Basin Bridge Project

Technical Report 5: Assessment of noise effects

Report June 2013

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Executive summary

Introduction
This report assesses the noise effects of proposed alterations to the State Highway network and associated changes to the local road network in the area of the Basin Reserve, Wellington (the Project). The report also assesses the construction noise effects of the Project.

The Project
For westbound State Highway 1 traffic, the Project is to provide a new link consisting of a bridge passing around the northern side of the Basin Reserve. The eastern abutment of the bridge meets with Paterson Street; and the western abutment of the bridge meets with Buckle Street. The Project is also to realign the State Highway 1 eastbound route between the southern end of Kent Terrace and Paterson Street heading towards the Mount Victoria Tunnel. The new link also alters traffic flows in the road network in the adjacent area, so the area assessed for noise is bounded in the west by Taranaki Street, in the south by Adelaide Road, in the east by the approaches to the Mount Victoria Tunnel, and in the north approximately 150 metres northward from Buckle Street and Ellice Street.

The Project design has evolved in an iterative process over several years and in that time measures to reduce noise have been incorporated into the Project design. In particular, road surfaces have been selected to be the quietest surfaces practicable. Good urban design and integrating the Project into the urban fabric as well as maintaining as far as practicable existing pedestrian and cycling flows is a dominant feature of the Project. Other than the barriers on the bridge which are primarily for safety, there is limited opportunity to include further barriers that would have a noise reduction effect. Building treatment is a further road-traffic noise mitigation option considered.

Throughout this iterative process of embedding noise mitigation into the do-minimum Project design, we have mainly followed the methodology set out in NZS 6806: 2010 the New Zealand Standard for Acoustics – Road-traffic noise – New and altered roads, but we have applied a more conservative assessment. NZS 6806: 2010 provides good guidance as to the extent of the area and the noise-sensitive land uses that should be considered, of how the changes in noise caused by the Project should be calculated, and of the approach to determining the best practicable option for any mitigation. However, we have considered a wider range of properties and land uses, a wider noise assessment area, and all road-traffic noise sources in the assessment area. We have also considered both the effects of the total noise level and the effects of the change in noise level.

The noise assessment
The assessment’s primary concern is noise effects of the Project on existing premises that are located near the Project and may be generally affected by road-traffic noise. Assessment is made for premises and facilities used for noise-sensitive activities such as residential activities and educational purposes. Assessment is made also for other important premises and facilities around the Project Area, including the Basin Reserve cricket ground, St Mark’s Anglican Parish and St Joseph’s Catholic Church, the area of the National War Memorial, the entrance to Government House, and the building of the Home of Compassion Crèche (former).
The response of people to noise is broad. For any particular level of noise, a portion of the population will find it disturbing and a proportion will find that same noise level of little concern. As noise levels change, there is a progressive change in the proportion of the population that is disturbed and the proportion that is undisturbed, with the proportion disturbed increasing as the noise levels increase.

In considering whether noise is reasonable, therefore, it is useful to have regard to guidelines or standards in which noise limits are recommended; these limits representing the view of stakeholders and experts as to the acceptable level of community disturbance. In general, these guidelines and standards are targeted at protecting health and reducing the worst of the noise effects on amenity. In assessing this Project, we make reference to Standards and guidelines well recognised in New Zealand especially NZS 6806: 2010 and the NZTA Noise Guidelines¹.

The baseline environment for establishing the Project’s effects

The Resource Management Act (1991) is particularly concerned with the effects of a project and there is a need to consider any change in effects that project brings about compared to effects that exist prior to the project.

For many projects, the current physical road environment and the physical road environment that will be receiving a project at the time of its construction are synonymous as there would be no physical changes between the two situations. Usually the only changes would be the traffic using those physical road environments.

Around the area of the Basin Reserve, there is a sequence of intended projects that will alter the physical road environment from that which exists currently. The first of these projects is intended to be the Buckle Street underpass with the creation of the National War Memorial Park, for completion by April 2015. This becomes part of the environment existing to receive the Project. Then the next intended project is the Basin Bridge, for completion by 2016. This is intended to be followed by a second Mount Victoria Tunnel for completion by approximately 2026.

We establish the Project’s effects by comparing the Project with the road layout with the Buckle Street undergrounding and National War Memorial Park completed. 2021 is used as the comparison year. Usually we would use a later comparison year, such as 2026. However, by 2026 the duplication of the Mount Victoria Tunnel is expected. For this Project, 2021 is the latest year of the available and useable traffic data. However, the single Mount Victoria Tunnel tends to restrict the amount of traffic that enters the Project area. So the traffic volumes in 2021 are taken as typical of future years as the throughput of the Mount Victoria Tunnel can increase no further until duplication of the Tunnel. We have also quantified the noise environment that currently exists, because this alone can be checked against noise measurements. This current noise environment was established in 2009 which is sufficient for adding to our understanding of the long-term road-traffic noise environment.

Methodology

The changes in noise level and the resultant total noise levels at each noise sensitive location with the Project are understood by establishing:

- the noise environment that would receive the Project, being the road layout without the Project as it would exist in 2021, operating with 2021 traffic for that road layout;
- the noise environment with the Project in the road layout as it would exist in 2021, operating with 2021 traffic for that road layout including the Project.

The role and effects of this Project in the context of future development of the transport network, including a second Mount Victoria Tunnel, were also considered.

Noise modelling is the primary tool for determining road-traffic noise environments as it allows an objective comparison of existing and future situations, and then determination of the effectiveness of noise reduction measures.

All road-traffic noise modelling methods for this assessment have been in line with NZS 6806: 2010. The modelling techniques used are well established in New Zealand. The model used is based on the Calculation of Road Traffic Noise (CRTN) model. The CRTN model was developed in the United Kingdom more than thirty years ago and research in New Zealand has validated the model as appropriate in New Zealand so long as some New Zealand-specific adjustments are applied.²

In our assessment of any road-traffic noise effects of the Project for each location:

- We identified the position with the greatest total noise level with the do-minimum Project, that is the Project as currently designed and without any additional noise mitigation. Then the potential effects of that total noise level are determined using guidance as to acceptable noise levels such as the “altered road” noise criteria from NZS 6806: 2010.
- At that same position with the greatest total noise level, we also identified the change in noise level caused by the do-minimum Project. Then the potential effects of that change are determined using guidance such as from the NZTA Noise Guidelines.³
- We identified a further position on the location. This is the position with the maximum noise level change caused by the Project. Then the potential effects of that change are determined using guidance such as from the NZTA Noise Guidelines.

To identify the position of greatest noise exposure for a location, receiver positions are modelled in a grid across the full faces of the building and the position of greatest exposure is revealed. Similarly, to identify the position of maximum change in noise level caused by the Project, receiver positions are modelled across the full faces of the building for both the do-minimum Project situation and the do-nothing receiving situation. The pairs of values for each modelled receiver position are compared and the position of maximum change is revealed.

² Adjustments to suit New Zealand conditions are made in accordance with Dravitzki, V. and Kvatch, I. (2007) Road surface effects on traffic noise: Stage 3 selected bituminous mixes. Land Transport NZ research report 326. 40pp. As recommended in Barnes, J., Ensor, M., Beca Carter Hollings and Ferner Ltd. and Hegley Acoustic Consultants Ltd. (1994) Traffic noise from uninterrupted traffic flows. Transit New Zealand Research Report 28. 75pp., a road surface correction of -2 was used as the base correction for asphaltic concrete.
³ While the primary guidance on the effects of noise level changes is from the NZTA Noise Guidelines, it is reinforced by guidance from the literature such as the study by Schultz on community noise impacts: Schultz, T. J. (1978). “Synthesis of social surveys on noise annoyance,” Journal of the Acoustical Society of America. 64, 377–405.
The grid of receivers was set with 1 metre spacing between the receivers. This method of a grid of receivers across the full faces of a building is a departure from the approach recommended by NZS 6806: 2010 but a more conservative one. NZS 6806:2010 would normally expect assessment for a habitable space at the exterior wall most affected by road-traffic noise. But the method of the grid of receivers is both effective and comprehensive. In the noise-study area there are many multi-storey buildings for which it is difficult to distinguish from the outside which rooms are the habitable spaces and which are service rooms or other and the older houses may have basement areas and attic rooms that are not apparent without a detailed internal property inspection. The coverage provided by our grid of receiver positions simplifies the assessment and the presentation of results. Noise effects on buildings can be quickly identified. If significant noise effects were identified for a grid receiver position then that position and the building in full can be further examined to identify how the habitable spaces are affected differentially.

In assessing the potential noise effects, we have applied a two-step process of:

- Considering the potential for effects due to the change in noise levels, using guidance such as from the NZTA Noise Guidelines; and
- Considering the potential for effects due to the total noise level, using guidance as to acceptable noise levels such as from NZS 6806: 2010;

If the change in noise level or the total noise level could have potential effect, we consider whether noise reduction features could be embedded in the Project design.

Findings and conclusions on road-traffic noise

The investigation has found that for the Project, as currently designed, noise levels in the area change very little and as a consequence its noise effects are negligible. In many instances, change in noise is an increase or decrease of no more than 1 dB L_{Aeq(24h)}. Seldom is it more than 2 dB L_{Aeq(24h)}.

Important open-air spaces such as the National War Memorial Park and the Basin Reserve experience only small changes in noise levels due to the Project, being only 1 to 2 dB L_{Aeq(24h)} either as a noise level increase or decrease, and these areas can be regarded as substantially unaffected by the Project.

The Project area is an area where the State Highway network intersects with the local road network. As a consequence, traffic volumes in the area are high and have been so for over fifty years. Various sections of roads in the area currently carry between 10,000 and 40,000 vehicles per day. Even though signposted speeds are only 50 km/h and the heavy vehicle component in the traffic flow is low (about 3 percent), with these high traffic volumes, road-traffic noise levels are already high at adjacent buildings and open-air spaces in the area. However, in some places there is close spacing of multiple buildings that creates quieter areas sheltered from road-traffic noise.

The Project introduces an elevated bridge link to the Project area road network with the bridge being positioned mainly over or very close to existing roadways. The new link shifts approximately 20,000 vehicles per day from the southern side of the Basin Reserve to the northern side. The noise effects of the bridge are superimposed over the noise of the at-grade traffic flows, and because these at-grade traffic volumes remain high, the traffic flow on the bridge causes only small noise level increases in the areas adjacent. Although the Project reduces traffic volumes in some areas, such as Sussex Street, the associated decrease in road-traffic noise effects is minor.
The iterative design process of this Project means the current design already incorporates the viable noise-mitigating features. As a consequence, noise effects are very small and the opportunity for further noise reduction is limited.

In some cases the Project causes noise level decreases (relative to those that would occur in the receiving environment without the Project having been built) but the total noise levels may be still high. Some guidance such as NZS 6806: 2010 encourages investigation of practicable mitigation where although noise levels have been decreased by the project noise levels are still high. We undertook this investigation even though the changes in noise caused by the Project are insufficient to fulfil the criteria required for invoking NZS 6806: 2010. However our understanding is that a project need only address the impacts of that project itself. Any mitigation further to that addressing the impacts of the project itself is not a requirement.

While building-modification mitigation via acoustic insulation could be considered, the context is, in many cases, high noise levels are an existing situation, either not affected by the Project or slightly reduced by the Project. Most of buildings in the Basin Reserve area have been built subsequent to establishment of the existing high noise levels. The noise levels have been present for more than fifty years. Buildings since then are likely to have been, or should have been, built with regard to these noise levels.

Overall, the investigation has found that the Project as currently designed changes noise levels in the area very little and as a consequence its noise effects are slight. The Project has slightly negative effects in the area close to the bridge but these are less than minor as the change in noise would in most cases be barely discernible. Elsewhere the Project has some slightly positive effects as existing high noise levels are slightly decreased but again this effect is minor or less than minor.

Construction noise

With respect to construction, the concept of reasonable noise means that limits on noise levels need to allow construction to occur in an efficient manner, but protect the adjacent community from unacceptably high levels of noise, especially when activities such as sleep are required and expected. Appropriate construction noise management and community liaison processes are a crucial step to achieve acceptable construction noise outcomes. These are addressed in a Construction Noise and Vibration Management Plan. A draft is already prepared and will be finalised prior to construction commencing and once the precise construction methodology has been formulated. The draft Management Plan is provided in the documentation set Volume 4: Management Plans and it shows the noise-related matters that would be covered in the final Management Plan.

NZS 6803: 1999 is the New Zealand Standard that applies to construction noise and, since it came into being, has been applied by the NZTA in all of its road construction projects.

- NZS 6803: 1999 contains tables of recommended desirable noise limits for construction. The Standard expects these tables will be modified by using the Standard as a guideline for setting noise limits that are specific to a project and specific to the situation in which the project is located.
- Ambient noise levels existing prior to construction are an important factor in setting the construction noise limits. For the situation in which this Project is located, road-traffic noise throughout the area is sustained at medium to high levels from about 6:00 am to 11:00 pm
with high noise levels above the 24 hour average level (expressed as $L_{Aeq(24h)}$) from about 7:00 am to 8:00 pm.

Commercial areas can usually accept higher noise levels at night time, since usually the premises are closed for business at night time. The commercial buildings nearest to the main construction are a Mitsubishi Motors building and the building of Regional Wine and Spirits. These two buildings are also very close to residential buildings, so for this Project, no separate construction noise limits are provided for commercial areas.

Following the guidance of NZS 6803: 1999 with the high noise receiving environment, the following construction noise limits are recommended for this Project:

<table>
<thead>
<tr>
<th>Time</th>
<th>Noise limits (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_{Aeq}$</td>
</tr>
<tr>
<td>Monday to Saturday</td>
<td></td>
</tr>
<tr>
<td>6:00 am through to 7:00 am</td>
<td>70</td>
</tr>
<tr>
<td>7:00 am through to 8:00 pm</td>
<td>75</td>
</tr>
<tr>
<td>8:00 pm through to 6:00 am</td>
<td>60</td>
</tr>
<tr>
<td>Sunday and public holidays</td>
<td>60</td>
</tr>
</tbody>
</table>

A flexible approach is needed. Where construction is very near residences it may be preferable that the noisy activity is confined to daytime hours. For construction near schools, churches or commercial premises, it may be preferable if the more noisy construction activity was outside normal hours of building occupation. Construction activity which is quieter because it is more distant could continue over extended hours. This approach is embodied in the Construction Noise and Vibration Management Plan (draft provided in the documentation set Volume: 4 Management Plans) which has been framed within the context of NZS 6803: 1999 and recognises the existing high ambient noise environment.

We have calculated likely construction noise levels by considering where and how groups of construction equipment will be working together to construct the Project. For most of the Project construction, the recommended construction noise limits can be met. However, it is noted for pier 3 and the associated bridge section and the cyclist/pedestrian bridge near Ellice Street, construction is close to residences. Construction of the eastern abutment is close to St Joseph’s Church, St Mark’s School, and 9 Dufferin Street. It could be that the construction noise will be greater than the proposed limit but it is still likely to be tolerable. The Construction Noise and Vibration Management Plan will set out how these more noisy activities for these construction features should be confined to those parts of the day that have less impact. Given the high existing noise levels, short periods of higher noise should be tolerable so long as there is good communication with affected properties.

In conclusion, provided the Construction Noise and Vibration Management Plan is appropriately finalised and adhered to, construction noise impacts will also be no more than minor. Construction noise levels will be only a modest increase over the ambient high noise levels and the more noisy construction activities will be for only a short to moderate portion of the total construction activity.
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1 Introduction

This report assesses the noise effects of proposed alterations to the State Highway network and associated changes to the local road network in the area of the Basin Reserve, Wellington (the Project). The report also assesses the construction noise effects of the Project.

The assessment’s primary concern is noise effects on existing premises that are located near the Project and may be generally affected by road-traffic noise. Assessment is made for premises and facilities used for noise-sensitive activities such as residential activities and educational purposes. Assessment is made also for other important premises and facilities around the Basin Reserve, including the Basin Reserve cricket ground, St Mark’s Anglican Parish and St Joseph’s Catholic Church, the area of the National War Memorial, the entrance to Government House, and the building of the Home of Compassion Crèche (former).

The report discusses the guidance for road-traffic noise assessment. The overarching requirement is set by the Resource Management Act that requires that effects on the environment are avoided, remedied or mitigated. The road-traffic noise level changes associated with the Project are determined and the effects of those changes are assessed with particular reference to NZS 6806: 2010 Acoustics – Road-traffic noise – New and Altered Roads and the former NZTA Noise Guidelines.

The effects of the Project are understood by establishing:

- the noise environment that would receive the Project, being the road layout without the Project as it would exist in 2021 operating with 2021 traffic for that road layout, termed the do-nothing receiving situation;
- the noise environment with the Project in the road layout as it would exist in 2021 operating with 2021 traffic for that road layout including the Project, termed the do-minimum Project situation.

Both the change in road-traffic noise levels caused by the Project and the resultant total road-traffic noise level (the cumulative effect of this Project in the road-traffic noise environment) were examined to identify potential effects. The report examines the practicability of mitigating potential noise effects with regard to the wider aims and aspects represented by other disciplines involved in the Project. This includes situations where the Project has reduced road-traffic noise levels but the total noise level remains high.

The report includes consideration of the role and effects of this Project in the context of future development of the transport network, including a second Mount Victoria Tunnel.

Proposed methodologies and activity sequencing for construction of the Project are provided in the documentation set Volume 4: Management Plans. NZS 6803: 1999 is the New Zealand Standard for construction noise and we use this as the primary guidance for calculation and consideration of the construction noise including recommendations for construction noise limits. Construction noise and its management are best addressed via a Construction Noise and Vibration Management Plan. A construction methodology has been drafted. Using that draft construction methodology, a

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draft Management Plan has been prepared and this is provided in the documentation set Volume 4: Management Plans.

1.1 Report structure
After Section 1.2, which is an overview of the Project as supplied by the NZTA, this report contains seven main sections, numbered from Section 2 to Section 8, and two short sections, Section 9 and Section 10, which are the conclusions and recommendations.

• Section 2 Road-traffic noise criteria
  This section provides a description of the overall requirements for road-traffic noise. This contains the broad requirements such as from the Resource Management Act, a discussion of whether District Plan limits are applicable, then the guidance provided by relevant New Zealand noise guidelines and standards.

• Section 3 Applying the noise criteria to this assessment
  The approach of NZS 6806: 2010 forms a major part of this assessment. NZS 6806: 2010 has a number of requirements in its application, such as the area to be assessed, the future traffic that is to be considered, and the noise criteria that are to be applied. Section 3 describes how these requirements were specifically addressed in this assessment.

• Section 4 Noise modelling for both current and future road-traffic noise levels
  This section outlines how the noise levels were calculated by noise modelling and outlines the features included in this noise modelling.

• Section 5 Assessment of the road-traffic noise environment
  This section describes the assessment of the road-traffic noise environment. This assessment includes the current environment. The year 2009 is used as the reference year. Noise measurements from this year are used to confirm the validity of the road-traffic noise modelling for use in the remainder of the assessment. The noise environment for the future year of 2021 is modelled for both the situation that would exist without the Project and the situation with the Project. These two modelled situations are compared in determining any effects of the Project. Section 5 outlines any noise effects of the Project in broad terms. It concludes with a discussion that demonstrates that the Project’s bridge structure has a small impact because it is largely placed in an area of existing high noise.

• Section 6 Assessment of do-minimum Project road-traffic noise levels and the Best Practicable Option to mitigate noise
  Section 6 is a detailed discussion of any noise effects of the Project. The noise study area is divided into six sub-areas. The Project is discussed for each sub-area. Total noise levels and noise level changes are stated for individual premises and facilities within the sub-area. Any potential effects and opportunities that may be present for reducing noise further are discussed.

Section 6 also considers whether there are practicable ways to reduce noise for locations where the noise, though reduced by the Project, is still high.

This section is particularly intended for people living in and using the premises and facilities in the noise study area.
• Section 7 Future changes to the noise environment
  This section helps place the Project in the context of further transport plans for the area, specifically the duplication of the Mount Victoria Tunnel. While this future project is not fully developed nor approved, traffic with the duplication operating will consequently affect the area affected by this Project. This section checks whether there could be potential noise issues when this future traffic flow occurs.

• Section 8 Construction noise
  Section 8 discusses construction noise. A summary is given of the main construction activities in terms of noise and an initial assessment of the potential construction noise levels is made. Reasonable construction noise limits are proposed with discussion of salient parts of a Construction Noise and Vibration Management Plan.
  This section is particularly relevant to people who live in or use areas very close to the major construction activities. These people will experience any potential construction noise effects the most and the needs of these people will influence the management of the construction noise.

• Section 9 Conclusions and Section 10 Recommendations
  Section 9 contains the conclusions of the noise assessment and Section 10 contains recommendations for noise conditions to ensure noise levels are managed.

1.2 Project description

The NZTA have advised that the Project is as follows:

The Project proposes to construct, operate and maintain new transport infrastructure for State Highway 1 at the Basin Reserve. A key component of the proposal is a multi-modal bridge that connects Paterson Street with Buckle Street. The bridge will provide a two lane one-way carriageway for SH1 westbound road users and includes a shared walking and cycling path on its northern side.

Proposed at-grade road improvements include changes to Dufferin Street and sections of Paterson Street, Rugby Street (including the intersection with Adelaide Road), Sussex Street, Buckle Street (SH1), Taranaki Street, Vivian Street (SH1), Pirie Street, Cambridge Terrace, Kent Terrace (SH1), Ellice Street and Hania Street. The overall road layout is shown diagrammatically on Figure 5.1 below.
The Project also provides urban design and landscape treatments. These include new landscaped open space areas, a new building under the bridge on the corner of Kent Terrace and Ellice Street, a new entrance and Northern Gateway Building to the Basin Reserve, an improved streetscape entrance to Government House and adjacent schools, a modified car park for St Joseph’s Church, dedicated bus lanes and bus stops around the Basin Reserve, as well as new walking and cycling paths.

Proposed landscaping and urban design treatments include low level plantings, raingardens, trees, terracing, architectural bridge design including sculptured piers, furniture and paving. These measures aim to contribute to the overall integration of the proposed bridge structure into the surrounding urban environment.

1.2.1 Transport Improvements

The Project proposes a grade-separated route (the bridge element) for SH1 westbound traffic on the northern side of the Basin Reserve. As a result, SH1 traffic will be removed from the local road network around the eastern, southern and western sides of the Basin Reserve.

The bridge soffit will be up to 7.3m above the ground surface and the top of the guard rail will up to 10.5m high above the ground. The bridge is approximately 263m long or 320m long if abutments are included. It will be supported by six sets of piers (2 are double piers) and six smaller diameter piers to support the western end of the shared pedestrian and cycleway. The bridge has a minimum width of approximately 11.3m and a maximum width of approximately 16.7m. There are 2 bridge joins, one at each end.

The Project proposes changes to the SH1 westbound route, the SH1 eastbound route, and other roads on the network where they connect with SH1, including clearways on the eastern part of SH1 Vivian Street (from Tory Street to Cambridge Terrace). These propose to improve the efficient and
safe movement of traffic (including buses), pedestrians and cyclists through intersections and provide entry and exit points for SH1. Supplementary works on the existing local road network are also proposed to be undertaken to take advantage of the additional capacity created by the SH1 improvements.

The Project proposes new pedestrian and cycling routes throughout the Project area as well as improvements to existing infrastructure. The majority of the works to improve the walking and cycling routes are located on the north side of the Basin Reserve and connect with Mount Victoria, Mount Victoria Tunnel and schools on Dufferin Street. These improvements will also connect with the National War Memorial Park which is currently under construction and also with potential future duplication of Mount Victoria Tunnel.

A reduction in state highway traffic on the roads around the Basin Reserve allows for more efficient northbound and southbound movements from Kent and Cambridge Terrace to Adelaide Road. Accordingly, new dedicated bus lanes are proposed to provide for better public transport movements around the Basin Reserve.

The key traffic flows around the Basin Reserve following the implementation of the proposed Project are shown in Figure 5.2 below and described thereafter.

![Figure 5.2: Proposed traffic directions for the Project](image)

The package of transportation improvements proposed by the Project are summarised below and followed by a brief description of the works:

- **SH1 westbound (from Mount Victoria Tunnel to Buckle Street)**
  - *The Bridge* - new direct link from Paterson Street to Buckle Street via a bridge;
  - *Buckle Street three laning* - provision of third lane along Buckle Street between Sussex Street (including minor modifications to Sussex Street) and Taranaki Street to improve capacity and accommodate the two lanes from the Bridge; and
  - *Taranaki Street improvements* – modifications to the layout of Taranaki Street and Buckle Street intersection to accommodate the three laning of Buckle Street and to increase capacity.
- **SH1 eastbound (from Vivian Street – Kent Terrace - Mount Victoria Tunnel)**
• **SH1 Eastbound re-alignment** - realignment of SH1 eastbound between Hania Street and Brougham Street; and

• **Vivian Street and Pirie Street Improvements** – as part of the modifications to the intersection of Pirie Street and Kent / Cambridge Terrace and Vivian Street, clearways on Vivian Street are proposed. The combination of improvements increases the capacity of the intersection for all traffic movements including public transport.

- Improvements to roads around the Basin Reserve
  - **Paterson Street / Dufferin Street intersection** – modifications to the layout of Paterson Street/Dufferin Street and change in priority at the signals to provide a significant increase in priority to Dufferin Street (south bound traffic from Kent Terrace/ Ellice Street);
  - **Adelaide Road / Rugby Street intersection** – reducing through lanes along Rugby Street from 3 lanes to 1 and allowing Adelaide Road traffic and Rugby Street traffic to flow at the same time. Pedestrian and cycling crossings will be via on-demand signals. Two lanes for access into Adelaide Road would remain with one operating as a bus lane;
  - **Ellice Street link** – new road link from Ellice Street to Dufferin Street/Paterson Street intersection (a similar vehicular movement can currently be made between Ellice Street and Dufferin Street). A new shared pathway for pedestrians and cyclists would be provided adjacent to this link to facilitate movements between the Mount Victoria suburb, the schools on Dufferin Street, and further south toward Adelaide Road;
  - **Dufferin Street improvements** – works to modify the layout of the road space and bus drop off zones on Dufferin Street and Rugby Street on the south east corner of the Basin Reserve and to improve vehicular access to Government House; and
  - **Basin Reserve Gateway** – treatment to Buckle Street where it meets Kent/Cambridge Terraces, and retains an entry point to the re-aligned SH1 eastbound.

- Walking, Cycling, Public Transport (throughout the Project Area)
  - **Walking and cycling path on bridge** – new walking and cycling path on the bridge between Paterson Street and Buckle Street / NWM Park;
  - **Existing pedestrian and cycle routes** – existing at-grade pathways are retained or enhanced and additional and alternative routes are provided. Additional and improved pedestrian and cycling access would be provided in the landscaped area on the corner of Cambridge Terrace and Buckle Street and between Brougham Street and Kent Terrace. These routes link to the proposed pedestrian and cyclist facilities proposed through NWM Park;
  - **Public Transport** - new dedicated bus lanes are proposed on Ellice Street, Dufferin Street and Buckle Street, and the southbound bus stop is proposed to be relocated from Adelaide Road onto Rugby Street; and
  - **Public Transport** - existing priority for buses from Kent Terrace onto Ellice Street is retained.

For further detail on the proposed transport improvements refer to the documentation set Volume 3, Technical Report 4: Assessment of Traffic and Transportation Effects. Details of the road design layouts are shown in the documentation set Volume 5: Plan and Drawing Set.

1.2.2 **Urban Design and Landscape**

Proposed urban design and landscape treatments to areas outside of the road carriageway form part of the Project works. The development of the proposed Project design has been iterative,
responsive and collaborative. As such, it has been developed through an Urban Landscape and Design Framework (refer to the documentation set Volume 3, Technical Report 2: Consultation summary report) to address the specific urban design principles for the Project. The Project proposes treatments to areas adjacent to the road network that would assist with the integration of the proposed bridge into the surrounding urban context.

Six zones and elements for the Project area have been identified within which character and zone specific principles for those areas have been developed to define the design intent and to provide a framework for post RMA consenting detailed design development. The zones are shown on Figure 5.3 below.

![Figure 5.3: Urban and landscape zones for proposed works outside of the traffic lanes](image)

These are briefly described for the urban and landscape zones below:

- **Zone 1 Cambridge/Buckle Bridge Interface Zone** - proposed landscape treatments to land between Cambridge Terrace and the NWM Park, which includes rain gardens and wetland plantings for stormwater treatment. This landscape area has been designed as a continuation of NWM Park. The terracing in the NWM Park starts from Kent and Cambridge Terraces and are reflective of the cultural heritage of the area, as cultivation terraces. Wetland planting
reflects the former Waitangi Lagoon which is now the Basin. The landscaping also provides an interface with the curtilage of the newly relocated Home of Compassion Crèche (former)\(^5\).

- **Zone 2 Kent/Cambridge Basin Gateway:** proposed landscaping between Kent/Cambridge Terrace responds to tangata whenua values in relation to the proposed historical wetland ecology and provides a safe and enlarged public access and gathering area relative to the Basin Reserve entrance. The proposed landscape aims to facilitate gathering and includes reconfigured pedestrian crossings, bus stops and Basin Reserve entrance.

- **Element 2.1 Entrance to the Basin Reserve** – proposes a combination of planting (pohutakawa trees) and a new Northern Gateway Building on the northern boundary within the Basin Reserve. The combination of new Northern Gateway Building and pohutakawa trees screen the bridge from general views from within the Basin Reserve. The new Northern Gateway Building is designed to specifically remove potential views of traffic on the bridge from the views of batsmen (facing bowlers from the north). The new Northern Gateway Building would provide space for player facilities and includes a wider entrance for visitors to the Basin Reserve that is aligned with the new entrance plaza located between Kent and Cambridge Terrace.

The new structure will occupy the space between the RA Vance Stand and the existing toilet block at the edge of the northern embankment. The new structure will be up to 65m long and up to 11.2m high and includes a screen that covers the gap between the new building and the RA Vance Stand. This option is preferred by the Basin Reserve Trust. Alternative mitigation proposals entailing a 45m long structure and a 55m long structure and consequent increases in proposed tree planting have also been considered and are assessed within this report.

- **Zone 3 Kent/Ellice Integrated building zone** – proposes a new building under the proposed bridge at the corner of Kent Terrace and Ellice Street which would be made available for commercial use. It is intended to re-establish the historical built / street edge in this location and the building helps incorporate the bridge into the built urban environment. A green screen is proposed to be located above the new building to provide a level of screening for the adjacent apartment building and assist to visually integrate the bridge with the buildings at this corner.

- **Zone 4 Paterson/Ellice/Dufferin Interface zone** – proposes to continue ground landscape linking from across Kent/Cambridge Terraces and additional tree planting around the Basin Reserve’s outer square.

The Project proposes works within St Joseph’s Church property using land that is currently used for car parking. Thus, the Project proposes to remove the existing building at 28 Ellice Street and to adjust the existing carpark and provide landscape improvements for the Church within the remaining space. All of these works are located on land owned by the Church.

- **Zone 5 Dufferin/Rugby Streets, Schools/Church/Government House Interface zone** which serves as a vehicular and pedestrian access area serving key adjacent land uses of the schools and Government House. Proposed works include the re-allocation of space in the roading corridor, layout modification and urban design and landscape treatments.

- **Zone 6 The Bridge Element** – the horizontal alignment of the Bridge has retained a close reference to the historic street pattern (the Te Aro Grid) to strengthen and define the Basin square. The vertical alignment has utilised underlying landform to achieve grade separation between north-south and east west routes. The width of the bridge has been kept to a minimum that meets safe traffic design standards for a 50km/h road. Abutments are integrated

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\(^5\) The Home of Compassion Crèche (former) is being relocated as part of the National War Memorial Park project.
and grounded in the form and material of the landscaping. Lighting on the bridge seeks to
minimise glare and spill onto surrounding areas and integrates with the bridge form and with
the adjacent NWM Park. Architectural lighting is provided underneath the bridge and across
the landscape, highlighting forms, surfaces and textures of the superstructure, undercroft,
piers, abutments and landscape. The combination of treatments and design promote the
perception of the bridge being an elevated street rather than motorway flyover.

The Project will result in a number of transport benefits for the State highway network and the local
road network (including public transport and walking and cycling) as well as new buildings,
structures and landscape treatments for the Basin Reserve area.

Construction of these transportation improvements is currently scheduled to start in 2014/15.

1.2.3 Related Projects

The Project forms part of the Tunnel to Tunnel package of works that in combination would
improve traffic and transportation between the Terrace Tunnel and Mount Victoria Tunnel. The
Tunnel to Tunnel package also comprises of:

- The Buckle Street Underpass as part of the National War Memorial Park project by the
  Ministry of Culture and Heritage. This project is currently under construction and expected to
  be completed by the end of 2014.

Other NZTA studies of SH1 sections that are also being considered or are being progressed
concurrently within Wellington:

- Duplication of Mount Victoria Tunnel (construction planned for 2017/18).
- Duplication of the Terrace Tunnel (subject to feasibility investigation in 2013/14).
- Roading improvements along Cobham Drive and Ruahine Streets (construction planned for
  2017/18).

While there are linkages between these projects, each one is complex and entails significant use of
resource. As a consequence each is being progressed separately while maintaining the
appropriate design standards and specifications in order to achieve the NZTAs strategic objectives
for the RoNS.
2 Road-traffic noise criteria

This section explains the legislative requirements and relevant standards and guidelines for road-traffic noise that have been considered in identifying whether the Project may have potential noise effects.

2.1 Resource Management Act

The overarching requirement for management of noise is established by the Resource Management Act, 1991 (RMA). Section 16(1) of the RMA states

Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level.

The RMA allows for areas of land to be designated for use as network utilities (such as roads and telecommunications facilities) or large public works (such as schools and prisons). A designation will be sought to cover all areas of the Project. The designation sought could be approved without modification or with modification and may be subject to conditions.

2.2 Reasonable noise

The response of people to noise is broad. For any particular level of noise, a portion of the population will find it disturbing and a proportion will find that same noise level of little concern. As noise levels change, there is a progressive change in the proportion of the population that is disturbed and the proportion that is undisturbed, with the proportion disturbed increasing as the noise levels increase.

This broad response is explained by various research findings. For example, research indicates that acceptance of noise is influenced by the extent that the noise is perceived to be necessary or unavoidable. Other research indicates that tolerance of noise depends on the extent that the noise intrudes into the activities that are sought to be undertaken. The effects of noise on amenity are therefore highly variable. Higher noise levels can also impact on health, perhaps indirectly by causing stress or by reducing the quality of sleep.

In considering whether noise is reasonable, it is useful to have regard to guidelines or standards in which noise limits are recommended; these limits representing the view of stakeholders and experts as to the acceptable level of community disturbance. In general, these guidelines and standards are targeted at protecting health and reducing the worst of the noise effects on amenity. In New Zealand, two significant documents providing guidance as to road-traffic noise are the NZTA Noise Guidelines and NZS 6806: 2010, which are discussed in Section 2.4.
2.3 Wellington City District Plan

The Wellington City District Plan\(^6\) contains planning maps which shade areas throughout the district to describe their usage and thus the rules that apply to those areas. Planning Map 16 covers the area of the Project, and is reproduced here in Figure 5.4. The Project area includes areas classed as suburban centre, institutional precinct, central area, inner residential area, and open area.

![Figure 5.4: Reproduction of an area of Planning Map 16 from the Wellington City District Plan](image)

Many District Plans in New Zealand do not include limits on road-traffic noise. In many instances the District Plans are explicit that road-traffic noise is excluded from noise limits. In its definitions (Section 3.10), the Wellington City District Plan states:

\[\text{The following activities and specific noise sources are not appropriately controlled using assessment by NZS 6802: 1991 Assessment of Environmental Sound and noise rules in this Plan, unless the rule states to the contrary:}\]

\[
\begin{align*}
\text{vehicles driven on a road (within the meaning of s.2(1) of the Transport Act 1962) or vehicular movements on any sites which are in keeping with normal residential activity} \\
[...]
\end{align*}
\]

Within Section 4.2.2.3 for Residential Areas, it states:

\[\text{Traffic noise is not controlled through rules in the District Plan and alternative actions will have to be initiated to avoid, remedy or mitigate intrusions from this source.}\]

Therefore, it is taken that road-traffic noise is excluded from the rules of the Wellington City District Plan but still it is implied that road-traffic noise needs to be managed. The noise limits from the Wellington City District Plan give guidance to general expectations of noise levels around the

\(^6\) Wellington City District Plan, operative 27/07/2000 with amendments available online
Project area. These noise limits are also relevant for considering the noise from construction of the Project.

The noise limits set in the Wellington District Plan for suburban centres are the same as for institutional precincts and the central area. From Section 7.1.1.1 for suburban centres, Section 9.1.1.2 for institutional precincts, and Section 13.1.1.1 for the central area:

*Noise emission levels when measured at or within the boundary of any site or at the outside wall of any building on any site, other than the site from which the noise is emitted, shall not exceed the following:*

- *At all times* 60 dBA(L10)
- *At all times* 85 dBA(Lmax)

Where noise from activities within a suburban centre, institutional precinct, or the central area enters inner residential areas:

*Noise emission levels when measured on any residential site in the Inner Residential Area must not exceed:*

- *Monday to Saturday 7am to 7 pm* 55 dBA(L10)
- *Monday to Saturday 7pm to 10pm* 50 dBA(L10)
- *At all other times* 40 dBA(L10)
- *All days 10 pm to 7 am* 70 dBA(Lmax)

From Section 5.1.1.1.1, noise emission levels within an “inner residential area” are expected to conform to the following limits:

- *Monday to Saturday 7am to 10 pm* 50 dBA(L10)
- *At all other times* 40 dBA(L10)
- *All days 10 pm to 7 am* 65 dBA(Lmax)

The Basin Reserve is an area of “Open Space A” where Section 17.1.1.1.1 is applied to noise:

*Noise emission levels from any activity located in an Open Space Area when measured at the Conceptual Boundary of the activity must not exceed 45 dBA(L10).*

These noise limits imply that when compared to users and residents within an inner residential area, more noise should be both expected and expected to be tolerated by users and residents of a suburban centre, institutional precinct, or the central area. Figure 5.4 shows the Project is mostly within the central area but some of the Project is in an inner residential area. However, it should be recognised that sharply defined boundaries may be not fully practicable given the nature of noise.
2.4 Noise guidelines and standards

For a number of years, the NZTA Noise Guidelines\(^7\) have had acceptance by Local Authorities and the Environment Court for establishing the effects of roading projects. Since 1991, these NZTA Noise Guidelines have been used on most capital projects on the state highway network and also by many local road controlling authorities. In the main, roading projects assessed under and made complying with the NZTA Noise Guidelines have had acceptance by the adjacent community.

In 2010, the New Zealand Standard for Acoustics – Road-traffic noise – New and altered roads (NZS 6806: 2010) was published. In May 2010, the NZTA stated, with immediate effect, NZS 6806: 2010 would be used in place of the NZTA Noise Guidelines.\(^8\)

Both the NZTA Noise Guidelines and NZS 6806: 2010 were developed with inputs from a wide range of stakeholders concerned with road-traffic noise; including from sectors of public health, local government, road controlling authorities, and acoustic professionals; with stakeholders representing central government and agencies involved in transport; and with public input. The preparation of these documents had regard to the scientific literature, World Health Organisations guidelines, and practices in other countries.

The RMA process is particularly concerned with the effects of the specific project and there is a need to consider any change in effects that the project brings about compared to effects that exist prior to the project. Applying NZS 6806: 2010 does involve identifying the change in noise levels caused by the project (calculated as the noise environment with the project in place minus the noise environment that would be receiving that project). The calculation of noise level change is used only to identify if there is change in noise level sufficiently large to warrant assessment under the standard. If an assessment is warranted, assessment with NZS 6806: 2010 provides noise criteria framed around absolute noise levels. The change in noise level caused by the project is not assessed so the effects of a specific project can be merged with the effects of previous projects (the cumulative effect).

While our assessment includes applying the noise level criteria of NZS 6806: 2010 to the Project’s noise levels, we believe it is also useful to consider the change in noise levels caused by the Project.

In this regard, the NZTA Noise Guidelines are a useful guide as they give more emphasis to the change in noise level caused by a project. The NZTA’s Noise Guidelines’ “average design noise levels” are formed around ensuring the impacts of changes in noise are minor. In general, where ambient noise is low, a quite large change in noise can still be considered to have minor effect; but where ambient noise is high then an increase more than a small amount could potentially have effect more than minor; and where ambient noise is very high then even smaller increases could potentially have effect more than minor. Figure 5.5 shows the NZTA Noise Guidelines’ relationship between ambient noise levels and average design noise levels. (The NZTA Noise Guidelines


describe noise levels by a different method than NZS 6806: 2010 but here the noise levels are adjusted to match the measurement position of NZS 6806: 2010.\(^9\)

![Free field design noise limit dB L\(_{Aeq(24h)}\)](image)

**Figure 5.5: Visual representation of the NZTA Noise Guidelines average design noise levels which we use as guidance on acceptable noise level increases**

2.4.1 NZS 6806: 2010

NZS 6806: 2010 Section 6 gives noise criteria. These noise criteria have been set to avoid adverse health effects associated with noise on people and communities, but with regard to the potential benefits to the wider community of new and altered roads. NZS 6806: 2010 identifies premises and facilities to be protected from road-traffic noise, Protected Premises and Facilities. NZS 6806: 2010 contains noise criteria to be applied to these Protected Premises and Facilities. The noise criteria are not rigid targets but rather frame a process which is to achieve the best practicable option to manage the road-traffic noise received at these premises and facilities. NZS 6806: 2010 provides guidance on developing noise mitigation options and evaluating how those options address the Best Practicable Option for noise mitigation. Some of the factors that have to be considered when identifying the Best Practicable Option are the technical feasibility of the mitigation, the life cycle costs of the mitigation, the extent that it delivers a worthwhile noise reduction, the views of the affected community, and impacts of the mitigation (such as visual or social or impacts on areas of environmental importance), and any safety issues associated with the mitigation. NZS 6806: 2010 also sets out a process to assist in developing the Best Practicable Option. This process includes the development of several noise mitigation options for consideration and including advice of other

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\(^9\) The NZTA Noise Guidelines describe the noise in the façade position, that is approximately 1 metre in front of a building wall. This position is exposed to both the noise source and noise reflected from the building wall. NZS 6806: 2010 uses the free-field position, that is a position free of noise reflections. As a general rule and from C5.2.1.5 of NZS 6806: 2010, the façade effect is 2.5 dB; so that the façade noise level = free-field noise level + 2.5 dB.
project specialists as to the impacts of those options as part of identifying the preferred Best Practicable Option for noise mitigation.

NZS 6806: 2010 provides its noise criteria in a table, reproduced here as Table 5.1. The table gives three categories of noise level targets for each of three project situations: altering an existing road; making a new road for high volumes of traffic; and making a new road for normal traffic volumes.

Table 5.1: Reproduction of “Table 2 Noise criteria” from NZS 6806: 2010

<table>
<thead>
<tr>
<th>Category</th>
<th>Altered roads</th>
<th>New roads with a predicted traffic volume &gt;75,000 AADT at the design year</th>
<th>New roads with a predicted traffic volume of 2,000 to 75,000 AADT at the design year</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (primary free-field external noise criterion)</td>
<td>dB L_{Aeq(24h)}</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>B (secondary free-field external noise criterion)</td>
<td>dB L_{Aeq(24h)}</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>C (internal noise criterion)</td>
<td>dB L_{Aeq(24h)}</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

NZS 6806: 2010 C6.1.2 notes:

*Issues such as the practicability, technical feasibility, and/or affordability of implementing noise mitigation measures of the potential adverse effects of noise mitigation measures (such as, any potential for safety or visual effects) may mean that it is not consistent with the best practicable option to achieve full compliance with any of criteria A, B, or C at one or more assessment positions in a particular case.*

NZS 6806: 2010 8.2.2 provides an additional expectation that mitigation measures should only be implemented if the combination of the measures would achieve an average reduction of at least 3 dB L_{Aeq(24h)} for the buildings the mitigation measures are intended to benefit (or a 5 dB L_{Aeq(24h)} reduction if only one building is intended to benefit from the mitigation measures).

- The Category A noise level is the preferred upper limit for road-traffic noise levels. Where consistent with the Best Practicable Option for the mitigation of road-traffic noise, the noise level of Category A should be achieved.
- The Category B noise level is an acceptable upper limit for those circumstances where achieving the Category A noise level is inconsistent with the Best Practicable Option.

The Category A and Category B upper limits are external noise criteria, thereby protecting both the outdoor noise environment and the indoor noise environment. Category C is an internal noise criterion and Category C is less preferred than achieving Category A or Category B.

- Where achieving Category A or Category B is inconsistent with the Best Practicable Option then an internal noise level of 40 dB is acceptable.
- Where achieving Category C is inconsistent with the Best Practicable Option, then internal noise levels shall be reduced as far as is practicable.
2.5 NZTA Environmental Plan

The NZTA Environmental Plan\(^\text{10}\) establishes an environmental policy for state highways. The Environmental Plan states that it is to enable the NZTA to integrate environmental and social considerations, including mitigation of road-traffic noise, into all aspects of state highway planning, construction, and maintenance. The Environmental Plan current at this time is Version 2, published in June 2008.

The NZTA Environmental Plan states in its foreword dedication to “avoiding whenever possible, enhancing if practicable, mitigating where required and remedying if feasible adverse environmental and social effects from state highway construction and operation.”

The NZTA Environmental Plan states the objectives regarding noise:

- N1 Reduce exposure to high traffic noise levels from the existing state highway network.
- N2 Determine reasonable noise requirements when seeking new or altering existing designations including when designating existing local roads by using RMA procedures.
- N3 Manage construction and maintenance noise to acceptable levels.
- N4 Influence activities adjacent to state highways to discourage noise-sensitive activities establishing in areas adversely affected, or likely to be in the future, by state highway traffic noise.

Objective N1 directs a Noise Improvement Programme. If road-traffic noise levels from the existing state highway network are above 65 dB \(L_{A_{eq}(24h)}\) in the façade position (62.5 dB \(L_{A_{eq}(24h)}\) in the free-field position) then potential noise issues are investigated. The noise level is not intended as a noise limit but rather a trigger for investigation. If an investigation identifies noise issues and practicable potential mitigation, the mitigation may be fundable by the Noise Improvement Programme. However, funding of the Noise Improvement Programme is limited and prioritised according to a set of criteria.

It is noted that Objective N1 is primarily directed at the existing state highway network. However, in developing new projects, it is preferable to avoid a situation where once the road was operational it would be investigated under the Environmental Plan.

Relevant to this Project and Objective N2, the NZTA Environmental Plan states designation conditions “should refer to noise criteria that deliver a reasonable noise level and implement the best practicable option.” Appropriate application of guidelines and Standards are ways of achieving Objective N2.

The NZTA Environmental Plan has a role in assessing the noise effects from construction of the Project (Objective N3). Though the NZTA Environmental Plan does not provide specific noise limits, it recognises that “noise issues associated with construction and maintenance activities on the state highway network can be particularly intrusive and disturbing, especially when undertaken at night. The effective management of such noise is essential in order to avoid unreasonable effects on communities and individuals.” The NZTA has produced further guidance documents addressing the management of noise from construction of roading projects.\(^\text{11}\)

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\(^{11}\) http://acoustics.nzta.govt.nz/management/construction
3 Applying the noise criteria to this assessment

3.1 Overview of our approach

In our assessment of potential road-traffic noise effects of the Project, our overall approach recognises that there are a number of factors that distinguish this Project from other projects. The factors include:

- While there is an existing high noise environment near to the main roads, the dense built environment provides many quiet areas relatively close by;
- While there is a new link, it is very close to existing roads; and
- There are numerous locations that should be considered as important to the community beyond the local residents.

Our overall approach mainly follows the methodology set out in NZS 6806: 2010 because this standard provides good guidance as to the extent of area and the noise-sensitive land uses that should be considered, of how the changes in noise caused by the Project should be calculated, and of the approach to determining the best practicable option for any mitigation. However we have applied a more conservative approach to our assessment as outlined in the following sections and summarised in Section 3.7.

In assessing the potential noise effects, we apply a two-step process of:

- Considering the potential for effects due to the change in noise levels, using guidance such as from the NZTA Noise Guidelines; and
- Considering the potential for effects due to the total noise level, using guidance as to acceptable noise levels such as from NZS 6806: 2010;

If the change in noise level or the total noise level could have potential effect, we consider whether further mitigation should be investigated. In this, we note some mitigation measures are already embedded in the current Project design through the iterative design process that has occurred to date.

In some cases the Project causes noise level decreases (relative to those that would occur in the receiving environment without the Project) but the total noise levels may be still high. Our understanding is that a project need only address the impacts of that project itself. Some guidance such as NZS 6806: 2010 encourages investigation of practicable mitigation where noise levels have been decreased by a project but are still high. We do this investigation while noting that any mitigation further to that addressing the impacts of the Project itself is not a requirement.

The following sections outline the factors needing to be considered in the road-traffic noise assessment using the process and definitions of NZS 6806: 2010 with adjustments to address the specific character of this Project.

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3.2 The design year

NZS 6806: 2010 applies its noise criteria to a design year ten to twenty years after the completion of the project. This future year is to recognise that a project may induce traffic growth and the noise effects of this growth are included in the assessment at this future year. For this Project, selection of the design year is complicated by the likelihood that a subsequent project will occur within this timeframe and further influence the traffic flows that will occur ten to twenty years after the completion of this Project. This likely subsequent project is the possible second tunnel under Mount Victoria.

To identify the effects of this Project, the design year is taken as 2021 with only one Mount Victoria Tunnel. The single Mount Victoria Tunnel tends to restrict the amount of traffic that enters the Project area. It is reasonable to assume the traffic volumes in 2021 with only the single Mount Victoria Tunnel are close to the maximum throughput until duplication of the Mount Victoria Tunnel. Therefore we accept the 2021 traffic volumes as sufficient for identifying the Project’s effects.

This Project’s Best Practicable Option for noise mitigation is determined based on traffic modelled for 2021 for the situation of the Project operating and only one tunnel under Mount Victoria. In Section 6.8, a secondary evaluation tests the future sufficiency of this Project’s Best Practicable Option for noise mitigation, with the traffic flow forecast for the situation of the year 2031 with two tunnels under Mount Victoria.

3.3 “Urban environment” and “rural environment”

NZS 6806: 2010 has application specific to “urban environments” or “rural environments” with those terms having meanings specific to that Standard. NZS 6806: 2010 uses the distinction in environments within setting the range of the noise study area; with a wider range for rural environments. Section 2.1 of NZS 6806: 2010 defines urban environments and rural environments via the Statistic New Zealand urban/rural profiling of census meshblocks. Meshblocks coded as a main urban area, a satellite urban community, or an independent urban community are classified as urban environments in NZS 6806: 2010. Any meshblock not classified as an urban environment is a rural environment in NZS 6806: 2010.

According to the NZS 6806: 2010 classification of the Statistics New Zealand meshblocks, and as expected, the Project is entirely within an “urban environment”.

We see the purpose of the distinction in NZS 6806: 2010 between these two environments is to ensure the area considered in the noise assessment is wide enough to include all premises and facilities which might be affected by noise from the project. Compared to open rural environments, generally noise will not spread as far in the more closely built urban environment before it mingles with the background noise levels.

3.4 Determining the noise study area

Within an urban environment, Clause 1.3.1(d) of NZS 6806: 2010 limits the Standard’s application for protection from road-traffic noise to an area within 100 metres of a new or altered road. The assessment of road-traffic noise effects is made for a range of properties within this area, selected as premises or facilities sensitive to noise and needing protection.
The distance of 100 metres is used as the basis for the range of the noise study area for this Project but this distance is not applied rigidly and is expanded in places to better understand the Project’s potential effects or perceptions of those effects.

- In some instances, an exact distance of 100 metres divides some groups of residential buildings that otherwise have similar characteristics including noise environment. We have expanded the noise study area to more fully or completely include such groups.

- We have expanded the noise study area to include the wider Basin Reserve area, particularly the open space of the Basin Reserve; and also Sussex Street, Rugby Street, and Tasman Street. This expansion recognises both the interest that residents, other users of the area, and the many people passing through the area have as to the Project and its road-traffic noise effects; and recognises that while some road links are physically unaltered, the Project can alter traffic flows on the link quite substantially.

- In some places, we have selected the range of the noise study area to maintain consistency with previous assessments made during the development of the current Project. This is particularly for the residential area in the southern end of Mount Victoria. This area includes multi-level residential buildings located on terrain higher than the proposed bridge. We have widened the noise study area here so as to determine the spread of noise into this area.

- South of the Basin Reserve, the noise study area includes only those buildings in the immediate vicinity of Rugby Street. We have chosen this as the noise effects of the Project will not occur or be apparent beyond this boundary. Perceived effects are due to intensification of the Adelaide Road area rather than due to the Project. The western extent of the noise study area is Taranaki Street so as to include effects of intersection changes here and changes in the Buckle Street Underpass traffic flows caused by the Project.

3.5 Premises and facilities for assessment

Within the noise study area, premises and facilities for noise-sensitive activities or of other importance are given particular regard in our road-traffic noise assessment.

Guidance for our selection of premises and facilities for assessment includes:

- Clause 1.4.1 of NZS 6806: 2010 which identifies buildings used for residential activities, buildings used as temporary or overnight accommodation, marae, spaces within buildings used for overnight patient medical care, teaching areas and sleeping rooms of educational facilities. NZS 6806: 2010 terms these Protected Premises and Facilities (PPFs).

- Section 3.10 of the Wellington City District Plan includes the definition of noise sensitive activities as any residential activity, residential accommodation for travellers, and early childhood centres.

- Guidance for open spaces in the noise study area was provided by the United States Department of Transportation Federal Highway Administration (FHWA) which categorises a range of activities and provides associated noise limits. The activities are broad including exterior areas where
serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose

and exterior areas used for parks, picnic areas, or active sports areas. Also included are residential activities, accommodation, places of worship and schools.\textsuperscript{13}

- Other guidance was provided by the New South Wales Government’s Transport Roads and Maritime Services section which defines noise sensitive locations as “areas in which people are more likely to be affected by noise, such as: homes, schools, hospitals, places of worship, parks.”\textsuperscript{14}

The premises and facilities to be considered were established by site visits supplemented by an existing knowledge of the area. The specific locations, outlines, and heights of the premises and facilities in the noise study area were identified from aerial photographs and drawing files supplied to us\textsuperscript{15}. The activities at all premises and facilities within the noise study area were inspected for noise-sensitivity. Figure 5.6 demonstrates the locations of those premises and facilities within the noise study area determined as requiring assessment. Note that all premises and facilities are included in the model, to account for their effects on propagation of the road-traffic noise, but only those judged as for noise-sensitive activities or of other importance are selected for noise assessment.

Within the noise study area:

- All premises and facilities fulfilling the definitions of NZS 6806: 2010 as noise-sensitive premises and facilities needing protection, referred to as PPFs, are assessed.
- In line with the FHWA guidance and the New South Wales guidance, the Seventh Day Adventist Church on Tasman Street, St Mark’s Church and St Joseph’s Church are assessed.
- Prior to commencement of this Project, the National War Memorial Park will be upgraded by the end of 2014. The National War Memorial Park entails undergrounding Buckle Street between Tasman Street/Tory Street and Taranaki Street (not shown in the aerial photograph underlying Figure 5.6). The intention of the National War Memorial Park is a dedicated space to remember those affected by war. Providing for this intention and also facilitating the ceremonies that will occur in this space, the National War Memorial Park is assessed.
- The Home of Compassion Crèche (former) building is assessed. Currently unoccupied, this building is registered as Category I with the New Zealand Historic Places Trust. Compared to its present (2012) position, prior to this Project, the building will be relocated as part of the National War Memorial Park project. Figure 5.6 shows the building in its relocated position and this is the position for which the noise assessment is undertaken.
- The Basin Reserve Pavilion is registered as Category II with the New Zealand Historic Places Trust. Also registered with the New Zealand Historic Places Trust, as an historic area, is the whole Basin Reserve area including the RA Vance Stand, the Wakefield Memorial, the Museum Stand, and other structures within the area. Four buildings within the Basin Reserve


\textsuperscript{15} “Basin Reserve Base – Buildings.dxf” supplied by Mark Edwards in email 16 October 2009
are assessed. Some positions within the sportsground are chosen to represent the overall grounds of the Basin Reserve area.

- On the corner of Buckle Street and Tasman Street is the former Mount Cook Police Station. This building is registered as Category I with the New Zealand Historic Places Trust. Though the building is currently used for commercial purposes, its heritage significance warrants its assessment.

Government House, although of great significance and having a gateway into the noise study area, lies well to the south. It is remote from any potential noise effects and was therefore not included.

The shapes shaded yellow in Figure 5.6 are only indicative. The shapes of the buildings in the noise modelling were accurate to the shape of the building, being based on the drawing file provided to the noise assessment\textsuperscript{16} and aerial photographs.

\textsuperscript{16} “Basin Reserve Base – Buildings.dxf” supplied by Mark Edwards in email 16 October 2009
Figure 5.6: Locations for assessment, indicated by yellow shading, around the area of the Basin Reserve for which road-traffic noise levels have been specifically assessed.
3.6 “Altered roads” and “new roads”

NZS 6806: 2010 considers roading projects using the terms “altered roads” and “new roads” with meanings specific to that Standard. Table 2 of NZS 6806: 2010 (reproduced in Table 5.1 of this report) shows different sets of noise criteria for altered roads and new roads. NZS 6806: 2010 should be consulted for a full explanation of its “altered road” and “new road” definitions.

For many state highway projects, the distinction between “altered road” and “new road” is clear. We find this Project does not easily fit the “altered road” and “new road” definitions of NZS 6806: 2010. Section 6.2 of NZS 6806: 2010 describes special cases where it may be appropriate to apply “altered roads” criteria to some assessment positions and “new roads” criteria to other assessment positions.

Clearly the Basin Reserve bridge itself is a new link but it is located above and immediately adjacent an existing road corridor so it is in a location already exposed to medium-to-high road-traffic noise. Other roads in the Project area are physically unaltered but their road-traffic usage is markedly changed due to the new bridge link of the Project and redirection or reorientation of road-traffic flows. While the Project does not readily fit the examples given in NZS 6806: 2010 Section 6.2 “Special cases”, that section shows that the standard envisages circumstances where a highly project-specific approach may be warranted.

Adjacent to many of these roads there exists a high noise environment. Both Section 6.2 “Special cases” of NZS 6806: 2010 and Appendix A of NZS 6806: 2010 show in applying NZS 6806: 2010 there should be regard to the existing road-traffic noise environment.

Modelling of the road-traffic noise environment that will receive the Project (for the year 2021) shows most of the noise study area is currently subject to moderate or high levels of road-traffic noise, so it appears appropriate to apply the noise criteria for altered roads. But that modelling does also show some of the residential area of Mount Victoria, such as around Moir Street, is currently subject to low levels of road-traffic noise. Figure 5.6 indicates the close spacing of buildings in this area, which means many of the buildings are currently well-shielded from road-traffic noise.

Therefore our approach is again tailored to the specific character of this Project. The altered road noise criteria of NZS 6806: 2010 are applied but we also have regard to the change in noise levels to ensure any noise effects are no more than minor, especially for assessed locations where existing road-traffic noise levels are low.

In selecting the “altered road” classification we note, when an existing road is subject to physical alterations, NZS 6806: 2010 judges its application is warranted only if the alterations would increase road-traffic noise by 3 dB $L_{Aeq(24h)}$ in a noise environment greater than or equal to 64 dB $L_{Aeq(24h)}$ or by 1 dB $L_{Aeq(24h)}$ in a noise environment greater than to equal to 68 dB $L_{Aeq(24h)}$. NZS 6806: 2010 is not applied where alterations to an existing road do not meet either of these conditions. For this Project, the design considered here has already been subject to an iterative design process whereby noise mitigation has been embedded in this design. Therefore, though the current design of the Project does not meet either of those conditions for noise increases sufficient to trigger application of NZS 6806: 2010, we still have undertaken a full assessment.

3.7 Extent of the Project and road-traffic noise sources to be considered

Section 3.3 has already described how the extent of the noise study area was selected wider than the NZS 6806: 2010 general expectations. We have also widened the extent of road-traffic noise
sources considered. Usually NZS 6806: 2010 confines its assessment to the noise from the new and altered roads plus connections to the existing road network. However, the bridge of the Project significantly alters traffic flows on existing roads around the Basin Reserve. Therefore, for this Project, we believe considering only the noise from the roads with specific physical Project works would not fully reflect the Project’s direct impacts on changing traffic flows on the adjacent road network and the consequent changed noise levels. Therefore, throughout this assessment, the noise level calculated at any one receiver is the noise level from the road-traffic on all the roads on the full road network (not just road-traffic on the new bridge link and other roads physically altered by the Project).

3.8 Summary of approach

The Project and the area in which it is located have necessitated a highly specific approach to fully assess the potential noise effects of the Project.

Overall we have adopted a very conservative approach to this assessment. Relative to the general expectations of NZS 6806: 2010:

- We have considerably widened the noise study area;
- We have expanded the range of locations assessed to include some heritage locations, churches, memorials, and recreational areas;
- We have assessed the total noise from road-traffic on all roads; and
- We have used not only the criteria of NZS 6806: 2010 but also, using the NZTA Noise Guidelines, we have considered the change of noise caused by the Project within the context of the total noise level at each location.
4 Noise modelling for both current and future road-traffic noise levels

Noise modelling is the primary tool for determining road-traffic noise environments as it allows an objective comparison of current and future situations, and then determination of the effectiveness of mitigation in reducing noise levels.

Calibration and validation have extensively established the reliability of noise modelling for assessing changes in noise levels, including New Zealand-specific calibration and validation.\(^{17}\)

While the match of modelled noise levels to measured noise levels is usually 1 to 2 dB $L_{A_{eq}(24h)}$, it is important to note:

- For any modelled project, the realism of the noise model strongly depends on the completeness and intricacy of its inputs. Road-traffic noise modelling is usually based on annual average daily traffic rates, neutral environmental conditions that neither enhance nor limit propagation of the noise, and usually with no account of extraneous noise sources such as industrial noise or aircraft or activity in the area.

- Noise measurements should also be considered not necessarily fully representative of the noise environment but should be used only as a “snapshot” of the noise environment as it specifically occurred during the noise measurement period.

All road-traffic noise modelling for this assessment has been in line with NZS 6806: 2010. The modelling techniques used are well established in New Zealand. The model used is based on the Calculation of Road Traffic Noise (CRTN) model. The CRTN model was developed in the United Kingdom more than thirty years ago and research in New Zealand has validated the model as appropriate in New Zealand so long as some New Zealand-specific adjustments are applied.\(^{18}\) The noise modelling software is SoundPLAN version 7.1 with current updates.

SoundPLAN fully takes into account the effects of terrain and buildings in the propagation of noise from the road-traffic into the surrounding environment. This capability is important for around the area of the Basin Reserve for three reasons.

- Low rises in the natural terrain, roads cut into the ground, or bunds as in the Basin Reserve, provide considerable screening of road-traffic noise.

- Closely spaced and multi-storeyed buildings interrupt the direct transmission of noise so that quiet areas can exist behind these buildings even though close to busy roads.

- Higher hills within the natural terrain mean that some locations are above the screening of the natural terrain and above the screening of other buildings so that they overlook busy roads.

With the combination of such effects, noise levels will be highly variable over the area.

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\(^{18}\) Adjustments to suit New Zealand conditions are made in accordance with Dravitzki, V. and Kvatch, I. (2007) Road surface effects on traffic noise: Stage 3 selected bituminous mixes. Land Transport NZ research report 326. 40pp. As recommended in Barnes, J., Enson, M., Beca Carter Hollings and Ferner Ltd. and Hegley Acoustic Consultants Ltd. (1994) Traffic noise from uninterrupted traffic flows. Transit New Zealand Research Report 28. 75pp., a road surface correction of -2 was used as the base correction for asphaltic concrete.
4.1 Use and display of noise modelling results

SoundPLAN calculates the noise level over the entire calculation area that may contribute noise to a particular calculation point. SoundPLAN calculates noise at spaced points over a defined grid so as to produce noise contours, as illustrated throughout this report. While these noise contours interpolate noise levels between the grid points, using finer spacing reduces any approximations. In addition, SoundPLAN calculates noise at specifically selected points. This is useful, for example, to identify the most exposed part of a façade on a building of interest.

The noise assessment makes use of both the noise contours and the noise levels calculated at identified positions. The noise contours can be useful for display and understanding of the noise environment and spread of noise in that environment. This report includes plots of these noise contours for these purposes.

We generally calculate and display the noise contours for a height 2.0 metres above ground level. Where pedestrians and cyclists make use of an area, we believe 2.0 metres is useful for understanding their experience of the noise environment. Clause 1.7.1 of NZS 6806: 2010 states:

> For any existing building, the assessment position means the exterior wall most affected by noise from the new or altered road being assessed and is 1.2 – 1.5 m above each floor level of interest in the building.

For buildings in the noise study area, we believe it reasonable to assume topography and housing construction would typically raise the floor of the ground storey some height above ground level. This height would vary from building to building and it is not feasible to conduct a survey of this. Therefore, we assume an calculation height of 2.0 metres is reasonable for the noise contours.

We do not use the noise contours to “read” noise values; for these we use the noise levels calculated at identified positions. The height of the noise contours typical through the report is not the only height used in modelling noise levels at identified positions. For building facades of interest, we use the noise values generated by modelling noise levels over a grid across the full façade, thus covering all storeys of any multi-storey building. This is an improvement over manual methods of noise calculation which would require a judgement to be made as to the most exposed position on the building. (The introduction to Section 6 adds to this explanation with Figure 5.14.)
5 Assessment of the road-traffic noise environment

5.1 Noise environments assessed in determining the potential effects of the Project

The RMA adopts an effects-based approach to assessment and we have considered both the effects of the change in noise levels and the effects of the cumulative noise levels.

Four noise environments were used in our assessment. Noise level changes were calculated using comparisons of the do-nothing noise environment and the do-minimum noise environment. Using the definitions of NZS 6806: 2010:

- The do-nothing noise environment
  
  The predicted road-traffic noise level at the assessment position(s) of protected premises and facilities at the design year assuming no alterations are made to the existing road.

  This is the environment that will receive the Project. It is the road layout in the year 2021 operating with traffic as forecast for the year 2021 (with Buckle Street undergrounded for the National War Memorial Park and with only one Mount Victoria Tunnel).

- The do-minimum noise environment
  
  The predicted road-traffic noise level at the assessment position(s) of protected premises and facilities at the design year, with the project implemented including safety barriers and other structures, which may provide incidental noise mitigation. The do-minimum noise environment does not include any mitigation measures that would be undertaken for the sole purposes of reducing noise effects.

  This is the Project without any noise-specific mitigation operating with traffic as forecast for the year 2021 (with only one Mount Victoria Tunnel).

Effects of the noise level changes were determined using the NZTA Noise Guidelines. Cumulative effects were determined using the total road-traffic noise levels of the do-minimum Project noise environment and the NZS 6806: 2010 noise criteria for altered roads, but with regard also to how the Project had increased (or decreased) these total noise levels.

In addition, two further noise environments are considered:

- The current noise environment
  
  This is the current road layout and current traffic operations (as they were prior to construction of the National War Memorial Park commencing). We have also used noise measurements to confirm this current noise environment.

- The future noise environment that would exist with this Project in place and subsequent projects in place
  
  This is the Project operating with traffic as forecast for the year 2031 with two Mount Victoria tunnels. This environment is included only to test the likely future sufficiency of the Best Practicable Option for noise mitigation that is determined for this Project.

5.2 The current noise environment

For many projects, the current physical road environment and the physical road environment that will be receiving a project are synonymous as there would be no physical changes between the
two situations. Usually the only changes would be the amount of traffic using those physical road environments.

Around the area of the Basin Reserve, there are complications because there is a sequence of intended projects that will alter the physical road environment from that which exists currently. The first of these projects is intended to be the Buckle Street underpass with creation of the National War Memorial Park, for completion by the end of 2014. That project is consented and is under construction and will be completed ahead of this Project; allowing for completion of this Project by 2016. This is intended to be followed by a second Mount Victoria Tunnel by approximately 2026. The environment that will receive the Project will therefore consist of what currently exists and the Buckle Street underpass. The do-nothing situation will be this road layout with the design year (2021) road-traffic volumes.

5.2.1 Establishing the current noise environment (2009)

It is useful to establish the noise environment that currently exists, because only this one can be checked against noise measurements. This is important for establishing the reliability of the modelling tools that will be needed to establish the noise level of the Project and other changes that may occur both prior to and subsequent to the Project.

The current noise environment we use was established in 2009. With respect to the way we use the current noise environment in our assessment, the relevance of the 2009 noise environment holds and does not need to be updated for 2013. The current noise environment is established by a two-step process which consists of noise modelling and measurements.

There are some important caveats in comparing modelled noise levels with measured noise levels. NZTA Research Report 446 “The variability of road traffic noise and implications for compliance with the noise conditions of roading designations” provides background and discussion, and some of the issues we give particular regard are highlighted here.

- Road-traffic is the only noise source in the modelled noise levels. While road-traffic is the dominant noise source at the noise measurement sites, other noise sources, such as aircraft, could be contributing to the resultant measured noise levels.
- Modelling road-traffic noise represents noise levels in what is known as “neutral” atmospheric conditions and the noise levels are calculated based on the annual average daily traffic rate on all roads that influence noise levels at that subject receiver location.
- Measurement of noise levels conducted in a residential area is recording propagated noise levels. This propagation is influenced by weather conditions. Wind strength and wind direction influence the noise levels received, as does the extent of cloud cover and sunshine at the time of the noise measurement. The scale of the effect of weather conditions increases with distance further from the noise source. Over the scale of the propagation distance given by this Project’s noise study area, weather conditions that still comply with NZS 6801: 2008 Acoustics – Measurement of Environmental Sound can cause a variation of ±3 dB.
- For measurement sites with major influence from road-traffic noise, road-traffic flow variations from the annual average daily traffic flow rate to the time of the measuring could probably

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cause a variation less than ±1 dB. Where a measurement site is adjacent a road with lower traffic flow, then variation from the annual average daily traffic flow rate during the measurement could cause greater variation in the noise level measured.

As there are multiple sources of variability in noise measurements, noise modelling is the primary tool we use in comparing one situation with another. Figure 5.7 illustrates both the modelled noise levels as the underlying contours and the measured noise levels superimposed over these modelled noise level contours.\(^{20}\)

It is acknowledged that the superimposed measured noise levels in Figure 5.7 cover a large area on the figure rather than the precise position of the measurement. The underlying noise contours represent noise levels at 2.0 metres above ground level whereas the measurements would typically have been made at about 1.5 metres above ground level. However Figure 5.7 verifies that the trends and magnitude of the noise measurements align with modelling of the situation. Note that we do not directly use these noise measurements and the noise modelling of the existing (2009) situation in the other parts of our assessment of the Project’s effects. We use them for understanding the long-established nature of the noise environment of this area.

\(^{20}\) Appendix 5.C shows a summary of the traffic volumes used in modelling the noise levels. The modelling included road surfacings as they currently exist, principally as indicated in the documentation set Volume 5: Plan and Drawing Set.
Figure 5.7: Road-traffic noise environment 2.0 metres above ground level modelled for the current (2009) situation with superimposed noise levels from measurements (free-field noise levels, $dB L_{Aeq(24h)}$)
While we have stated modelling is the primary tool we use in this noise assessment, noise measurements can provide other different information. Figure 5.8 is constructed from data recorded during a continuous 24 hour noise measurement taken at Dufferin Street. The figure illustrates a feature of the noise environment around the Basin Reserve, as it exists now and as it will continue whether or not the Project is built. Figure 5.8 shows the minute-by-minute variation (with the light blue line) and the hour-by-hour variation (by the dark blue line). The $L_{\text{Aeq(24h)}}$ is shown by the dotted red line. What is notable for this area is the noise levels are sustained as high over much of the 24 hour period and only during early morning hours do noise levels decline with the reduced traffic flow.

Another feature of the nature of the noise environment currently existing around the Basin Reserve is that it is little changed over many years. Table 5.2 indicates this through data on the annual average daily traffic flow on Paterson Street.\(^{21}\) Also, a 1961 count at the southern end of Cambridge Terrace/Kent Terrace gives a traffic flow of 25,000 vehicles per day.\(^{22}\)

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles per day</td>
<td>25,000</td>
<td>33,000</td>
<td>36,600</td>
<td>37,060</td>
<td>37,995</td>
<td>38,077</td>
<td>38,751</td>
<td>38,565</td>
<td>35,782</td>
</tr>
</tbody>
</table>

Considering only the volume of the traffic flow, the change in the number of vehicles between 1980 and 2011 would cause an increase of 1.8 dB $L_{\text{Aeq(24h)}}$, but other factors also affect road-traffic noise. Vehicle design has improved over the years and typically vehicles are quieter now than forty years ago. In addition, as traffic flow increases, typically average speeds decrease which also lowers road-traffic noise levels.

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\(^{21}\) Data from the NZTA reports on state highway traffic volumes and from www.heritagehelp.co.nz/mtvic.html

5.3 The do-nothing noise environment that will receive the Project

Note that NZS 6806: 2010 uses some terminology used also by other disciplines but defines it differently. In particular, in traffic modelling “do-minimum” is the situation without any project having been built but only, perhaps, some minor modifications to the situation currently existing necessary to allow increased future traffic volumes. In NZS 6806: 2010, this situation is the “do-nothing”. The NZS 6806: 2010 “do-minimum” is the project without any noise-specific mitigation. Care is needed when using this NZS 6806: 2010 concept of the do-nothing noise environment because it is a somewhat hypothetical construct. Many roading projects in urban environments are believed necessary because without them the road network performance would deteriorate and congestion would mount and likely decrease road-traffic speeds with consequent changes in road-traffic noise levels. These factors are too unpredictable to include in calculating the do-nothing noise environment. Consequently, the do-nothing noise environment is modelled as a projection of current behaviour into the future.

In modelling the do-nothing receiving noise environment, roads have been modelled as sealed with the road surface types that are currently in place.\(^{23}\) Note however, for various reasons including engineering, often different road surface types are used when resealing and therefore the road surface types in the 2021 do-nothing receiving situation could be different from those currently present, with consequently different noise levels. However, the known intended future reseals show little change in road surface type by 2021.

In modelling the do-nothing noise environment, the road layout is as would exist in 2021. Section 5.2 described the intended sequencing of projects around the area of the Basin Reserve. That intended sequence is used in modelling the do-nothing noise environment for the road layout as it would exist in 2021 without this Project being in place; that is the Buckle Street underpass would be in place and there would be one Mount Victoria Tunnel. Figure 5.9 shows the do-nothing road-traffic noise environment. This is the environment that will receive the Project. The coloured contour bands illustrate the noise level 2.0 metres above ground level. The broken or dashed blue line within the coloured contour bands represents 64 dB $L_{Aeq(24h)}$. As discussed previously, this noise level is significant to NZS 6806: 2010 as the upper threshold of Category A for “altered roads”. The solid or continuous blue line represents 67 dB $L_{Aeq(24h)}$. From NZS 6806: 2010, this is the upper threshold of Category B for “altered roads”.

There is one area in Figure 5.9 which should be treated with some caution, which is the traffic flows westbound on Rugby Street, northbound on Tasman Street and at-grade westbound on Buckle Street in front of the War Memorial. Design for traffic movements into the Buckle Street underpass and accessing Tory Street is still evolving. Figure 5.9 is based on traffic flows as advised in July 2012\(^{24}\), but with traffic that was at that time turning from Sussex Street into Buckle Street rerouted via Rugby Street and Tasman Street. Further traffic flows were advised in March 2013 following revisions to the Taranaki Street intersection and permitting lane changes within the Memorial Park Tunnel. The effect of these traffic flows changes on the do-nothing receiving situation noise levels calculated to date appears very small.

\(^{23}\) The documentation set Volume 5: Plan and Drawing Set contains a plan showing the road surfaces that are currently in place

\(^{24}\) Appendix 5.C shows a summary of the traffic volumes used in modelling the noise levels.
Figure 5.9: Road-traffic noise environment 2.0 metres above ground level for the do-nothing situation that will receive the Project (free-field noise levels, $dB L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Absolute noise levels</th>
<th>$dB L_{Aeq(24h)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 45</td>
<td>NO</td>
</tr>
<tr>
<td>≤ 47</td>
<td>RT</td>
</tr>
<tr>
<td>≤ 49</td>
<td>H</td>
</tr>
<tr>
<td>≤ 51</td>
<td></td>
</tr>
<tr>
<td>≤ 53</td>
<td></td>
</tr>
<tr>
<td>≤ 55</td>
<td></td>
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<td>≤ 57</td>
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<td>≤ 59</td>
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<td>≤ 61</td>
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<td>≤ 63</td>
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<td>≤ 65</td>
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<tr>
<td>≤ 67</td>
<td></td>
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<tr>
<td>≤ 69</td>
<td></td>
</tr>
<tr>
<td>≤ 71</td>
<td></td>
</tr>
<tr>
<td>≤ 73</td>
<td></td>
</tr>
</tbody>
</table>

Road surface: 67 dB $L_{Aeq(24h)}$
Bridge surface: 64 dB $L_{Aeq(24h)}$
5.4 The do-minimum Project noise environment

NZS 6806: 2010 makes a distinction between design features that are deliberately provided to reduce noise effects and those design features included in the project for other purposes but have also an influence on the noise effect. The design that occurs prior to inclusion of any design features deliberately provided to reduce noise is referred to as the do-minimum design.

NZS 6806: 2010 defines the “do-minimum” noise assessment scenario:

The predicted noise levels at the assessment position(s) of [Protected Premises and Facilities] at the design year with the project implemented including safety barriers and other structures (which may have an incidental noise mitigating effect). This assessment is not to include any measures undertaken for the sole purpose of reducing noise.

This clearly states the do-minimum design is not the design with nothing being done to mitigate noise effects. Rather, the do-minimum design separates out design features provided for another main purpose (but which may have also a noise mitigation effect) from those design features provided which have noise mitigation as their main purpose. The do-minimum design is the project without any noise-specific mitigation.

In practice, this rigid separation of the noise-specific design features and design features specific to other project aims can blur as the project progresses. As input from other specialist disciplines in the project team is used to develop the noise mitigation features of the Best Practicable Option, then, very often, choosing a noise mitigation design features takes into account potential other benefits. For example, bunding or walls included to mitigate noise may also improve landscaping and may assist social outcomes by desirable separation of activities or providing privacy. This encouragement and enhancement of integrated project design is an attribute of NZS 6806: 2010.

It is important to recognise the process of determining the Best Practicable Option for noise mitigation design features builds on the design of the project current at that time. Any new features then become embedded into the ongoing project design. The process is repeated so the project design develops iteratively. Eventually a particular project design will be set and designation for that design will be sought. The designation conditions will set out any noise mitigation design features required. The designation conditions will usually include a process that allows some flexibility should these design features need to change due to practicability issues.

5.4.1 Design of the do-minimum Project and noise reduction embedded in the design

The design of the Project has been an iterative process spread over about two years. Within that process, opportunities have been taken to minimise noise as far as is practicable by incorporating noise reduction features in the do-minimum Project design.

Overall, what is notable about noise mitigation options for this Project and this area is the extent that those options are heavily constrained both by the nature of the site and other urban design requirements. This is a mature area of roading and road surface types have usually already been selected with some consideration of road-traffic noise within the constraints of tight turning manoeuvres applying high stress and demanding high friction. The road surfaces for the Project are similarly constrained. Noisy road surfaces have already been avoided in the current do-minimum Project design, so the opportunities for reduction of noise via road surface selection are limited. The area has high pedestrian flows which could be adversely affected by barriers and also space for barriers is restricted. Urban design of usable spaces and integration of the road into its urban environment, an environment where road-traffic noise is expected, is a strong component of
the Project’s design. These factors all limit options to further reduce noise beyond reductions already embedded in the current do-minimum Project design.

- Noise reduction via road surface

Road-traffic noise generation is affected by properties of the traffic, such as the volume of traffic with its percentage of heavy vehicles and flow characteristics, plus the condition and type of the road surface. The road-traffic noise modelling takes account of the effect of the road surface on noise generation via a surface correction factor. Land Transport New Zealand Research Report 326\textsuperscript{25} gives surface correction factors for New Zealand conditions. To illustrate the effect of road surface selection; for the total traffic volume and the heavy vehicles portion of the flow forecast for 2021 with the Project operational and using asphaltic concrete as the reference road surface against which the noise effect of other road surfaces is judged:

- Using stone mastic asphalt, the relative noise difference would be an increase of 1.1 dB.
- Using open graded porous asphalt, the relative noise difference would be a decrease of 0.3 dB.
- Using high voids open graded porous asphalt, the relative noise difference would be a decrease of 2.2 dB.
- Using double-layer open graded porous asphalt, the relative noise difference would be a decrease of 2.3 dB

An important part of the do-minimum Project is the choice of road surface. Usually for roads of the type of this Project and in the vicinity of this Project, if there was no particular limitation on the choice of road surface, stone mastic asphalt or asphaltic concrete would be chosen. During the course of developing the current design of this Project, the do-minimum Project situation has evolved to now include some sections of road surfaces quieter than those originally proposed. In accordance with processes of NZS 6806: 2010, the process of this evolution included:

- Modelling of Project situations with various quieter road surfaces to establish the extent of effect possible. The example road surface effects listed above show the noise reductions that could be achieved between the default road surfaces (stone mastic asphalt) and other quieter road surfaces is no more than 3.3 dB and more typically 1.0 to 1.5 dB. These are only small gains in noise improvement and need to be balanced against other pavement requirements and serviceability. NZS 6806: 2010 provides a guide that mitigation should achieve a reduction of 3 dB L\textsubscript{Aeq(24h)} for it to be considered as effective although this needs to be tempered by some research that shows there is some benefit in smaller reductions if the noise level is already high\textsuperscript{26}.

- Discussion with other Project disciplines to understand the engineering constraints on use of some road surfaces. With the alignment and trafficking of the roads throughout the Project area, the engineering advice is that the selection of road surface is limited to those capable of withstanding relatively high levels of stress. Open graded porous asphalt is known as a quieter road surface and high voids open graded porous asphalt even quieter; but the feasibility of these road surfaces is limited where there is tight turning or other high


stress vehicle movements. These engineering constraints therefore excluded these surfaces from high stress areas such as the Kent Terrace/Ellice Street corner.

- Engineering advice included the financial implications of road surface selection. For example, while the initial costs of asphaltic concrete and open graded porous asphalt may be comparable, open graded porous asphalt has a much shorter service life. Therefore, as the noise difference for the traffic forecast for this Project is open graded porous asphalt only 0.3 dB quieter than asphaltic concrete, then asphaltic concrete is the preferred surface in many locations.

The documentation set Volume 5: Plan and Drawing Set contains a plan of the road surfaces intended, modelled as our do-minimum Project road surfaces. Other roads in the do-minimum-Project have been modelled with road surfaces matching the assumptions made for modelling of the do-nothing situation.

- Noise reduction via barriers

Barriers are not viable in many situations through the Project due to the immediate topography, nature and usage of the urban environment, multi-story buildings, and proximity between buildings and roads. Incorporating barriers was given serious consideration as the experience of the Wellington Inner City Bypass had shown acceptance of noise-reduction barriers adjacent to residential buildings because the barriers were of high-quality urban design so that they appear as a natural part of the built environment.

Noise reduction via barriers is examined even where it would obviously compromise other Project design criteria to confirm that the noise benefit offered by that mitigation is not warranted against its compromising of other Project design criteria and outcomes. Appendix 5B provides an example of this process for one location, the Grandstand Apartments building at 80 Kent Terrace. After this process was complete the only barriers included in the Project design are on the bridge and its approaches.

In the do-minimum Project situation, the bridge is modelled with continuous solid barriers at a height of 0.8 metres on both sides of the bridge, assumed as provided for safety purposes. These barriers have some slight effect on mitigation of road-traffic noise from the bridge but this is incidental to their main purpose of provision for safety.

- Bridge joints

The Basin Bridge will be constructed with a continuous deck. There will be a bridge expansion joint at either end of the deck, joining the deck to the two fixed abutments. These joints expand and contract to accommodate the movement of the bridge. Public consultation and input from other Project disciplines has shown concern about the noise of vehicles over the joints that will occur at either end of the bridge.

We are aware of a number of locations along the Wellington motorway where bridge expansion joints may cause noticeable noise effects both for noise-sensitive activities beside the bridge joint and for people using the space beneath the bridge. We are also aware of other bridge expansion joints with acceptable noise performance.

The noise from bridge joints is not a factor that can be dealt with in our model for road-traffic noise and needs to be considered separately. Usually, a bridge joint will introduce some tonal aspect into the noise, even though in some situations the total noise increases very little.

The NZTA has commissioned research into noise from bridge joints and methods by which it can be practicably reduced. As at early June 2013, a report of this research has not yet been published but an early draft has been made available to us. Part of the research is a literature
review. The literature review outlines the noise generating mechanisms of bridge expansion joints, including the observation that some of the mechanisms are not fully understood. While the literature has sourced a number of investigations into causes of complaint and remedial solutions, the literature generally lacks studies which methodically investigate the generic noise characteristics of a wide range of bridge expansion joint types. The literature review summarises advantages and disadvantages of a number of bridge expansion joint types. The literature also emphasises that joint performance is influenced by the quality of the installation.

A second part of the research has reviewed the NZTA bridge database to identify for measurement a range of existing bridge expansion joints, including joints designed to minimise noise. Measurements were made with an instrumented vehicle travelling over a range of bridge expansion joint types in Auckland, Tauranga, and Wellington. Analysis of the data gives understanding of the in-service performance of a range of bridge expansion joints to inform design and installation in this Project.

The main finding of the research is that in comparison to other joint types, finger type joints are shown to have both lower noise and a more consistent noise effect. This knowledge has been used to inform the design of the bridge expansion joint. A condition of the Project is for the constructor to use bridge expansion joints of this finger joint type or a type with equivalent or better noise performance. Therefore, any potential issue from noise at bridge expansion joints can be minimised.

5.4.2 Road-traffic noise environment for the do-minimum Project

Figure 5.10 shows the road-traffic noise environment modelled for the do-minimum Project situation. The coloured contour bands illustrate the noise level 2.0 metres above ground level.
Figure 5.10: Road-traffic noise environment 2.0 metres above ground level for the do-minimum Project situation (free-field noise levels, $dB_{L_{Aeq(24h)}}$)
5.5 Effects of the Project on the noise environment

The way the Project changes the noise environment can be investigated via a comparison of the do-minimum-Project situation versus the do-nothing situation, and Figure 5.11 is a visual demonstration of this comparison. The figure is constructed as the do-minimum Project situation noise environment (shown in Figure 5.10) minus the do-nothing situation noise environment (shown in Figure 5.9).

The coloured contour bands in Figure 5.11 illustrate the difference in road-traffic noise level 2.0 metres above ground level.

- Where the difference is negative, towards the green end of the scale, the do-minimum-Project noise environment is quieter than the do-nothing noise environment, so the noise levels with the Project in place are quieter than the noise levels if the existing road layout was retained.
- Where the difference is positive, towards the red end of the scale, the do-minimum-Project noise levels are higher than the do-nothing noise levels; so the noise levels with the Project in place are higher than the noise levels if the existing road layout was retained.

Where the nature of the noise and the changed noise are of the same type, here being road-traffic noise, some guidance towards interpreting the effects of change in the same type of noise follows in Note box 1.
Note box 1: Interpreting coloured contours showing change in the road-traffic noise environment

Figure 5.11 and a series of figures in Section 6 show change in the road-traffic noise environment. The figures use coloured contour bands to show the extent of noise level change. In the figures showing change in the road-traffic noise environment:

- There is a very light yellow coloured contour band for the interval -0.5 to 0.5 dB $L_{Aeq(24h)}$ which is an increase of noise of up to 0.5 dB $L_{Aeq(24h)}$ or a decrease of noise of up to 0.5 dB $L_{Aeq(24h)}$. This range can be interpreted as no change as it is extremely unlikely anyone could detect this scale of change in noise. This scale of change is also at the margins of measurable difference in noise levels.

- There is a yellow coloured contour band for an increase of noise between 0.5 and 1.5 dB $L_{Aeq(24h)}$ and a very light green coloured contour band for a decrease of noise between 0.5 and 1.5 dB $L_{Aeq(24h)}$. This 0.5 to 1.5 dB $L_{Aeq(24h)}$ range can be interpreted as a scale of change in noise level most people are unlikely to detect. Reliable measurements of this scale of change in noise can also be difficult.

- There is a darker yellow coloured contour band for an increase of noise between 1.5 and 2.5 dB $L_{Aeq(24h)}$ and a light green coloured contour band for a decrease of noise between 1.5 and 2.5 dB $L_{Aeq(24h)}$. This 1.5 to 2.5 dB $L_{Aeq(24h)}$ range can be interpreted as a scale of change in noise level where people might notice the change.

- In the figures showing change in the road-traffic noise environment, there are further colour bands indicating a range of noise increases or decreases of increasingly larger magnitude which are changes in noise more readily noticeable.

Note that a change in the noise level does not necessarily constitute an impact or effect on the community. The change in noise level may be noticed by the community but simply noticing the change is not an effect either. There is an extensive scientific literature on noise effects. Typically noise has an effect by interfering with our activities. For example, some noise may make listening to conversations more difficult which creates annoyance or some noise may prevent proper sleep which can then have health impacts. Increases in noise may increase these effects.

Research and literature show people’s response to noise is extremely broad and individually subjective. Generally the percentage of the population disturbed by noise increases only slowly as the noise level increases.
Figure 5.11: Change in the road-traffic noise environment 2.0 metres above ground level for the comparison of the do-minimum-Project situation versus the do-nothing situation that will receive the project, to illustrate effects of the Project (free-field noise levels, dB $L_{Aeq(24h)}$).
Figure 5.11 shows for the majority of the noise study area, the change in noise levels of the do-minimum Project compared with the do-nothing situation is within 1.5 dB $L_{Aeq(24h)}$ increase or decrease. As discussed before, most people are unlikely to notice this scale of change. Therefore, we can say generally the scale of noise effects of the Project is very minor or negligible for the majority of the area.

Figure 5.11 shows two very localised areas close to the roadway with strong red colouring indicating the road-traffic noise levels are higher with the do-minimum Project in place compared to noise levels with the do-nothing situation. There is one area of strong green colouring indicating a decrease in noise between the two situations. These noise changes are particularly associated with the change in road layout: noise level increases where the bridge abutments are introduced and noise level decreases where the link from Kent Terrace to Paterson Street is moved to accommodate the bridge abutment.

In Figure 5.11, the more pale green colouring around the southern half of the Basin Reserve demonstrates the road-traffic noise environment is slightly quieter with the do-minimum-Project in place compared to that noise environment with the do-nothing situation. This change in noise environment is directly related to the traffic flow changes between the two situations, as the road-traffic transfers onto the bridge. Road layout changes in this area between the two situations are small and have only slight, if any, effects on the noise environment.

Relative to the do-nothing situation, in the do-minimum Project situation the traffic flow decreases along Ellice Street between Hania Street and Brougham Street. This influences noise level decreases shown by the green colouring along this link in Figure 5.11. The traffic transferring from this link will redistribute through the local road network but it is understood that traffic modelling of this redistribution is complex. However, in terms of road-traffic noise, as any of the traffic volumes involved are small, regardless of the redistribution patterns that eventuate, the noise effects of the redistribution will be less than minor and most likely negligible.

### 5.5.1 Particular effects of the bridge

Public consultation and input from other Project disciplines has shown concern about the effects of the bridge as a source of road-traffic noise.

We believe one factor that helps in addressing this concern is understanding the traffic volume on the bridge relative to the traffic volume at-grade. For instance, near the corner of Kent Terrace and Ellice Street: the 2021 do-minimum traffic volume on the bridge is about 15,500 vehicles per day (annual average daily traffic); and at-grade the do-minimum traffic volume is about 31,500 vehicles per day turning from Kent Terrace (southward) to Ellice Street (eastward).\(^{27}\) In this area at ground level, the at-grade traffic would clearly be the dominant noise source. (Principal traffic flow inputs to the noise assessment are indicated in the appendices to this report.)

We have constructed and inspected cross-sections of the road-traffic noise environment to illustrate the contribution of the bridge to the noise environment. The diagrams are effectively looking eastwards and the cross-section is taken from north of the Basin Reserve through buildings adjacent Kent Terrace, then across the Basin Reserve, to south of the Basin Reserve through buildings adjacent Adelaide Road, as indicated in Figure 5.12.

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\(^{27}\) Appendix 5.D shows a summary of the traffic volumes used in modelling the noise levels.
The diagrams in Figure 5.13 are cross-sections of road-traffic noise environments, up to about 50 metres above ground level.

- The first diagram illustrates the contribution to the road-traffic noise environment of the bridge and its traffic but with no other roads or traffic present. This diagram indicates the effect across the Basin Reserve of the bridge and its traffic is slight.
- The second diagram illustrates the contribution of the at-grade roads and their traffic.
- The third diagram is for the combination of those contributions, being the do-minimum Project situation. This diagram is substantially similar to the second diagram for the contribution of the at-grade roads and their traffic, indicating the at-grade traffic is the dominant noise source.

Therefore while the bridge does contribute to the road-traffic noise environment, this section establishes that the effects of the bridge are minor compared to the extent of other road-traffic noise already in the Project area.

This feature affects the potential for effective noise mitigation via mitigation of the bridge noise source. The do-minimum Project situation has the bridge surfaced with high stress open graded porous asphalt which we are advised is the quietest feasible road surface for the bridge. With the characteristics of the traffic using the bridge, if they were available for use and later found to be technically feasible, quieter road surfaces such as high voids open graded porous asphalt or two-layer open graded porous asphalt could reduce the source noise by 2 dB. However this noise reduction is diluted when combined with the contributions to receivers by traffic on the at-grade roads so the effect of any quieter road surfaces on the bridge is likely to be negligible for most receivers.
Figure 5.13: Road-traffic noise environment cross-section from north of the Basin Reserve through Kent Terrace to south of the Basin Reserve through Adelaide Road buildings (free-field noise levels).

<table>
<thead>
<tr>
<th>Noise Environment</th>
<th>Noise Levels (dB L Aeq(24h))</th>
</tr>
</thead>
<tbody>
<tr>
<td>North, Kent Terrace buildings</td>
<td>≤ 45</td>
</tr>
<tr>
<td>Basin Reserve</td>
<td>45 &lt; ≤ 47</td>
</tr>
<tr>
<td>South, Adelaide Road buildings</td>
<td>47 &lt; ≤ 49</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project and its traffic on both the bridge and the at-grade roads</td>
<td>51 &lt; ≤ 53</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project at-grade roads and their traffic but no traffic on the bridge</td>
<td>53 &lt; ≤ 55</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project bridge and its traffic but no other traffic on at-grade roads</td>
<td>55 &lt; ≤ 57</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project bridge and its traffic but no other traffic on at-grade roads</td>
<td>57 &lt; ≤ 59</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project bridge and its traffic but no other traffic on at-grade roads</td>
<td>59 &lt; ≤ 61</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project bridge and its traffic but no other traffic on at-grade roads</td>
<td>61 &lt; ≤ 63</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project bridge and its traffic but no other traffic on at-grade roads</td>
<td>63 &lt; ≤ 65</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project bridge and its traffic but no other traffic on at-grade roads</td>
<td>65 &lt; ≤ 67</td>
</tr>
<tr>
<td>Noise environment from the do-minimum Project bridge and its traffic but no other traffic on at-grade roads</td>
<td>67 dB L Aeq(24h)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Road Surface</th>
<th>Bridge Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>67 dB L Aeq(24h)</td>
<td>64 dB L Aeq(24h)</td>
</tr>
</tbody>
</table>
6 Assessment of do-minimum Project road-traffic noise levels and the Best Practicable Option to mitigate noise

Section 5 provided an overview of the effects of the Project, concluding that any effects appear to be less than minor and most likely negligible. This section, Section 6, contains details for each of the locations identified as requiring assessment. The details include the noise level change caused by the Project, the total noise level with the Project, and discussion of any opportunities that may exist to reduce road-traffic noise levels for that location.

This section contains tables showing road-traffic noise levels. These noise levels are used to identify the effect of the do-minimum Project on road-traffic noise. For each assessed location:

- We identified the position on the assessed location with the greatest total noise level with the do-minimum Project. Then the potential effects of that total noise level are determined using guidance as to acceptable noise levels such as the “altered road” noise criteria from NZS 6806: 2010.
- At that same position with the greatest total noise level, we also identified the noise level change caused by the do-minimum Project. Then the potential effects of that change are determined using guidance such as from the NZTA Noise Guidelines.
- We identified a further position on the assessed location. This is the position with the maximum noise level change caused by the do-minimum Project. Then the potential effects of that change are determined using guidance such as from the NZTA Noise Guidelines.

To identify the position of greatest noise exposure for an assessed location, receiver positions are modelled in a grid across the full faces of the building (as demonstrated in Figure 5.14) and the position of greatest exposure is revealed. (Similarly, to identify the position of maximum change in noise level caused by the Project, receiver positions are modelled across the full faces of the building for both the do-minimum Project situation and the do-nothing receiving situation. The pairs of values for each modelled receiver position are compared and the position of maximum change is revealed.)

The grid of receivers was set with 1 metre spacing between the receivers. This method of a grid of receivers across the full faces of a building is a departure from the approach recommended by NZS 6806: 2010, but a more conservative one. NZS 6806: 2010 would normally expect assessment for a habitable space at the exterior wall most affected by road-traffic noise. But the method of placement of the grid of receivers is both effective and comprehensive. In the noise-study area there are many multi-storey buildings for which it is difficult to distinguish from the outside which rooms are the habitable spaces and which are service rooms or other and the older houses may have basement areas and attic rooms that are not apparent without a detailed internal property inspection. The coverage provided by our grid of receiver positions simplifies the assessment and the presentation of results. Noise effects on buildings can be quickly identified. If significant noise effects were identified for a grid receiver position the than position and the building in full can be further examined to identify how the habitable spaces are affected differentially.

28 The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
6.1 Notes to this section

Figure 5.15 shows how the following sections correspond to subareas within the noise study area.

- Section 6.2 is a special section describing the National War Memorial Park, the Home of Compassion Crèche (former) building, and the Basin Reserve.
• Section 6.3 describes assessed locations west of Cambridge Terrace and north of Buckle Street.
• Section 6.4 describes assessed locations west of Sussex Street between Buckle Street and Rugby Street.
• Section 6.5 describes assessed locations south of Rugby Street.
• Section 6.6 describes assessed locations east of Dufferin Street between Ellice Street and Rugby Street.
• Section 6.7 describes assessed locations east of Kent Terrace and north of Ellice Street.
• Section 6.8 is another special section considering any road-traffic noise effects of the Project mitigation structures of the Northern Gateway Building and the Building under the Bridge.

Each section includes a table giving details for each assessed location in the subarea. In the tables:

• All noise levels in the tables are stated as 24 hour equivalent noise levels measured in A-weighted decibels, dB $L_{Aeq(24h)}$, for the free-field position.
• Noise levels and noise level changes are reported to the first decimal place. While it is recognised that this level of precision is higher that can be reliably measured or perceived, we have maintained this level of detail because it avoids some of the anomalies and potential confusion that can arise if the noise levels are rounded to whole numbers only, especially when comparing one modelled situation with another or for inspecting the effect of noise mitigation. Using one decimal place, still some noise level changes shown in the tables will appear incorrectly calculated ($\pm 0.1 \text{ dB } L_{Aeq(24h)}$) but this is a rounding error.\(^{29}\)

In each table, the first column contains an abbreviation of the address of the assessed location and an alphanumeric identifier assigned to that location. The identifier is also used in the figure showing the area.

After the first column in the tables, the next ten columns are in two groups:

• One group, columns 2 to 6, shows details relating to the assessed location’s position of greatest exposure to road-traffic noise in the do-minimum Project situation.
• The second group, columns 7 to 11, shows details relating to the position on the assessed location where there is the maximum noise level change caused by the do-minimum Project. The position of maximum change is explained in Note box 2 on page 48.

• The five columns in each group show the do-nothing situation noise level, the do-minimum Project situation noise level, the height of that position on the location\(^{30}\), the direction or outlook that position faces towards, and the change in noise level caused by the Project.

Both groups of details are considered in determining potential effects of the do-minimum Project.

\(^{29}\) For a further comment on this, please refer to the footnote in Section 6.2.2

\(^{30}\) Note the heights are determined automatically and based on approximate representations of the buildings (including the building heights) provided to the noise assessment (“Basin Reserve Base – Buildings.dxf” supplied by Mark Edwards in email 16 October 2009) and a ground model that also involves approximations. The heights are provided to give some indication of the location of the subject position and are not intended to be used in an absolute sense.
Note box 2: Change in noise level at the “position of maximum change”

The change in noise level caused by the do-minimum Project is calculated by comparing the do-minimum Project situation noise level with the do-nothing receiving situation noise level.

- The change in noise level is greater than zero if the noise level increases with the do-minimum Project relative to the do-nothing receiving situation.
- The change in noise level is less than zero if the noise level decreases with the do-minimum Project relative to the do-nothing receiving situation; so the do-minimum Project makes it quieter.

The change in noise level is calculated for a full grid of receiver positions modelled across the full faces of the each assessed building. From the range of all the noise level changes across a building’s grid of receiver positions, we use “maximum change” to indicate the greatest noise level increase, being the largest change in noise level greater than zero.

However, if all the noise level changes calculated are less than zero for all the building’s grid of receiver positions, we use “maximum change” to indicate the smallest noise level decrease. For example, if a building’s noise level changes ranged between a decrease of -1.0 dB and a decreases of -3.5 dB, then the smallest of those noise level decreases is -1.0 dB and this is reported as the “maximum change”.

6.2 The National War Memorial Park, the Home of Compassion Crèche (former) building, the Basin Reserve

6.2.1 The National War Memorial Park

Section 3.5 explains the National War Memorial Park which will be completed by the end of 2014, prior to commencement of this Project. Therefore the National War Memorial Park is part of the environment receiving the Project. The National War Memorial Park lies between two areas that may be influenced by the Project. Although the road (Buckle Street) will be in a underpass directly in front of the main memorial area, there will be altered flows of traffic at the eastern underpass portal and on Tory Street, and altered flows of traffic emerging from the western underpass portal and there may be altered turning movements at the Buckle Street/Taranaki Street/Arthur Street intersection. The main Buckle Street and westbound State Highway traffic flow will be in the underpass but an access lane to buildings on the southern side of Buckle Street and the National War Memorial buildings will be retained at surface level. Figure 5.16 shows the road-traffic noise environment for the do-minimum Project situation for this area. It is shown that the National War Memorial Park generally has a low noise environment with noise levels typically 49 to 53 dB $L_{Aeq(24h)}$. 
Figure 5.16: Do-minimum Project road-traffic noise environment 2.0 metres above ground level for the area of the National War Memorial Park (free-field noise levels, $dB L_{Aeq(24h)}$)

Figure 5.17: shows the change in noise level caused by the do-minimum Project at 2.0 metres above ground level. The noise level changes and colourings are as explained in Note box 1 on page 40 in Section 5.5. The noise level changes caused by the Project are seen to be only small and so the Project is considered to have no significant effect on the National War Memorial Park.

Figure 5.17: Road-traffic noise level changes caused by the do-minimum Project 2.0 metres above ground level for the area of the National War Memorial Park (free-field noise levels, $dB L_{Aeq(24h)}$)

The building of the Hall of Memories and the National Carillon is a tall building overlooking the area that may be influenced by the Project. To identify any potential effects at higher levels, Figure
5.18 shows the road-traffic noise levels on the facades of the building for the do-minimum Project situation and Figure 5.19 shows the road-traffic noise level changes caused by the do-minimum Project. The building is in a low noise environment. While higher portions of the building are more exposed to road-traffic noise than lower portions of the building, still noise levels are only low to moderate.

Figure 5.18: Two views of the road-traffic noise exposure at facades of the Hall of Memories and National Carillon for the do-minimum-Project situation (adjusted to free-field noise levels, $dB\ L_{Aeq(24h)}$)

Figure 5.19: Two views of the road-traffic noise level changes caused by the do-minimum Project at facades of the Hall of Memories and National Carillon (adjusted to free-field noise levels, $dB\ L_{Aeq(24h)}$)

Table 5.3 gives noise levels for the Hall of Memories and the National Carillon. For each, the table provides details for the position with the greatest exposure to road-traffic noise in the do-minimum Project situation; and details for the position where there is the maximum noise level change caused by the do-minimum Project.
Table 5.3: Road-traffic noise levels for the Hall of Memories and the National Carillon (free-field position, dB $L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
</tr>
<tr>
<td></td>
<td>Approximate height of position (m)</td>
<td>Facing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Do-nothing receiving situation</td>
</tr>
<tr>
<td>B07 Hall of Memories</td>
<td>52.5</td>
<td>52.9</td>
</tr>
<tr>
<td>B07 Carillon tower</td>
<td>57.4</td>
<td>57.6</td>
</tr>
</tbody>
</table>

Over the facades of the Hall of Memories and the Carillon tower, the maximum noise level increases caused by the do-minimum Project are 1.0 dB $L_{Aeq(24h)}$. We have also inspected the total noise level at the front doorway to the structure and here the do-minimum Project noise level is 51.7 dB $L_{Aeq(24h)}$ at 1.5 metres above ground level and 52.0 dB $L_{Aeq(24h)}$ at 2.0 metres above ground level. The Project causes a noise level increase of 0.4 dB $L_{Aeq(24h)}$ at each height. The magnitude of noise level changes would likely not be noticed by most people and reliable measurement of the change would be difficult, so the Project is considered as having negligible effect.

We also use the United States Department of Transportation Federal Highway Administration (FHWA) guidance for noise in exterior “lands on which serenity and quiet are of extraordinary significance and serve an important public need.” 23 CFR Part 772 “Procedures for abatement of highway traffic noise and construction noise” states the criteria for impact determination is 57 dB $L_{eq(1h)}$ and 60 dB $L_{10(1h)}$. (Note it is intended either of these sound levels are used, but not both, and the values are for impact determination only and are not design standards for noise abatement measures.) With this guidance, we consider the effects of the Project to be less than minor.

The Project’s effects on this area require no further noise mitigation.

6.2.2 The Home of Compassion Crèche (former)

The Home of Compassion Crèche (former) building is constructed of reinforced concrete and brick. The building is registered as Category I with the New Zealand Historic Places Trust. Note that compared to its present (2012) position, prior to this Project, the building will be relocated as part of the National War Memorial Park project. Figure 5.20 indicates the current position of the building and the building in its relocated position for which the noise assessment is undertaken.

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31 The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
Figure 5.20: The current position of the Home of Compassion Crèche (former) building and the position where it will be relocated prior to this Project

- Figure 5.21 shows the road-traffic noise environment around the Home of Compassion Crèche (former) building for the do-nothing receiving situation.
- Figure 5.22 shows the road-traffic noise environment around the Home of Compassion Crèche (former) building for the do-minimum Project situation.
- Figure 5.23 shows how noise levels change between the do-nothing receiving situation and the do-minimum Project situation. The noise level changes and colourings are as explained in Note box 1 on page 40 in Section 5.5.
- Table 5.4 details noise levels for the Home of Compassion Crèche (former) building.
**Figure 5.21:** Do-nothing receiving road-traffic noise environment 2.0 metres above ground level for the area of the Home of Compassion Crèche (former) building (free-field noise levels, $\text{dB } L_{\text{Aeq}(24h)}$)

<table>
<thead>
<tr>
<th>Absolute noise levels</th>
<th>$\text{dB } L_{\text{Aeq}(24h)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$45 &lt;$</td>
<td>$\leq 45$</td>
</tr>
<tr>
<td>$47 &lt;$</td>
<td>$\leq 47$</td>
</tr>
<tr>
<td>$49 &lt;$</td>
<td>$\leq 49$</td>
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<tr>
<td>$51 &lt;$</td>
<td>$\leq 51$</td>
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<td>$53 &lt;$</td>
<td>$\leq 53$</td>
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<td>$55 &lt;$</td>
<td>$\leq 55$</td>
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<tr>
<td>$57 &lt;$</td>
<td>$\leq 57$</td>
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<td>$59 &lt;$</td>
<td>$\leq 59$</td>
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<td>$61 &lt;$</td>
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<td>$\leq 63$</td>
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<tr>
<td>$65 &lt;$</td>
<td>$\leq 65$</td>
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<tr>
<td>$67 &lt;$</td>
<td>$\leq 67$</td>
</tr>
<tr>
<td>$69 &lt;$</td>
<td>$\leq 69$</td>
</tr>
<tr>
<td>$71 &lt;$</td>
<td>$\leq 71$</td>
</tr>
<tr>
<td>$73 &lt;$</td>
<td>$\leq 73$</td>
</tr>
</tbody>
</table>

**Figure 5.22:** Do-minimum Project road-traffic noise environment 2.0 metres above ground level for the area of the Home of Compassion Crèche (former) building (free-field noise levels, $\text{dB } L_{\text{Aeq}(24h)}$)

<table>
<thead>
<tr>
<th>Absolute noise levels</th>
<th>$\text{dB } L_{\text{Aeq}(24h)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$45 &lt;$</td>
<td>$\leq 45$</td>
</tr>
<tr>
<td>$47 &lt;$</td>
<td>$\leq 47$</td>
</tr>
<tr>
<td>$49 &lt;$</td>
<td>$\leq 49$</td>
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<tr>
<td>$51 &lt;$</td>
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<tr>
<td>$67 &lt;$</td>
<td>$\leq 67$</td>
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<tr>
<td>$69 &lt;$</td>
<td>$\leq 69$</td>
</tr>
<tr>
<td>$71 &lt;$</td>
<td>$\leq 71$</td>
</tr>
<tr>
<td>$73 &lt;$</td>
<td>$\leq 73$</td>
</tr>
</tbody>
</table>
Technical Report 5: Assessment of noise effects

Figure 5.23: Road-traffic noise level changes caused by the do-minimum Project 2.0 metres above ground level for the Home of Compassion Crèche (former) building (free-field noise levels, dB $L_{Aeq(24h)}$)

Table 5.4: Road-traffic noise levels for the Home of Compassion Crèche (former) building (free-field position, dB $L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change $^{32}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do-minimum Project situation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Approximate height of position (m)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Facing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Change caused by do-minimum Project</td>
<td></td>
</tr>
<tr>
<td>Home of Compassion Crèche (former)</td>
<td>64.6</td>
<td>67.3</td>
</tr>
</tbody>
</table>

In the do-minimum Project situation, at its position of greatest exposure to total road-traffic noise, the Home of Compassion Crèche (former) building has a noise level just above the 67 dB $L_{Aeq(24h)}$ threshold into Category C using NZS 6806: 2010 noise criteria for altered roads. The property is owned by the NZTA and as owner of the property the NZTA has given acceptance of any noise effects and does not request any further noise mitigation. However, the changes in noise caused by the Project are still noted. When the cumulative effects of the National War Memorial Park and this Basin Bridge Project are considered, the do-minimum Project situation noise levels for the Home of Compassion Crèche (former) building in its position of relocation due to the National War Memorial Park project are very similar to the noise levels that would exist if the building had been left in its current position (as indicated in Figure 5.7 for the current/2009 situation) and this Basin Bridge Project was not built. In the period between its relocation as part of the National War

$^{32}$ The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
Memorial Park project and this Project, the Home of Compassion Crèche (former) building will have a period with a temporary lower noise environment.

During this Project’s development, noise mitigation options were investigated for the Home of Compassion Crèche (former) building. As Section 5.4 explained, the do-minimum Project has already evolved to include use of the quietest road surfaces feasible. A potential barrier was modelled adjacent to the road from the end of the bridge then westwards past the Home of Compassion Crèche (former) building. Other Project disciplines stated this barrier would have unacceptable outcomes for other Project disciplines. The barrier was said to reduce public amenity plus concerns were raised about personal security for pedestrians. The barrier was said to be undesirable for its visual effects and also social effects limiting connectivity. The barrier conflicted with the intended urban design of the building being in direct view at the head of Sussex Street. The barrier could also have some adverse heritage effects as it was highlighted there had been other efforts to remove safety barriers from in front of the building to increase its connection to the environment.

As part of this investigation of noise-mitigation options, building-modification mitigation to provide reduction of internal noise levels was also considered, though it would not address noise levels for any of the area outside of the Home of Compassion Crèche (former) building. Mitigation via any building-modification would need to be achieved with sensitivity to the building’s heritage context. Acoustic insulation and any other prevention measures need to be implemented without compromising heritage values, especially in relation to windows and doors. Also noted is that upgrading of windows and seals may necessitate provision of alternative ventilation to satisfy the New Zealand Building Code Clause G4 for ventilation. The need for internal mitigation also depends on the building’s usage and there would be many potential usages for which the internal noise environment is satisfactory without further mitigation.

In conclusion, the Project requires no further noise mitigation for the Home of Compassion Crèche (former) building: first because the owner does not desire any mitigation to be provided; and second because potential mitigation options further than those already embedded within the Project design are not practicable.

6.2.3 Basin Reserve

The Basin Reserve Pavilion is registered as Category II with the New Zealand Historic Places Trust. The whole Basin Reserve area is registered as an historic area, including the RA Vance Stand and other structures within the area. Four buildings within the Basin Reserve area are assessed. Some positions within the sports ground were chosen to represent the overall grounds of the Basin Reserve area.

The Basin Reserve area is regarded as an important feature of the Project area. The ground and its immediate surrounds are registered as a historic area with the New Zealand Historic Places Trust. The Basin Reserve Pavilion is registered as Category II with the New Zealand Historic Places Trust and houses the New Zealand Cricket Museum. The RA Vance Stand is used by spectators and also provides facilities such as the Long Room for functions and meetings. The
ground itself, when not in use for sport or some open-air community events, acts as a thoroughfare for pedestrians and cyclists and as a quieter green space within the urban environment.

Over time the configuration of the Basin Reserve, as to its buildings and embankments, has evolved to accommodate its adjacent environment of busy road-traffic routes. These features partly shield the playing ground from surrounding road-traffic noise so that the current noise level is understood to be regarded as satisfactory for the sports played on the Basin Reserve playing area and for the spectators who watch. Conversations in the playing area are readily achieved at an acceptable voice level. This road-traffic noise assessment has treated the Basin Reserve as empty, without spectator crowds, but in major competition games, there is substantial noise generated within the Basin Reserve by spectator crowds and by loudspeaker systems for public address and music so that any potential issues with road-traffic noise are lessened.

Figure 5.24 shows four buildings shaded yellow within the area of the Basin Reserve. These buildings are assessed. Figure 5.24 also shows two positions, in the playing field and on the embankment area, where receivers have been modelled to give noise level values.

Figure 5.25 shows the road-traffic noise environment for this area for the do-minimum Project situation and Figure 5.26 shows the noise level changes caused by the do-minimum Project.

For the four buildings assessed, Table 5.5 shows road-traffic noise levels so any effects of the do-minimum Project can be determined. Table 5.6 shows the road-traffic noise levels for the two additional receiver positions modelled in the Basin Reserve grounds.

Figure 5.24: Assessed locations shaded yellow in the area of the Basin Reserve plus circles indicating two receiver positions
Figure 5.25: Do-minimum Project road-traffic noise environment 2.0 metres above ground level for the Basin Reserve (free-field noise levels, $dB \ L_{Aeq(24h)}$)

Figure 5.26: Road-traffic noise level changes caused by the do-minimum Project 2.0 metres above ground level for the Basin Reserve (free-field noise levels, $dB \ L_{Aeq(24h)}$)
Table 5.5: Road-traffic noise levels for the Basin Reserve (free-field position, dB $L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change$^{34}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
</tr>
<tr>
<td></td>
<td>Approximate height of position (m)</td>
<td>Approximate height of position (m)</td>
</tr>
<tr>
<td></td>
<td>Facing</td>
<td>Change caused by do-minimum Project</td>
</tr>
<tr>
<td>E01 RA Vance stand</td>
<td>65.7</td>
<td>67.4</td>
</tr>
<tr>
<td>E02 Museum grandstand</td>
<td>72.3</td>
<td>69.6</td>
</tr>
<tr>
<td>E03 adjacent Sussex</td>
<td>60.4</td>
<td>58.8</td>
</tr>
<tr>
<td>E04 adjacent Rugby</td>
<td>70.2</td>
<td>68.7</td>
</tr>
</tbody>
</table>

Table 5.6: Road-traffic noise levels for receivers in the Basin Reserve grounds (free-field position, dB $L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Receiver</th>
<th>Height above ground</th>
<th>Do-nothing receiving situation</th>
<th>Do-minimum Project situation</th>
<th>Change caused by do-minimum Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>near centre of ground</td>
<td>1.5 m</td>
<td>56.1</td>
<td>56.0</td>
<td>-0.1</td>
</tr>
<tr>
<td>near centre of ground</td>
<td>2.0 m</td>
<td>56.5</td>
<td>56.4</td>
<td>-0.1</td>
</tr>
<tr>
<td>on northeast embankment</td>
<td>1.5 m</td>
<td>59.1</td>
<td>59.3</td>
<td>0.2</td>
</tr>
<tr>
<td>on northeast embankment</td>
<td>2.0 m</td>
<td>60.6</td>
<td>60.3</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

Figure 5.26 shows for a substantial area of the Basin Reserve, there is little change in noise levels between the do-nothing receiving situation and the do-minimum Project situation. Over almost all of the Basin Reserve playing area, noise level changes with the do-minimum Project are within 1.5 dB $L_{Aeq(24h)}$ as a noise increase or decrease.

For the buildings in the Basin Reserve area, Table 5.5 shows increases in road-traffic noise at the northern end of the RA Vance Stand. The noise increases are considered to have effect less than minor given the usage of the building/structure and the orientation of the facades with noise increases. The noise levels for the other assessed locations (and other areas of the RA Vance Stand) decrease by a small amount. No further noise mitigation is required.

The values in Table 5.6 show with the do-minimum Project operational, noise levels in the centre of the playing area are just quieter than 57 dB $L_{Aeq(24h)}$. On the inside of the northeast embankment, noise levels are less than 61 dB $L_{Aeq(24h)}$. These noise levels are almost identical to the noise levels that would exist in the do-nothing receiving situation.

There are no specific New Zealand criteria as regards to road-traffic noise into outdoor spaces and recreational areas. We have considered the noise level changes caused by the Project against scales of speech interference. With regard to the typical noise level in the Basin Reserve playing area, the degree of change in noise, shown in Figure 5.26 to be typically 1 to 2 dB $L_{Aeq(24h)}$, is smaller than the amount of change in noise that would have to occur for a speaker to have to alter

$^{34}$ The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
how they speak to maintain effective communication. Typically the change in noise that would cause a speaker to change from normal to raised voice, or raised to loud voice is an increment of about 5 dB.

We can also use the United States Department of Transportation Federal Highway Administration (FHWA) guidance for noise in exterior open areas, of the type of active sport areas, recreation areas, parks, and picnic areas. 23 CFR Part 772 “Procedures for abatement of highway traffic noise and construction noise” states the criteria for impact determination is 67 dB $L_{eq(1h)}$ and 70 dB $L_{10(1h)}$. (Note it is intended either of these sound levels are used, but not both, and the values are for impact determination only and are not design standards for noise abatement measures.) Taking all these factors into account, we consider the effects of the Project on the Basin Reserve grounds will be less than minor when in its normal use as a quiet area or for local recreation, and for there to be no effect for major sports events when crowds are present.

### 6.3 West of Cambridge Terrace and north of Buckle Street

Aside from the Home of Compassion Crèche (former) building (discussed in Section 6.2) there are three locations to be assessed in the area west of Cambridge Terrace and north of Buckle Street. There are two Tory Street buildings that could be used as residences, A08 and A09. These buildings front onto Tory Street. A07 is immediately to the west of the rear of these two buildings, further from Tory Street. A07 is part of Mount Cook School. Mount Cook School has a number of buildings but we have assessed only the one closest to Buckle Street. These buildings will be those most exposed to potential effects of the Project. The traffic flow on Tory Street is principally unchanged between the receiving do-nothing situation and the do-minimum Project situation. For A07, A08, and A09 there is potential influence from increased traffic flow into the Buckle Street underpass with the Project operational.

- Figure 5.27 shows the positions and reference-identifiers for the assessed locations in this area.
- Figure 5.28 shows the road-traffic noise environment for the do-minimum Project situation.
- Figure 5.29 shows how noise levels change between the do-nothing receiving situation and the do-minimum Project situation. The noise level changes and colourings are as explained in Note box 1 on page 40 in Section 5.5.
- Table 5.7 details noise levels for the assessed locations.
Figure 5.28: Do-minimum Project road-traffic noise environment 2.0 metres above ground level for the area west of Cambridge Terrace and north of Buckle Street (free-field noise levels, dB $L_{Aeq(24h)}$)

Figure 5.29: Road-traffic noise level changes caused by the do-minimum Project 2.0 metres above ground level for the areas west of Cambridge Terrace and north of Buckle Street (free-field noise levels, dB $L_{Aeq(24h)}$)
Table 5.7: Road-traffic noise levels for the area west of Cambridge Terrace and north of Buckle Street (free field position, $dB L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change</th>
<th>Change caused by do-minimum Project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
<td>Approximate height of position (m)</td>
</tr>
<tr>
<td>A07 Mount Cook School</td>
<td>53.0</td>
<td>53.4</td>
<td>2</td>
</tr>
<tr>
<td>A08 176 Tory</td>
<td>66.2</td>
<td>66.2</td>
<td>3</td>
</tr>
<tr>
<td>A09 178 Tory</td>
<td>66.0</td>
<td>66.1</td>
<td>3</td>
</tr>
</tbody>
</table>

The Mount Cook School building closest to Buckle Street, A07, is well-shielded from road-traffic noise. Towards Tory Street, A08 176 Tory and A09 178 Tory have high exposure to road-traffic noise, and this is consistent between the do-minimum Project situation and the do-nothing receiving situation. For A08 176 Tory and A09 178 Tory, the noise levels at the position of greatest exposure are Category B noise levels using the NZS 6806: 2010 noise criteria for altered roads. However, the noise level changes caused by the do-minimum Project are negligible and well within a scale that most people would not detect and cannot be reliably measured. Therefore, there are no adverse effects of the do-minimum Project. Investigation of mitigation is not required.

6.4 West of Sussex Street between Buckle Street and Rugby Street

The area west of Sussex Street between Buckle Street and Rugby Street includes the National War Memorial Park which is discussed in Section 6.2. Other assessed locations in the area, discussed in this Section, are:

- the former Mount Cook Police Station (B09) which although currently used for commercial purposes is assessed as it is registered as Category I with the New Zealand Historic Places Trust;
- a number of multi-unit residential buildings such as Tasman Gardens (C01, C02, C03), Massey University Basin Reserve Complex and Te Awhina Complex accommodation (C04 to C10);
- a church on Tasman Street (C12);
- the Marksman Motor Inn motel (C20); and
- individual houses.

(23 Tasman Street is used as a veterinary clinic and is not assessed.)

- Figure 5.30 shows the positions and reference-identifiers for the assessed locations in this area.
- Figure 5.31 shows an aerial view of the road-traffic noise environment (2.0 metres above the ground) for the do-minimum Project situation. Figure 5.33 shows a three-dimensional view of

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35 The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
the area between Tasman Street and Sussex Street as viewed from north of Buckle Street for the do-minimum Project situation.

- Figure 5.32 shows how noise levels change between the do-nothing receiving situation and the do-minimum Project situation. The noise level changes and colourings are as explained in Note box 1 on page 40 in Section 5.5.

- Figure 5.34 shows these noise level changes on a three-dimensional view of the area between Tasman Street and Sussex Street as viewed from north of Buckle Street.

- Table 5.8 details noise levels for the assessed locations.

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Figure 5.30: Assessed locations shaded yellow in the area west of Sussex Street between Buckle Street and Rugby Street
Figure 5.31: Do-minimum Project road-traffic noise environment 2.0 metres above ground level for the area west of Sussex Street between Buckle Street and Rugby Street (free-field noise levels, $dB L_{Aeq(24h)}$)

Figure 5.32: Road-traffic noise level changes caused by the do-minimum Project 2.0 metres above ground level for the area west of Sussex Street between Buckle Street and Rugby Street (free-field noise levels, $dB L_{Aeq(24h)}$)
Figure 5.33: Road-traffic noise exposure at facades of buildings fronting Buckle Street for the do-minimum Project situation (adjusted to free-field noise levels, dB $L_{Aeq(24h)}$)

Figure 5.34: Road-traffic noise level changes caused by the do-minimum Project at facades of buildings fronting Buckle Street (adjusted to free-field noise levels, dB $L_{Aeq(24h)}$)
Table 5.8: Road-traffic noise levels for the area west of Sussex Street between Buckle Street and Rugby Street (free field position, $L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
</tr>
<tr>
<td>B09 13 Buckle</td>
<td>64.8</td>
<td>65.7</td>
</tr>
<tr>
<td>C01 1 Tasman (Front)</td>
<td>61.4</td>
<td>61.8</td>
</tr>
<tr>
<td>C02 1 Tasman (Back)</td>
<td>61.1</td>
<td>61.7</td>
</tr>
<tr>
<td>C03 1 Tasman (Garage)</td>
<td>56.6</td>
<td>57.0</td>
</tr>
<tr>
<td>C04 4 Sussex</td>
<td>70.5</td>
<td>67.7</td>
</tr>
<tr>
<td>C05 4 Sussex (Back)</td>
<td>52.4</td>
<td>51.6</td>
</tr>
<tr>
<td>C06 22 Sussex Back</td>
<td>49.5</td>
<td>48.3</td>
</tr>
<tr>
<td>C07 22 Sussex Front</td>
<td>71.4</td>
<td>68.6</td>
</tr>
<tr>
<td>C09 22 Sussex</td>
<td>70.2</td>
<td>67.7</td>
</tr>
<tr>
<td>C10 22 Sussex</td>
<td>69.9</td>
<td>67.5</td>
</tr>
<tr>
<td>C11 30 Sussex</td>
<td>70.6</td>
<td>68.4</td>
</tr>
<tr>
<td>C12 27 Tasman</td>
<td>60.6</td>
<td>60.7</td>
</tr>
<tr>
<td>C13 33 Tasman</td>
<td>59.0</td>
<td>59.2</td>
</tr>
<tr>
<td>C14 35 Tasman</td>
<td>52.7</td>
<td>51.4</td>
</tr>
<tr>
<td>C15 37 Buckle</td>
<td>55.3</td>
<td>55.4</td>
</tr>
<tr>
<td>C16 39 Tasman</td>
<td>60.2</td>
<td>60.4</td>
</tr>
<tr>
<td>C17 39 Tasman (Back)</td>
<td>53.0</td>
<td>52.4</td>
</tr>
<tr>
<td>C18 41 Buckle</td>
<td>59.8</td>
<td>60.1</td>
</tr>
<tr>
<td>C19 73 Rugby</td>
<td>62.2</td>
<td>63.1</td>
</tr>
<tr>
<td>C20 40 Sussex</td>
<td>69.4</td>
<td>67.4</td>
</tr>
<tr>
<td>C21 80 Rugby</td>
<td>61.9</td>
<td>62.9</td>
</tr>
<tr>
<td>C22 46 Sussex</td>
<td>67.0</td>
<td>65.7</td>
</tr>
<tr>
<td>C23 48 Sussex</td>
<td>67.5</td>
<td>66.2</td>
</tr>
</tbody>
</table>

The Project affects this area via a large decrease of traffic flow on Sussex Street; with the do-minimum Project situation traffic flow being about 60 percent less than the do-nothing receiving situation. The Project’s bridge and the connection into the Buckle Street underpass influence the road-traffic noise environment around Buckle Street and the corner of Buckle Street and Sussex Street. Figure 5.31 and Figure 5.32 represent the road-traffic noise levels 2.0 metres above ground level whereas some of the road layout changes influence road-traffic noise levels higher than this height. However, Table 5.8 represents the receivers modelled all across the full faces of the assessed locations.

Table 5.8 shows for many assessed locations in this area the do-minimum Project causes noise level decreases. Where the do-minimum Project causes noise level increases, many of these are within a scale that most people would not detect and cannot be reliably measured.

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36 The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
• For B09 13 Buckle (the former Mount Cook Police Station on the corner of Buckle Street and Tasman Street) the do-minimum Project causes a maximum road-traffic noise level increase of 1.2 dB $L_{Aeq\text{(24h)}}$. Where exposure to road-traffic noise is greatest, the do-minimum Project causes a noise level increase of 0.9 dB $L_{Aeq\text{(24h)}}$. Using the NZS 6806: 2010 noise criteria for altered roads as guidance, the part of the building with greatest exposure to road-traffic noise has a Category B noise level in the do-minimum Project situation and in the do-nothing receiving situation. The adverse effects of the do-minimum Project could be considered less than minor but because the total noise level is high, mitigation for this location is given some consideration. Section 5.4 explained how the do-minimum Project has already evolved to use the quietest road surfaces feasible. There is insufficient space for barriers to protect the building from noise.

It is noted the Buckle Street underpass (not part of this Project) decreases road-traffic noise levels for the building’s position of greatest exposure to road-traffic noise compared to the road layout currently existing without the Buckle Street underpass. The net effect of the two projects overall is a noise level decrease of about 4 dB $L_{Aeq\text{(24h)}}$. The building’s heritage status is noted as a potential factor against the practicability of building-modification mitigation. No further noise mitigation is proposed.

• C01 1 Tasman and C02 1 Tasman are multi-unit residential buildings, and C03 1 Tasman is not residential but associated with the multi-residential units. For these buildings, the maximum noise level changes caused by the do-minimum Project occur at positions with medium noise exposure or Category A noise levels using the NZS 6806: 2010 noise criteria for altered roads. For these buildings, where exposure to total road-traffic noise is greatest, the do-minimum Project causes noise level increases less than 1.0 dB $L_{Aeq\text{(24h)}}$ and these will have no significant effect. No further noise mitigation is proposed.

For C04 4 Sussex the maximum noise level change caused by the do-minimum Project is an increase of 0.7 dB $L_{Aeq\text{(24h)}}$ but at this position the total road-traffic noise level is only 58.3 dB $L_{Aeq\text{(24h)}}$ for the do-minimum Project. This noise level increase is considered to have little effect. On the building where exposure to the total road-traffic noise with the do-minimum Project is greatest, the noise level is high, 67.7 dB $L_{Aeq\text{(24h)}}$, which is a Category C noise level using NZS 6806: 2010 noise criteria for altered roads. However the do-minimum Project causes a noise level decrease of 2.8 dB $L_{Aeq\text{(24h)}}$ at this position so the Project has no adverse effect. No further noise mitigation is warranted for C04 4 Sussex but it was investigated to identify if a lower total noise level could be practicably achieved. The positions of greatest exposure for this location are at heights above the ground-storey of the building and this influences the feasibility of barriers for mitigation. In addition to other physical site constraints, input from other Project disciplines was that any barrier in this vicinity would have unacceptable effects on the Project’s urban design and personal security outcomes. Section 5.4 explained how the do-minimum Project has already evolved to use the quietest road surfaces feasible. The building is new and the noise environment has been consistent since the building’s construction. The Project causes insignificant noise level increases or minor noise level decreases to parts of the building. Noise mitigation by barriers or by quieter road surface is not practicable. Therefore, no further noise mitigation is proposed.

• For C19 73 Rugby the maximum noise level change caused by the do-minimum Project is an increase of 1.7 dB $L_{Aeq\text{(24h)}}$. This occurs at a position with moderate-high noise exposure (58.9 dB $L_{Aeq\text{(24h)}}$) and therefore the noise level change is considered to have no significant effect. Where the total road-traffic noise level with the do-minimum Project is greatest, the do-minimum Project causes a noise level increase less that 1.0 dB $L_{Aeq\text{(24h)}}$. At this position the noise level is high, 63.1 dB $L_{Aeq\text{(24h)}}$, but is a Category A noise level using NZS 6806: 2010 noise criteria for altered roads. Therefore, no further noise mitigation is proposed.
For C21 80 Rugby, C22 46 Sussex and C23 48 Sussex the maximum noise level changes caused by the do-minimum Project are increases between 1.1 and 1.7 dB $L_{Aeq(24h)}$. The noise level increases appear related to traffic flow increases on Tasman Street and Rugby Street (which are heavily influenced by the current status of the road layout proposed around the Buckle Street underpass project).

For C21 80 Rugby, at the position on the building where total exposure to road-traffic noise is greatest, the do-minimum Project noise level is Category A using NZS 6806: 2010 noise criteria for altered roads and the do-minimum Project causes a noise level increase of 1.0 dB $L_{Aeq(24h)}$. The combined effect of the total noise level (62.9 dB $L_{Aeq(24h)}$) and the noise level increase is considered to be no more than minor.

For C22 46 Sussex and C23 48 Sussex, at the position on the building where total exposure to road-traffic noise is greatest, the do-minimum Project causes a noise level decrease of 1.3 dB $L_{Aeq(24h)}$.

Overall, the do-minimum Project’s effects on these assessed locations do not require further noise mitigation.

6.5 South of Rugby Street

South of Rugby Street, road layout changes between the do-nothing receiving situation and the do-minimum Project situation have little influence. There are some slight traffic flow changes on Adelaide Road included in the supplied traffic flow information but these changes are more influenced by the expected high density residential development in the Adelaide Road area, rather than the Project.

In this area there are five locations assessed. There are two semi-detached residences at the Rugby Street/Belfast Street corner; a boarding house on the Adelaide Road/Rugby Street corner (G01 1-11 Adelaide); and two multi-storey buildings with residences.

- Figure 5.35 shows the positions and reference-identifiers for the assessed locations.
- Figure 5.36 shows the road-traffic noise environment for the do-minimum Project situation.
- Figure 5.37 shows how noise levels change between the do-nothing receiving situation and the do-minimum Project situation. The noise level changes and colourings are as explained in Note box 1 on page 40 in Section 5.5.
- Table 5.9 details noise levels for the assessed locations.

![Figure 5.35: Assessed locations shaded yellow in the area south of Rugby Street](image-url)
Figure 5.36: Do-minimum Project road-traffic noise environment 2.0 metres above ground level for the area south of Rugby Street (free-field noise levels, dB $L_{Aeq(24h)}$)

Figure 5.37: Road-traffic noise level changes caused by the do-minimum Project 2.0 metres above ground level for the area south of Rugby Street (free-field noise levels, dB $L_{Aeq(24h)}$)
Table 5.9: Road-traffic noise levels for the area south of Rugby Street (free field position, $dB\ L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
</tr>
<tr>
<td></td>
<td>Approximate height of position (m)</td>
<td>Facing</td>
</tr>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
</tr>
<tr>
<td></td>
<td>Approximate height of position (m)</td>
<td>Facing</td>
</tr>
<tr>
<td>F03 55 Rugby (west)</td>
<td>71.7</td>
<td>70.9</td>
</tr>
<tr>
<td>F03 53 Rugby (east)</td>
<td>72.7</td>
<td>71.7</td>
</tr>
<tr>
<td>G01 1-11 Adelaide</td>
<td>70.6</td>
<td>68.7</td>
</tr>
<tr>
<td>G03 13-15 Adelaide</td>
<td>66.9</td>
<td>67.8</td>
</tr>
<tr>
<td>G04 5 Alfred</td>
<td>63.5</td>
<td>62.6</td>
</tr>
</tbody>
</table>

For F03 55 Rugby (west) and F03 53 Rugby (east) the do-minimum Project causes noise level decreases, but still the total road-traffic noise levels for these assessed locations are high, each being Category C using NZS 6806: 2010 noise criteria for altered roads. Though these two locations are detailed in Table 5.9, by the time the Project is operational the situation around these buildings will be quite different from now.

A supermarket is consented in the area between Tasman Street/Rugby Street/Belfast Street. The properties of F03 55 Rugby (west) and F03 53 Rugby (east) are owned by the supermarket. Plans for the supermarket site show these two buildings retained and integrated into a pocket park on the Rugby Street/Belfast Street corner. The intended usage of the buildings is not defined but it appears unlikely the buildings would be used as residences. As the Project causes noise level decreases for F03 55 Rugby (west) and F03 53 Rugby (east), even though the total noise level is high for these buildings, no further mitigation is recommended.

With respect to the noise level changes caused by the do-minimum Project for any of the other three assessed locations in the area south of Rugby Street, noise level increases are not more than 1.0 $dB\ L_{Aeq(24h)}$ and in their context are considered to have less than minor effects.

The total road-traffic noise levels for G01 1-11 Adelaide and G03 13-15 Adelaide are high, each being Category C using NZS 6806: 2010 noise criteria for altered roads, but this is not an effect of the Project so no further mitigation is recommended.

Noted also in this area is the entrance to Government House where Rugby Street meets Dufferin Street. As they are well to the south of the Project area, any premises or facilities associated with Government House are not affected by road-traffic noise of the do-minimum Project.

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37 The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
6.6 East of Dufferin Street between Ellice Street and Rugby Street

There are three clusters of assessed locations in the area east of Dufferin Street between Ellice Street and Rugby Street.

- Figure 5.38 shows the positions and reference-identifiers for the assessed locations in this area.
- Figure 5.39 shows the road-traffic noise environment for the do-minimum Project situation.
- Figure 5.40 shows how noise levels change between the do-nothing receiving situation and the do-minimum Project situation. The noise level changes and colourings are as explained in Note box 1 on page 40 in Section 5.5.
- Table 5.10 and Table 5.11 detail noise levels for the assessed locations.

![Figure 5.38: Assessed locations shaded yellow in the area east of Dufferin Street between Ellice Street and Rugby Street](image)
The Project introduces the approach to the bridge into this area, raising the height of the road-traffic noise source. In this regard, note Figure 5.39 and Figure 5.40 represent the road-traffic noise levels 2.0 metres above ground level whereas some of the road layout changes influence road-traffic noise levels higher than this height. The noise level contours are intended only as illustrative. Noise level values are given in Table 5.10 for assessed locations in this area south of Paterson Street and Table 5.11 for assessed locations north of Paterson Street. These values are from modelling of receivers all across the full faces of the assessed locations.
Figure 5.40 shows an area of strong red colour indicating the Project causes a strong noise level increase, and another area of strong green colour indicating the Project causes a strong noise level decrease. As explained in Section 5.5.1, these noise level changes are related to the change in road layout: for instance noise level increases where the link from Kent Terrace to Paterson Street is moved to accommodate the bridge abutment.

Table 5.10: Road-traffic noise levels for the area east of Dufferin Street between Paterson Street and Rugby Street (free-field position, dB $L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change</th>
<th>Change caused by do-minimum Project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
<td>Approximate height of position (m)</td>
</tr>
<tr>
<td>H01 9 Dufferin</td>
<td>69.2</td>
<td>64.6</td>
<td>6</td>
</tr>
<tr>
<td>H02 9 Dufferin (Back)</td>
<td>69.5</td>
<td>62.7</td>
<td>5</td>
</tr>
<tr>
<td>H03 11 Dufferin</td>
<td>66.8</td>
<td>64.4</td>
<td>6</td>
</tr>
<tr>
<td>H04 2 Paterson</td>
<td>70.2</td>
<td>67.0</td>
<td>5</td>
</tr>
<tr>
<td>H05 15-17 Dufferin</td>
<td>63.2</td>
<td>61.9</td>
<td>4</td>
</tr>
<tr>
<td>H06 19 Dufferin</td>
<td>54.8</td>
<td>53.9</td>
<td>3</td>
</tr>
<tr>
<td>H07 13 Dufferin</td>
<td>69.2</td>
<td>68.4</td>
<td>3</td>
</tr>
</tbody>
</table>

- For H06 19 Dufferin, the maximum road-traffic noise level change caused by the do-minimum Project is an increase of 1.9 dB $L_{Aeq(24h)}$ but this occurs where the noise exposure is only 49.2 dB $L_{Aeq(24h)}$ and therefore the noise level increase is considered to have an effect less than minor. For this assessed location, the noise level at the position of greatest exposure to road-traffic noise with the do-minimum Project is well within Category A using NZS 6806: 2010 noise criteria for altered roads and here the do-minimum Project causes a noise level decrease. No further mitigation is proposed.

- For H07 13 Dufferin, the maximum road-traffic noise level change caused by the do-minimum Project is an increase of 3.6 dB $L_{Aeq(24h)}$ but this occurs where the noise exposure is only 47.7 dB $L_{Aeq(24h)}$ and therefore the noise level increase is considered to have an effect less than minor. The noise level is Category C using NZS 6806: 2010 noise criteria for altered roads at this assessed location’s position of greatest exposure to road-traffic noise with the do-minimum Project. However, as the do-minimum Project causes a noise level decrease, still the effects of the Project are considered less than minor.

- Even though the do-minimum Project decreases noise levels for properties, H01 9 Dufferin, H03 11 Dufferin, H04 2 Paterson, and H07 13 Dufferin, and further noise mitigation was found to be not warranted, still their total noise levels exceed Category A using NZS 6806: 2010 noise criteria for altered roads. So further noise mitigation was investigated to identify if an improved noise environment could be practicably achieved.

The positions on the buildings where total road-traffic noise exposure is greatest are each above the heights of barriers that could be accommodated by the site constraints and within acceptable outcomes for other Project disciplines and so barriers would have limited (or negligible) mitigation effect. Section 5.4.1 explained how the do-minimum Project has already

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38 The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
evolved to use the quietest road surfaces feasible. H07 13 Dufferin and H04 2 Paterson are noted as being relatively new buildings and the noise environment has been consistent since their construction. Because the Project’s effects are less than minor and further mitigation is not practicable, no further mitigation is proposed.

Noted also in this area are school grounds of Wellington College adjacent to the southern edge of Paterson Street. Additional free-field receivers have been modelled in the playing fields and on the tennis court area. The do-minimum Project causes negligible noise level changes at these receivers, generally less than 0.5 dB $L_{Aeq(24h)}$ which is a scale unlikely to be detected by most people and difficult to reliably measure. The Project is considered to have negligible effect on these school grounds.

Table 5.11: Road-traffic noise levels for the area east of Dufferin Street between Ellice Street and Paterson Street (free-field position, $dB L_{Aeq(24h)}$)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
</tr>
<tr>
<td>P02 32 Ellice</td>
<td>61.9</td>
<td>60.8</td>
</tr>
<tr>
<td>P03 150-152 Brougham</td>
<td>60.8</td>
<td>59.3</td>
</tr>
<tr>
<td>P04 154-156 Brougham</td>
<td>66.4</td>
<td>67.4</td>
</tr>
<tr>
<td>Q01 44 Ellice</td>
<td>60.3</td>
<td>60.1</td>
</tr>
<tr>
<td>Q02 46 Ellice</td>
<td>50.4</td>
<td>50.3</td>
</tr>
<tr>
<td>Q03 48 Ellice</td>
<td>59.0</td>
<td>59.0</td>
</tr>
<tr>
<td>Q04 50 Ellice</td>
<td>59.7</td>
<td>59.7</td>
</tr>
<tr>
<td>Q05 52 Ellice</td>
<td>59.3</td>
<td>59.3</td>
</tr>
<tr>
<td>Q07 56 Ellice</td>
<td>56.5</td>
<td>56.5</td>
</tr>
<tr>
<td>Q08 58 Ellice</td>
<td>57.3</td>
<td>57.3</td>
</tr>
<tr>
<td>Q09 60 Ellice</td>
<td>59.0</td>
<td>59.1</td>
</tr>
<tr>
<td>Q10 62 Ellice</td>
<td>58.0</td>
<td>58.0</td>
</tr>
<tr>
<td>Q11 64 Ellice</td>
<td>59.2</td>
<td>59.2</td>
</tr>
<tr>
<td>Q12 66 Ellice</td>
<td>57.9</td>
<td>57.9</td>
</tr>
<tr>
<td>Q13 68 Ellice</td>
<td>58.1</td>
<td>58.1</td>
</tr>
<tr>
<td>Q14 70 Ellice</td>
<td>48.4</td>
<td>48.4</td>
</tr>
<tr>
<td>Q16 72 Ellice</td>
<td>48.5</td>
<td>48.5</td>
</tr>
<tr>
<td>Q17 74 Ellice</td>
<td>54.6</td>
<td>54.6</td>
</tr>
<tr>
<td>Q18 76 Ellice</td>
<td>56.3</td>
<td>56.4</td>
</tr>
<tr>
<td>Q19 78 Ellice</td>
<td>49.3</td>
<td>49.2</td>
</tr>
<tr>
<td>Q20 80 Ellice</td>
<td>54.8</td>
<td>54.8</td>
</tr>
<tr>
<td>Q21 82 Ellice</td>
<td>53.6</td>
<td>53.6</td>
</tr>
<tr>
<td>Q22 86 Ellice (N-north)</td>
<td>58.9</td>
<td>58.9</td>
</tr>
<tr>
<td>Q23 86 Ellice (North)</td>
<td>57.8</td>
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</tr>
<tr>
<td>Q24 86 Ellice (South)</td>
<td>57.8</td>
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</tr>
</tbody>
</table>

39 The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
Table 5.11 shows for many assessed locations in this area the do-minimum Project causes noise level increases less than 1.0 dB $L_{Aeq(24h)}$ and for most assessed locations the noise level change is either no change or a small decrease. The effect of this scale of noise level change is considered to be negligible.

- For P02 32 Ellice and P03 150-152 Brougham at the position of maximum change, the do-minimum Project causes noise level increases of 2.1 and 2.9 dB $L_{Aeq(24h)}$ respectively. For each location, this noise level increase occurs where the noise exposure is low/moderate and therefore the noise level increases are considered to have effect no more than minor. At these locations' positions of greatest exposure to road-traffic noise, the noise level is Category A using NZS 6806: 2010 noise criteria for altered roads and the do-minimum Project causes a noise level decrease. No further mitigation is proposed.

- P04 is St Joseph’s Church. This is a very-recently constructed building and it is understood to have been designed anticipating works around the Basin Reserve with design decisions made to accommodate effects of works. The quiet interior has been confirmed during site visits. At the position of maximum change, the do-minimum Project causes a noise level increase of 2.8 dB $L_{Aeq(24h)}$. The maximum noise level change caused by the do-minimum Project is an increase of 2.8 dB $L_{Aeq(24h)}$. This occurs where the noise exposure is only moderate, 55.9 dB $L_{Aeq(24h)}$ and therefore the noise level increase is considered to have an effect less than minor. At this assessed location’s position of greatest exposure to road-traffic noise, the noise level is Category C using NZS 6806: 2010 noise criteria for altered roads. However as the do-minimum Project causes a noise level increase of only 1.0 dB $L_{Aeq(24h)}$, still the effects of the
Project are considered no more than minor given that the building’s interior has already been
designed with the expectation of road-traffic noise. No further mitigation is proposed.

At another stage of the Project’s development, noise mitigation options were investigated for
this assessed location. As Section 5.4 explained, the do-minimum Project has already evolved
to use the quietest road surfaces feasible. With regard to barriers, any effectiveness of these is
limited to lower levels of the building and the assessed location’s positions of greatest
exposure to road-traffic noise are at higher levels. A potential barrier was modelled adjacent
the northern side of Paterson Street but, in addition to its lack of noise mitigation effect, input
from other Project disciplines stated a barrier of this type would have unacceptable effects on
the Project’s urban design and personal security outcomes. No further noise mitigation is
proposed.

- Q14 70 Ellice, Q16 72 Ellice, Q19 78 Ellice, Q25 86 Ellice, Q27 145 Brougham, Q30 143
Brougham, and Q40 84 Ellice have similar characteristics in terms of the do-nothing receiving
situation and the do-minimum Project situation. Figure 5.38 shows these locations front local
roads with low traffic flows or are located within the block surrounded by such local roads.
Table 5.11 shows that at each location’s position of maximum change, the changes in noise
level caused by the do-minimum Project are increases of between 1.0 and 2.0 dB L_{Aeq(24h)}.
These occur where the noise exposure is low/moderate and therefore the do-minimum Project
is considered to have negligible effect.

Typically, at each location’s position of greatest exposure to road-traffic noise, the noise level
is very close to consistent between the do-minimum Project situation and the do-nothing
receiving situation (except Q30 143 Brougham where the do-minimum Project causes an
increase of 0.6 dB L_{Aeq(24h)} but this increase is still within a scale not reliably measured and
would be not detected by most people and the total noise level is still only 51.6 dB L_{Aeq(24h)}).
For these assessed locations, the do-minimum Project has negligible effect and no further
noise mitigation is proposed.

- Q34 7 Paterson, Q36 11 Paterson, Q37 17 Paterson, Q38 19-21 Paterson, and Q39 23
Paterson are locations that front the local road part of Paterson Street adjacent and above the
state highway part of Paterson Street joining to the Mount Victoria Tunnel. For these assessed
locations, at the position of maximum change, the changes in noise level caused by the do-
minimum Project are increases up to 1.8 dB L_{Aeq(24h)}, though exposure to total road-traffic noise
remains low/moderate at these positions.

For these assessed locations the noise levels at the positions of greatest exposure to road-
traffic noise are well within Category A of the NZS 6806: 2010 noise criteria for altered roads
and for all the do-minimum Project causes a slight decrease in noise level. No further noise
mitigation is proposed for these locations.

- At Q33 7 Paterson, at the position of maximum change, the noise level change caused by the
do-minimum Project is an increase of 1.7 dB L_{Aeq(24h)}. This occurs where the noise level is only
47.6 dB L_{Aeq(24h)} so the do-minimum Project is considered to have negligible effect. At this
assessed location’s position of greatest exposure to total road-traffic noise, the do-minimum
Project noise level is 64.2 dB L_{Aeq(24h)}, which just exceeds Category A of the NZS 6806: 2010
noise criteria for altered roads; but at this position the do-minimum Project causes a noise
level decrease of 0.2 dB so, again, the effect of the Project is considered no more than minor.

It is noted that Table 5.11 shows, with the do-minimum Project at their positions of greatest
exposure to road-traffic noise, Q29 151 Brougham and Q33 7 Paterson have total road-traffic noise
levels exceeding 64.0 dB L_{Aeq(24h)} which is the upper threshold of Category A using the
NZS 6806: 2010 noise criteria for altered roads. The buildings are near to the corner of Brougham
Street and the local road part of Paterson Street. The properties of these buildings are owned by
the NZTA. These properties were purchased a number of years ago by the NZTA, or its related predecessors, in anticipation of road projects in this area, and these properties will be removed as part of the Mount Victoria Tunnel duplication. This Project (of the Transport Improvements around the Basin Reserve) is considered to have noise effects no more than minor on these locations and so no further noise mitigation is proposed; but in addition, it is acknowledged as owner of the properties, the NZTA has previously given acceptance of any noise effects and does not request any further noise mitigation.

6.7 East of Kent Terrace and north of Ellice Street

The area east of Kent Terrace and north of Ellice Street includes the Grandstand Apartments building at 80 Kent Terrace. This building has one part about seven storeys high adjacent to Kent Terrace and the part of the building behind this is two storeys high. The rooftop of the two-storey part is an open-air space for recreation and leisure-type activities which has an inbuilt 2.5 to 3.0 metre high barrier already surrounding it. To recognise the form of the Grandstand Apartments building it is identified as two locations, I07 and I08. Other Kent Terrace premises and facilities in the noise study area are not assessed as they are not used for noise-sensitive activities nor of other significance.

37 Hania Street (J07) is used as a residence and it is the only Hania Street premise or facility to be assessed.

East of Hania Street and north of Ellice Street is a residential area of closely-spaced buildings. These locations are assessed. Section 3.6 and Section 5.2.1, establishing the current noise environment, each highlighted the close spacing of these buildings which means many are currently well-shielded from road-traffic noise. This area also includes on the corner of Brougham Street and Ellice Street, the Melksham Apartments building (O15 131 Brougham) which is about ten storeys high.

Section 3.4 discussed some reasons for our extension of the noise study area to include areas beyond a rigid application of the NZS 6806: 2010 definition of 100 metres distant from the project works. This is important to this area. Figure 5.41 shows how the terrain of the area slopes up from the Basin Reserve; moving from below to level with and then above the height of the bridge. Public consultation and input from other Project disciplines showed some perceptions of an issue of elevation and spread of road-traffic noise from the raised structure. Extending the noise study area means we can address these perceptions.
Figure 5.41: Elevations for the do-minimum Project for the area east of Kent Terrace and north of Ellice Street

- Figure 5.42 shows the positions and reference-identifiers for the assessed locations in this area.
- Figure 5.43 shows the road-traffic noise environment for the do-minimum Project situation.
- Figure 5.44 shows how noise levels change between the do-nothing receiving situation and the do-minimum Project situation. The noise level changes and colourings are as explained in Note box 1 on page 40 in Section 5.5.
- Table 5.12 details noise levels for the assessed locations.

Figure 5.42: Assessed locations shaded yellow in the area east of Kent Terrace and north of Ellice Street
Figure 5.43: Do-minimum Project road-traffic noise environment 2.0 metres above ground level for the area east of Kent Terrace and north of Ellice Street (free-field noise levels, dB $L_{Aeq(24h)}$)

Figure 5.44: Road-traffic noise level changes caused by the do-minimum Project 2.0 metres above ground level for the area east of Kent Terrace and north of Ellice Street (free-field noise levels, dB $L_{Aeq(24h)}$)
### Table 5.12: Road-traffic noise levels for the area east of Kent Terrace and north of Ellice Street (free-field position, \(d_B L_{Aeq(24h)}\))

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Do-nothing receiving situation</td>
<td>Do-minimum Project situation</td>
</tr>
<tr>
<td>I07 80 Kent (7 storeys)</td>
<td>68.9</td>
<td>68.9</td>
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<td>I08 80 Kent (2 Storeys)</td>
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<td>57.5</td>
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<tr>
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<td>49.2</td>
</tr>
<tr>
<td>K02 29 Moir</td>
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<td>48.4</td>
</tr>
<tr>
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<td>49.5</td>
<td>49.6</td>
</tr>
<tr>
<td>K04 25 Moir</td>
<td>50.0</td>
<td>50.1</td>
</tr>
<tr>
<td>K05 23 Moir</td>
<td>49.2</td>
<td>49.3</td>
</tr>
<tr>
<td>K06 21 Moir</td>
<td>49.7</td>
<td>49.9</td>
</tr>
<tr>
<td>K07 19 Moir</td>
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<td>47.9</td>
</tr>
<tr>
<td>K08 17 Moir</td>
<td>49.7</td>
<td>49.9</td>
</tr>
<tr>
<td>K09 15 Moir</td>
<td>45.0</td>
<td>45.7</td>
</tr>
<tr>
<td>K10 13 Moir</td>
<td>47.7</td>
<td>48.0</td>
</tr>
<tr>
<td>K11 11 Moir</td>
<td>46.8</td>
<td>47.2</td>
</tr>
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<td>K12 9 Moir</td>
<td>49.2</td>
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<td>K13 7 Moir</td>
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<td>K16 27 Ellice (Back)</td>
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<tr>
<td>L13 142 Brougham</td>
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</tr>
</tbody>
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40 The position of maximum change is explained in Note box 2 on page 47 in Section 6.1.
<table>
<thead>
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<th>Identifier</th>
<th>Position of greatest exposure</th>
<th>Position of maximum change</th>
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<td>Baseline Project situation</td>
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</tr>
<tr>
<td>O15 131 Brougham</td>
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<td>58.6</td>
</tr>
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</table>
Table 5.12 shows for the majority of assessed locations in this area east of Kent Terrace and north of Ellice Street, the building’s position with the maximum noise level change has an increase of less than 1.0 dB $L_{Aeq(24h)}$. This scale of noise level change would likely not be detected by most people and is difficult to establish through measurement. The Project is considered as having no effect on these locations and no further noise mitigation is required. The total road-traffic noise levels for these locations are low or moderate and also require no further noise mitigation.

There are sixteen locations shown in Table 5.12 for which, at the building’s position with the maximum noise level change, the increase is between 1.0 and 2.0 dB $L_{Aeq(24h)}$. The modelling has been inspected and the positions of these changes have only low noise exposure, almost always less than 50 dB $L_{Aeq(24h)}$. The total noise level for the do-minimum Project for these buildings is also low to moderate, almost always less than 57 dB $L_{Aeq(24h)}$. The Project has negligible effects for these assessed locations. No further noise mitigation is required.

Of the 93 assessed locations listed in Table 5.12, there are only three for which at the building’s position with the maximum noise level change, the increase is more than 2.0 dB $L_{Aeq(24h)}$.

K17 21 Ellice, K18 23 Ellice, and K19 25 Ellice are very near to the Dufferin Street/Ellice Street corner. These assessed locations have maximum noise level increases of 1.5 to 2.6 dB $L_{Aeq(24h)}$ and these occur at positions with moderate noise exposure. Where exposure to road-traffic noise is greatest, the do-minimum Project causes noise level increases of 0.9 to 1.1 dB $L_{Aeq(24h)}$ and the noise levels are towards or approximately equal to the upper limit of Category A using the NZS 6806: 2010 noise criteria for altered roads.
While it is likely the do-minimum Project with have less than minor effects for these locations, it is possible they would exceed Category A due to traffic flow changes once other roading projects forecast for this area are operating. (See Section 6.8.) Consideration was given to potential noise mitigation options that should be considered now rather than retrofitted later.

Section 5.4 explained how the do-minimum Project has already evolved to use the quietest road surfaces feasible. These locations are multi-storey buildings and for each, the position with greatest exposure to road-traffic noise is above the ground storey of the building and this influences the feasibility of barriers for mitigation. In addition to other physical site constraints, the input from other Project disciplines is that any barrier in this vicinity, especially one of sufficient size to have any worthwhile noise mitigation effect, would have unacceptable effects on the Project’s urban design and personal security outcomes. Therefore it does not appear practicable to fit barriers in this area as part of this Project.

No further noise mitigation is necessary for this current Project because the effects of the noise level changes caused by this Project are negligible. Beyond this Project, other projects proposed in the area should be carefully investigated for their effects on these locations.

• O15 131 Brougham is the Melksham Apartments building. The sides of the building facing towards the Project are the northwest face and southwest face and these are ten storeys high. Although about one block removed from the Project, as the building is much higher than others nearby there is the potential for effects from the Project because of the uninterrupted path from the bridge to the upper storey apartments.

The following set of diagrams in Figure 5.45, Figure 5.46, and Figure 5.47 give three pairs of three-dimensional views of the Melksham Apartments building.

• The figure on the left side of each pair depicts the long face of the building fronting to Brougham Street, the northwest face, and the face of the building fronting towards Ellice Street, the southwest face. This view is approximately eastward.

• The figure on the right side of each pair depicts the long southeast face of the building and the northeast face of the building. This view is approximately westward with the Basin Reserve beyond (and the bridge).

![Figure 5.45: Two views of the road-traffic noise exposure at facades of the Melksham Apartments building (O15) for the do-nothing receiving situation (adjusted to free-field noise levels, dB L_{Aeq(24h)})](image)
The pair of views in Figure 5.45 show the road-traffic noise levels for the do-nothing receiving situation. The pair in Figure 5.46 show the road-traffic noise levels for the do-minimum Project situation. On the northwest and southwest faces, the figure on the left side of each pair, noise levels are moderate between 55 and 59 dB $L_{Aeq(24h)}$. The southeast and northeast faces, the figure on the right side of each pair, are more sheltered from road-traffic noise, with noise levels ranging from about 45 to 55 dB $L_{Aeq(24h)}$.

The pair of views in Figure 5.47 show the change in noise level caused by the do-minimum Project at facades of the Melksham Apartments building (O15). There is effectively no change over the northwest, southwest, and southeast faces. The right side of the pair in Figure 5.47 shows an area of small change, between 0.5 and 1.5 dB, on the northeast face. (Table 5.12 shows the position of greatest noise level change for O15 131 Brougham is facing northeast and is 0.5 dB $L_{Aeq(24h)}$.)

The effects of the changes caused by the Project and the effects of the total noise level are negligible for this assessed location, and no further mitigation is required.
The position on the Grandstand Apartments building that experiences the greatest change in noise caused by the do-minimum Project occurs on the I07 80 Kent (7 storeys) portion of this building, but at a height lower down on the building where the two portions of the building connect. This position on the building is at about the rooftop area of the two-storeyed portion of the building which is also at about the height of the bridge. This rooftop area is used as an outdoor space and is enclosed by 2.5 to 3.0 metres high solid barriers. It appears noise could be entering the rooftop area contained by the solid barriers then reflect within this space. The barriers are modelled as non-absorptive which is consistent with their appearance and this would influence the reflections. The change in noise level caused by the do-minimum Project is 2.8 dB $L_{Aeq(24h)}$ making the total road-traffic noise level at this position 52.1 dB $L_{Aeq(24h)}$. The effect of this change is considered less than minor.

The building’s position with greatest exposure to road-traffic noise is on the façade facing towards Kent Terrace and this position is beneath the height of the bridge. The change in noise caused by the do-minimum Project at this position is only 0.1 dB $L_{Aeq(24h)}$ and there is no effect caused by this very small noise level change.

The following set of diagrams in Figure 5.48, Figure 5.49, and Figure 5.50 give three pairs of three-dimensional views of the Grandstand Apartments building.

- The figure on the left side of each pair depicts the face of the building fronting to Kent Terrace, the northwest face, and the face of the building fronting towards the Basin Reserve, the southwest face. This view is approximately as if looking towards the building from about the roadside adjacent to the RA Vance Stand but high above ground level.
- The figure on the right side of each pair depicts the face of the building fronting towards the Basin Reserve, the southwest face, and the face of the building fronting towards Hania Street. This view is approximately as if looking towards the building from about the Hania Street/Ellice Street corner adjacent to the Regional Wine and Spirits store.

The pair in Figure 5.48 show the road-traffic noise levels for the do-nothing receiving situation. The building face fronting to Kent Terrace has a high noise environment while the face fronting to Hania Street is exposed to only medium-high noise levels.

The pair in Figure 5.49 show the road-traffic noise levels for the situation with the do-minimum Project operational. Noise levels are very similar between the do-nothing receiving situation and the do-minimum Project situation but appear slightly reduced in the do-minimum Project situation.

The pair in Figure 5.50 show the change in noise level caused by the do-minimum Project, calculated for each position as the do-minimum Project noise level minus the do-nothing receiving situation noise level. These figures use the same convention as used elsewhere in this report with the noise level changes and colourings are as explained in Note box 1 on page 40 in Section 5.5.

With the exception of the small noise level increase above the second storey rooftop area, Figure 5.50 may be surprising to some observers in that it shows noise levels are either unchanged or decreased by the do-minimum Project. There are several known contributions to this expected effect:

- The at-grade traffic is the dominant road-traffic noise source so that the bridge traffic generally only slightly modifies the road-traffic noise environment.
- The do-minimum Project includes a section of quieter road surface on the Kent Terrace/Ellice Street corner. This section starts near the northern end of the Grandstand.
Apartments building and continues around into Ellice Street and through to Paterson Street.

- The bridge structure tends to partly screen the Grandstand Apartments building from the ground-level traffic contributing to the darker green area on the southwest and southeast faces. From earlier in this report, Figure 5.13 showing a cross-section of the road-traffic noise environment intersecting the bridge indicated how the bridge is preventing an even spread of the noise from the at-grade traffic.

![Figure 5.48: Two views of the road-traffic noise exposure at facades of the Grandstand Apartments building (I07/I08) for the do-nothing receiving situation (adjusted to free-field noise levels, dB L_{Aeq(24h)})](image)

![Figure 5.49: Two views of the road-traffic noise exposure at facades of the Grandstand Apartments building (I07/I08) for the do-minimum Project situation (adjusted to free-field noise levels, dB L_{Aeq(24h)})](image)
With regards to road-traffic noise, the do-minimum Project’s effects on the Grandstand Apartments building are considered to be less than minor and further mitigation of any effects is not required.

For the do-minimum Project situation, parts of the northwest face of the Grandstand Apartments building, towards Kent Terrace, have noise levels greater than 67 dB $L_{Aeq(24h)}$ which is the threshold into Category C using NZS 6806: 2010 noise criteria for altered roads; but at these positions, noise levels are either unchanged or slightly decreased by the Project. This high noise environment predates the building of the Grandstand Apartments.

For the do-minimum Project situation, parts of the southwest face of the Grandstand Apartments building have noise levels between 64 and 67 dB $L_{Aeq(24h)}$ which is the range of Category B using NZS 6806: 2010 noise criteria for altered roads. But at these positions, the Project actually causes noise level decreases. The do-minimum Project noise levels on this face are the best practicable.

Consultation with the Grandstand Apartments building owners was undertaken much earlier in the development of this Project. In response to this consultation, the options for a section of extra barrier to be provided on the bridge where that bridge is adjacent to the Grandstand Apartments building was considered. As the proposal of this barrier is not initiated by assessment of the Project’s noise effects, discussion of it is not included in the main body of this report. However discussion of that barrier proposal is included in Appendix B which summarises the noise assessment undertaken earlier.

6.8 Project mitigation structures

6.8.1 Northern Gateway Building

The Project description (Section 1.2) includes a new Northern Gateway Building for the northern boundary within the Basin Reserve. The structure is described as a mitigation option that may be up to 65 metres long. Other options for the structure are 55 metres long or 45 metres long. Figure
5.51 is the view from a cricket pitch in the centre of the Basin Reserve looking approximately northwards. It indicates the position of the Northern Gateway Building adjacent the RA Vance stand, shown in the left of the view. This position is currently occupied in part by the CS Dempster Gate which will be relocated to the south of the Basin Reserve near to the JR Reid Gate adjacent Adelaide Road/Rugby Street.

![Northern Gateway Building 65 metre long option](image)

Figure 5.51: Northern Gateway Building 65 metre long option

The structure in Figure 5.51 is 65 metres long. It demonstrates the form of the Northern Gateway Building for any of the three length options, 65 or 55 or 45 metres long. The structure form has a relatively open foyer-type ground level topped with two solid levels.

The primary purpose of the Northern Gateway Building is to screen views of traffic on the Basin Bridge for north-facing batsmen playing in the Basin Reserve. Such a screening structure is not required for mitigation of the Project’s noise effects. We have investigated to confirm such a structure would not create adverse noise effects for other locations.

The noise model was run for the do-minimum Project situation without the Northern Gateway Building and then run with each of the three Northern Gateway Building length options.

Figure 5.52 illustrates the comparison of the do-minimum Project situation without the Northern Gateway Building and that situation with the 65 metre long Northern Gateway Building. This figure uses a scale with increments of 1 dB L_{Aeq(24h)}. It shows pale yellow over all of the area (-0.5 to 0.5 dB L_{Aeq(24h)}) which is effectively no change in noise level. For further information, the comparison illustrated in Figure 5.52 is repeated in Figure 5.53 but this figure uses a scale with finer increments of 0.2 dB L_{Aeq(24h)}. Still, it shows pale yellow over almost all of the area (-0.1 to 0.1 dB L_{Aeq(24h)}). For the height shown in the figure, 2.0 metres above ground level, the Northern Gateway Building provides some slight screening of road-traffic noise to some of the Basin Reserve area, shown by the area of light green shading in Figure 5.53. This area of light green shading represents noise level decreases between -0.1 to -0.5 dB L_{Aeq(24h)} and this scale of noise level change would have no effect.
Figure 5.52: Changes to the do-minimum Project situation road-traffic noise environment 2.0 metres above ground level associated with inclusion of the Northern Gateway Building 65 metres long option, to illustrate the effects of the Northern Gateway Building at 65 metres long (free-field noise levels, dB \( L_{Aeq(24h)} \)).

Figure 5.53: Copy of Figure 5.52 using a finer scale to further illustrate the effects of the Northern Gateway Building at 65 metres long (free-field noise levels, dB \( L_{Aeq(24h)} \)).

Figure 5.52 and Figure 5.53 illustrate the effects of the Northern Gateway Building for only 2.0 metres above ground level. We have also inspected the effects at other heights above ground level. For each of the three Northern Gateway Building length options, we have modelled and inspected receivers across all the faces of all the nearby locations to investigate for effects from substantial noise reflections off the structure. There were no noise level changes greater than...
0.1 dB $L_{Aeq(24h)}$. This confirms the Northern Gateway Building causes no adverse noise effects for nearby locations.

At heights further above ground where the Northern Gateway Building is solid, the structure provides greater screening to the area to the south of the structure. At these heights, generally this screening would not affect any receivers, only perhaps spectators on a south-facing balcony of the Northern Gateway Building. We have considered the noise levels on the northern face of the Northern Gateway Building, for each of the three Northern Gateway Building length options. There are areas across this northern face with noise levels over 64 dB $L_{Aeq(24h)}$ and some areas, particularly towards the eastern end, with noise levels over 67 dB $L_{Aeq(24h)}$. As the Northern Gateway Building is a new purpose-built structure, there is opportunity for its design to have regard to the noise environment. Noise-sensitivity of the activities inside the Northern Gateway Building should be considered during its design, particularly if glazing or opening windows on the northern face of the structure are intended.

Where the Northern Gateway Building is to be constructed, there are currently some sections of fences or gates and the CS Dempster Gate. These “ground level” structures will be removed or relocated for the Northern Gateway Building. The modelling has assigned to these structures no effect on road-traffic noise entering the Basin Reserve area. Somewhat similarly, though there is some structure to the foyer-type ground level of the Northern Gateway Building, this has been assigned no effect on road-traffic noise entering the Basin Reserve area. To test the effects of this assumption, we have modelled the effect that the fences or gates would have on road-traffic noise entering the Basin Reserve area if the fences or gates were of noise barrier quality.

For individuals using the Basin Reserve area near to the northern gateway area, the existing ground level structures may provide a visual screen of the at-grade road-traffic noise sources (such as traffic on Kent Terrace) which could create a sense of reducing road-traffic noise effects. The form of the foyer-type ground level of the Northern Gateway Building may retain some of the visual screening effect through its columns and such. However, relative to the visual screening effect of the existing ground level structures, the Northern Gateway Building may diminish some of the visual screening effect and there could be a sense that the open foyer-type ground level of the new structure has caused a larger increase in noise than is the reality. Note that while these psycho-acoustic effects are known to sometimes occur, they are not predictable either as to occurrence or extent and are discussed only as a possibility.

In conclusion, the Northern Gateway Building 65 metre long option has little effect in screening the Basin Reserve area from road-traffic noise and no road-traffic noise effect on adjacent properties. The road-traffic noise effects of the structure at other length options, 55 metres or 45 metres, are the same as for the 65 metre long option. Table 5.13 restates the conclusion with the incremental effect of the 55 metre long option and the 65 metre long option compared with the effect of the 45 metre long option. Table 5.13 also includes comparison of the construction noise effects of the three Northern Gateway Building length options.
Table 5.13: Summary of noise effects of the three Northern Gateway Building length options

<table>
<thead>
<tr>
<th>Effect</th>
<th>Summary</th>
<th>Effects additional to the 45 metre long option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45 metre long option</td>
<td>55 metre long option</td>
</tr>
<tr>
<td>Screening of the Basin Reserve area from road-traffic-noise</td>
<td>Negligible effect at ground level</td>
<td>Negligible additional effect</td>
</tr>
<tr>
<td>Road-traffic noise on adjacent properties</td>
<td>No effect</td>
<td>No additional effect</td>
</tr>
<tr>
<td>Construction noise</td>
<td>Small additional effect to the overall construction noise effects</td>
<td>Negligible additional effect</td>
</tr>
</tbody>
</table>

6.8.2 Building under the Bridge

The Project description (Section 1.2) includes a new commercial building at the corner of Kent Terrace and Ellice Street, partly under the Basin Bridge. A primary purpose of this Building under the Bridge is to incorporate the bridge into the built urban environment. It is not required for mitigation of the Project's noise effects. We have investigated to confirm this Building under the Bridge will not create adverse noise effects in other locations.

The noise model was run for the do-minimum Project situation without the Building under the Bridge then run with that building included. We have modelled and inspected receivers across all faces of all the nearby locations to investigate for effects from substantial noise reflections off the structure or other effects on noise propagation caused by the structure. There were no noise level changes greater than 0.1 dB $L_{A_{eq}(24h)}$. The Building under the Bridge provides some screening of noise but at locations or to an extent considered to have only slight effect.

We have also considered the road-traffic noise levels for the Building under the Bridge, particularly the facades facing west towards Kent Terrace and south towards Ellice Street. On the western and southern faces there are large areas with noise levels over 64 dB $L_{A_{eq}(24h)}$ and some areas with noise levels over 67 dB $L_{A_{eq}(24h)}$. We note the building is intended for commercial usage, which is often considered not a noise-sensitive activity. However, as a new building the design and construction of the building should have regard to the surrounding noise environment.

Above the Building under the Bridge, parallel to the 80 Kent Terrace (Grandstand Apartments) building façade facing towards the bridge is to be a tall green screen of porous framework and creeping plants. This screen will extend well above the height of the bridge to provide visual screening of the bridge from the windows facing this direction. This green screen will not provide any mitigation of noise, though it may provide some perception of noise mitigation through the visual screening.

In conclusion, the road-traffic noise effects of the Building under the Bridge are small, if any.
7 Future changes to the noise environment

This Project is intended for completion by 2016. It is intended that a second Mount Victoria Tunnel will be completed by approximately 2026. The capacity of the single Mount Victoria Tunnel limits traffic volumes entering the Basin Reserve area. When the second Mount Victoria Tunnel is operational, traffic entering the Basin Reserve area will increase. (A summary diagram of the traffic volumes we were provided is contained in Appendix 5.E.) We have modelled the do-minimum Project with traffic volumes for the year 2031 which include the additional traffic flows with the second Mount Victoria Tunnel operational, to ensure the effects addressed for this Project are sufficient also for the situation where increased traffic flows enter the Project area with the second Mount Victoria Tunnel operational. The road-traffic noise environment is illustrated in Figure 5.54.

With the two Mount Victoria Tunnels operating, traffic modelling forecasts traffic flow increases on the road network around the Basin Reserve area. On Paterson Street the traffic volume increases about 25 percent, on the bridge the traffic volume increases about 40 percent, on Kent Terrace the traffic volume increases about 20 percent, and on Cambridge Terrace the traffic volume increases about 30 percent.

Figure 5.55 shows the noise level changes with the 2031 traffic flows on the road network. Over much of the Basin Reserve area, the noise increase between 2021 and 2031 is less than 1 dB $L_{Aeq(24h)}$. Figure 5.55 shows the area of Cambridge Terrace and Kent Terrace and the area of Ellice Street and Paterson Street have a change in noise level of greater than 1.5 dB $L_{Aeq(24h)}$ at 2.0 metres above ground level between 2021 and 2031. For the most exposed positions on buildings in these areas, noise level increases are mainly 1.6 to 1.8 dB $L_{Aeq(24h)}$. This change would place 21, 23, and 25 Ellice Street in 2031 into Category B using NZS 6806: 2010 noise criteria for altered roads. The Mount Victoria Tunnel duplication project is still under investigation and currently has not been approved. Ongoing investigations for design of the Mount Victoria Tunnel duplication project will need to consider the noise issues including 21, 23, and 25 Ellice Street.

Noise levels expected when the second Mount Victoria Tunnel is operational in 2031 do not alter the noise mitigation decisions made for this current Project.
Figure 5.54: Road-traffic noise environment 2.0 metres above ground level for the do-minimum Project operating with traffic forecast for 2031 (free-field noise levels, $dB L_{Aeq(24h)}$)
Figure 5.55: Comparison of the do-minimum-Project operating with traffic forecast for 2021 compared to that do-
minimum Project operating with traffic forecast for 2031, to illustrate effects of the change in traffic flows (free-field
noise levels, dB $L_{Aeq(24h)}$)
8 Construction noise

8.1 Requirements on construction noise

Section 2.1 explained the overarching requirement for management of noise is established by Section 16 of the RMA which requires the best practicable option to be selected to ensure that emissions of noise do not exceed a reasonable level. This applies to the noise from road-traffic using the Project once it is operational and also the noise from construction activities to make the Project. With respect to construction, reasonable noise levels need to allow construction to occur in an efficient manner but protect the adjacent community from high levels of noise, especially when activities such as sleep are required and expected.

Appropriate construction noise management and community liaison processes are also important to achieve acceptable construction noise outcomes. It is normal that these would be addressed in a Construction Noise (and Vibration) Management Plan. A constructor has already been appointed for construction of this Project (pending approval of the Project), a draft construction methodology and a draft Management Plan have been prepared. The draft Management Plan is provided in the documentation set Volume 4: Management Plans. The draft Management Plan is informed by the assessment of construction noise reported here.

8.1.1 NZS 6803: 1999

There is a New Zealand Standard NZS 6803: 1999 for Acoustics – Construction noise. This is the standard that applies to all construction projects and, since it came into being, it has been applied by the NZTA in all of its road construction projects.

An extensive history of practice has evidenced that construction noise managed within the guidance set out in NZS 6803: 1999\textsuperscript{41} is acceptable to the New Zealand public.

NZS 6803: 1999 notes in its foreword that the RMA requires adoption of the Best Practicable Option to ensure that noise levels are reasonable. This reference to the Best Practicable Option is important because the reasonableness of noise will be context-specific. Thus proper use of NZS 6803: 1999 is as guidance for setting construction noise limits that are specific to a project being undertaken and the specific situation in which that project is located. Setting construction noise limits needs to take into account:

\begin{itemize}
  \item The practicability of undertaking work within those limits; and
  \item The ambient noise levels existing prior to construction.
\end{itemize}

NZS 6803: 1999 contains “desirable upper limits for construction noise received by the community for the reasonable protection of health and amenity” Table 2 of NZS 6803: 1999, reproduced here as Table 5.14, recommends upper construction noise limits for residential zones and dwellings in rural areas; Table 3 of NZS 6803: 1999 is for industrial and commercial areas. However, NZS 6803: 1999 expects the Standard will be used as guidance to modify these tables “according to the type of land use, time of day and anticipated duration of the construction work” to establish a set of construction noise limits specific to the project.

\textsuperscript{41} And also the NZS 6803: 1999 predecessor NZS 6803P: 1984
Table 5.14: Reproduction of “Table 2 Recommended upper limits for construction noise received in residential zones and dwellings in rural areas” from NZS 6803: 1999

<table>
<thead>
<tr>
<th>Time of week</th>
<th>Time period</th>
<th>Duration of work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Typical duration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$L_{eq}$</td>
</tr>
<tr>
<td>Weekdays</td>
<td>0630-0730</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>0730-1800</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>1800-0630</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>2000-0630</td>
<td>45</td>
</tr>
<tr>
<td>Saturdays</td>
<td>0630-0730</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>0730-1800</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>1800-2000</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>2000-0630</td>
<td>45</td>
</tr>
<tr>
<td>Sundays and public holidays</td>
<td>0630-0730</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>0730-1800</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>1800-2000</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>2000-0630</td>
<td>45</td>
</tr>
</tbody>
</table>

The variation of recommended upper limits seen across Table 5.14 illustrates how time of day and construction duration can be factored into the setting of construction noise limits, discussed further in Section 8.2.

Beyond just complying with construction noise limits, NZS 6803: 1999 states “the best practicable options should always be adopted to ensure that the emission of noise from the site is minimised.” Thus, effort to minimise construction noise is enduring and requires ongoing avoidance of unnecessary noise in all construction-related activities.

The construction noise limits adopted for a project should not be exceeded unless it is not practicable to achieve them. Where the best practicable options for noise avoidance have been applied to construction activities and the activity does not comply with the relevant noise limits, special arrangements and management will be required; and these should be outlined in the Construction Noise (and Vibration) Management Plan.

Note the Wellington City requirements of construction noise are set out below in Section 8.1.3. As will be seen, many of the factors that NZS 6803: 1999 expects to be considered in establishing construction noise limits correspond to the factors Wellington City expects to be considered.

8.1.2 NZTA Environmental Plan

The NZTA Environmental Plan sets a formal objective to “manage construction and maintenance noise to acceptable levels.”

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42 NZS 6803: 1999 7.2.1(b) states “typical duration” means construction work at any one location for more than 14 calendar days but less than 20 weeks

43 NZS 6803: 1999 7.2.1(a) states “short-term” means construction work at any one location for up to 14 calendar days

44 NZS 6803: 1999 7.2.1© states “long-term” means construction work at any one location with a duration exceeding 20 weeks

45 Objective N3, NZTA Environmental Plan, June 2008
The Environmental Plan states that during construction of a project, potentially unreasonable construction noise effects will be managed and minimised, as far as is practicable, in accordance with NZS 6803: 1999. The preferred mechanism of construction noise management is a Construction Management Plan, or equivalent, which must include a noise management component.

8.1.3 Wellington City District Plan

Section 2.3 of this report outlines the Wellington City District Plan planning maps, the city area types, and the associated noise limits for each area type.

The Council has a Policy for construction noise in residential areas. It states:

The Council uses the New Zealand Standard on construction noise as a guide to assess and control construction noise in residential areas. The same residential limits also apply to any construction work that affects residential properties in the Central Area zone of the city. Work is considered noisy if it is loud enough to unreasonably disrupt anyone’s peace, comfort or convenience.

The Council states times when construction can be carried out:

- Monday - Friday 6:30am – 7:30am Quiet preparation work only
  7:30am – 6:00pm
  6:00pm – 8:00pm Extra work at a reduced noise level
- Saturday 7:30am – 6:00pm

Noisy construction work is not permitted on Sundays and public holidays.

Exemption to work outside these hours can be applied for. Application for exemption needs to include:

- Reasons for the work and why it has to be done outside permitted hours;
- The type of work and what equipment will be used;
- The work location and distance from residents [taken to also include other noise-sensitive activities for the situation of this Project];
- How long the work will go for and when it will take place;
- Predictions for the noise level as it reaches residential properties within earshot;
- If the work is going to take a long time or take place overnight, an acoustic consultant’s report showing how the noise can be managed; and
- Evidence of consultation, such as letters, with any potentially affected parties, and any special arrangements, including times of operation, that have been proposed or agreed during these discussions.

In the Council’s advice for “How to apply to do construction work outside standard working hours”, it is stated:
If you want to do construction work, including road maintenance and demolition work that cannot be carried out during the permitted working hours [...] Therefore, it is taken that the Council’s policy and rules for construction noise are expected to apply to road construction activities.

8.2 Factors influencing reasonable construction noise

Established practice with construction noise shows:

- A proviso on construction noise acceptability relates to the hours of the day during which the construction noise occurs. Usually high levels of construction noise are acceptable only during daytime and only on weekdays, although construction noise on Saturdays can also be accepted. However, where background noise levels are high and/or where there are sensitive day time land uses (such as schools) then a different approach might be acceptable. Acceptance of construction noise during the night is particularly dependent on (the public perception of) its necessity and dependent on appropriate notification of its occurrence.

- If the public have a strong understanding of when the construction noise is going to occur and its likely duration and the purpose of the associated construction activity, there is usually a good acceptance of the construction noise. Experience from many construction projects is that the public will accept construction noise levels, even 25 to 30 dB above normal noise levels, so long as that noise level increase is for a finite period and also if good noise management practices are publicly-perceived as being followed.

"Construction noise" covers all construction work activities, including maintenance and demolition work. Road construction activities have some particular characteristics relevant to generation of noise.

- In comparison to sites of building construction, most sites of road construction are longer. Even though this Project is shorter and smaller in scale than many road construction projects, still it extends over about 300 metres. Relative to any fixed (receiver) location, the centre of road construction activity moves nearer and further away as different works progress. Though longer construction sites may have construction activity occurring simultaneously at numerous areas along the site, still any one (receiver) location is affected by the full impact of construction activity for only a portion of the full construction period.

- While the overall duration of a road construction may be long, road construction is notable for its intermittent character. Phases of work will occur in one area then pause either while that phase is continued in other sections and/or to allow periods for settling of any fill or underlying materials or for the hardening of concrete structural elements to occur before continuing with the next phase.

8.3 Project construction

Detail of the methodologies used and the potential sequencing of that work are provided in the documentation set Volume 4: Management Plans.

A draft construction methodology and programme has been prepared and is provided in the documentation set Volume 4: Management Plans. The draft plan provides a reasonably detailed outline of the intended programme for the construction and the methodologies that at this stage are viewed as suitable for the work.

From a noise impact perspective, relevant aspects of the construction are:
• The main construction activities
• The proximity of those activities to adjacent noise sensitive land uses
• The noise levels of those activities
• The duration of the activities
• The timing of the activities with respect to time of day, time of week (weekday or weekend), and in some situations time of the year such as school holidays or the Christmas period.

The draft methodology and programme describes activities that fall into two main categories. There are those activities typical of roading improvement projects. These involve forming short sections of realigned roadway, reconfiguring intersections, reconstructing the upper layers of roadways, rearranging kerbings and traffic islands, and landscaping activities. These types of activities are included in the Project but are also noted as quite typical urban activities that occur from time to time at numerous locations across the city. Then there are those activities such as construction of the bridge, the Northern Gateway Building and the building at the Kent Terrace/Ellice Street corner. These activities are similar to construction of any large building within the central area of the city and are a more concentrated activity on a site and involved piling, erecting formwork, setting out reinforcing steel, periods of pouring concrete, then dismantling of the formwork.

The draft methodology and programme identifies:

1. The expected duration of construction is 28 months with 6 months being an additional contingency.

2. The main construction element is the bridge, divided into its subcomponents of:
   • Forming western and eastern abutments and associated retaining structures;
   • Piling for the six piers;
   • Forming the piers;
   • In situ forming of the bridge deck, undertaken in stages;
   • Forming the separate pedestrian/cycleway that connects to the bridge, involving smaller diameter piling and piers, and forming the deck from prefabricated sections;
   • Realignment of the eastern traffic stream from Kent Terrace to Paterson Street so as to accommodate the bridge.

Because a key feature of the construction methodology is to keep the existing transport network as close to fully functional as practicable, over the construction period the bridge site is not a continuous work zone. Rather, each pier and abutment of the bridge is enclosed in a separate work zone.

In addition, within the overarching trend of construction is forming the foundations, then piers, then bridge deck, the activity in each work zone occurs at different periods within the construction and in separate stages of foundations, at ground, and above ground activities, until such stage as false formwork can be placed to carry the deck-forming activities and transport activity pass beneath. There is a general trend for activity to commence at both the western and eastern ends working towards the centre areas. Therefore, for adjacent noise sensitive land uses, it is likely that construction activity will occur nearby for most of the construction period but it will be marked by periods of intense activity lasting from one or two days, for example during concrete pours, to a few weeks, for example during driving the pile casings or boring the piles.
Periods between these more intense activities are more commonly lower intensity activities such as erecting or dismantling formwork or placing reinforcing or periods of no activity such as waiting for concrete to come to strength or waiting for the next construction phase.

3. The Northern Gateway Building is a typical building project. It requires piling, placing of formwork and reinforcing and pouring concrete, and also lifting precast elements into place. This building construction is scheduled to occur in approximately the second and third quarters of the construction period.

4. As far as practicable, traffic flows are intended to be maintained as normal throughout construction. The realignment of Kent Terrace/Ellice Street/Paterson Street to the Mount Victoria Tunnel is to be made operational within the first few months of construction. Therefore, many of the noise sensitive receivers who could be affected by noise from the bridge construction will actually be separated from that noise source by substantial traffic flows. Exceptions are the 80 Kent Terrace (Grandstand Apartments building), the Regional Wine and Spirits premise, and the 21 Ellice Street residence. Still, a major traffic flow occurs near to these buildings and also separates them from construction of the Northern Gateway Building.

5. The roading-type construction and landscaping occur either at the start of the construction period, to aid traffic flows throughout the construction period, or near the end of the construction period once the bridge is operational.

6. The need for some specific night work is identified, such as when placing false formwork as part of the bridge construction or delivering prefabricated elements. If it facilitated the operation of the network, a possible need to work over some holiday periods is also identified.

8.3.1 Noise levels for bridge construction

For the Project’s bridge structure, the main construction activities are excavations and ground strengthening for the bridge abutments, excavation in preparation for the piers, inserting the pile casings into the ground, then boring out the casing to form the cavity for the pile, forming and placing reinforcing steel cages in the cavity, filling the pile cavities with concrete, forming the concrete formwork for the piers; then repeating the process of installing the reinforcing and pouring concrete to form the pier. Forming the bridge deck follows a similar process. After formwork is put in place to allow traffic to flow underneath, formwork for the bridge deck is erected; and the process of placing reinforcement and concrete is repeated.

Each bridge pier is expected to take three to four months to make, each pier being a small self-contained worksite. The piling casing and boring activities, though not necessarily the noisiest activity is probably the most intensive activity likely to take two to four weeks for each pier. Inserting the pile casings is most likely to be by oscillated piling but vibratory piling may be needed.

Piling and making the piers for the eastern section of the pedestrian/cycleway will be quicker, probably a total time of only one month each, as these piles are much smaller than the main bridge piers.

To estimate the noise levels typical of bridge construction activities, we have used NZS 6803: 1999 supplemented with some local measurements. NZS 6803: 1999 provides noise levels for construction equipment when it is fully in use. For each type of equipment, NZS 6803-1999 there is a range of values quoted as the data has been built up from a number of construction projects. The data is quite often for an activity that may involve two to three items of equipment to undertake the activity. From NZS 6803: 1999:
• Table C.4 gives for vibratory pile driving for inserting steel casings a noise level of 93 dB $L_{Aeq}$ at 10 metres.

• If casting piles in situ, for boring the pile cavity Table C.4 gives a noise level of 81 to 87 dB $L_{Aeq}$ at 10 metres.

• For “pumping concrete to foundations [or to the bridge deck], and compaction, with a concrete mixer truck, a concrete pump, a compressor, and two poker vibrators gives a total noise level at 10 metres of about 87 dB $L_{Aeq}$ using Table C.6

There is also additional information on alternate piling techniques. Measurements made in Wellington show that oscillatory piling of piling cases has a noise level of 75 dB $L_{Aeq}$ at 10 metres.

These are the noisiest activities and much of the other activity will be less noisy and will involve the use of electric and pneumatic power tools with associated compressors and generators, used to prepare the formwork.

Within other projects we have measured specific construction activities. In general, modern well-maintained equipment is a little less noisy than the values provided within NZS 6803: 1999. Poorly maintained equipment can be more noisy than the NZS 6803: 1999 values.

8.3.2 Noise levels for forming new at-grade road sections or for modifying existing roads

NZS 6803: 1999 identifies that noise from road forming equipment and machinery clusters will have a total noise level of about 80 to 85 dB $L_{Aeq}$ at 10 metres.

For forming the modified eastern road link and other at-grade road alterations, the typical clusters of plant and machines will be usually two trucks and a major item of plant such as an excavator or a roller or a compactor or a paving machine. Using the data of NZS 6803: 1999, the combined noise levels for these various clusters will be typically 84 dB $L_{Aeq}$ at 10 metres distance.

8.3.3 Noise of individual vehicles using public roads

The noise of construction traffic using public roads to access the construction site is not under special control but is generally controlled under the Land Transport: Vehicle Equipment Rules regulation for noise of individual vehicles. Provided the vehicles comply with this requirement, there is unlikely to be any cumulative impact. About 3 percent of the vehicles currently using the nearby road network are classed as heavy commercial vehicles, which equates to about 750 to 1000 heavy commercial vehicles per day on various sections of this nearby road network. Given expected construction traffic volumes, the relative average noise level increases will almost certainly be undetected by most people.

8.4 Factors in calculating noise levels

8.4.1 Intermittent use

Not all plant items will be operating on full power at any one time as some will be paused in their activities to allow the activities of other plant items. For example, a loader removing bored material from piling would be on low power as it waits for the boring and for the truck to drive up. Then while the loader is on high power moving the bored material into the truck, that truck is on low power. To
allow for this, a further 3 dB could typically be deducted from the noise level data given in NZS 6803: 1999. This equates to allowing that an item of plant or machinery is actively operating only 50 percent of the time and is on low power or idling the remainder of the time.

It should be noted that the use of $L_{Aeq}$ in NZS 6803: 1999 also allows for a fluctuation in noise of the plant or machinery within operation. For example, the loader will generate a range of noise levels as it first scoops its load, part raises the load, reverses, then lifts its load to advance to the truck. $L_{Aeq}$ averages out these fluctuations but does not include the low power/high power fluctuations described above.

### 8.4.2 Noise reduction with distance from noise source

For the locations adjacent to the construction activities, the noise level at the location will be equal to the noise level at the source less any “distance effect” on the noise. A distance adjustment factor (in dB) is calculated according to NZS 6803: 1999 for hard ground:

$$\text{Distance adjustment} = 20 \log_{10} \left( \frac{R}{10} \right)$$

$R$ is the distance between the noise source and the receiver location (such as a house located on an affected property). Table 5.15 shows a sample of adjustments for distances between the centre of construction activities and receiver locations. Note that these distances and distance adjustments are for unimpeded noise propagation. Generally noise from construction of the Basin bridge to the closest receivers will be unimpeded. Thereafter the close spacing of the buildings significantly reduces propagation to the buildings beyond.

**Table 5.15: Noise reduction with distance for the construction equipment**

<table>
<thead>
<tr>
<th>Distance from noise source (m)</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>120</th>
<th>140</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of noise (dB)</td>
<td>0</td>
<td>6</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>22</td>
<td>23</td>
</tr>
</tbody>
</table>

Based on the likely noise level from various contributions of equipment being 82 to 87 dB, noise levels are therefore likely to be less than 75 dB at 25 to 40 metres, less than 70 dB at 40 to 70 metres, and less than 64 dB at 80 to 140 metres.

The distance adjustments in Table 5.15 can be readily applied to construction activities occurring at one principal location, such as pier construction. For example, there are various piling techniques. If the typical noise level for vibratory piling of 93 dB at 10 metres is used, then those noise levels are about 75 dB at 80 metres. Comparatively, 75 dB can be achieved at 10 metres if oscillatory piling is used. Whereas vibratory piling techniques, if used, would likely be the dominant noise source, the noise levels of oscillatory piling techniques would be similar to the noise levels from other construction activities.

### 8.4.3 Effective distance from mobile noise source

For other construction activities such as forming at-grade road sections, during construction clusters of plant or machinery cannot all be in the same location at a single time. For mobile sources of noise, such as the bulk of road construction activities, the equipment is moving around a work area. For this Project, that area would likely be about 50 metres in length. As equipment
moves within this 50 metres length, the effective distance from noise source to receiver location is greater than the distance of closest approach when the equipment is directly opposite the receiver location.

Table 5.16: Typical effective distance based on a nominal 50 metre long work area and corresponding noise reduction with distance for the construction equipment

<table>
<thead>
<tr>
<th>Closest approach (m)</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical effective separation (m)</td>
<td>26</td>
<td>35</td>
<td>44</td>
<td>53</td>
</tr>
<tr>
<td>Reduction of noise (dB) compared to noise levels at ten metres distance</td>
<td>8</td>
<td>11</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>

These distance and distance adjustments are for unimpeded noise propagation.

For a typical cluster of road-forming plant and machinery with a noise level of 84 dB L_{Aeq} at 10 metres, Table 5.17 shows the noise levels at various “closest approach” distances with the range of distances selected to cover the locations of noise-sensitive activities near to the site and calculation of the noise levels taking account of fluctuations in activity-intensity and the inability of all equipment of the cluster to be at one point at one time.

Table 5.17: Likely construction noise levels (dB) for forming or modifying the at-grade road sections

<table>
<thead>
<tr>
<th>Likely cluster of pant and machines</th>
<th>Nominal noise at 10 metres distance</th>
<th>Closest approach in metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two trucks with one of excavator or roller or compactor or paving machine</td>
<td>84</td>
<td>20</td>
</tr>
</tbody>
</table>

8.4.4 Noise levels near receiving buildings

When measuring close to the front of a building, the noise is reflected back from the wall of the building, thereby reinforcing the noise so that the measurement is increased by typically 2.5 dB.

8.5 Receiver locations nearest to main construction activities

8.5.1 Bridge construction activities

Figure 5.30 and Figure 5.38 show properties in the area. Those closest to the bridge construction are 4 Sussex Street (C04); the Home of Compassion Crèche (former, which is unoccupied and owned by NZTA, and so not considered further for construction noise); 80 Kent Terrace (the Grandstand Apartments building) (I07 and I08); 21, 23, and 25 Ellice Street (K17, K18, and K19); St Joseph’s Church (P04); St Mark’s School (H04); and 9 Dufferin Street (H01 and H02).

Table 5.18 shows the distance from these properties to key features of the bridge (for distances up to 150 metres).
Table 5.18: Nominal distances between key construction features and close properties

<table>
<thead>
<tr>
<th>Feature</th>
<th>Property</th>
<th>4 Sussex</th>
<th>80 Kent</th>
<th>21 Ellice</th>
<th>St. Joseph’s</th>
<th>St Mark’s</th>
<th>9 Dufferin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete face of western abutment</td>
<td></td>
<td>52</td>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pier 1</td>
<td></td>
<td>85</td>
<td>62</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pier 2</td>
<td></td>
<td>125</td>
<td>25</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pier 3</td>
<td></td>
<td>12</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pier 4</td>
<td></td>
<td>45</td>
<td>115</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pier 5</td>
<td></td>
<td>25</td>
<td>80</td>
<td>100</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pier 6</td>
<td></td>
<td>47</td>
<td>45</td>
<td>65</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete face of eastern abutment</td>
<td></td>
<td>70</td>
<td>30</td>
<td>40</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The noise levels generated are highly dependent on the precise nature of the equipment and method of construction used.

Table 5.15 indicates that if a noise level from equipment being used for construction in a fixed position was 82 to 87 dB at 10 metres, then that would be 75 dB L_{Aeq} at 25 to 40 metres distant. Table 5.17 indicates that noise levels from mobile equipment for road forming or modifying would be 75 dB L_{Aeq} at about 25 metres distant. These distances from the equipment where 75 dB L_{Aeq} is achieved will reduce significantly if the equipment being used is 3 or even 5 dB quieter than the equipment used in these calculations.

There are several situations where the noise may exceed 75 dB L_{Aeq}. These may include:

- At 80 Kent Terrace (the Grandstand Apartments building) when constructing piers 2, 3, and 4.
- At 21 Ellice Street when constructing piers 4 and 5 and piers for the pedestrian/cyclist bridge.
- At St Joseph’s Church and St Mark’s School when the eastern abutment is being constructed.

However it is likely that if the construction noise does exceed 75 dB L_{Aeq} then any exceedance would be by only 3 to 5 dB L_{Aeq}.

The Construction Noise and Vibration Management Plan, which is Appendix B of the Construction Environmental Management Plan, sets out the process by which the compliance with the noise limits will be established. This process will involve the measurement of the equipment noise levels before work commences, calculation of noise levels at receivers and noise monitoring to ensure compliance. The Construction Noise and Vibration Management Plan also sets out the process that will be followed if it is assessed that it is likely that the noise limits might be exceeded. These
will include an assessment as to whether the effect of the exceedance is only minor, and undertaking a series of steps to minimise the effect in consultation with a Wellington City Council officer.

### 8.5.2 Receiver locations near the Northern Gateway Building

Table 5.18 includes the distances from the closest receivers to the Northern Gateway Building. The eastern portion of the building is closest to the receivers but with the separation distance being 40 metres or more, and the building construction activities being similar to that for the bridge construction, noise levels less than 75 dB \( L_{Aeq} \) are likely.

### 8.6 The noise environment that will receive the construction noise

The existing ambient noise environment influences the construction noise level that would be acceptable for a project and the hours of the day when the noise would be more tolerable.

Section 5 of this noise assessment report sets out the noise environment of the Project area. Figure 5.7 shows the noise levels of the Project area as at 2009, both as measured levels and as modelled levels. Figure 5.9 shows the noise environment that would be expected in 2021 with the Memorial Park project in place (and without the Basin Bridge). For the Project area there is very little change in noise levels between these two situations. Particularly for the area of the bridge itself, the adjacent buildings are already in a high noise environment. In most instances these buildings are either separated from the Project by a busy road or are located so that they are equally exposed to the road-traffic noise and the Project-construction noise.

The tables of Section 6 show the road-traffic noise level at each of the main receiver positions. Table 5.19 summarises the noise levels for the main receivers closest to the Project’s key construction features. These are mainly residences but include a church and a school.

<table>
<thead>
<tr>
<th>Property</th>
<th>Do-nothing receiving situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C04 4 Sussex</td>
<td>70.5</td>
</tr>
<tr>
<td>I07 80 Kent (7 storey)</td>
<td>68.9</td>
</tr>
<tr>
<td>I08 80 Kent (2 storey)</td>
<td>63.6</td>
</tr>
<tr>
<td>K17 21 Ellice</td>
<td>62.8</td>
</tr>
<tr>
<td>K18 23 Ellice</td>
<td>61.5</td>
</tr>
<tr>
<td>K19 25 Ellice</td>
<td>61.7</td>
</tr>
<tr>
<td>P04 St Joseph’s Church</td>
<td>66.4</td>
</tr>
<tr>
<td>H01 9 Dufferin (front)</td>
<td>69.2</td>
</tr>
<tr>
<td>H02 9 Dufferin (back)</td>
<td>69.5</td>
</tr>
<tr>
<td>H04 St Mark’s School</td>
<td>70.2</td>
</tr>
</tbody>
</table>

Figure 5.8 is repeated here as Figure 5.56. The figure illustrates how the noise level adjacent to the Basin Reserve varies over the day with the noise equal to or exceeding the 24 hour average between 6:00 am and 6:00 pm but significantly remaining within about 3 to 4 dB of this average level until about 11:00 pm. It is only in the early hours 12:00 am to 5:00 am that noise levels decrease significantly below the daily average.
The noise pattern shown in Figure 5.56 is consistent with the pattern of traffic flow through the area, as illustrated by traffic count data from the Paterson Street counting station shown in Figure 5.57. Note it requires a doubling of traffic volume to increase noise by 3 dB.

Construction noise limits for the area

Section 8.6 has identified the medium to high road-traffic noise throughout this area and that these noise levels are sustained from about 6:00 am to 11:00 pm with high noise levels above the 24 hour average level (expressed as $L_{Aeq(24h)}$) from about 7:00 am to 8:00 pm. NZS 6803: 1999 has as
recommended noise levels 75 dB for daytime and 70 dB for shoulder periods but reducing by 5 dB for construction work of long-term duration exceeding 20 weeks in one location.

The existing ambient noise levels would justify normal daytime construction activity extending from about 7:00 am to 8:00 pm, with construction activity at a lower noise level in the shoulder periods from 6:00 am to 7:00 am and 8:00 pm to 10:00 pm.

Given the existing ambient noise levels, no reduction for work of long duration should be made. If this was done then construction noise would often be at only the same level as the daytime ambient noise level. NZS 6803: 1999 is framed around construction noise levels being higher than normal but being acceptable because of their temporary nature. This is well-established practice.

Table 5.20 sets out recommended construction noise limits for the area. In applying them a flexible approach is needed. Where construction is near residences the noisy activity is confined to daytime hours, but for construction near schools, churches or commercial premises, it could be preferable if the more noisy construction activity was outside normal hours of building occupation. Construction activity which is quieter because it is more distant could continue over extended hours. This approach is recognised by a Construction Noise and Vibration Management Plan (draft provided in the documentation set Volume 4: Management Plans), which has been framed within the context of NZS 6803: 1999 and recognise the existing high ambient noise environment.

For most of the Project construction, the recommended construction noise limits in Table 5.20 can be met. However, it is noted for pier 3 and the associated bridge section and the cyclist/pedestrian bridge near Ellice Street, construction is close to residences; and construction of the eastern abutment is close to St Joseph’s Church, St Mark’s School, and 9 Dufferin Street. The Construction Noise and Vibration Management Plan should set out how the more noisy activities for these construction features should be confined to those parts of the day that have less impact. However, given the high existing noise levels, short periods of higher noise should be tolerable so long as there is good communication with affected properties.

The recommended construction noise limits are a close match to those which are being applied to the National War Memorial Park project construction which is to the immediate west of this Project area. The construction noise limits for the National War Memorial Park project are contained in the legislation that empowered that project. There are some small modifications for this Project.

Table 5.20 contains no separate noise limits for commercial areas. Commercial areas can usually accept higher noise levels at night time, since usually the premises are closed for business at night time. The commercial buildings nearest to the main construction are a Mitsubishi Motors building and the building of Regional Wine and Spirits. These two buildings are also very close to residential buildings so for this Project no separate construction noise limits are provided for commercial areas.

The construction noise limit recommended overnight, from 8:00 pm through to 6:00 am, is guided by the Wellington City District Plan. However in this instance the Project area, while mainly in the central area crosses into the inner residential area at its eastern end. While these types of areas have different noise limits in the Wellington City District Plan, the physical exposure to road-traffic noise for both areas is uniform and quite high. Therefore the central area noise limit of 60 dB $L_{Aeq}$ is retained and the $L_{Amax}$ is the more appropriate 75 dB.
Table 5.20: Recommended construction noise limits

<table>
<thead>
<tr>
<th>Time</th>
<th>Noise limits (dB)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L_{Aeq}</td>
<td>L_{Amax}</td>
</tr>
<tr>
<td>Monday to Saturday</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00 am through to 7:00 am</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>7:00 am through to 8:00 pm</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>8:00 pm through to 6:00 am</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Sunday and public holidays</td>
<td>60</td>
<td>75</td>
</tr>
</tbody>
</table>

These construction noise limits should allow construction to proceed efficiently but provide protection for those living in or using the adjacent areas. For most of the construction, these noise limits can be adhered to. Some portions of construction may exceed these limits, but this depends greatly on the noise attributes of the specific equipment used. The Construction Noise and Vibration Management Plan sets out a process by which noise levels will be assessed and monitored, and management of any exceedance of the noise limits that cannot be avoided.
9 Conclusions

The investigation has found that the Project as currently designed changes noise levels in the area very little and as a consequence its noise effects are slight. In many instances, change in noise is an increase or decrease of no more than 1 dB $L_{Aeq(24h)}$. Seldom is it more than 2 dB $L_{Aeq(24h)}$.

Important open-air spaces such as the National War Memorial Park and the Basin Reserve experience only small changes in noise levels due to the Project, being only 1 to 2 dB $L_{Aeq(24h)}$ either as a noise level increase or decrease, and the effect of the Project on these areas can be regarded as negligible.

The Basin Reserve area is an area where the State Highway network intersects with the local road network. As a consequence, traffic volumes in the area are high and have been so for over fifty years. Various sections of roads in the area currently carry between 10,000 and 40,000 vehicles per day. Even though signposted speeds are only 50 km/h and the heavy vehicle component in the traffic flow is low, with these high traffic volumes, road-traffic noise levels are already high at adjacent buildings and open-air spaces in the area. However, in some places there is close spacing of multiple buildings that creates quieter areas sheltered from road-traffic noise.

The Project introduces an elevated bridge link to the Basin Reserve area road network with the bridge being positioned mainly over or very close to existing roadways. The new link shifts approximately 20,000 vehicles per day from the southern side of the Basin Reserve to the northern side. The noise effects of the bridge are superimposed over the noise of the at-grade traffic flows, and because these at-grade traffic volumes remain high, the traffic flow on the bridge causes only small noise level increases in the areas adjacent. Although the Project reduces traffic volumes in some areas, the associated decrease in road-traffic noise is small.

The iterative design process of this Project means the current design already incorporates the viable noise-mitigating features. As a consequence, noise effects are very small and the opportunity for further noise reduction is limited. In some cases the Project causes noise level decreases (relative to those that would occur in the receiving environment without the Project having been built) but the total noise levels may be still high. Some guidance such as NZS 6806: 2010 encourages investigation of practicable mitigation where although noise levels have been decreased by the project noise levels are still high. We undertook this investigation even though the changes in noise caused by the Project are insufficient to fulfil the criteria required for invoking NZS 6806: 2010. However our understanding is that a project need only address the impacts of that project itself. Any mitigation further to that addressing the impacts of the project itself is not a requirement.

While building-modification mitigation via acoustic insulation could be considered, in many cases the context is high noise levels are an existing situation, either not affected by the Project or slightly reduced by the Project. Most of buildings in the Basin Reserve area are newer and as the existing high noise levels have been present for more than fifty years these newer buildings are likely to have been built with regard to these noise levels.

Overall, the investigation has found that the Project as currently designed changes noise levels in the area very little and as a consequence its noise effects are slight. The Project has slightly negative effects in the area close to the bridge but these are less than minor as the change in noise would in most cases be barely discernible and elsewhere the Project has some slightly positive effects as existing high noise levels are slightly decreased but again this effect is minor or less than minor.
In conclusion, provided the Construction Noise and Vibration Management Plan is appropriately finalised and adhered to, construction noise impacts will also be no more than minor. Construction noise levels will be only a modest increase over the ambient high noise levels and the more noisy construction activities will be for only a short to moderate portion of the total construction activity.
10 Recommendations

In application for the designation, the NZTA will provide a set of draft conditions and these conditions typically contain conditions for construction noise and operational noise. The following recommendations are made in regard to these conditions.

Construction is close to several locations of noise-sensitive activities. There is the need for the construction activity to be actively managed to ensure noise levels are acceptable and to ensure good communication practices to manage the impacts. This is best achieved by a Construction Noise and Vibration Management Plan and the need for this should be reflected in the conditions. A draft Construction Environmental Management Plan and associated Construction Noise and Vibration Management Plan have been prepared and will be submitted as part of the designation application. Our assessment has shown, with proper implementation of this Construction Noise and Vibration Management Plan, it will be possible to construct the Project within acceptable noise levels.

For operational noise, our assessment has shown the potential road-traffic noise effects are often insignificant or much less than minor and always no more than minor, and no additional noise mitigation has been recommended. In this Project, unusually for a roading project, the main construction feature, the bridge, is not the major road-traffic noise source which is the ground-level traffic.

The main feature that could be varied which could significantly alter noise is the road surfaces used on the roads at ground level and on the bridge. A condition should limit these road surfaces to those close to, or better than, the acoustic performance of those used in this assessment. The bridge joints are a potential noise nuisance. A condition of the Project is for the constructor to use bridge expansion joints of finger joint type or a type with equivalent or better noise performance. Therefore, any potential issue from noise at bridge expansion joints can be minimised.
Appendix 5.A  The road-traffic noise environment at a range of heights

Reviewers had questioned whether the noise contour diagrams throughout the report were understating the noise effects of the Project by plotting at a height of 2.0 metres above ground level. In a highly-built area, buildings will block the spread of noise and the noise effects may be greater if assessed at a greater height. As stated earlier, we use the noise level contours only to demonstrate and understand the spread of noise. Noise calculations were made for the full height of all buildings in the model. However, this appendix has been prepared to confirm there has been no distortion.

The noise contours in the following figures represent the noise levels calculated for a range of heights above ground level. The other items in the figures, such as the shaded areas representing buildings and the positions of the roads, consistently overlay the noise contours (rather than disappearing as the calculation height moves above the height of these items).

As expected, noise levels are higher above ground as noise spreads and there is less to impede the spread of noise. However, unless one is in a building, there is no one able to experience the noise at these greater heights; and where one is in a building this has already been calculated. As the effect of height is similar for the do-nothing receiving situation and the do-minimum Project situation, then the noise effect, determined by the difference between these two situations, remains unchanged.

2021 do-nothing receiving situation

2021 do-minimum Project situation

One metre above ground level
2021 do-nothing receiving situation
Two metres above ground level

2021 do-minimum Project situation

Three metres above ground level

Four metres above ground level
2021 do-nothing receiving situation
Five metres above ground level

2021 do-minimum Project situation

Six metres above ground level
Appendix 5.B  Summarised discussion of a section of extra barrier on the bridge

In response to early consultation with owners of the Grandstand Apartments building (107/108) at 80 Kent Terrace, other Project disciplines suggested a section of extra barrier where the bridge is adjacent the Grandstand Apartments building. It was proposed this barrier could be designed to provide some benefits to users of the bridge; and that section of extra barrier could provide some reduction of road-traffic noise levels received at the Grandstand Apartments building.

A section of barrier, illustrated by the cross-section in the following figure, was proposed for us to investigate. We were directed to consider the proposed barrier form in increments, shown by the marks across the cross-section, to determine the effectiveness of relative extents of the barrier.

Proposal for the form of a section of extra barrier on the bridge

- Three increments of the extra barrier were modelled: a vertical 6.0 metre high barrier; a vertical 6.0 metre high barrier topped with a sloped section; and a vertical 6.0 metre high barrier topped with two sloped sections.
- The do-minimum Project includes a 0.8 metre high barrier along each edge of the bridge adjacent to the traffic lanes. In the noise modelling of the extra barrier and its increments, this 0.8 metre high barrier is unchanged outside of the section where the extra barrier is included.
- The section of extra barrier is positioned approximately adjacent the Grandstand Apartments building, along the northern edge of the bridge, as indicated in the following figure.
The following set of figures show the road-traffic noise at facades of the Grandstand Apartments building.

- For this first figure, the bridge has only the 0.8 metre high barriers of the do-minimum Project situation.
- For this second figure, the bridge has the 0.8 metre high barriers and a section of extra barrier 6.0 metres high.
  - On the façade facing towards Kent Terrace, there is negligible change between Figure 2 and Figure 1.
  - On the façade facing towards the bridge and extra barrier, changes between Figure 2 and Figure 1 are visible.
  - On the façade facing over the rooftop space, changes between Figure 2 and Figure 1 are barely visible.
- For this third figure, the bridge has the 0.8 metre high barriers and a section of extra barrier 6.0 metres high topped with a sloped section of barrier.
  - On the façade facing towards Kent Terrace, there is negligible change between Figure 3 and Figure 2.
  - On the façade facing towards the bridge and extra barrier, changes between Figure 3 and Figure 2 are barely visible.
  - On the façade facing over the rooftop space, changes between Figure 3 and Figure 2 are visible.
- For this fourth figure, the bridge has the 0.8 metre high barriers and a section of extra barrier 6.0 metres high topped with two sloped sections of barrier.
  - On the façade facing towards Kent Terrace, there is negligible change between Figure 4 and Figure 3.
  - On the façade facing towards the bridge and extra barrier, changes between Figure 4 and Figure 3 are barely visible.
  - On the façade facing over the rooftop space, changes between Figure 4 and Figure 3 are slight.
Following these four figures, Figure 1 to Figure 4, are three figures that show the road-traffic noise level changes at facades of the Grandstand Apartments building caused by different options for a section of extra barrier on the bridge.

- A section of extra barrier on the bridge does not affect noise levels on the façade facing Kent Terrace, which is the façade with greatest exposure to road-traffic noise.
- A section of extra barrier on the bridge could provide noise mitigation effects for some parts of the façade facing towards the bridge and extra barrier.
- A section of extra barrier on the bridge could provide some substantial noise level decreases on parts of the façade facing over the rooftop space.

The extra barrier here investigated is not initiated by assessment of the Project’s noise effects. The extra barrier is not required for mitigation of the Project’s noise effects but if it was built it would provide some noise level reductions that would be noticeable for some parts of the Grandstand Apartments façade facing towards the bridge and some parts of the façade facing over the rooftop space.

*Road-traffic noise at facades of the Grandstand Apartments building for situations of different options for a section of extra barrier on the bridge (adjusted to free-field noise levels, dB $L_{Aeq(24h)}$)*

Figure 1: Barriers on the bridge 0.8 metres high (The do-minimum Project)
Road-traffic noise at facades of the Grandstand Apartments building for situations of different options for a section of extra barrier on the bridge (adjusted to free-field noise levels, \(dB \ L_{\text{Aeq(24h)}}\)).

Figure 2: Barriers on the bridge 0.8 metres high plus a section of 6.0 metre high extra barrier.

```
<table>
<thead>
<tr>
<th>Absolute noise levels</th>
<th>(dB \ L_{\text{Aeq(24h)}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 &lt;</td>
<td>(\leq 45)</td>
</tr>
<tr>
<td>47 &lt;</td>
<td>(\leq 47)</td>
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<td>49 &lt;</td>
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<td>51 &lt;</td>
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<tr>
<td>73 &lt;</td>
<td>(\leq 73)</td>
</tr>
</tbody>
</table>
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Figure 3: Barriers on the bridge 0.8 metres high plus a section of 6.0 metre high extra barrier topper with a sloped section.

```
<table>
<thead>
<tr>
<th>Absolute noise levels</th>
<th>(dB \ L_{\text{Aeq(24h)}})</th>
</tr>
</thead>
<tbody>
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<td>(\leq 67)</td>
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<tr>
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<td>(\leq 69)</td>
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<tr>
<td>71 &lt;</td>
<td>(\leq 71)</td>
</tr>
<tr>
<td>73 &lt;</td>
<td>(\leq 73)</td>
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</tbody>
</table>
```
Road-traffic noise at facades of the Grandstand Apartments building for situations of different options for a section of extra barrier on the bridge (adjusted to free-field noise levels, dB $L_{Aeq(24h)}$)

Figure 4: Barriers on the bridge 0.8 metres high plus a section of 6.0 metre high extra barrier topped with two sloped sections

Change in noise levels

<table>
<thead>
<tr>
<th>dB $L_{Aeq(24h)}$</th>
<th>≤ -6.5</th>
<th>-6.5 &lt;</th>
<th>-5.5 &lt;</th>
<th>-4.5 &lt;</th>
<th>-3.5 &lt;</th>
<th>-2.5 &lt;</th>
<th>-1.5 &lt;</th>
<th>-0.5 &lt;</th>
<th>0.5 &lt;</th>
<th>1.5 &lt;</th>
<th>2.5 &lt;</th>
<th>3.5 &lt;</th>
<th>4.5 &lt;</th>
<th>5.5 &lt;</th>
<th>6.5 &lt;</th>
<th>7.5 &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute noise levels</td>
<td>≤ 45</td>
<td>≤ 47</td>
<td>≤ 49</td>
<td>≤ 51</td>
<td>≤ 53</td>
<td>≤ 55</td>
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<td>≤ 67</td>
<td>≤ 69</td>
<td>≤ 71</td>
<td>≤ 73</td>
<td>≤ 75</td>
</tr>
</tbody>
</table>
Road-traffic noise level changes at facades of the Grandstand Apartments building caused by different options for a section of extra barrier on the bridge (adjusted to free-field noise levels, $dB_{Leq(24h)}$)

Figure 6: The effect of the 6.0 metre high section of extra barrier topped with a sloped section (Figure 3 minus Figure 1)

<table>
<thead>
<tr>
<th>Change in noise levels $dB_{Leq(24h)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ -6.5</td>
</tr>
<tr>
<td>-6.5 &lt; -5.5</td>
</tr>
<tr>
<td>-5.5 &lt; -4.5</td>
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<td>-4.5 &lt; -3.5</td>
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<td>-3.5 &lt; -2.5</td>
</tr>
<tr>
<td>-2.5 &lt; -1.5</td>
</tr>
<tr>
<td>-1.5 &lt; -0.5</td>
</tr>
<tr>
<td>-0.5 &lt; 0.5</td>
</tr>
<tr>
<td>0.5 &lt; 1.5</td>
</tr>
<tr>
<td>1.5 &lt; 2.5</td>
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<td>2.5 &lt; 3.5</td>
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<td>3.5 &lt; 4.5</td>
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<td>4.5 &lt; 5.5</td>
</tr>
<tr>
<td>5.5 &lt; 6.5</td>
</tr>
<tr>
<td>6.5 &lt; 7.5</td>
</tr>
<tr>
<td>7.5 &lt;</td>
</tr>
</tbody>
</table>

Figure 7: The effect of the 6.0 metre high section of extra barrier topped with two sloped sections (Figure 4 minus Figure 1)

<table>
<thead>
<tr>
<th>Change in noise levels $dB_{Leq(24h)}$</th>
</tr>
</thead>
<tbody>
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<td>≤ -6.5</td>
</tr>
<tr>
<td>-6.5 &lt; -5.5</td>
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<td>-4.5 &lt; -3.5</td>
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<td>-3.5 &lt; -2.5</td>
</tr>
<tr>
<td>-2.5 &lt; -1.5</td>
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<tr>
<td>-1.5 &lt; -0.5</td>
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<td>-0.5 &lt; 0.5</td>
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<td>0.5 &lt; 1.5</td>
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<tr>
<td>1.5 &lt; 2.5</td>
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<td>6.5 &lt; 7.5</td>
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<tr>
<td>7.5 &lt;</td>
</tr>
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</table>
Appendix 5.C Traffic flows for the current (2009) situation

The principal traffic flow information used in the road-traffic noise modelling for the year 2009 was received by email from Richard Sprosen (Opus International Consultants) on 21 October 2009. A spreadsheet was provided with traffic flow information for other roads in the area. The traffic flow figures are from modelled outputs, not from traffic counts.
Appendix 5.D  Traffic flows forecast for the year 2021 with the do-nothing receiving situation and with the do-minimum Project situation (and one Mount Victoria Tunnel)

The principal traffic flow information used in the road-traffic noise modelling for the year 2021 was received by email from Sarah Baxter (Opus International Consultants) on 6 July 2012. Traffic flows modelled for the do-nothing receiving situation (2021)
Traffic flows modelled for the do-minimum Project situation (2021)

Since we received this traffic flow information, the road layout has had minor alterations resulting in minor alterations to the traffic flows. Accordingly, we received updated traffic flow information on 6 March 2013. We have checked the updated traffic flow information and the changes do not alter our assessment of the road-traffic noise.
Appendix 5.E  Traffic flows forecast for the year 2031 with the Project completed and the second Mount Victoria Tunnel completed

The principal traffic flow information used in the road-traffic noise modelling for the year 2031 was received by email from Sarah Baxter (Opus International Consultants) on 6 July 2012.

Traffic flows modelled for 2031 with the Project completed and the second Mount Victoria Tunnel completed

Since we received this traffic flow information, the road layout has had minor alterations resulting in minor alterations to the traffic flows. Accordingly, we received updated traffic flow information on 6 March 2013. We have checked the updated traffic flow information and the changes do not alter our assessment of the road-traffic noise.