## 7.5 Noise and vibration

This section assesses noise and vibration impacts of the project. The assessment is supported by a noise and vibration working paper, which is presented in Volume 4 - Working paper 6. The assessment has addressed the Director General's requirements (as detailed in **Table 7-34** below) as well as the relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*.

**Table 7-34 Director General's requirements - noise and vibration**

| Requirements | Where addressed |
|---|---|
| Assess construction and operational noise and vibration impacts of the project, in accordance with the Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009), NSW Road Noise Policy (Department of Environment, Climate Change and Water, 2011), and Assessing Vibration: a Technical Guideline (Department of Environment and Conservation, 2006). | Section 7.5.3 – Construction noise and vibration<br>Section 7.5.4 – Operational noise and vibration |

### 7.5.1 Guidelines and methodology

#### Operational Noise

The assessment of operational road traffic noise impacts has been undertaken in compliance with the *Road Noise Policy* (RNP) (DECCW, 2011) and the *Environmental Noise Management Manual* (ENMM) (RTA, 2001). These guidelines detail the criteria and methods used to assess impacts on noise sensitive receivers for road projects undertaken in NSW.

Targeted noise monitoring at three residential locations was undertaken in February and March 2012 to measure road traffic noise from the existing alignment. The noise at these locations was measured using noise loggers that continuously record noise levels. Noise monitoring was undertaken in conjunction with traffic counts to allow calibration of noise levels with traffic levels.

While noise monitoring provides a snapshot of the noise environment at specific locations, noise modelling is used to establish the baseline noise levels and noise management levels for the existing environment to allow the impact of the construction and operation of the project to be assessed. The noise monitoring undertaken at the three locations was used to calibrate the noise model developed for the project.

The noise model uses factors such as the number and type of vehicles, their speed, the road alignment and gradient and the road surface type to predict noise levels. Current and future traffic volumes used for the modelling were sourced from the Traffic and Transport working paper (Volume 4 - Working paper 4) and are based upon the outputs from the Sydney Strategic Travel Model. This model is operated by the Bureau of Transport Statistics within Transport for NSW and is used for projecting travel patterns in Sydney, Newcastle and Wollongong under different land use, transport and pricing scenarios.

The noise model was used to predict the existing and future traffic noise levels for the day and night periods, being the $L_{Aeq, (15\ hour)}$ and $L_{Aeq, (9\ hour)}$ respectively. For the purposes of road traffic noise assessments, these periods are defined as:

- $L_{Aeq, (15\ hour)}$ represents the $L_{Aeq}$ noise level for the period 7 am to 10 pm.
- $L_{Aeq, (9\ hour)}$ represents the $L^{Aeq}$ noise level for the period 10 pm to 7 am.

### Assessment criteria

The Road Noise Policy (RNP) classifies work to an existing road as a "redevelopment". This classification applies to the project. The influence of traffic noise on existing receivers due to the project is defined in the RMS Environmental Noise Management Manual in Practice Note (i) as:

"A site is defined as having an "existing road traffic noise exposure" if the prevailing noise level from the existing road alignment(s) under consideration is equal to or greater than 55 dB(A) $L_{Aeq\ (15hr)}$ (day) or 50 dB(A) $L_{Aeq\ (9hr)}$ (night)."

The objective of any noise mitigation is to achieve these levels for at least a period of ten years after project completion. The criteria for the road redevelopment for the project have been summarised from the RNP and are presented in **Table 7-35**.

**Table 7-35 Road traffic noise base criteria**

| | | Noise Criteria | |
|---|---|---|---|
| **Road category** | **Type of project/land use** | **Day 7am -10pm** | **Night 10pm – 7am** |
| Freeway/arterial/ sub-arterial roads | Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads | $L_{Aeq\ (15hour)}$ 60 dB (A) | $L_{Aeq\ (9hour)}$ 55 dB (A) |

In addition to the base criteria, the ENMM identifies a category of highly affected noise sensitive receivers that have been termed "acute". These receivers experience noise levels that would be greater than or equal to $L_{Aeq\ (15hour)}$ 65 dB(A) and $L_{Aeq\ (9hour)}$ 60 dB(A). In these instances an assessment of noise mitigation in accordance with ENMM practice note (iv) is required.

Assessment criteria for other non residential land uses are also detailed in the RNP. These are a special category of receiver that are not necessarily residential, but require consideration due the nature of activities associated with their use, such as passive recreation. These criteria do not require an assessment against a 'build' and 'no build' scenario in the same ways as residential sensitive receivers. Thompson Square parkland has been identified as an area of passive recreation adjacent to the project and as such has an $L_{Aeq\ 15\ hour}$ daytime noise criterion of 55 dB(A).

## Operational vibration

A site-specific vibration site law was established for the ground conditions between the project and sensitive receivers on Bridge Street. The law was developed using sensitive vibration monitoring equipment to measure the vibration impacts at various distances from these locations and is explain in further detail in the Noise and vibration working paper (Volume 4 – Working paper 6).

Existing traffic data and the site law was then applied to predict levels at the building footings. These predictions were then repeated for new alignment and 2026 traffic levels to identify operational vibration impacts caused by the project.

Predicted operational vibration levels were assessed against Australian and International Standards and Guidelines, including:

- "Assessing Vibration: A Technical Guideline" (DEC, 2006).
- Australian Standard AS2670.2 'Evaluation of human exposure to whole-body vibration'. Identical to International Standard ISO 2631-1:1997.
- British Standard BS7385: Part 2 Evaluation and measurement of vibration in buildings, 0 580 22188 1 (British Standards Institution, 1993).
- BS5228:2009 Part 2 Code of Practice for noise and vibration control on construction and open sites-Vibration (British Standards Institution, 2009).
- German Standard DIN 4150: Part 3 – 1999 Effects of Vibration on Structures (German Institute for Standardisation, 1999).

## Construction noise

The assessment of construction noise impacts was undertaken in compliance with the *Interim Construction Noise Guidelines* (ICNG) (DECC, 2009). These guidelines recognise the potential for impacts from construction noise on the community and have identified noise management levels and standard working hours to minimise these impacts.

The construction of the project was divided into phases based upon the types of activities and their location (see **Table 7-42**). To assess the noise impacts from each phase of construction, the location and the types of plant and equipment used were determined. This information was used in the project specific noise model to predict noise levels at sensitive receivers adjacent to the project. These predicted noise levels were compared against the noise management levels (NML) developed for each sensitive receiver to assess the potential impact of construction and the requirement for mitigation measures.

### Assessment criteria

For the construction noise assessment, noise management limits for residential receivers are based upon the $L_{A90}$ noise levels in the day, evening and night periods - with 10 dB(A) added to the $L_{A90}$ noise level for the day time period and 5 dB(A) added the $L_{A90}$ noise levels for the evening and night time periods (See **Table 7-36**). For non residential receivers the ICNG identifies specific noise management levels that are not based upon $L_{A90}$ noise levels (see **Table 7-37**). Standard construction hours are also specified by the ICNG (see **Table 7-38**)

**Table 7-36 NML time periods**

| NML time periods | Period in day |
|---|---|
| Day time | 7am to 6pm |
| Evening | 6pm to 10pm |
| Night time | 10pm to 7am |

**Table 7-37 Non-residential noise management levels**

| Type of non-residential receiver | Noise management level |
|---|---|
| Industrial premises: external $LAeq_{(15min)}$ | 75 dB(A) |
| Offices, retail outlets: external $LAeq_{(15min)}$ | 70 dB(A) |
| Classrooms: internal $LAeq_{(15min)}$ | 45 dB(A) |
| Places of worship: internal $LAeq_{(15min)}$ | 45 dB(A) |
| Hotels Motels: external $LAeq_{(15min)}$ | 60 dB(A) |
| Passive recreational land: external $LAeq_{(15min)}$ | 60 dB(A) |

**Table 7-38 Standard hours of construction**

| Day | Time |
|---|---|
| Monday to Friday | 7 am to 6 pm |
| Saturday | 8 am to 1 pm |
| Sunday and Public Holidays | No work |

## Construction vibration

Where construction activities were identified within 20 metres of a residential or heritage sensitive receiver, impacts have been quantified and assessed using the site laws developed for the operational vibration assessment. Based on the site law and experience from other similar construction projects, vibration impacts on buildings greater than 20 metres away from the construction site would be negligible.

Works that are likely to generate an impact include the use of standard construction equipment (excavators, trucks etc) in close proximity to buildings or the use of rock hammers, rock breakers, compactors or piling rigs. Using in-house and published data to determine typical vibration levels associated with these activities, vibration levels at nearby sensitive receivers were predicted and compared against relevant guidelines.

### 7.5.2 Existing environment

The following sections identify the sensitive receivers potentially impacted by noise generated from the project, the baseline noise levels at sensitive receivers used for the operational noise impact assessment and the noise management levels used for the construction noise impact assessment. The Noise and vibration working paper (Volume 4 - Working paper 6) contains details on the noise monitoring locations and data.

#### Identification of sensitive receivers

The study area comprises a mixture of residential and commercial receivers, many of which are buildings or items with local and/or State heritage significance. The closest residences are located along Old Bridge Street adjacent to the southern approach road of the existing bridge and at the northern end of the project on the corner of Freemans Reach Road and Wilberforce Road.

There are around 175 sensitive receivers situated within a 200 metres radius of the project, comprising a mixture of residential and commercial buildings (including hotels, retail outlets, and offices). Noise and vibration from the construction and operation of project would not impact receivers greater than 200 metres from the project due to the topography, relatively short length of the project and the influence of other noise sources. Many of these receivers are already exposed to traffic noise from surrounding roads.

The highest impacts of operational and construction noise from the project would be limited primarily to the receivers adjacent to the project. Receivers beyond the first row of buildings would have the benefit of shielding by the intervening rows of buildings and would be impacted by other roads in the area. Therefore, only the properties immediately adjacent to the project were considered. The locations of these sensitive receivers are presented in **Figure 7-30**. While all sensitive receivers could potentially be impacted by the project, sensitive receivers R1 to R4 would experience the greatest impacts due to their close proximity to the project.

#### Baseline noise levels

The estimated $L_{Aeq}$ levels for day time and night time periods at residential receivers in 2016 are presented in **Table 7-39**. These are the baseline noise levels that all operational impact predictions are compared against. It should be noted that only noise levels at residential receivers are presented in **Table 7-39** as only residential receivers require consideration for operational noise mitigation. However, if at source noise mitigation measures are applied (eg Noise barriers or low noise pavement) the benefits could be experienced by non-residential receivers.

The receivers identified as T1 and T2 (see **Figure 7-30**) are locations within Thompson Square parkland. T1 is representative of users of the parkland close to the existing road, with T2 being in the parkland at the furthest distance from the alignment. Noise predictions at these two locations would provide an indication of the highest and lowest levels within Thompson Square parkland.

**Table 7-39 Predicted baseline noise levels for residential receivers (2016)**

| ID | Day time $L_{Aeq}$ dB(A) | Night time $L_{Aeq}$ dB(A) |
|---|---|---|
| R1 | 66 | 61 |
| R2 | 65 | 61 |
| R3 | 71 | 67 |
| R4 | 61 | 57 |
| R5 | 59 | 54 |
| R6 | 58 | 53 |
| R7 | 57 | 53 |
| R8 | 56 | 52 |
| R9 | 55 | 51 |
| R10 | 55 | 51 |
| R11 | 56 | 52 |
| R12 | 57 | 53 |
| R13 | 56 | 52 |
| R14 | 57 | 52 |
| R15 | 55 | 51 |

## Noise management levels

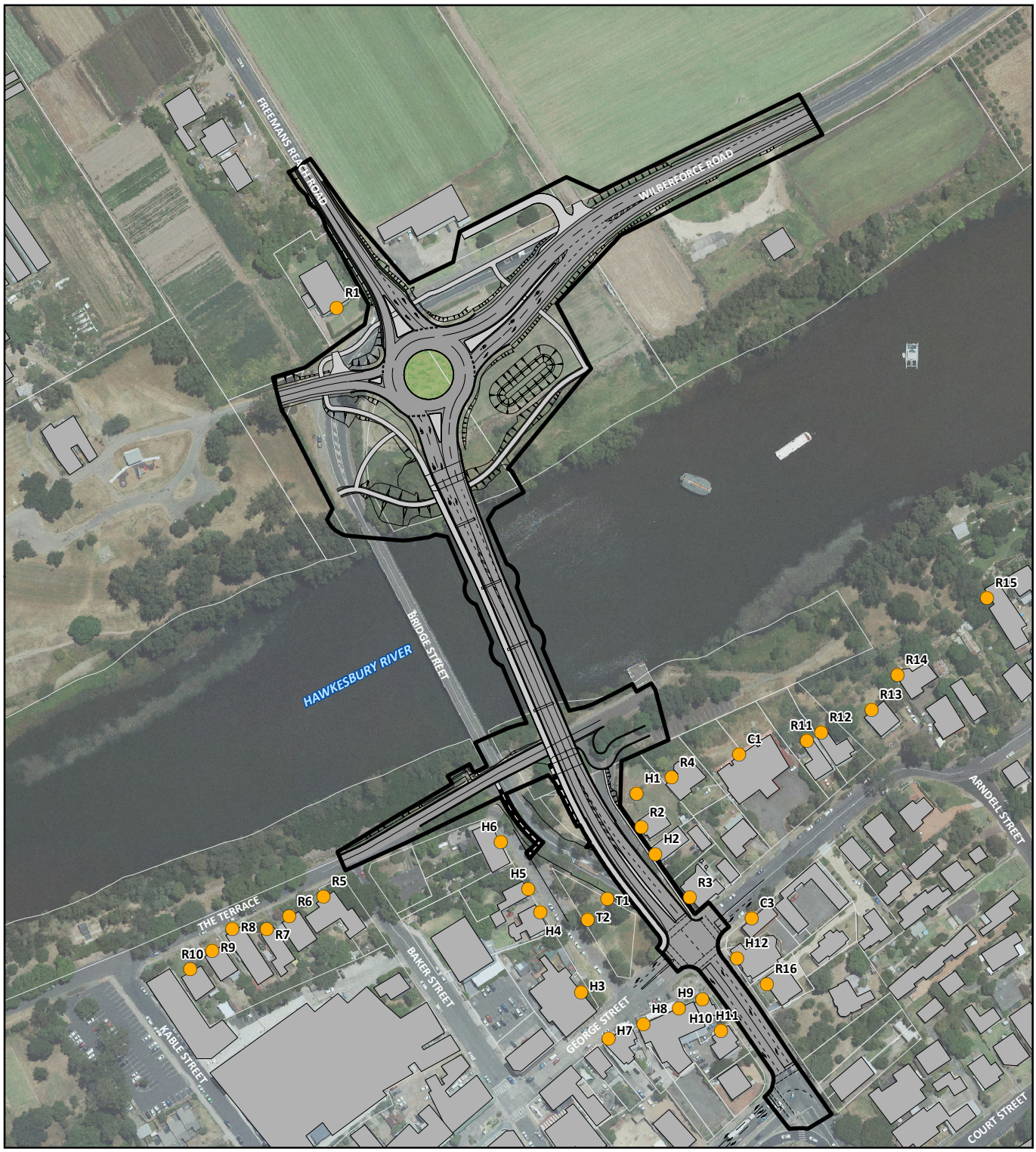
The noise management levels for potentially impacted sensitive receivers from construction activities are summarised in **Table 7-40**.

**Table 7-40 Noise management levels**

| Receiver | | | *Noise Management Levels / dB(A) | | |
|---|---|---|---|---|---|
| | | | Day time 7am – 6pm ($L_{Aeq}$) | Evening 6pm – 10pm ($L_{Aeq}$) | Night time 10pm – 7am ($L_{Aeq}$) |
| R1 | 27 Freemans Reach Road | | 68 | 55 | 44 |
| R2 | 4 Bridge Street | | 72 | 61 | 46 |
| R3 | 10 Bridge Street | Ground Floor | 70 | 70 | 70 |
| | | First Floor | 72 | 61 | 46 |
| R4 | 53 George Street | | 55 | 47 | 32 |
| R5–R15** | See Figure 7-30 for location | | 55 | 47 | 32 |
| R16*** | 16 Bridge Street | | 72 | 61 | 46 |
| C1, C3, | See Figure 7-30 for location | | 60 | 60 | 60 |
| H2 – H12 | See Figure 7-30 for location | | 70 | 70 | 70 |

**Daytime NML = RBL +10dB(A), Evening NML = RBL +5dB(A), Night-time NML = RBL +5dB(A), or absolute levels for commercial receivers. **In the absence of measured background noise levels at these specific locations, monitoring data at R4 assumed to be representative of noise at receivers R5-R15. *** In the absence of measured background noise levels at R16, monitoring data at R3 (first floor) assumed to be representative of noise at this receiver.*

# Figure 7-30 | Location of sensitive receivers




Indicative only – subject to detailed design

LEGEND

- Receiver
- Concept design
- Concept design footprint
- Building footprint
- Cadastral boundary



GDA 1994 | MGA Zone 56
A4 1:3,000

0 100
Metres


AUSIMAGE SKM

## Existing vibration

Attended vibration monitoring was undertaken at two locations along Bridge Street. These locations were at the kerbside (about 0.5 metres from the kerb and one metre from the line of the closest wheel) in front of 4 Bridge Street (R2) and at the kerbside in front of 10 Bridge Street (R3). Monitoring was also undertaken simultaneously at the facade of 4 and 10 Bridge Street.

The results of traffic vibration monitoring are provided in **Table 7-41**. The maximum peak particle velocity (PPV) at the buildings was less than 0.002mm/s. At these locations the road traffic would be the only source contributing to the vibration levels. These vibration levels would not be perceptible to humans and would not cause damage to heritage structures.

**Table 7-41 Road traffic vibration data**

| Vehicle Class | Speed | Maximum recorded PPV/ $mms^{-1}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Bridge to Roundabout (north to south) @5m from source | | | Roundabout to Bridge (south to north) @1m from source | | | Maximum PPV At Structure ($mms^{-1}$) | Maximum PPV At Structure ($mms^{-1}$) |
| | | x | y | z | x | y | z | z | z |
| Car/SUV/4wd (under 2.5T) | 5-20$kmh^{-1}$ | 0.06 | 0.07 | 0.09 | 0.07 | 0.08 | 0.10 | <0.002 | <0.002 |
| | >20$kmh^{-1}$ | 0.06 | 0.07 | 0.09 | 0.07 | 0.08 | 0.11 | <0.002 | <0.002 |
| Van/Lightweight truck (2.5T - ) | 5-20$kmh^{-1}$ | 0.06 | 0.07 | 0.10 | 0.08 | 0.09 | 0.11 | <0.002 | <0.002 |
| | >20$kmh^{-1}$ | 0.06 | 0.07 | 0.09 | 0.08 | 0.08 | 0.12 | <0.002 | <0.002 |
| Large Van (2 axel 5T - ) | 5-20$kmh^{-1}$ | 0.07 | 0.08 | 0.09 | 0.11 | 0.11 | 0.16 | <0.002 | <0.002 |
| | >20$kmh^{-1}$ | 0.08 | 0.08 | 0.10 | 0.12 | 0.11 | 0.20 | <0.002 | <0.002 |
| Small Truck | 5-20$kmh^{-1}$ | 0.09 | 0.08 | 0.14 | 0.27 | 0.22 | 0.28 | <0.002 | <0.002 |
| | >20$kmh^{-1}$ | 0.10 | 0.10 | 0.18 | 0.30 | 0.22 | 0.44 | <0.002 | <0.002 |
| Large Truck | 5-20$kmh^{-1}$ | 0.22 | 0.31 | 0.87 | 0.25 | 0.35 | 0.87 | <0.002 | <0.002 |
| | >20$kmh^{-1}$ | 0.24 | 0.33 | 0.88 | 0.26 | 0.40 | 1.02 | <0.002 | <0.002 |

### 7.5.3 Construction impacts

## Construction noise

Construction activities have been identified for eight phases of construction, as described in **Table 7-42**.

**Table 7-42 Construction phases and major construction activities**

| Construction phase | Construction activities |
|---|---|
| Site establishment/early works | Archaeological investigations<br>Utility adjustments<br>Construction of the casting yard<br>Installation of environmental controls<br>Establishment of hard stand, construction compound and other construction facilities<br>Minor road works for site access<br>Clearing of vegetation to facilitate above activities |
| Bridge pier and northern abutment construction | Non-terrestrial impact piling (riverbed) up to 9 piles per pier (4 piers)<br>Concrete pumping from northern approach<br>Terrestrial bored piling at northern abutments |
| Construction and launching of bridge (including casting yard) | Bridge casting in northern casting yard<br>Bridge form and steel work<br>Incrementally launch bridge<br>Concrete pumping on bridge<br>Concrete pours and surface construction |
| Southern approach road construction | Terrestrial bored piling at southern bridge abutment<br>Construction of land bridge or concrete panel fill southern approach road<br>Paving and asphalting |
| Removal of casting yard and northern road construction | Earthworks and clearing for new roundabout and northern approach road<br>Paving and asphalting |
| Southern end of Bridge Street tie-in and intersection | Standard road construction including earthworks<br>Paving and asphalting<br>Fill of existing southern cutting |
| Existing bridge demolition | Superstructure removal – road saws, grinders, cranes<br>Substructure removal – oxy cutters and cranes |
| Use of laydown/construction compound | Use of area at the Windsor Wharf car park as a laydown area (plant storage and potential materials stockpile). To be used throughout each construction phase |

Generally these phases would occur sequentially, however some phases may overlap – for example construction of the southern approach road and the construction and launching of the incrementally launched bridge may occur concurrently. **Table 7-43** summarises the predicted noise levels for each of the construction phases at each sensitive receiver and includes the cumulative impact where phases of construction would be concurrent.

The noise levels presented in **Table 7-43** are the maximum noise levels a sensitive receiver would experience in a 15 minute period and assume that all construction equipment identified for the construction activity would be operating simultaneously.

While this worst case scenario may occur occasionally, typically the noise generated would be lower that the noise levels presented in **Table 7-43**. This is because not all the construction plant and equipment would be operating simultaneously due to construction sequencing and the extremely limited construction site areas. Presented in the sections following the table is further discussion of the noise impacts from each of the construction phases.

Where NMLs are exceeded at a sensitive receiver, mitigation measures would need to be considered and this is discussed in **Section 7.5.5**. Where a sensitive receiver is exposed to noise levels of 75dB(A) or greater, as a result of construction activities, the receiver would be classed as 'highly noise affected' and would be afforded additional consideration.

**Table 7-43 Summary of noise management levels**

| Receiver | NML / dB(A) | | | Phase of construction noise predictions / dB(A) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Daytime | Evening | Night | Establish site and early works | Bridge pier | Incremental launched bridge | Southern approach road | Northern approach road | Southern tie-in | Bridge demolition | Southern compound |
| **R1** | 68 | 55 | 44 | 63 | 64 | 63 | 57 | **69** | 54 | 58 | 44 |
| **R2** | 72 | 61 | 46 | 67 | 69 | 61 | **77** | 51 | 69 | 65 | 43 |
| **R3** | 72 | 61 | 46 | 54 | 62 | 50 | 65 | 46 | **84** | 60 | 31 |
| **R4** | 55 | 47 | 32 | **64** | **72** | **65** | **74** | **55** | 49 | **66** | **63** |
| **R5** | 55 | 47 | 32 | 52 | **65** | **60** | **58** | 54 | 41 | **65** | 45 |
| **R6** | 55 | 47 | 32 | 52 | **64** | **57** | **56** | 54 | 43 | **64** | 38 |
| **R7** | 55 | 47 | 32 | 52 | **65** | **58** | **56** | 54 | 40 | **64** | 37 |
| **R8** | 55 | 47 | 32 | 51 | **63** | **56** | 55 | 53 | 39 | **63** | 42 |
| **R9** | 55 | 47 | 32 | 50 | **60** | **56** | 45 | 53 | 41 | **61** | 31 |
| **R10** | 55 | 47 | 32 | 51 | **61** | **57** | 47 | 53 | 45 | **61** | 34 |
| **R11** | 55 | 47 | 32 | 53 | **65** | **59** | 53 | 54 | **56** | **60** | 43 |
| **R12** | 55 | 47 | 32 | 53 | **66** | **60** | **55** | 54 | 49 | **62** | 50 |
| **R13** | 55 | 47 | 32 | 52 | **65** | **59** | **60** | 54 | 54 | **61** | 51 |
| **R14** | 55 | 47 | 32 | 50 | **62** | **56** | **59** | 52 | 46 | **58** | 48 |
| **R15** | 55 | 47 | 32 | 51 | **63** | **57** | **59** | 54 | 45 | **59** | 47 |
| **R16** | 72 | 61 | 46 | 37 | 47 | 40 | 49 | 41 | **75** | 52 | 30 |
| **H2** | 70 | - | - | 59 | 67 | 60 | **70** | 48 | **73** | 62 | 38 |
| **H3** | 70 | - | - | 53 | 65 | 58 | 65 | 52 | **72** | 59 | 48 |
| **H4** | 70 | - | - | 56 | 67 | 61 | 69 | 53 | 69 | 60 | 52 |
| **H5** | 70 | - | - | 58 | 68 | 62 | **70** | 53 | 68 | 61 | 53 |
| **H6** | 70 | - | - | 62 | **72** | 64 | **74** | 54 | 66 | 68 | 55 |
| **H7** | 70 | - | - | 49 | 62 | 55 | 58 | 51 | **70** | 56 | 41 |
| **H8** | 70 | - | - | 49 | 63 | 56 | 59 | 51 | **73** | 58 | 42 |
| **H9** | 70 | - | - | 49 | 63 | 56 | 59 | 51 | **78** | 58 | 41 |
| **H10** | 70 | - | - | 49 | 61 | 54 | 58 | 51 | **85** | 55 | 35 |
| **H11** | 70 | - | - | 45 | 56 | 49 | 52 | 46 | **73** | 49 | 29 |
| **H12** | 70 | - | - | 47 | 59 | 45 | 59 | 46 | **84** | 56 | 32 |
| **C1** | 60 | - | - | 53 | **68** | **62** | **61** | 55 | 47 | **64** | 55 |
| **C3** | 60 | - | - | 47 | 58 | 51 | 48 | 51 | **76** | 46 | 39 |
| **T1** | 60 | - | - | 54 | **64** | 57 | **65** | 50 | **84** | **60** | 49 |
| **T2** | 60 | - | - | 52 | **63** | 56 | **64** | 50 | **73** | 60 | 46 |

**Green** notes exceedance of daytime NML, **Red** notes daytime prediction exceeds ICNG 'highly noise affected criteria

**Table 7-44 Potential works outside standard construction hours compared to noise management levels**

| Receiver | Evening NML / dB(A) | Activity noise prediction / dB(A) | | | | | | Night-time NML / dB(A) | Activity noise prediction / dB(A) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Site establishment early and works | Bridge pier construction | Northern approach road | | Southern approach road | | | Site establishment early and works | Bridge pier construction | Northern approach road | | Southern approach road | |
| | | Southern approach utilities | Bridge casting | Earthworks | Paving | Existing road removal | Paving | | Southern approach utilities | Bridge casting | Earthworks | Paving | Existing road removal | Paving |
| **R1** | **55** | 44 | 62 | 63 | 67 | 52 | 48 | **44** | 44 | 62 | 63 | 67 | 52 | 49 |
| **R2** | **61** | 61 | 51 | 45 | 50 | 67 | 59 | **46** | 61 | 51 | 45 | 50 | 67 | 59 |
| **R3** | **61** | 51 | 36 | 31 | 44 | 82 | 69 | **46** | 51 | 36 | 31 | 44 | 82 | 69 |
| **R4** | **47** | 60 | 54 | 50 | 54 | 47 | 40 | **32** | 60 | 54 | 50 | 54 | 47 | 40 |
| **R5** | **47** | 46 | 53 | 49 | 53 | 39 | 34 | **32** | 46 | 53 | 49 | 53 | 39 | 34 |
| **R6** | **47** | 34 | 52 | 49 | 52 | 41 | 36 | **32** | 34 | 52 | 49 | 52 | 41 | 36 |
| **R7** | **47** | 36 | 53 | 49 | 52 | 38 | 33 | **32** | 36 | 53 | 49 | 52 | 38 | 33 |
| **R8** | **47** | 43 | 51 | 48 | 52 | 37 | 32 | **32** | 43 | 51 | 48 | 52 | 37 | 32 |
| **R9** | **47** | 32 | 51 | 47 | 51 | 39 | 34 | **32** | 32 | 51 | 47 | 51 | 39 | 34 |
| **R10** | **47** | 34 | 52 | 47 | 51 | 43 | 38 | **32** | 34 | 52 | 47 | 51 | 43 | 38 |
| **R11** | **47** | 41 | 53 | 49 | 53 | 52 | 54 | **32** | 41 | 53 | 49 | 53 | 52 | 54 |
| **R12** | **47** | 42 | 53 | 49 | 53 | 46 | 47 | **32** | 42 | 53 | 49 | 53 | 46 | 47 |
| **R13** | **47** | 48 | 52 | 48 | 52 | 48 | 52 | **32** | 48 | 52 | 48 | 52 | 48 | 52 |
| **R14** | **47** | 46 | 50 | 46 | 50 | 44 | 39 | **32** | 46 | 50 | 46 | 50 | 44 | 39 |
| **R15** | **47** | 45 | 51 | 48 | 53 | 43 | 41 | **32** | 45 | 51 | 48 | 53 | 43 | 41 |
| **R16** | **61** | 35 | 37 | 34 | 39 | 68 | 73 | **46** | 35 | 37 | 34 | 39 | 68 | 73 |
| **H2** | **70** | 55 | 47 | 43 | 47 | 71 | 61 | **70** | 55 | 47 | 43 | 47 | 71 | 61 |
| **H3** | **70** | 51 | 52 | 46 | 50 | 70 | 65 | **70** | 51 | 52 | 46 | 50 | 70 | 65 |
| **H4** | **70** | 55 | 53 | 47 | 51 | 67 | 61 | **70** | 55 | 53 | 47 | 51 | 67 | 61 |
| **H5** | **70** | 56 | 53 | 47 | 52 | 66 | 60 | **70** | 56 | 53 | 47 | 52 | 66 | 60 |
| **H6** | **70** | 60 | 54 | 48 | 53 | 64 | 58 | **70** | 60 | 54 | 48 | 53 | 64 | 58 |
| **H7** | **70** | 44 | 50 | 46 | 49 | 68 | 63 | **70** | 44 | 50 | 46 | 49 | 68 | 63 |
| **H8** | **70** | 45 | 51 | 46 | 49 | 71 | 67 | **70** | 45 | 51 | 46 | 49 | 71 | 67 |
| **H9** | **70** | 45 | 51 | 46 | 49 | 73 | 76 | **70** | 45 | 51 | 46 | 49 | 73 | 76 |

| Receiver | Evening NML / dB(A) | Activity noise prediction / dB(A) | | | | | | Night-time NML / dB(A) | Activity noise prediction / dB(A) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Site establishment and early works | Bridge pier construction | Northern approach road | | Southern approach road | | | Site establishment and early works | Bridge pier construction | Northern approach road | | Southern approach road | |
| | | Southern approach utilities | Bridge casting | Earthworks | Paving | Existing road removal | Paving | | Southern approach utilities | Bridge casting | Earthworks | Paving | Existing road removal | Paving |
| **H10** | **70** | 44 | 50 | 45 | 49 | 73 | 83 | **70** | 44 | 50 | 45 | 49 | 73 | 83 |
| **H11** | **70** | 38 | 46 | 38 | 45 | 67 | 71 | **70** | 38 | 46 | 38 | 45 | 67 | 71 |
| **H12** | **70** | 45 | 40 | 35 | 44 | 76 | 82 | **70** | 45 | 40 | 35 | 44 | 76 | 82 |
| **T1** | **70** | 51 | 50 | 45 | 49 | 82 | 67 | **70** | 51 | 50 | 45 | 49 | 82 | 67 |
| **T2** | **70** | 50 | 49 | 45 | 49 | 71 | 64 | **70** | 50 | 49 | 45 | 49 | 71 | 64 |

Light grey shading denotes exceedance of NML

### Works outside of standard construction hours

A number of activities would be required to be undertaken outside of standard construction hours. Generally works outside of standard construction hours works are considered reasonable where the works are below the relevant NML. However often the noise of works undertaken outside of standard construction hours would be above NMLs and cannot be easily mitigated. Works that may be required outside standard construction hours are detailed in **Table 7-45.** These works are compared to sensitive receiver NMLs for evening and night time periods in **Table 7-44**.

Following detailed construction planning, additional activities may need to be undertaken outside of standard construction hours. The process of assessing additional works outside of standard construction hours would be identified in the Construction Noise and Vibration Management Plan (see **Section 7.5.5**).

**Table 7-45 Works outside standard construction hours**

| Construction phase | Justification |
|---|---|
| The delivery of oversize bridge elements. | Delivery outside of standard hours of construction may be required due to road safety requirements. Oversize loads are generally only allowed on the roads during night time periods when traffic levels are low. |
| The delivery and demobilisation of plant and large construction equipment. | Delivery outside of standard hours of construction may be required due to road safety requirements. Oversize loads are generally only allowed on the roads during night time periods when traffic levels are low. |
| Emergency work. | Work may be required outside of standard construction hours to respond to emergency situations that pose a risk to safety or the environment. |
| Utility adjustments | Some services may be located within the existing alignment and traffic on the existing alignment may require diversion to allow a service adjustment to be undertaken safety. Traffic diversions on busy roads are generally only permitted outside standard construction hours to minimise the impact on the road network. Also the cutover of existing services to new services may need to be undertaken in off-peak periods which are generally outside standard construction hours. |
| Major traffic diversions, including full or partial road closures. | Due to traffic disruptions it would be unlikely that daytime Road Occupancy Licences would be granted and therefore night-time works would be required where works is undertaken on existing network. |
| Bridge works – including concrete pours, concrete bridge casting, steel fixing, formwork construction and the craning of materials during incremental launch. | These works may be required outside of standard hours due to timing constraints and requirements associated with concrete pours. |

| Construction phase | Justification |
|---|---|
| Road tie-in works (including paving and asphalting) – | The tie-in of the proposed northern and southern approach roads, along with bridge road surface construction. These works may be required outside of standard construction hours as they will involve possible 24 hour concrete pours and will involve working on the existing road network. Due to traffic disruptions it would be unlikely that daytime Road Occupancy Licences would be granted and therefore night-time works would be required where works is undertaken on existing network. |
| Other works that are required outside standard hours and are approved by the appropriate regulatory authority | These would be justified, assessed and approval sought as required. |

**Site establishment and early works**

Site establishment and early works would be undertaken during standard construction hours, and the daytime noise management level (NML) would be exceeded at one sensitive receiver. The highly noise affected criteria would not be exceeded at any receiver. The daytime NML at R4 (54 George Street) would be exceeded as a result of archaeological investigations near the southern abutment. These works are short term with the noisiest part of the works from jack hammering of the existing road pavement and excavation of test pits. Once a test pit is opened, works are manual with hand tools with minimal noise emissions. Therefore the impacts associated with daytime archaeological works and the site establishment works as a whole would be considered to be minor.

**Bridge piers**

Bridge pier construction works would be undertaken in the day time. For a worst case noise assessment it has been assumed that impact piling would be used to install the piles for the bridge piers. However, it is more likely that bored piles would be used due to the geotechnical properties of the river bed and underlying bedrock. Bored piling would result in substantially lower noise impacts than impact piling. If it occurred, impact piling would be the single highest noise emitting activity and as the construction site is in the river, more sensitive receivers would be exposed to the noise as they would have direct line of sight to the construction area. As a result the daytime NML at 16 sensitive receivers along the southern riverbank and within Thompson Square parkland would be exceeded during impact piling. The highly noise affected criteria of 75dB(A) would not be exceeded at any receiver.Other works included in the bridge pier construction are works at the northern bridge abutment. The northern abutment works would be relatively quiet and noise levels at all sensitive receivers would be below the NML for daytime.

**Construction and launching of bridge**

The construction and launching of the bridge from the northern bank would occur predominately in the daytime, however some works outside standard construction hours may be required. Activities outside standard construction hours could include concrete pours, the operation of the jacks to push the bridge over the river and the fixing of steel and formwork in the casting yard. The latter two activities would result in the exceedances of the NML at one sensitive receiver (R4).

Concrete pours may extend into the evening or start early in the morning to meet the temperature specifications for concrete and/or to fully complete a pour for a half span of the bridge in one day. Concrete pours for the bridge would occur once every seven to ten working days.

During daytime concrete pours and paving works on the bridge, noise levels would exceed NMLs at up to 13 receivers, however the highly noise affected criteria is not predicted to be exceeded.

**Southern approach road**

Fifteen sensitive receivers would be exposed to noise greater than their specific NMLs from southern approach road works. This includes the exceedance of highly noise affected criteria at R2 (4 Bridge Street). Exceedances of the daytime NML for Thompson Square parkland would also occur. These exceedances are due to the close proximity of works to sensitive receivers rather than excessively noisy activities.

If paving works are required outside of standard construction hours and are in close proximity to sensitive receivers, noise levels would exceed both evening and night time NMLs by up to 30dB(A), causing sleep disturbance at two residential sensitive receivers (R3 and R16).

**Northern approach road**

The majority of the construction works for the northern approach road would be undertaken in standard construction hours. Two receivers would be exposed to noise above their daytime NMLs, however the exceedance would only be about 1dB(A), therefore the impact is considered to be low.

The final paving works to tie in the northern approach road with Freemans Reach Road and Wilberforce Road would be undertaken outside of standard construction hours in periods of low traffic. During these works 12 sensitive receivers would be exposed to noise levels above evening and night time NMLs.

**Southern approach road tie-in**

The final section of road pavement to tie in the new southern approach road with Bridge Street and George Street would occur outside the standard construction hours as temporary closure of the southern approach road to the existing bridge would be required. Closure of the southern approach road to the existing bridge could only occur at night time when traffic levels were low.

For works outside the standard construction hours, impacts would be restricted to residential dwellings on Bridge Street including R2, R3 and R16 and commercial premises that operate after 10pm.

**Existing bridge demolition**

Bridge demolition works would be restricted to standard construction hours and there would be 14 receivers exposed to construction noise above their day time NML, however the highly noise affected criteria would not be exceeded at any sensitive receivers. Noise exceedances would result from activities such as saw and grinder use during the demolition of the existing bridge superstructure. These activities would occur for short periods of time, with the remainder of activities associated with bridge demolition relatively quiet.

### Southern laydown/compound use

The operation of the southern laydown area next to the Windsor Wharf car park would not have a significant impact throughout the duration of works. Noise emissions would be restricted to short periods where equipment or materials are being collected or delivered. Only the closest receiver to this area, R4 (53 George Street) would be exposed to noise levels exceeding their day time NML.

## Construction vibration

Vibration from construction activities may cause structural damage to buildings. Heritage buildings are often particularly sensitive to vibration impacts due to their age and the materials and techniques used in their construction. Vibration from construction activities may also be perceptible to residents in buildings adjacent to the project. This may cause discomfort if the vibration is substantial and/or occurs for an extended period of time.

To assess the impact of construction vibration, activities that are known to cause substantial vibration were identified. For the project, these activities were impact piling, rock breaking (jack hammering) and vibratory rolling. The location where these activities would be undertaken and the proximity of sensitive residential receivers and heritage buildings were also determined. This information and the site law developed for vibration propagation was used to estimate vibration levels from construction at key sensitive receivers. The estimated vibration levels from high vibration activities and a comparison to relevant structural damage and human comfort vibration criteria is presented in **Table 7-46**. As vibration from construction activities would rapidly dissipate with distance from its origin, only sensitive receivers adjacent to construction sites would be potentially impacted.

While impact piling would generate the highest vibration levels, because it would be undertaken in the river for the piers and therefore is distant from sensitive receivers, it would not exceed the vibration criteria at any sensitive receivers. Rock breaking would be undertaken in close proximity to sensitive receivers especially along the southern approach road. Vibration levels from rock breaking would exceed the human comfort criterion at sensitive receiver R2 and exceed the structural damage criterion at H1 (heritage wall at 4 Bridge Street) and C2. Vibration levels from vibratory compaction would exceed the human comfort criterion at all adjacent sensitive residential receivers and would be just below the structural damage criterion for heritage structures at all sensitive heritage receivers.

**Table 7-46 Construction vibration levels and potential impacts on sensitive receivers**

| ID | Criteria | | Impact Piling | | Rock Breaking | | Vibratory compaction | |
|---|---|---|---|---|---|---|---|---|
| | Structural Damage (PPV) $mms^{-1}$ | Human Comfort (VDV) $mms^{-1}$ | PPV $mms^{-1}$ | VDV $mms^{-1}$ | PPV $mms^{-1}$ | VDV $mms^{-1}$ | PPV $mms^{-1}$ | VDV $mms^{-1}$ |
| R1 | 5 | 0.4 | <0.2 | <0.25 | 0.4 | 0.3 | 2.5 | 1 |
| R2 | 5 | 0.4 | <0.2 | <0.25 | 3 | 1.9 | 2.5 | 1 |
| R3 | 3 | 0.8 | <0.2 | <0.25 | 1.8 | 0.2 | 2.5 | 1 |
| R16 | 5 | 0.4 | - | - | 1.8 | 0.2 | 2.5 | 1 |
| H1 | 3 | - | <0.2 | - | 3 | 1.9 | 2.5 | 1 |
| H2 | 3 | 0.4 | <0.2 | <0.25 | 1.8 | 0.2 | 2.5 | 1 |
| H6 | 3 | 0.4 | <0.2 | <0.25 | 0.4 | 0.3 | 2.5 | 1 |
| H7 | - | 0.4 | - | - | 0.4 | 0.3 | 2.5 | 1 |
| H8 | 3 | 0.4 | - | - | 0.4 | 0.3 | 2.5 | 1 |
| H9 | 3 | 0.4 | - | - | 0.4 | 0.3 | 2.5 | 1 |
| H10 | 3 | 0.4 | - | - | 0.4 | 0.3 | 2.5 | 1 |
| H11 | 3 | 0.4 | - | - | 0.4 | 0.3 | 2.5 | 1 |
| H12 | 3 | 0.4 | - | - | 0.4 | 0.3 | 2.5 | 1 |
| C2 | 3 | 0.4 | - | - | 3 | - | 2.5 | 1 |

Shaded cell indicates vibration level is equal or above relative vibration criterion

### 7.5.4 Operational impacts

## Operational Noise

A number of different scenarios were modelled to predict operational noise impacts from the operation of the project and the need for consideration of noise mitigation. The key scenarios for impact assessment are:

- The “do nothing” or “no project” option – This scenario assumes that the existing bridge and approach roads are retained. Traffic levels for the year that the project would have become operational (2016) and 10 years after opening (2026) are used to provide a basis for comparison.
- The project becomes operational – This scenario assumes that the project is built. Traffic levels at opening and 10 years after the project becomes operational (2026) are used in the model to predict noise levels and identify sensitive receivers where noise mitigation must be considered.

The results of the noise modelling for both scenarios and for each residential sensitive receiver are presented in **Table 7-47** and have also been presented as day and night time noise contours overlaid on aerial photography for the project in 2026 (see **Figure 7-31** and **Figure 7-32**)

Residential sensitive receivers not directly adjacent to the project (R5-R10 on The Terrace and R11-R15 on George Street) noise levels from the project in 2026 are predicted to decrease slightly in comparison to existing noise levels. This would be due to the improved road surface and/or the changed alignment and location of the bridge and approach roads.

Residential sensitive receivers directly adjacent to the project include R1, R2, R3 and R4. The sensitive receiver R1, at the corner of Freemans Reach Road and Wilberforce Road is predicted to benefit from a reduction in noise levels due to the relocation of the northern intersection further to the south east. Sensitive receivers R2 and R3, currently experience acute levels of noise and this is predicted to continue with the project. Noise levels at both these receivers are predicted to increase by 2026. At sensitive receiver R4, the project would result in an increase of about 2 dB(A) over existing levels.

Based on the noise impact assessment results and application of the RNP and ENMM, noise mitigation options for receivers R2, R3 and R4 must be considered and are further discussed in **Section 7.5.5**.

*Thompson Square parkland*

Thompson Square parkland is currently bisected by the southern approach road to the existing bridge and is subject to traffic noise from Bridge Street, Windsor Bridge and to a lesser extent George Street. The existing daytime noise levels are within the range of 72 dB(A) close to Bridge Street, down to about 63 dB(A) closer to The Terrace.

The noise levels in Thompson Square parkland with the project would be similar to existing levels ranging from 72 dB(A) to about 64 dB(A). The noise levels for both the project and no build daytime scenarios in 2026 (see **Figure 7-33** and **Figure 7-34**) indicate that both scenarios would exceed the criterion for recreational use. The area of Thompson Square parkland impacted by the higher noise levels would decrease slightly with the project especially the northern area of the parkland near the river.

This is because the new southern approach road would be along the eastern side of the parkland, rather than the existing situation where the southern approach road bisects the parkland.

## Operational vibration

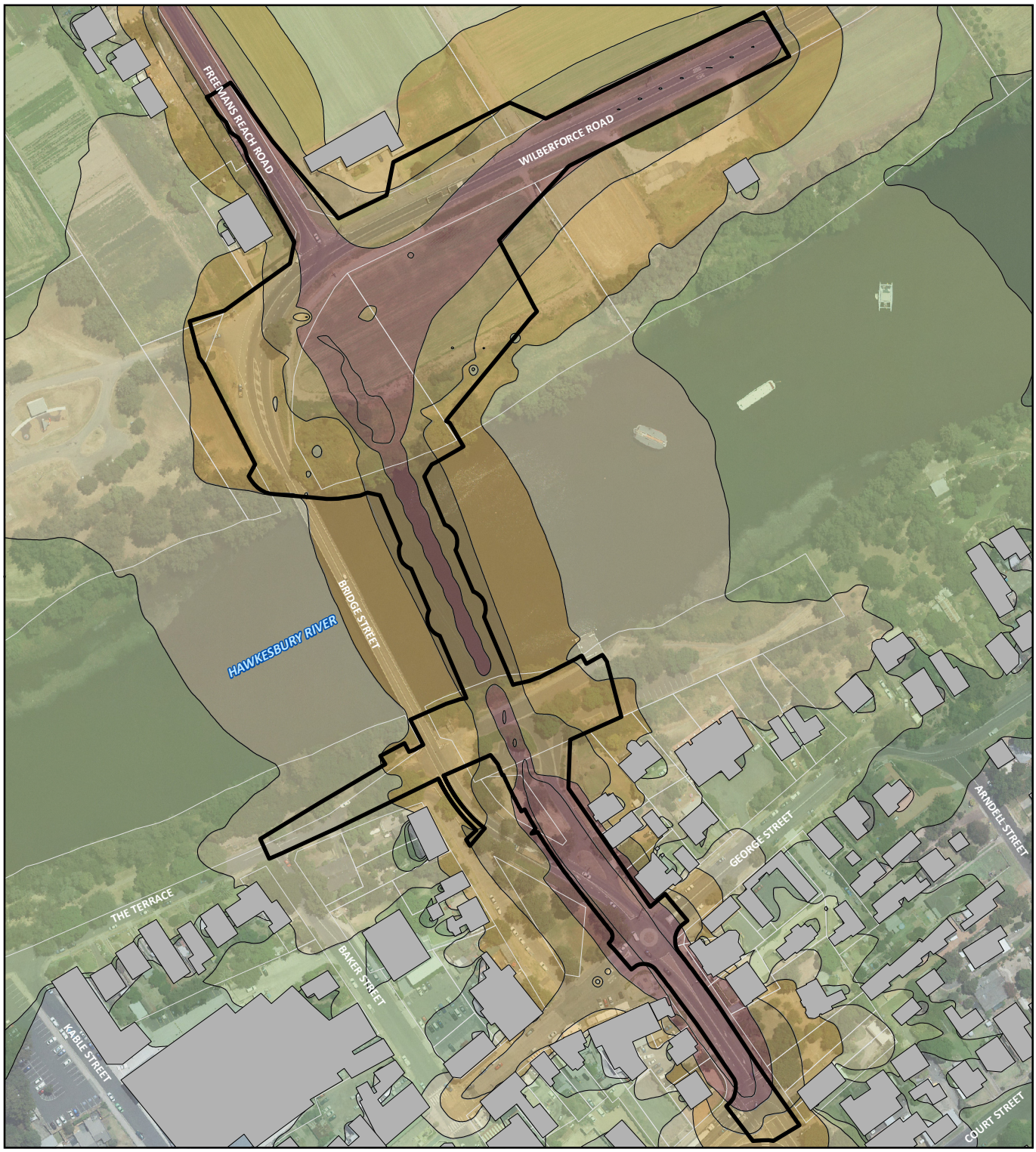
Based upon the vibration monitoring of the existing road and consideration of the new alignment and the increase in traffic over time, vibration from the operation of the project would not exceed human comfort or building damage criteria at adjacent buildings. Further details on the assessment of operational vibration can be found in the Noise and vibration working paper (Volume 4 – working paper 6). No mitigation measures would be required to minimise vibration impacts from the operation of the project.

**Table 7-47 Predicted noise levels up to 2026**

| ID | Year of opening No project $L_{Aeq}$ | | Year of opening With project $L_{Aeq}$ | | 2026 No project $L_{Aeq}$ | | 2026 With project $L_{Aeq}$ | | Changes in noise levels 10 years after opening $L_{Aeq}$ | | Exceeds acute criteria 60 dB(A) night & 65 dB(A) day | | Considered for noise mitigation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Day | Night | Day | Night | Day | Night | Day | Night | Day | Night | Day | Night | |
| R1 | 66 | 61 | 62 | 58 | 67 | 61 | 63 | 58 | -3.7 | -3.3 | No | No | No |
| R2 | 65 | 61 | 70 | 66 | 65 | 61 | 71 | 67 | 5.4 | 6.0 | **Yes** | **Yes** | **Yes** |
| R3 | 71 | 67 | 71 | 68 | 71 | 67 | 72 | 68 | 0.5 | 0.8 | **Yes** | **Yes** | **Yes** |
| R4 | 61 | 57 | 63 | 59 | 61 | 57 | 63 | 59 | 1.9 | 2.6 | No | No | **Yes** |
| R5 | 59 | 54 | 54 | 50 | 60 | 54 | 55 | 51 | -4.7 | -3.8 | No | No | No |
| R6 | 58 | 53 | 53 | 49 | 58 | 53 | 54 | 50 | -4.3 | -3.6 | No | No | No |
| R7 | 57 | 53 | 53 | 49 | 58 | 53 | 53 | 49 | -4.4 | -3.5 | No | No | No |
| R8 | 56 | 52 | 53 | 49 | 57 | 52 | 53 | 49 | -3.2 | -2.5 | No | No | No |
| R9 | 55 | 51 | 51 | 47 | 56 | 51 | 52 | 47 | -4.0 | -3.5 | No | No | No |
| R10 | 55 | 51 | 51 | 47 | 56 | 51 | 52 | 48 | -3.8 | -3.0 | No | No | No |
| R11 | 56 | 52 | 55 | 51 | 57 | 52 | 56 | 52 | -1.0 | -0.2 | No | No | No |
| R12 | 57 | 53 | 55 | 51 | 57 | 53 | 56 | 52 | -1.4 | -0.7 | No | No | No |
| R13 | 56 | 52 | 55 | 51 | 57 | 52 | 55 | 51 | -1.5 | -0.9 | No | No | No |
| R14 | 57 | 52 | 55 | 51 | 57 | 52 | 56 | 51 | -1.6 | -1.1 | No | No | No |
| R15 | 55 | 51 | 53 | 49 | 56 | 51 | 54 | 50 | -1.8 | -1.3 | No | No | No |

Note: shading indicates an exceedance of Road Noise Policy criteria

Figure 7-31 | Day time noise levels with the project in 2026




Indicative only – subject to detailed design

LEGEND

- Concept design footprint
- Building footprint
- Cadastral boundary

Noise assessment (dB)

- 45
- 50
- 55
- 60
- 65
- > 65

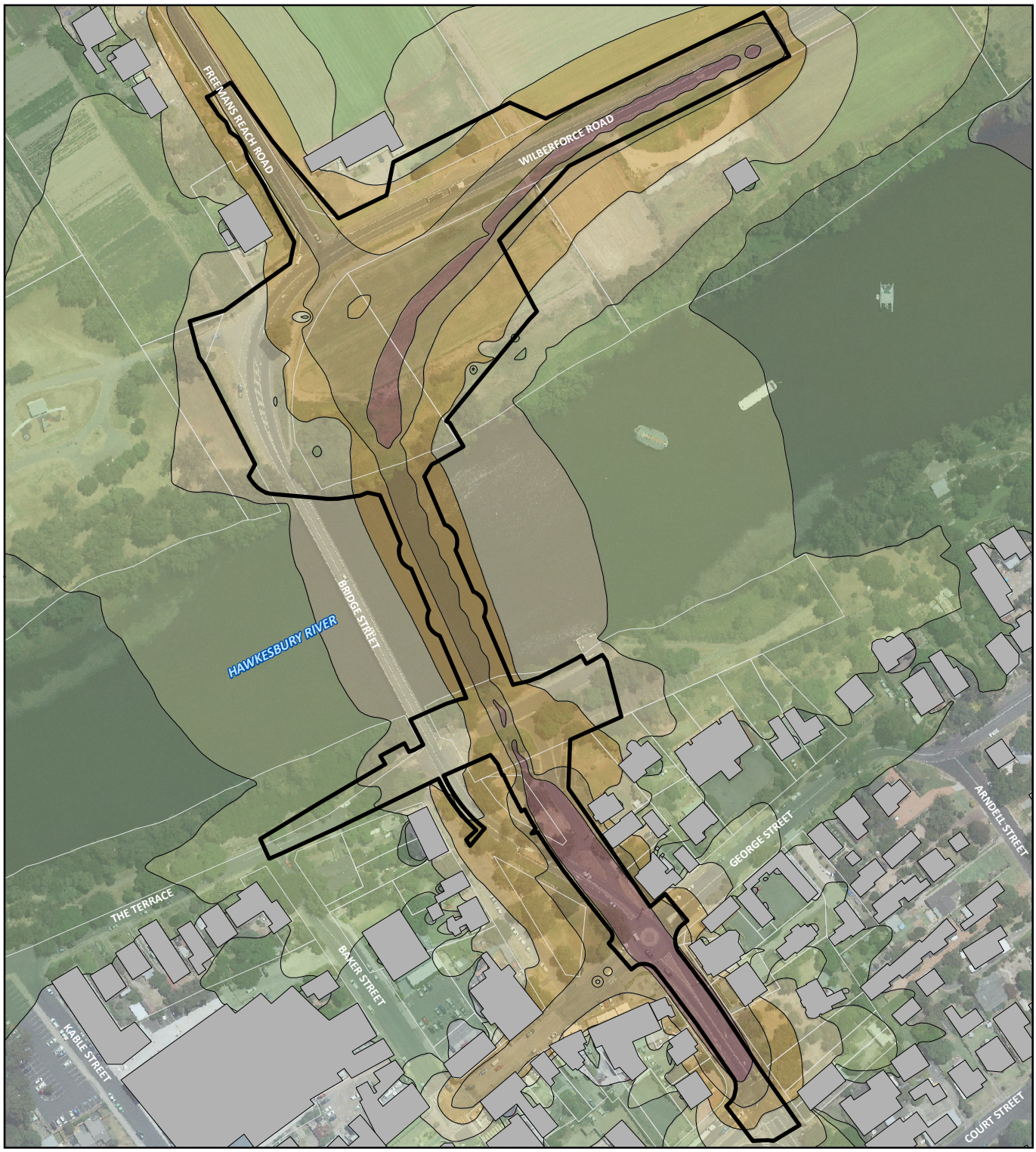


GDA 1994 | MGA Zone 56
A4 1:2,750

0 100
Metres


AUSIMAGE SKM

Figure 7-32 | Night time noise levels with the project in 2026




Indicative only – subject to detailed design

LEGEND

- Concept design footprint
- Building footprint
- Cadastral boundary

Noise assessment (dB)

- 45
- 50
- 55
- 60
- 65
- > 65

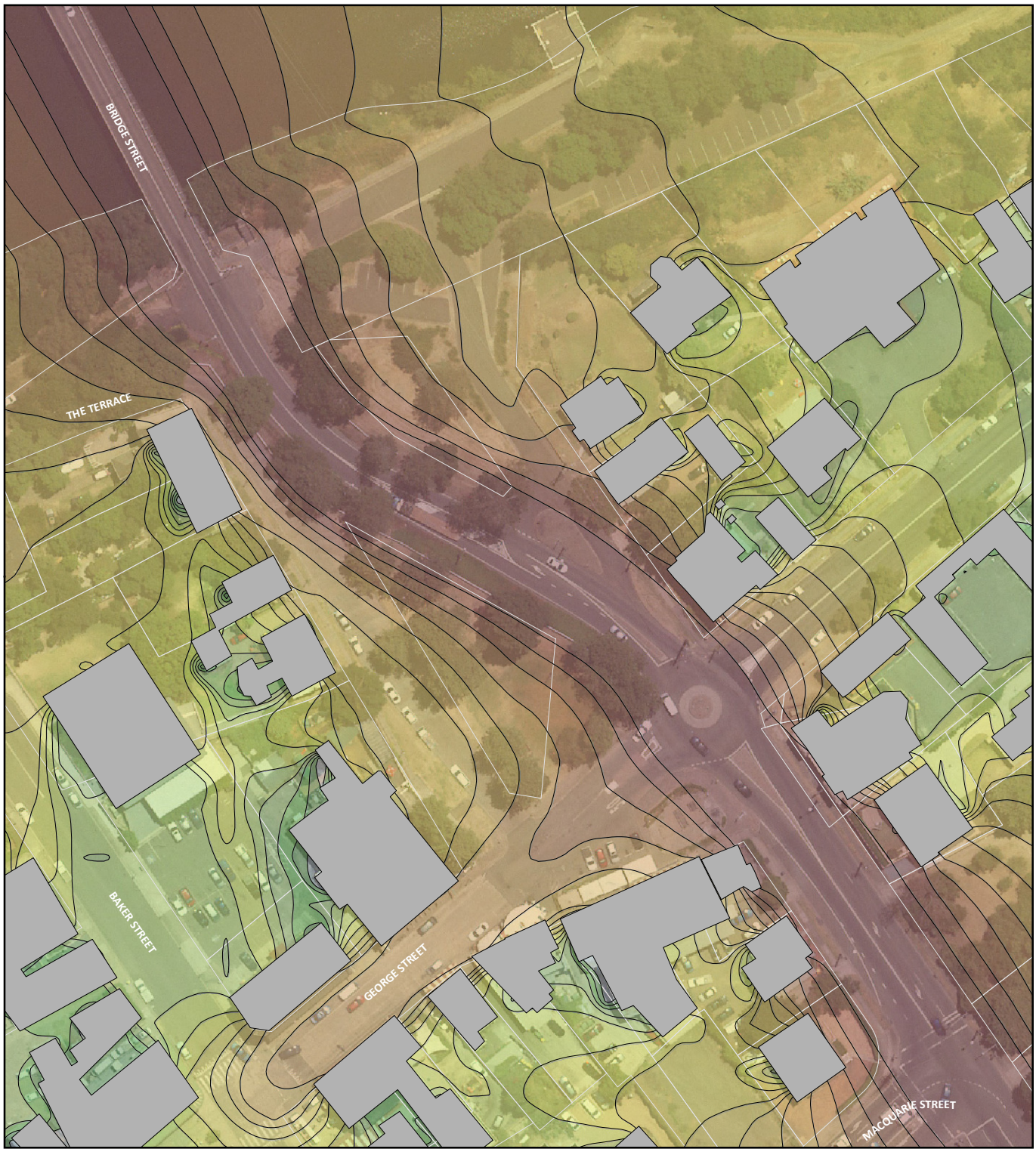


GDA 1994 | MGA Zone 56
A4 1:2,750

0 100
Metres


AUSIMAGE SKM

Figure 7-33 | Noise levels in Thompson Square parkland “No build” in 2026




Indicative only – subject to detailed design

LEGEND

- Building footprint
- Cadastral boundary

Noise assessment (dB)

- 45 - 46
- 47 - 48
- 49 - 50
- 51 - 52
- 53 - 54
- 55 - 56
- 57 - 58
- 59 - 60
- 61 - 62
- 63 - 64
- 65 - 66
- 67 - 68
- 69 - 70
- 71 - 72
- 73 - 74



GDA 1994 | MGA Zone 56
A4 1:1,200

0 40
Metres


AUSIMAGE SKM

Figure 7-34 | Noise levels in Thompson Square parkland with the project in 2026


Indicative only – subject to detailed design

LEGEND

- Concept design footprint
- Building footprint
- Cadastral boundary

Noise assessment (dB)

| | | |
|---|---|---|
| 45 - 46 | 55 - 56 | 67 - 68 |
| 47 - 48 | 57 - 58 | 69 - 70 |
| 49 - 50 | 59 - 60 | 71 - 72 |
| 51 - 52 | 61 - 62 | 73 - 74 |
| 53 - 54 | 63 - 64 | |
| | 65 - 66 | |



GDA 1994 | MGA Zone 56
A4 1:1,200

0 40
Metres


AUSIMAGE SKM

### 7.5.5 Environmental management measures

## Construction

*Noise*

Exceedances of the project NMLs would occur at most sensitive receivers and would depend upon the location and type of construction activities. Construction noise environmental management measures will be implemented wherever possible to minimise noise impacts. These will be detailed in a Construction Noise and Vibration Management Plan (CNVMP) and will include general controls such as:

- Further detailed noise impact assessments will be undertaken of all construction works and works outside standard construction hours once detailed construction planning is complete as the location and type of construction works may change. These detailed noise impact assessments will be used to identify affected sensitive receivers and develop detailed mitigation measures.
- The nearest noise sensitive receivers will be notified of future works and expected levels of noise well in advance of the works occurring.
- Construction programming will be developed to minimise noise impacts - this may include time and duration restrictions and respite periods, and will be developed after consultation with affected receivers.
- Where possible, works outside of standard construction hours will be planned so that noisier works are carried out in the earlier part of the evening or night time.
- Where noisy works are required outside of standard construction hours, negotiated agreements will be sought with affected sensitive receivers.
- Where possible, the use of noisy plant simultaneously and/or close together will be avoided.
- Equipment and excavation work sites will be orientated away from sensitive receivers where possible to reduce noise emissions.
- Equipment will be maintained in efficient working order.
- Quieter construction methods will be used where feasible and reasonable. This may include grinding, rock splitting or terrain levelling instead of rock breaking where it is feasible and reasonable.
- Where acceptable from a work health and safety perspective, quieter alternatives to reversing alarms (such as spotters, closed circuit television monitors and ‘smart’ reversing alarms) will be used particularly during out of hours activities.
- All noise complaints will be investigated and appropriate mitigation measures implemented where practicable to minimise further impacts.
- Truck movements will be restricted to identified haulage routes and the routes outlined in the Construction Traffic Management Plan
- Noise monitoring will be undertaken to assess compliance with NMLs and assess the effectiveness of noise mitigation The use of temporary noise shielding will be considered at locations along Bridge Street where substantial exceedances of noise criteria are predicted. In addition where work is undertaken in close proximity to Thompson Square or along Freemans Reach Road, temporary noise barriers will be considered.

*Vibration*

A Construction Noise and Vibration Management Plan will be prepared for the project and it will contain detailed assessment methods for high risk works, identification of sensitive receivers, complaints handling process, consultation protocols, monitoring requirements and mitigation measures. Mitigation measures that will be contained in the plan include:

- Buildings/structural conditions surveys will be undertaken prior to and following construction works at receivers within 50 metres of piling, rock breaking and vibratory compaction activities, including the heritage retaining wall at 4 Bridge Street.
- No impact piling works will be undertaken within 20 metres of any heritage structure, unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria.
- Rock breaking/hammering will not be undertaken within seven metres of any heritage item or building unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria.
- Rock breaking/hammering will not be undertaken within five metres of any non heritage building unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria.
- Where rock breaking/hammering is planned within 10 metres of any occupied dwelling, the occupants will be notified of the works and the duration of the activity will be restricted, unless otherwise agreed with affected residents.
- Where heavy plant is used within seven metres of a heritage structure, attended vibration monitoring will be undertaken to assess compliance with project specific vibration criteria.
- Where an exceedance of project specific vibration criteria for structural damage is recorded during monitoring, work will cease immediately and alternative construction methods will be used.

## Operation

*Noise*

Based on the noise impact assessment results and application of the RNP and ENMM, noise mitigation options for receivers R2, R3 and R4 must be considered. When considering operational noise mitigation, options to mitigate traffic noise at its source are considered first. At-source mitigation options generally include low noise road pavement and noise barriers. Consultation with RMS and road design engineers was undertaken to determine the feasibility of using low noise road pavement on the project. The use of low noise pavement was not possible as:

- It is RMS policy not to use low noise pavement on bridges due to safety issues with this type of pavement from the elevated profile of the pavement at the road edges.
- It would not provide any substantial noise reduction from the southern and northern approach roads. This is because of the short length of both roads, the design speeds are low which minimises any benefits of low noise pavements and the transition from the different pavement type on the bridge would result in noise impacts.

Noise barriers were not considered suitable for the project as they would be visually intrusive and would impact upon the heritage vistas and values of Thompson Square. As at-source noise mitigation options are not feasible, the ENMM recommends architectural treatment of individual buildings for noise mitigation as the next option.

Sensitive receivers R2 and R4 are residential properties of weatherboard and masonry construction respectively. At sensitive receiver R3 the ground floor of the building is currently operated as a commercial premise, whereas the upper floor is a residential premise. Therefore only the upper floor qualifies for architectural treatment under the ENMM. In selecting appropriate architectural treatment options, the type, condition and fabric of the building needs to be considered to provide the optimum internal noise benefit. At the receiver location R3, the implementation of architectural treatments is not straightforward as the other properties due to the heritage significance of the structure. This property is recognised as; "..a rare and excellent example of Victorian Regency Style architecture." and is listed as a heritage item on the LEP. Therefore any architectural treatment options must be sympathetic to the character, style and heritage value of the building.

As discussed in **Section 7.1.5**, a qualified heritage architect was engaged to inspect the residential section of R3 and recommend potential architectural treatments that provide noise mitigation while not impacting on the heritage values of the building (CityPlan Heritage, 2012). The heritage architect recommended measures that could be implemented without resulting in a significant impact to the heritage values of the building. Appropriate architectural noise environmental management measures for heritage listed buildings will be developed based on these recommendations and in agreement with property owners, and will be installed by suitably qualified professionals.

For sensitive receivers R2 and R4, a building inspection and identification of architectural treatment options will be undertaken before construction commences. This was not undertaken for the EIS as the buildings are not heritage listed and therefore specific architectural treatments do not have to be identified at this stage. Selection of any architectural treatments would also be undertaken in consultation with the owners of affected properties. Wherever possible architectural treatments of buildings will be undertaken before major construction activities commence to provide noise mitigation during construction.

*Vibration*

As vibration from the operation of the project would be below relevant guidelines, no environmental management measures are required.