within the Construction Noise and Vibration Management Plan (CNVMP). The CNVMP provides a detailed process for managing and mitigating construction noise effects and contains information regarding communication, training, maintenance of machinery and equipment and any other noise generating sources during construction.
Noise from the operation of the proposed Expressway has been assessed using modelling software to consider a baseline scenario without mitigation and potential noise effects for sensitive receptors along the alignment (primarily residential use). Noise mitigation options have been designed in conjunction with the Project engineers, landscape architects, urban designers and the construction team and the best practicable option (BPO) selected. In summary, the assessment of traffic noise effects (Technical Report 15, Volume 3) finds that while the introduction of the proposed Expressway into what is generally a currently low noise environment will result in a significant increase in noise level, the selected mitigation design of the proposed Expressway is generally able to avoid noise levels above the most stringent Category A (57 dB $L_{Aeq(24h)}$) within the NZ Standard which is considered to be an appropriate noise level for residential use and mitigates adverse effects on noise sensitive activities.

Vibration effects from the construction and operation of the Project are also considered in this assessment. The primary vibration concerns are the potential for damage to buildings, and the human response to vibration. The effects of construction vibration relate to the use of vibrating machinery and movement of heavy vehicles, whilst the effects of operation relate to the quality of the road surface. Vibration levels generated by construction are typically higher than those from operation but will be temporary and of a limited duration within any location. All potential vibration effects, both from construction and operation of the Project, will be such that no specific mitigation is considered necessary beyond effective management in accordance with the CNVMP, and maintenance of the road surface in accordance with normal processes.

Overall, the noise and vibration effects resulting from the construction and operation of the Project have been identified and addressed within the proposed Expressway design development and can be suitably mitigated during construction in accordance with the CNVMP.

19.1 Introduction

This Chapter presents the assessment of the noise and vibration effects, both during construction and once the proposed Expressway is operational. The information contained in this Chapter is based on five following technical reports in Volume 3:

- Assessment of Traffic Noise Effects (Technical Report 15);
- Assessment of Construction Noise Effects (Technical Report 16);
- Pre-Construction Noise Level Survey (Technical Report 17);
- Assessment of Vibration Effects (Technical Report 18); and
- Ambient Vibration Assessment Report (Technical Report 19)

A CNVMP has also been prepared as part of this application (this plan is contained within Volume 4, CEMP Appendix F) and has been referenced throughout this Chapter.

19.1.1 RMA framework

Under the provisions of the Resource Management Act 1991 (RMA) there is a duty to adopt the best practicable option (BPO) to ensure that the noise from any development does not exceed a reasonable level.

The standards NZS6806:2010 applied in the assessment and proposed mitigation of road traffic noise from new road and altered roads and NZS6803:1999 applied in the assessment of construction noise are based on the BPO approach.

19.2 Existing environment - noise

A survey of existing ambient noise levels was carried out within each of the four sectors of the alignment to provide a reference point for the assessment of noise effects (Technical Report 17, Volume 3). The existing noise environments for each Sector are discussed below.

19.2.1 Sector 1- MacKays Crossing to Raumati Road

The noise environment in Sector 1 varies from relatively elevated noise levels in areas close to the existing SH1 (e.g. at Leinster Avenue) to relatively quiet in areas removed from local main roads (for example, towards Raumati Road). Noise levels were measured at twelve locations, including two long duration noise level surveys. Noise levels ranged from 42 to 68 dB $L_{Aeq(24h)}$.

19.2.2 Sector 2 - Raumati Road to Mazengarb Road

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 nineteen locations, including two long duration surveys. Noise levels ranged from 42 to 55 dB $L_{Aeq(24h)}$.

19.2.3 Sector 3 - Mazengarb Road to North of Te Moana interchange

The character of Sector 3 is predominantly 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 ranged from 42 to 53 dB $L_{Aeq(24h)}$.

19.2.4 Sector 4 - North of Te Moana Interchange to Peka Peka Road

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 ranged 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 construction of the proposed Expressway; 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.

19.3 Construction noise effects

19.3.1 Assessment criteria

The relevant noise criteria used in the assessment of construction noise levels are set out in NZS6803:1999. The Standard provides for higher noise criteria during normal working hours for construction noise received in residential areas to enable construction activity to take place. For commercial and industrial areas, less stringent noise criteria are specified during night-time when it is less likely that persons or business activities would be affected by construction noise.

It is noted that the ambient noise levels in the area under consideration are generally low. Therefore, even although construction activities will achieve compliance with the daytime construction noise criteria, there will be a significant increase in overall noise level during the construction phase. This is, as set out in Standard NZS6803:1999, an expected and inevitable result of large construction projects in the vicinity of receivers.

19.3.2 Assessment of construction noise effects

The alignment passes through areas of both rural and residential land use. Residential use is considered a sensitive receiver and is generally sensitive to construction noise effects, especially during night hours. The construction activities that may cause adverse noise effects include:

- Fill delivery for preload construction;
- Excavation and fill;

- Off-road earthworks transport;
- Road base course and sealing works;
- Bridge construction, including piling & vibro-replacement[137];
- Local road realignment and resurfacing; and
- Construction of noise barriers along property boundaries.

For most large-scale construction projects, minor exceedances of the construction noise criteria for brief periods of time are common. Provided these exceedances are temporary and of limited duration, this may not be unreasonable. The duration of a construction activity exceeding criteria that could be considered to be reasonable may vary from site to site and activity to activity.

Construction is not generally proposed over a 24 hour period for this Project as generally it can practicably be completed without significant night-works. However, some bridges are likely to require night-time construction to reduce the impacts on traffic on major local roads. This would likely be confined to activities relating to bridge beam placement in order to minimise the duration of night-time construction. Furthermore, it is possible that some other unforeseen construction activities may be required during night-time.

In the event that night-time works occur for one or two nights, this may be acceptable provided that residents have been informed and a clear time frame provided. However, should night-time works be on-going for several consecutive nights, and at a noise level that affects residents' ability to sleep, then alternatives should be considered such as the temporary relocation of the most affected residents. A set process for considering whether such measures are required to address any issues should they arise is set out in the CNVMP.

The assessment within Technical Report 16, Volume 3, identifies the proposed construction activity and closest positions where daytime/night time construction noise criteria are potentially exceeded. Section 10.8 of the CNVMP contains a hierarchy of management procedures/options to mitigate potential exceedance of the construction noise standards. For activities that are likely to exceed the construction noise criteria, active noise management and mitigation measures are recommended. These measures are detailed in the CNVMP and will reduce, avoid and mitigate noise emissions as far as practicable.

While construction noise levels are higher than on-going operational noise levels, it is commonly accepted that for any construction to occur, noise criteria must be less stringent, with the understanding that construction is a temporary activity with a limited duration, particularly in a project such as the proposed Expressway, with construction moving along the alignment.

In summary, it is considered that the Project can be constructed within reasonable noise criteria, provided that the BPO of mitigation is implemented throughout and contractors are committed to managing construction noise on an on-going basis. It is noted that the ambient noise levels in the area under consideration are generally low. Therefore, even when achieving compliance with the daytime

[137] Vibro-replacement is the process of constructing stone columns using a vibratory probe (vibroflot).

construction noise criteria in the Standard, there will be a significant increase in overall noise level during the construction phase. This is an expected and inevitable result of large construction projects in the vicinity of sensitive receivers.

19.4 Operational traffic noise effects

19.4.1 Assessment criteria

19.4.1.1 New Zealand Standard NZS6806:2010

Traffic noise has been assessed in accordance with the New Zealand Standard NZS6806:2010. Noise levels 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 BPO for mitigation.

Table 19.1: Noise Criteria NZS6806

Category	Criterion	Altered Roads	New Roads[138]
A	Primary	64 dB $L_{Aeq(24h)}$	57 dB $L_{Aeq(24h)}$
B	Secondary	67 dB $L_{Aeq(24h)}$	64 dB $L_{Aeq(24h)}$
C	Internal	40 dB $L_{Aeq(24h)}$	40 dB $L_{Aeq(24h)}$

The Project has been assessed based on the new road criteria. However, criteria for altered roads have been included as they are relevant in locations where the Project will connect to the existing State highway at either end of the Project. Category A and B noise level criteria are measured at the outside façade of a PPF (PFFs are described later in section 19.4.2), and when these are exceeded, Category C criteria apply inside the building.

These categories have been developed for design and consenting, rather than assessment purposes. However, in general terms:

- Category A indicates that a reasonable external noise level is achieved that allows for noise sensitive activities being carried out without adverse effects.
- Category B indicates an increased level of noise compared to Category A but noise sensitive activities would generally be able to be undertaken inside a building with windows open.
- Category C indicates that mitigation may be required to achieve an acceptable level of noise inside, with windows closed.

To ensure the noise assessment has a complete understanding of the Kāpiti context, ambient noise measurements have been recorded as set out in section 19.2. However, as the existing ambient noise level along the alignment is not controlled by current road traffic noise, it is not practicable to model existing noise levels in the vicinity of the proposed alignment.

[138] with a predicted traffic volume of 2,000 to 75,000 AADT at the design year.

19.4.1.2 NZTA (Transit) noise guidelines

Prior to the development of NZS6806, the NZTA's predecessor 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, has an internal requirement that an assessment in accordance with the Noise Guidelines be undertaken for any Project which is being consented during the first two years of adoption of NZS6806 in order to gain an understanding of the implications of the new Standard. Generally similar to the assessment methodology prescribed in NZS6806, the Noise Guidelines differ 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. The noise assessment includes reference to the NZTA noise guidelines, generally, as one of the mitigation options.

19.4.2 Protected premise and facilities (PPFs)

PPFs are defined fully in NZS 6806:2010 but include facilities such as:

- buildings used primarily for residential activities;
- marae;
- spaces within buildings used for overnight medical care; and
- teaching areas and sleeping rooms in buildings used as education facilities.

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. NZS6806 stipulates that, in an urban area as determined by Statistics New Zealand, all PPFs within 100 metres of the alignment shall be assessed. The whole alignment traverses an urban area within the meaning of that term in the Standard. The noise assessment for the Project has been undertaken in accordance with this limitation.

However, in some circumstances to address concerns raised during consultation on the Project the NZTA has also included additional buildings in the assessment for informative purposes only, for example El Rancho, Christian Holiday Park.

The full assessment methodology is outlined within Technical Report 15, Volume 3.

19.4.3 Assessment of operational traffic effects

Several operational scenarios for new roads are to be assessed under NZS6806. These include:

- **Existing noise environment** - noise surveys of the existing environment have been undertaken to assist assessment. Most of the alignment is not controlled by current traffic noise therefore it is not possible to model the existing traffic environment for large sections of the alignment.
- **A future Do- minimum scenario** – represents a future scenario at the design year where a project has been implemented without any specific 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.
- **Future mitigation options** – future scenarios at the design year whereby mitigation has been design to reduce noise levels in order to achieve compliance with the relevant noise criteria and fulfil the BPO test.

The noise level change due to the Project is predicted to be considerable in some areas, with increases ranging for most affected dwellings from 10 to 21decibels.

The Do-minimum scenario serves as the basis for the assessment of noise mitigation options. The modelling outcomes of the Do-minimum scenario are described in Table 9.2 below.

Table 19.2: Predicted noise levels for the Do- minimum scenario

Area	Key modelling results	Is the Do minimum scenario the selected BPO?
Sector 1		
West of the proposed Expressway – Leinster Avenue area	A total of 21 PPFs are in the area to the west of the proposed Expressway at Leinster Avenue. The Do-minimum scenario includes low noise road surface material (OGPA) and concrete edge barriers on the bridge over Poplar Avenue. 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.	No
West of the proposed Expressway – Raumati South	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. Three PPFs are predicted to be within Category B, with the remaining PPFs in Category A.	Yes
East of the proposed Expressway – Raumati South	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. Of the 11 PPFs assessed, two would be within Category B with the remaining dwellings within Category A.	No

Area	Key modelling results	Is the Do minimum scenario the selected BPO?
Sector 2		
West of proposed Expressway – Raumati Road	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. 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.	No
East of proposed Expressway – Rata Road	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. Of the Four PFFs assessed, two 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.	Yes
West of proposed Expressway – South of Kāpiti Road	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 likely to be perceived as a doubling in noise, compared with the existing noise environment. Two PPFs would be within Category C. 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.	No
East of proposed Expressway – Kāpiti Road to Mazengarb Road area	The Do-minimum scenario includes low noise road surface (OGPA) on the proposed Expressway, dense asphalt on the ramps of the Kāpiti Interchange and 1.1 metre concrete edge barriers positioned on the proposed Expressway bridge edges across Kāpiti Road. 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.	No
West of proposed Expressway – Cheltenham Drive area	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 LAeq(24hr), an increase between 4 and 18 decibels depending on the location of the dwellings in relation to the proposed Expressway. Of the 42 PPFs assessed, 28 would be within Category A, with the remaining 14 PPFs predicted to be in Category B.	No

Area	Key modelling results	Is the Do minimum scenario the selected BPO?
Sector 3		
West of proposed Expressway – Mazengarb Road area	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. The introduction of the proposed Expressway into the currently 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 LAeq(24hr).	No
East of proposed Expressway – Mazengarb Road area	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. The introduction of the proposed Expressway into the currently 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 $L_{Aeq(24hr)}$.	No
Otaihanga Road area	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. There are four PPFs assessed within 100m of the proposed Expressway.	No
El Rancho	The camp is outside the 100m assessment area set out in NZS6806. However, it has been included in the assessment for informative purposes. 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 11000m. This barrier will have a significant shielding effect on the elevated proposed Expressway for the El Rancho facilities.	Yes
East of proposed Expressway – Kauri Road area	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.	No

Area	Key modelling results	Is the Do minimum scenario the selected BPO?
West of proposed Expressway – South of Te Moana Road	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 without the implementation of additional mitigation.	No
West of proposed Expressway – North of Te Moana Road	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.	No
Sector 4		
East of proposed Expressway – End Farm Road	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, 20 decibels above the existing noise levels. Both PPFs would be within Category C.	No
West of proposed Expressway – Peka Peka Road	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.	No
East of proposed Expressway – Hadfield Road	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.	Yes

As a result of the initial assessment summarised in Table 19.2, noise mitigation options were assessed for all areas. NZS 6806:2010 sets out a process for the evaluation of mitigation options. The process is not purely based on reaching a specific noise level or noise reduction but aims to achieve the BPO by taking into account aspects such as the visual and urban design implications, constructability and value-for-money of various mitigation options. This is intended to produce a more integrated solution than if noise mitigation was considered in isolation.

A full description of the mitigation options evaluated for each area is contained in Technical Report 15, Volume 3. In four areas the Do-minimum scenario was selected to constitute the BPO, i.e. no additional mitigation would be implemented. The reasons for this are summarised in Table 9.3 below:

Table 19.3: Areas where the Do- minimum scenario was selected as BPO

Area	Reason mitigation was not recommended
Sector 1	
West of the proposed Expressway – Raumati South	Taking into consideration the minimal noise level reductions and adverse visual effects of any noise barriers being installed on the bridge over Raumati Road, the Project team selected the Do-minimum option as BPO. In addition, all but three PPFs will be within Category A, with the remaining being in Category B, therefore the predicted noise environment for all dwellings is considered to be suitable for residential use
Sector 2	
East of proposed Expressway – Rata Road	A barrier option was developed from an acoustic point of view. However, it's intrusiveness due to its height in relation to the dwellings meant it was not considered further. In addition, half of the PPFs would be within Category A and the other half within Category B, thus the predicted noise levels are suitable for residential use.
Sector 4	
East of proposed Expressway – Hadfield Road	Category A would be achieved without additional mitigation. However, due to the selection of OGPA as the BPO mitigation option for dwellings in Peka Peka Road, noise levels at the Hadfield Road dwelling are predicted to remain unchanged from current noise levels.

The remaining areas where mitigation options were selected as BPO are summarised below in Table 9.4 below:

Table 19.4: Currently proposed mitigation

Area	Selected noise mitigation
Sector 1	
West of the proposed Expressway – Leinster Avenue area	The mitigation option selected is a 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 LAeq(24hr).
East of the proposed Expressway – Raumati South	A 2 metre barrier along the proposed Expressway was selected as mitigation. This option retains all PPFs within Category A and achieves an average mitigation of 3 decibels. This option also achieves compliance with the Noise Guidelines criteria.
Sector 2	
West of proposed Expressway – Raumati Road	A 2 metre high barrier along the western side of the proposed Expressway, extending from chainage 4520 to chainage 4780, has been selected as BPO. Predicted noise levels for this option show that all PPFs would be within Category A, with noise levels of 52 and 53 dB LAeq(24hr), i.e. similar to existing noise levels.

Area	Selected noise mitigation
West of proposed Expressway – South of Kāpiti Road	The mitigation option here includes 2 metre high barriers along the common boundaries with several properties, a 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 will be 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. Structural mitigation achieves noise level reductions of between 2 and 9 decibels, with an average of 4 decibels. At all PPFs but one (21Observation Place – Category B) Category A will be achieved.
East of proposed Expressway – Kāpiti Road to Mazengarb Road area	The selected mitigation option includes a 1.1 metre high concrete safety barrier along the southbound off ramp and the proposed Expressway edge. Bunds between 2 and 3 metres would be 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. Noise level reductions of up to 7 decibels would be achieved by this mitigation option.
West of proposed Expressway – Cheltenham Drive area	The selected mitigation option involves a split barrier/bund and lower barrier along the proposed Expressway respectively. A 4m high bund provides natural screening, and a 2.5 metre barrier would be constructed from the northern termination of the bund. This option provides a good degree of noise level reduction and avoids adverse visual and shading effects on residential properties.
Sector 3	
West of proposed Expressway – Mazengarb Road area	Category A at all PPFs west of the proposed Expressway 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 LAeq(24hr) which is an appropriate noise environment for residential use.
East of proposed Expressway – Mazengarb Road area	A 2 metre barrier has been selected for mitigation, 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 LAeq(24hr), suitable for residential use.
Otaihanga Road area	A 1.1 metre bridge barrier is considered to be practicable and could be designed to blend into the rural environment. 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 will be within Category B and therefore suitable for residential use.
East of proposed Expressway – Kauri Road area	A 3 metre high bund extending for approximately 280 metres along the eastern side of the proposed Expressway has been selected. 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 $L_{Aeq(24h)}$, well within the most stringent noise criteria Category A. These noise levels are well suited and appropriate for residential use.
West of proposed Expressway – South of Te Moana Road	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. The use of OGPA on the altered section of Te Moana Road will achieve noise reductions of up to 6 decibels for the most affected dwellings. 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 elevated by Te Moana Road. Resulting noise levels with the implementation of mitigation are appropriate for residential use.

Area	Selected noise mitigation
West of proposed Expressway – North of Te Moana Road	The use of OGPA on Te Moana Road will achieve noise reductions of up to 6 decibels for the most affected dwellings. 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.
Sector 4	
East of proposed Expressway – End Farm Road	The selected mitigation option involves OGPA which will continue on from the new Smithfield Road bridge extending from approximately chainage 14600 to chainage 15400. Noise levels would be reduced by 4 to 5 decibels to 61 dB $L_{Aeq(24h)}$ at both PPFs. This is within Category B and considered to be an acceptable noise level for residential use.
West of proposed Expressway – Peka Peka Road	The use of OGPA has been selected as BPO. 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.

As a result of the noise assessment, the following road surfaces will be used on the proposed Expressway:

- Chip seal from the south Project boundary at chainage 19000 to chainage 2400;
- OGPA from south of the Poplar Interchange at chainage 2400 to just north of the Te Moana Interchange chainage 12500;
- Chip seal from chainage 12500 to chainage 14600;
- OGPA surfacing from chainage 14600 to chainage 15400;
- Chip seal surface from chainage 15400 to chainage 17000; and
- OGPA surfacing from chainage 1700 up to the northern Project boundary at Te Kowhai Road.

The mitigation measures set out in Table 19.4 describe the options selected by the Project team to constitute the BPO to mitigate the potential adverse noise effects from the operation of the proposed Expressway.

In summary, mitigation options for operational noise have been assessed in accordance with NZS 6806:2010 and noise mitigation is proposed in a number of areas, mainly where the Project is in close proximity to residential areas. As such, operational road noise will be able to be mitigated to an acceptable level in accordance with NZS 6806:2010.

19.5 Existing environment - vibration

19.5.1 Existing ground conditions

Peat and sand are the two predominant ground conditions within the location of the proposed Expressway alignment. Vibration energy travels slower and covers less distance in soft or aerated ground conditions, as compared to hard ground conditions.

Peat is classified as soft ground, with unique vibration properties given that the consistency changes from saturated to dry. Sand is classified as soft or competent depending on the level of compaction.

19.5.2 Vibration through peat

Investigations on saturated peat (which is typical in the location of the proposed Expressway due to the high water table) found that:

- significant ground vibrations from construction can be generated in peat, particularly as a result of any weight-shift of machinery; and
- vibration will reduce with distance more than it does in hard ground conditions.

19.5.3 Ambient vibration survey results

Surveys of existing ambient vibration[139] levels were undertaken at dwellings adjacent to the Project alignment, and adjacent to the existing SH1 route in Raumati South. This information on ambient vibration levels is contained in Technical Report 19, Volume 3. The existing vibration environments are discussed below.

19.5.3.1 Dwellings adjacent to the Project alignment

The ambient vibration resulting from existing traffic is low. Most residents felt no vibration in their homes and those that did were not disturbed by it. House vibrations due to traffic were often well below the vibration levels resulting from the activities of the occupants. This indicates that residents can become accustomed to moderately high levels of dwelling vibration, provided the source of vibration is identifiable and not unexpected.

19.5.3.2 Dwellings adjacent to the existing SH1 route

Vibration levels were higher in this location, with frequent peaks attributed to heavy vehicle traffic and trains. While residents could feel the traffic vibrations, they were generally not disturbed by them, having become somewhat accustomed to them. A similar effect would be expected for residents adjacent to the proposed Designation; however, the proposed Expressway vibration will be better controlled with an improved road surface.

[139] Ambient vibration refers to the existing vibration at a given receiver location. This includes any and all vibration sources in the vicinity of the receiver (i.e. traffic vibration for houses adjacent to existing roads).

19.6 Construction vibration effects

The construction phase is expected to generate the highest vibration levels, due to the heavy machinery used for earthworks and other activities. Potential adverse effects are most likely to arise from the construction activities outlined in Table 5.1 of Technical Report 18, Volume 3.

The primary potential adverse effect of construction vibration is structural damage of dwellings or private structures such as garages or swimming pools and infrastructure assets such as roads and buried pipes. The secondary potential adverse effect of construction vibration is annoyance and disturbance of people, and the possible damage of property inside dwellings (for example, ornaments and crockery, if they are not well secured or not sitting on level surfaces).

Annoyance is considered a secondary effect because it varies from receiver[140] to receiver and can generally be managed through the CNVMP, whereas the risk of damage to buildings and structures is unambiguous.

19.6.1 Methodology

Construction vibration effects have been assessed through on-site measurement of identified machinery, heavy vehicles and construction activities, as well as the review of data from relevant standards and previous measurements. This data has been analysed and processed to establish risk contours for identified sensitive receivers (dwellings) along the proposed Expressway.

19.6.2 Assessment criteria

The construction vibration criteria for this Project are based on the draft NZTA vibration guide for managing vibration during construction associated with State highway projects. The guide addresses both building damage and human response to vibration by applying appropriate international vibration standards in a dual category approach. The Project vibration criteria selected for the construction phase are as follows:

Category A: adopts criteria from British Standard BS 5228-2:2009 and is designed to practically address the human response effects in dwellings during the daytime and night-time periods, and offices during the daytime. For other building types, and offices during the night-time (i.e. unoccupied), the policy reverts to the residential building damage criterion from German Standard DIN 4150-3:1999.

If measured or predicted vibration levels exceed the Category A criteria then a suitably qualified expert shall be engaged to assess and manage construction vibration and to comply with the Category A criteria. If the Category A criteria cannot be practicably achieved, the Category B criteria shall be applied.

[140] In the context of vibration, a receiver refers to a building or building occupant (typically residential) which may receive vibration as part of the construction and/or operation of the Project.

Category B: is generally designed to protect buildings against damage and adopts criteria from DIN 4150-3:1999 and BS 5228-2:2009, but retains a higher degree of night-time protection for occupied dwellings at night using human response criteria of BS 5228-2:2009.

If measured or predicted vibration levels exceed the Category B criteria then construction activity shall only proceed if there is continuous monitoring of vibration levels and effects on those buildings at risk of exceeding the Category B criteria by suitably qualified experts.

Table 9.5 is a reduced version of Table C2 from the draft NZTA guide, with aspects not relevant to the Project removed, and some clarification of terms added.

Table 19.5: Project construction vibration criteria

Receiver	Details	Category A	Category B
Occupied dwellings	Night-time 2000h - 0630h	0.3 mm/s PPV	1 mm/s PPV
	Daytime 0630h - 2000h	1 mm/s PPV	5 mm/s PPV
Other occupied buildings*	Daytime 0630h - 2000h	2 mm/s PPV	5 mm/s PPV
All other buildings	Vibration – continuous**	5 mm/s PPV	50% of Line 2 values in Table B.2 of BS 5228-2:2009

* 'Other occupied buildings' is intended to include daytime workplaces such as offices, community centres etc., not industrial buildings. Schools, hospitals, rest homes etc. would fall under the occupied dwellings category.

** This line addresses 'continuous' or 'long-term' vibration (as opposed to 'transient' or 'short-term' vibration – refer Appendix B.1 for definitions) as there is no construction machinery proposed which produces transient vibration. The 50% modifier to values in Table B.2 of BS 5228-2:2009 is recommended in that Standard for continuous vibration sources.

These criteria are to be implemented through the CNVMP.

19.6.3 Building damage risk

To assess the potential for building damage effects, receivers close to significant vibration sources have been identified and categorised as high[141] or medium[142] risk of exceeding the risk assessment criterion

[141] High Risk - include those dwellings where vibration levels are likely to exceed the risk assessment criteria. This does not necessarily imply that damage will be caused to the building structure, but these are the receivers subject to the highest vibration levels.

[142] Medium Risk – These dwellings are close to the risk contour and some construction activities may produce vibration levels close to the risk assessment criteria, with possible intermittent exceedance.

of 5 mm/s PPV[143] (being the Project criterion for residential buildings, adopted from German Standard DIN 4150-3:1999).

The results of the risk assessment are provisional, and must be refined and supported by site-specific measurements of high-vibration equipment once construction begins, as recommended in the CNVMP. As these measurements occur on-site, the risk categories can be refined and improved controls can be achieved.

The provisional results (refer to Tables 5.7.1 – 5.7.4 of Technical Report 18, Volume 3) indicate that within all Sectors of the Project, there is a high risk of construction activities exceeding the criteria at some receivers. Construction activities that have the potential to breach the noise criteria will have a noise assessment undertaken. All practicable measures (these measures are detailed in section 10 of the CNVMP) will be undertaken to achieve compliance with the noise criteria. If the measured levels are higher than the noise criteria plus 5 dBA, the works causing the exceedance shall cease and a Site Specific Construction Noise Management Plan (SSCNMP) will be provided to KCDC. The residential area between Kāpiti and Mazengarb Roads (within Sector 2), contains the highest number of at-risk receivers by a significant margin, due to the close proximity of a large number of residences to the proposed Designation.

There are a number of residential swimming pools on properties adjacent to the Project alignment. These are not covered by the risk assessment criterion; however, the risk of damage to the pool structure is acknowledged, particularly for those directly adjacent to the boundary. This issue would be managed by the CNVMP.

Buildings or dwellings not founded on a more stable base than peat (i.e. a suitable sand building platform or piles which extend down to a layer of sand) are at risk of differential settlement which may lead to building or property damage. There is potential for vibration from construction works to accelerate settlement and cause damage to these susceptible buildings. There are no known vibration sensitive or multi-storey buildings located near the proposed designation and the vast majority of residential dwellings adjacent to the proposed designation are understood to be located on either slab-on-grade, or piles founded on earth (sand, not peat). While unlikely, the potential for this effect occurring as a result of construction vibration will be addressed on a case-by-case basis through the management procedures outlined within the CNVMP.

Construction vibration may be felt at locations further from the proposed Expressway which have not been investigated. These effects can be managed by the Category A Project criteria outlined within the CNVMP.

It is understood there is concern that burials within the Takamore Urupā may be at risk of disturbance from construction vibration. These risks are considered low due to the soft ground conditions which will serve to envelop and protect any buried remains in a liquid suspension. Liaison with the Takamore Trust

[143] PPV stands for Peak Particle Velocity, measured in mm/s. This is the standard metric for assessing construction vibration levels.

during the construction phase (through the CNVMP) will seek to ensure any concerns over this issue are addressed.

Any remaining at risk receivers will be protected by adopting best practicable options for the construction phase, in conjunction with liaison and monitoring implemented through the CNVMP to control and mitigate any effects.

Existing structures with the potential to incur damage from construction vibration (including the burials within the Takamore Urupā) will be assessed before works commence. The same structures will be monitored during construction and re-assessed once works have been completed and any damage caused as a result of vibration from construction of the Project will be repaired. This process is explained within the CNVMP.

19.6.4 Human response to vibration

The potential for annoyance due to vibration activities is addressed by Category A of the Project Criteria outlined in the CNVMP. For temporary construction activities, higher vibration levels will generally be tolerated – if sensitive receivers are well informed of construction activities and consider that the construction operation is well controlled and managed (i.e. through the CNVMP) – because their concern over potential damage to their building can be mitigated.

Night-time construction may be required in certain areas. However, the use of high-vibration machinery at night is not currently anticipated. Potential nuisance and annoyance will be reduced by clearly communicating to nearby residents and building occupiers when and for how long the vibrations from construction activities will occur.

As long as this information is communicated accurately and with adequate forewarning, the public is generally reasonably accepting of temporary construction activity effects. Procedures for this communication are set out in the CNVMP.

19.7 Operational traffic vibration effects

19.7.1 Methodology

Operation vibration effects have been assessed through site measurements of heavy vehicle movements, and from information obtained by discussions with residents.

19.7.2 Assessment criteria

The standard adopted for operation vibration of this Project is Norwegian Standard NS 8176.E:2005 *"Vibration and Shock – Measurement of vibration in buildings from landbased transport and guidance to evaluation of its effects on human beings"*.

The details of assessment criteria and standards are contained within Technical Report 18, Volume 3.

19.7.3 Assessment of vibration effects

The primary effect of operation vibration relates to the annoyance of and disturbance to people.

Vibration effects potentially resulting from the operation of the proposed Expressway depend heavily on whether the road is smooth and even. The main potential vibration issue from the completed proposed Expressway would be from heavy vehicle movements passing over imperfections in the road surface.

The proposed Expressway has been designed to avoid cracking and unevenness in road surface over time. This outcome is achieved by a combination of excavation and replacement of peat with sand, and/or preloading of peat with a sand/gravel mix (as detailed within Technical Report 35, Volume 3).

The proposed Expressway will be predominantly surfaced with OGPA, except at the northern end from chainage 15100m to the northern tie-in at approximately chainage 18050m, which will be chip seal (refer to Technical Report 15, Volume 3). There is a difference in roughness between these surfaces, but the effect of this on vibration production is minor compared to that of larger-scale bumps and dips. The most common vibration issue arises when repairs, particularly backfilled trenches, are carried out poorly.

Road surface maintenance is a policy issue for all pavement types, and there is an existing NZTA framework to seek to ensure that the pavement of State highways does not degrade below a certain level of roughness[144].

There is a small likelihood that the closest residents will feel traffic vibration from the proposed Expressway. However, the vibrations are not anticipated to exceed a level where human comfort is compromised. Vibration monitoring may be undertaken on a case-by-case basis if complaints of traffic vibration are received.

In summary, the operation vibration effects are predicted to be negligible (i.e. very unlikely to cause annoyance), provided the road surface of the proposed Expressway is maintained according with normal processes.

19.8 Mitigation of construction noise and vibration effects

Potential construction noise and vibration effects can be suitably managed and mitigated through effective construction management in accordance with the CNVMP. The CNVMP will form part of a comprehensive suite of environmental controls within the Construction Environmental Management Plan (CEMP, Volume 4) for the construction phase of the Project.

[144] In New Zealand this roughness is categorised using the National Association of Australian State Road Authorities (NAASRA) method which uses a surface profiling machine to evaluate the state of the road surface.

As discussed, a CNVMP has been developed for this Project (refer to CEMP Appendix F, Volume 4). This document outlines the methodology for assessing, managing and mitigating the Project construction noise and vibration effects.

The CNVMP will specifically address the potential Project construction noise and vibration effects, identify the standards that all Project construction activities must comply with (i.e. the Project criteria) and outline the best practicable options for noise and vibration management throughout the Project construction period (being 4 to 5 years).

The CNVMP will contain:

- The construction noise and vibration Project criteria;
- Hours of operation, including times and days when high-vibration machinery would be used;
- A list of machinery to be used;
- Requirements for vibration measurements of relevant machinery prior to construction or during their first operation, to confirm risk contours;
- Requirements for building condition surveys of critical dwellings prior to and after completion of construction works, and during the works if required;
- Requirements for identifying any existing infrastructure assets (services, roads etc) which may be at risk of vibration induced damage during construction;
- Requirements for identifying any existing infrastructure assets (services, roads and the like) which may be at risk of vibration induced damage during construction;
- Roles and responsibilities of personnel on site;
- Construction operator training procedures, particularly regarding the use of excavators;
- Construction noise and vibration monitoring and reporting requirements;
- Mitigation options, including alternative strategies where full compliance with the Project Criteria cannot be achieved;
- Management schedules containing site specific information;
- Methods for receiving and handling complaints about construction noise and vibration (the CNVMP (CEMP Appendix F, Volume 4) also presents this as a flow diagram); and
- The procedure for managing vibration damage to existing services such as roads and underground pipelines.

19.9 Mitigation of operational noise and vibration effects

Operational noise and vibration effects can be mitigated to acceptable levels within the relevant Standards. Operational noise mitigation is discussed extensively in Section 19.4.3 above and operational vibration mitigation in Section 19.7.3 above.

19.10 Summary of effects after mitigation

Overall, it is considered that the proposed Expressway Project can be constructed and operated such that any adverse noise and vibration effects can be avoided, remedied or mitigated using best practicable options. Given this, the management of noise and vibration effects is consistent with the RMA.