Environment
Effects Statement

Technical Report C
Surface noise and vibration

NORTH EAST LINK PROJECT

North East Link Environment Effects Statement
Technical report C – Surface noise and vibration impacts assessment

Prepared for:
North East Link
Level 14
121 Exhibition Street
Melbourne Victoria 3000

SLR Ref: 640.11671-R01
Version No: Final
April 2019

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122 Australia

T: +61 3 9249 9400
E: melbourne@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
640.11671-R01-FINAL	10 April 2019	David Lindsey Gustaf Reutersward	Gustaf Reutersward David Lindsey	Robert Hall

EXECUTIVE SUMMARY

This technical report is an attachment to the North East Link Environment Effects Statement (EES). It has been used to inform the EES required for the project and defines the Environmental Performance Requirements (EPRs) necessary to meet the EES objectives.

Overview

North East Link ('the project') is a proposed new freeway-standard road connection that would complete the missing link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The Major Transport Infrastructure Authority (MTIA) is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

On 2 February 2018, the Minister for Planning declared North East Link to be 'public works' under *Section 3(1) of the Environment Effects Act 1978,* which was published in the *Victorian Government Gazette* on 6 February 2018 (No. S 38 Tuesday 6 February 2018). This declaration triggered the requirement for the preparation of an EES to inform the Minister's assessment of the project and the subsequent determinations of other decision-makers.

The EES was developed in consultation with the community and stakeholders and in parallel with the reference project development. The reference project has been assessed in this EES. The EES allows stakeholders to understand the likely environmental impacts of North East Link and how they are proposed to be managed.

SLR Consulting Australia (SLR) was commissioned to undertake a surface noise and vibration assessment to inform the EES.

Surface noise and vibration

The scoping requirements for the EES issued by the Minister for Planning set out the specific environmental matters to be investigated and documented in the project's EES, which informs that scope of the EES technical studies. The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating the project.

The following evaluation objective is relevant to the surface noise and vibration assessment:

> To minimise adverse air quality, noise and vibration effects on the health and amenity of nearby residents, local communities and road users during both construction and operation of the project.

EXECUTIVE SUMMARY

Noise and vibration from the construction and operation of North East Link has the potential to impact sensitive land uses. It is important to quantify these effects to understand the potential impacts on sensitive uses such as residences, kindergartens, schools and aged care facilities, allowing for mitigation measures and management strategies to be identified and developed. The management of noise and vibration is important to minimise amenity impacts on affected sensitive uses and to prevent vibration-induced damage to property assets and other infrastructure.

Existing conditions

Long-term ambient noise from the existing traffic stream was measured at 59 locations and the vibration at 21 locations along the project corridor. The ambient noise levels were used to document the prevailing noise environment, to calibrate the noise model and to set the construction and SEPP-N1 noise criteria. The results of the existing conditions measurements were not included in the analysis where there were periods of high wind or rain, or when it was apparent there was evidence that local noise activities influenced the measurements.

The $L_{A10(18hour)}$ levels of traffic recorded along the corridor vary between 52 dBA to 74 dBA, depending on the heights of the monitoring points relative to the roadway, the presence (or not) of noise walls, the angle-of-view to the roadway. These levels are consistent with expectations for a residential area, given the surrounds and the proximity to a transport corridor.

Construction noise and vibration assessment

Key points:

Construction noise and vibration has been assessed using noise objectives in line with other current major infrastructure projects underway in Greater Melbourne (such as the Melbourne Metro and West Gate Tunnel Project). The assessment has shown that:

- Routine construction works would be undertaken in accordance with the EPA Victoria *Noise Control Guidelines* (EPA 1254).
- In local areas there would be receivers which would exceed the nominated Noise Management Level (NML) for varying periods of time, especially during some anticipated unavoidable works completed out-of-hours. As a result, more detailed construction noise and vibration mitigation and management measures would be developed as part of the detailed design once final construction methods and equipment are known.
    - ‘Noise management level’ is a noise level (from the construction works) which triggers a particular action which is intended to manage the construction noise impacts.
    - ‘Unavoidable works’ are works that cannot practicably meet the schedule requirements because the work involves continuous work — such as a concrete pour — or would otherwise pose an unacceptable risk to life or property or risk a major traffic hazard.
- There would be a short period (between 2 to 6 weeks) when a number of receivers along the Eastern Freeway would experience increased levels of the current road noise due to existing noise walls being demolished (before the walls were replaced as part of the project).

EXECUTIVE SUMMARY

- Due to the existing number of vehicles on the roads in the study area, the inclusion of construction traffic from the project (including spoil trucks) does not dramatically increase the overall traffic noise levels (increase predicted to be up to 0.9 dBA $L_{Aeq\ (1\ hour)}$ during the day period and 0.6 dBA $L^{Aeq\ (1\ hour)}$ during the night-time period) on some roads.
- A high number of receivers may fall within the empirical 'safe working distances' for vibration intensive plant equipment (such as large rock-breakers and vibratory rollers) and so consideration of appropriate processes and plant will be required during the detailed design phase of the project. These empirical distances are generally conservative in nature, so further assessment and vibration monitoring would be undertaken during construction to mitigate vibration impacts.

Further detail:

The assessment has evaluated the potential noise impacts of surface construction works including:

- Noise from construction activities
- Change in noise along key spoil haulage routes
- Elevation of road traffic noise due to temporary noise wall removal/replacement.

The prediction of noise during construction was undertaken using three-dimensional models of the existing ground and project design. Sources of noise and vibration were modelled at the locations anticipated to form the construction areas for the project and to account for plant and equipment likely to be required to construct the project. Predicted noise levels are compared with NMLs to identify the requirement for mitigation and/or management measures.

Consistent with most major construction projects in urban areas, noise impacts are likely as North East Link works would require the use of noise intensive equipment at times and would generally be in the near vicinity of sensitive receivers. At any location, the potential impacts can vary greatly depending on factors such as the relative proximity of sensitive receivers, the overall duration of the construction works, the intensity of the noise and vibration levels, the time at which the construction works are undertaken, and the character of the noise or vibration emissions.

The activities likely to be required to construct the above-ground aspects of the project would involve conventional road and tunnel infrastructure construction equipment such as rock-breakers, earth moving equipment, piling equipment, paving plant, concreting equipment, cranes and road header tunnelling equipment.

The construction works would be undertaken in accordance with the EPA Victoria *Noise Control Guidelines* (EPA 1254) during the normal working hours of:

- 7.00 am to 6.00 pm Monday to Friday (day)
- 7.00 am to 1.00 pm on Saturdays (day).

However, some construction activities could not practicably meet the above requirements because the work would involve continuous work, such as a concrete pour, or would otherwise pose an unacceptable risk to life or property or risk a major traffic hazard or result in significant traffic interruptions along the Eastern Freeway and M80 Ring Road and surrounding road network. These activities may be considered to be unavoidable works and would generally start after the evening traffic peak period when traffic volumes had reduced.

EXECUTIVE SUMMARY

Some anticipated unavoidable works that may include noisy construction activities undertaken outside normal working hours are included in the assessment to inform the scheduling of construction and management of noise during the detailed design phase.

Other works which may be undertaken outside normal working hours may include:

- Low-noise works that are inherently quiet or unobtrusive and are determined to comply with the relevant noise limit at the nearest sensitive receiver
- Work where the noise impacts are mitigated (for example, no impulsive noise and average noise levels over any half hour do not exceed the background) through actions specified in a Noise Management Plan supported by acoustic assessment.

Site-specific Construction Noise and Vibration Management Plans (CNVMP) would be required to be developed during the detailed design phase and these would include all instances where works are proposed outside standard construction hours. The CNVMPs would provide a detailed assessment of potential noise levels and site-specific measures to control potential noise impacts and minimise the potential for disturbance at affected receivers.

The noise model predictions and assessment indicate that some construction activities have the potential to cause more significant impacts. These include:

- Excavation works for the depressed roadway, and cut and cover tunnel section north of Lower Plenty Road
- Existing bridge structure demolition undertaken outside normal working hours
- Viaduct earthworks and construction undertaken outside normal working hours.

Careful mitigation strategies would be required to minimise impacts of these construction activities. A framework for adopting additional mitigation measures has been adopted as per the requirements of the NSW Roads and Maritime Services *Construction Noise and Vibration Guideline* (CNVG). These measures may include: physical mitigation of plant, equipment and operations, limits to the hours of operation (for some operations), duration respite, notifications and direct consultation with the community. If mitigation was unable to alleviate the impacts, other measures such as temporary relocation could then be considered.

The assessment has evaluated the potential impacts of the additional construction period traffic due to the haulage of spoil generated from the project (TBMs, road headers, cut and cover and other open excavations). Construction haulage routes and two-way truck volumes have been identified. Due to the existing number of vehicles on the roads, the inclusion of the spoil trucks would not dramatically increase the overall traffic noise levels, so while the trucks may be identifiable on the roads, they would not lead to a significant acoustical impact. The highest increases are predicted to be 0.9 dBA $L_{Aeq\ (1\ hour)}$ during the day period and up to 0.6 dBA $L_{Aeq\ (1\ hour)}$ during the night-time, for the month of peak activity.

The assessment has evaluated the potential impacts of surface construction works from vibration-intensive equipment (not tunnelling) using a safe working distance approach, including:

- Cosmetic damage to structures
- Human comfort.

EXECUTIVE SUMMARY

The separation distance(s) between the construction works and the nearest sensitive receivers would generally be sufficient so that nearby buildings are unlikely to suffer cosmetic damage for most of the construction equipment. Operation of large rock-breakers and vibratory rollers has the potential to generate some of the highest construction vibration impacts due to the high vibration characteristics of the plant.

The assessment indicates the surface works using large rock-breakers and vibratory rollers and other high vibration plant items may result in a large number of receivers within the nominated minimum working distance for human comfort vibration. In practice, vibration impacts from most construction activities would be intermittent.

The project would endeavour to install new noise walls ahead of the demolition of the existing walls. However, in a few locations where noise walls would be replaced, it may not be possible to erect the new noise walls before the existing noise walls were demolished and there would be a period where there are no noise walls between the Eastern Freeway and the residences. This time has been estimated to be:

- Four to six weeks for concrete wall sections
- Two to three weeks for timber wall sections.

The temporary increase in road traffic noise is anticipated to be typically in the range of 5 dBA to 15 dBA.

Operational noise

Key points:

The road traffic noise objectives used for North East Link is based on the existing VicRoads policy, applied conservatively (ie categorising all roads as new, rather than upgraded for M80 and Eastern Freeway).
The numeric values of the noise objectives are consistent with those used for the West Gate Tunnel Project.
Traffic noise was predicted to 11,476 residential or noise sensitive buildings. With the incorporation of the mitigation outlined in this report (consisting of the use of low noise pavements and noise walls), only 159 noise sensitive buildings exceed the 63 dBA assessment level for Category A and Category B buildings.
These properties would be the subject of further considered for ‘at property’ noise treatments to mitigate impacts, subject to further detailed design assessment post-approval.

The introduction of North East Link (and associated noise mitigation) tends to reduce the project-wide traffic noise levels by approximately 1 dBA (assuming noise from local roads and project roads). It is noted that for Category A and Category B buildings:

- 35 buildings along the corridor would experience a very significant noise reductions of 10 dBA or more due to North East Link
- 382 one buildings along the corridor would experience a significant noise reduction of 5 dBA to 10 dBA
- 1,883 properties would experience noise reductions by between 2 dBA to 5 dBA
- 8,287 properties are predicted to experience no noticeable change in their noise environment (-2 dBA to + 2 dBA)
- 889 properties are predicted to experience an increase of more than 2 dBA.

EXECUTIVE SUMMARY

The properties above include all noise sensitive buildings in the study area. An analysis of the distribution of the predicted change in traffic noise for 2036, with and without the project (adopting the upper limit of the predicted traffic volume range) shows that:

- A high number of properties that fall in the range of +/- 2dBA (representing no noticeable change to the noise environment). Many of these houses are located sufficiently far from the project alignment, so as not to be adversely affected by the project.
- The project provides the most noise reduction to those locations having noise levels higher than approximately 60.5 dBA (compared to the do-nothing scenario); so that more impacted buildings receive the highest benefit from the noise mitigation measures.

Road traffic noise would reduce at many other properties in the adjoining suburbs once the project was operating by diverting traffic from the current road network to North East Link. This would be more noticeable on roads currently used by trucks.

Further detail:

Buildings along the corridor were categorised based on information in other specialist studies and information available in the public domain. In accordance with the VicRoads assessment guidelines, these categories were:

- Category A – Dwellings, aged persons homes, hospitals, motels, caravan parks and other buildings with residential uses
- Category B – Schools, kindergartens, libraries, places of worship and other noise sensitive community uses
- Non-assessable buildings – these include industrial, commercial, sporting facilities, clubs.

The assessment of road traffic noise for Category A buildings in Victoria and is based on the $L_{A10(18hour)}$ noise index, while Category B buildings uses the $L_{A10(12hour)}$ index. The $L_{A10(18hour)}$ level is the average of the one-hour L_{A10} noise levels between 6 am and midnight.

A review of Victorian policy and guidelines applicable to road traffic noise was undertaken as part of the study and the project decided to adopt traffic noise objectives aimed at providing a higher level of acoustic amenity (by setting more stringent objectives) than would normally be required by a strict interpretation of the VicRoads *Traffic Nosie Reduction Policy (2005)*.

The assessment approach used in the assessment was based on the VicRoads *Road Design Note 06-01, July 2010*, excepting that a project-specific noise objectives has been adopted. It would be reasonable that mitigation is considered whenever the contribution of noise from the North East Link corridor (including on/off ramps), exceeds the $L_{A10(18hour)}$ level of 63 dBA for Category A buildings and 63 dBA $L_{A10(12hour)}$ for Category B buildings. This criterion is numerically consistent with that adopted for the West Gate Tunnel Project. Consistent with VicRoads procedures, the design criteria are to apply 10 years after project opening (the design year, 2036). Consideration is also given to mitigation from the cumulative effects of noise from local roads, as specified in the project Environmental Performance Requirement NV01.

EXECUTIVE SUMMARY

The design of mitigation measures was based on achieving compliance with the 63 dBA criterion at Category A and Category B buildings for noise arising from North East Link and minimising the cumulative noise impacts from areas that may also be affected by non-project roads. In accordance with the scoping requirements, an assessment of impacts was also undertaken against WHO night-time noise guidelines. The WHO assessment resulted in the identical number of residences at the ground floor being impacted compared with the project noise objectives, with no new properties being identified.

The operational noise model was calibrated against existing conditions and used to determine the noise mitigation measures along the corridor.

Apart from low noise asphalt, noise walls are the most usual form of mitigation along dedicated road corridors. The consideration of noise walls is balanced against:

- Potential visual impacts
- Potential urban design considerations
- Potential community safety/crime prevention considerations such as isolated walkways
- Impacts of a noise wall on traffic and pedestrian connectivity between the project road and the local road network
- Potential overshadowing impacts
- Restrictions to driver sight-lines
- Form of future development of the residual land which may itself provide a wall to traffic noise
- Considerations of local context based on feedback from the community during the project's consultation phase.

The noise assessment has adopted road surface correction based on the general principle of using quieter noise pavement (open-graded asphalt) along the extent of the main carriageway of the project, with dense graded asphalt on the ramps and viaducts. Where the assessment required additional mitigation (over and above that provided by the proposed noise walls), the use of open-graded asphalt was examined where it provides significant acoustic benefit to an area. The use of open-graded asphalt is recommended and is to be further considered for two viaducts at the southern interchange (the viaduct transporting vehicles travelling west along the Eastern Freeway into the tunnel, and the viaduct transporting vehicles from the tunnel in an easterly direction on the Eastern Freeway), subject to detailed design acceptance. Should the use of open-graded asphalt prove not to be feasible, some additional dwellings may qualify for treatment.

Extensive noise walls have been incorporated into the design, with the maximum height set to 10 metres along the corridor and four metres on viaducts. Noise walls are proposed on several existing bridge structures, noting that these recommendations precede the assessment of the bridge to ensure it can withstand the additional structural/wind load or other design considerations that result. If it proves the bridge walls are not feasible, a small number may qualify for at-property treatments, as a means of noise control (in lieu of the bridge wall).

EXECUTIVE SUMMARY

Where noise walls and low noise pavement does not provide sufficient noise mitigation to a noise sensitive building, at-property treatment to the affected Category A or Category B building may be considered at the detailed design phase of the project. At-property treatments are an upgrade to key façade elements of a building intended to provide an improved acoustic environment within the dwelling. At-property treatments provided would depend on the extent of the exceedance, but may include some or all of the following:

- Courtyard screen walls
- Glazing upgrading
- Seals on door jambs and around openable windows
- Door upgrading
- Inclusion of roof insulation
- Sealing of eaves, vents and underfloor (below the bearers)
- Provision of mechanical ventilation systems (not air conditioning) where windows are required to be closed for noise control purposes. This allows fresh air to be supplied to the room, in accordance with the Building Code of Australia requirements.

North East List would reduce traffic noise on many roads away from the project compared with the 2036 ‘no project’ scenario. Some roads show a slight increase in traffic noise in the southern portion of the roads intersecting the Eastern Freeway (such as at Station Street, Surry Road in Springvale) and in the west of the site (Childs Road, Dalton Road, Edgars Road and MacDonalds Road). However, the highest increase is only 1.4 dBA which is considered negligible and generally unnoticeable.

A set of Environmental Performance Requirements (EPRs) have been developed for the project that are designed to appropriately manage operational noise, construction noise and surface vibration to mitigate impacts.

DOCUMENT NAVIGATION

CONTENTS

DOCUMENT NAVIGATION

DOCUMENT NAVIGATION

TABLES

DOCUMENT NAVIGATION

DOCUMENT NAVIGATION

FIGURES

DOCUMENT NAVIGATION

DOCUMENT NAVIGATION

Structure of the EES

Summary Report

EES main report

1. Introduction
2. Project rationale
3. Legislative framework
4. EES assessment framework
5. Communications and engagement
6. Project development
7. Urban design
8. Project description
9. Traffic and transport
10. Air quality
11. Surface noise and vibration
12. Tunnel vibration
13. Land use planning
14. Business
15. Arboriculture
16. Landscape and visual
17. Social
18. Human health
19. Historical heritage
20. Aboriginal cultural heritage
21. Ground movement
22. Groundwater
23. Contamination and soil
24. Surface water
25. Ecology
26. Greenhouse gas
27. Environmental management framework
28. Conclusion

Technical reports

A. Traffic and transport
B. Air quality
C. Surface noise and vibration
D. Tunnel vibration
E. Land use planning
F. Business
G. Arboriculture
H. Landscape and visual
I. Social
J. Human health
K. Historical heritage
L. Aboriginal cultural heritage
M. Ground movement
N. Groundwater
O. Contamination and soil
P. Surface water
Q. Ecology
R. Greenhouse gas

Attachments

I. Sustainability approach
II. Urban design strategy
III. Risk report
IV. Stakeholder consultation report
V. Draft Planning Scheme Amendment
VI. Works Approval Application

EES Map Book

DOCUMENT NAVIGATION

Abbreviations

Abbreviation	Definition
CEMP	Construction Environmental Management Plan
CNVG	NSW Roads and Maritime Services provides the complementary document Construction Noise and Vibration Guideline
CNVMP	Construction Noise and Vibration Management Plan
DGA	Dense graded asphalt
OGA	Open graded asphalt
DIN 4150	Structural Vibration – Part 3: Effects of vibrations on structures (2016)
EES	Environment Effects Statement
EMF	Environmental Management Framework
EPA	Environment Protection Authority (Victoria)
EPR	Environmental Performance Requirement
ICNG	NSW EPS's interim construction noise guideline
NELP	North East Link Project
NML	Noise Management Level
OEMP	Operations Environmental Management Plan
PER	Public Environment Report
Publication 1254	Noise Control Guidelines, Publication 1254, 2008
RBL	Rating Background Level
RMS	Roads and Maritime Services (NSW)
SEPP	State Environmental Planning Permit
TBM	Tunnel Boring Machine
VDV	Vibration Dose Value
WHO	World Health Organisation

Glossary

Term	Definition
Buildings	Unless specifically qualified, buildings generally refer to Category A or Category B.
Category A (buildings)	Residential buildings, as defined by VicRoads, *Traffic Noise Reduction Policy* 2005.
Category B (buildings)	Other (non-residential) noise sensitive buildings, as defined by VicRoads *Traffic Noise Reduction Policy* 2005.
Daytime period	Monday to Friday 7:00 am to 6:00 pm, and Saturday 7:00 am to 1:00 pm.
Department of Transport	The Victorian Department of Transport is responsible for delivering the government's transport infrastructure agenda. It was formed on 1 January 2019 when the former Victorian Department of Economic Development, Jobs, Transport and Resources transitioned into the Department of Transport and the Department of Jobs, Precincts and Regions.
Design year	10 years after project opening.

DOCUMENT NAVIGATION

Term	Definition
Environmental Management Framework	The EMF sets out the proposed governance framework for managing the environmental effects of the project and outlines clear accountabilities for the delivery and monitoring of the implementation of the recommended Environmental Performance Requirements.
Environmental Performance Requirements	The minimum environmental outcomes that must be achieved for design, construction and operation of North East Link project, regardless of the design solution delivered.
Evening or weekend period	Monday to Friday 6:00 pm to 10:00 pm, Saturdays 1:00 pm to 10:00 pm and Sundays – all day.
Impact assessment	An impact is the effect of an action on a resource or system. An impact assessment evaluates the severity and significance of the change through consideration of the: • Value or sensitivity of a resource or system that is affected by an action • Consequence or magnitude of the effect on that resource or system. The ability of the system to recover or for mitigation measures to be applied.
Major Transport Infrastructure Authority	The Major Transport Infrastructure Authority (MTIA) is the proponent for the North East Link project. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.
Main line	Portion of the road that contains the principal route or line of a roadway.
Metropolitan Melbourne	Area defined as 'Metropolitan Melbourne' in Clause 72 of the Victoria Planning Provisions.
Night-time period	Any night: 10:00 pm to 7:00 am.
Noise management level.	A noise level (from the construction works) which triggers a particular action which is intended to manage the construction noise impacts.
Non project roads	All roads that are not project roads.
North East Link Project	North East Link Project is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP was formerly known as the North East Link Authority prior to 1 January 2019. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.
Project roads	Project roads are defined to be the M80 Ring Road (east of Plenty Road), the Greensborough Bypass (west of the Plenty River Bridge and up to the M80 Ring Road interchange with North East Link), the upgrade of the Eastern Freeway (between Hoddle Street and Springvale Road) and the new North East Link freeway (connecting the M80 Ring Road to the Eastern Freeway), including all access ramps.
Reference project	One feasible way for North East Link to be delivered that would meet the Victorian Government's objectives.
Risk	Risk is measured as a combination of the magnitude of potential consequences of an event happening, and the likelihood of the event and associated impact occurring.
Traffic noise	The façade reflected $L_{A10(18hour)}$ noise level.
Normal working hours	Defined in EPA Victoria Noise Control Guidelines (Publication No 1254 as being between: • 7 am — 6 pm Monday to Friday • 7 am — 1 pm Saturdays.
Unavoidable works	Works that cannot practicably meet the schedule requirements because the work involves continuous work — such as a concrete pour — or would otherwise pose an unacceptable risk to life or property, or risk a major traffic hazard.
Zoning levels	The zoning level is determined via a specific SEPP N-1 procedure and is used to determine site noise limits. It is based on the ratio of residential to commercial/industrial land use within a prescribed distance of a receiver.

(DO NOT DELETE SECTION BREAK)

1 Introduction

1.1 Purpose of this report

North East Link ('the Project') is a proposed new freeway-standard road connection that would complete the missing link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The Major Transport Infrastructure Authority (MTIA) is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

On 2 February 2018, the Minister declared the works proposed for North East Link as Public Works and issued a decision confirming that an Environment Effects Statement (EES) is required for the project due to the potential for significant environmental effects.

Similarly, the project was also referred to the Australian Government's Department of the Environment and Energy on 17 January 2018. On 13 April 2018 the project was declared a 'controlled action', requiring assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Separate to this EES, a Public Environment Report (PER) is required to be prepared to satisfy the EPBC Act requirements and assess the impacts of the project on Commonwealth land and matters of national environmental significance (MNES).

The purpose of this report is to assess the potential surface noise and vibration impacts associated with North East Link and to define the Environmental Performance Requirements (EPRs) necessary to meet the EES objectives.

The report focuses on potential surface noise and vibration impacts of at-grade and elevated sections of North East Link. Impacts from the tunnelled section is covered in a separate technical report, Technical report D – tunnel vibration.

1.2 Why understanding noise and vibration is important

Noise and vibration from the construction and operation of North East Link have the potential to impact sensitive land uses such as residences, kindergartens, schools and aged care facilities near the project corridor, as shown in Figure 3-1 in **Section 3**. The degree of impacts depends on several factors, including the proximity to the noise/vibration source.

Quantifying the extent of noise exposure to people who live along the project corridor allows for mitigation measures to be identified and tailored on a community-wide basis. The management of noise and vibration is important to minimise amenity impacts on affected sensitive uses and to prevent vibration-induced damage to property assets and other infrastructure.

Environmental Performance Requirements (EPRs) have been prepared and are designed to ensure that noise and vibration from the construction and operation of North East Link are conducted according to strict guidelines and controls, including the development of the project's Construction Noise and Vibration Management Plan (CNVMP).

2 EES scoping requirements

2.1 EES evaluation objectives

The scoping requirements for the EES released by the Minister for Planning set out the specific environmental matters to be investigated and documented in the project's EES, which informs the scope of the EES technical studies. The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating the project.

The following evaluation objective is relevant to the surface noise and vibration assessment:

> To minimise adverse air quality, noise and vibration effects on the health and amenity of nearby residents, local communities and road users during both construction and operation of the project.

2.2 EES scoping requirements

The aspects from the scoping requirements relevant to the noise and vibration evaluation objective is shown in **Table 2-1** as well as the location where these items have been addressed in this report.

Table 2-1 Scoping requirements relevant to surface noise and vibration

Aspect	Scoping requirement	Section addressed
Key issues	Generation of airborne, ground borne or regenerated vibration from construction that could adversely affect residential amenity or infrastructure	Section 8 and Technical report J – Human health
	Effects of noise generated during construction from plant and equipment or vehicle movement adversely affecting residential amenity or other sensitive land uses.	Section 8
	Generation of traffic noise either through direct, reflected or reverberated noise from vehicles during operation as well as from use of engine brakes that could adversely affect residential amenity or other sensitive land uses.	Appendix G Section 9
	Generation of airborne noise from fixed sources such as tunnel ventilation systems during project operations that could adversely affect residential amenity or other sensitive land uses.	Section 10
	Potential for impact on health of sensitive receivers due to exposure to vehicle emissions (both noise and air).	Refer Technical report J – Human health
Priorities for characterising the existing environment	Identify residences (including sites that are the subject of current planning permit applications or planning scheme amendments), urban developments (where development proposals are identified in the planning scheme or form part of a seriously entertained planning proposal [Note 1]) and land uses (schools, hospitals, outdoor recreation sites, etcetera.) that require a particular focus on protecting the beneficial uses of the air and noise environment relating to human health and wellbeing, local amenity and aesthetic enjoyment.	Appendix B
	Identify residences, and other sensitive land uses, property assets or infrastructure that may be vulnerable to air borne, ground borne or regenerated vibration from construction activities.	Appendix B
	Measure and map the background noise levels L_{A90} exempt of noise from an industrial or commercial nature; and existing ambient noise levels L_{Aeq} including existing commercial and industrial sources (noting any tonal and/or impulse noises) as per SEPP N-1.	Figure 6-1, Figure 6-4, Figure 6-7 and Figure 6-8
	Measure and map the existing traffic noise levels using hourly L_{10} and L_{Aeq} across the periods of 0600-2200, and 2200-0600 as per AS2702-1984 Acoustics - Methods for the Measurement of Traffic Noise and VicRoads Traffic Noise Measurement Requirements for Acoustic Consultants.	Appendix E

Aspect	Scoping requirement	Section addressed
	Characterise existing ground vibration conditions through measurement and describe geological conditions that might influence the transmission of vibrations and regenerated noise from construction works.	Section 8.7
	Characterise the existing health status of the population in the vicinity of the Project.	Refer Technical report J – Human health
Design and mitigation measures	Propose siting, design, mitigation and management measures to control emissions of dust or other air pollutants and noise from construction activities.	Section 8.4, Section 8.8.9
	Propose design, mitigation and management measures to control generation of airborne or ground borne vibrations from construction.	Section 8.4
	Proposed design, mitigation and management measures to control noise generated from tunnel ventilation systems and other fixed sources during operation.	Section 10
	Propose siting, design, mitigation and management measures to minimise generation of: • traffic noise from existing and new and upgraded surface or elevated roads or interchanges; • breakout noise from tunnel portals, openings or any enclosed structure; and • engine brake noise; either through direct, reflected or reverberated noise from elevated structures, infrastructure or vehicles during operation due to the redistribution of traffic in the vicinity of the Project, increased heavy vehicle traffic in the project area or altered road and traffic conditions.	Section 9 and Appendix I Appendix I Section 9.11 Section 9 and Appendix G
Assessment of likely effects	Analyse potential for relevant construction noise standards set out in the NSW Interim Construction Noise Guideline and EPA Victoria Noise Control Guidelines (Publication No 1254) to be exceeded, considering timing, duration, localities and any relevant special noise characteristics (for example; tonality, impulsiveness).	Section 8
	Analyse potential for traffic noise levels to be exceeded during the day and night time periods and compare predicted traffic noise levels in the year of opening of the project and ten years hence according to the criteria under the VicRoads Traffic Noise Policy 2005 (or any subsequent updates to this policy) and relevant criteria from the World Health Organization Night Noise Guidelines for Europe 2009.	Section 9
	Analyse potential for noise from fixed sources such as tunnel ventilation systems to exceed noise standards as set out in SEPP N-1.	Section 10
	Analyse the impact of engine brake noise and the likelihood of sleep disturbance, based on a qualitative assessment of the proportion of freight vehicles predicted to utilise the project and the per centage of those vehicles anticipated to represent a risk of engine brake noise.	Refer Technical report J – Human health
	Analyse potential for vibration to cause disturbance to occupants of residential buildings or other sensitive land uses or cause adverse effects on property and infrastructure (see also Section 4.7 below for potential effects of vibration on heritage and cultural heritage values).	Section 8.8.5
	Predict any improvements to air quality or noise levels due to project operation.	Section 9.10
	Evaluate any changes to air quality and noise conditions for nearby residents and local communities that the project will deliver, particularly through redistribution or management of heavy vehicle traffic or altered road and traffic conditions and the implications of these for human health and amenity.	Refer Technical report J – Human health
Approach to manage performance	Describe the environmental performance requirements to set air quality, traffic noise and vibration outcomes that the project must achieve.	Section 11

Note 1: A seriously entertained planning proposal is generally defined as a document that has been through the exhibition (public consultation) process, been adopted in its final form by the council and submitted to the Planning Minister's office for consideration.

2.3 Linkages to other reports

This report relies on or informs the technical assessments as indicated in **Table 2-2**.

Table 2-2 Linkages to other technical reports

Specialist report	Relevance to this impact assessment
Technical report K – Historical heritage	Identifies the heritage infrastructure along the alignment, including the potentially sensitive elements and the existing condition. Provides details of the Heide Museum of Modern Art, Banyule House and Clarendon Eyre as the closest heritage elements to the tunnel alignment.
Technical report D – Tunnel vibration	Lists the permissible noise objectives for vibration and generated noise from tunnelling works and the nominated mitigation measures.
Technical report Q – Ecology	Potential for impacts on wildlife.
Technical report A – Traffic and transport	Details relevant traffic flow data (existing and future vehicle classifications, volumes and speeds).
Technical report J – Human health	This report on surface noise and vibration provided noise level input into the assessment of impacts on human health.
Technical report H – Landscape and visual	Highlights locations where plantings provide a visual disconnect to the freeway, and noise wall design input for assessment of shading and visual amenity.
Technical report E – Land use planning Technical report I – Social	Impacts to community buildings and parklands.

3 Project description

3.1 Overview

The North East Link alignment and its key elements assessed in the Environment Effects Statement (EES) include:

- **M80 Ring Road to the northern portal** – from the M80 Ring Road at Plenty Road, and the Greensborough Bypass at Plenty River Drive, North East Link would extend to the northern portal near Blamey Road utilising a mixture of above, below and at surface road sections. This would include new road interchanges at the M80 Ring Road and Grimshaw Street.
- **Northern portal to southern portal** – from the northern portal the road would transition into twin tunnels that would connect to Lower Plenty Road via a new interchange, before travelling under residential areas, Banyule Flats and the Yarra River to a new interchange at Manningham Road. The tunnels would then continue to the southern portal located south of the Veneto Club.
- **Eastern Freeway** – from around Hoddle Street in the west through to Springvale Road in the east, modifications to the Eastern Freeway would include widening to accommodate future traffic volumes and new dedicated bus lanes for the Doncaster Busway. There would also be a new interchange at Bulleen Road to connect North East Link to the Eastern Freeway.

These elements are illustrated in **Figure 3-1**. The project would also improve existing bus services from Doncaster Road to Hoddle Street through the Doncaster Busway as well as pedestrian connections and the bicycle network with connected shared use paths from the M80 Ring Road to the Eastern Freeway.

For a detailed description of the project, refer to EES Chapter 8 – Project description.

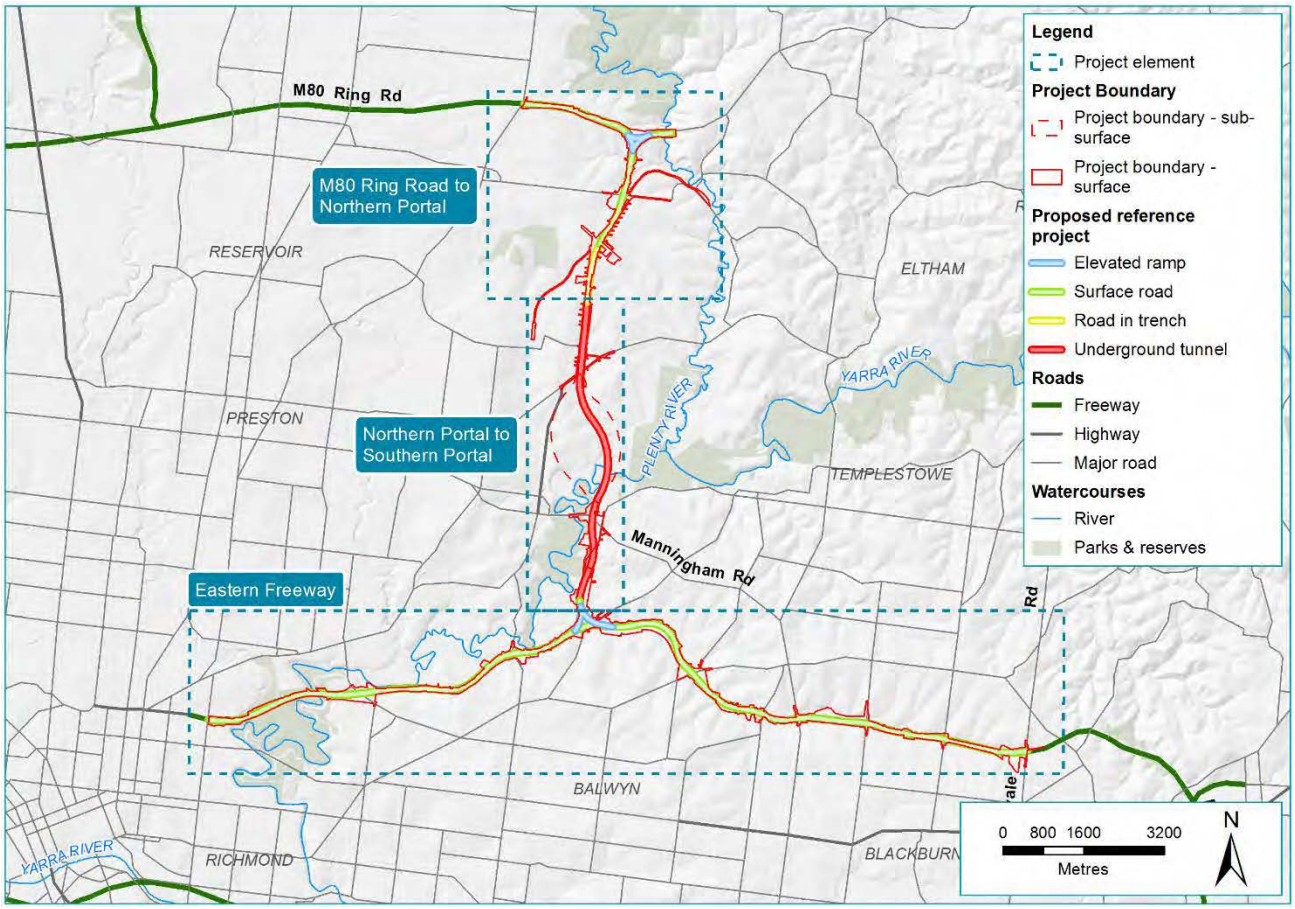


Figure 3-1 Overview of North East Link

3.2 Construction

Key construction activities for North East Link would include:

- General earthworks including topsoil removal, clearing and grubbing vegetation
- Relocation, adjustment or installation of new utility services
- Construction of retaining walls and diaphragm walls including piling
- Ground treatment to stabilise soils
- Tunnel portal and dive shaft construction
- Storage and removal of spoil
- Construction of cross passages, ventilation structures and access shafts
- Installation of drainage and water quality treatment facilities
- Installation of a Freeway Management System
- Tunnel construction using tunnel boring machines (TBMs), mining and cut and cover techniques
- Installation of noise walls
- Restoration of surface areas.

3.3 Operation

Following construction of North East Link, the key operation phase activities would include:

- Operation and maintenance of new road infrastructure
- Operation and maintenance of Freeway Management System
- Operation of North East Link motorway control centre
- Operation and maintenance of the tunnel ventilation system
- Operation and maintenance of water treatment facilities
- Operation and maintenance of the motorways power supply (substations)
- Maintenance of landscaping and Water Sensitive Urban Design (WSUD) features.

4 Legislation, policy, guidelines and criteria

4.1 Legislation, policy and guidelines

Numerous legislative, policy and guidance documents were found to be relevant to this surface noise and vibration impact assessment and are discussed further in this report. The key legislation, policy and guidance documents relevant to this impact assessment for the project are summarised in **Table 4-1**. Further detail is provided in **Section 4.2** to **Section 4.8**.

Table 4-1 Key legislation, standards and policy

Legislation, policy, standards and guidelines	Relevance to this impact assessment
Australian Government	
There is no Australian Government legislation or policy directly applicable for noise and vibration from construction applicable for North East Link	
Victorian Government	
EPA Victoria - Environment Protection Act 1970 – SEPP (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1)	Operation – Fixed facilities
Transport Integration Act 2010	Operational – Traffic Noise
VicRoads – Traffic Noise Reduction Policy (2005)	Operation – Traffic noise
Local	
There is no relevant legislation or policy directly applicable for noise and vibration from construction applicable to North East Link.	
Guidelines	
ASHRAE Chapter 48, Sound and Vibration Control15 (ASHRAE)	Construction - Vibration
AS/NZS 2107:2016 Australian/New Zealand Standard Acoustics-Recommended design sound levels and reverberation times for building interiors1	Operation – Traffic noise and fixed infrastructure construction – airborne noise
Australian Standard - AS2187.2-2006 Explosives – Storage and Use Part 2: Use of explosives	Construction – overpressure and vibration caused by blasting
Australian Standard AS 2436-2010 (R2016) Guide to noise and vibration control on construction, demolition and maintenance sites	Construction – Airborne noise Construction – Surface vibration
British Standards BS6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting	Construction – Surface vibration
British Standards BS 5228-1 Code of practice for noise and vibration control on construction and open sites. Noise (2014)	Construction – Airborne noise
British Standards BS5228-2 Code of practice for noise and vibration control on construction and open sites – Vibration (2014)	Construction – Surface vibration
EPA Victoria – Noise Control Guidelines Publication 1254 (2008)	Construction – Airborne noise.
EPA Victoria - Environmental Guidelines For Major Construction Sites, Publication 480 (1996)	Construction – Airborne noise.
VicRoads - Noise Guidelines – Construction and Maintenance Works (2007)	Construction – Airborne noise.
German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (2016)	Construction – Surface vibration (Structural damage)
NSW Environment Protection Authority (EPA, NSW) – Interim Construction Noise Guideline (2009)	Construction – Airborne noise
NSW Environment Protection Authority (EPA, NSW) – Assessing Vibration: A Technical Guideline, (December 2006)	Construction – Surface vibration (Human amenity)
NSW Roads and Maritime Services (RMS, NSW) – Construction Noise and Vibration Guideline (2016)	Construction – Provides approach to mitigation framework

Legislation, policy, standards and guidelines	Relevance to this impact assessment
NSW Roads and Maritime Services (RMS, NSW) - Environmental Noise Management Manual (2001)	Operation – Determining maximum noise events (practice note 3)
Road Design Note (RDN) 06-01 – Interpretation and application of VicRoads Traffic Noise Reduction Policy 2005	Operation – Traffic noise
VicRoads - Traffic Noise Measurement Requirements for Acoustic Consultants (2011)	Operation – Traffic noise
World Health Organisation - Night Noise Guidelines for Europe (2009)	Operation – Traffic noise

4.2 Construction noise – policy and legislation

4.2.1 Australian Government

The Australian Constitution leaves the power of environmental enforcement to the states and territories. None of these states or territories have delegated the power to the Australian Government. Consequently, there is no Australian Government legalisation or policy that relates to noise or vibration criteria for large-scale infrastructure projects.

Assessment of impacts on Australian Government infrastructure would be undertaken using relevant Victorian Government legalisation, policies and guidelines summarised in **Table 4-1**, with the project-specific criteria summarised in **Section 4.8**.

4.2.2 State – Airborne noise

Airborne noise is sound transmitted through the air to a receiving point. It differs from ground-borne noise, which is transmitted by ground vibration into structures and converted to noise by radiation of the internal finishes (mainly via the walls and ceiling).

4.2.2.1 EPA Victoria

Victoria does not have statutory limits for airborne noise. Rather EPA Victoria provides two guidance documents:

- *Noise Control Guidelines*, Publication 1254, 2008 (EPA 1254)
- *Environmental Guidelines for major construction sites*, Publication 480 Best Practice Environmental Management, 1996 (EPA Publication 480).

Publication 1254

The EPA Victoria web page (<https://www.epa.vic.gov.au/our-work/publications/publication/1996/february/1254>) the use of Publication 1254 as being:

> *These guidelines [publication 1254] are primarily intended to be used by municipal officers to assist in the resolution of complaints or to avert a possible noise nuisance. Some guidelines have been prepared so that they could be incorporated into a permit condition of a development or embodied as a local law. The guidelines are designed, however, to be the basis of assessment and not the last word. This replaces publication TG302-92, issued July 1992.*

It provides recommended working hours for construction sites and guideline levels for works undertaken outside normal working hours. The recommendations given in Section 2 of EPA Victoria 1254 are summarised in **Table 4-2** and used as the basis for determining construction noise criteria for North East Link.

Table 4-2 Construction and demolition recommendations, EPA Victoria 1254

Time period	Guideline level
Normal working hours Monday to Friday 7 am to 6 pm Saturdays 7 am to 1 pm	No noise level guidelines apply
Weekend and evening work hours Monday to Friday 6 pm to 10 pm Saturdays 1 pm to 10 pm Sundays – all day Public holidays – all day	Construction noise levels should not exceed the background L_{A90} level by: 10 dBA or more for up to 18 months after project commencement 5 dBA or more, after 18 months after project commencement
Night 10 pm to 7 am any day	Noise is to be inaudible within a habitable room, of any residential premises.

The noise criteria for an area is based on the background noise level measurements which prevail in the area. (refer to **Section 6.5**).

The following key limitations of this guideline have been identified:

- The lack of a robust assessable definition for 'inaudible within a habitable room' during the night period. This is due to the highly complex nature of noise, which can be subjective and not quantifiable. Therefore, it does not provide a pragmatic or reproduceable means for easily assessing compliance of the works.
- The absence of daytime noise criteria. A project of this size is expected to have extended periods of high intensity construction work during the daytime that could cause a disturbance to nearby sensitive receivers.

It is therefore recommended that other supporting documents are also considered when determining noise management methods and environmental performance requirements.

Publication 480

The EPA Victoria web page (<https://www.epa.vic.gov.au/our-work/publications/publication/1996/february/480>) *Environmental Guidelines for Major Construction Sites* provides additional guidance on construction and demolition site noise.

> *This document [publication 480] is designed to provide developers and contractors with guidelines on how to implement sound practices that minimise environmental impacts and eliminate health risks and nuisance to residents near a construction site. Topics covered include: environmental management planning, risk assessment and management, noise and vibration issues. The publication highlights an approach to environmental management that is cost effective.*

The objective of this document is to provide a set of measures to be considered for works undertaken on major construction sites to minimise nuisance from noise and vibration.

While noise limits are not provided in the document, measures to be considered before construction starts are:

- Undertake pre-construction measurements of ambient noise levels adjacent to the construction site
- Assess expected noise levels from construction activities which may affect the surrounding community
- Plan and schedule suitable times of operation for noisy equipment vehicles, and operations
- Adopt good practice techniques when managing noise from on-site vehicles, machinery and other equipment on site
- Manage traffic in and out of the site
- Consider noise abatement measures where required.

Table 4-3 Environmental Guidelines for Major Construction Sites – EPA Victoria Publication 480

Period	Requirements
Monday to Friday 7 am to 6 pm Saturdays 7 am to 1 pm	Noise from activity likely to cause nuisance to nearby residents should be restricted to the hours listed, except where for practical reasons the activity is unavoidable.
Monday to Sunday 10 pm to 7 am	Noise should not be above background noise levels inside any adjacent residence.

The *Guidelines for Major Construction Sites* allows for work outside normal working hours where it is unavoidable, such as to avoid a risk of a major traffic hazard. The guidelines recommend that impacts of night work on the community is managed by restricting construction hours, limiting noise levels inside adjacent residential buildings and the notification of residents when unavoidable out-of-hours works would occur.

4.2.2.2 NSW EPA – Airborne noise

The NSW EPA *Interim Construction Noise Guideline* (ICNG) provides a methodology to assess the impacts from construction noise, and to consider mitigation (where needed) which adopts reasonable and feasible work practices. It recommends a four-stage process for managing noise impacts:

- Identify noise sensitive land uses
- Identify the hours of operation
- Identify the noise impacts, at the sensitive land uses
- Select and apply best work practices to minimise noise impacts.

Furthermore, the NSW Roads and Maritime Services provides the complementary document *Construction Noise and Vibration Guideline* (CNVG) which provides a useful framework for the management of impacts and application of additional mitigation that is particularly relevant for large road construction projects.

Table 4-4 Recommended standard hours and construction noise management levels for residences: ICNG

Time Period	Noise Management Level (NML)
Normal construction hours Monday to Friday 7:00 am to 6:00 pm Saturdays 8:00 am to 1:00 pm (no work Sundays or public holidays)	> RBL + 10 dBA: Noise affected >75 dBA: highly noise affected
Outside normal construction hours	> RBL + 5 dBA: Noise affected

RBL: Rating Background Level, The term RBL is described in detail in the NSW Industrial Noise Policy (EPA 2000).

For noise at non-residential sensitive receivers, the following noise management levels apply.

Table 4-5 Construction noise management levels for non-residential noise-sensitive land use: ICNG

Land use	Legislation, policy and guidelines
Classrooms in schools and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas characterised by sporting activities and activities which generate their own noise, making them less sensitive to external noise intrusion	External noise level 65 dBA
Passive recreation areas characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example reading, meditation	External noise level 60 dBA
Community centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS/NZS 2107:2016 for specific uses.

Table 4-6 Construction noise management levels for commercial and industrial land uses: ICNG

Land use	Construction noise management level, $L_{Aeq\ (15min)}$ (applies when properties are in use)
Industrial premises	External noise level 75 dBA
Offices, retail outlets	External noise level 70 dBA

It should be noted the above noise levels are 'Management Levels' over which a set framework of mitigation measures may be employed. They are not intended as absolute criteria which cannot be exceeded under any circumstance.

4.3 Construction vibration – policy and legislation

There is no Australian Government legislation or policy that specifies acceptable amenity or structural damage levels for vibration associated with construction.

Victoria does not currently have legislative requirements or guidance limits to govern vibration originating from construction activities. Of Victorian Government policies and guidelines, only EPA Victoria Publication 480 refers to vibration from construction sites. This publication provides comment about damage from vibration being limited to 50 metres from a construction site, based on a British study. The document does not provide criteria or guidelines relating to vibration.

Australian Government organisations such as SafeWork Australia provide guidelines for the control of vibration with respect to occupational health and safety for users of vibration intense equipment, such as vibratory compactors and nail guns but this is not related to environmental vibration impact assessment.

Australian Standard AS2436-2010 is an over-arching qualitative guide to noise and vibration control on construction, demolition and maintenance sites. The standard does not directly propose permissible levels of vibration but references other Australian, British and German standards. These standards are based on significant research to indicate guideline values for acceptable levels of vibration.

4.3.1 Damage to buildings and structures

There are two international standards sometimes used to assess the potential for damage from construction works.

- DIN 4150 (2016): Structural Vibration – Part 3: *Effects of vibrations on structures*
- BS 7385-2 (1993): Evaluation and Measurement for Vibration in Buildings.

Figure 4-1 shows a comparison of the recommended vibration levels from DIN 4150 and BS 7385.

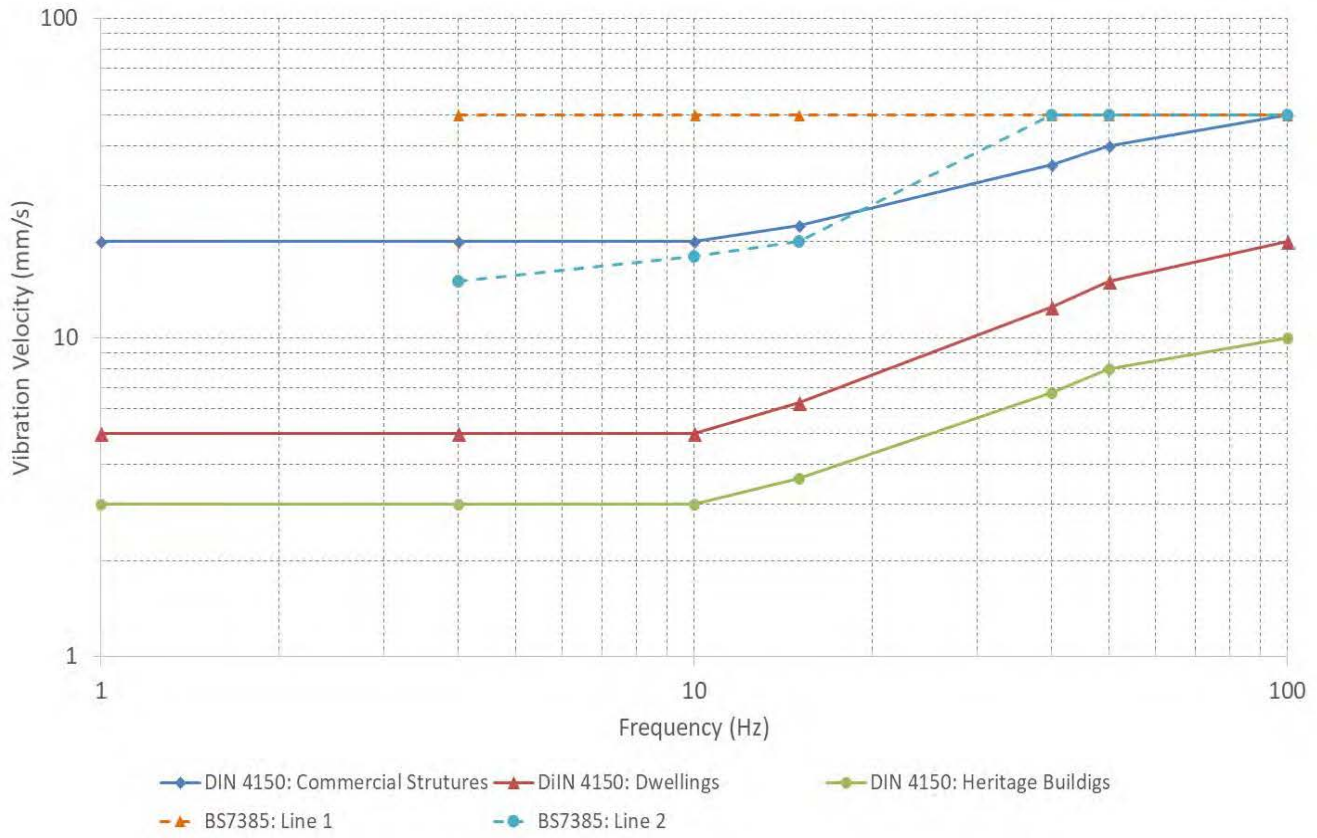


Figure 4-1 Comparison of vibration standards

The two standards differ in their functionality. As opposed to the '*minimal risk of cosmetic damage*' approach adopted in BS 7385 (95 per cent probability of no effect), the '*safe limits*' given in DIN 4150 are the levels up to which no damage due to vibration effects has been observed for the class of building. '*Damage*' (in dwellings or vibration-sensitive structures) is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present and the separation of partitions or intermediate walls from load bearing walls.

DIN 4150 represents a lower risk of building damage and has been adopted for use on North East Link.

Table 4-7 Structural damage 'safe limits' for construction short-term vibration at structures

Group	Type of structure	Vibration velocity (PPV) in mm/s				
		At foundation, all directions (x, y, z), at a frequency of (1)			Vibration at horizontal plane (x, y) of highest floor	Top most floor, vertical direction (z) all frequencies
		< 10 Hz	10 Hz – 50 Hz	50 Hz – 100 Hz	all frequencies	
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and are of great intrinsic value (listed buildings)	3	3 to 8	8 to 10	8	20[2]

Notes

1. For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column would be used.
2. Refer standard for clarifications

Where appropriate, EPRs would directly reflect the values within standards or guidelines from which they are drawn. For transparency and clarity, all parameters that feed into monitoring or form the basis of predictions (such as the dominant vibration frequency, crest factors or the equipment operating periods) would be presented in the Construction Noise and Vibration Management Plan (CNVMP).

4.3.2 Damage to buried pipework

DIN 4150 provides target vibration levels to minimise damage to buried pipework.

Table 4-8 Short-term vibration on pipework (peak component level mm/s)

Pipe material	Guideline value on pipe (mm/s)
Reinforced or sprayed concrete, tubbing segments	80
Concrete, stone	60
Masonry	40

Notes: 1. Refer to the standard in all situations
2. Long term exposure may warrant a reduction in the guideline value by 50%
3. Pipework assumed to be in god condition and laid with current technology

Very brittle pipes such as cast iron may require specific consideration. In all cases, where the owner of the assets has specific requirements, these take priority and would not be exceeded.

4.3.3 Human comfort vibration criteria

4.3.3.1 General

Humans are far more sensitive to vibration than is commonly realised. They can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not be disturbing or annoying. An individual's response to that perception, and whether the vibration is 'normal' or 'abnormal' depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, is presented in the German Standard DIN 4150 Part 2 1975. The resulting degrees of perception for humans are suggested by the vibration level categories given in **Table 4-9**.

The information presented in **Table 4-9** suggests that people would just be able to feel floor vibration at levels of about 0.15 mm/s and that the motion becomes 'noticeable' at a level of approximately 1 mm/s.

Table 4-9 Peak vibration levels and human perception of motion

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz.

4.3.3.2 Human comfort criteria for construction vibration

Neither the Australian Government nor Victorian Government have specific guidelines or criteria that relate to human comfort from vibration from construction sites.

The NSW EPA *Assessing Vibration: a technical guideline* (2006) provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV). The VDV is dependent upon the level and duration of the vibration event, as well as the number of events occurring during the daytime or night-time period.

The VDVs recommended in the guideline for intermittent nature are presented in British Standard 6472 (1992) *Guide to evaluation of human exposure to vibration in building* nominates criteria for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a low probability of adverse comment from occupants.

Table 4-10 shows the range of vibration dose values corresponding to the various degrees of adverse comment, which may be expected in the buildings surrounding the project. For assessment purposes, the upper end of the range corresponding to low probability of adverse comments would be adopted as the preferred target value.

Table 4-10 Vibration Dose Values ($m/s^{1.75}$) above which various degrees of adverse comment may be expected in residential buildings, offices and workshops

Location	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
Residential buildings –16-hour day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings – 8-hour night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Offices – 16-hour day	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2
Workshops – 16-hour day	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

The above target levels apply for both the vertical and lateral directions, provided appropriate weightings are used

Situations exist where motion magnitudes above the dose levels given in BS 6472 can be acceptable, particularly for temporary disturbances and infrequent events of short-term duration, specifically for a construction projects where the impacts are for a finite period.

When short-term works such as piling, demolition or compaction give rise to impulsive vibrations, it should be borne in mind that undue restriction on vibration levels can significantly prolong these operations and result in greater annoyance.

Australian Government organisations such as SafeWork Australia provide guidelines for the control of vibration with respect to occupational health and safety for users of vibration intense equipment, such as vibratory compactors and nail guns.

4.3.4 AS 2187.2 Explosives storage and use – overpressure

Construction blasting can result in vibration pulses being propagated through the air, and the effect is termed ‘overpressure’ or sometimes ‘air-blast’.

The Australian Standard AS 2187.2-2006 recognises this overpressure effect can cause discomfort to persons and proposes a peak overpressure limit (as defined in the standard) of between 115 dBL and 125 dBL depending on the duration of blasting. Overpressure from blasting activities is, however, short-term with exposure at any single residence not likely to be more than several seconds per blast. When compared with other natural phenomena, like wind and thunder, these effects would often exceed 115 dBL for many hours during a day. It is, however, common to impose an overpressure limit on blasting activities so they follow best practices.

The AS2187.2-2006 values for overpressure from blasting are given in **Table 4-11**. These values are indicative of human comfort chosen by some regulatory authorities. All the values are expressed as peak linear sound pressure levels.

Table 4-11 Overpressure limits for human amenity (reproduced from AS2187.2-2006)

Category	Type of blasting operations	Peak overpressure value (dBL)
Sensitive site	Operations lasting longer than 12 months or more than 20 blasts	115 dBL for 95% blasts per year. 120 dBL maximum unless agreement with occupier that a higher limit may apply
Sensitive site	Operations lasting less than 12 months or less than 20 blasts	120 dBL for 95% blasts per year. 125 dBL maximum unless agreement with occupier that a higher limit may apply
Occupied non-sensitive sites such as factories and commercial premises	All blasting	125 dBL maximum value unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specification or levels that can be shown to adversely affect the equipment operation

Additionally, peak overpressure levels have the potential to cause damage to building elements, such as cracked windows. A limit of 133 dBL is recommended as a safe level that would prevent structural/architectural damage from overpressure.

The recommended AS2187.2-2006 values for overpressure from blasting to protect building elements are given in **Table 4-12**.

Table 4-12 Recommended overpressure limits for damage control (reproduced from AS2187.2-2006)

Category	Type of blasting operations	Peak overpressure value (dBL)
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All blasting	133 dBL maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables located above the ground	All blasting	Limit to be determined by structural design methodology (refer AS2187)

4.3.5 AS 2187.2 Explosives storage and use – Vibration from blasting

Australian Standard AS2187.2-2006 is applicable for the protection of personal amenity from blasting, as well as other construction aspects that generate infrequent, short duration, impulsive vibration events. The Australian Standard AS2187.2-2006 also references the British Standard BS7385-2:1993 for the protection of building elements for vibration related damage from blasting.

The human amenity criteria presented in **Table 4-13** are appropriate for continuous or semi-continuous sources of vibration. They are not applicable to impulsive, short-term vibration like that generated by blasting activities. These activities are universally assessed using a measure of the peak level of vibration and comparing this measure to acceptable Performance Guidelines.

Section J of the Australian Standard AS2187.2-2006 is comprehensive compared with earlier versions of the same standard and proposes limits of vibration for maintaining human amenity together with limits for preventing cosmetic damage to structures. Table J4.5A of the Australian Standard is reproduced in **Table 4-13** which lists the human amenity criteria.

Table 4-13 Vibration limits for human amenity (reproduced from AS2187.2-2006)

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site	Operations lasting less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites such as factories and commercial premises	All blasting	25 mm/s maximum value unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specification or levels that can be shown to adversely affect the equipment operation

Table J4.4.2.1 of the Australian Standard AS2187.2-2006 indicates limits of vibration for prevention of cosmetic damage that are consistent with the British Standard BS7385-2:1993. This is summarised in **Table 4-14**.

Table 4-14 Transient vibration guide values for cosmetic damage (reproduced from AS2187.2-2006)

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	-
Un-reinforced or light framed structure. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

The Australian Standard AS2187.2-2006 further defines cosmetic damage as the formation of hairline cracks on drywall surfaces, the growth of existing cracks in plaster or drywall surfaces or the formation of hairline cracks in the mortar joints of brick/concrete constructions. Minor damage is defined as the formation of cracks or loosening and falling of plaster or drywall surfaces, or cracks through brick/concrete blocks. The Australian Standard also proposes limits for vibration for control of damage to structures as listed in **Table 4-15**.

Table 4-15 Recommended vibration limits for control of damage (reproduced from AS2187.2-2006)

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Other structures or architectural elements that include masonry, plaster and plasterboard in their construction	All blasting	Frequency dependent damage limit criteria as in Table J4.4.2.1
Unoccupied structures of reinforced concrete or steel construction	All blasting	100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply
Service elements, such as pipelines, powerlines and cables	All blasting	Limit to be determined by structural design methodology (refer AS2187)

4.3.6 Ground borne noise

Ground borne noise is sound that a receiving point receives, having been transmitted through the ground as vibration and causes movement in the building structure. It differs from air borne noise, as discussed in **Section 4.2.1** above.

There is no Australian Government or Victorian Government legalisation or policies that set ground born noise limits from large-scale infrastructure projects.

The NSW EPS *interim construction noise guideline* (ICNG) provides a methodology to assess the impacts from ground borne noise and considers mitigation (where needed) which adopts reasonable and feasible work practices.

Table 4-16 Guideline target levels for ground borne noise: ICNG

Time period	Legislation, policy and guidelines
Residences	40 dBA (internal): 6:00 pm to 10:00 pm 35 dBA (internal): 10:00 pm to 7:00 am No requirement: 7:00 am to 6:00 pm

Noise levels are taken in a wide area around the centre of the room.

4.3.7 Scientific equipment

No location has been identified as housing vibration-sensitive scientific equipment along the corridor. However, should an assessment prove to be required, the assessment would be conducted in accordance with the lower of the criteria corresponding to:

- ASHRAE Chapter 48, Sound and Vibration Control15 (ASHRAE), applicable to the type of instrumentation (as detailed in **Table 4-17**)
- Manufacturers specification for specific equipment.

Table 4-17 Recommended vibration limits for control of damage (reproduced from ASHRAE)

Category	Peak component particle velocity (mm/s)
Bench microscopes up to 100x magnification; laboratory robots	Operating room
Bench microscopes up to 400x magnification; optical and other precision balances; co-ordinate measuring machines; metrology laboratories; optical comparators; micro electronics manufacturing equipment; proximity and Projection aligners, etcetera.	VC-A
Microsurgery, eye surgery, neurosurgery; bench microscope at magnification greater than 400x; optical equipment on isolation tables; microelectronic manufacturing equipment such as inspection and lithography equipment (including steppers) to 3 mm line widths	VC-B
Electron microscopes up to 30,000x magnification; microtomes; magnetic resonance images; microelectronics manufacturing equipment such as lithography and inspection equipment to 1 mm detail size	VC-C
Electron microscopes at magnification greater than 30,000x; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ½ micron metre; includes electron beam systems	VC-D
Un-isolated laser and optical research systems; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ¼ micro m; includes electron beam systems	VC-E

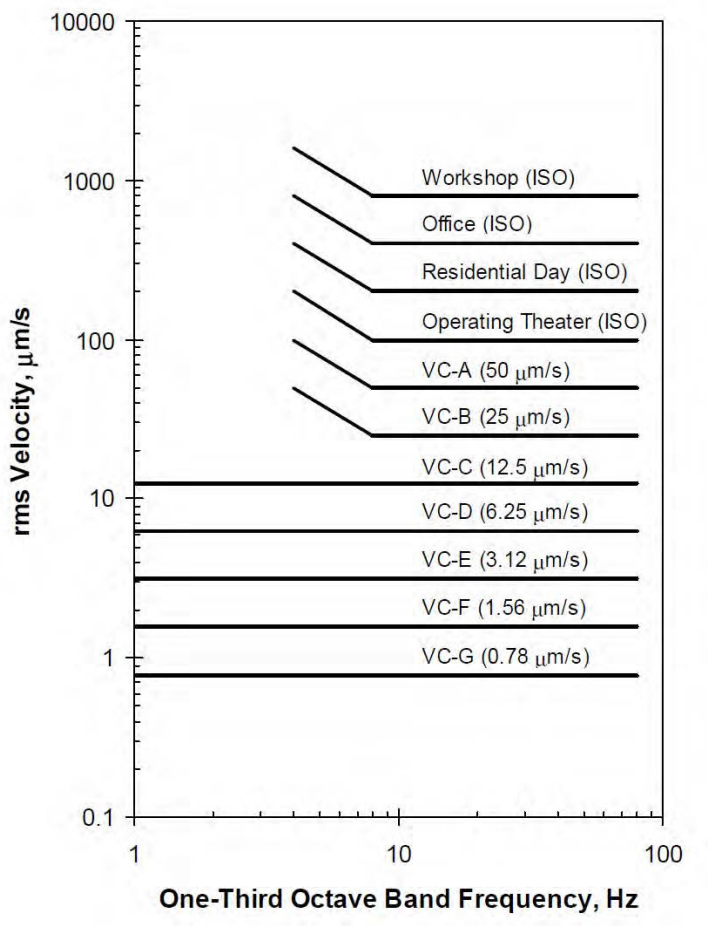


Figure 4-2 ASHRAE Vibration Curves

4.4 Operational noise assessment

4.4.1 Overview

VicRoads sets the criteria for road traffic noise in Victoria and is based on an $L_{A10(18hour)}$ noise index. The $L_{A10(18hour)}$ level is the average of the individual one-hour noise levels between 6 am and midnight. The $L_{A10(1hour)}$ index is a statistical index which represents the highest $10^{\%}$ noise level in a one-hour period.

The project scoping requirements for North East Link have outlined requirements beyond the scope of the VicRoads TNRP:

> *Analyse potential for noise levels to be exceeded during the day and night time periods and compare predicted traffic noise levels in 2026 and 2036 to the criteria under the VicRoads Traffic Noise Reduction Policy 2005 (or any subsequent updates to this policy) and relevant criteria from the World Health Organization Night Noise Guidelines for Europe 2009.*

The project and the design of noise mitigation measures is based on VicRoads Traffic Noise Reduction Policy and Road Design Note (RDN) 06-01, with the adoption of some adjustments, which acts to provide an enhanced level of protection to the communities along the project. Separately, an assessment of impacts is conducted against the night-time WHO guidelines, (as discussed in **Section 4.4.4**). A review of the relevant documentation and subsequent project standard has been presented in the following sections.

4.4.2 VicRoads Traffic Noise Reduction Policy

As discussed in **Section 4.4.1**, the VicRoads noise limits of the *Traffic Noise Reduction Policy (2005)* have not been adopted as the stand-alone criteria for North East Link. However, relevant sections have been adopted for the project and are discussed in this section.

Receiver locations

The project has also adopted the measurement and modelling receiver locations used by VicRoads. The VicRoads RDN states that:

> *The receptor point, where modelling for noise barriers and measurements are undertaken at a noise sensitive building, is the centre of the window of the most exposed external façade facing the traffic noise. The receptor point will be at the lowest habitable level of the building.*

Noise sensitive buildings

Noise sensitive buildings are defined as:

- Category A – Dwellings, aged persons homes, hospitals, motels, caravan parks and other buildings with residential uses
- Category B – Schools, kindergartens, libraries, places of worship and other noise sensitive community uses.

The policy does not apply to:

- Category A and Category B Noise Sensitive Buildings that are not impacted by noise generated by traffic on the North East Link alignment
- Category A or Category B Noise Sensitive Buildings where such land use is incompatible with current zoning requirements in the relevant planning scheme
- Traffic noise from local council roads
- Traffic noise at public open space, recreational, industrial, commercial and agricultural land uses (caretakers' dwellings associated with these uses may be considered on a case-by-case basis)
- Building developments or development precincts where planning approval was not granted or exhibited prior to the announcement of the project.

Noise limits

The following facade reflected noise criteria from the project's roads apply:

- Category A Buildings: $L_{A10(18hour)}$, façade reflected traffic noise level of 63 dBA (NV01) (measured between 6 am and midnight)
- Category B Buildings: $L_{A10(12hour)}$, façade reflected traffic noise level of 63 dBA (NV01) (measured between 6 am to 6 pm).

Rounding of noise levels

In accordance with standard acoustic practices:

- Calculated or measured traffic noise levels have been rounded and reported to the nearest whole number. The value of 60.4 dBA, for example would be reported as 60 dBA, whereas 60.5 would be reported as 61.

- The difference between two noise levels have been determined based on the unrounded values, and then rounded and reported to one decimal place. For example, 60.3 – 58.2 would be reported as 2.1 dBA.

4.4.3 VicRoads Traffic Noise Reduction Policy Review – Discussion Paper (August 2015)

VicRoads has conducted two rounds of public consultation 2015 to hear community and industry views towards the management of the traffic noise. Since the public consultation, there has been no update to the policy or assessment procedure. Consequently, no consideration of a revised policy document has been included in this assessment.

4.4.4 World Health Organisation – Night-time noise guidelines 2009

The VicRoads *Traffic Noise Reduction Policy* (2005) does not provide specific guidance for night-time traffic noise emissions. In accordance with the project's scoping requirements, an assessment of impacts is also conducted against the World Health Organisation (WHO) *Night-time noise guidelines for Europe* (2009), as this provides guidance for the assessment of night-time impacts. This guideline recognises the health impacts of night noise exposure, most significantly with regards to sleep disturbance and related health problems.

The WHO recognises that if quiet outdoor noise environment of 40 dBA ($L_{Aeq,}$ night) could be achieved, the public (children, chronically ill and the elderly) would be afforded protection. It also recognises this long-term target is not always achievable or achievable in the short-term. For residents around the current study area, night-time noise levels typically vary between 55 dBA to 63 dBA. These levels are considered typical, within an urban/suburban environment near a major transport corridor. Until long-term strategies are implemented such that a quieter environment is achievable in such an environment, the WHO recommends a free-field, outdoor night-time noise target of 55 dBA L_{Aeq} applies for Member States of the European Union.
This accounts for noise travelling directly from the road to a point on the outside of a dwelling at night.

In Australia, the normal practice for the measurement of road traffic is to conduct the measurements with the microphone located at one metre from the most exposed facade of a dwelling, noting that in Victoria the practice is to monitor adjacent to the most exposed window of the most exposed facade of a dwelling.

A microphone in this position measures the noise from the road as well as noise reflected from the dwelling façade. The reflected noise approximately doubles the sound energy and increases the level by approximately 2.5 dBA compared with a free field value.

Thus, the equivalent WHO night-time noise guideline for traffic noise measured one metre from a facade (consistent with Australian practices) would be $L_{Aeq(8hr)}$ 58 dBA (rounding the 57.5 dBA to the nearest whole number). This is consistent with the WHO recommendation to use an adjustment of 3 dBA when converting between façade reflected and free-field levels.

4.4.5 Project noise objectives

A review of Victorian policy and guidelines applicable to road traffic noise has identified an opportunity to adopt a framework with objectives aimed at providing a higher level of acoustic amenity in impacted areas by setting more stringent objectives.

The road traffic noise objectives used for North East Link is based on the existing VicRoads policy, applied conservatively (ie categorising all roads as new, rather than upgraded for M80 and Eastern Freeway).
The numeric values of the noise objectives are consistent with those used for the West Gate Tunnel Project.

In accordance with the project's scoping requirements and the VicRoads Traffic Noise Reduction Policy, traffic noise levels must be designed for the time, 10 years after opening. This is also referred to as the design year. For North East Link, the design year is 2036.

Assessment location

The measurement location shall be one metre from the façade of all assessable buildings and set to a height of 1.5 metres above floor level. In terms with the policy, the assessment is restricted to the room adjacent to ground floor only. The calibration of the noise model assessed the traffic noise at the height of the microphone at which the measurements were undertaken. The prediction of noise levels for project-wide assessment, was taken to be 1.5 metres above the prevailing terrain height.

For Category A buildings, assessed rooms include: bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre or sunroom.

Applicability of the assessment criteria

- Noise levels calculated using acoustic modelling software would be evaluated against the Assessment Criteria at Noise Sensitive Buildings 10 years after the project's completion (design year)
- Only Noise Sensitive Buildings that exceed the assessment criteria and are exposed to traffic noise from the North East Link alignment would be considered for noise mitigation
- The treatment of traffic noise resulting from the movement of traffic on local roads does not form a part of this assessment
- The assessment criteria do not include the consideration of noise associated with the following:
    - Construction or maintenance of roads and associated infrastructure
    - Other forms of transit (trains, aircraft etcetera) or industry
    - The assessment criteria would not apply to minor works within the North East Link alignment (such as bicycle lanes, minor realignments, changes to line marking and pavement replacement).

Assessment criteria

Noise mitigation would be integrated into the project design to limit noise from the project's roads to no more than the following assessment criteria at all affected noise sensitive buildings at the assessment location.

Table 4-18 Operational airborne road traffic noise assessment objectives for North East Link

Period	Noise Sensitive Buildings Criteria dBA)	
	Category A (6 am to midnight)	Category B (6 am to 6 pm)
Daytime (6 am to midnight)	63 $L_{A10(18hour)}$	63 $L_{A10(12hour)}$

Cumulative noise

The assessment of cumulative noise on the non-project roads which would intersect North East Link, including the increase in traffic noise on local roads due to the redistribution of traffic is not addressed in the VicRoads RDN-06-01 *Interpretation and application of VicRoad*s Traffic Noise Reduction Policy (2005).

The proposed assessment of cumulative impacts is based on examining the impacts arising from a comparison of the traffic noise levels (from the project and major non-project roads) in 2036 with and without the project. Impacts are considered to occur where this increase is greater than 2 dBA, and the contributed noise from the project exceeds the project's noise objectives. Traffic noise increases of less than 2 dBA are considered insignificant, under broadly similar traffic conditions. This process allows for the practical and quantifiable assessment of impacts due to the redistribution of traffic experienced at receivers on non-project roads.

The North East Link alignment is defined in EES Chapter 8 – Project description. Roads considered under this policy include freeways (and ramps) identified as part of the North East Link alignment only.

4.5 Operational traffic noise mitigation

Noise walls and low noise pavements are the primary forms of noise mitigation available to the project. There may be instances where the resulting traffic noise levels at the design year do not achieve compliance with the project noise objectives. This may be due to constraints such as access requirements, cost, visual amenity, safety, maintenance and construction standards, feasibility of construction, access, siting, land ownership, drainage and the location of underground services. In these cases, at-property noise abatement would be considered as a supplementary form of mitigation.

At-property noise abatement means the physical modification of a noise sensitive building to better protect its occupants from external noise. The type and form of any mitigation treatments offered to owners of noise sensitive buildings would depend on the magnitude of the mitigation required, the construction of the building and the use of the rooms most affected. Mitigation would not involve façade re-building but may involve:

- Courtyard screen walls
- Glazing upgrading
- Seals on door jambs and around openable windows
- Door upgrading
- Inclusion of roof insulation
- Sealing of eaves, vents and underfloor (below the bearers)
- Provision of mechanical ventilation systems (not air conditioning) where windows are required to be closed for noise control purposes. This allows fresh air to be supplied to the room, in accordance with the Building Code of Australia requirements.

Note:

- Building developments or development noise precincts where planning approval was not granted or exhibited prior to the approval of the project would not be eligible for building mitigation (as detailed in NV01).
- At-property noise abatement to the ground floor of residential dwellings and restricted to bedrooms, studies, living, dining and kitchen areas that have windows or doors in the façade being treated. Corridors, laundries, bathrooms, garages sheds and workshops are not normally treated.
- The final selection of mitigation would be determined on a case-by-case basis during the detailed design phase of the Project, having consideration of the building construction, the extent of mitigation required and the acoustic benefit of the types of mitigation. Although not binding, some consideration would be given to the guidelines detailed in Section 7.3 of the NSW Roads and Maritime publication, *Noise Mitigation Guideline, April 2015 (as amended)*.

- The extent of any at-property mitigation offered, would be determined considering any future design development, the acoustic effectiveness of any form of mitigation in the unique circumstance and the per-dwelling budget allocation.

4.6 Traffic noise monitoring

Traffic noise monitoring must be undertaken in accordance with the VicRoads *Traffic Noise Measurements Requirements for Acoustic Consultants* before the project's construction starts, when it opens and in 2036 (the design year) to verify compliance with this policy.

Supplementary remedial action would need to be taken if the measured traffic noise levels demonstrate that the assessment objectives was not met.

4.7 Operational noise – fixed infrastructure

The State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade No 1 – SEPP-N1) prescribes procedures for determining the statutory environmental noise limits which apply at noise sensitive locations such as residential areas, with respect to noise due to commercial, industrial and trade operations.

4.7.1 State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No.1

SEPP N-1 would be used to determine the noise limits applied to the operation of fixed infrastructure such as the tunnel ventilation system. It is applied within the metropolitan region as defined in Schedule 1 of the Planning and Environment Regulations 1988 and is therefore also applicable to other industrial sites within the project boundary.

4.7.2 Methodology

EPA Victoria developed the SEPP N-1 noise assessment procedure to protect people from industrial noise that may affect normal domestic and recreational activities, including sleep at night.

SEPP N-1 balances the needs of industry with the protection of sensitive uses, which is why different levels apply depending on the planning land-use zoning and the amount of background noise in the area.

The noise limits prescribed by SEPP N-1 apply to the area of land on the noise sensitive property, which is within 10 metres of the noise sensitive building.

SEPP N-1 describes a noise sensitive property as:

a. That part of the land within the apparent boundaries of any piece of land which is within a distance of 10 metres outside the external walls of any of the following buildings:

   - Dwellings (except Caretaker's House)

   - Residential Buildings

b. that part of the land within the apparent boundaries of any piece of land on which is situated any of the following buildings which is within a distance of 10 metres outside the external walls of any dormitory, ward or bedroom of such buildings:

- Hospital, Institutional Home
- Hotel, Motel, Caretaker's House, Work Release Hostel
- Reformative Institution
- Tourist Establishment.

The SEPP N-1 noise limits are dependent on:

- SEPP N-1 primarily set their limits and recommended levels according to the land-use Zoning Levels, based on the planning scheme zoning types within 70-metre and 200-metre radii of the noise sensitive area
- The time of day (different limits apply at various times of the day)
- The background noise level (L_{A90}) in the noise sensitive area, in the absence of noise due to commercial, industrial or trade operations.

SEPP N-1 noise limits would apply during all periods of fixed infrastructure operation. It is assumed the fixed facilities plant and machinery would operate 24-hours a day. Accordingly, the most stringent night-time limit has been adopted for assessing the potential impacts.

Under SEPP N-1, noise from the source under consideration is measured to determine its impact over a continuous 30-minute period. Adjustments to the measured noise level are applied to account for the duration of the noise source and the effects associated with noise characteristics such as tonality, intermittency and impulsiveness.

Note that these noise limits do not apply to noise from:

- Noise from road and rail corridors and residential noise
- Non-commercial vehicles, on or off the site, except for maintenance activities
- Audible emergency alarms, including reversing beepers from trucks.

Noise limits applicable to the fixed facility operational noise are presented in **Section 10**. Notwithstanding that some noise sources are not included in the SEPP N-1 assessment, the operators of premises still have an obligation to minimise their noise emissions and consequently, measures would be taken to minimise impacts (such as avoid reversing, use visual or less intrusive broadband reverse alarms where possible).

4.7.3 Time periods

Provisional noise limits for noise sensitive areas near the proposed tunnel portals (likely ventilation system location) have been determined as part of this report. These limits are based on the results of background noise measurements at residences located near the proposed portal openings.
EPA Policy SEPP N-1 would apply to noise emissions from fixed industrial infrastructure to surrounding residential areas. **Table 4-19** outlines the time classifications as defined by SEPP N-1.

The day, evening and night period noise limits were determined based on measured background noise levels and the relevant planning scheme zones in the vicinity of the ventilation systems. Using Zoning Levels and the averages of the measured background noise levels, noise limits were determined for day, evening and night periods using the procedure prescribed by SEPP N-1. These limits are shown in **Section 10** but will re-assessed during the detailed design phase of the project**.**

SEPP N-1 prescribes different noise limits for different periods of the day to account for the varying ambient acoustic conditions over the duration of a day. For example, the noise limits during the night-time are more stringent than during the day time as the background (ambient) noise levels are generally lower during the night period, thus the noise impact would be greater during the night period, particularly during times of sleep.

4.8 Overview – Project-specific noise objectives

4.8.1 Hierarchy of requirements

In establishing project-specific noise objectives, it is useful to consider the hierarchy of requirements inferred by the numerous references outlined in **Section 4.1**.

While the associated terminology is often used interchangeably, sometimes there can be differences in their meaning or application.

Table 4-19 Hierarchy of requirements

Periods		Time
Policy	Normative	A formal, brief, and high-level statement or plan that embraces an organization's general beliefs, goals, objectives, and acceptable procedures for a specified subject area. Policies always state required actions and may include pointers to standards. Policy attributes include the following: • Require compliance (mandatory) • Failure to comply results in disciplinary action • Focus on desired results, not on means of implementation • Further defined by standards and guidelines.
Standard		A mandatory action or rule designed to support and conform to a policy. • A standard would make a policy more meaningful and effective. • A standard typically includes one or more accepted specifications.
Guideline	Informative	General statements, recommendations, or administrative instructions designed to achieve the policy's objectives by providing a framework within which to implement procedures. • A guideline can change frequently based on the environment and would be reviewed more frequently than standards and policies. • A guideline is not mandatory, rather a suggestion of a best practice. Hence 'guidelines' and 'best practice' are interchangeable.

Similar to the above the terms used to define criteria are also often in a type of hierarchy.

Table 4-20 Hierarchy of criteria

Periods		Time
Limit	Normative	• Regulated or statutory requirement • Typically, compliance is mandatory
Guideline Level		• Informative, non-statutory • Not mandatory, rather a suggestion of a best practice
Management Level	Informative	• Action levels for management of noise or vibration impact • Provides for a framework of mitigation responses

4.8.2 Construction criteria

During construction a pragmatic and adaptive approach is required to manage noise impacts. Depending on the extent of impact and the scale of the works, managing noise impacts may involve engaging the community. As more information becomes available through each stage of the project, the description of feasible and reasonable work practices would need to be made more detailed.

The Noise Management Levels (NMLs) presented in **Table 4-21** are to apply to any quantitative assessment. In all cases these levels would not simply be included in licence or planning approval conditions, but rather are intended to guide the need for, and the selection of, work practices to minimise noise impacts.

Table 4-21 and **Table 4-22** provides an overview of the criterion against which the assessment for the construction noise and vibration assessment would be undertaken.

Table 4-21 Management levels for construction noise assessment

Environmental Consideration	Reference	Assessment Criteria (L_{Aeq})
Noise from construction works	ICNG Victoria EPA Publication 1254 Victoria EPA Publication 480	ICNG during daytime periods Background noise + 5 dBA during evening and weekend periods Note: 1 Not exceed background noise during night-time periods.
Amenity (health and community buildings)	NSW ICNG (2009) Table 3	60 dBA: Amenity (health and community buildings) for Schools, hospitals, Place of worship, community and childcare centres Note 2
Amenity (commercial buildings)	NSW ICNG (2009) Section 4.1.3	70 dBA, office and retail, when in use
Amenity (Industrial premises)	NSW ICNG (2009) Section 4.1.3	75 dBA
Ground borne noise	ICNG	internal noise level for residences 40 dBA evening 35 dBA night-time

1. The project would be under construction for over 18 months. Consequently, the assessment of construction impacts has been compared with the over 18 month condition when describing construction impacts.
2. Internal noise levels sited in NSW ICNG (2009) have been adjusted from an internal level to an external level for assessment purposes. This value was obtained by assuming that the noise reduction from outside to inside being 15 dBA as per the WHO Guidelines for Community Noise (1999)

Table 4-22 Guideline targets for construction vibration assessment

Environmental Consideration	Governing Reference	Guideline Level Note: 1
Human exposure to vibration (VDV)	NSW Assessing Vibration: A technical Guide (Table 2.4)	<0.4 m/s$^{1.75}$ for residences (day) <0.26 m/s$^{1.75}$ for residences (night) <0.8 m/s$^{1.75}$ for offices, schools or education institutions, and places of worship
Vibration: damage to buildings (excluding blasting)	DIN 4150 (2016)	Specific criteria apply for dwellings, commercial building and heritage buildings.
Vibration: Damage to underground pipework	DIN 4150 (2016) asset owners' specific criteria (as applicable)	
Overpressure: Blasting – Amenity	AS2187.2-2006 Appendix J	115 to 125 dB(L) peak: during normal construction hours
Overpressure: Blasting – Structural damage	AS2187.2-2006 Appendix J	133 dB(L) peak: during normal construction hours
Vibration: Vibration from Blasting	AS2187.2-2006	Frequency dependent criteria

1. All Guideline levels shall be applied to the ground level of the relevant building unless explicitly stated otherwise in the Governing Reference.

With reference to **Table 4-21** and **Table 4-22**, the following comments apply:

- The term background noise is defined as average L_{A90} noise measured over the assessment period. The ICNG determines the background noise differently to the practices used in Victoria. To avoid confusion the background noise over any day, evening or night-time period is determined by the average of the measured L_{A90} values for that time period.
- EPA Publication 1254 allows for the evening criteria to be background + 10 dBA for the first 18 months following contract award. Consequently, during the detailed design phase when contractors are preparing *Construction Noise and Vibration Management Plans*, they shall be entitled to consider the specific requirements of EPA Victoria Publication 1254. For this assessment, the longer-term background + 5 dBA criterion would be adopted which provides for a more conservative assessment and is on the basis that many aspects of the project construction may extend beyond the 18-month time-frame.
- The EPA Publication 480 requirement of 'noise should not be above background noise levels inside any adjacent residence between 10 pm and 7 am' is somewhat impractical as it depends upon numerous factors such as the acoustic performance of each buildings construction, the level of internally generated noise, and the level and character of the external ambient noise environment. For the practical purposes of assessment, the EPA 480 night-time criterion has been defined to be an external level of construction noise that does not exceed the average night-time background noise level.

4.8.3 Operational noise objectives

The assessment of operational noise will follow the objectives detailed in **Table 4-23**. Parklands are not assessed against set quantitative objectives; rather, the impacts would be assessed by comparing the difference in traffic noise between the 2036 with and without the project.

Table 4-23 Operational noise criterion

	Governing reference[1]	Limit
Fixed plant	SEPP-N1	As set within SEPP-N1
Traffic noise from North East Link (facade corrected traffic noise)	Project-specific guideline targets	Category A buildings: $L_{A10(18hour)}$: 63 dBA Category B buildings: $L_{A10(12hour)}$: 63 dBA
Traffic Noise on local roads	Project-specific criteria	Change in noise in design year from 'with project' to 'without project' for design year to be not greater than 2 dBA AND Category A $L_{A10(18hour)}$: 63 dBA and B buildings $L_{A10(12hour)}$: 63 dBA (from North East Link roads)

1. All Guideline levels shall be applied to the ground level of the relevant building unless explicitly stated otherwise in the Governing Reference.

5 Method

5.1 Overview of method

This section describes the method that was used to assess the potential impacts of North East Link.
A risk-based approach was applied to prioritise the key issues for assessment and inform measures to avoid, minimise and offset potential effects. **Figure 5-1** shows an overview of the assessment method.

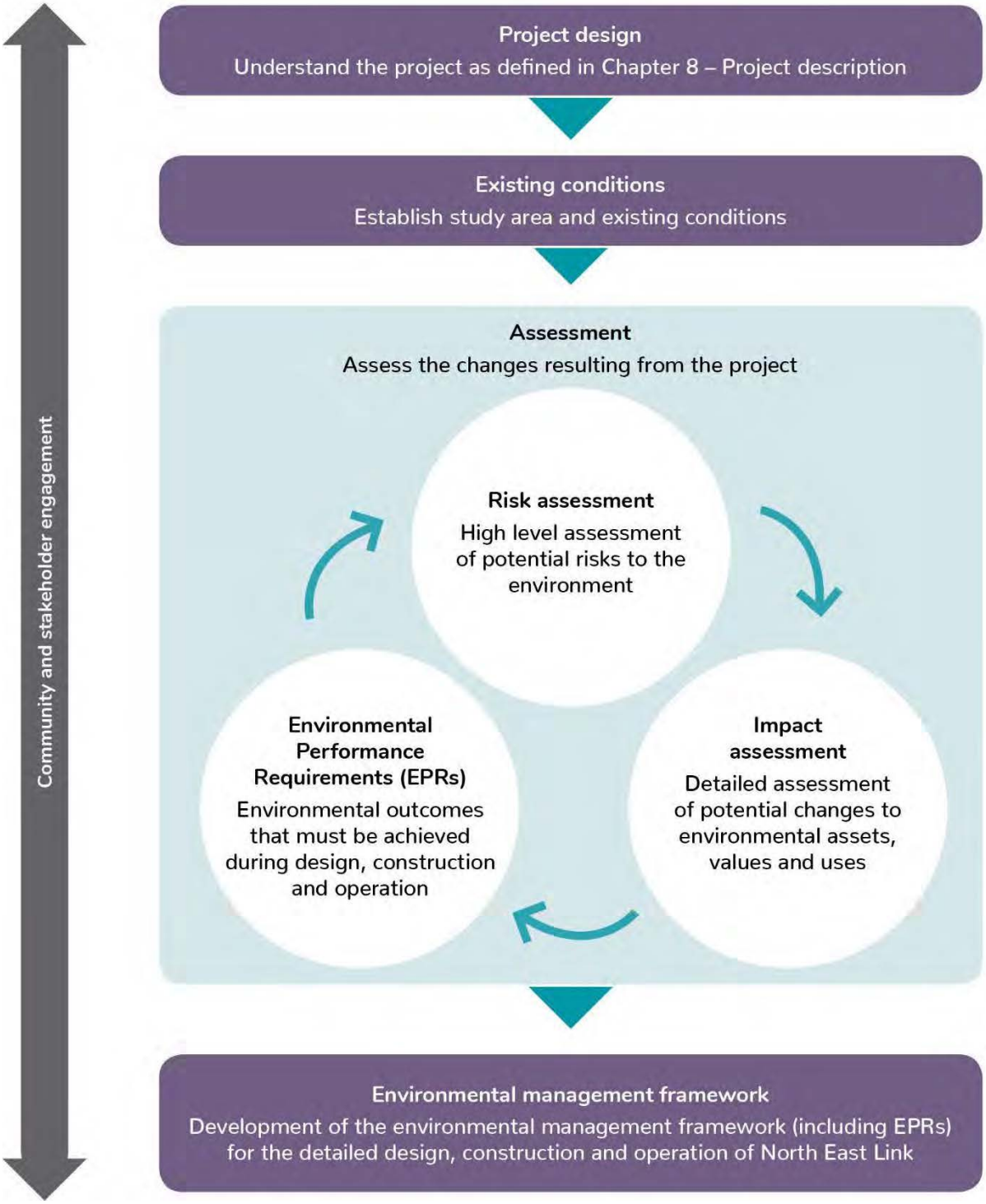


Figure 5-1 Overview of assessment method

The following sections outline the method adopted for the noise and vibration impact assessment.

5.2 Study area

The operational noise and vibration assessment considered potential operational impacts up to a distance of (approximately) 350 metres either side of the project alignment, while the construction assessment was assessed to a distance of 400 metres. The 350-metre range represents the limit of the road traffic noise prediction algorithm and establishes a sufficient distance to determine impacts into the existing minor, non-project road network. A distance of 350 metres was considered appropriate as the acoustic conditions at distances of greater than 350 metres would be less influenced by impacts from the project compared with other environmental sources such as local road traffic. For construction noise, a 400-metre buffer distance would, from experience, capture all relevant impacts.

To focus on specific locations within the study area, the existing conditions assessment has been separated into five project noise precincts along the project alignment:

- **Noise Precinct 1** – M80 Ring Road to Lower Plenty Road. This incorporates the entire 'M80 Ring Road to northern portal project element, and the northern portion of the northern portal to southern portal element.
- **Noise Precinct 2** – Lower Plenty Road to Manningham Road interchange. This corresponds to the middle-to-northern portion of the northern portal to southern portal project element.
- **Noise Precinct 3** – Manningham Road interchange to and including the Bulleen Road interchange. This corresponds to the middle to southern portion of the northern portal to southern portal project element, and the Bulleen Road interchange portion of the Eastern Freeway project element**.**
- **Noise Precinct 4** – Eastern Freeway east of Bulleen Road interchange. This corresponds to the portion east of the Bulleen Road interchange section of the Eastern Freeway project element**.**
- **Noise Precinct 5** – Eastern Freeway west of Bulleen Road interchange. This corresponds to the section west of the Bulleen Road Interchange of the Eastern Freeway project element**.**

The five precincts are shown in **Figure 5-2**. Assets and values identified as applicable for each receiver type are described in **Table 5-1**.

Table 5-1 Assets and values

Receiver	Asset/Value
Residential (Category A) and community buildings (Category B)	Human amenity – operational airborne traffic noise Human amenity – airborne noise and vibration(surface) impacts during construction Structural damage – vibration (surface) during construction
Outdoor recreation and public open spaces[1]	Human amenity – operational airborne traffic noise Human amenity – airborne noise impacts during construction
Commercial and industrial buildings[2]	Human amenity – noise and vibration impact during construction Structural damage – vibration (surface) during construction
Heritage buildings[3]	Structural damage – vibration (surface) during construction
Special infrastructure and Structures (above ground and buried)	Structural damage – vibration (surface) during construction

Note 1: The amenity of outdoor recreation and public open spaces is not expected to be impacted by vibration during construction

Note 2: Commercial and industrial buildings are not considered to be sensitive to operational traffic noise. This is consistent with the VicRoads guidelines

Note 3: Heritage buildings have also been considered in accordance with the applicable receiver type, for example, Category A buildings, where occupied

Impacts were required to be considered for some areas outside the study area, such as traffic noise impacts on local roads. These areas have been specifically identified within the relevant impact assessment sections of this report.

Operational noise is assessed to a distance of 350 metres and construction noise to a distance of 400 metres from the project's roads.

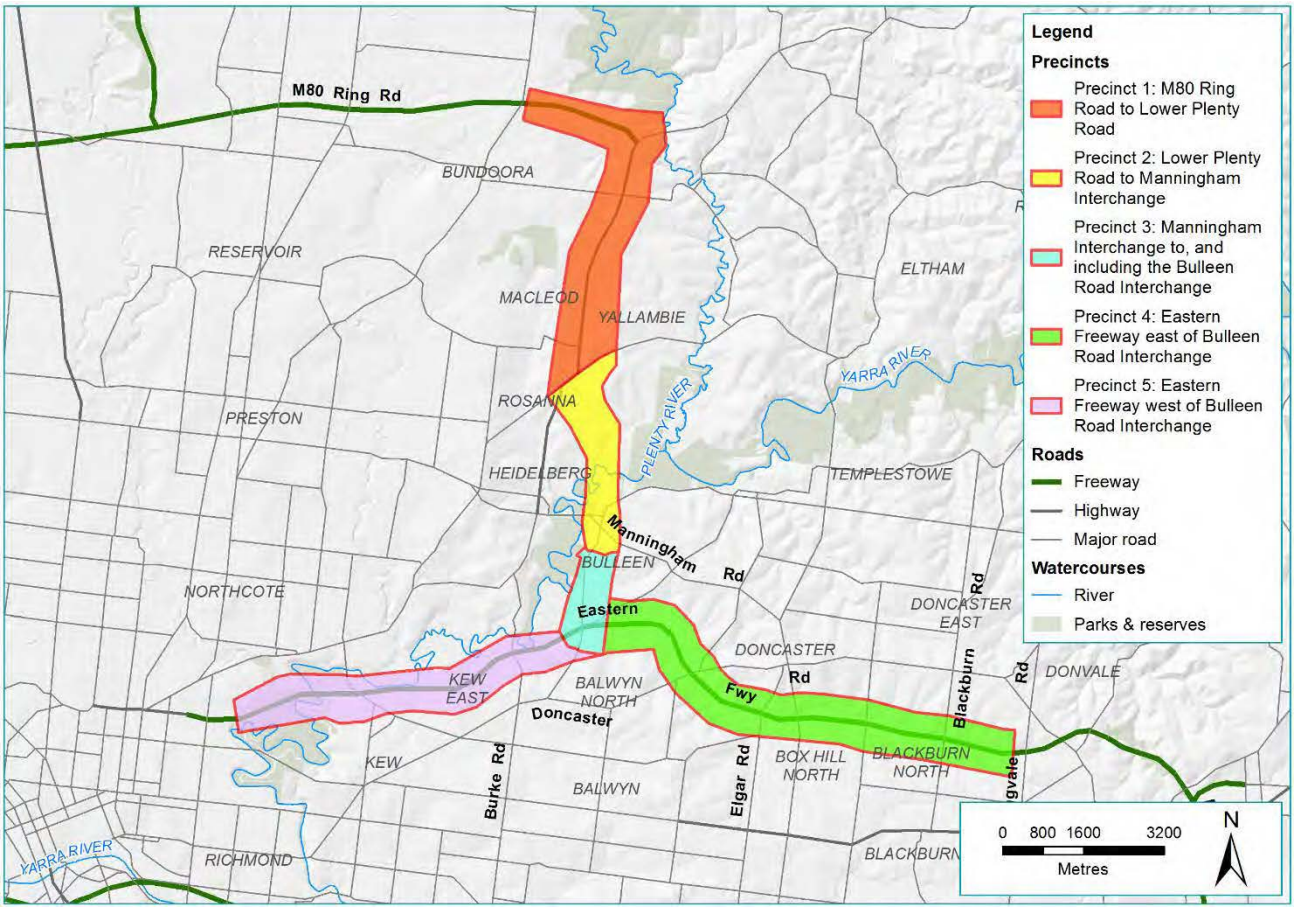


Figure 5-2 Noise precincts within the study area

5.3 Project design alternatives

An alternative design exists around the design of the operation of the Manningham Road interchange. A high-level assessment of the impacts from this is described in **Section 9.10**.

5.4 Existing conditions

Baseline noise and vibration measurements undertaken along the project corridor formed the basis of the existing conditions assessment. This was used to provide a base line assessment of the current noise and vibration environment. The process for these surveys is further described in **Appendix D** and **Appendix E.** This data has been used to inform the assessment.

5.4.1 Classification of sensitive receivers

The areas adjacent to the project comprise land use categorised as residential, industrial, Commonwealth land (Simpson Barracks), mixed use commercial, recreational or public open space. Most buildings adjacent to the project alignment are currently exposed to varying levels of traffic noise.

An estimation of the types of receivers which may be impacted by the project was undertaken using aerial maps of existing land uses adjacent to the project alignment. This, in conjunction with cadastral information, was used to determine the classification of residential, community, heritage, commercial, industrial, educational, recreational and other land uses.

5.4.2 Site investigations

Site investigations and monitoring were used to develop an understanding of the existing conditions at various locations within the study area by establishing the following:

- The existing noise environment at residential and community buildings, Commonwealth land, noise sensitive facilities and open spaces adjacent to the investigation area
- The range of vibration levels experienced in areas where there are no notable local vibration sources near the proposed tunnelling path.

Noise and vibration monitoring sites were established in consultation with the local community. Community input into potential monitoring locations was provided during community sessions and door knocks of the local community.

The following monitoring program was undertaken:

- 59 unattended noise measurement sites were established at locations adjacent to the project boundary that are potentially impacted by the project
- 21 unattended vibration measurement sites were established at locations adjacent to the project boundary potentially impacted by the project
- 20 short-term attended noise measurement sites were established at recreation and public open spaces, one measurement site was established at a community recreation centre, and three sites were established at Simpson Barracks (Commonwealth land) to capture a sample of noise levels at these locations in conjunction with observations of the dominant noise sources within the area
- Noise and vibration monitoring locations are shown in **Figure 6-1, Figure 6-4, Figure 6-7** and **Figure 6-9** with the results summarised and discussed in **Sections 6.7**
- Existing noise and vibration conditions were monitored and reported with reference to the following descriptors:
  - Noise $L_{A10(18hour)}$, L_{A90} (day), L_{A90} (evening), L_{A90} (night)
  - Vibration: PPV (peak particle velocity mm/s).

Further details of the results and methodology adopted for taking field measurements, the locations selected for noise and vibration (surface) monitoring are provided in **Appendix D**.

As part of the noise model validation process, data measured at each location was reviewed to determine periods where noise levels were contaminated by the effects of adverse weather or abnormal noise sources. These periods were removed from subsequent analysis when determining the $L_{A10(18hour)}$ and $L_{Aeq(8hour)}$ noise indices. The following noise indices were of interest:

- $L_{A10(18hour)}$ – used in the model validation process
- $L_{Aeq(8hour)}$ – used to assess the relationship between the daytime and night-time noise levels, when examining the potential impacts against the WHO night-time noise guidelines
- L_{A90} (day, evening and night-time) – used for assessment of construction and fixed plant noise.

As well as removing data affected by wind or rain, a visual inspection of the daily profiles was undertaken and data further excluded from the analysis where it was considered likely to have been affected by spurious noise sources. An example of this data is presented in **Figure 5-3**. In terms of the L_{A10} index, traffic on major roads is relatively consistent through the weekday period (the quieter weekend periods are not included in the analysis).

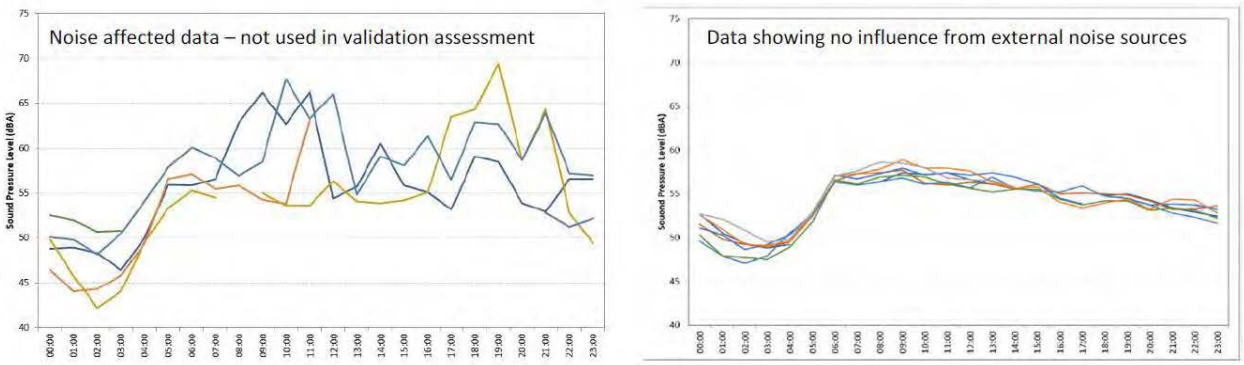


Figure 5-3 An example of data excluded from the analysis due to too much scatter in the data

5.5 Risk assessment

An environmental risk assessment has been completed to evaluate the potential impacts of North East Link. The risk-based approach is shown in **Figure 5-4** and is integral to the EES as required by section 3.1 of the scoping requirements and the *Ministerial guidelines for assessment of the environmental effects under the Environment Effects Act 1978*.

Specifically, the EES risk assessment aimed to:

- Systematically identify the interactions between project elements and activities and assets, values and uses
- Focus the impact assessment and enable differentiation of significant and high risks and impacts from lower risks and impacts
- Inform development of the reference project to avoid, mitigate and manage environmental impacts
- Inform development of EPRs that set the minimum outcomes necessary to avoid, mitigate or manage environmental impacts and reduce environmental risks during delivery of the project.

This section presents an overview of the EES risk assessment process. EES Attachment III Environmental risk report describes each step in the risk assessment process in more detail and contains a consolidated risk register.

This technical report describes the risks associated with the project on [technical discipline]. Wherever risks relating to this study are referred to, the terminology 'risk XX01' is used. Wherever EPRs relating to this study are referred to, the terminology 'EPR XX1' is used. The risk assessment completed for this study is provided as Appendix C. Figure 5-4 shows this process.

5.5.1.1 Rating risk

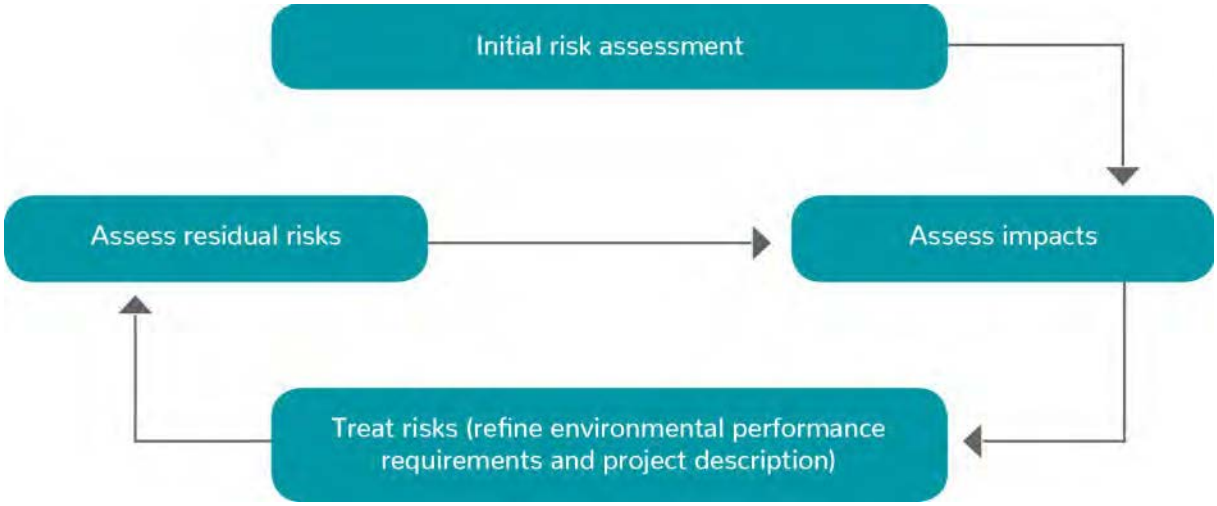


Figure 5-4 Risk-based approach

5.5.1.2 Rating risk

Risk ratings were assessed by considering the consequence and likelihood of an event occurring. In assessing the consequence, the extent, severity and duration of the risks were considered. These are discussed below.

5.5.1.3 Assigning the consequences of risks

'Consequence' refers to the maximum credible outcome of an event affecting the objectives in relation to an asset, value or use. Consequence criteria as presented in Chapter 4 – EES assessment framework, were developed for the North East Link EES to enable a consistent assessment of consequence across the range of potential environmental effects. Consequence criteria were assigned based on the maximum credible consequence of the risk pathway occurring. Where there was uncertainty or incomplete information, a conservative assessment was made on the basis of the maximum credible consequence.

Consequence criteria have been developed to consider the following characteristics:

- Extent of impact
- Severity of impact
- Duration of threat.

Severity has been assigned a greater weighting than extent and duration as this is considered the most important characteristic.

Each risk pathway was assigned a value for each of the three characteristics, which were added together to provide an overall consequence rating.

Further detail on the consequence criteria are provided Chapter 4 – EES assessment framework.

5.5.1.4 Assigning the likelihood of risk

'Likelihood' refers to the chance of an event happening and the maximum credible consequence occurring from that event. The likelihood criteria are presented in **Table 5-2**.

Table 5-2 Likelihood of an event occurring

Likelihood of Activity	Definition
Planned	The event is certain to occur
Almost certain	The event is almost certain to occur one or more times a year
Likely	The event is likely to occur several times within a five-year timeframe
Possible	The event may occur once within a five-year timeframe
Unlikely	The event may occur under unusual circumstances but is not expected (ie once within a 20-year timeframe)
Rare	The event is very unlikely to occur but may occur in exceptional circumstances (ie once within a 100-year timeframe)

5.5.1.5 Risk matrix and risk rating

Risk levels were assessed using the matrix presented in **Table 5-3**.

Table 5-3 Risk matrix

Likelihood	Consequence				
	Negligible	Minor	Moderate	Major	Severe
Rare	Very low	Very low	Low	Medium	Medium
Unlikely	Very low	Low	Low	Medium	High
Possible	Low	Low	Medium	High	High
Likely	Low	Medium	Medium	High	Very high
Almost certain	Low	Medium	High	Very high	Very high
Planned	Planned	Planned	Planned	Planned	Planned

5.5.1.6 Planned events

North East Link would result in some planned events, being events with outcomes that are certain to occur (ie planned impacts such as land acquisition), as distinct from risk events where the chance of the event occurring, and its consequence is uncertain. Although planned events are not risks, these were still documented in the risk register as part of Attachment III – Risk report for completeness and assigned a consequence level in order to enable issues requiring further assessment or treatment to be prioritised.

These planned events were assessed further through the impact assessment process.

5.5.1.7 Risk evaluation and treatment

The risk assessment process was used as a screening tool to prioritise potential impacts and the subsequent level of assessment undertaken as part of the impact assessment. For example, an issue that was given a risk level of medium or above, or was identified as a planned event with a consequence of minor or above, would go through a more thorough impact assessment process than a low risk.

Where initial risk ratings were found to be 'medium' or higher, or were planned events with a consequence of 'minor' or higher, options for additional or modified EPRs or design changes were considered where practicable. It should be noted that the consequence ratings presented in the risk register are solely based on the consequence criteria presented in Attachment III – Risk report. Further analysis and evaluation of the impacts potentially arising from both risks and planned events and information on how these would be managed is provided in **Sections 8, 9** and **10**.

5.6 Impact assessment

5.6.1 Construction assessment method

This study has assessed the impact of noise and vibration activities from the surface works during the project's construction on noise and vibration-sensitive buildings in the study area. The methodology for the impact assessment is summarised in the following sections, with further details provided in **Appendix F**.

5.6.1.1 Overview

Construction activities associated with the project would generally include:

- Commencement of early and temporary works, including construction power, water supply, ancillary site establishment, demolition works, property and utility adjustments and public transport modifications (if required)
- Construction of the road tunnels, interchanges, intersections and roadside infrastructure
- Haulage of spoil generated during tunnelling and excavation activities
- Construction and fit-out of the motorway control centre and ancillary operations buildings
- Upgrades to surface roads and construction of bridges
- Operations of the construction service yards and laydown areas
- Implementation of environmental management and pollution control facilities for the project.

This report presents the assessment of the potential construction noise and vibration impacts as a result of the Project, and the identification of typical feasible and reasonable noise and vibration mitigation measures. The assessment would inform the design of feasible and reasonable mitigation measures.

The following approach has been used to assess airborne construction noise:

- Sensitive receivers in the vicinity of the construction works have been identified.
- Baseline noise monitoring has been undertaken to quantify and characterise the existing ambient noise environment along the project route.
- Identification of noise-sensitive catchment areas likely to be affected by construction noise and vibration.

- Specific Noise Management Levels (NMLs) have been established based on baseline noise conditions determined from measurements within the project corridor to assist in the evaluation of potential construction noise impacts and a framework for a pragmatic approach to their management and mitigation.
- Typical construction scenarios have been identified. They include construction equipment, time of use (during normal working hours or outside normal working hours) and locations.
- An acoustic model has been built using the environmental noise modelling software package SoundPLAN version 8.1. The ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2) methodology has been used to predict construction noise levels for each of the typical construction scenarios.
- Calculation of noise and vibration levels likely to be associated with construction works at sensitive receivers and the evaluation of the extent of resulting impacts, as detailed in **Section 11** and **Appendix H**. This does not include ground-borne noise and vibration associated with tunnelling activities.
- Where NMLs are predicted to be exceeded options for alternative construction methodologies and/or mitigation have been considered. These measures would be developed and implemented through subsequent Construction Environmental Management Plans (CEMP).

5.6.1.2 Mitigation Strategy

Due to the nature of construction activities in urban areas it is inevitable that there would be noise impacts from construction sites. The NMLs identified in this report have been applied to determine measures for the control of potential construction noise impacts at sensitive receivers.

The project would apply all feasible and reasonable work practices to meet the NMLs, where possible, and inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels, duration of noise generating construction works, and contact details during construction.

A Construction Environmental Management Plan (CEMP) would be prepared during the detailed design phase and implemented through all construction activities. A Construction Noise and Vibration Management Plan (CNVMP) would be included in the CEMP to provide the framework and mechanisms for the management and mitigation of all potential noise and vibration impacts from the project. The CNVMP is expected to include procedures for dealing with potential impacts outside normal working hours.

A framework for developing the mitigation of construction noise impacts for the project is discussed **Appendix F.**

5.6.1.3 Describing predicted surface construction vibration impacts

Vibration surface works are surface level construction activities with the potential to generate vibration impacts with equipment. This excludes the construction of tunnels with tunnel boring machines (TBM) and mined technique, which is assessed in Technical report D – Tunnel vibration.

Typical surface construction works with the potential to generate vibration include demolition works, excavation works, piling, and the construction of the roadway and ancillary equipment.

To readily comply with the structural damage and human amenity, criteria are presented to address:

- Human amenity (annoyance and ability to sleep)
- Buildings (residential, community, commercial and heritage)
- Damage to infrastructure (telecommunication, water and power).

Indicative construction activities associated with surface works that are expected to generate vibration have been identified.

Working closer than the safe working distances presented in **Section 8.8.4** would be avoided to readily comply with the structural damage and human amenity criteria presented in **Section 4.8**. Works impacting heritage and infrastructure have been discussed on a case-by-case basis.

The primary form of mitigation for vibration impacts is to ensure vibration intensive works do not occur inside the boundary for safe working distances. Any vibration intensive activities carried out within close proximity would be monitored and managed to ensure compliance with construction vibration criteria or to otherwise apply mitigation measures, such as using lower-impact equipment, to protect the structural integrity of buildings and amenity of building occupants.

In some circumstances, construction activity would need to occur within the boundary set for safe working distance due to the type of work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced, resulting in a potential change in operating equipment.

Vibration generated by construction works would be managed in accordance with the CEMP. The CEMP would address and comply with the EPRs for protecting human amenity and damage to buildings and structures.

5.6.2 Operation assessment method

5.6.2.1 Operational road traffic noise assessment

The assessment has been completed to demonstrate compliance with the project-specific road traffic noise objectives specified in EPR NV1; see **Section 11**. The methodology adopted for the prediction of road traffic noise is discussed in the following sections.

5.6.2.2 Modelling assumptions

Road traffic noise levels were calculated using SoundPLAN v8.1 software, which implements the Calculation of Road Traffic Noise (CoRTN) algorithm. The UK Department of Transport devised the CoRTN algorithm and with suitable corrections. This method has been shown to give accurate predictions of road traffic noise under Australian conditions.

Noise levels for each sensitive building in the model have been calculated with a receiver point positioned one metre in front of the most exposed façade of the building, at 1.5 metres above ground. This is representative of the ground floor of the most exposed façade of a habitable room.

For residential dwellings, the assessment point is one metre from each façade. The assessment was based on the highest façade point, on the ground floor level of the building.

Road surface corrections have been applied in accordance with the table presented in Section 5.4 of the VicRoads *Road Design Note 06-1*:

- Dense graded asphalt = 0 dBA correction
- Open-graded asphalt = -3 dBA correction
- Tyned/Broomed concrete = +1 to +4 dBA correction
- Hessian Dragged Concrete = +2 to +4 dBA correction
- Exposed Aggregate concrete = -1 to +1 dBA.

It is accepted that the acoustic performance of open graded asphalt (OGA) road surfacing varies with time. When freshly laid, it would provide a higher acoustic performance, and over time slowly degrades. The 3 dBA correction is recommended by VicRoads Road (Design Note 0601, Interpretation and application of VicRoads Traffic Noise Reduction Policy, 2005).

For a section of the M80 Ring Road between Plenty Road and the interchange, a correction of +3 was used for the paved concrete section of the roadway.

The traffic volumes and vehicle types that underpin the noise modelling were derived from the strategic transport model – refer to Technical report A – Traffic and transport.

The traffic data the modelling is based on assumes the truck curfew in place on some of the local roads would continue into the future.

The acoustic model has assumed the average ground absorption coefficient of 0.55 (low-medium absorption).

The overall approach and input parameters used for the operation noise modelling are discussed in **Appendix G.**

5.6.2.3 Noise from portals

The traffic noise assessment utilises the SoundPLAN calculation NORD 2000 algorithm for portal noise emissions. The portal correction (tunnel effect) considers traffic flow, length of tunnel and portal opening and generates four separate noise sources evenly distributed across the tunnel opening. SLR has undertaken a comparison with a paper presented at Internoise 96 – Olafsen, S., '*Noise from road tunnel openings – an engineering approach*,' proceedings of Inter-noise 96, pp. 675–678 and found both methods to give reasonably consistent sound power levels. On this basis, the approach taken for this assessment is considered appropriate.

Reference to procedures used by TNM (*Supplemental Guidance on the Application of FHWA's Traffic Noise Model, 2014*, Chapter 13 – Tunnel Openings); says:

> *The [TNM] research team has come up with best modelling practices for an approximate calculation of the 'tunnel effect'. Should users require a more precise evaluation of the tunnel effect, or the effects of variables not addressed in this research, the research team suggests the use of other commercially available environmental noise prediction models to supplement the best modelling practices described herein.*
>
> *The best modelling practices for TNM users are based on the modelling technique that was found to yield the best agreement with the tunnel-openings algorithms in SoundPLAN.*

The tunnel effects used in SoundPLAN and modelled are considered sufficiently accurate for use on the project.

Noise from portals can be reduced by incorporating absorptive lining for a section of tunnel length before the end of the tunnel. The nature of any lining would be made in consultation with the project team, to minimise visual impacts. The lining may consist of features such as slotted/perforated panels or open absorption on the walls/ceiling and other treatments. The exact treatment would be subject to detailed design and driven by the acoustic requirements.

5.6.2.4 Noise modelling scenarios

Several modelling scenarios were prepared in accordance with the scoping requirements and to identify where there are benefits and disadvantages across the project. The scenarios were:

- 2018 existing conditions – Road traffic noise levels have been modelled with existing (2018) road traffic volumes. This model was validated against the baseline noise measurements and road traffic surveys.
- 2026 with project – This represents the traffic flows for the year of opening and incorporates the proposed new project road alignment and walls design, and major arterial road traffic flows based on Technical report A – Traffic and Transport (refer to **Section 5.8, Limitations, uncertainties and assumptions** reference to 'year of opening').
- 2036 with project – This represents the design year (10 years after project opening), including noise wall design and project design road alignment, and major arterial road traffic flows based on Technical report A – Traffic and transport (refer to **Section 5.8, Limitations, uncertainties and assumptions** reference to 'design year').
- 2036 no project – This predicted the future noise emissions based on the existing noise wall design and road alignment, the 2036 traffic flows based on Technical report A – Traffic and transport.

These scenarios have been modelled to evaluate traffic noise impacts at noise sensitive receivers as follows:

- Category A – Residential dwellings, aged persons home, hospitals, motels, caravan parks and other buildings of a residential nature
- Category B – Schools, kindergartens libraries and other noise-sensitive community buildings.

The purpose of this assessment is to determine if there is an exceedance of applicable noise standards for the design year of the project and to inform the assessment of impacts on health (refer to Technical report J – Human health). Noise mitigation has been applied to the project where noise levels are predicted to exceed the project noise objectives.

Additionally, traffic noise impacts at open parks and recreational areas and Noise Precincts have also been assessed to establish the potential impacts in these areas in accordance with the EES scoping requirements.

5.6.2.5 Future noise attenuation

New or improved noise walls have been included into the future design where existing noise walls are being upgraded or there are exceedances of the noise objectives. Indicative noise wall footprints and dimensions have been incorporated into the operational traffic noise model for the year 2026 and the design year 2036.

Noise walls are the most usual form of mitigation along dedicated road corridors. However, when considering the impacts, the potential noise reduction is balanced against:

- Potential visual impacts
- Potential urban design considerations
- Potential community safety/crime prevention considerations such as isolated walkways
- Impacts of a wall on traffic and pedestrian connectivity between adjacent areas of the project adjacent to North East Link
- Potential overshadowing impacts
- Form of future development of the residual land which may itself provide a barrier to traffic noise

- Considerations of the local context based on feedback from the community during the project's consultation phase.

Noise wall heights for North East Link would be limited to a maximum height of 10 metres, and frequently they are somewhat lower, having consideration of the above. The proposed noise wall design for the project is presented in **Appendix I**. For areas of the project where road widening would occur, existing walls would need to be removed and new walls installed. The replacement walls would be at least the same height or higher than walls replaced. Modelling includes the effect of multiple reflections between parallel noise walls (assuming acoustically hard, reflective surfaces on the noise wall faces).

On advice from the road design team, noise walls on viaducts or elevated structures would be limited to four metres high. This decision takes into account loading (including wind loading). This principle is also adopted on road projects in NSW.

The height of the noise walls would be limited in height to 10 metres, taking into account overshadowing, engineering considerations and constructability. In NSW for example, the maximum heights of walls are eight metres, due to consideration of overshading, visual impacts cost and reduced incremental acoustic benefits with increasing height.

Overhanging (or cantilevered) noise walls as shown in **Figure 5-5** can reduce the effective height of a noise wall (in some circumstances), but they have a higher cost associated with construction and maintenance. These type of walls could also inherently impose some height restrictions on the roadway. During detailed design, consideration may be given to overhanging (or cantilevered) noise walls, where additional noise reduction is required.

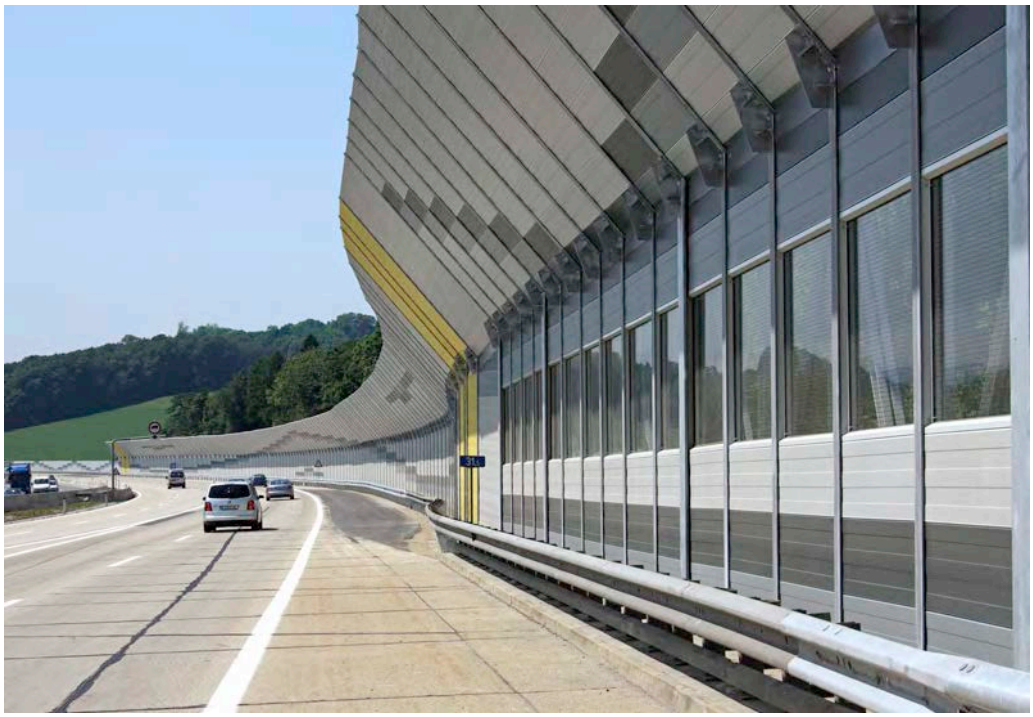


Image sourced from http://www.a1highways.com.au/noise-barriers, 20 December 2018

Figure 5-5 Example of cantilevered barrier

It should be noted that the noise wall design presented shows the proposed heights for the reference project of North East Link. Noise wall heights may be modified during detailed design to meet the project noise or other design requirements.

Open graded asphalt (OGA) would be used on the main carriageways, with dense graded asphalt (DGA) on the viaducts and ramps. The use of quieter OGA road surface pavements has been explored in areas other than for the main carriageways, where additional noise mitigation is warranted. The choice of road pavement surfaces and textures must meet several criteria including structural integrity, skid resistance, water shedding and design life as well as potential noise generating characteristics. The road pavement surface's noise performance throughout its duration and the need to maintain that performance by cleaning or replacing the pavement are also important considerations. The noise assessment considers the use of quieter noise pavement in the form of open-graded asphalt across the extent of the main carriageway along the project.

Where the combination of quieter OGA road surface pavements and noise walls do not provide sufficient noise attenuation due to their height, access breaks or noise diffracting around the ends of walls (for example, where they need to stop at a cross-street), at-property noise mitigation would be considered for any noise sensitive property in still excess of the design goals resulting from noise radiating from North East Link.

At-property mitigation measures and property boundary walls may also be considered if the applicable criteria cannot be met by the proposed noise walls and OGA in the project design. A sensitive receiver would be considered eligible for the consideration of noise mitigation in the circumstances discussed in **Section 4.5.**

5.6.3 Validation monitoring

All the baseline monitoring locations were reviewed, and some discounted as not being suitable for use in the validation process based on:

- The adverse influence from prevailing meteorological conditions
- The hourly profile of the data being inconsistent with adjacent sites
- The observed presence of extraneous noise sources
- The terrain profile accurately representing the conditions at the receiver location
- A wide scatter in the day-to-day noise levels
- The monitoring station not being located immediately adjacent to the M80 Ring Road or the Eastern Freeway.

Within those days short-listed for inclusion in the monitoring, the following days were excluded from the data:

- Weekends – this is because the modelling uses the AAWT (annual average weekday traffic), which does not include the lower volume weekend periods
- Public holidays
- School holidays
- Days which had a noise profile substantially lower from adjacent days – for example, this may be due to a day adjacent to a long weekend or may be attributable to prevailing winds or other unknown factors.

It is noted the VicRoads guideline document *Traffic Noise Measurement Requirements for Acoustic Consultants* (Section 7 Weather) provides the following:

> *The ideal weather conditions for measuring traffic noise is fine with little or no wind. However, these conditions are not always available and so the instrument operator shall ensure that environmental conditions that may significantly affect the noise levels are controlled within appropriate limits.*

Furthermore, the guideline provides the following:

> *The wind speed at the microphone in any direction shall not exceed 3 m/s for any significant period/s during the conduct of the measurements.*

It is further noted that CoRTN predictions apply for neutral propagation conditions and consequently, the policy applies when there is minimal meteorological influence on propagation. The analysis of monitored noise data has been undertaken in accordance with this requirement.

Locations were selected for calibration along the route to provide a reasonable degree of coverage of the various geographic areas.

5.6.3.1 Prediction difference

The difference between the predicted and measured noise level is known as the 'prediction difference' (PD). Where the prediction difference is significant and/or consistent across various monitoring locations, a calibration value (offset) to the model predicted value may be justified. The calibration value would take into consideration the average and spread of prediction differences as well as balance the risk between non-compliance and overdesign.

From [1] the recommended calibration factor is defined as:

> *Calibration factor = - mean PD + safety factor*

The safety factor depends on the standard deviation of the prediction differences and the level of risk considered acceptable, where 'risk' means the probability that a residence would have an actual noise level greater than the predicted noise level.

For a 5 per cent risk of under-prediction, the safety factor is 1.6 * standard deviation of the dataset. Importantly, this does not equate to 5 per cent of receivers being non-compliant, as the reality is that only a very few receivers are compliance critical (that is a predicted noise level at or very close to the noise objective level) and the vast majority of receivers are below the noise limit by a margin. Furthermore, if the noise level was under predicted at a compliance critical receiver, the level of under prediction and therefore the level of non-compliance would not likely be significant.

5.6.3.2 Maximum noise levels

A maximum noise level assessment has been conducted in accordance with the procedure *Preparing an Operational Noise and Vibration Assessment* (Roads and Maritime, 2011) using guidance contained in Practice Note iii of the Environmental Noise Management Manual (ENMM).

It is noted the ENMM states that while a maximum noise level assessment is required to be undertaken for new and upgraded road infrastructure projects, it would only be used as a tool to help prioritise and rank mitigation strategies and would not be applied as a decisive criterion in itself. The objective of the maximum noise level assessment is to determine whether maximum noise levels are likely to increase or decrease as a result of the project.

The maximum noise level assessment includes an evaluation of the number and distribution of night-time pass-by events in accordance with the ENMM. A maximum noise level event is defined within the ENMM as being any pass-by where:

- The maximum noise level of the event is greater than 65 dBA L_{AFmax}; and
- The $L_{AFmax} - L_{Aeq(1hour)}$ is greater than or equal to 15 dBA.

The community has raised concerns about sleep disturbance due to individual traffic noise events (short bursts of sound such as truck engine brakes). It should be noted that strategies are currently being implemented to reduce road traffic noise across Victoria's road network which may reduce the number of maximum noise levels events over the longer term.

These strategies include local council requirements to include noise mitigation in new dwellings, metropolitan plans to increase the use of public transport and state wide plans for upgrades of major transport routes.

In addition, state wide strategies for sharing freight with rail modes are expected to result in reduced noise from heavy vehicle freight on roads in many areas and a corresponding reduction in high noise level events from road traffic.

5.6.3.3 Vegetation

While vegetation on its own is sometimes considered to be an effective tool for reducing noise, this is not supported by evidence. VicRoads and the Roads and Maritime Services NSW both have guidelines that discuss effective forms of noise mitigation. These documents mention the following with regards to vegetation:

VicRoads – A Guide to the Reduction of Traffic Noise – For use by Builders, Designers & Residents (2003)

> *With normal house setbacks vegetation would not cause a measurable reduction in noise but may create psychological benefits for residents. Screening a road with trees and shrubs is an economical and pleasant way to of improving the environment. By removing the noise source from view, planting can reduce people's awareness of traffic and also reduce the annoyance it causes.*

Roads and Maritime Services NSW – Noise wall design guideline – A design guideline to improve the appearance of noise walls in NSW (2016)

> *There is a commonly held belief that vegetation is an effective noise barrier. However, unless there is a substantial width of vegetation the benefit is generally psychological – if you can't see the traffic it reduces the perception of noise – but does not reduce measured noise levels. While this effect alone can be a powerful mitigation tool it cannot be relied upon to reduce measured noise levels.*

Although increasing the amount of vegetation is considered to have a positive impact on the community it has not been recommended as a mitigation measure for reducing predicted noise levels.

5.6.3.4 Operational vibration impacts

Vibration levels generated by smooth roads at grade (without discontinuities such as speed bumps or pot holes) result in levels that are typically well below the threshold of perception in nearby sensitive receivers. Vibration from heavy trucks using smooth roads typically generate low vibration levels below 0.2 mm/s at the building's footings located approximately 20 metres from the roadway. This is consistent with the existing conditions measurements undertaken as part of this assessment.

Consequently, the impacts from operational vibration have not been further assessed within this report.

5.6.3.5 Fixed infrastructure noise assessment

A computer noise model of the proposed fixed facilities has been undertaken to predict the potential noise impact at the nearest sensitive receivers in reference to the relevant SEPP N-1 noise limits (see **Section 10**)

The following sections detail the modelling software and the methodology that was adopted and lists the assumptions and parameters used for the calculations.

Note that a Works Approval under the *Environment Protection Act 1970* is required for industrial and waste management activities such as road tunnel ventilation systems as they are listed as a Scheduled Premises under the Environment Protection (Scheduled Premises) Regulations 2017. SEPP N-1 Effective Noise Levels due to the proposed operations were predicted using 'SoundPLAN' environmental noise modelling software, version 8.1. The modelling was undertaken using the ISO 9613- 2:1996 prediction method. The ISO 9613-2:1996 Standard provides a method of calculating environmental noise from fixed plant items, as distinct from the CoRTN method, used for the prediction of road traffic noise.

A computer noise model of the site and surrounds was developed to predict the noise emissions.
The computer noise model was created adopting the following assumptions:

- Topographical data within the tunnel study area
- Design layouts and drawings of the facilities
- Assumed sound power level information for the various noise-emitting plant and equipment items proposed to be installed as part of the project
- Noise from audible warning devices is not assessed under SEPP N-1 and has not been included within the noise model
- Noise mitigation requirements are based on the predicted noise levels at noise sensitive receivers and the required noise reductions to meet the noise limits.

5.7 Rationale

The assessment of surface noise and vibration are based on local requirements. Where these requirements do not exist, accepted interstate or international guidelines have been adopted. The recommended guidelines, metrics and approach are commonly adopted for major infrastructure projects in Australia.

Calculations of the resulting noise and vibration have been undertaken using standard software, accepted by government departments throughout Australia.

Several scenarios for construction and operational conditions are modelled and based on information sourced from various project team disciplines, based on their experience. Equipment and procedures other than that assessed could be adopted by the successful tenderer, but these must be assessed to ensure their suitability, as part of the tender design.

5.8 Limitations, uncertainties and assumptions

- This report is limited to surface noise and vibration impacts. Vibration and regenerated noise impacts from underground tunnelling, including cut-and-cover tunnels and effects from piling in the trench north of Blamey Road to Watsonia railway station are assessed and discussed in Technical report D – Tunnel vibration.
- Surface noise and vibration impacts on fauna have not been discussed within this report. Refer to Technical report Q – Ecology for further details about impacts on wildlife within the project study area.
- An assessment of noise impacts and human health has not been included within this assessment. Refer to Technical report J – Human health for a discussion of specific potential health impacts linked to noise exposure from the project.
- Noise monitoring was undertaken at selected locations when the landholder provided approval. Specific locations of interest to the reader may not have been monitored due to lack of availability, poor site suitability or monitoring instrument security at the location of interest.
- The exact number of sensitive receivers along the full length of the study corridor has not been determined by site inspection. Rather, this information has been estimated using available GIS information and with reference to other specialist reports.
- Inputs used to develop the EES-stage operational noise model are based on preliminary datasets that would continue to be refined throughout the design of the project. Changes to the horizontal or vertical alignment of the road, topography, traffic volumes, road speeds and surfaces would impact the predicted noise levels.
- Meteorological data for the monitoring period is indicative only with respect to the conditions at the noise monitoring locations.
- Details of the ground conditions are not described within this document.
- The project scoping requirements are also relevant to other associated studies. These studies would address the relevant scoping requirements where applicable to each specific project boundary.
- The design of the flood walls, ramps and finished surface levels, north of Lower Plenty Road have progressed since this report was prepared.
- Assessment heights are 1.5 metres above the prevailing height of the floor level. Where the house is on highly sloping ground, the ground floor of the building may be elevated, or be below the surface level. This may slightly underestimate the predicted level in some instances.
- The design of the project alignment has been subject to on-going refinement and minor change; thus the locations of some noise walls may also be in slightly different positions in the reference project, compared with that assessed in this report.
- The CoRTN noise model references an Australian validated noise model but utilises the original emission database. However, this is offset by the calibration process, which aligns the measured and predicted levels (inclusive of a safety factor).

- The bus movements that form part of the general traffic flow (including those travelling on the dedicated bus way) are modelled as being a 'heavy vehicle' (truck). This may result in an over estimation of the predicted future emissions, particularly along the areas immediately adjacent to the dedicated busway.

The cumulative effects of noise and vibration surface construction works and those induced by vibration from underground works have not been assessed as:

- Separate and independent criteria apply to both vibration sources
- There is only a low likelihood of the surface construction and in-tunnel construction combining due to the geographical locations of the works.

Traffic volumes prepared for the EES have been adopted for the purposes of this report. Accordingly, for modelling purposes this report has adopted 2026 as the 'year of opening' and 2036 as the 'design year' consistent with the traffic forecasts developed for the EES. The upper limit of the predicted traffic volume range provided was conservatively selected for the noise impact assessment.

AECOM undertook the baseline noise and vibration monitoring and some stakeholder engagement meetings which have been used to inform this assessment, as part of their role, prior to SLR's engagement to undertake the surface noise and vibration impact assessment for the EES.

5.9 Stakeholder engagement

5.9.1 General

Stakeholders and the community were consulted to support the preparation of the North East Link EES and to inform the project and to better understand of potential impacts. **Table 5-4** lists specific engagement activities that have occurred in relation to noise and vibration, with more general engagement activities occurring at all stages project. Feedback received during community consultation sessions is summarised in **Section 5.10**.

Table 5-4 Stakeholder engagement undertaken for noise and vibration

Activity	When	Matters discussed	Outcome
VicRoads	March 2018	North East Link noise limits and approach	VicRoads review of the proposed North East Link noise standard.
Transport for Victoria	March 2018 May 2018 July 2018	North East Link noise limits and approach	Transport for Victoria's review and feedback of the proposed North East Link noise standard.
EPA	24 May 2017	Status of EPA Victoria noise policy EES noise assessment report format Lessons Learnt from previous major transport projects	Clarity regarding EPA's position on noise emissions from the project during operation and construction.
Belle Vue Primary School	15 June 2018	North East Link noise monitoring program EES noise modelling and impact assessment process Approach to noise mitigation	Belle Vue Primary School was provided with a VicRoads contact to follow up with questions about their existing noise impacts, and a project contact should any additional issues arise.
Kalker Montessori Centre	11 September 2018	North East Link noise monitoring program EES noise modelling and impact assessment process Approach to noise mitigation	Kalker Montessori was provided with contact details, should they have any further questions

5.10 Community feedback

In addition to consultation undertaken with specific stakeholders, consultation has been ongoing with the community throughout the design development and the EES process. Feedback relevant to the surface noise and vibration assessment is summarised in **Table 5-5**, along with where and how the assessment addresses those topics in this report.

Table 5-5 Community consultation feedback addressed by surface noise and vibration impact assessment

Issues raised during community consultations	How it's been addressed
Information about existing noise levels recorded along the project alignment to be made available.	The baseline noise survey is fully documented in Section 6 of this report.
Increased traffic noise from residents living along the new North East Link between Lower Plenty Road and the M80 Ring Road and the length of the upgrades to the Eastern Freeway.	The possibility of increased noise has been a key concern raised through consultation with local stakeholders and communities. The purpose of the noise impact assessment is to assess changes in noise impacts related to the project and identify any required mitigation, in line with the EES scoping requirements. Noise assessment findings and recommended mitigation approaches are detailed in Section 9 of this report, together with the recommended heights of noise walls (Appendix I).
Increased traffic noise from residents living along feeder roads to interchanges including Grimshaw Street, Greensborough Road, Lower Plenty Road and Bulleen Road south of the Eastern Freeway.	The possibility of increased noise has been a key concern raised through consultation with local stakeholders and communities. Section 9.11 of this report and addresses the change in noise on roads away from North East Link project roads.
Increased truck noise from residents living along the new North East Link between Lower Plenty Road and the M80 Ring Road and the length of the upgrades to the Eastern Freeway.	Section 9 describes the traffic noise impacts due to the change in traffic volumes (including changes in heavy vehicles). The noise impact assessment assesses changes in noise impacts related to the project and identifies any required mitigation, in line with the EES scoping requirements. The noise assessment in Section 9 of this report presents the findings and recommended mitigation approaches are detailed in the impact assessment section, together with the recommended heights of noise walls (Appendix I).
Existing noise levels from residents whose properties front or back on to areas of open space along the Eastern Freeway, and requests for impact assessments and noise mitigation measures to consider how sound travels through parklands. Locations frequently mentioned include: • Koonung Reserve (near Estelle Street and Furneaux Street, Bulleen) • Koonung Creek Reserve (near Balwyn Road, Balwyn North) • Koonung Creek Reserve (near Lincoln Avenue and Frank Sedgman Reserve, Mont Albert North).	The noise assessment in Section 9 includes those properties with parkland between the houses and the project roads. Modelling includes the effects of the open space on the traffic noise levels. The assessment and the need for noise mitigation is undertaken at each of the houses in the noise model. An assessment of the change in future traffic noise in the parkland spaces is also undertaken.
Old wooden noise walls in the project area are not effective and require upgrades. Locations frequently mentioned include the M80 Ring Road between Plenty Road and Greensborough Bypass and the Eastern Freeway between Burke Road and Bulleen Road.	All timber noise walls in the project area are proposed to be replaced as part of the project works. Their heights would the same as or higher than existing noise walls.

Issues raised during community consultations	How it's been addressed
Noise levels at night in some locations are already high, particularly along Greensborough Road and the Eastern Freeway, and requests for this to be considered in impact assessments and management measures.	Traffic noise emissions to the community is a key element of the noise study. The noise assessment initially measured and documented the existing noise environment (Section 6). The noise assessment (Section 9) process considers the future noise levels and determines the need for, and types of mitigation approaches to minimise noise from the project roads. This process is detailed in the impact assessment section, together with the recommended heights of noise walls (Appendix I). While impacts from the project roads are mitigated to the project criterion, noise from non-project roads may not qualify for mitigation.
Existing noise from trucks using engine brakes at night, particularly along the Eastern Freeway in sections with downhill declines, and requests for restrictions to be put in place or better enforced, particularly once North East Link and the upgraded Eastern Freeway are operating and more trucks use these roads.	Section 9.12 discusses engine brake noise. The project is design helps to minimise the possible use of engine brakes. Signage would be considered to encourage drivers not to use truck brakes. The health impacts associated with discrete noise events (that is, engine brake noise from truck), have been discussed in the EES Technical report J – Human health.
Noise based on road type including: • Noise travelling long distances from ramps and viaducts at the M80 and Eastern Freeway interchanges. • Noise travelling up and out of the North East Link trench in Watsonia. • Noise traveling out of tunnel entry and exit ramps at Lower Plenty Road and Manningham Road.	The noise assessment in Section 9 of this report considers noise from the main carriageways, ramps, trenched sections and vehicles travelling into and out of the tunnel portals. The noise assessment findings and recommended mitigation approaches are detailed in the impact assessment section, together with the recommended heights of noise walls (Appendix I).
Noise from tunnel ventilation structures.	Noise from the ventilation structures must comply with SEPP N-1 requirements, and this has been assessed. Mitigation measures have been incorporated into the design, which is discussed in Section 10
Height of homes (ie two-story dwellings and above) to be considered in impact assessments and noise mitigation measures.	The project is consistent with the VicRoads Traffic Noise Reduction Policy which stipulates the assessment be conducted at the ground floor level of a building.
Noise travelling to elevated areas that are some distance from North East Link and the Eastern Freeway, particularly at night or on windy days and request for topography and wind direction and speed to be considered in impact assessments and mitigation measures.	The *Methodology* (Section 5) and *Legislation and Policy* (Section 4) sections describe how the noise impact assessment was conducted and consideration of factors including existing noise levels, weather conditions and sources of noise. Modelling considers the level of the topography and the relative height of the buildings, and height of the road/ramps. The assessment is conducted under neutral weather conditions, as per set practices and procedures. The objectives are aimed at providing a higher level of acoustic amenity in impacted areas by setting more stringent objectives at the dwellings. This process aligns with standards applied on similar projects across Australia/internationally.
Noise impacts on schools including Bellevue Primary, St Martin of Tours, St Marys and Watsonia Primary.	Section 9 includes an assessment at all schools, and community facility buildings along the corridor.
Increased noise near sporting fields on Bulleen Road.	Section 9 includes an assessment at sporting and recreational facilities along the corridor.
Noise from construction sites, particularly at night and requests for more information about how this will be managed.	Impacts from construction noise has been undertaken along the entire project corridor and is discussed in Section 8. The findings and recommended mitigation approaches are detailed in the impact assessment section for each section of the project.
Noise walls to be built before construction starts to protect residents from noise.	It is proposed to install noise walls ahead of the demolition of existing walls, where it is feasible to do so. A specific Environmental Performance Requirement (EPR) has been put in place to specifically address this (NV3).
Information about the location and height of noise walls.	The noise report fully documents the proposed noise walls, including maps and heights (Appendix I).
Noise assessments to take place once the project is operating to ensure the project noise standard is being met and for the results to be made available to the public.	There is a requirement that noise monitoring is required to be undertaken on project opening, and again after 10 years after project opening. (NV 2).

5.11 Peer review

This assessment has been independently peer reviewed by Mr Darren Tardio of Enfield Acoustics Pty Ltd. The peer reviewer reviewed and provided feedback on drafts of this report, as well as the methodology, approach, assumptions and assessment criteria applied to the assessment. The peer reviewer's methodology is set out in his peer review report, which also included addressing whether there were any additional matters which should be considered as part of the impact assessment in order to address the EES scoping requirements, 'public works' Order or to otherwise adequately assess the likely impacts of the project relevant to this assessment or the management of those impacts. The peer reviewer also considered whether there were any gaps or matters in this assessment which they disagreed with. The final peer review report is attached as **Appendix M** of this report. This sets out the peer reviewer's conclusions, and whether all of their recommendations have been addressed in this report.

The focus of the peer review was the suitability of the proposed noise and vibration EPRs. **Table 5-6** presents SLR's response to the key issues raised in the peer review report.

Table 5-6 Response to independent reviewer comments

Reference Paragraph	SLR Response
Paragraph 28: Acoustic descriptor	EPR NV1 refers to the L_{A10} noise index as the acoustic descriptor for the specified noise limits. Although the term $L_{A10(18hour)}$ is not used, it is considered that there is no ambiguity regarding the requirements and therefore the EPR was not amended.
Paragraph 31: Multi storey residential buildings	The assessment was undertaken in accordance with VicRoads *Road Design Note 06-01 (July 2010)*, which undertakes the assessment to the lowest habitable level of a building. Accordingly, the assessment is considered to be in accordance with current practice. Notwithstanding the approach taken, SLR are not aware of any multi-level developments which exceed the criteria outlined in paragraph 31.
Paragraph 34: Noise monitoring locations	The peer reviewers' comments regarding monitoring locations are reasonable. Nevertheless, the noise monitoring locations would be determined in accordance with VicRoads Traffic Noise Measurement Requirements for Acoustic Consultants – September 2011. The Independent Environmental Auditor would need to consider the adequacy of the proposed noise monitoring program when assessing compliance with EPR NV2. The most appropriate noise monitoring locations may not be the ones used during the planning and assessment of the project. Accordingly, no change was made to EPR NV2.
Paragraph 53: Continuous vibration	The construction noise and vibration targets would be established as part of the CNVMP and reviewed and verified by the Independent Environmental Auditor. This would include measures for the management of short-term noise events if relevant. Accordingly, no change was made to EPR NV8.
Paragraph 59: Temporary noise walls	EPR NV13 already requires the installation of permanent noise attenuation ahead of adjacent works where feasible. The next level of detail regarding provision of measures to address noise exposure associated with the removal existing noise walls would be provided in the CNVMP (EPR NV4) and this plan would be reviewed and verified by the Independent Environmental Auditor. Due to the existence of these controls, no change was made to EPR NV13.

6 Existing conditions

This section describes the findings of the existing conditions assessment for the project. The existing conditions assessment is undertaken to establish the baseline conditions for the noise and vibration environment within the study area. This is important for understanding the current impacts and for identifying where changes to the environment may occur due to the project.

Information presented in this section of the report includes a summary of:

- The types of receivers within the study that are sensitive to noise and vibration
- The dominant noise and vibration sources
- The measured noise and vibration levels within the project study area.

Further information regarding the existing conditions assessment has been provided in **Appendix G**.

6.1 Noise Precincts

Land use adjacent to the project is categorised as predominantly residential, although there are areas of industrial, Commonwealth land, commercial, public open space, and community spaces.

A review of the types of receivers which may be impacted by existing traffic noise was undertaken using maps of the existing land use adjacent to the project alignment and building attribute footprints provided by Melbourne Water.

The assessment has been separated into five geographic-based Noise Precincts across the study area, as described in **Section 5.2** and shown in **Figure 5-2** above.

6.2 Noise Precinct 1: M80 Ring Road to Lower Plenty Road

6.2.1 General

Noise Precinct 1 extends from the M80 Ring Road down to Lower Plenty Road, near the intersection of Greensborough Road and Lower Plenty Road. This section would include a mixture of above, below and at surface road sections. This would include new road interchanges at the M80 Ring Road, Grimshaw Street, and Lower Plenty Road and includes the northern portal and associated ventilation structure. The suburbs of Greensborough, Watsonia North, Watsonia, MacLeod, Yallambie and Rosanna border this section of the alignment.

Land use adjacent to Noise Precinct 1 is categorised as residential, community, commercial, industrial, Commonwealth land and public open space. Most receivers within Noise Precinct 1 are suburban residential.

Sensitive receivers within Noise Precinct 1 are summarised in **Table 6-1**.

Table 6-1 Sensitive receivers – Noise Precinct 1

Category	Location/Description
M80 Ring Road (east of Plenty Road) to Lower Plenty Road	
Commonwealth land	Simpson Barracks is an Australian Army facility located on Commonwealth land along Greensborough Road and includes a residential land use component. Located in the south west of the barracks, low- and mid- rise dwellings serve as accommodation for military personnel. Road traffic noise from Greensborough Road is the main ambient noise source on the site. Building facilities at Simpson Barracks are located approximately 250 metres from the road and extend east into the suburb of Yallambie.
Category A – Noise Sensitive Residential Buildings	Greensborough and Watsonia North – The area surrounding the M80 Ring Road into Greensborough Road up until Grimshaw Street is predominantly residential. This area covers the suburbs of Greensborough and Watsonia North. Dwellings are generally low-rise residential, standalone conventional housing stock. From the M80 Ring Road and Greensborough Highway into Greensborough Road, the interface between residences and the road commonly includes acoustic noise walls and/or roadside mounds. Any acoustic mitigation controls for the interface between residential land use and the road end at Grimshaw Street. Road traffic noise dominates the ambient noise environment in this area.
	Grimshaw Street through to Lower Plenty Road – The area of Greensborough Road from Grimshaw Street through to Lower Plenty Road is predominantly residential. This area covers the suburbs of Watsonia, Macleod, Yallambie and Rosanna. Dwellings are generally low-rise residential, standalone conventional housing stock. Along Greensborough Road, these generally face onto the road or are separated from the main road by park reserves. Dwellings along Greensborough Road do not have any noise mitigation controls and tend to experience higher traffic noise levels the closer they are located to the intersection of Greensborough Road and Lower Plenty Road. Road traffic noise dominates the ambient noise environment in this area. This area includes the retirement villages of: • MS Respite Services – 303-311 Greensborough Road • Baptcare Strathalan 50 Braidhill Road, Macleod.
Category B – Noise Sensitive Community Buildings	• St Mary's Church and Parish Primary School, 210 Grimshaw Street, Greensborough • Concord School – 16 Meagher Street • Watsonia Primary School, 240 Nell Street, Watsonia • St Martin of Tours Primary School, 2-12 Silk Street, Rosanna • Watsonia Library, 4/6 Ibbottson Street, Watsonia • Abacus Child Care Centre, 3 William Street, Greensborough • Greensborough College, Nell Street • Watsonia Occasional Child Care Centre – 58 Gabonia Ave, Watsonia • Greensborough Road Early Learning and Kinder – 51-53 Greensborough Road, Macleod • Holy Spirit Anglican Church – Corner of Watsonia Road and Ibbottson Street • Grace Baptist Church – 240 Nell Street West, Watsonia • Watsonia Uniting Church – 71 Devonshire Road, Watsonia.

Category	Location/Description
Outdoor recreation and public open spaces	• AK Lines Reserve – Grimshaw Street, Watsonia • Borlase Reserve, Borlase Street, Yallambie • Coleen Reserve – Fahey Crescent • Fell Reserve – Access via Grimshaw Street and Lorimer Street, Greensborough • Gabonia Avenue Reserve – 56 Gabonia Avenue, Watsonia • Garvey Oval – Ambrose Treacy Drive • Gillingham Reserve – Gillingham Street, Watsonia North • Greensborough bypass path – • Greensborough Collendina Reserve – cnr Collendina Crescent and Eastgate Drive, Greensborough • Hughes Circuit Reserve – Hughes Circuit, Bundoora • Kalparrin Gardens – Yando Street, Greensborough • Maroondah Aqueduct – Chappell Drive, Bundoora • Plenty River Drive Reserve – 73 Plenty River Drive, Greensborough • Plenty River Linear Reserve – Plenty River Drive • Sarah's Reserve – 2 Sophie Place, Greensborough • St Mary's Reserve – cnr Greensborough Road and Grimshaw Street, Greensborough • Trist Street Reserve – 24 Trist St, Watsonia • Unnamed reserve – Off Callan Walk • West Mayling Reserve – Mayling Court, Watsonia • Winsor Reserve – Somers Avenue, Macleod

6.2.2 Commercial land use

The Watsonia Village Neighbourhood Centre is located adjacent to the project area and has a large concentration of commercial land uses. Commercial land uses within Watsonia Village includes a mixture of retail, food and small independent local stores and a post office, clustered around the Watsonia railway station. Watsonia Village comprises one- and two-storey buildings and has an abundance of on-street parking along the main street.

A small number of commercial land uses are located off Grimshaw Street along Greensborough Road and the Hurstbridge rail line, including fast food outlets and, accommodation and a post office. These retail outlets are in detached residential dwellings or purpose-built multi-storey facilities.

6.2.3 Industrial land use

There are limited industrial land uses within Noise Precinct 1. Several industrial land uses are located in the City of Whittlesea that are north of M80 and outside the project area. These industrial land uses operate in the Janefield Technology Estate.

6.2.4 Field measurements

To establish an understanding of the existing noise conditions in Noise Precinct 1, unattended, long-term noise monitoring was conducted at 21 residential locations and three schools. Attended, short-term noise monitoring was also conducted at five locations in public parks, reserves and at Simpson Barracks. The results are presented in

Figure 6-1 and are discussed in the following sections.

Further details of the methodology and monitoring results are provided in **Appendix D**.

6.2.5 Average background noise levels (L_{A90})

Unattended ambient noise monitoring was undertaken to record the average background noise levels (L_{A90}) at each site shown in Figure 6-1 and Table 6-6. The measured noise levels have been used to develop the construction noise criteria and to determine criteria for the operation of the ventilation structure.

6.2.6 Traffic noise monitoring results (L_{A10})

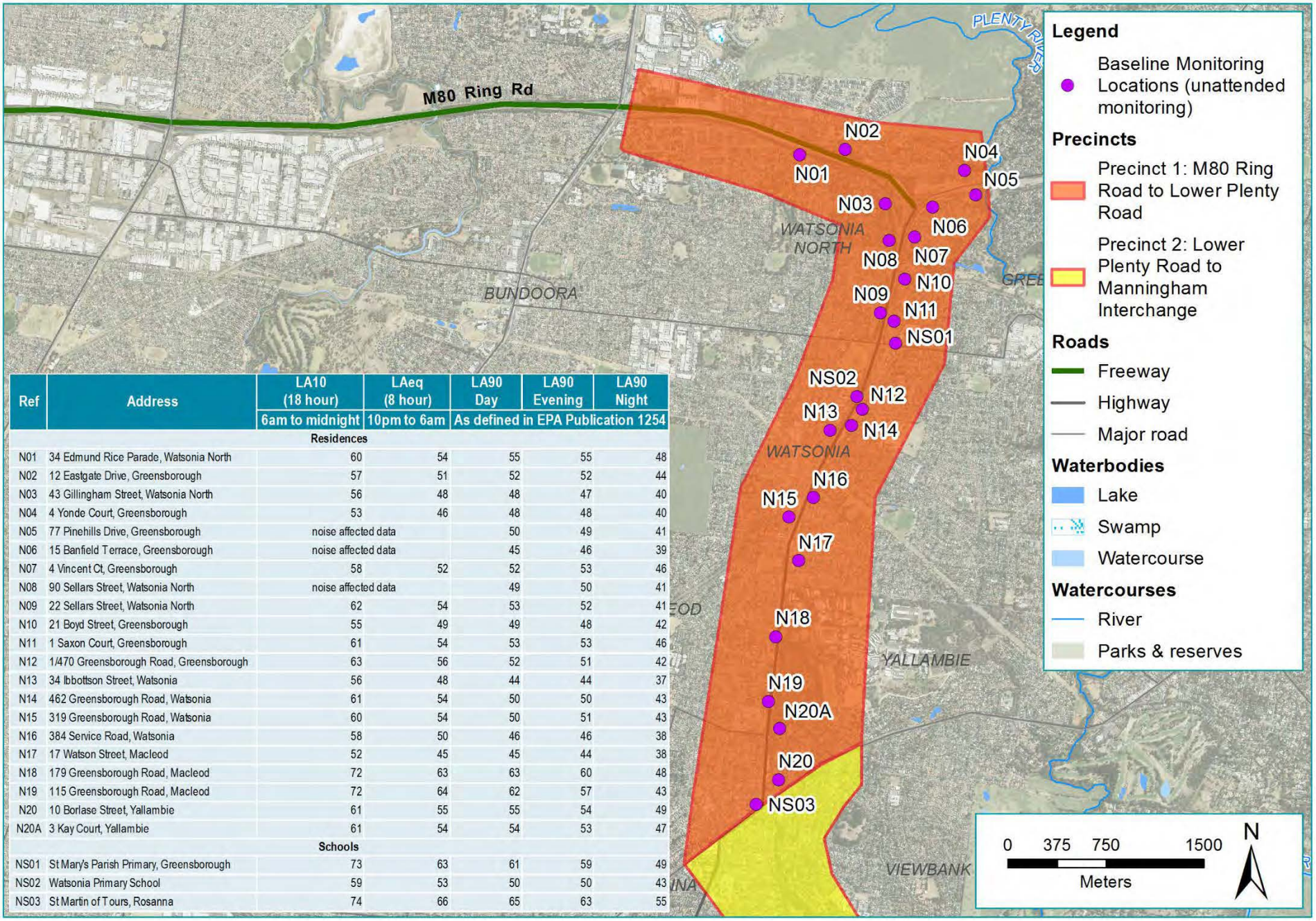
The noise environment was surveyed at 24 noise sensitive locations along the M80 Ring Road, Greensborough Road and nearby major roads.

The $L_{A10(18\ hr)}$ noise level refers to the average noise of the individual 18, one-hour L_{A10} noise levels between 6 am to midnight. $L_{A10(18\ hr)}$ noise levels are used to describe the operational traffic noise levels and to validate the existing noise model where the monitoring location is suitable for traffic noise measurements.

Table 6-6 shows the summary of noise measurements showing the average weekday $L_{A10(18h)}$ noise levels at each unattended monitoring location within Noise Precinct 1. Locations suitable for the validation of the noise model are provided in **Appendix G**.

6.2.7 Existing noise levels for outdoor recreational and public open spaces and on Commonwealth land

Short-term, attended noise measurements were conducted in public open spaces and at Simpson Barracks. **Table D-5** in **Appendix G** contains a summary showing the $L_{A90(30\ min)}$, $L_{Aeq(30\ min)}$ and $L_{A10(30\ min)}$ noise levels obtained at these locations within Noise Precinct 1. Each noise measurement was undertaken in conjunction with site observations to review a snapshot of the existing noise levels, characterise the existing environment and aid in the understanding of potential impacts (construction and operation) on these areas. Note that measurements were taken over a 30-minute period and are not indicative of compliance with road traffic noise guideline targets.



Ref	Address	LA10 (18 hour)	LAeq (8 hour)	LA90 Day	LA90 Evening	LA90 Night
		6am to midnight	10pm to 6am	As defined in EPA Publication 1254		
	Residences					
N01	34 Edmund Rice Parade, Watsonia North	60	54	55	55	48
N02	12 Eastgate Drive, Greensborough	57	51	52	52	44
N03	43 Gillingham Street, Watsonia North	56	48	48	47	40
N04	4 Yonde Court, Greensborough	53	46	48	48	40
N05	77 Pinehills Drive, Greensborough	noise affected data		50	49	41
N06	15 Banfield Terrace, Greensborough	noise affected data		45	46	39
N07	4 Vincent Ct, Greensborough	58	52	52	53	46
N08	90 Sellars Street, Watsonia North	noise affected data		49	50	41
N09	22 Sellars Street, Watsonia North	62	54	53	52	41
N10	21 Boyd Street, Greensborough	55	49	49	48	42
N11	1 Saxon Court, Greensborough	61	54	53	53	46
N12	1/470 Greensborough Road, Greensborough	63	56	52	51	42
N13	34 Ibbottson Street, Watsonia	56	48	44	44	37
N14	462 Greensborough Road, Watsonia	61	54	50	50	43
N15	319 Greensborough Road, Watsonia	60	54	50	51	43
N16	384 Service Road, Watsonia	58	50	46	46	38
N17	17 Watson Street, Macleod	52	45	45	44	38
N18	179 Greensborough Road, Macleod	72	63	63	60	48
N19	115 Greensborough Road, Macleod	72	64	62	57	43
N20	10 Borlase Street, Yallambie	61	55	55	54	49
N20A	3 Kay Court, Yallambie	61	54	54	53	47
	Schools					
NS01	St Mary's Parish Primary, Greensborough	73	63	61	59	49
NS02	Watsonia Primary School	59	53	50	50	43
NS03	St Martin of Tours, Rosanna	74	66	65	63	55

Figure 6-1 Maps of measured noise levels for Noise Precinct 1

6.2.8 Maximum noise level events

Maximum noise events have been considered at two residential locations along the M80 Ring Road, over multiple nights. These residents are considered representative of receivers along this section of the alignment.

The number of discrete maximum events varies hour-to-hour and night-to-night. **Figure 6-2** and **Figure 6-3** show a summary of average number of maximum events over the three nights of monitoring (for the same hour) and the highest number of maximum noise level events (for each particular hour) recorded over the night-time (10 pm to 6 am) at each site.

Maximum night-time noise level events at Site N01 were typically in the range 60 to 70 dBA, however levels up to 77 dBA during the night-time period were recorded over the monitoring period.

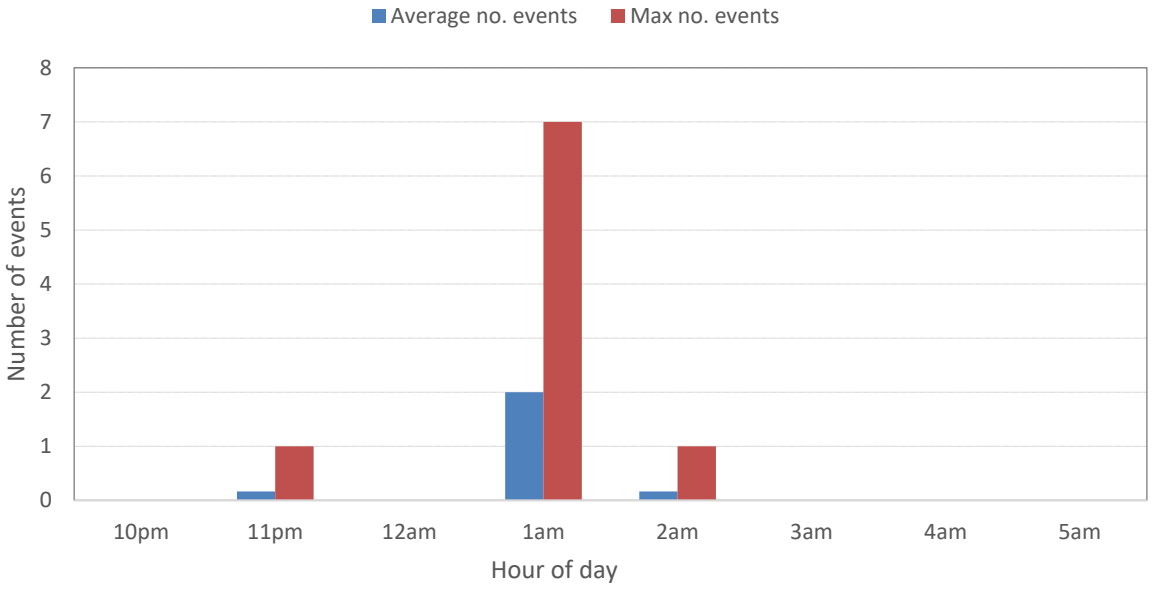


Figure 6-2 Maximum noise level event analysis for Site N01 – 34 Edmund Rice Parade

At Site N19, night-time noise levels from truck movements were typically in the range 75 to 85 dBA with levels up to 94 dBA recorded. While the ambient noise environment in these areas is controlled by road traffic noise, other non-road noise sources may also have influenced some measured levels and cannot be confirmed for all events. Notwithstanding, for the purpose of identifying relative maximum noise level baselines, the data is considered representative of this location.

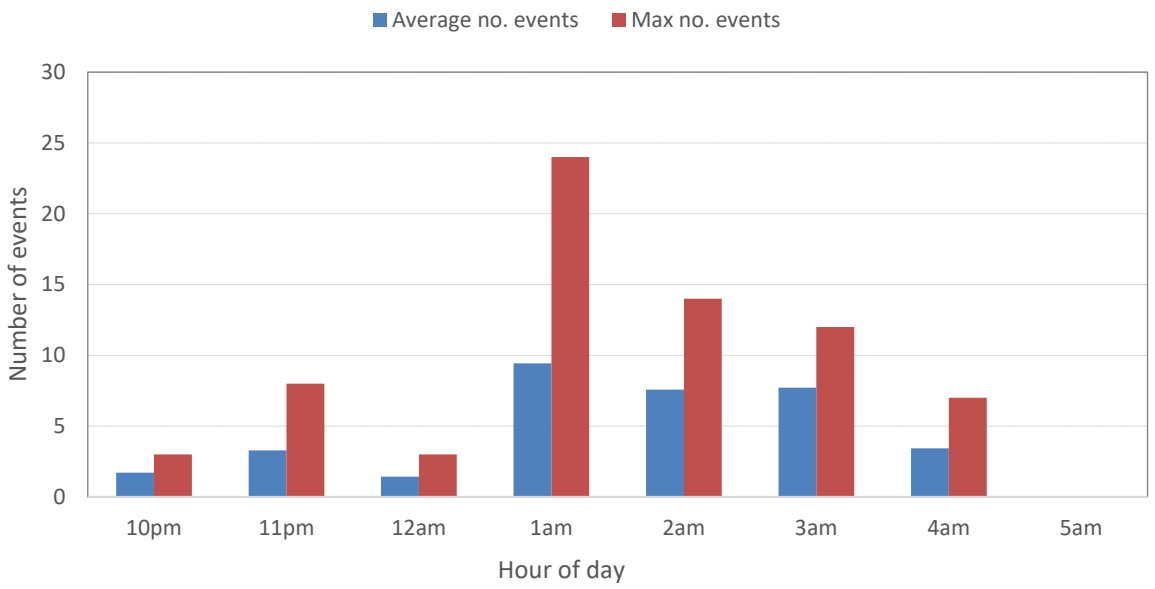


Figure 6-3 Maximum noise level event analysis for Site N19 – 115 Greensborough Road

The maximum noise level events shown in **Figure 6-2** and **Figure 6-3** indicate these areas are currently exposed to maximum noise levels events as defined by the NSW RMS ENMM Practice Note iii.

Maximum noise level events at night were most frequent between 1 am and 3 am at each location. These maximum noise events represent the emergence of a particular noise event in the prevailing noise environment ($L_{Aeq(1hr)}$). During the busier times of the day, the difference between L_{Aeq} and maximum noise levels diminishes, resulting in fewer maximum noise level events. This is demonstrated in **Figure 6-2** and **Figure 6-3** where maximum events are most prevalent in the early hours of the morning – when there is less traffic on the roads.

6.2.9 Summary existing conditions assessment

Noise Precinct 1 covers the area from the M80 Ring Road down to Lower Plenty Road. This area covers the suburbs of Greensborough, Watsonia North, Watsonia, MacLeod, Yallambie and Rosanna. The project boundary covers a mixture of suburban noise sensitive receivers, commercial properties, major roads and railway lines.

Key observations from the existing conditions monitoring include:

- Ambient noise environment is dominated by noise from Greensborough Road and the M80 Ring Road
- Non-traffic noise sources include occasional high-level aircrafts, people/domestic noises and railway movements on the Hurstbridge rail line
- Noise mitigation measures currently in place include noise walls and mounds along the M80 Ring Road section. There is only a limited section of only low-height roadside noise mitigation controls along Greensborough Road beyond the Grimshaw Street intersection. Dwellings along this section of road tend to experience higher traffic noise levels the closer they are located to the intersection of Greensborough Road and Lower Plenty Road
- Discrete maximum noise events are typically caused by heavy vehicle movements, the use of vehicle engine brakes and motorbikes. This is could be expected for residents immediately adjacent to a major road corridor

- Measured background levels are considered typical for urban environments near freeways and major arterial roads
- Sensitive receivers near Grimshaw Street can be exposed to high contributions from this major road as well as from Greensborough Road. Noise from trains also contribute to the noise environment in this area
- The intersections of Greensborough Road and Grimshaw Street and Greensborough Road and Lower Plenty Road correspond to higher levels of road traffic noise
- High maximum night-time noise levels were typically measured near major intersections along Greensborough Road. This is expected, due to the stop-start nature of intersections.

Details of the methodology is provided in **Appendix D** and the monitoring results in **Appendix E**.

6.3 Noise Precinct 2: Lower Plenty Road to Manningham Road interchange

Noise Precinct 2 extends from Lower Plenty Road to the Manningham Road interchange. In this section, twin tunnels would travel underneath residential areas of Rosanna and Heidelberg.

Land use in Noise Precinct 2 mostly includes residential and public open spaces. Industrial and community land use also form part of Noise Precinct 2.

To establish an understanding of the existing noise and vibration conditions in Noise Precinct 2, the following monitoring was conducted along the project alignment:

- Unattended vibration monitoring at 19 residential and commercial locations
- Unattended, long-term noise monitoring at four residential locations and two schools
- Attended, short-term noise monitoring at four locations in public parks.

There are no sensitive receivers relating to airborne noise, as the tunnels would be underground. Sensitive receivers within Noise Precinct 2 are summarised in **Table 6-2**. The methodology for this approach is discussed in **Appendix D.**

Table 6-2 Sensitive receivers – Noise Precinct 2

Category	Location/Description
Noise Precinct 2	
Category A – Noise Sensitive Residential Buildings	The areas adjacent to and surrounding the project area between the northern and southern portals are characterised by low density, detached low-rise dwellings. There is increased residential density along Templestowe Road and Manningham Road towards Bulleen Plaza Neighbourhood Centre. Dwellings in this area are typically separated from the main road by high wooden or brick fences. Houses along Bulleen Road, near the Banksia Street intersection do not generally have any traffic noise mitigation controls.
Category A – Vibration Sensitive Residential and Commercial Buildings	The assessment area of the tunnels between the northern and southern portal is mainly suburban residential. The existing vibration conditions here show minimal sources of elevated vibration. Refer to Technical report D – Tunnel vibration.

6.3.1 Commercial land use

Commercial land uses within Noise Precinct 2 are located along Templestowe Road, Bulleen Road and within the Bulleen Industrial Estate which is located adjacent to the Yarra River off Manningham Road. These commercial areas do not have any noise mitigation controls.

6.3.2 Industrial land use

Industrial land uses within Noise Precinct 2 are generally limited to the Bulleen Industrial Estate. The estate contains several light industrial businesses including auto repair premises. These businesses are housed within single or two-storey warehouses and do not have any road traffic noise mitigation controls.

6.3.3 Field measurements

Noise and vibration field measurements were undertaken to provide an understanding of the existing conditions at various locations within Noise Precinct 2. These results are presented in **Table 6-6** and discussed in the following sections.

Full details of results and the method adopted for undertaking noise and vibration monitoring are provided in **Appendix D**.

6.3.4 Ambient background noise monitoring results (L_{A90})

Unattended ambient noise monitoring was undertaken at six residential and community locations in Noise Precinct 2 to record the average background noise levels (L_{A90}) at each site shown in Figure 6-4. The measured noise levels have been used to develop indicative construction noise management levels in reference to the NSW ICNG and to determine SEPP-N1 criteria for the operation of the ventilation structure.

6.3.5 Traffic noise monitoring results (L_{A10})

Table 6-6 presents the site summaries of average weekday $L_{A10(18hr)}$ noise levels for the monitoring period. Locations suitable for the validation of noise model are provided in **Appendix G**.

6.3.6 Existing noise levels for outdoor recreational and public open spaces

Short-term, attended measurements were conducted at recreational and public open spaces near the intersection between Bullen Road and Manningham Road and surrounding Bulleen Road. **Table D-5 in Appendix D** contains a summary showing the $L_{A90(30\ min)}$, $L_{Aeq(30\ min)}$ and $L_{A10(30\ min)}$ noise levels obtained at the one long-term monitoring site along Bulleen Road. The noise survey was undertaken in conjunction with site observations to review a snapshot of the existing noise levels to characterise the existing environment and aid in the understanding of potential impacts (construction and operation) on these areas. Note that measurements were taken over a 30-minute period and are not indicative of compliance with road traffic noise objectives.

Ref	Address	LA10 (18 hour)	LAeq (8 hour)	LA90 Day	LA90 Evening	LA90 Night
		6am to midnight	10pm to 6am	As defined in EPA Publication 1254		
	Residences					
N21	218 Bulleen Road, Bulleen	65	58	57	55	50
N22	2 Golden Way, Bulleen	74	65	60	59	47
N23	3 Ilma Court, Bulleen	62	55	51	50	45
N24	8 Ben Nevis Grove, Bulleen	56	50	50	52	47
N32	52 Columba Street, Balwyn North	56	49	52	51	45
N33	150 Mountain View Road, Balwyn North	60	55	56	56	49
	Schools					
NS04	Belle Vue Primary School, Balwyn North	62	56	56	53	47
NS06	Marcellin College, Bulleen	67	60	60	56	47
NS07	Trinity Maries Playing Fields, Bulleen	65	58	57	56	43

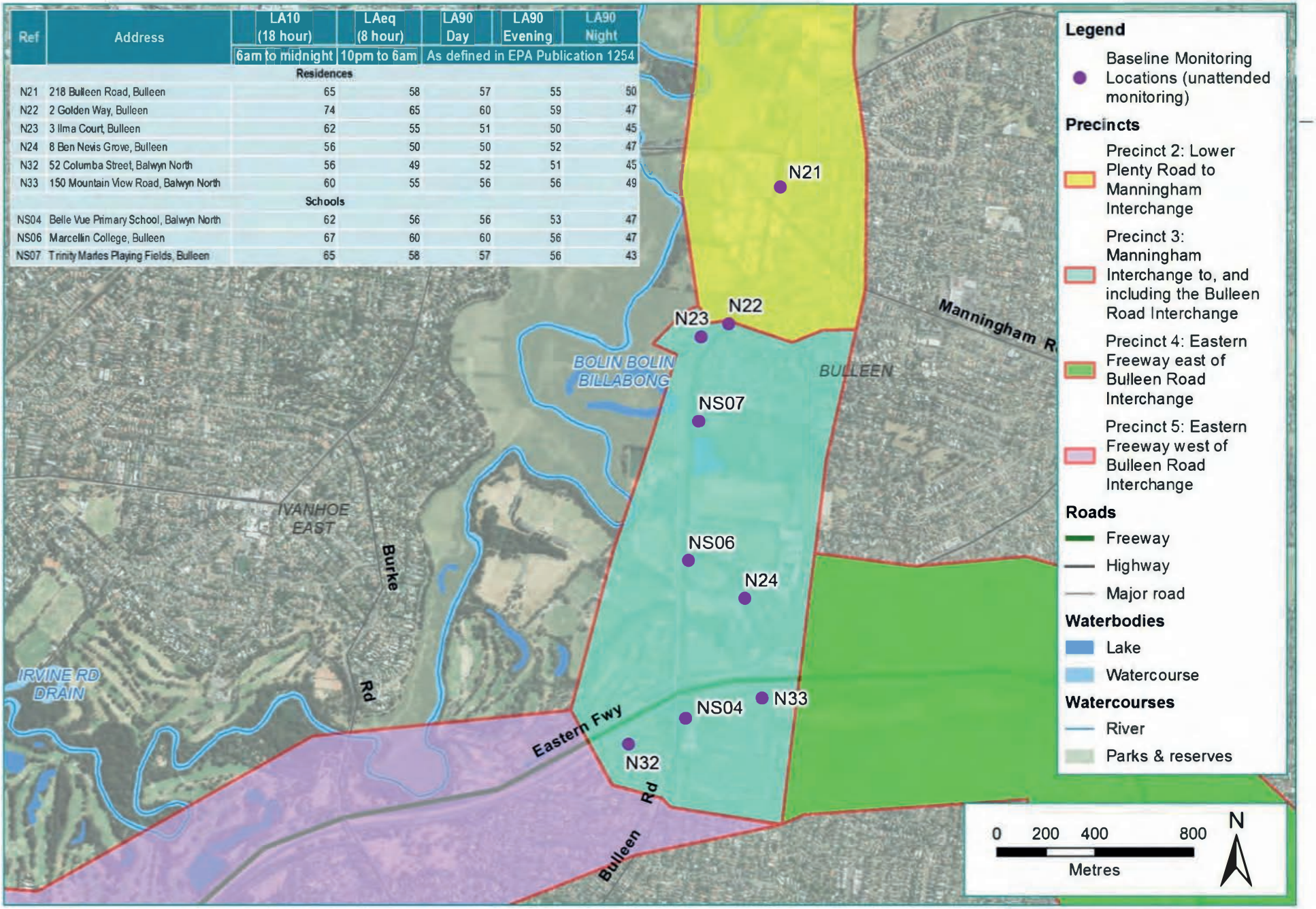
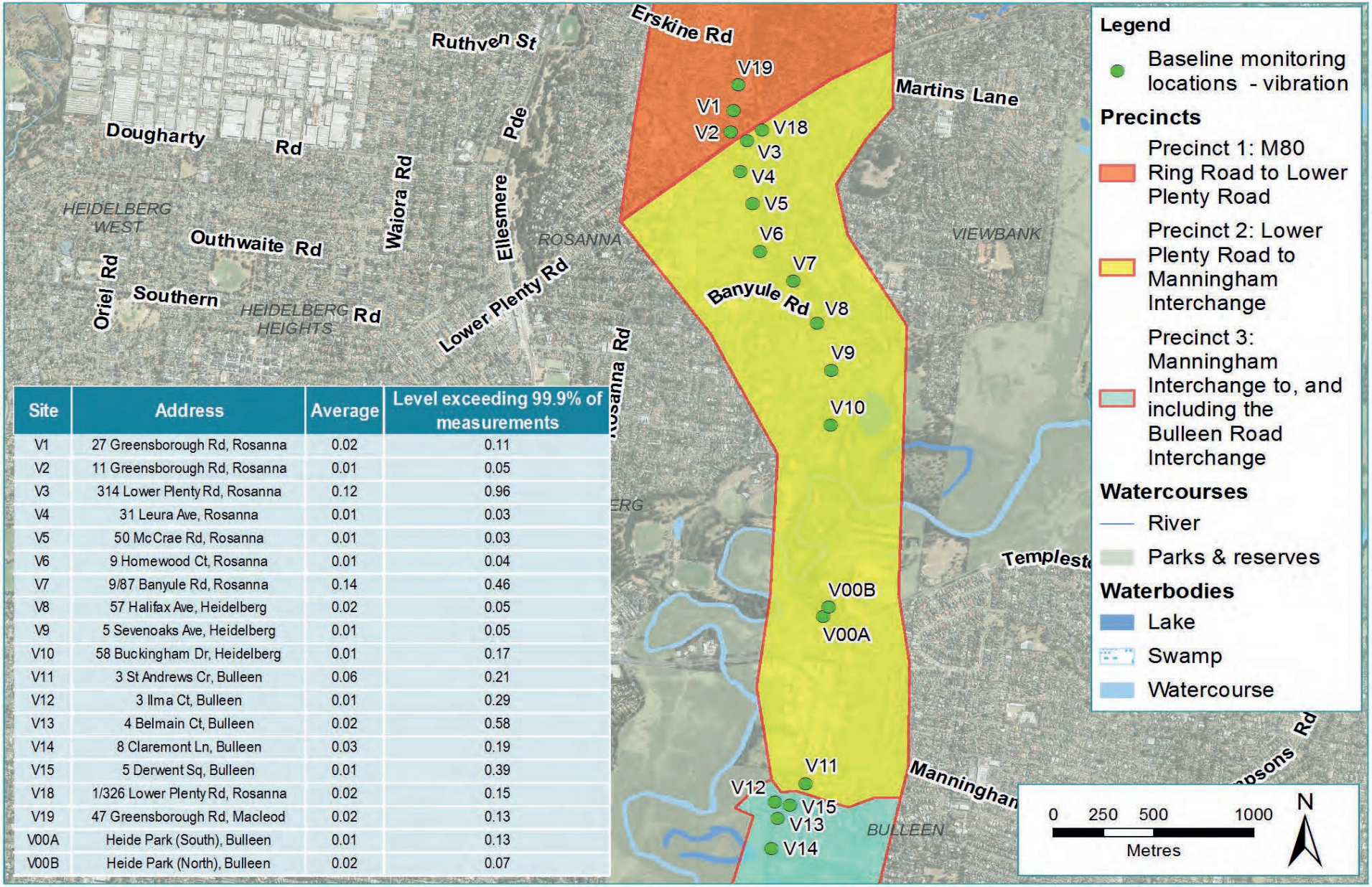


Figure 6-4 Maps of measured noise levels for Noise Precinct 2 and Noise Precinct 3



Site	Address	Average	Level exceeding 99.9% of measurements
V1	27 Greensborough Rd, Rosanna	0.02	0.11
V2	11 Greensborough Rd, Rosanna	0.01	0.05
V3	314 Lower Plenty Rd, Rosanna	0.12	0.96
V4	31 Leura Ave, Rosanna	0.01	0.03
V5	50 McCrae Rd, Rosanna	0.01	0.03
V6	9 Homewood Ct, Rosanna	0.01	0.04
V7	9/87 Banyule Rd, Rosanna	0.14	0.46
V8	57 Halifax Ave, Heidelberg	0.02	0.05
V9	5 Sevenoaks Ave, Heidelberg	0.01	0.05
V10	58 Buckingham Dr, Heidelberg	0.01	0.17
V11	3 St Andrews Cr, Bulleen	0.06	0.21
V12	3 Ilma Ct, Bulleen	0.01	0.29
V13	4 Belmain Ct, Bulleen	0.02	0.58
V14	8 Claremont Ln, Bulleen	0.03	0.19
V15	5 Derwent Sq, Bulleen	0.01	0.39
V18	1/326 Lower Plenty Rd, Rosanna	0.02	0.15
V19	47 Greensborough Rd, Macleod	0.02	0.13
V00A	Heide Park (South), Bulleen	0.01	0.13
V00B	Heide Park (North), Bulleen	0.02	0.07

Figure 6-5 Map of measured vibration levels (Noise Precinct 1 to Noise Precinct 3)

6.3.7 External vibration measurements

Vibration measurements were undertaken predominantly in Noise Precinct 1, Noise Precinct 2 and Noise Precinct 3, although mainly in Noise Precinct 2 where the project would be in tunnels. The locations and results of these measurements are presented in **Figure 6-5** and discussed in **Appendix D.**

6.3.8 Maximum noise level events

Maximum noise events have been considered in two residential locations along the Eastern Freeway, which are representative of receivers along this section of the alignment.

Maximum noise level events at night were most frequent between 1 am and 3 am at each location. These maximum noise events represent the emergence of a particular noise event in the prevailing noise environment ($L_{Aeq(1hr)}$). During the busier times of the day, the difference between L_{Aeq} and maximum noise levels diminishes, resulting in fewer maximum noise level events. This is demonstrated in **Figure 6-6** where maximum events are most prevalent in the early hours of the morning – when there is less traffic on the roads.

Figure 6-6 shows the average and maximum number of maximum noise level events recorded over the night-time measurement period at Site 23. Maximum night-time noise levels at this site were typically up to 75 to 80 dBA. While this area is controlled by road traffic noise, it cannot be confirmed that noise associated with each maximum noise level is attributable to road traffic.

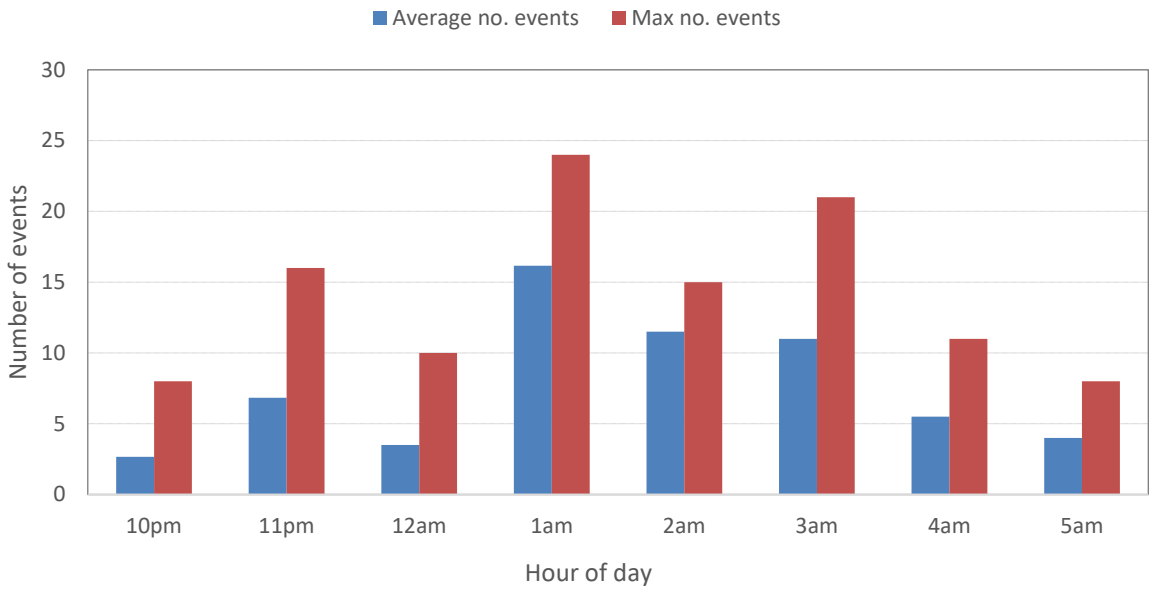


Figure 6-6 Maximum noise level analysis for Site N23 – 3 Ilma Court

The maximum noise level events shown in **Figure 6-6** identifies that this area is currently exposed to maximum noise levels events that have the potential for awakening reactions, particularly between 1 am and 3 am, due to the lower ambient noise levels.

A summary of the maximum level for each hour at the monitoring location within Noise Precinct 2 is presented in **Appendix E**.

6.3.9 Summary of existing conditions assessment

Noise Precinct 2 extends from Lower Plenty Road, south to the Manningham Road interchange. This area would include a new intersection at Manningham Road and covers the suburbs of Rosanna and Heidelberg.

Key observations from the existing conditions monitoring include:

- The ambient noise environment along Bulleen Road and near the intersection of Manningham Road is dominated by road traffic noise.
- There are generally no specific noise mitigation controls in place for residences in Noise Precinct 2.
- The average measured Peak Particle Velocity (PPV, mm/s) for each monitored site was below the threshold for human annoyance.
- Discrete maximum noise events are typically caused by heavy vehicle movements, the use of vehicle engine brakes and motorbikes. This is typical of major road corridors.
- Sensitive receivers near the intersection of Manningham Road tend to experience high levels of road traffic noise. Traffic banks up in these areas during peak traffic times, and so the prevalence of stop-start traffic and the use of truck brakes would be high.
- The highest maximum night-time levels were typically measured near the intersection of Manningham Road and Bulleen Road.

Monitoring undertaken in Noise Precinct 2 is summarised in **Table 6-6**.

6.4 Noise Precinct 3 Manningham Road interchange to Bulleen Road (south of Eastern Freeway)

Noise Precincts 3 extends from the Manningham Road interchange south along Hoddle Street, including the Bulleen Road interchange, to just past the Eastern Freeway, as shown in **Figure 5-1.**

Noise Precinct 3 works include the tunnel section from Bridge Street to just south of the Veneto Club (north of the Eastern Freeway) and would be constructed using cut-and-cover or mined construction techniques. Noise Precinct 3 includes a new interchange at Bulleen Road and the Eastern Freeway with elevated ramps connecting to the Eastern Freeway. This section of the alignment runs through the suburbs of Bulleen, Heidelberg East, Bulleen and Balwyn North.

Noise Precinct 3 predominantly features residential and open space land uses.

To establish an understanding of the existing noise and vibration conditions in Noise Precinct 3, the following monitoring was conducted along the alignment:

- Unattended, long-term noise monitoring at five residential or noise sensitive locations
- Attended, short-term noise monitoring at six locations in outdoor recreation/public open spaces.

Sensitive receivers within Noise Precincts 3 are summarised in **Table 6-3**. The methodology for this approach is discussed in **Appendix D.**

Table 6-3 Sensitive receivers – Noise Precinct 3

Category	Location/Description
Category A – Noise Sensitive Residential Buildings	Residential land uses are generally one and two storey detached dwellings. Residences in this area have differing exposure to road traffic noise. While there is limited exposure to freeway noise around the Manningham Road interchange, to the south, residents have some exposure to the Eastern Freeway.
Category B – Noise Sensitive Community Buildings	• Belle Vue Primary School, 20 Highview Road, Balwyn North. • Veneto Club, 191 Bulleen Road, Bulleen. • Marcellin College, 160 Bulleen Road, Bulleen.
Outdoor Recreation and Public Open Spaces	• Trinity Grammar School Sporting. • Carey Grammar Sports Complex.

6.4.1 Commercial land use

There is only isolated commercial activity along Bulleen Road, south of the Manningham Road interchange.

6.4.2 Industrial land use

There is no industrial land use in Noise Precinct 3.

6.4.3 Field measurements

Noise measurements were undertaken to provide an understanding of the existing conditions at various locations within Noise Precinct 3. The results are presented in Figure 6-4 and discussed in the following sections.

Details of the methodology is provided in **Appendix D** and the monitoring results in **Appendix E**.

6.4.4 Average background noise levels (L_{A90})

Unattended and attended ambient noise monitoring, including those in public open and outdoor recreational spaces, was undertaken to record the average background noise levels (L_{A90}) at each site. This information is detailed in **Table 6-6** and **Table D-5** in **Appendix D.** The longer-term unattended measured noise levels have been used to develop indicative construction noise target levels and to determine SEPP-N1 criteria for the operation of the ventilation structure.

Note that short-term measurements were taken over a 30-minute period and are not indicative of compliance with road traffic noise objectives.

6.4.5 Traffic noise monitoring results (L_{A10})

The noise environment was surveyed at five residential and community locations along or adjacent to Bulleen Road. A summary of the measured unattended surveys is presented in **Table 6-6** showing the average weekday $L_{A10(18hr)}$ noise levels for the monitoring period. Locations suitable for the validation of the noise levels are provided in **Appendix G**.

6.4.6 Summary of existing conditions monitoring

Noise Precinct 3 works extend from Bridge Street to south of the Bulleen Road interchange with the Eastern Freeway. This section of the project alignment runs through the suburbs of Bulleen, Heidelberg East, Bulleen and Balwyn North.

Key observations from the existing conditions monitoring along the Eastern Freeway include:

- Ambient noise environment in the area is dominated by road traffic noise and those residents closest to the Eastern Freeway tend to be above the project's noise objective.
- Other sources contributing to the local noise environment include noise from occasional passing **aircraft**, surrounding local roads and local activities.
- Discrete maximum noise events are typically caused by heavy vehicle movements, the use of vehicle engine brakes and motorbikes. This is typical of major road corridors with inclines or declines of the road gradient.
- Noise sensitive receivers located near ramps tend to experience higher maximum noise levels, due to the stop-start nature of the traffic flow.

Details of the methodology is provided in **Appendix D** and the monitoring results in **Appendix E**.

6.5 Noise Precinct 4: Eastern Freeway, east of Bulleen Road

Noise Precinct 4 extends along the Eastern Freeway east of Hoddle Street through to Springvale Road.

Noise Precinct 4 works would include modifications to the Eastern Freeway, including the widening of the freeway to accommodate future traffic volumes and to provide new dedicated bus lanes for the Doncaster Busway and associated works. The suburbs of Balwyn North, Bulleen, Balwyn North, Doncaster, Doncaster East, Donvale, Box Hill North, Blackburn North and Nunawading border this section of the project alignment. The proposed road widening of the Eastern Freeway is contained to within the existing road reserve.

Noise Precinct 4 predominantly features residential and open space land uses.

To establish an understanding of the existing noise and vibration conditions in Noise Precinct 4, the following monitoring was conducted along the project alignment:

- Unattended, long-term noise monitoring at 20 residential or noise sensitive locations
- Attended, short-term noise monitoring at 11 locations in outdoor recreation and public open spaces.

Sensitive receivers within Noise Precinct 4 are summarised in **Table 6-4**. The methodology for this approach is discussed in **Appendix D.**

Table 6-4 Sensitive receivers – Noise Precinct 4

Category	Location/Description
Eastern Freeway, from East of Bulleen Road to Springvale Road	
Category A – Noise Sensitive Residential Buildings	Residential land uses are generally one and two storey detached dwellings built on land above the line of the freeway on the northern boundary of the Eastern Freeway, and in line with the freeway on its southern boundary Residences in this area are generally exposed to high levels of road traffic noise from the Eastern Freeway. The interface between dwellings and the adjacent freeway commonly includes a park or reserve, as well as an acoustic noise wall. The area between Bulleen Road and Doncaster Road, covering the suburbs of Balwyn North and Bulleen, is predominantly residential interspersed with parks and reserves along the boundary of the Eastern Freeway. Residential areas are generally characterised by low density, detached dwellings. Residences in this area are generally exposed to high levels of road traffic noise from the Eastern Freeway. The interface between dwellings and the adjacent freeway commonly includes a park or reserve, as well as an acoustic noise wall. The areas between Doncaster Road and Springvale Road along the Eastern Freeway are predominantly residential, interspersed with community parkland and reserves. The Koonung Creek Trail follows the line of the Eastern Freeway on its southern boundary. Residential land uses are generally one and two-storey detached dwellings built on land above line of the freeway on the northern boundary of the Eastern Freeway, and in line with the freeway on its southern boundary. Medium density townhouses are also located in Noise Precinct 4. Residences in this area are generally exposed to high levels of road traffic noise from the Eastern Freeway. The interface between dwellings and the adjacent freeway commonly includes a park or reserve, as well as an acoustic noise wall.
Category B – Noise Sensitive Community Buildings	• Kalker Montessori Centre, 1–3 Estelle Street, Bulleen. • Birralee Primary School, Heyington Avenue, Doncaster. • Wonderland Childcare and Kinder, 6 High Street, Doncaster. • Applewood Retirement Village, 5 Grand Blvd, Doncaster. • North Eastern Jewish Centre (Yeshurun Congregation), 6 High Street, Doncaster. • Birralee Primary School, 8–26 Heyington Ave, Doncaster. • Japara Sydney Williams Apartments/Japara Millward Nursing home, 31 Blackburn Road, Doncaster East. • Heatherwood School, 370 Springvale Road, Donvale. • Presbyterian Theological College, 684 Elgar Road, Box Hill North. • Warekila Preschool, 38 Kett Street.
Outdoor Recreation and Public Open Spaces	• Musca Street Reserve, Musca Street, Balwyn North. • Koonung Creek Reserve, Balwyn North. • Manningham Park Reserve, Park Avenue, Doncaster. • Freeway Golf Course, Columba Street, Balwyn North. • Boroondara Tennis Centre, Bulleen Road, Balwyn North. • Bulleen Cricket Club, Furneaux Grove, Melbourne. • Winfield Road Reserve, Winfield Road, Balwyn North. • Katrina Street Reserve Playground, Katrina Street, Doncaster. • Elgar Park, Belmore Road, Mont Albert North. • Tram Road Reserve, Tram Road, Doncaster. • Koonung Creek Linear Park, Windella Quadrant, Doncaster. • Boronia Grove Reserve, Leeds Street, Doncaster East. • Slater Reserve, Grosvenor Street, Blackburn North. • Eastern Freeway Linear Reserve, Kett Street, Nunawading. • North Box Hill Tennis Club, Elizabeth Street, Box Hill North. • Frank Sedgman Reserve, Paul Avenue, Box Hill North.

6.5.1 Commercial land use

There is only isolated commercial activity along the line of the Eastern Freeway between Hoddle Street and Doncaster Road.

A small number of commercial premises operate within the Joseph Street light industrial cluster, located south of the freeway in Blackburn North, within the City of Whitehorse. Noise Precinct 4 is separated from the freeway by the Koonung Creek Trail reserve and noise walls or mounds.

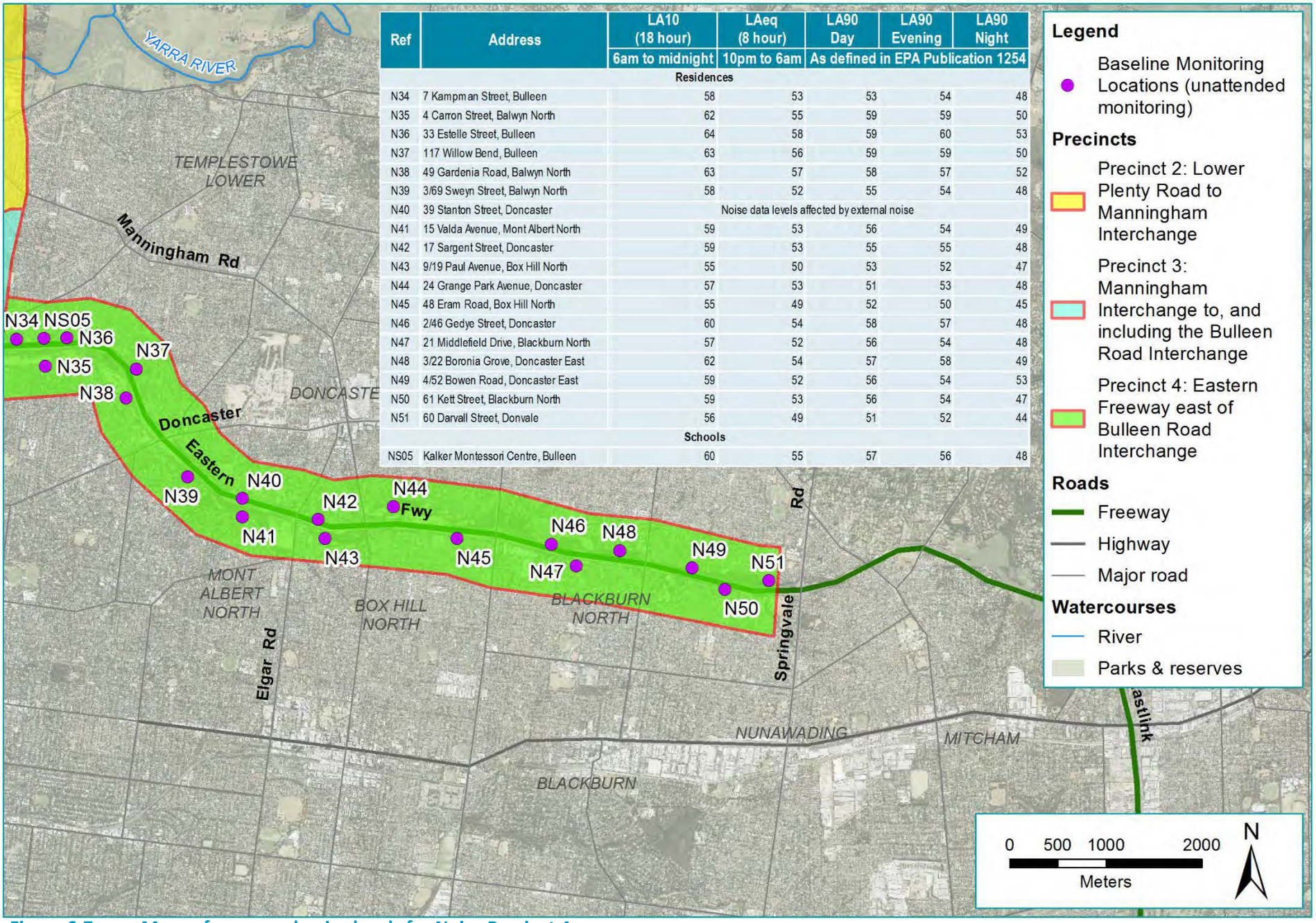
6.5.2 Industrial land use

Industrial land use in Noise Precinct 4 is generally limited to the Joseph Street industrial estate and a power substation located adjacent to the Eastern Freeway. Noise Precinct 4 is separated from the freeway by the Koonung Creek Trail reserve and includes noise walls or mounds.

6.5.3 Field measurements

Noise measurements were undertaken to provide an understanding of the existing conditions at various locations within Noise Precinct 4. The results are presented in

Figure 6-7 and discussed in the following sections. Details of the methodology is provided in **Appendix D** and the monitoring results in **Appendix E.**



Ref	Address	LA10 (18 hour)	LAeq (8 hour)	LA90 Day	LA90 Evening	LA90 Night
		6am to midnight	10pm to 6am	As defined in EPA Publication 1254		
	Residences					
N34	7 Kampman Street, Bulleen	58	53	53	54	48
N35	4 Carron Street, Balwyn North	62	55	59	59	50
N36	33 Estelle Street, Bulleen	64	58	59	60	53
N37	117 Willow Bend, Bulleen	63	56	59	59	50
N38	49 Gardenia Road, Balwyn North	63	57	58	57	52
N39	3/69 Sweyn Street, Balwyn North	58	52	55	54	48
N40	39 Stanton Street, Doncaster	Noise data levels affected by external noise				
N41	15 Valda Avenue, Mont Albert North	59	53	56	54	49
N42	17 Sargent Street, Doncaster	59	53	55	55	48
N43	9/19 Paul Avenue, Box Hill North	55	50	53	52	47
N44	24 Grange Park Avenue, Doncaster	57	53	51	53	48
N45	48 Eram Road, Box Hill North	55	49	52	50	45
N46	2/46 Gedye Street, Doncaster	60	54	58	57	48
N47	21 Middlefield Drive, Blackburn North	57	52	56	54	48
N48	3/22 Boronia Grove, Doncaster East	62	54	57	58	49
N49	4/52 Bowen Road, Doncaster East	59	52	56	54	53
N50	61 Kett Street, Blackburn North	59	53	56	54	47
N51	60 Darvall Street, Donvale	56	49	51	52	44
	Schools					
NS05	Kalker Montessori Centre, Bulleen	60	55	57	56	48

Figure 6-7 Maps of measured noise levels for Noise Precinct 4

6.5.4 Average background noise levels (L_{A90})

Unattended and attended ambient noise monitoring, including those in public open and outdoor recreational spaces, was undertaken to record the average background noise levels (L_{A90}) at each site. This information is detailed in **Table D-5** in **Appendix D.** The longer-term unattended measured noise levels have been used to develop indicative construction noise target levels and to determine SEPP N-1 criteria for the operation of the ventilation structure. These are presented in **Table 6-6**.

Note that short-term measurements were taken over a 30-minute period and are not indicative of compliance with road traffic noise objectives.

6.5.5 Traffic noise monitoring results (L_{A10})

The noise environment was surveyed at 20 residential and community locations along the Eastern Freeway. A summary of the measured unattended surveys is presented in **Table 6-6** showing the average weekday $L_{A10(18hr)}$ noise levels for the monitoring period.

6.5.6 Maximum noise events

Maximum noise events have been considered in at a residential location along the Eastern Freeway in Noise Precinct 4, which is considered representative of receivers along this section of the project alignment.

Figure 6-8 is a summary of average and maximum number of maximum noise level events recorded over the night-time (10 pm to 6 am) measurement period. Maximum night-time noise levels at Site N40 were typically as high as 60 to 70 dBA although measurements were recorded as high as 77 dBA during this period. While these areas are controlled by road traffic noise, it cannot be confirmed that noise associated with each maximum noise level is attributable to road traffic.

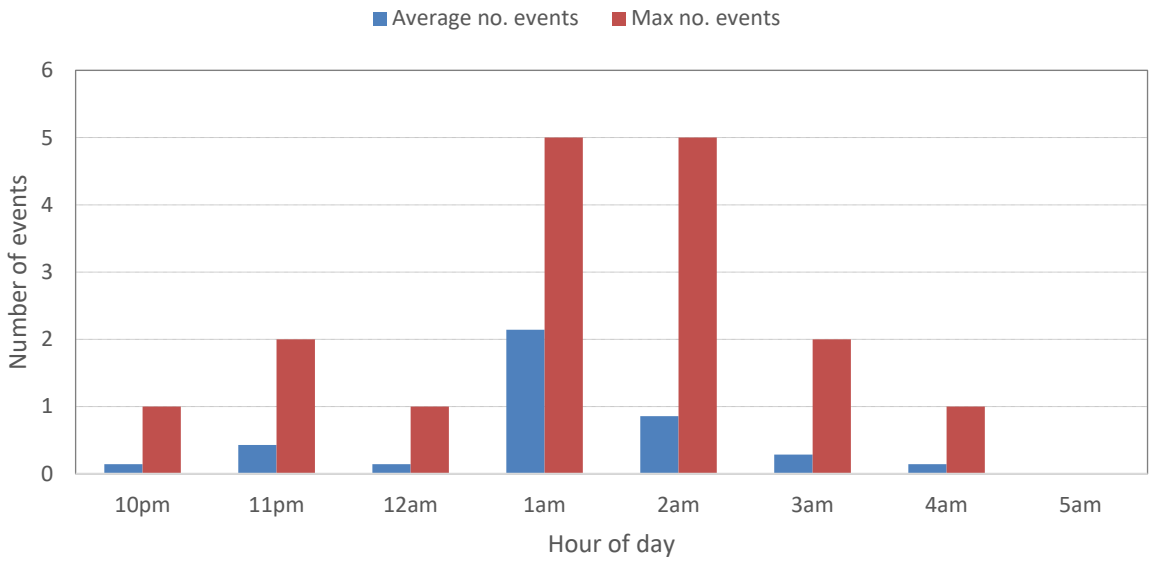


Figure 6-8 Maximum noise level event analysis for Site N40 – 39 Stanton Street

The maximum noise level events shown in **Figure 6-8** identify that these areas are currently exposed to maximum noise levels events that have the potential for awakening reactions. Maximum noise events tend to occur in the early hours of the morning.

It is important to remember that maximum noise events have been assessed with reference to the overall noise conditions at the time ($L_{Aeq(1hr)}$). With an increase in L_{Aeq} noise levels, the difference between L_{Aeq} and maximum noise levels would decrease resulting in fewer maximum noise level events, explaining why the maximum events are most prevalent in the early hours of the morning, when there is much less traffic on the roads.

6.5.7 Summary of existing conditions monitoring

Noise Precinct 4 covers works along the Eastern Freeway east of Bulleen Road to Springvale Road. The suburbs of Balwyn North, Bulleen, Balwyn North, Doncaster, Doncaster East, Month Albert North, Box Hill North, Blackburn North, Donvale and Nunawading border this section of the project alignment. The project boundary covers a mix of residential and community noise sensitive receivers, as well as public open spaces and industrial land use.

Key observations from the existing conditions monitoring along the Eastern Freeway include:

- Ambient noise environment in the areas bordering the Eastern Freeway is dominated by road traffic noise and those residents closest to the Eastern Freeway tend to be above the project's noise criteria.
- Other sources contributing to the local noise environment include noise from occasional passing aircraft, surrounding local roads and local activities.
- Noise walls and occasionally mounds are the typical noise mitigation control for residential areas along the Eastern Freeway. Most open spaces are separated from the freeway by acoustic noise walls. Exceptions to this are along the Koonung Creek Reserve.
- Discrete maximum noise events are typically caused by heavy vehicle movements, the use of vehicle engine brakes and motorbikes. This is typical of major road corridors with inclines or declines of the road gradient.
- Noise sensitive receivers located near ramps tend to experience higher maximum noise levels, due to the stop-start nature of the traffic flow.
- Residences near parks and reserves which do not have noise mitigation controls tend to experience higher levels of road traffic noise.

Details of the methodology is provided in **Appendix D** and the monitoring results in summarised in **Table 6-6** and **Appendix E**.

6.6 Noise Precinct 5: Eastern Freeway Hoddle Street to and Bulleen Road

Noise Precinct 5 extends along the Eastern Freeway from Hoddle Street to Bulleen Road.

Noise Precinct 5 works would include modifications to the Eastern Freeway, including the widening of the freeway to accommodate future traffic volumes, new dedicated bus lanes for the Doncaster Busway and associated works. The suburbs of Clifton Hill, Fairfield, Alphington, Kew, Kew East and Balwyn North border this section of the project alignment. The proposed road widening of the Eastern Freeway is contained to within the existing road reserve.

Noise Precinct 5 predominantly features open space and residential land use.

To establish an understanding of the existing noise and vibration conditions in Noise Precinct 5, the following monitoring was conducted along the project alignment:

- Unattended, long-term noise monitoring at seven residential and noise sensitive locations
- Attended, short-term noise monitoring at three locations in outdoor recreation and public open spaces.

Sensitive receivers within Noise Precinct 5 are summarised in **Table 6-5**. The methodology for this approach is discussed in **Appendix D.**

Table 6-5 Sensitive receivers – Noise Precinct 5

Category	Location/Description
Eastern Freeway, from Hoddle Street to Bulleen Road	
Category A – Noise Sensitive Residential Buildings	Residential land uses are generally one and two-storey detached dwellings built on land above the line of the freeway on the northern boundary of the Eastern Freeway, and in line with the freeway on its southern boundary Residences in this area are generally exposed to high levels of road traffic noise from the Eastern Freeway. The interface between dwellings and the adjacent freeway commonly includes a park or reserve, as well as an acoustic noise wall. The area between Burke Road and Bulleen Road covering the suburb of Balwyn North is predominantly residential interspersed with parks and reserves along the boundary of the Eastern Freeway. Residential areas are generally characterised by low density, detached dwellings. Residences in this area are generally exposed to high levels of road traffic noise from the Eastern Freeway. The interface between dwellings and the adjacent freeway commonly includes a park or reserve, as well as an acoustic noise wall. The area west of Burke Road is a mix of ow rise residential and open parkland. Residences in this area are generally exposed to high levels of road traffic noise from the–Eastern Freeway.
Category B – Noise Sensitive Community Buildings	• Royal Talbot Rehabilitation Centre, 1 Yarra Blvd, Kew. • Melbourne Polytechnic, Yarra Bend Road, Fairfield.
Outdoor Recreation and Public Open Spaces	• Musca Street Reserve, Musca Street, Balwyn North. • Jack O'Toole Reserve, Kilby Road, Kew East. • Hays Paddock, Leason Street, Kew East. • Latrobe Golf Club, Farm Road, Alphington. • Yarra Flats Park.

6.6.1 Commercial land use

There is only isolated commercial activity in Noise Precinct 5, along the line of the Eastern Freeway near Hoddle Street.

Kew Golf Club is located on the north boundary of the Eastern Freeway between Belford Road and Burke Road.

6.6.2 Industrial land use

Industrial land use in Noise Precinct 5 is generally limited to the Joseph Street industrial estate and a power substation located adjacent to the Eastern Freeway. Noise Precinct 5 is separated from the freeway by the Koonung Creek Trail reserve and includes noise walls or mounds.

6.6.3 Field measurements

Noise measurements were undertaken to provide an understanding of the existing conditions at various locations within Noise Precinct 5. The results are presented in **Section 6.7** and **Figure 6-9** and discussed in the following sections.

Details of the methodology is provided in **Appendix D** and the monitoring results in **Appendix E**.

Ref	Address	LA10 (18 hour)	LAeq (8 hour)	LA90 Day	LA90 Evening	LA90 Night
		6am to midnight	10pm to 6am	As defined in EPA Publication 1254		
Residences						
N25	10 Vaughan Crescent, Kew	56	51	55	53	48
N27	32 Kilby Road, Kew East	64	58	59	60	52
N28	20 Willow Grove, Kew East	Noise data levels affected by external noise				
N29	7 Fairway Drive, Kew East	60	54	55	55	50
N30	1549B Old Burke Road, Kew East	62	55	58	58	50
N31	21 Orion Street, Balwyn North	57	51	53	52	47

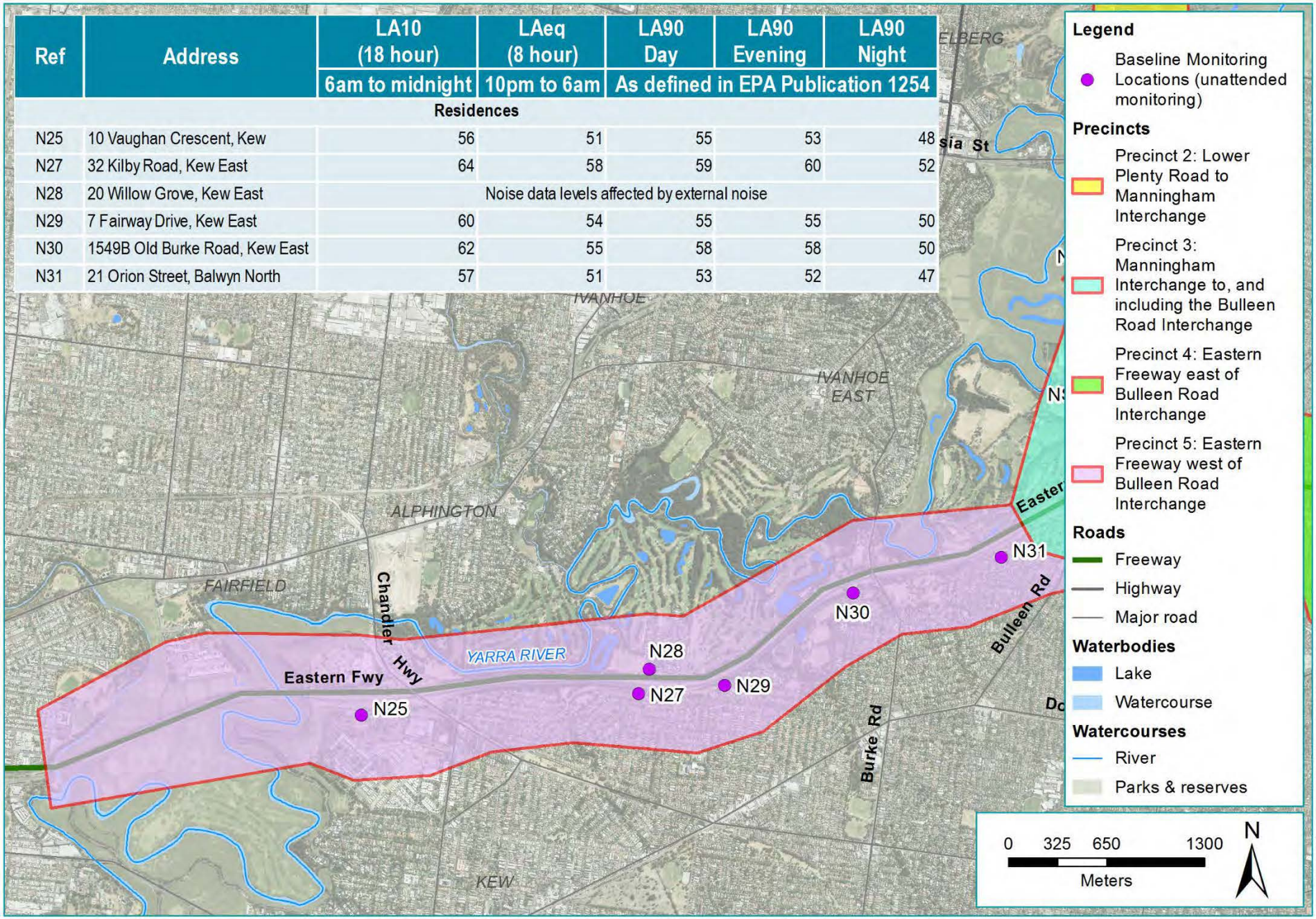


Figure 6-9 Maps of measured noise levels for Noise Precinct 5

6.6.4 Average background noise levels (L_{A90})

Unattended and attended ambient noise monitoring, including those in public open and outdoor recreational spaces, was undertaken to record the average background noise levels (L_{A90}) at each site. This information is detailed in **Table D-5** in **Appendix D.** The longer-term unattended measured noise levels have been used to develop indicative construction noise target levels and to determine SEPP-N1 criteria for the operation of the ventilation structure.

Note that short-term measurements were taken over a 30-minute period and are not indicative of compliance with road traffic noise objectives.

6.6.5 Traffic noise monitoring results (L_{A10})

The noise environment was surveyed at six residential and community locations along the Eastern Freeway. A summary of the measured unattended surveys is presented in **Table 6-6** showing the average weekday $L_{A10(18hr)}$ noise levels for the monitoring period. Locations suitable for the validation of the noise levels are provided in **Appendix G**.

6.6.6 Maximum noise events

Maximum noise events have been considered in two residential locations along the Eastern Freeway, which are representative of receivers along this section of the project alignment.

Figure 6-10 summarises the average and maximum number of maximum noise level events recorded over the night-time (10 pm to 6 am) measurement period at each site. At Site N31, night-time noise levels were typically as high as 75 to 85 dBA and measured as high as 94 dBA. While these areas are controlled by road traffic noise, it cannot be confirmed that noise associated with each maximum noise level is attributable to road traffic.

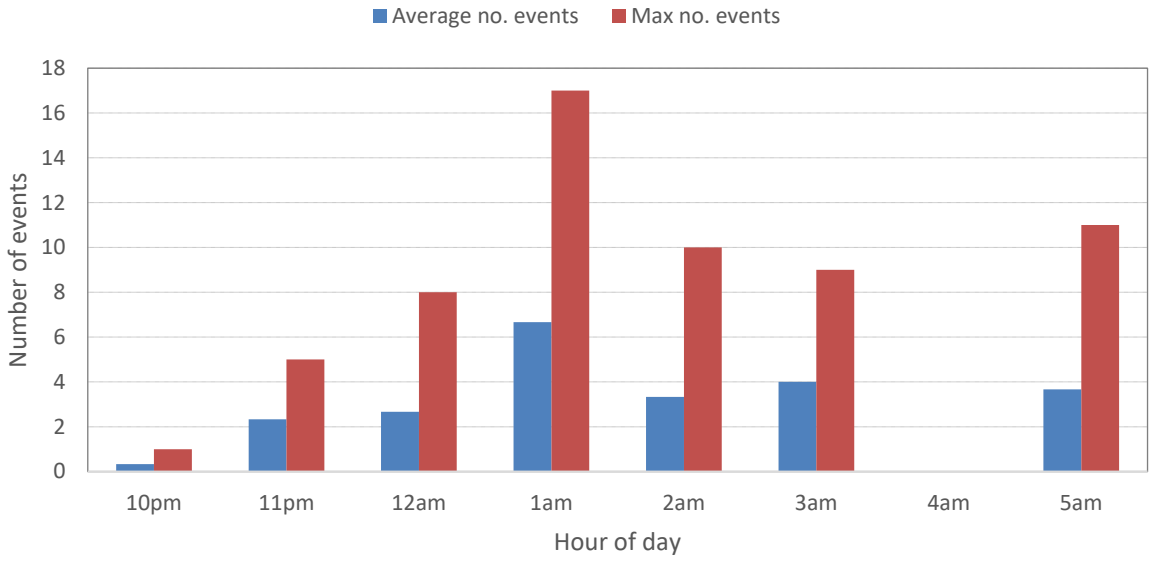


Figure 6-10 Maximum noise level event analysis for Site N31 – 21 Orion Street

The maximum noise level events shown in **Figure 6-10** identify that these areas are currently exposed to maximum noise levels events that have the potential for awakening reactions. Maximum noise events tend to occur in the early hours of the morning.

It is important to remember that maximum noise events have been assessed with reference to the overall noise conditions at the time ($L_{Aeq(1hr)}$). With an increase in L_{Aeq} noise levels, the difference between L_{Aeq} and maximum noise levels would decrease resulting in fewer maximum noise level events, explaining why the maximum events are most prevalent in the early hours of the morning, when there is much less traffic on the roads.

6.6.7 Summary of existing conditions monitoring

Noise Precinct 5 covers proposed works along the Eastern Freeway between Hoddle Street and Bulleen Road. The suburbs of Clifton Hill, Fairfield, Alphington, Kew, Kew East and Balwyn North border this section of the project alignment. The project boundary covers a mix of residential and community noise sensitive receivers, as well as public open spaces and industrial land use.

Key observations from the existing conditions monitoring along the Eastern Freeway include:

- Ambient noise environment in the areas bordering the Eastern Freeway is dominated by road traffic noise and those residents closest to the Eastern Freeway tend to be above the project's noise objectives.
- Other sources contributing to the local noise environment include noise from occasional passing aircraft, surrounding local roads and local activities.
- Discrete maximum noise events are typically caused by heavy vehicle movements, the use of vehicle engine brakes and motorbikes. This is typical of major road corridors with inclines or declines of the road gradient.
- Noise sensitive receivers located near ramps tend to experience higher maximum noise levels, due to the stop-start nature of the traffic flow.
- Residences near parks and reserves which do not have noise mitigation controls, tend to experience higher levels of road traffic noise.

Details of the methodology is provided in **Appendix D** and the monitoring results in **Appendix E**.

6.7 Summary of measured noise levels

The key measured noise indices to be used for ongoing assessment construction and traffic noise assessment purposes are summarised in **Table 6-6**. This table shows the results of the ambient monitoring and whether the data was used:

- In determining the background noise levels in a noise precinct
- If it was used as part of the operation road traffic noise validation process
- For measuring the maximum truck passby noise emission levels.

Table 6-6 Summary of unattended noise levels

Ref	Address	$L_{A10(18hour)}$	$L_{Aeq(8\ hour)}$	L_{A90} Day	L_{A90} Evening	L_{A90} Night	Background	Validation	Max Noise Assessment
		6 am to midnight	10 pm to 6 am	As defined in EPA Publication 1254					
Residences									
N01	34 Edmund Rice Parade, Watsonia North	60	54	55	55	48	✓	✓	✓
N02	12 Eastgate Drive, Greensborough	57	51	52	52	44	✓	✓	
N03	43 Gillingham Street, Watsonia North	56	48	48	47	40	✓	✓	
N04	4 Yonde Court, Greensborough	53	46	48	48	40	✓		
N05	77 Pinehills Drive, Greensborough	noise affected data		50	49	41	✓		
N06	15 Banfield Terrace, Greensborough	noise affected data		45	46	39	✓		
N07	4 Vincent Ct, Greensborough	58	52	52	53	46	✓	✓	
N08	90 Sellars Street, Watsonia North	noise affected data		49	50	41	✓		
N09	22 Sellars Street, Watsonia North	62	54	53	52	41	✓		
N10	21 Boyd Street, Greensborough	55	49	49	48	42	✓		
N11	1 Saxon Court, Greensborough	61	54	53	53	46	✓	✓	
N12	1/470 Greensborough Road, Greensborough	63	56	52	51	42	✓		
N13	34 Ibbottson Street, Watsonia	56	48	44	44	37	✓		
N14	462 Greensborough Road, Watsonia	61	54	50	50	43	✓		
N15	319 Greensborough Road, Watsonia	60	54	50	51	43	✓		
N16	384 Service Road, Watsonia	58	50	46	46	38	✓		
N17	17 Watson Street, Macleod	52	45	45	44	38	✓		
N18	179 Greensborough Road, Macleod	72	63	63	60	48	✓		
N19	115 Greensborough Road, Macleod	72	64	62	57	43	✓		✓
N20	10 Borlase Street, Yallambie	61	55	55	54	49	✓		
N20A	3 Kay Court, Yallambie	61	54	54	53	47	✓		
N21	218 Bulleen Road, Bulleen	65	58	57	55	50	✓		
N22	2 Golden Way, Bulleen	74	65	60	59	47	✓		
N23	3 Ilma Court, Bulleen	62	55	51	50	45	✓		✓
N24	8 Ben Nevis Grove, Bulleen	56	50	50	52	47	✓		
N25	10 Vaughan Crescent, Kew	56	51	55	53	48	✓		
N26	30 Kellett Gr, Kew	failed logger							
N27	32 Kilby Road, Kew East	64	58	59	60	52	✓		
N28	20 Willow Grove, Kew East	Noise data levels affected by external noise					✓		
N29	7 Fairway Drive, Kew East	60	54	55	55	50	✓		
N30	1549B Old Burke Road, Kew East	62	55	58	58	50	✓	✓	

Ref	Address	$L_{A10(18hour)}$	$L_{Aeq(8\ hour)}$	L_{A90} Day	L_{A90} Evening	L_{A90} Night	Background	Validation	Max Noise Assessment
		6 am to midnight	10 pm to 6 am	As defined in EPA Publication 1254					
N31	21 Orion Street, Balwyn North	57	51	53	52	47	✓	✓	✓
N32	52 Columba Street, Balwyn North	56	49	52	51	45	✓	✓	
N33	150 Mountain View Road, Balwyn North	60	55	56	56	49	✓		
N34	7 Kampman Street, Bulleen	58	53	53	54	48	✓	✓	
N35	4 Carron Street, Balwyn North	62	55	59	59	50	✓		
N36	33 Estelle Street, Bulleen	64	58	59	60	53	✓		
N37	117 Willow Bend, Bulleen	63	56	59	59	50	✓		
N38	49 Gardenia Road, Balwyn North	63	57	58	57	52	✓		
N39	3/69 Sweyn Street, Balwyn North	58	52	55	54	48	✓		
N40	39 Stanton Street, Doncaster	Noise data levels affected by external noise							✓
N41	15 Valda Avenue, Mont Albert North	59	53	56	54	49	✓		
N42	17 Sargent Street, Doncaster	59	53	55	55	48	✓	✓	
N43	9/19 Paul Avenue, Box Hill North	55	50	53	52	47	✓	✓	
N44	24 Grange Park Avenue, Doncaster	57	53	51	53	48	✓	✓	
N45	48 Eram Road, Box Hill North	55	49	52	50	45	✓	✓	
N46	2/46 Gedye Street, Doncaster	60	54	58	57	48	✓	✓	
N47	21 Middlefield Drive, Blackburn North	57	52	56	54	48	✓	✓	
N48	3/22 Boronia Grove, Doncaster East	62	54	57	58	49	✓		
N49	4/52 Bowen Road, Doncaster East	59	52	56	54	53	✓	✓	
N50	61 Kett Street, Blackburn North	59	53	56	54	47	✓	✓	
Schools									
NS01	St Mary's Parish Primary, Greensborough	73	63	61	59	49	✓		
NS02	Watsonia Primary School	59	53	50	50	43	✓		
NS03	St Martin of Tours, Rosanna	74	66	65	63	55	✓		
NS04	Belle Vue Primary School, Balwyn North	62	56	56	53	47	✓		
NS05	Kalker Montessori Centre, Bulleen	60	55	57	56	48	✓		
NS06	Marcellin College, Bulleen	67	60	60	56	47	✓		
NS07	Trinity Marles Playing Fields, Bulleen	65	58	57	56	43	✓		

6.8 Project-specific traffic noise corrections

The assessment of traffic noise levels against the night-time WHO requirements requires the relationship between the $L_{A10(18hour)}$ and the $L_{Aeq(8hour)}$. These relationships would be used to determine the relative day-time ($L_{a10(18hour)}$) and night-time ($L_{Aeq(8hour)}$) traffic noise parameters from the CoRTN calculated $L_{A10(18hour)}$.

The median difference between the $L_{A10(18hour)}$ and the $L_{Aeq(8hour)}$ noise index for those locations used in the validation process was shown to be -5.6 dBA. Of relevance, the night-time noise levels include the contribution from one-off events, such as engine brakes, where they are a feature of an area. By comparison, analysis shows that if all locations were used to develop the above relationships (not just the locations used for validation purposes), there would be no meaningful change to the $L_{A10(18hour)}$ to $L_{Aeq(8hour)}$ correction. It is noted that the current traffic curfew would not have had any noticeable effect on this conversion.

A specific model calibration factor of -1.9 dBA was determined based on the measured and predicted traffic noise levels for 2018, as detailed in **Appendix G.** The noise modelling for 2036 assumes the future day-night profile of traffic is similar to the current pattern and on this basis, the measured conversion factors can be applied to the future (2036) predicted traffic levels.

An analysis of the noise surveys used for the calibration locations, indicates there is an average difference of 0.5 dBA between the $L_{A10(18hour)}$ and the $L_{A10(12hour)}$ noise indices. The assessment of Category B buildings is against an $L_{A10(12hour)}$ criterion of 63 dBA on this project, which equates to an equivalent $L_{A10(18hour)}$ level of 62.5 dBA.

7 Risk assessment

A risk assessment of project activities was performed in accordance with the methodology described in **Section 5.5**. The risk assessment has been used as a screening tool to prioritise the focus of the impact assessments and development of EPRs. The risk pathways link project activities (causes) to their potential effects on the environmental assets, values or uses that are considered in more detail in the impact assessment. Risks were assessed for the construction and operation phases of the project.

The identified risks and associated residual risk ratings are listed in **Table 7-1**. The likelihood and consequence ratings determined during the risk assessment process provided in **Appendix C** with the adopted EPRs presented in **Section 11.**

There are no planned events within the surface noise and vibration impact assessment.

Table 7-1 Noise and vibration (surface works) risks

Risk ID	Potential threat and effect on the environment	Risk rating
Construction		
Risk SNV01	Noise generated by surface works during construction (including transport of spoil) causes an increase in noise or vibration affecting amenity at sensitive receivers	Medium
Risk SNV02	Mitigation measures required to mitigate surface works during construction are not feasible, reasonable or practical	Low
Risk SNV03	Human impact vibration (VDV) resulting by surface works during construction (including transport of spoil) causes loss of amenity at sensitive receivers	Low
Risk SNV04	Structural damage to buildings resulting by surface works during construction (including transport of spoil) causes damage to structures	Low
Risk SNV05	Vibration to sensitive scientific equipment from construction works	Low
Risk SNV06	Vibration damage to underground services from construction vibration works	Low
Operation		
Risk SNV08	Traffic noise generated by the redistribution of traffic on the wider road network causes an increase in noise affecting amenity at sensitive receivers	Low
Risk SNV09	Traffic noise mitigation measures required to reduce road traffic noise levels are not feasible, reasonable or practical	Low
Risk SNV10	Additional post-opening mitigation required	Low
Risk SNV11	The traffic noise along North East Link causes an increase in noise affecting amenity at sensitive receivers	Low
Risk SNV12	Human impact vibration (VDV) at sensitive receivers generated by the redistribution of traffic due to operation causes an increase in noise	Low
Risk SNV13	Structural damage at sensitive receivers, resulting from traffic on North East Link	Low
Risk SNV14	Noise emissions from fixed plant exceed criteria and affects amenity at sensitive receivers	Low
Risk SNV15	Reverberant noise in the depressed roadway is not adequately addressed in the noise model	Low
Risk SNV16	Risk of increased engine brake noise along corridor	Medium

8 Construction impact assessment

8.1 Works description

8.1.1 Construction activities

The activities likely to be required to construct the above-ground aspects of the project would involve conventional road and tunnel infrastructure construction equipment such as rock-breakers, earth moving equipment, piling equipment, paving plant, concreting equipment, cranes and road header tunnelling equipment.

A number of scenarios have been developed to assess potential impacts associated with the project's construction. **Table 8-1** outlines the construction scenarios and corresponding activities, as well as noting the anticipated durations that the various works would be completed in.

It should be noted that for the indicated durations, the scheduled activities:

- Would not occur at full capacity
- Would not be expected to be undertaken every day
- Would not be carried out in proximity to individual receivers.

Table 8-1 Construction activities and period of construction

Works	Activities	Hours of work 2			Indicative duration
		Normal	Out of hours works		
		Day	Evening	Night	
General earthworks	Power generation	·	✓	✓	12–24 months
	Demolition of existing structures (no rock hammering)	✓	✓	✓	24–weeks
	Rock hammering of existing concrete structures	✓	✓	✓	6–12 months
	Crushing, screening and vegetation clearing	✓	·	·	3–6 months
Road widening and realignment	Earthworks (with rock hammering)	✓	·	·	Over 24 months
	Road tie-in works (major road)	✓	·	·	6–12 months
Viaduct construction	Ground improvement, piling; columns and pile-caps	✓	✓	✓	6–12 months
	Bridge deck and parapets	✓	✓	✓	12–18 months
Open cut road works	Piling; excavation of decline/trench	✓	✓	✓	12–18 months
	Earthworks (no rock hammering)	✓	✓	✓	12–18 months
	Road tie-in works (major road)	✓	✓	✓	12–24 months
Cut and cover road works	Piling; excavation of decline/trench	✓	✓	✓	6–12 months
	Earthworks (no rock hammering)	✓	✓	✓	Over 24 months
	Road tie-in works (major road)	✓	✓	✓	3–6 months

Works	Activities	Hours of work 2			Indicative duration
		Normal	Out of hours works		
		Day	Evening	Night	
Local road works	Earthworks (no rock hammering) (local road)	✓	✓	·	6–12 months
	Rock hammering only	✓	·	·	3–6 months
	Road tie-in works (local road)	✓	✓	✓	6–12 months
Ground improvement	Ground improvement	✓	·	·	6–12 months
Compound construction	Establishment of construction facilities	✓	·	·	3–6 months
Compound operation	General worksite and car parking	✓	✓	✓	Over 24 months
	Workshop; deliveries; maintenance; storage	✓	✓	✓	Over 24 months
Laydown zone operation	Construction laydown zone	✓	✓	✓	Over 24 months
Shared use path	Shared use path construction	✓	·	·	6–12 months
Share use overpass construction zone	Shared use overpass construction	✓	·	·	13 months
Spoil management zone	Spoil management zone	✓	✓	✓	Over 24 months
Batching plant	Batching plant	✓	✓	✓	Over 24 months
Relocation/Installation of utilities	Service installation relocation	✓	·	·	12–24 months
Drainage works	Service installation relocation	✓	·	·	12–24 months
Land bridges/overpasses	Ground improvement, piling; columns and pile-caps	✓	✓	✓	6–12 months
	Land bridge/overpass construction	✓	✓	✓	6–9 months
Tunnel portal and dive shaft construction	Piling; excavation of decline/trench	✓	✓	✓	6–12 months
	Rock hammering only	✓	·	·	3–6 months
TBM assembly and launch	Tunnel launch preparation	✓	✓	✓	6–12 months
TBM tunnelling	TBM tunnelling	✓	✓	✓	Over 24 months
Construction of access shafts	Access shaft construction	✓	·	·	1–3 months
Construction of ventilation structures	Construction of ventilation structures	✓	·	·	3–6 months
Mined tunnelling	Mined tunnelling (tunnelling, spoil handling and tunnel lining)	✓	✓	✓	Up to 36 months
Toll entry/exit	Toll gantry construction	✓	✓	✓	1–3 months

Note 1: Durations are indicative only and that more definitive durations can only be provided once a contractor is selected and methods are submitted and approved.

Note 2: Out of hours works. This also includes works that occur during. During the daytime on Saturday between 1 pm – 6 pm, on Sunday and public holidays between 8 am – 6 pm.

8.1.2 Working hours

The construction activities would be undertaken in accordance with the EPA Victoria *Noise Control Guidelines* (EPA 1254) during the normal working hours of:

- 7.00 am to 6.00 pm Monday to Friday (day)
- 7.00 am to 1.00 pm on Saturdays (day).

However, some construction activities cannot practicably meet these working hours for reasons including public and construction worker safety, design and quality considerations and to avoid significant traffic interruptions along the Eastern Freeway and M80 Ring Road and surrounding road network. These activities may be considered 'unavoidable works' and would generally start after the evening traffic peak period when traffic volumes have reduced.

Any construction activities being undertaken as unavoidable works must present a clear and unambiguous rationale for them being undertaken outside normal working hours with approval being sought from the Independent Environmental Auditor.

Surface construction activities that may be considered unavoidable works and undertaken outside normal working hours could typically include:

- Switching traffic lanes on the Eastern Freeway and M80 Ring Road to provide access between the completed permanent works associated with the project
- Switching traffic lanes on local roads to newly constructed pavement, including asphalting, line marking and the installation of traffic barriers and signals
- Works over rail lines
- Demolition of infrastructure along the Eastern Freeway to accommodate construction of the project including bridge overpasses, noise walls and vegetation
- Installation of signage and tolling infrastructure in close proximity to traffic
- Relocation of services at locations close to traffic
- Asphalt placement
- Delivery of oversized and precast items to construction sites
- Crane lifts which require lane closures, or where the works are restricted.

Some anticipated unavoidable works that may include noisy construction activities would be completed outside normal working hours are included in the assessment to inform the scheduling of construction and management of noise during the detailed design phase.

Other construction activities which are not qualified as unavoidable works that may be undertaken outside normal construction hours may include:

- Low-noise works that are inherently quiet or unobtrusive and are determined to comply with the relevant inaudibility requirement at the nearest sensitive receiver
- Where the noise impacts are mitigated (for example, no impulsive noise and average noise levels over any half hour do not exceed the background) through actions specified in a Noise Management Plan supported by expert acoustic assessment.

Where construction activities are proposed outside standard construction hours, site-specific CNVMPs would be developed in accordance with EPR NV4. The CNVMPs would include a detailed assessment of potential noise levels and site-specific measures to manage noise impacts and minimise the disturbances at affected receivers.

The CNVMPs would include a framework for the management of impacts and the application of additional mitigation, which would closely follow the NSW Roads and Maritime Services *Construction Noise and Vibration Guideline* (CNVG), which is discussed in greater detail in **Appendix F.**

Except for emergency works, no construction activities would take place outside standard hours without prior approval of the Independent Environmental Auditor and prior discussion with and/or notification of local residents and businesses as per EPR NV4.

8.1.3 Construction schedule

Subject to planning approval, construction of the project is planned to start in the second quarter of 2019, with full completion planned for mid-2027 (including commissioning). The indicative construction program for the project is shown in **Figure 8-1.**

Figure 8-1 Indicative construction schedule

8.1.4 Locations of works

Not all works (shown in **Table 8-1**) would be required throughout the entire project alignment. **Table 8-2** gives an overview of the works and various construction activities anticipated to be required in each of the project Noise Precincts together with the actual assessed scenarios which have been modelled.

Table 8-2 Construction activity locations

Works	Activities	Assessed scenarios	Noise Precinct				
			1	2	3	4	5
			North East Link North (M80 and Plenty Rd to Lower Plenty Rd)	North East Link Tunnel (Lower Plenty Rd - Manningham Rd Int)	North East Link South (Manningham Rd Int to Eastern Fwy Int)	Eastern Fwy Upgrades (East)	Eastern Fwy Upgrades (West)
General	General earthworks (topsoil removal, clearing and grubbing vegetation)	Crushing, screening and vegetation clearing Earthworks (with rock-breakers) Earthworks (no rock-breakers)	•	•	•	•	•
	Demolition of existing structures	Demolition – Kempston Street Bridge Demolition – Grimshaw Street Bridge Demolition – Doncaster Road Bridge	•			•	•
	Ground improvement			•	•		

Works	Activities	Assessed scenarios	Noise Precinct				
			1	2	3	4	5
			North East Link North (M80 and Plenty Rd to Lower Plenty Rd)	North East Link Tunnel (Lower Plenty Rd - Manningham Rd Int)	North East Link South (Manningham Rd Int to Eastern Fwy Int)	Eastern Fwy Upgrades (East)	Eastern Fwy Upgrades (West)
Operation centre/ workshop/ laydowns/ construction zones	Compound (construction/operation)	Compound construction Compound operation	•	•	•	•	•
	Construction laydown zone		•	•	•	•	•
	Spoil management zone		•	•		•	•
Utility works	Relocation of communications/transmission towers		•				
	Sewer relocation				•		
	Pressure reducing station relocation		•				
	New substations			•	•		
Drainage and water treatment	Waterway realignment/diversions		•		•	•	•
	Waterway culvert construction				•	•	•
	Water treatment plant construction			•	•		
Surface works	Road widening and realignment	Road tie-in works (major road)	•	•	•	•	•
	Viaduct road construction	Viaduct earthworks		•	•	•	
	Interchange construction	Viaduct construction	•	•	•	•	
	Land bridges/overpasses					•	
	Local road works (adjacent to North East Link)	Land bridge/overpass construction	•	•	•	•	•
	Shared used road works		•		•	•	•
Excavation works	Open cut decline/trench	Piling of decline/trench Excavation of surface of decline/trench Excavation at 5-m depth decline/trench	•	•			
	Cut and cover	Piling of Manningham cut/cover Excavation of surface of Manningham cut/cover Excavation at 5-m depth Manningham cut/cover		•	•		
Tunnelling	Tunnel Portal and Dive Shaft Construction	Piling of decline/trench Excavation of surface of decline/trench Excavation at 5-m depth decline/drench Tunnel launch preparation Tunnel launch preparation (alternative location)		•	•		
	Mined tunnelling				•		
	TBM assembly and launch	Tunnel launch preparation Tunnel launch preparation (alternative location)		•			
	TBM tunnelling	TBM tunnelling TBM tunnelling (alternative location)		•			
	Construction of access shafts			•	•		
	Construction of ventilation systems				•		
Freeway management	Toll entry/exit		•	•	•	•	

8.2 Overview of construction noise modelling

All details relating to the methodology and assumptions for the noise modelling of construction impacts are provided in **Appendix F.**

8.3 Predicted noise levels and NML exceedances – Noise Precincts

The assessment evaluates the risk (SNV01) that noise generated by surface works during construction causes an increase in noise that adversely impacts the amenity at sensitive receivers. This is primarily done through evaluating worst case predicted levels against guideline targets of EPR NV 3.

Table 8-3 Risk table extract

Risk ID	Potential threat and effect on the environment
Risk SNV01	Noise generated by surface works during construction (including transport of spoil) causes an increase in noise or vibration affecting amenity at sensitive receivers
Risk SNV02	Mitigation measures required to mitigate surface works during construction are not feasible, reasonable or practical

To manage the risk (SNV02), as shown in **Table 8-3**, where mitigation measures required to mitigate surface works during construction are not feasible, reasonable or practical a framework for the management of impacts and the application of additional mitigation has been developed which follows the approach by the complementary NSW documents, the *Interim Construction Noise Guideline* (ICNG) and the *Construction Noise and Vibration Guideline* (CNVG). This framework uses Noise Management Levels (NML) that are determined as a function of the background noise level, that align with the requirements of EPR NV3 and would be adopted by all requisite CNVMPs as necessitated by EPR NV4.

The methodology outlined in CNVG and the use of NMLs would provide a tool for determining suitable levels of additional mitigation that can be applied in each location where the project construction noise criteria is exceeded.

The following tables colour the predicted noise levels based on the exceedance of the NML during that period and for that receiver type as derived (refer to in **Section 4.8**). A description of the subjective perception of NML exceedance bands is given below:

- Noise levels 1 to 10 dBA above NML – noticeable to clearly audible
- Noise levels 11 dBA to 20 dBA above NML – clearly audible to moderately intrusive
- Noise levels >20 dBA above NML – moderately intrusive to highly intrusive.

For most construction activities, it is expected that construction noise levels would frequently be lower than the levels shown in the noise map presented in **Appendix H**, which show the worst-case noise prediction for all construction scenarios. Specific impacts in each of the Noise Precincts are discussed further in the subsequent sections.

8.3.1 Noise Precinct 1 (North)

Noise Precinct 1 covers the northern most part of North East Link and construction works generally include:

- The widening of the M80 Ring Road and Greensborough Bypass
- The grade-separated Greensborough Bypass interchange

- The Grimshaw Street interchange
- Temporary relocation of Watsonia railway station car park
- The trench section, land bridges and cut and cover tunnels
- Lower Plenty Road interchange and northern tunnel portal.

Noise Precinct 1 corridor predominantly comprises residential properties. A limited number of commercial properties are located to the east of the Grimshaw Street intersection and to the west near Watsonia railway station. Educational institutions include St Mary's Parish Primary School off Grimshaw Street and Watsonia Primary School off Meagher Street.

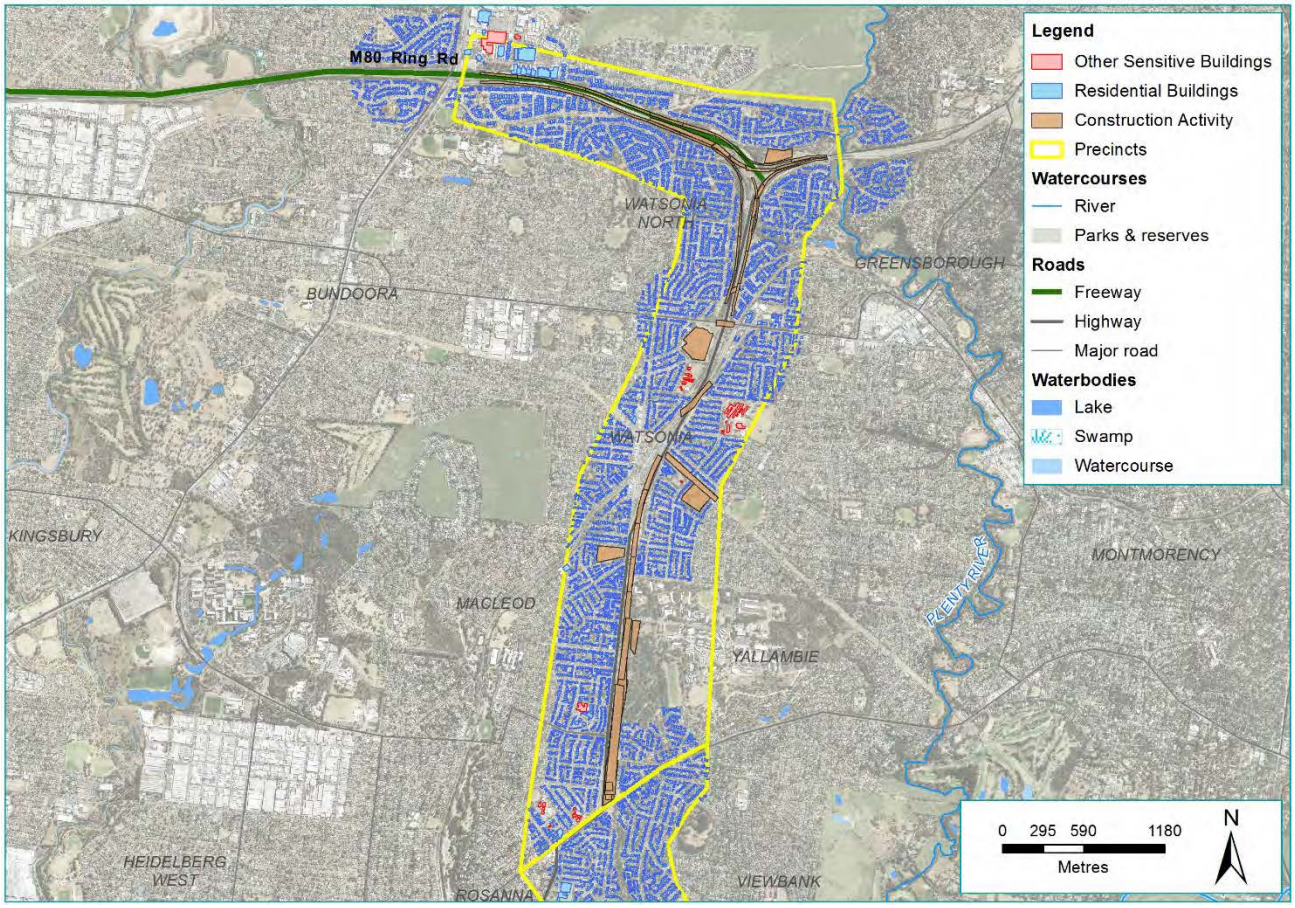


Figure 8-2 Noise Precinct 1 modelled construction works (North)

The predicted NML exceedances in Noise Precinct 1 are summarised in **Table 8-4**. The assessment presented takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are summarised in bands of 10 dBA and are separated into daytime, evening and night-time periods, as appropriate.

Table 8-4 Overview of predicted NML exceedances – Noise Precinct 1

Activity ID	Scenario	Duration[1] (Months)	Number of Noise Sensitive Buildings									
			HNA[2, 3]	Normal			Out of hours works [4]					
				Daytime			Evening			Night-time		
	(NML Exceedance levels ->)			1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA
W.0001	Compound construction	3 – 6	-	-	-	-						
W.0002	Compound operation	> 24	-	-	-	-	-	-	-	-	-	-
W.0003	Demolition – Kempston Street Bridge	3 – 6	13	50	11	5	131	29	8	325	99	26
W.0004	Demolition – Grimshaw Street Bridge	3 – 6	-	47	6	-	164	18	-	736	95	9
W.0006a	Piling of decline/trench	12 – 18	-	11	-	-						
W.0006b	Excavation of surface of decline/trench	12 – 18	-	11	-	-						
W.0006c	Excavation at 5-m depth decline/trench	12 – 18	-	72	1	-						
W.0007	Land Bridge/overpass construction	9 – 9	-	2	-	-						
W.0008	Crushing, screening and vegetation clearing M80 Ring Road	3 – 6	56	320	74	-						
W.0009	Earthworks (with rock-breakers)	6 – 12	4	154	12	-						
W.0010	Road tie-in works (major road)	> 24	39	245	50	-						
W.0014	Tunnel launch preparation (north option)	6 – 12	3	9	-	-						
W.0015	TBM tunnelling (north option)	> 24	-	-	-	-	-	-	-	3	-	-
W.0017	Viaduct construction	12 – 18	-	15	1	-	64	9	-	307	27	6
W.0018	Viaduct earthworks	12 – 18	-	10	1	-	40	5	-	283	17	3
W.0020 a	Watsonia railway station Clearing and civils	<3	-	4	-	-						
W.0020 b	Watsonia railway station Pavement and road tie ins	3 – 6	-	1	-	-						

Legend

1 - 10 dB above NML (noticeable to clearly audible) | 11 dB - 20 dB above NML (clearly audible to moderately intrusive) | > 20 dB above NML (moderately intrusive to highly intrusive)

Note 1: Durations should be regarded as indicative. The duration of the impacts would be less than the overall duration and depends on the rate of progress.

Note 2: HNA=Highly Noise Affected. Based on NSW ICNG definition (predicted L_{Aeq} noise at residential receiver is 75 dBA or greater) during the day.

Note 3: Based on worst-case predicted noise levels.

Note 4: Out of hours works. During the daytime this refers to the period on Saturday between 1 pm – 6 pm, on Sunday and public holidays between 8 am – 6 pm.

The above shows that during normal construction hours moderately intrusive noise impacts (11 to 20 dBA above NML) may occur at receivers adjacent to the road corridor in Watsonia North and Greensborough from the clearing and widening works along the M80 Ring Road and Greensborough Road. Similarly, the receivers adjacent to the excavation works of the decline trench in Watsonia and Macleod may experience moderately intrusive impacts while intensive works are nearby, particularly when the rock breaker is operating.

Construction activities are anticipated to occur into the evening and night-time period due primarily to site occupation and safety considerations and may potentially impact a significant number of receivers. These include the residential areas adjacent to receivers adjacent to the road corridor in Watsonia North and Greensborough surrounding the works required for demolition of the Kempston Street Bridge, as well as at Grimshaw Street and aspects of the construction of elevated viaduct of the northern interchange.

However, is however that during most activities it is expected that construction noise levels would frequently be lower than the worst-case levels predicted above for significant periods of time. This would be apparent as works move around the site and are therefore more distant from receivers, and when less noisy activities are being undertaken.

8.3.1.1 Worst-case impacts during standard daytime construction hours

During standard daytime construction hours,

shows that activities which use noise intrusive plant items, such as a rock-breaker, tub grinder or concrete saw result in the most receivers with NML exceedances. The highest impacts are predicted during the following works in Noise Precinct 1:

- W.0003 – Demolition – Kempston Street Bridge
- W.0004 – Demolition – Grimshaw Street Bridge
- W.0006c – Excavation at 5-m depth decline/trench
- W.0008 – Crushing, screening and vegetation clearing
- W.0010 – Road tie-in works (major road).

The activities with potential for the highest number of NML exceedances are ‘W.0008 – Crushing, Screening and Vegetation Clearing’, with approximately 56 receivers and ‘W.0010 – Road Tie-in Works (Major Road)’ with approximately 39 receivers in the Highly Noise Affected category. This is a result of these activities being linear and required along a significant length of the project. In the demolition scenarios the use of the rock breaker is required in a more confined area and so the impacts are more localised.

Figure 8-3 indicates the distribution of the predicted exceedances for the activity ‘W.0008 – Crushing, Screening and Vegetation Clearing’ for receivers within Noise Precinct 1 during the daytime.

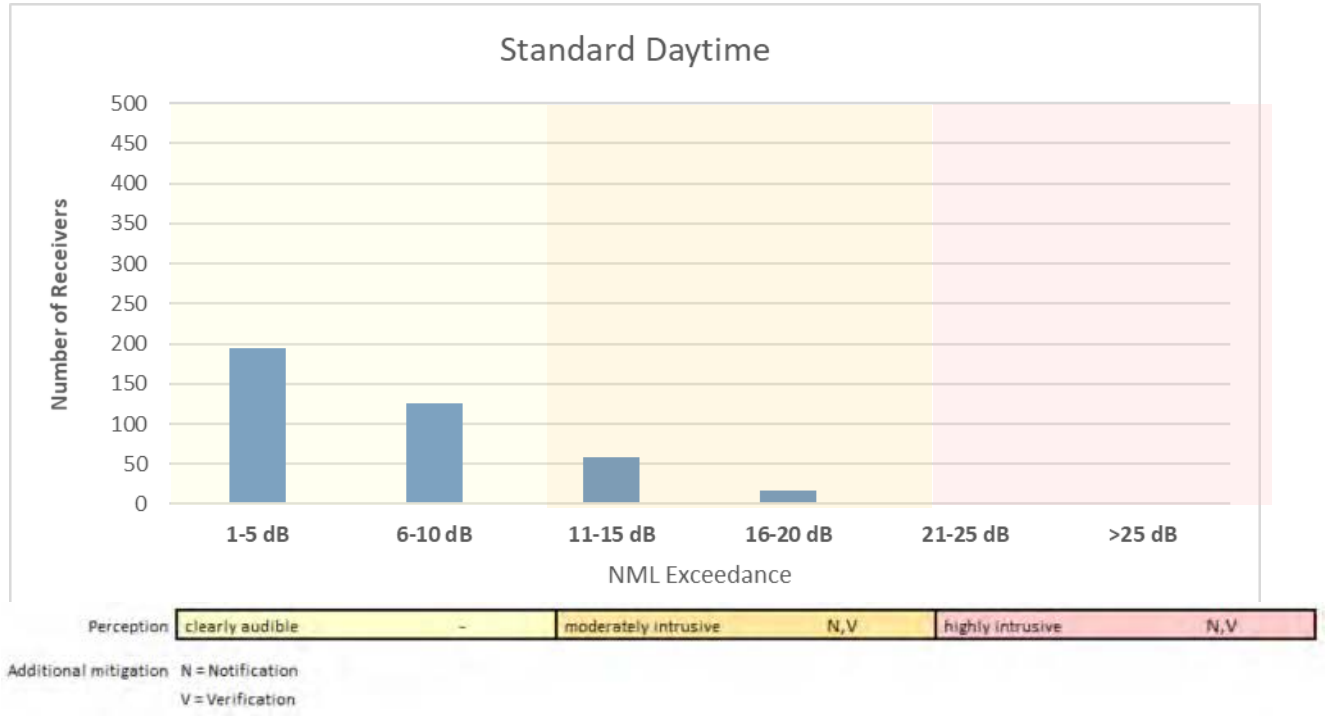


Figure 8-3 **NML exceedances daytime – W.0008 – crushing, screening and vegetation clearing (with tub grinder)**

Figure 8-3 shows that the predicted worst-case scenario for this activity is unlikely to result in highly intrusive noise impacts (>20 dBA above NML) and up to 74 receivers experiencing moderately intrusive noise impacts (11 to 20 dBA above NML). Most of the receivers in Noise Precinct 1 are subject to considerably lower or no NML exceedances.

The highest impacts are typically seen at receivers immediately adjacent to the clearing activities and are primarily due to the operation of the tub grinder/mulcher, which is likely only to be required to be operated for a relatively short period (several days only) before being relocated to a different area. On-site noise mitigation options would include: strategic placement of the tub grinder/mulcher away from residences, temporary acoustic shielding and the management of equipment and processes.

Figure 8-4 indicates the distribution of the predicted exceedances for the activity 'W.0006c – Excavation at 5 m depth Decline/Trench' for receivers within Noise Precinct 1 during the daytime.

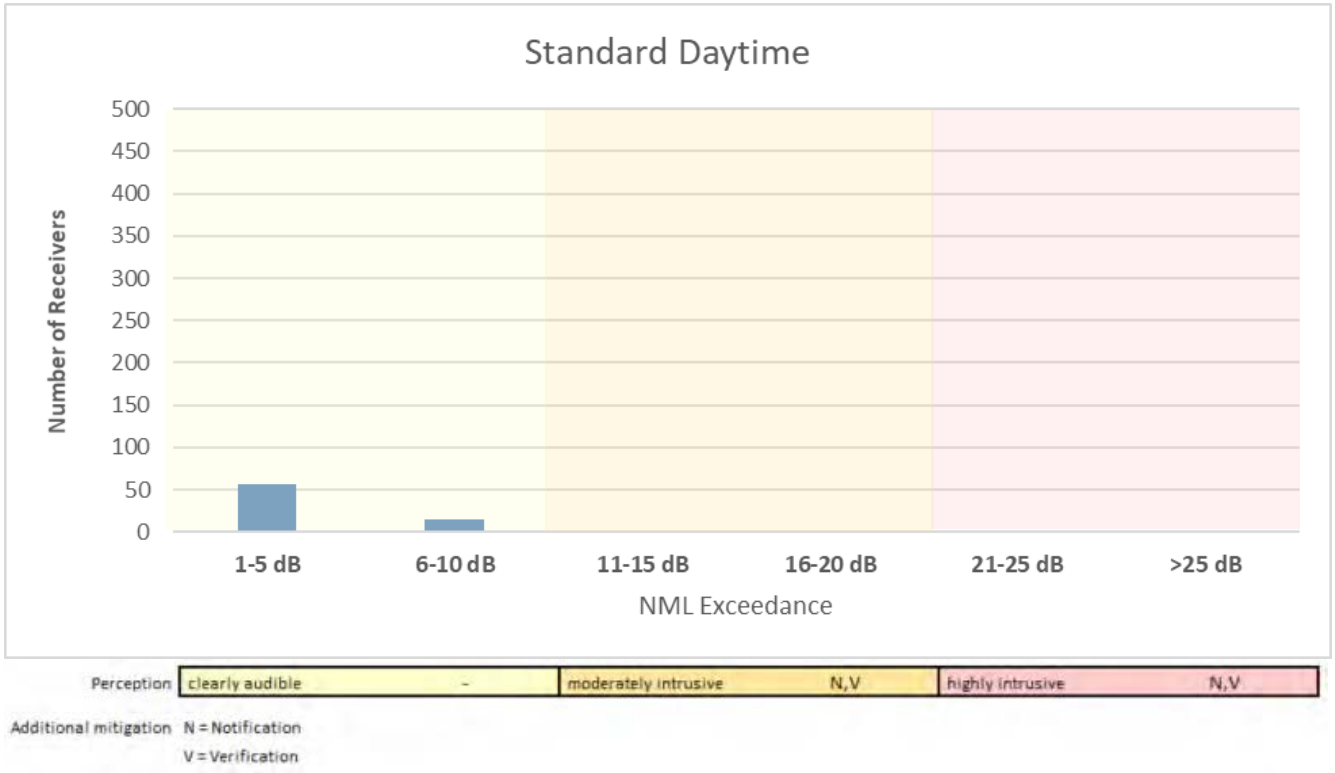


Figure 8-4 NML exceedances daytime – W.0006c – excavation at 5m depth decline/trench (with rock breakers)

Figure 8-4 shows that the predicted worst-case scenario for this activity is unlikely to result in highly intrusive noise impacts (>20 dBA above NML) and none categorised as 'highly noise affected'. The predictions indicate that a single receivers may experience moderately intrusive noise impacts (11 to 20 dBA above NML) and the majority of the receivers in Noise Precinct 1 are subject to lower levels of impacts as a result of this activity.

The above impacts result from the use of rock-breakers in this construction activity. As the decline trench is excavated deeper the works would become progressively more shielded. When the rock-breakers are not in use the noise levels and corresponding NML exceedances are predicted to reduce by around 9 dBA which eliminates the NML exceedance for the majority of identified receivers.

The duration of the total activity is anticipated to be around 12 to 18 months. As construction activity progresses along the project alignment, the worst-case predicted impacts at any one receiver would be expected for a shorter duration. Potential on-site noise mitigation options would include:

- Use of alterative excavation methods other than rock breaking (with large rockbreaker)
- Hoarding around excavation area
- Temporary acoustic shielding around equipment
- Particularly noisy operations should be confined to periods of the day where residents are likely to be at work or not at home.

8.3.1.2 Worst-case Impacts during out-of-hours works

Construction activities outside standard daytime construction hours would likely be required regularly in Noise Precinct 1 given the interface constraints that limit the hours upon which works can take place safely.

During out of hours works, **Table 8-4** shows that activities which use noise intrusive plant items, such as a rock-breaker, result in the most receivers with NML exceedances. The highest impacts are predicted during the following construction activities in Noise Precinct 1:

- W.0003 – Demolition – Kempston Street Bridge
- W.0004 – Demolition – Grimshaw Street Bridge
- W.0017 – Viaduct construction
- W.0018 – Viaduct earthworks.

Figure 8-5 indicates the distribution of exceedances for 'W.0004 – Demolition – Grimshaw Street Bridge' for receivers within Noise Precinct 1 during the night-time.

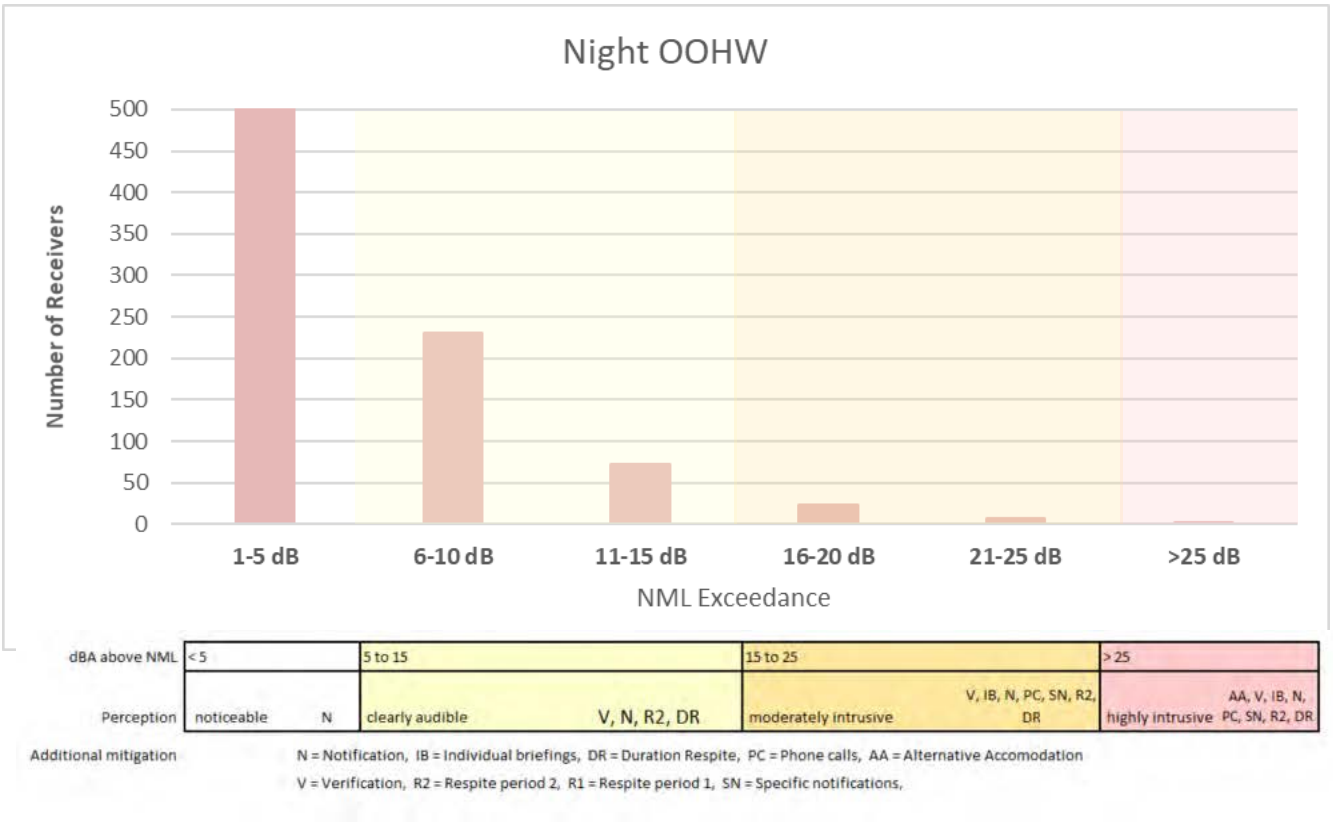


Figure 8-5 NML exceedances night-time – 'W.0004 – demolition – Grimshaw Street Bridge (with rock breakers)'

Figure 8-5 shows that the predicted worst-case scenario for this activity may result in highly intrusive noise impacts (>25 dBA above NML) at up to 2 receivers. The predictions indicate that up to 30 receivers may experience moderately intrusive noise impacts (15 to 25 dBA above NML) and that the works may be clearly audible at up to 303 receivers (5 to 15 dBA above NML).

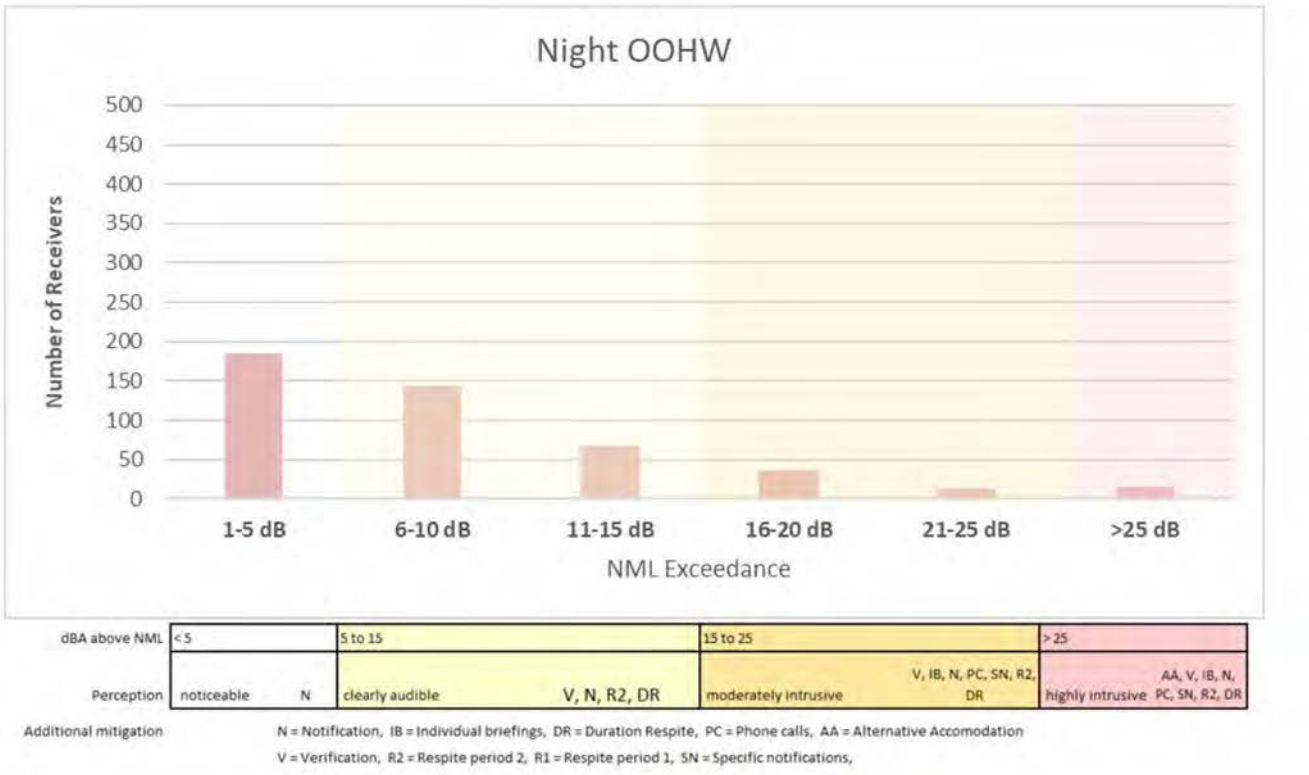


Figure 8-6 NML exceedances night-time – 'W.0003 – demolition – Kempston Street bridge (with breaker)'

Figure 8-6 shows that the predicted worst-case scenario for this activity may result in highly intrusive noise impacts (>25 dBA above NML) at up to 14 receivers. The predictions indicate that up to 46 receivers may experience moderately intrusive noise impacts (15 to 25 dBA above NML) and that the works may be clearly audible at up to 207 receivers (5 to 15 dBA above NML).

The above night-time impacts from bridge demolition works result from the use of rock-breakers in this construction activity.

Potential on-site noise mitigation options would include:

- Use of alterative demolition methods to rock breaking
- Hoarding around demolition construction area
- Localised temporary acoustic shielding around equipment
- Particularly noisy operations should be confined to periods of the day where possible.

8.3.1.3 Other sensitive receivers

Other sensitive receivers such as educational facilities, hospitals and childcare centres which are potentially affected by construction activities in Noise Precinct 1 have been assessed against the criteria detailed in **Section 4.8.**

No exceedances of the daytime NML for other sensitive receivers are predicted.

8.3.2 Noise Precinct 2 (tunnel section and Manningham Road interchange)

Noise Precinct 2 covers the tunnel section of North East Link and generally includes:

- North East Link tunnels
- Manningham Road interchange
- Manningham Road cut and cover tunnel section.

The Noise Precinct 2 corridor predominantly comprises residential properties south of Lower Plenty Road (south of the northern portal) to the Manningham Road interchange. It comprises a section of the tunnels and is predominantly commercial properties around the Manningham Road interchange with a mixture of commercial and residential properties to the east of Bulleen Road.

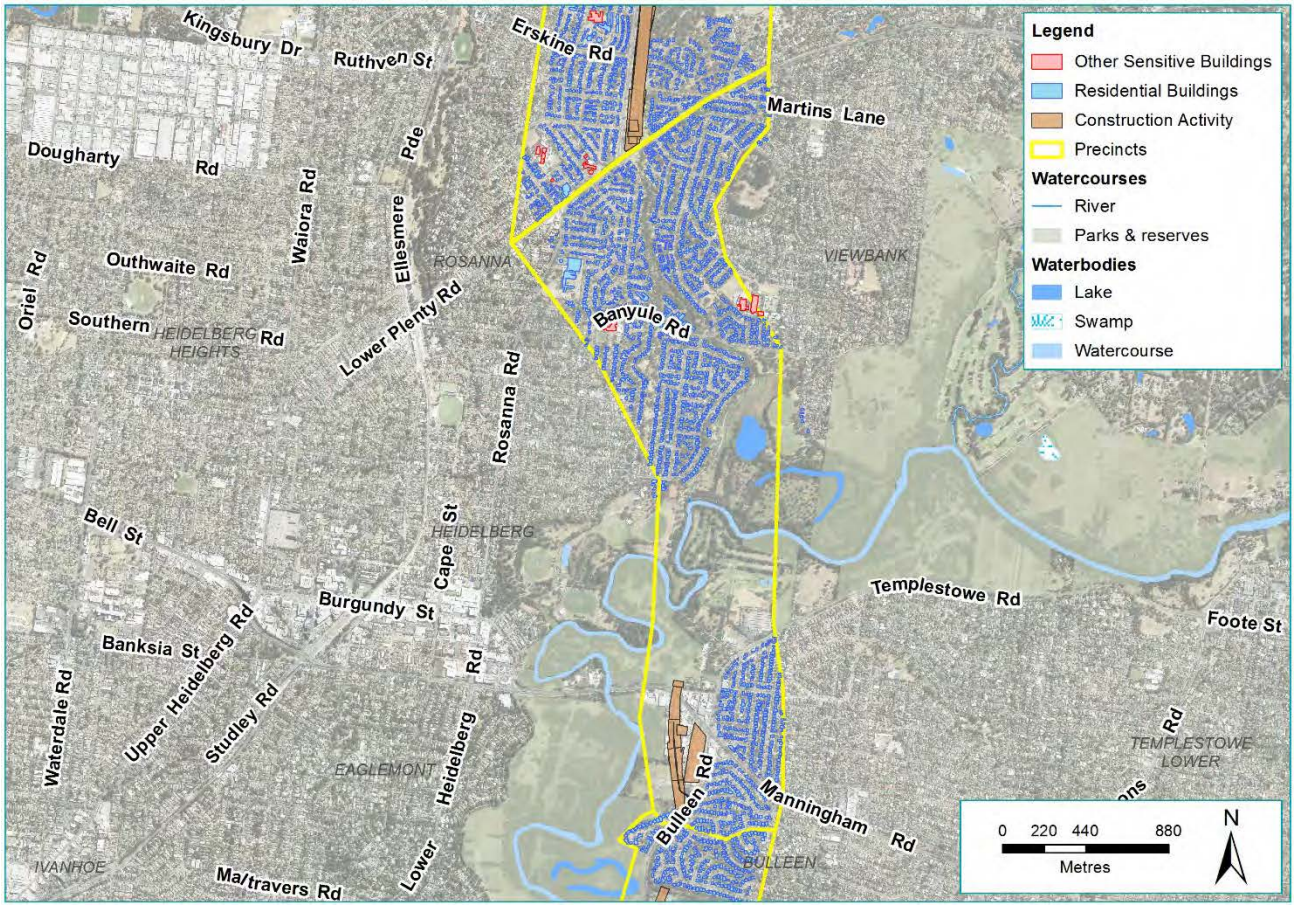


Figure 8-7 Noise Precinct 2 modelled construction works (tunnel portals and tunnel section)

The predicted NML exceedances in Noise Precinct 2 for all receivers are summarised in **Table 8-5**. The assessment presented takes into consideration all construction scenarios associated with the project in this area. The number of receivers predicted to experience exceedances of the NMLs are summarised in bands of 10 dBA and are separated into daytime, evening and night-time periods, as appropriate.

Table 8-5 Overview of predicted NML exceedances – Noise Precinct 2

Activity ID	Scenario	Duration[1] (Months)	Number of Noise Sensitive Buildings									
			HNA[2,3]	Normal			Out of hours works [4]					
				Daytime			Evening			Night		
	(NML Exceedance levels ->)			1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA
W.0001	Compound construction	3 – 6	-	-	-	-						
W.0002	Compound operation	> 24	-	-	-	-	-	-	-	-	-	-
W.0006a	Piling of decline/trench	12 – 18	-	-	-	-						
W.0006b	Excavation of surface of decline/trench	12 – 24	-	-	-	-						
W.0006c	Excavation at 5-m depth decline/trench	> 24	-	7	-	-						
W.0014	Tunnel launch preparation (south option)	12 – 18	-	-	-	-						
W.0015	TBM tunnelling (south option)	> 24	-	-	-	-	-	-	-	-	-	-
W.0016a	Piling of Manningham Rd cut/cover	12 – 18	1	1	-	-						
W.0016b	Excavation of surface of Manningham Rd cut/cover	12 – 18	1	1	-	-						
W.0016c	Excavation at 5-m depth Manningham Rd cut/cover	6 – 12	-	5	1	-						
W.0019a	TBM retrieval ground prep	3 – 6	-	-	-							
W.0019b	TBM retrieval Piling	3 – 6	-	-	-							
W.0019c	TBM retrieval Excavation	6 – 9	-	-	-							
W.0019d	TBM retrieval equipment removal	<3	-	-	-							

Legend

1 - 10 dB above NML (noticeable to clearly audible) | 11 dB - 20 dB above NML (clearly audible to moderately intrusive) | > 20 dB above NML (moderately intrusive to highly intrusive)

Note 1: Durations should be regarded as indicative. The duration of the impacts would be less than the overall duration and depends on the rate of progress.

Note 2: HNA=Highly Noise Affected. Based on NSW ICNG definition (predicted L_{Aeq} noise at residential receiver is 75 dBA or greater) during the day.

Note 3: Based on worst-case predicted noise levels.

Note 4: Out of Hours Works. During the daytime this refers to the period on Saturday between 1 pm – 6 pm, on Sunday and public holidays between 8 am – 6 pm.

The above shows that construction noise levels that are clearly audible are predicted at a relatively small number of receivers in Rosanna are predicted during the excavation of the decline trench near Lower Plenty Road in the north of Noise Precinct 2 and at a relatively small number of receivers in Bulleen during the excavation of the Manningham Road cut and cover tunnels in the south of this Noise Precinct.

However, it is noted that during most activities it is expected that construction noise levels would frequently be lower than the worst-case levels predicted above for significant periods of time, such as when the works move around the site and are more distant from receivers, and when less noisy activities are being undertaken.

8.3.2.1 Worst-case Impacts during standard daytime construction hours

During standard daytime construction hours, **Table 8-5** shows that activities which use noise intrusive plant items, such as a rock-breaker, result in the most receivers with NML exceedances. The highest impacts are predicted during the following works in Noise Precinct 2:

- W.0016c – Excavation at 5-m depth Manningham Road cut/cover.

Figure 8-8 indicates the distribution of the predicted exceedances for this activity for receivers within Noise Precinct 2 during the daytime.

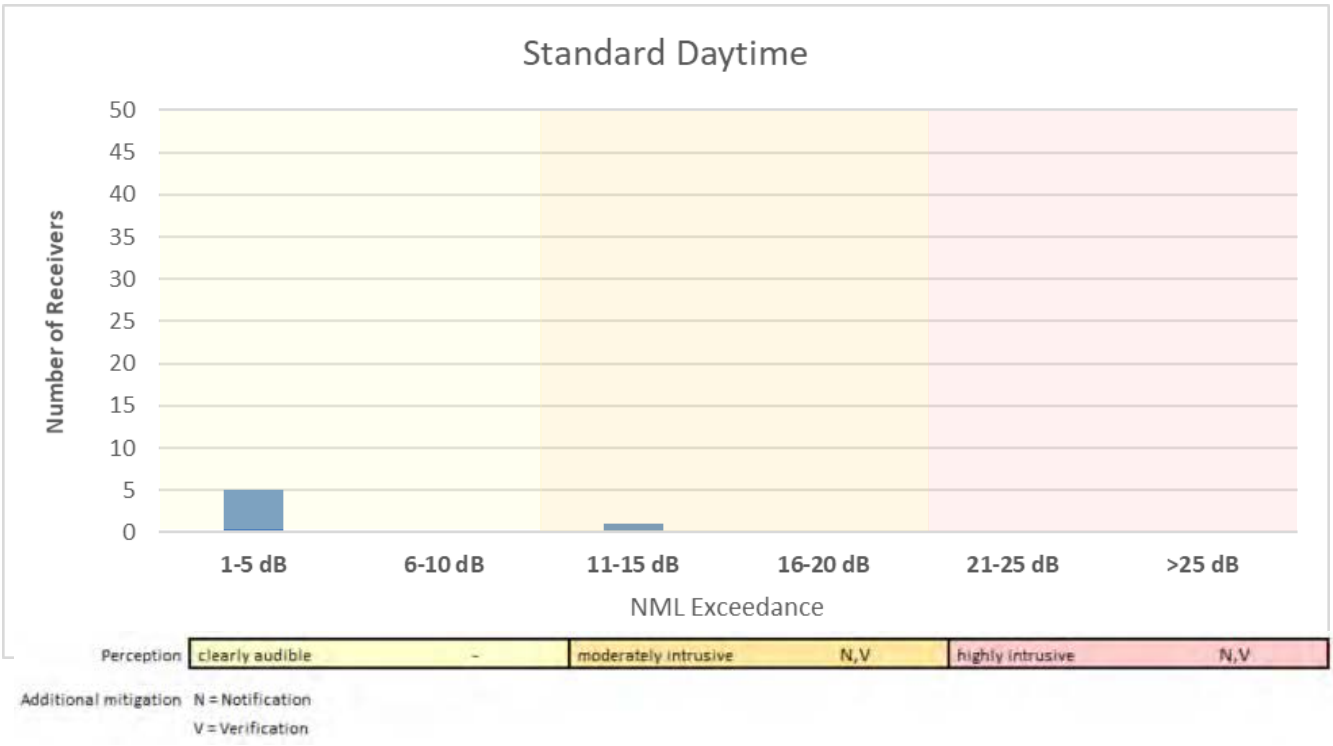


Figure 8-8 NML exceedances daytime – 'W.0016c – excavation at 5-metre depth Manningham Road cut/cover (with rock-breakers)'

Figure 8-8 shows that the predicted worst-case scenario for this activity may result in moderately intrusive noise impacts (11 to 20 dBA above NML) is limited to 1 receiver, with the majority of the receivers in Noise Precinct 2 being subject to considerably lower, or no NML exceedances. No receivers are expected to be in the Highly Noise Affected category.

The above impacts result from the use of a rock-breaker in this construction activity. As the trench would be excavated deeper into harder ground which may necessitate the use of rock-breakers, the works would become progressively more shielded.

When the rock-breakers were not in use, the noise levels and corresponding NML exceedances are predicted to reduce by around 9 dBA which eliminates the NML exceedances.

The duration of the total activity is anticipated to be around 12 to 18 months. As construction progresses along the project alignment, the worst-case predicted impacts at any one receiver would be expected for a shorter duration.

8.3.2.2 Other sensitive receivers

Other sensitive receivers such as educational facilities, hospitals and childcare centres which are potentially affected by construction activities in Noise Precinct 2 have been assessed against the criteria detailed in **Section 4.8.**

No exceedances of the daytime NML for other sensitive receivers are predicted.

8.3.3 Noise Precinct 3 (Manningham Road interchange to Eastern Freeway interchange)

Noise Precinct 3 covers the northern most part of North East Link and generally covers:

- Manningham Road cut and cover tunnel s
- South tunnel portal
- Eastern Freeway interchange.

Noise sensitive receivers in the Noise Precinct 3 corridor predominantly comprise:

- Residential properties to the north of the Marles Playing Fields at Trinity Grammar School Sporting Complex in Bulleen
- Residential properties to the north and south of Thompsons Road in Bulleen
- Residential properties to the east and west side of Bulleen Road in Balwyn North
- The educational facilities of Bellevue Primary School and Marcellin College.

Commercial properties in Noise Precinct 2 include the Veneto Club and Manningham Hotel and Club and well as numerous sporting clubs and playing fields.

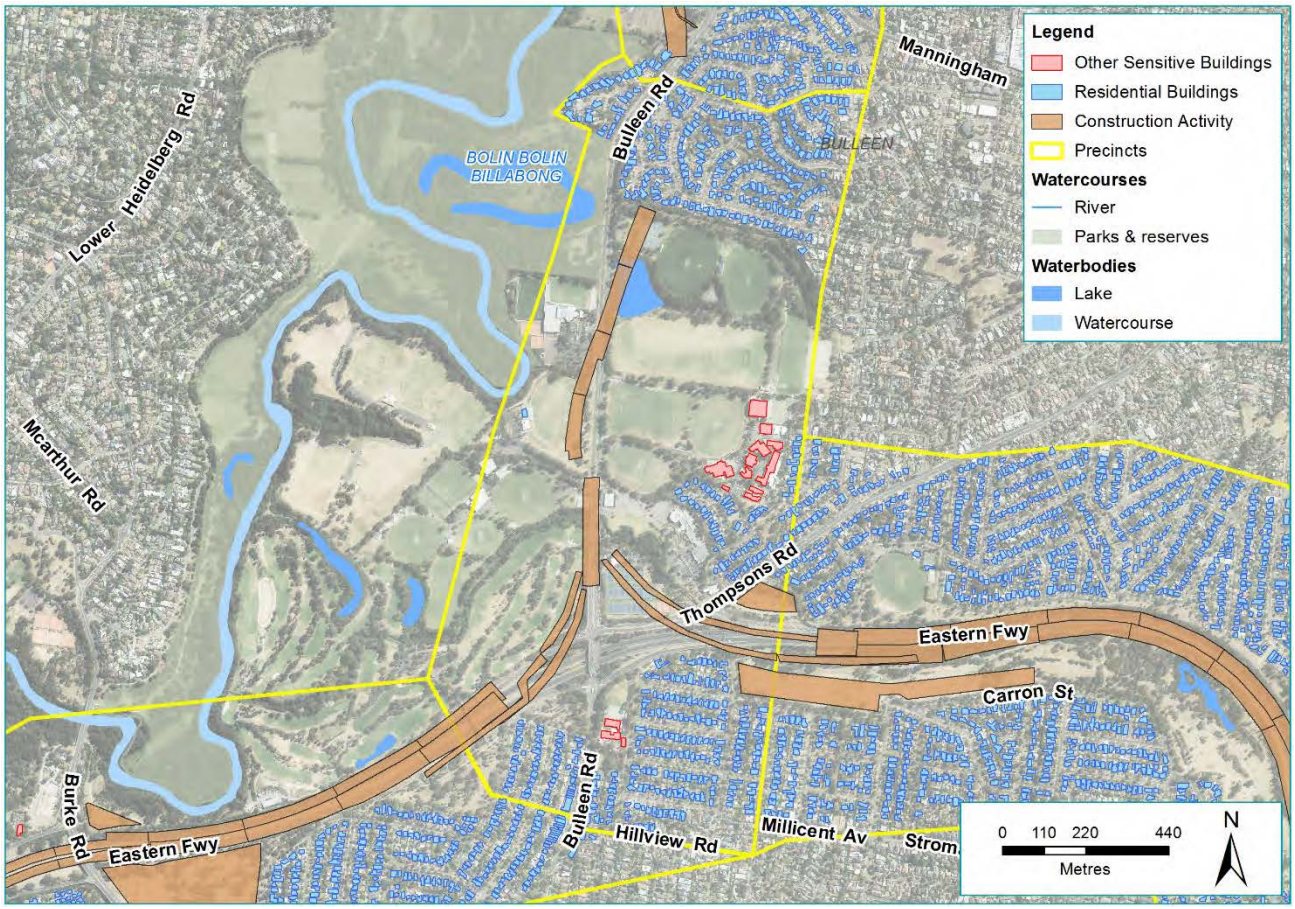


Figure 8-9 Noise Precinct 3 modelled construction works (Manningham Road interchange to Eastern Freeway interchange)

Table 8-6 Overview of predicted NML exceedances – Noise Precinct 3

Activity ID	Scenario	Duration[1] (Months)	Number of Noise Sensitive Buildings									
			HNA[2,3]	Normal			Out of hours works[4]					
				Daytime			Evening			Night-time		
	(NML Exceedance levels ->)			1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA
W.0001	Compound construction	3 – 6	-	-	-	-						
W.0002	Compound operation	> 24	-	-	-	-	-	-	-	-	-	-
W.0011	Crushing, screening and vegetation clearing Eastern Freeway	3 – 6	-	3	-	-						
W.0012	Earthworks (no rock-breakers)	6 – 12	-	-	-	-						
W.0013	Road tie-in works (major road)	> 24	-	1	-	-						
W.0016a	Piling of Manningham Rd cut/cover	6 – 12	-	3	-	-						

Activity ID	Scenario	Duration[1] (Months)	Number of Noise Sensitive Buildings									
			HNA[2,3]	Normal			Out of hours works[4]					
				Daytime			Evening			Night-time		
	(NML Exceedance levels ->)			1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA
W.0016b	Excavation of surface of Manningham Rd cut/cover	6 – 12	-	3	-	-						
W.0016c	Excavation at 5-m depth Manningham Rd cut/cover	12 – 18	-	7	1	-						
W.0017	Viaduct construction	12 – 18	-	-	-	-	1	-	-	34	-	-
W.0018	Viaduct earthworks	6 – 12	-	-	-	-	-	-	-	13	-	-

Legend

1 - 10 dB above NML (noticeable to clearly audible) | 11 dB - 20 dB above NML (clearly audible to moderately intrusive) | > 20 dB above NML (moderately intrusive to highly intrusive)

Note 1: Durations should be regarded as indicative. The duration of the impacts would be less than the overall duration and depends on the rate of progress.

Note 2: HNA=Highly Noise Affected. Based on NSW ICNG definition (predicted L_{Aeq} noise at residential receiver is 75 dBA or greater) during the day.

Note 3: Based on worst-case predicted noise levels.

Note 4: Out of Hours Works. During the daytime this refers to the period on Saturday between 1 pm – 6 pm, on Sunday and public holidays between 8 am – 6 pm.

The above shows clearly audible construction noise levels at a relatively small number of receivers in Bulleen during the excavation of the Manningham Road cut and cover tunnel in the north of Noise Precinct 2 during normal construction hours.

Construction activities that are anticipated to occur into the evening and night-time period due primarily to site occupation and safety considerations include some aspects of the construction of the elevated viaducts of the interchange. These may potentially cause clearly audible construction noise levels a more significant number of receivers in Balwyn North.

However, it is noted that during most activities, it is expected that construction noise levels would frequently be lower than the worst-case levels predicted above for significant periods of time, such as when the works move around the site and are more distant from receivers, and when less noisy activities are being undertaken.

8.3.3.1 Worst-case impacts during standard daytime construction hours

During standard daytime construction hours, **Table 8-6** shows the activity with potential for the highest number of NML exceedances is 'W.0016c – Excavation at 5-m depth Manningham Rd cut/cover', with up to seven receivers experiencing clearly audible construction noise levels and one location predicting moderately intrusive levels, which results from the use of a rock-breakers in this construction activity.

The duration of the total activity is anticipated to be up to 18 months. As construction progresses along the project alignment, the worst-case predicted impacts at any one receiver would be expected for a shorter duration.

8.3.3.2 Worst-case Impacts during out-of-hours works

Construction activities outside standard daytime construction hours would likely be required in Noise Precinct 2 for viaduct earthworks and construction, given the interface constraints that limit the hours upon which construction works can take place safely.

Figure 8-10 indicates the distribution of exceedances for 'W.0017 Viaduct construction' for receivers within Noise Precinct 2 during the night-time.

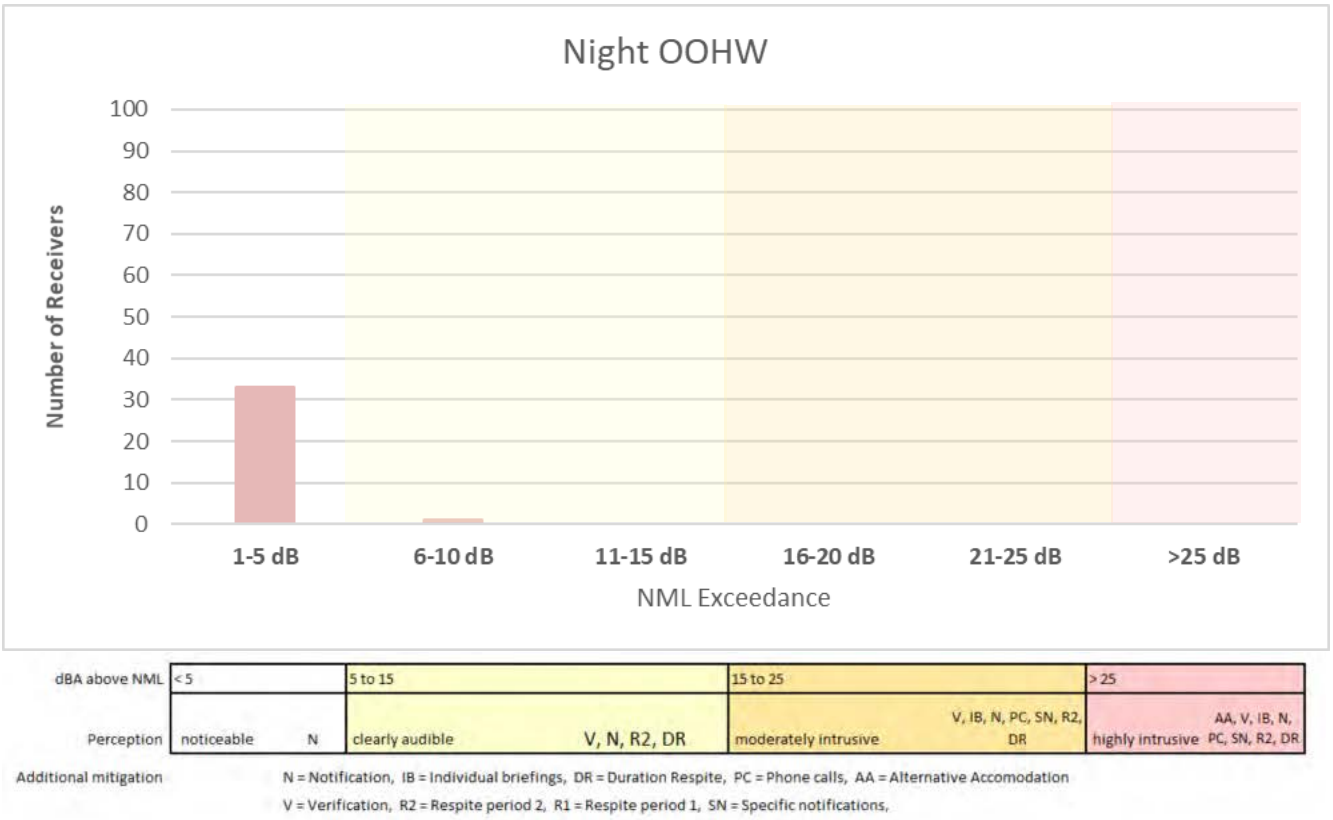


Figure 8-10 NML exceedances night-time – 'W.0017 Viaduct construction'

Figure 8-10 shows that the predicted worst-case scenario for this activity indicates the works may be clearly audible at up to 34 receivers (5 to 15 dBA above NML).

The duration of the total activity is anticipated to be up to 18 months. However, as construction progressed along the project alignment, the worst-case predicted impacts at any one receiver would be expected for a shorter duration.

8.3.3.3 Other sensitive receivers

Other sensitive receivers such as educational facilities, hospitals and childcare centres which are potentially affected by construction activities in Noise Precinct 2 have been assessed against the criteria detailed in **Section 4.8.**

No exceedances of the daytime NML for other sensitive receivers are predicted.

8.3.4 Noise Precinct 4 Eastern Freeway upgrades (East)

Noise Precinct 4 covers the portion of the Eastern Freeway to the east of the Bulleen Road interchange upgrade and generally includes:

- Widening of the Eastern Freeway for new lanes
- Demolition and rebuilding of Doncaster Road bridge over the Eastern Freeway
- Provision for the Doncaster Busway
- Temporary relocation of Doncaster Park and Ride facility to the south-western corner of the interchange.

The Noise Precinct 4 corridor predominantly comprises either:

- Parkland reserves abutting the Eastern Freeway with residential properties beyond
- Residential properties abutting the Eastern Freeway.

Several sporting clubs and facilities are along the corridor. A considerable proportion of the corridor has extensive existing noise walls.

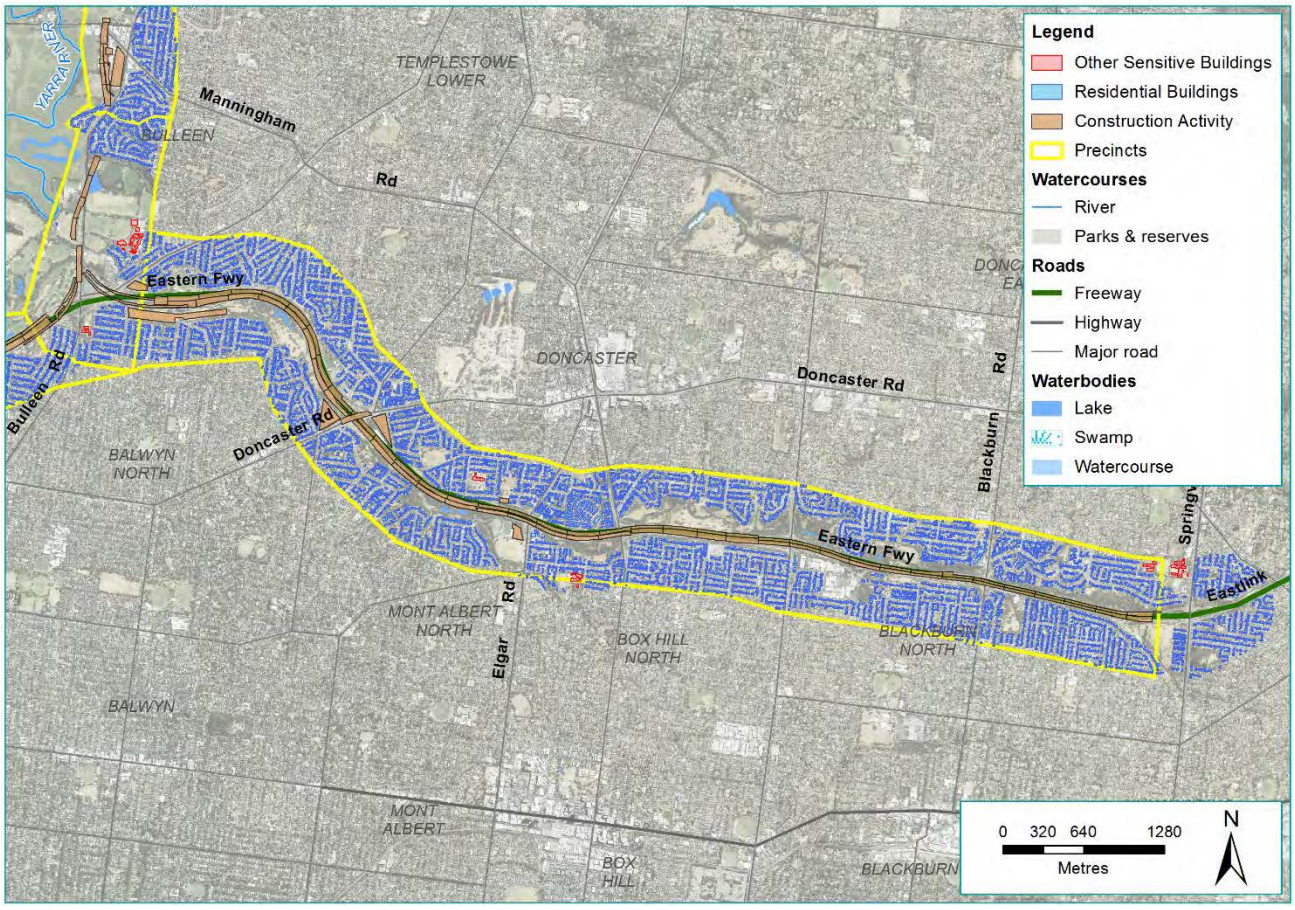


Figure 8-11 Noise Precinct 4 modelled construction works (Eastern Freeway upgrades – East)

Table 8-7 Overview of predicted NML exceedances – Noise Precinct 4

Activity ID	Scenario	Duration[1] (Months)	Number of Noise Sensitive Buildings									
			HNA[2, 3]	Normal			Out of hours works [4]					
				Daytime			Evening			Night-time		
(NML Exceedance levels ->)				1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA	1–10 dBA	11–20 dBA	>20 dBA
W.0001	Compound construction	3–6	-	2	-	-						
W.0002	Compound operation	> 24	-	-	-	-	1	-	-	2	-	-
W.0005	Demolition – Doncaster Road bridge	1–3	1	26	1	-	154	9	-	410	40	4
W.0011	Crushing, screening and vegetation clearing	3–6	1	110	2	-						
W.0012	Earthworks (no rock-breakers)	> 24	-	14	-	-						
W.0013	Road tie-in works (major road)	> 24	-	60	-	-						
W.0017	Viaduct construction	12–18	-	-	-	-	-	-	-	17	-	-
W.0018	Viaduct earthworks	12–18	4	-	-	-	-	-	-	29	-	-
W.0020 a	Doncaster Park and Ride Clearing and site preparation	<3	-	1	-	-						
W.0020 b	Doncaster Park and Ride Pavement and road tie - ins	3–6	-	1	-	-						

Legend

1 - 10 dB above NML (noticeable to clearly audible) | 11 dB - 20 dB above NML (clearly audible to moderately intrusive) | > 20 dB above NML (moderately intrusive to highly intrusive)

Note 1: Durations should be regarded as indicative. The duration of the impacts would be less than the overall duration and depends on the rate of progress.

Note 2: HNA=Highly Noise Affected. Based on NSW ICNG definition (predicted L_{Aeq} noise at residential receiver is 75 dBA or greater) during the day.

Note 3: Based on worst-case predicted noise levels.

Note 4: Out of Hours Works. During the daytime this refers to the period on Saturday between 1 pm – 6 pm, on Sunday and public holidays between 8 am – 6 pm.

Table 8-7 shows that during normal construction hours moderately intrusive noise impacts (11 to 20 dBA above NML) may occur in pockets of receiver adjacent to the road corridor in Bulleen, Balwyn North, Mont Albert North, Doncaster, Box Hill North and Doncaster East from the clearing and widening works along the Eastern Freeway.

During out of hours works, moderate and high noise impacts are predicted for a more significant number of localised receiver in Balwyn North and Doncaster which are close to the Doncaster Road bridge demolition works.

8.3.4.1 Worst-case impacts during standard daytime construction hours

During standard daytime construction hours, **Table 8-7** shows the activity with potential for the highest number of NML exceedances is 'W.0011 – Crushing, screening and vegetation clearing', with a single receptor predicted to be in the Highly Noise Affected category.

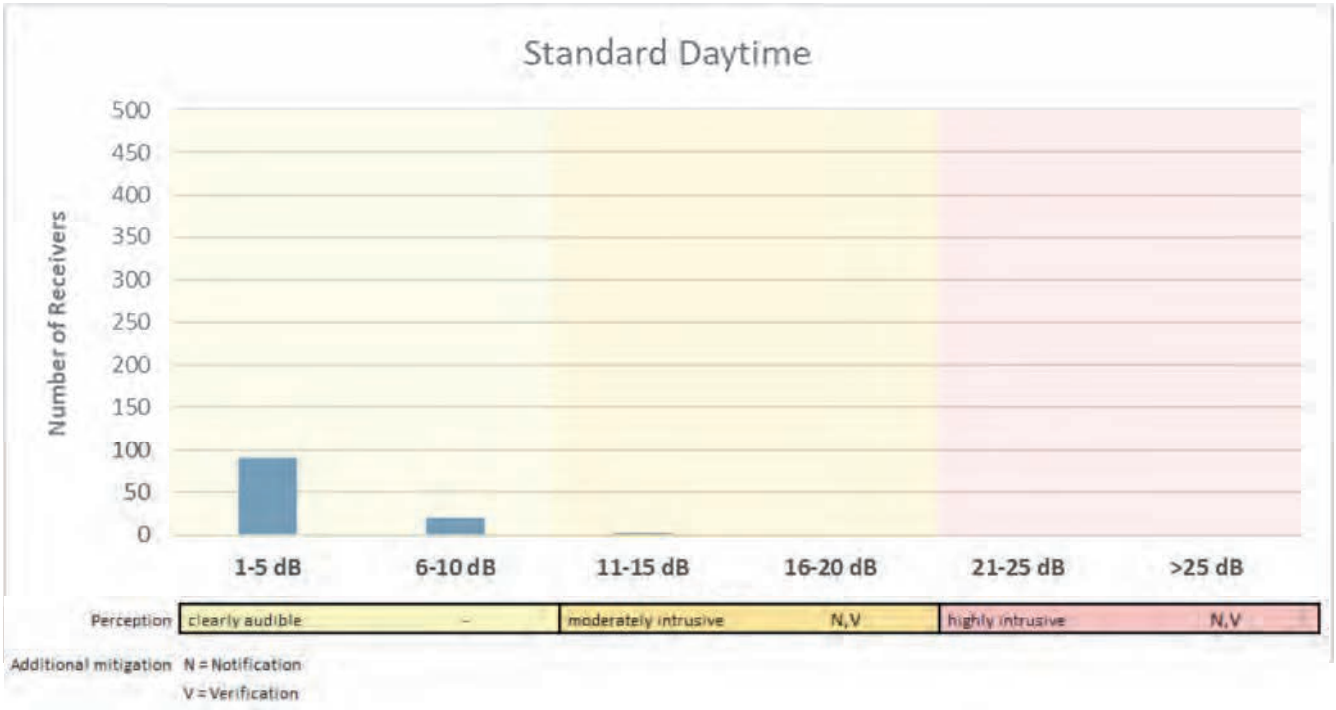


Figure 8-12 NML exceedances daytime – W.0011 – crushing, screening and vegetation clearing (with tub grinder)

The highest impacts are typically seen at receivers which are immediately adjacent to the clearing activities.

Figure 8-12 shows that the predicted worst-case scenario for this activity may result in approximately two receivers experiencing moderately intrusive noise impacts (11 to 20 dBA above NML) and are primarily due to the operation of the tub grinder/mulcher, which is likely only to be required to be operated for a relatively short period (several days only) before being relocated to a different area. On-site noise mitigation options would include: strategic placement of the tub grinder/mulcher away from residences, temporary acoustic shielding and the management of equipment and processes.

8.3.4.2 Worst-case Impacts during out-of-hours works

Construction activities outside standard daytime construction hours would likely be required in Noise Precinct 4 given the interface constraints that limit the hours upon which some construction activities can take place safely.

Figure 8-13 indicates the distribution of exceedances for 'W.0006 – Demolition – Doncaster Road Bridge' for receivers within Noise Precinct 4 during the night-time.

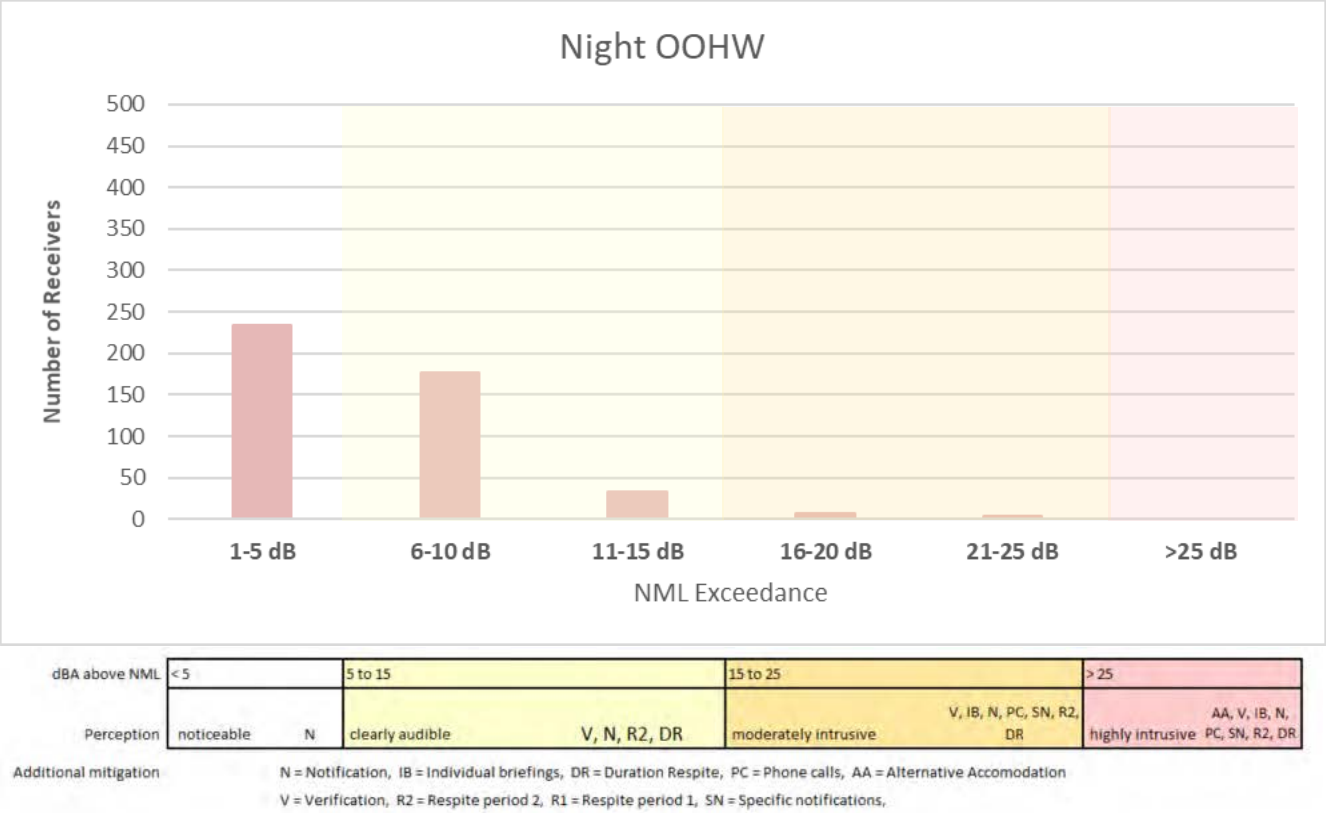


Figure 8-13 NML exceedances night-time – 'W.0005 – demolition – Doncaster Road bridge'

Figure 8-13 shows that the predicted worst-case scenario for this activity is unlikely to result in highly intrusive noise impacts (>25 dBA above NML). The predictions indicate that up to 11 receivers may experience moderately intrusive noise impacts (15 to 25 dBA above NML) and that the works may be clearly audible at up to 209 receivers (5 to 15 dBA above NML).

The above night-time impacts from bridge demolition works result from the use of rock-breakers in this construction activity.

Potential on-site noise mitigation options would include:

- Use of alterative demolition methods to rock breaking; approximately 5 dBA to 15 dBA reduction
- Hoarding around demolition construction area; approximately 5 dBA reduction
- Localised temporary acoustic shielding around equipment; approximately 5 dBA reduction
- Particularly noisy operations should be confined to periods of the day where possible.

8.3.4.3 Other sensitive receivers

Other sensitive receivers such as educational facilities, hospitals and childcare centres which are potentially affected by construction activities in Noise Precinct 4 have been assessed against the criteria detailed in **Section 4.8.**

A 1 dBA marginal exceedance of the daytime NML for other sensitive receivers is predicted for the Birrallee Primary School, during 'W.0008 – Crushing, screening and vegetation clearing' works, primarily due to the operation of the tub grinder/mulcher, which is likely only to be required to be operated for a relatively short period (several days only) before being relocated to a different area. On-site noise mitigation options would include: strategic placement of the tub grinder/mulcher away from residences, temporary acoustic shielding and the management of equipment and processes.

8.3.5 Noise Precinct 5 Eastern Freeway upgrades (West)

Noise Precinct 5 covers the portion of the Eastern Freeway to the west of the Bulleen Road interchange upgrade and generally includes:

- Widening of the Eastern Freeway for new lanes between Chandler Highway and Bulleen Road
- Bridge strengthening at the Eastern Freeway Bridges over the Yarra River
- Provision for the Doncaster Busway.

The Noise Precinct 5 corridor predominantly comprises:

- Parkland reserves abutting the southern side of the Eastern Freeway with residential properties beyond
- Residential properties abutting the Eastern Freeway.

Several golf courses and facilities are along northern side of the Eastern Freeway. A considerable proportion of the corridor has extensive existing noise walls.

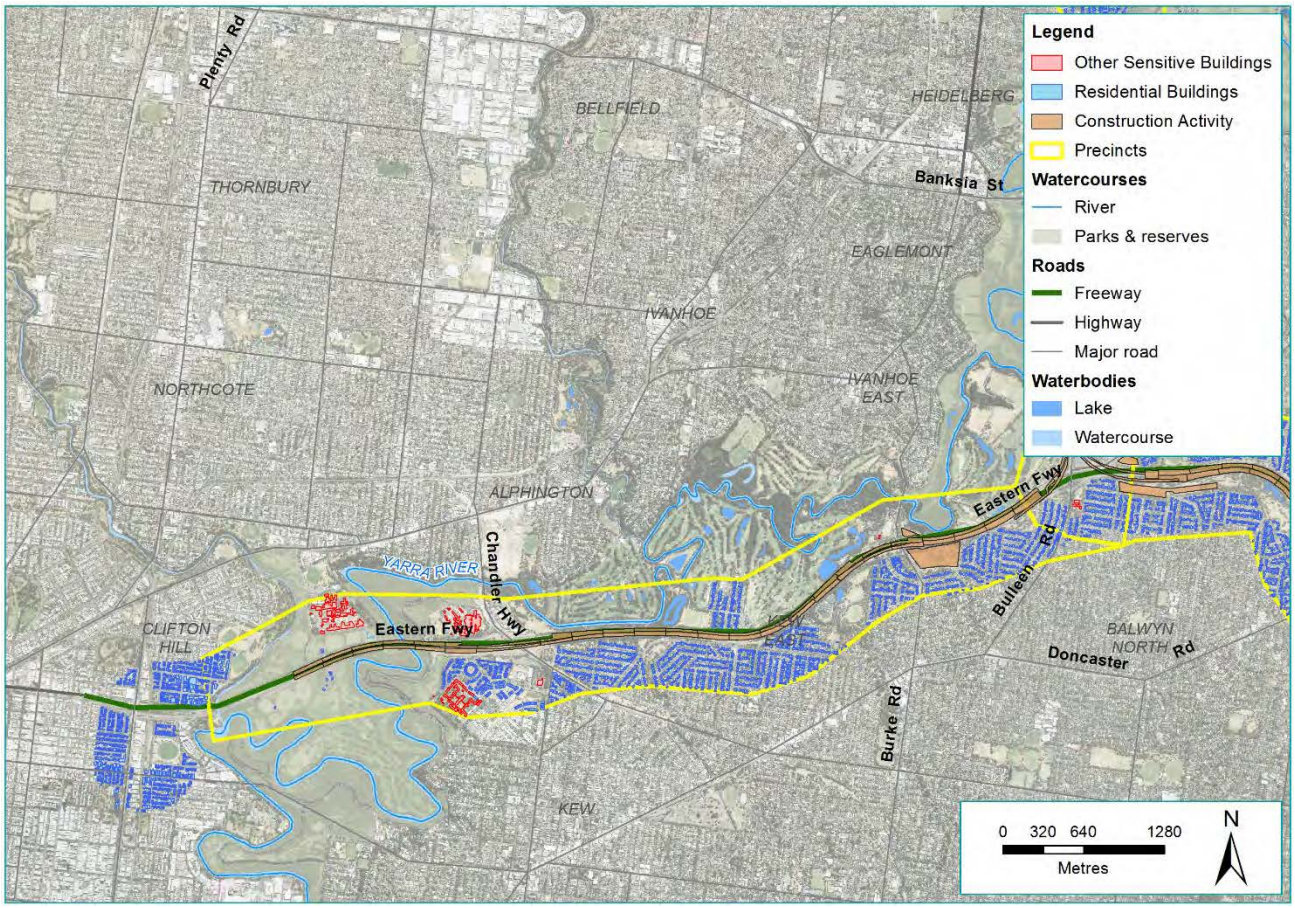


Figure 8-14 Noise Precinct 5 modelled construction works (Eastern Freeway upgrades – West)

Table 8-8 Overview of predicted NML exceedances – Noise Precinct 5

Activity ID	Scenario	Duration[1] (Months)	Number of Noise Sensitive Buildings									
			HNA[2,3]	Normal			Out of hours works [4]					
				Daytime			Evening			Night-time		
	(NML Exceedance levels ->)			1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA	1-10 dBA	11-20 dBA	>20 dBA
W.0001	Compound construction	3 – 6	-	-	-	-						
W.0002	Compound operation	> 24	-	-	-	-	-	-	-	-	-	-
W.0008	Crushing, screening and vegetation clearing	3 – 6	-	33	-	-						
W.0009	Earthworks (no rock-breakers)	12 – 18	-	4	-	-						
W.0010	Road tie-in works (major road)	> 24	-	13	-	-						
W.0017	Viaduct construction	12 – 18	-	-	-	-	-	-	-	-	-	-
W.0018	Viaduct earthworks	6 – 12	-	-	-	-	-	-	-	1	-	-

Legend

1 - 10 dB above NML (noticeable to clearly audible) | 11 dB - 20 dB above NML (clearly audible to moderately intrusive) | > 20 dB above NML (moderately intrusive to highly intrusive)

Note 1: Durations should be regarded as indicative. The duration of the impacts would be less than the overall duration and depends on the rate of progress.

Note 2: HNA=Highly Noise Affected. Based on NSW ICNG definition (predicted L_{Aeq} noise at residential receiver is 75 dBA or greater) during the day.

Note 3: Based on worst-case predicted noise levels.

Note 4: Out of Hours Works. During the daytime this refers to the period on Saturday between 1 pm – 6 pm, on Sunday and public holidays between 8 am – 6 pm.

The above shows that during normal construction hours clearly audible construction noise levels (1 to 10 dBA above NML) may occur in pockets of receiver adjacent to the road corridor in Balwyn North, Kew East and Kew from the clearing and widening works along the Eastern Freeway.

During out of hours works, noticeable construction noise levels are predicted for one localised receiver in Balwyn North and which is close to the elevated viaduct construction works at the eastern end of Noise Precinct 5.

However, it is noted that during most activities it is expected that construction noise levels would frequently be lower than worst-case levels predicted above for significant periods of time, such as when the works move around the site and are more distant from receivers, and when less noisy activities are being undertaken.

8.3.5.1 Worst-case Impacts during standard daytime construction hours

During standard daytime construction hours, **Table 8-8** shows the activity with potential for the highest number of NML exceedances is 'W.0008 – Crushing, screening and vegetation clearing', albeit with no receiver predicted to be in the Highly Noise Affected category. Up to 33 receivers are predicated to exceed the daytime NML by up to 10 dBA which results from the use of a tub grinder in this construction activity, which is only expected to be undertaken during the daytime period.

The duration of the total activity is anticipated to be 3 to 6 months. As construction activity progressed along the alignment, the worst-case predicted impacts at any one receiver would be expected for a shorter duration. On-site noise mitigation options would include: strategic placement of the tub grinder/mulcher away from residences, temporary acoustic shielding and the management of equipment and processes.

8.3.5.2 Worst-case impacts during out-of-hours works

Construction activities outside standard daytime construction hours would likely be required in Noise Precinct 5 given the interface constraints that limit the hours upon which some construction activities can take place safely.

Figure 8-15 indicates the distribution of exceedances for 'W.0018 – Viaduct earthworks' for receivers within Noise Precinct 5 during the night-time.

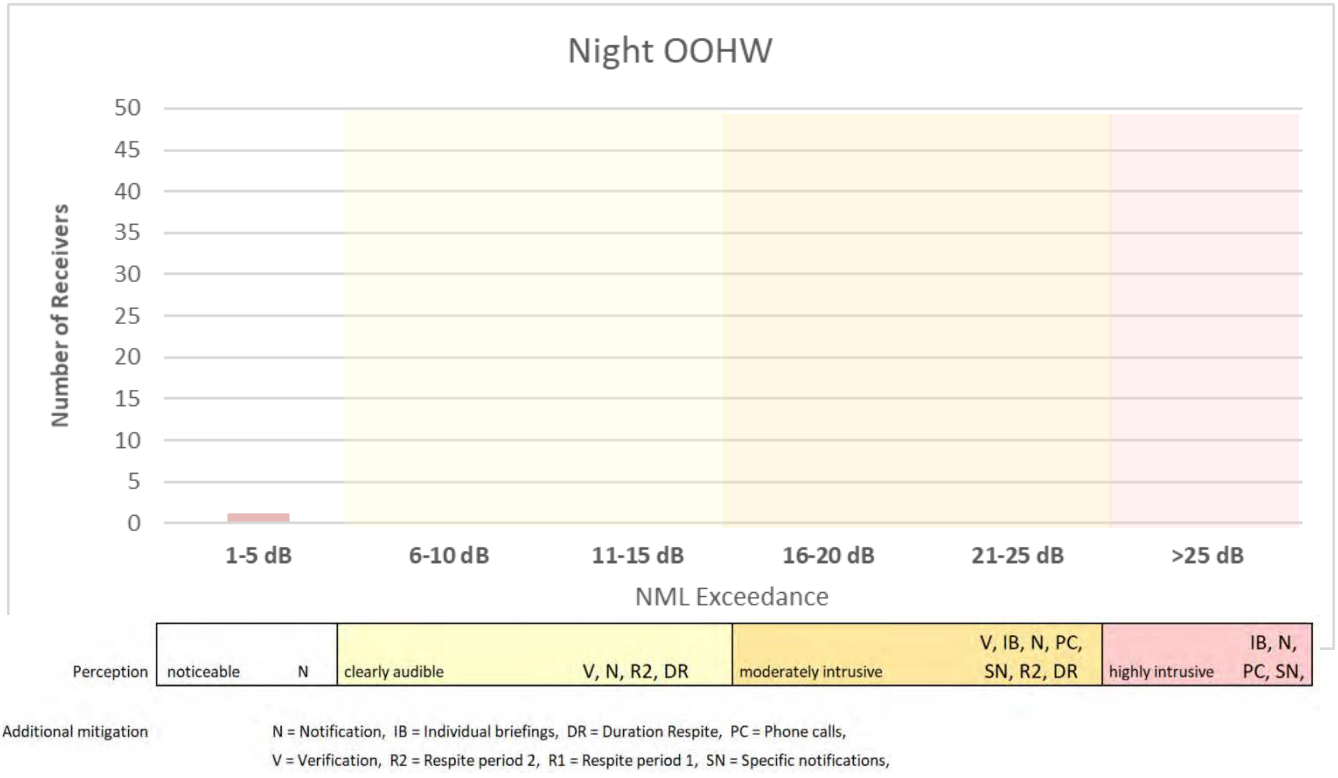


Figure 8-15 NML Exceedances night-time – 'W.0018 – viaduct earthworks'

Figure 8-15 shows that the worst-case impacts are quite limited for this activity. It indicates the works may be noticeable at only a single receiver (1 to 5 dBA above NML).

The duration of the total activity is anticipated to be 6 to 12 months. However, as construction progressed along the project alignment, the worst-case predicted impacts at any one receiver would be expected for a shorter duration.

8.3.5.3 Other sensitive receivers

Other sensitive receivers such as educational facilities, hospitals and childcare centres which are potentially affected by construction activities in Noise Precinct 5 have been assessed against the criteria detailed in **Section 4.8.**

A 5 dBA to 8 dBA exceedance of the daytime NML for other sensitive receivers is predicted for the Royal Talbot Rehabilitation Centre during 'W.0008 – Crushing, screening and vegetation clearing' and 'W.0010 – Road tie-in works (major road)' primarily due to operation of the of the tub grinder/mulcher, which would only be required to be used for short periods of time in any one location. Furthermore, the relevant spaces occupied by patients in the Royal Talbot Rehabilitation Centre are likely to have a significantly better acoustic performance to that assumed across the project (such as non-openable upgraded glazing and high ambient noise environment from the Eastern Freeway and Chandler Highway).

8.4 Managing residual impacts

A strategy for mitigating and managing potential construction noise impacts is detailed in **Appendix F,** which outlines standard and additional mitigation measures.

A framework for adopting additional mitigation measures has been adopted as per the requirements of the Roads and Maritime Services *Construction Noise and Vibration Guideline* (CNVG), as captured in NV4. Suitable additional mitigation measures have been determined for the potentially most impacting construction activity in each Noise Precinct during normal working hours and for out of hours where they are anticipated to occur.

The noise modelling has indicated the number of receptors for which additional mitigation measures would be recommended and are presented graphically in their respective NML Exceedance Figures, where the standard daytime periods works are defined as per **Figure 8-16** and night-time as per **Figure 8-17**.

dBA above NML	< 10	10 to 20	> 20
Perception	clearly audible -	moderately intrusive N,V	highly intrusive N,V
Additional mitigation	N = Notification V = Verification		

Figure 8-16 Standard daytime – exceedances above NML, perception and additional mitigation

Where predicted daytime construction noise impacts indicate receivers as being in the Highly Noise Affected category or exceeding the NML by more than 10 dBA, the appropriate mitigation action would include notification and verification through noise monitoring.

dBA above NML	< 5	5 to 15	15 to 25	> 25
Perception	noticeable N	clearly audible V, N, R2, DR	moderately intrusive V, IB, N, PC, SN, R2, DR	highly intrusive AA, V, IB, N, PC, SN, R2, DR
Additional mitigation	N = Notification, IB = Individual briefings, DR = Duration Respite, PC = Phone calls, AA = Alternative Accomodation V = Verification, R2 = Respite period 2, R1 = Respite period 1, SN = Specific notifications,			

Figure 8-17 Night-time – exceedances above NML, perception and additional mitigation

Construction Noise and Vibration Management Plans (CNVMPs) would be required to evaluate all works undertaken outside normal working hours that detail the specific activities being undertaken, the level of impact anticipated and the appropriate management and additional mitigations to be employed.

8.5 Spoil haulage

There would be significant spoil generated from the tunnelling process (TBMs, road headers, cut and cover and other open excavations). Additionally, other construction areas along the project would generate surplus spoil during construction. The estimated amount of spoil to be generated is presented in **Table 8-9** below.

Table 8-9 Source and amount of spoil generated from the project

Source	Amount generated
M80 Ring Road to northern portal	1,541,000 m³
Northern portal to southern portal	3,186,000 m³
Eastern Freeway	374,000 m³
Total	5,101,000 m³

NB: Estimates are based on in situ volumes (solid volumes) to be excavated, not on 'loose' (excavated) volumes

Spoil that is unable to be reused would be removed from the storage sites by truck via designated haulage routes (see **Figure 8-18**). Several potential disposal sites have been identified for surplus spoil and other opportunities may be realised at the time of construction.

Truck haulage routes

Construction haulage routes have been identified to provide construction-related traffic with efficient access to the freeway and arterial road network and between worksites, minimising the impact on local traffic and local roads wherever possible.

The primary routes are the ones that would be mainly used to connect the construction sites to the west, north-west and south-east of Melbourne via the M80 Ring Road, the Hume Highway and Eastlink.
The secondary routes would provide alternatives routes from the construction sites for works on the north-south corridor where needed. For spoil that is to be transported from the major works site at the Manningham Road, Bulleen Road and the western end of the Eastern Freeway it is envisaged these trucks would follow a route along Banksia Street through either Sydney Road, High Street and Plenty Valley Road and Greensborough Road.

The indicative construction haulage routes are shown in **Figure 8-18**. The anticipated two-way truck volumes on these routes has been provided as an average daily volume for the peak truck volume month. It is expected that spoil haulage would not occur during the morning and evening peak traffic periods and that haul movements would be occur during the night period on only a few non-curfew roads.

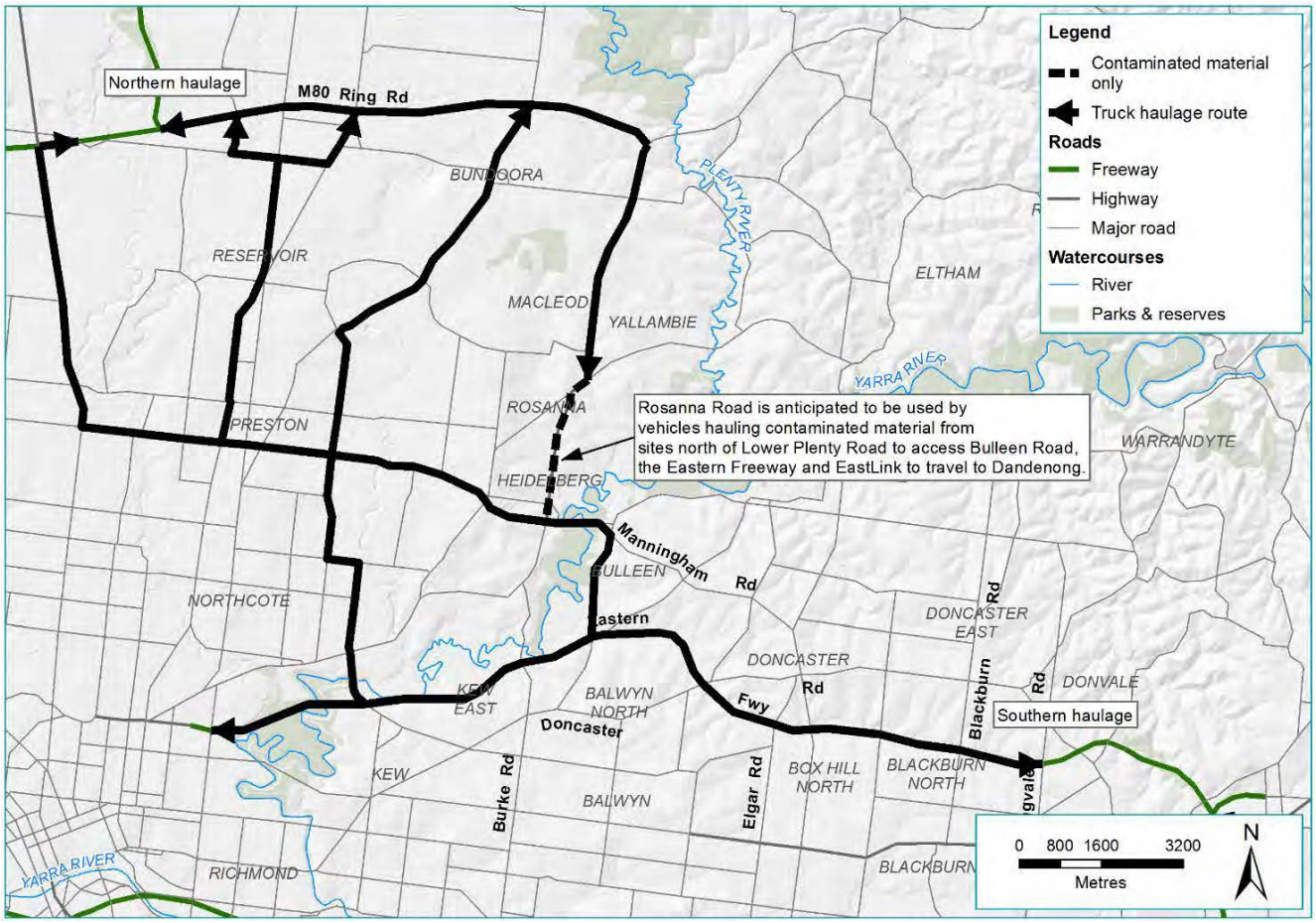


Figure 8-18 Indicative construction haul routes

Table 8-10 presents the calculated change in noise due to the movement of trucks on the proposed haul routes during the peak month of construction in January 2023.

Table 8-10 L_{Aeq} noise level increase from spoil haulage in peak month of project

Route segment	Change n noise level L_{Aeq} (dBA)	
	Day (6 am to midnight)	Night (midnight to 6 am)
M80 Ring Road	0.9 dBA	0.0 dBA
Chandler Highway	0.0 dBA	0.0 dBA
Bulleen Road	0.1 dBA	0.0 dBA
Bulleen Road	0.3 dBA	0.3 dBA
Bell Street	0.2 dBA	0.6 dBA
Eastern Freeway	0.4 dBA	0.1 dBA
Rosanna Road	0.2 dBA	0.0 dBA
Sydney Road	0.1 dBA	0.2 dBA
St Georges Road/Spring Street/High Street	0.1 dBA	0.2 dBA
Plenty Road	0.1 dBA	0.2 dBA

During the day period and owing to the high existing volume of vehicles on the roads, the inclusion of the spoil trucks results in a negligible increase the overall daytime traffic noise levels, so the trucks may be identifiable on the roads but are not predicted to lead to a significant acoustical impact. The highest increase is predicted to be only 0.9 dBA over the average of the day and 0.6 dBA over the average of the night.

The assessment has assumed:

- Vehicles leaving the southern sites can travel west along Bell Street or south along Bulleen Road, east along the Eastern Freeway. Once at the corner of Bell Street and Station Street, the trucks would disperse into one of the three alternative routes as shown in **Figure 8-18**. Noise modelling has not extended along these alternative routes, but this would be conducted during the detailed design phase, when these and other alternatives would be considered.
- The traffic impacts are referenced to 2023 flows.

Impacts from haul trucks are best minimised through management practices; the Construction Noise and Vibration Management Plan (CNVMP) would consider:

- Ensuring that vehicles comply to the National Heavy Vehicle Law and regulations, are well maintained and equipped with adequate and functioning mufflers
- A suitable location for truck to idle, while awaiting their turn to be loaded
- The merits of a driver education program, to prohibit the unnecessary use of engine brakes
- The route selection criteria include consideration of the route with the least noise impacts such as by minimising the number of affected receptors, gradients, reversing movements required
- Where construction activities need to be extended into the night-time the project should demonstrate delivery of best practice outcomes with regard to night-time noise impact and compliance with relevant codes and regulations. Further, it is necessary to demonstrate that:
    - Unavoidable night work was justified and has been approved
    - Best practice measures were adopted to reduce on-site noise emissions and to attenuate noise leaving the project
    - Off-site mitigation was matched to predicted exceedances of the noise criteria
    - Stakeholder engagement enabled residents to understand the justification for unavoidable night work and its impact and to make informed decisions about acceptance of off-site mitigation measures
    - Systems were in place through the construction phase to deliver the anticipated mitigation and community engagement outcomes.

8.6 Temporary removal of noise walls

North East Link would include new or modified noise walls to achieve the project's noise criteria.
Where possible, new noise walls would be installed ahead of the demolition of existing walls. However, in a number of locations where noise walls would be replaced, it would not be possible to erect the new noise walls before the existing noise walls were demolished due to engineering limitations and space restrictions.

Appendix I shows those noise walls which would likely remain and those which would be replaced.

Where this occurs, there would be a period where there would be no noise wall between the Eastern Freeway and the residence. This time has been estimated to be:

- Four to six weeks for concrete wall sections
- Two to three weeks for timber wall sections.

Additional temporary measures such as temporary noise walls may be able to be installed by the construction contractor to minimise traffic and construction noise during these periods. These temporary noise walls would likely be located closer to the residence, where this proves to be feasible.

When the existing noise wall was removed, there would be a noticeable increase in the ambient levels of traffic noise. The extent of impacts would depend on the height of the wall and the noise reduction provided by the wall, which varies along the corridor.

The temporary increase in road traffic noise is anticipated to be typically in the range 5 dBA to 15 dBA.

8.7 Temporary relocation of car parks

8.7.1 Watsonia railway station

A portion of the existing Watsonia railway station car park would be required to accommodate the proposed construction of the project and to provide the local connection road between Watsonia Road and Grimshaw Street.

These proposed works would consequently require the entrance and car parking facility to be reconfigured and it is likely that at least half the existing car park would be relocated to an alternative parking facility within the high voltage easement to the east of Watsonia railway station. It is possible this relocation would remain in place for two to three years.

Access to the temporary car park would likely be via Elder Street and Frensham Road.

The noise impacts associated with the use of the temporary car park have been evaluated and the following is anticipated:

- The increase in traffic noise along Elder Street and Frensham Road as a result of traffic accessing the car park would likely be less than 1 dBA during the worst-case morning peak hour
- The increase in ambient noise at adjacent residences due to the normal use of the temporary car park would likely be between 1 dBA to 3 dBA during the worst-case morning peak hour.

In consideration of the negligible increases in noise from the temporary car park minimal noise impacts are expected.

Notwithstanding the above, it is possible that short-term noise events such as car starts and door slams have the potential to occur near residences and consideration should be given during detailed design to providing a temporary noise screen (for example, 2.4-metre high) at the common boundary to the car park.

8.7.2 Doncaster Park and Ride

The existing Park and Ride facility at the Doncaster Road interchange accommodates approximately 400 car parking spaces, a bus stop with turn-around facility and bicycle storage. This site would be impacted by the project's construction and would require the relocation of the existing facility to a temporary alternative location. Several alternatives could be considered and include:

- Maintaining the current facility on a reduced footprint with a subsequent reduction in car parking. This is not desirable as bus commuters would tend to park in local streets
- Temporary relocation of the facility to Doncaster Shopping Town

- Temporary relocation of the facility to the Koonung Creek Reserve (area bounded by Doncaster Road, Gardenia Road and the Eastern Freeway).

The relocation of the facility into the Koonung Creek Reserve is the most likely solution given its proximity to the existing Doncaster Park and Ride and its access to the Eastern Freeway. This open space is expected to provide the same number of bays along with a bus turn-around. Furthermore, it is anticipated the west-bound on-ramp would need to be temporarily relocated closer to residents to accommodate the Doncaster Road bridge upgrade works.

It is possible this relocation would remain in place for two to three years.

The noise impacts associated with the use of the temporary car park have been evaluated and the following is anticipated:

- The increase in traffic noise to residential receptors in Koonung Street, Gardenia Road and Doncaster Road due to the relocated on-ramp and busses accessing the Park and Ride facility would likely be less than 1 dBA
- The increase in ambient noise at adjacent residences due to the normal use of the temporary Park and Ride facility would likely be less than 1 dBA during the worst-case morning peak hour.

In consideration of the insignificant increases in noise from the temporary car park, minimal noise impacts are expected.

Notwithstanding the above, it is possible that short-term noise events such as car starts and door slams have the potential to occur near residences and consideration should be given during detailed design to providing a temporary noise screen (for example, 2.4-metre high) at the common boundary to the car park.

8.8 Construction vibration assessment – surface works

The relevant policy and legislation related to construction vibration are detailed in **Section 4.3.**

8.8.1 Cosmetic damage screening level

It is noted that applicable cosmetic damage criteria for this project are based on German Standard DIN 4150 which is generally considered to be more conservative than BS 7385.

For most construction plant, the dominant frequency of ground vibration is typically between 20 Hz and 50 Hz. With reference to Line 2 of DIN 4150 this gives a PPV vibration level greater than 7.5 mm/s which corresponds to the minimum BS 7385 levels (assuming the plant could cause a resonant response in an unreinforced building or light framed structure).

As such, the safe working distances presented in are based on the vibration not exceeding a PPV level of 7.5 mm/s.

8.8.2 Human response screening level

In relation to human comfort (response), the safe working distances in **Table 8-11** relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels occurring over shorter periods are permitted.

8.8.3 Construction vibration assessment

The proposed construction activities with the most significant potential for vibration impacts are during the use of vibratory rollers, rock-breakers and driven piling.

Vibratory rolling has been identified as a potential activity within the following scenarios:

- Earthworks
- Roadworks – Asphalt surfacing and road tie-ins.

Rock-breaking has been identified as a potential activity within the following scenarios:

- Demolition of existing structures
- Piling – Excavation of decline/trench.

8.8.4 Safe working distances

As a guide, safe working distances for 'cosmetic' damage and human comfort considerations for typical items of vibration intensive plant are provided in the TfNSW *Construction Noise Strategy* (CNS) and are reproduced below in **Table 8-11**.

Table 8-11 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe working distance (metres)	
		Cosmetic damage (7.5 mm/s)	Human response (NSW EPA Vibration Guideline) ($0.26mm/s^{1.75}$)
Vibratory roller	< 50 kN (Typically 1–2-t)	5 m	15 m to 20 m
	< 100 kN (Typically 2–4-t)	6 m	20 m
	< 200 kN (Typically 4–6-t)	12 m	40 m
	< 300 kN (Typically 7–13-t) **	15 m	100 m
	> 300 kN (Typically 13–18-t)	20 m	100 m
	> 300 kN (Typically > 18-t) *	25 m	100 m
Small hydraulic hammer	300 kg – 5 to 12-t excavator	2 m	7 m
Medium hydraulic hammer	900 kg –12 to 18-t excavator **	7 m	23 m
Large hydraulic hammer	1600 kg – 18 to 34-t excavator **	23 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	< 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures.
** Used for vibration prediction purposes

The safe working distances for building damage should always be complied with. The distances are noted as being indicative and would vary depending on the particular item of plant and local geotechnical conditions. They apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Where vibration intensive construction activities are required to be undertaken within the specified safe working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied and appropriate mitigations applied if necessary.

In relation to human comfort, the safe working distances relate to continuous vibration. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels occurring over shorter periods are allowed.

8.8.5 Vibration assessment summary

Table 8-12 summarises the number of buildings that fall within the cosmetic damage and human response safe working distances with the use of a large or medium rock breaker.

Table 8-12 Total number of buildings within safe working distance – rock breakers

Noise Precinct/works	Number of noise sensitive buildings			
	Large hydraulic hammer 1600 kg – 18 to 34-t		Medium hydraulic hammer 900 kg – 12 to 18-t	
	Cosmetic damage (7.5 mm/s)	Human response (0.26mm/s$^{1.75}$)	Cosmetic damage (7.5 mm/s)	Human response (0.26mm/s$^{1.75}$)
Noise Precinct 1: Demolish bridges Excavation trench	35	270	1	35
Noise Precinct 2: Excavation trench	13	98	4	13
Noise Precinct 3: Manningham Rd cut/cover	2	15	-	2
Noise Precinct 4: Demolish bridge	1	10	-	1
Noise Precinct 5:	-	-	-	-
TOTAL	51	393	5	51

Vibration from large rock breakers may be perceptible at properties within 73 metres from works associated with:

- The Kempston Street and Grimshaw Street bridges in Noise Precinct 1
- The excavation of the decline and trench in Noise Precinct 1 and Noise Precinct 2
- The excavation of the Manningham Road cut/cover tunnels in Noise Precinct 3
- Doncaster Road bridge in Noise Precinct 4.

Table 8-13 provides a summary of the number of buildings that fall within the cosmetic damage and human response safe working distances with the use of a large or medium vibratory roller.

Table 8-13 Total number of buildings within safe working distance – vibratory rollers

Noise Precinct/works	Large vibratory roller > 300 kN (Typically > 18-t)		Medium vibratory roller < 300 kN (Typically 7–13-t)	
	Cosmetic damage (7.5 mm/s)	Human response (0.26mm/s$^{1.75}$)	Cosmetic damage (7.5 mm/s)	Human response (0.26mm/s$^{1.75}$)
Noise Precinct 1 M80 Ring Road widening	101	594	50	594
Noise Precinct 2	-	-	-	-
Noise Precinct 3 Eastern Freeway widening	-	11	-	11
Noise Precinct 4 Eastern Freeway widening	37	882	5	882
Noise Precinct 5 Eastern Freeway widening	2	263	1	263
TOTAL	140	1750	56	1750

Vibration from large rock vibratory rollers may be perceptible at properties within 100 metres from works associated with:

- The widening of the M80 Ring Road in Noise Precinct 1
- The widening of the Eastern Freeway in Noise Precinct 3, Noise Precinct 4 and Noise Precinct 5.

8.8.6 Cosmetic damage assessment summary

The separation distance(s) between the construction activities and the nearest sensitive receivers would generally be sufficient so that nearby buildings would unlikely suffer cosmetic damage from most of the construction equipment. However, based on the arrangement of the work zones, some items of construction equipment may have the potential to be operated closer to sensitive receivers than the recommended minimum working distances. Operation of large rock-breakers and vibratory rollers has the potential to generate some of the highest construction vibration impacts due to the high vibration characteristics of the plant.

The indicative assessment presented in **Table 8-12** indicates that up to 51 buildings in the vicinity of the works may be within the cosmetic damage safe working distance should a large rock-breaker was at the outer extents of each works area or up to five buildings if a medium rock-breaker was used.

The indicative assessment presented in **Table 8-13** indicates that up to 140 buildings in the vicinity of the works may be within the cosmetic damage safe working distance if a large vibratory roller was used at the outer extents of each works area, or up to 56 buildings if a medium vibratory roller was used.

The required locations for vibration intensive equipment would be reviewed during detailed design to account for finalised information relating to the ground propagation characteristics, equipment type and specific works location. While the assessment has predicted that many buildings may be within the safe working distances for large rock-breakers and large vibratory rollers, it is anticipated that vibration impacts would be able to be controlled in all cases to avoid cosmetic damage to any structures.

8.8.7 Human comfort vibration assessment

The assessment presented in **Table 8-12** indicates the surface works using a large rock-breaker may result in a large number of receivers (around 393) within the nominated minimum working distance for human comfort vibration.

The assessment presented in **Table 8-13** indicates the surface works using a large vibratory roller may result in a large number of receivers (around 1750) within the nominated minimum working distance for human comfort vibration.

Receivers adjacent to the construction areas have been identified as likely to perceive vibration impacts at times during construction works. This is expected to be primarily due to works associated with rock-breakers, vibratory rollers and other high vibration plant items.

In practice, vibration impacts from most construction activities would be intermittent throughout construction of the project. The required locations for vibration intensive equipment would be reviewed during detailed design when finalised information relating to the works is available.

8.8.8 Sensitive built structures and natural features

Heritage buildings are to be considered on a case-by-case basis and detailed inspections of heritage-listed structures would be undertaken for all potentially affected heritage structures before construction works started.

Where a historic building or structure is deemed to be sensitive to damage from vibration (following inspection) it is recommended to reduce the vibration criteria. However, it is noted that BS 7385 states that *'a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive'* and therefore the building is not automatically be assumed to be sensitive to vibration on the basis of it being a heritage item.

The construction type classifications and structural integrity of all the listed heritage items would be confirmed at detailed design by a suitably qualified structural engineer. This information can then be used to verify the applicable vibration criteria and associated impacts, and potentially feasible and reasonable mitigation options.

Several structures and natural features that may be considered sensitive to vibration from the construction activities have been identified in Technical report K – Historical heritage. These include; trees, river banks, buildings, rock structure and bridges.

The guidelines used by the surface works noise and vibration assessment only addresses built structures such as buildings, bridges and the like. Other forms of structures are best addressed on an individual basis, using appropriate management systems. For example, a number of 'no go zones' have been identified which exclude surface works from around key areas. No go zones have been designated for sensitive areas such as:

- A vegetated patch near the intersection of the M80 Ring Road and Plenty Road. This area contains Grassy Eucalypt Woodland of the Victorian Volcanic Plain an EVC listed as critically endangered under the *Environment Protection and Biodiversity Act 1999* ('EPBC Act').
- Bolin Bolin Billabong located between Bulleen Road and the Yarra River. This area is a known site of cultural significance and ecological value and is non-EPBC related.
- A portion of Yarra Bend Park, south of the Eastern Freeway. This area is home to the Grey-headed Flying-fox a species listed as vulnerable under the EPBC Act.

The Banyule Flats, Warringal Parklands and the Yarra River as well as the Heide Museum of Modern Art and sculpture park have been included within a designated 'conditional no go zone'. Surface works would not be permitted as part of the project with the possible exception of activities relating to site investigations, relocation of minor utilities and ground improvement.

No heritage-listed buildings have been identified in Technical report K – Historical heritage that would require a vibration assessment under Line 3 of DIN 4150 (deemed to be vibration sensitive) from surface construction works.

Technical report K – Historical heritage identifies the Veneto Club in Bulleen Road (Noise Precinct 3) as being potentially of local architectural significance. However, owing to its robust concrete construction it is not considered to be vibration sensitive. Notwithstanding the above, this building is located 60 metres from the proposed cut-and-cover roadway and preliminary calculations indicate the PPV vibration levels at the footing of the Veneto Club would be well below the Line 3 damage criteria.

Other buildings which are heritage listed include the Heide I and Heide II buildings (at 5–7 Templestowe Road, Bulleen) and 22–40 Bridge Road Bulleen. These building are more than 200 metres from any proposed surface construction activities and are not considered at-risk.

Impacts on heritage buildings from tunnelling works are discussed in Technical report – Tunnel vibration.

Further investigation of heritage items would be undertaken during detailed design within the site-specific Construction Noise and Vibration Management Plans (CNVMPs).

8.8.9 Scientific equipment

No building has yet been identified as containing vibration-sensitive scientific equipment, but this will be confirmed during the detailed design phase of the project.

8.8.10 Vibration mitigation

Dependent upon the equipment to be used, where vibration-intensive construction activities are proposed within 100 metres of sensitive receivers, these works would be confined to the less sensitive daytime period, where possible.

The potential impacts from vibration are to be considered in the site-specific CNVMP to be developed during the detailed design phase when more information is available on the schedule for the works, the equipment to be used and the localised geotechnical conditions. The CNVMP would include preliminary vibration site-law testing to confirm vibration modelling assumptions and results, and conclusions or requirements drawn from it.

In general, mitigation measures that would be considered are summarised as follows:

- Relocate vibration-generating plant and equipment to areas within the site to lower the vibration impacts
- Investigate the feasibility of rescheduling the hours of operation of major vibration-generating plant and equipment
- Use lower vibration-generating items of excavation plant and equipment such as smaller capacity rock-breakers or concrete crushers/pulverisers in place of rock-breakers
- Minimise consecutive construction activities in the same locality (if applicable)

- Use dampened rock-breakers and/or 'city' rock-breakers to minimise the impacts associated with rock-breaking works
- If vibration-intensive construction activities are required within the safe working distances, vibration monitoring or attended vibration trials would be undertaken to ensure that levels remain below the cosmetic damage criterion
- Where necessary, building condition surveys would be completed before and after the works to identify existing damage and any damage due to the works.

In all cases it is anticipated that vibration impacts would be able to be controlled to avoid cosmetic damage to any structures.

Measurements of existing ambient vibration levels would be undertaken at receivers identified as having vibration-sensitive or scientific equipment during the detailed design phase.

8.9 Alternative design options

Although the reference project for North East Link has largely been finalised, there are currently two design options being considered for the arrangement of the Manningham Road interchange, and two locations for the launch of the tunnel boring machine (TBM) being considered. For information on the design options, refer to EES Chapter 8 – Project description.

This section explains how the potential impacts associated with the alternative design options would differ from the impacts associated with the project design assessed in Noise Precinct 1 in **Section 8.3.1** and Noise Precinct 2 in **Section 8.3.2**.

8.9.1 Manningham Road interchange alternative

The potential construction noise and vibration impacts of the alternative design for the Manningham Road interchange have been reviewed. The primary difference between the design options are the precise locations of the entry and exit portals of the ramps adjacent to Avon Street and Austin Street in Bulleen.

Both design options are likely to result in very similar levels of impact.

8.9.2 TBM launch site options

The reference project includes two options for the location of primary administration and construction for the tunnelling works. These are at the following locations:

- Proposed southern TBM launch site option – Bridge Street extending south to Golden Way in Bulleen
- Alternative northern TBM launch site option – Lower Plenty Road extending north to Blamey Road.

The proposed southern TBM launch site option is located within the industrial/commercial Noise Precinct of Greenaway Street and Kim Close and would include primary workshops and storage facilities for the works with access via a dedicated entrance at Bulleen Road. An acoustic shed would be placed west of Mangan Street. The nearest residential receivers are approximately 150 metres to 250 metres from TBM launch site facilities. The TBM retrieval would take place within the trench excavation north of Lower Plenty Road.

The alternative northern TBM launch site option would include primary workshops and storage facilities for the works with access to the northern TBM launch site through Blamey Road to the north and Erskine Road to the south. An acoustic shed would be placed at the adjacent to Moorwatha Street, with the nearest residential receivers along Greensborough Road and Boorlase Street approximately 30 to 50 metres from TBM launch site facilities. The TBM retrieval would take place with two specially constructed shafts, located north of Banksia Street in Banksia Park. The two shafts are approximately 25-metres wide x 50-metres long each and the works required would consist of general earthworks and pad preparation, piling and excavation with the retrieval of the TBM components being achieved with heavy lift gantries and cranes.

The potential construction noise and vibration impacts of the two TBM launch site options have been reviewed. The primary differences between the two options are the available area to contain all the facilities and the significant difference in set-back difference to the nearest residential receivers as well as the origin point from which significant spoil haul traffic would be generated.

The proposed southern TBM launch site option provides a significantly lower number of impacts with regards to construction noise and vibration.

The spoil haul route for the southern TBM launch site option would be to the west along Banksia Street and Bell Street and north along Rosanna Road/Greensborough Road and three alternative routes of Sydney Road, High Street and Plenty Road resulting in small increases in noise level and noise events on these routes during the night period. The northern TBM launch site option would be contained in a truck curfew zone and so potentially unable to operate spoil haulage during the night-time and so there are no increases in night-time noise levels or noise events on the haul route of Greensborough Road.

The construction of the southern TBM retrieval shaft has been modelled and the highest noise generating construction activity is anticipated to be the excavation works which utilise several large rockbreakers once the depth of the shaft has reached hard ground. High noise activities such as rock-breakers are not expected to be required outside standard work hours and no noise impacts are anticipated.

9 Operational noise and vibration impact assessment

9.1 Noise model inputs

SoundPLAN is a software package which enables the prediction of traffic noise from a road corridor using 3-D ground terrain, road design strings (including gradients), building height and locations, traffic volumes, vehicle categories and speed, road surface characteristics and the acoustic shielding provided by existing and proposed noise walls. Throughout this report, any reference to traffic, traffic noise or the like is linked to the average annual weekday traffic levels, which are typically higher than on weekends or public holidays.

The Calculation of Road Traffic Noise (CoRTN) 1988 prediction technique was adopted as the basis for the prediction methodology. CoRTN is widely used and accepted throughout Australia and is the recommended road traffic noise calculation and prediction technique recommended by VicRoads (refer Road Design Note 06-01, July 2010).

Noise calculation and prediction locations were positioned one metre in front of the ground floor of every façade of every building. The highest predicted noise level at any point on the building was used for assessment purposes (17 August 2017). A complete overview of the traffic noise modelling process and assumptions are detailed in **Appendix G**.

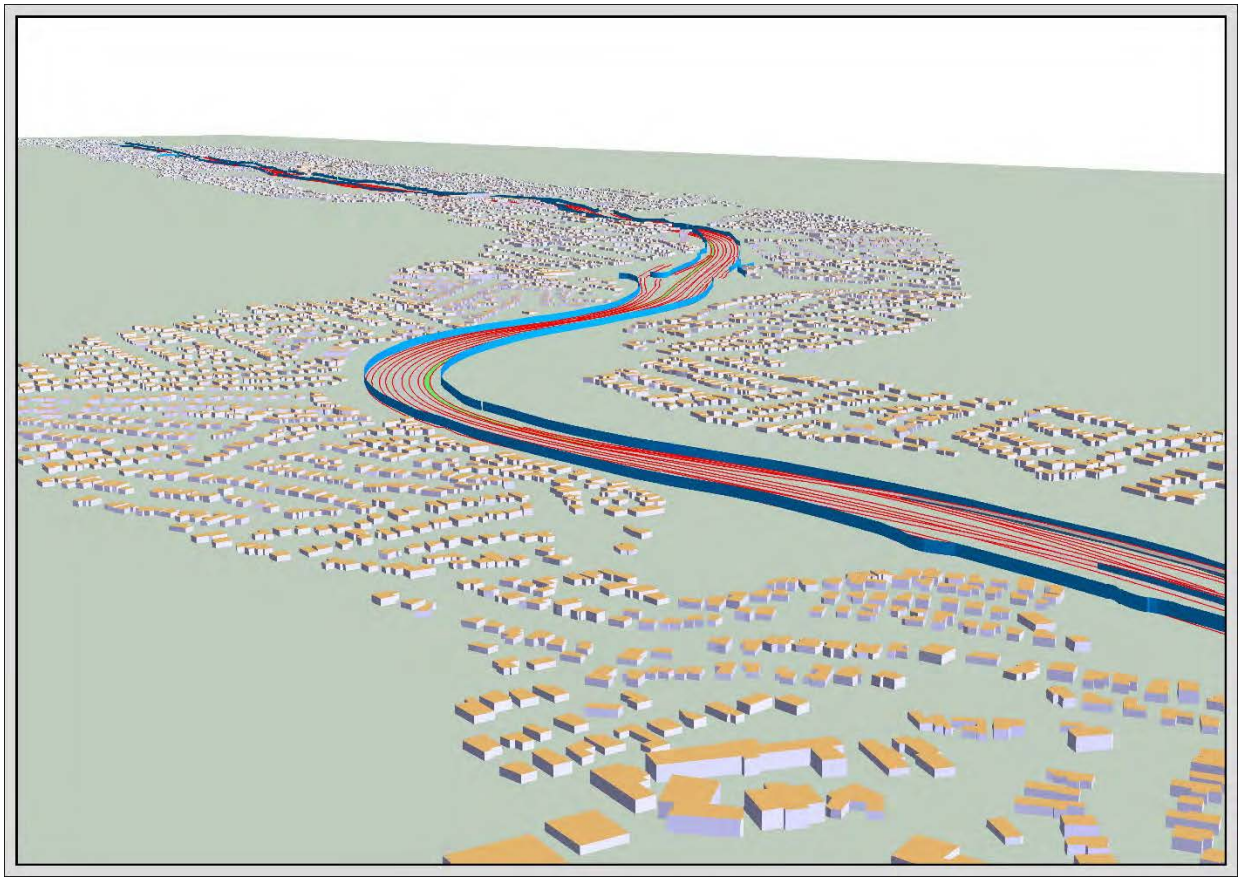


Figure 9-1 3D Typical view of noise model showing houses, road and walls

The predictions and assessment apply to Category A buildings and Category B buildings that are either existing or known to be planned and approved at the date of planning approval for North East Link.

9.2 Noise model validation

Noise model validation is undertaken for the existing conditions noise model (2018). Validation involves the comparison of the measured and modelled noise levels at the same assessment location to verify the accuracy of the noise model. Suitable noise monitoring results that were captured as part of the existing conditions assessment (refer **Section 6**) were used for validating the noise model for 2018 conditions (refer **Section 6.6**).

The calibration value was determined based on the average and the spread in prediction differences, to balance the risk between non-compliance and overdesign. The calibration difference was separately determined for noise monitoring locations around the M80 Ring Road and the Eastern Freeway and the lower of the two corrections applied (being the more conservative approach).

The modelling adopted a -1.9 dBA calibration factor to all predicted modelling, thus incorporating a safety factor to be incorporated into the design.

An overview of the traffic noise validation process has been provided in **Appendix G**.

9.3 Noise mitigation

Several forms of noise mitigation were considered as part of the considerations for noise reduction, to protect the amenity of noise sensitive receivers (identified as risk SNV08, SNV09).

Primary noise mitigation for North East Link would include a combination of low noise road surface pavement on most sections of the main carriageways, existing concrete noise walls and new noise walls constructed within the project construction footprint. Architectural noise abatement has been considered where noise walls cannot be practically constructed or modified to achieve the project noise standard.

Further discussion on the types of noise mitigation is provided in **Section 5.6.2.5**.

9.4 Assessment scenarios

The risk assessment methodology described in **Section 5.5** identified various levels of consequence for increasing traffic noise levels and maintaining compliance with the proposed noise standards as a result of the project. Using this guidance, the risk of noise disturbance at sensitive receivers due to traffic noise from the project is **LOW**.

1. Four modelling situations have been outlined (in the subsequent paragraph below) that would be used to assess the risk and satisfy the project scoping requirements within each identified Noise Precinct:
2. Determine if there is an exceedance of the applicable project noise standard applicable to freeway roads and associated on and off ramps only. Mitigation has been provided where the modelled noise level at Category A receivers are above 63 dBA $L_{A10(18h)}$ or Category B receivers are above 63 dBA $L_{A10(12h)}$ at the lowest habitable level for opening year (2036) and the design year (2036).
3. Compare the change in noise levels at Category A and Category B buildings and open parks and recreational areas between the existing and the future ‘with project’ and ‘without project’ scenarios. The predicted results include the combined traffic noise from freeway and arterial roads that are adjacent or cross the project alignment.
4. Note that this situation is intended to provide a high-level overview of the typical changes in the noise environment that residents can expect, for various scenarios as well as identify discrete location where sensitive building would increase by more than 2 dBA (see **Section 4.4.5**).

5. An assessment of calculated changes in noise level emissions from roads located outside the project study area (See **Section 9.11**). Noise levels have been compared with the situation if the project was not built for the year 2036.

The modelled traffic noise scenarios that have been used to inform the above situations and form the basis of the assessment are:

- 2018 Existing: noise from existing traffic flows
- 2026 with project (including proposed noise walls)
- 2036 with project, 10 years after project opening (including proposed noise walls)
- 2036 without project, the project does not proceed and does not include additional mitigation.

The subsequent discussion on the assessment has been divided into five Noise Precincts as shown in **Figure 5-1** in **Section 5.2**. Refer to Section **5.8**, *Limitations, uncertainties and assumptions* for commentary on 2026 and 2036 modelled traffic scenarios.

9.5 Traffic noise assessment, 2036 with project

Traffic noise levels corresponding to the future 2036 traffic flows (with project) have been modelled on the future road alignments, using the future projected traffic flows.

For each of the five Noise Precincts, several buildings (a mix of residential and noise-sensitive properties) have been selected to broadly represent the change in traffic noise levels along the project corridor. These properties are intended to provide a high-level assessment, and they would not be considered definitive for all properties in the identified street.

Even within the same street, it is recognised the noise environment can vary (sometimes dramatically) due to the position of the property with respect to the roadway and the influence of intervening structures. The tables describing the existing, the 'no project' and 'with project' scenarios are intended to demonstrate the relative noise environment that residents can expect for the various scenarios.

Some buildings may indicate high levels of noise. The values presented are the combined influence of noise from North East Link and any arterial road in the immediate area. The design of noise mitigation is based on the need to reduce noise from the project to achieve compliance with the 63 dBA (NV01) criterion (where it is feasible and reasonable to do so). However, where the traffic noise is dominated by the local non-project road, no mitigation packages would be considered.

Table 9-1, Table 9-4, Table 9-6, and **Table 9-9** present the typical range in traffic noise levels along a selection of streets close to the project roads, and were elected as they are most impacted by the project. At these locations a range of noise levels is provided, representing the 'typical' upper and lower predicted traffic noise levels.

9.5.1 Noise Precinct 1

9.5.1.1 Summary of project road works

The project corridor between Plenty Road and Lower Plenty Road would be approximately seven kilometres. Project-related works would involve:

- Widening works along the entire length

- The creation of a smooth-flowing interchange at the current signalised Greensborough Bypass and M80 Ring Road intersection
- The widening of Greensborough Road leading into a new cut-and cover trench.

9.5.1.2 Sensitive receivers

A list of the noise-sensitive receivers is detailed in **Table 6-1**.

9.5.1.3 Noise mitigation recommended to achieve NV01

Mitigation measures in this area include:

- The use of low-noise, open-graded asphalt (OGA) on the main carriageway
- New noise walls and replacement of the existing walls along the main carriageway of heights three metres to 10 metres, as shown in **Appendix I**
- Upgrades to the roads at the interchange would incorporate four-metre noise walls on two viaducts
- It is anticipated that eleven properties may qualify for at-property mitigation, although this number is subject to detailed design updates and review.

9.5.1.4 Change in traffic noise levels

Table 9-1 presents the calculated range of levels of road traffic noise for a selection of locations along the route and includes noise from North East Link and from nearby arterial roads in the immediate vicinity.

The existing noise levels often vary dramatically (approximately 10 dBA or more) for residents along sections of Noise Precinct 1, depending on their distance from the roadway and the exposure to the traffic stream. This is reflected within the results.

Table 9-1 Calculated typical road traffic noise levels – Noise Precinct 1

Receiver type	$L_{A10(18hour)}$ Road traffic noise level (dBA)			Difference (dBA)	
	Existing (2018)	Do nothing (2036)	With project (2036)	With/without project (2036)	Change from current (with project)
Category A – Residential					
Hughes Circuit, Bundoora	57 to 63	58 to 64	57 to 60	-4 to 0	-3 to 0
Emond Rice Parade, Watsonia Nth	53 to 57	54 to 59	58 to 61	2 to 4	3 to 5
Eastgate Dr, Greensborough	55 to 60	56 to 62	58 to 61	-2 to 2	0 to 4
Banfield Terrace, Greensborough	55 to 61	56 to 62	58 to 60	-4 to 2	-3 to 3
Sellars Street, Watsonia nth	56 to 70	58 to 71	57 to 64	-9 to 0	-8 to 1
Hamlet Street, Greensborough	65 to 71	66 to 71	59 to 66	-9 to -3	-8 to -1
Ibbottson Street, Watsonia	59 to 66	60 to 67	57 to 62	-7 to -1	-6 to 0
Service Road (between Elder Street and Sarong Street), Watsonia	61 to 66	63 to 67	57 to 59	-8 to -5	-7 to -3
Greensborough Road (South of Watsonia Road), McLeod	72 to 77	72 to 77	70 to 75	-5 to -1	-5 to -1
Borlase Street, Yallambie	65 to 67	66 to 68	58 to 64	-8 to -3	-8 to -3

Receiver type	$L_{A10(18hour)}$ Road traffic noise level (dBA)			Difference (dBA)	
	Existing (2018)	Do nothing (2036)	With project (2036)	With/without project (2036)	Change from current (with project)
Category B – Community					
Watsonia Primary School/Concord School/Grace Baptist Church	61 to 67	61 to 66	60 to 61	-5 to -1	-5 to -1
Baptcare Strathalan, McLeod	74 to 76	73 to 75	71 to 73	-2	-2
Watsonia Library, Watsonia	68	69	60	-9	-8

The total predicted traffic noise exceeds the 63 dBA (NV01) traffic noise assessment guideline target at some buildings in Noise Precinct 1. This particularly applies to residents that experience noise from roads such as Greensborough Road, Grimshaw Street or other similar arterial roads. In these locations the noise environment is dominated by traffic noise on non-project roads and the cumulative increase of traffic noise from the project and the existing roads is not predicted to increase by more than 2 dBA. Consequently, these properties would not be further considered for noise mitigation.

9.5.1.5 Discussion: Category A – Residential properties

Plenty Road to the M80 Ring Road interchange

Widening works along the M80 Ring Road would allow for additional traffic lanes to be built for a projected increase in traffic volumes. This would require existing earth mounds and timber noise walls next to the existing road reserve to be replaced with new noise walls. Noise walls would be installed adjacent to the new road reserve, so that residents and the shared use paths are shielded from the freeway.

New noise walls have been designed to achieve the EPR requirements of NV01 at the residential buildings located in this area. For residents east of the interchange and before the Plenty River Bridge, the noise walls vary from 5–10 metres high, with four-metres high on the elevated viaducts. Concerns were raised during the public consultation sessions by some community members between Macorna Street and Gillingham Street about the introduction of new viaducts to provide a connection between North East Link and the M80 Ring Road and the Greensborough Bypass and the M80 Ring Road. The concerns focused on the likelihood that vehicles on these elevated viaducts would be visible and therefore associated with a significant increase in traffic noise. The increase in traffic noise in these areas is considered to be negligible to slight, though as a result of the noise mitigation, all residences in this assessment area, comply with the project noise objectives.

The existing levels of traffic noise ($L_{A10(18hour)}$) vary throughout the wider area, with levels typically being in the range 50 dBA to 61 dBA (depending on the proximity to the freeway). The change in noise between the future (2036) 'without project' and 'with project' scenarios across the wider assessment area would typically vary between a reduction of 3 dBA to an increase of 2 dBA. Changes of noise within this range are considered unlikely to be noticeable.

Plenty River Bridge to the M80 Ring Road interchange

Residents on the northern and southern sides of the Greensborough Bypass (east of the interchange) are predicted to experience traffic noise decreases of up to 6 dBA during operation of North East Link, representing a significant reduction in traffic noise. Across the assessment area, residents may typically experience decreases of -3 dBA and increases of up to 2 dBA. Changes in this range are unlikely to be noticed. No property in this assessment area is predicted to experience residual impacts that exceed the traffic noise objectives.

The noise modelling indicates an acoustic benefit to install a four-metre noise wall on the southern side of the Plenty River Bridge, although it is noted this section of the bridge is outside the project scope of works. The feasibility of installing this wall has not been reviewed by the designers and is therefore subject to further consideration, including its constructability. If these bridge barriers are not feasible, as part of this or other projects, a small number of houses in the immediate area to the south-west of the bridge may qualify for at-property treatment.

M80 Ring Road interchange to Grimshaw Street

Noise walls have been designed so that residents in this segment are predicted to experience lower noise levels during operation of North East Link. Noise walls north of the Kempston Street bridge would be 10 metres high on both sides of North East Link, except on viaducts, where a limit of four metres applies. South of the bridge, the walls would be seven to eight metres high. Additional detailing of the walls is required to minimise the leakage of noise through access gaps in the walls required for the shared use path.

Notwithstanding the increase in traffic flows, future noise reductions across the assessment area are predicted due to the proposed mitigation measures, which are generally in the order of 5 dBA (extending to more than 10 dBA) in 2036 when comparing the 'with project' with the 'without project' scenarios. At a small number of locations, insignificant increases of 1 dBA are predicted. There are 10 buildings in this area that may qualify for further consideration of at-property treatments, during the detailed design phase of the project.

Land to the west of Vincent Court would be required for the construction of new surface ramps and elevated viaducts that connect the M80 Ring Road and Greensborough Bypass to the realigned Greensborough Road. The location of these new roads has been discussed with residents who expressed concerned about the potential increase in traffic noise levels. Due to the available space within the construction footprint and the surface and elevated roads crossing over each other, it was not feasible to construct a single continuous noise wall that provided sufficient mitigation. To achieve EPR NV01 in this location, a combination of viaduct, road-side property boundary noise walls and at-property treatments has been proposed.

Grimshaw Street to Blamey Road

North East Link would be in a trench at this section of the project. For the area south of Watsonia Road, a series of land bridge walkways have been developed to enable pedestrian and cyclist access between the areas east and west areas of the project. The area between these land bridge walkways is a visual connection with the project's road network below, but so this does not lead to a breakout of noise, a four-metre high noise wall has been incorporated into the design.

Between Grimshaw and Watsonia Road, the project would reduce noise to the residents (across the assessment area) generally up to 6 dBA (with some residents experiencing reductions of over 10 dBA) compared with the 'without project' scenario. At some locations, insignificant increases of 1 dBA are predicted. The upper range of the noise reductions represents a significant reduction in the future noise environment. One property in this area is predicted to have residual noise impacts and would be subject to consideration of at-property mitigation during detailed design.

Reduced traffic volumes (compared with the 2036 'without project' scenario) would reduce noise by up to 4 dBA for parts of Grimshaw Road, corresponding to a slight decrease in the level of traffic noise.

At the very north of Grimshaw Road, a slight realignment to the west (at the Watsonia Road intersection) would mean an insignificant increase in the overall level of traffic noise of less than 2 dBA. This is not considered significant and applies to only a few buildings, and it is not anticipated to result in the loss of acoustical amenity to the occupants of residential or commercial buildings in this region.

Modelling indicates that mitigation can be provided such that traffic noise from North East Link is predicted to comply with the project noise goal of 63 dBA at all residences along Greensborough Road. However, traffic noise from Greensborough Road (non-project) would still exceed the 63 dBA criterion, although as the project would provide a noticeable reduction in noise, these residences would not qualify for further consideration of noise mitigation.

Blamey Road to Lower Plenty Road

South of Blamey Road, North East Link would be in tunnels so traffic noise would only originate from entry and exit ramps, south of Strathallan Road. Consequently, modelling indicates the traffic noise from the project is predicted to readily comply with the relevant project noise objectives. The design incorporates a series of three to five-metre noise walls along the ramps north of Plenty Road. These noise walls are subject to review, as flood mitigation walls are to be introduced and would most likely modify or replace the currently nominated walls.

For residents along Greensborough Road, immediately north of Erskine Road, the combined noise from North East Link and non-project roads would reduce noise by 1 dBA to 3 dBA compared with the 2036 'without project' scenario. However, traffic noise from Greensborough Road (non-project) would still exceed the 63 dBA criterion. The project does not trigger the 2 dBA increase in noise on non-project roads, and results in a small reduction in noise, these residences would not qualify for further consideration of noise mitigation.
For residents south of Erskine Road (including the Baptcare Strathalan Macleod aged-care facility), North East Link would mean a decrease of around 2 dBA at the properties fronting Greensborough Road. As noted, this area is subject to future refinement due to the introduction of the flood walls.

9.5.1.6 Discussion: Category B – Community

Table 9-2 summarises the expected project impacts to key community buildings in Noise Precinct 1.

Table 9-2 Noise Precinct 1 – Discussion of typical impacts to key community buildings

Community building	Overview of project impacts
St Mary's Parish Primary School St Marys Church	Total traffic noise at St Marys School is predicted to increase by approximately 1 dBA during operation of North East Link, though noise from North East Link is below the project noise objectives. Traffic noise at the school buildings is controlled by local traffic on Grimshaw Street and would remain high (~approximately 74 dBA). As the contributed noise from the project is below the project noise objectives, and the total noise does not increase by 2 dBA or more, no further consideration of noise mitigation would be considered.
Watsonia Primary School, Concord School and the Grace Baptist Church	Traffic noise at the Concord and Watsonia primary schools and Grace Baptist Church would typically decrease by between 1 dBA to 5 dBA (and up to 10 dBA at one facade) due to the new noise walls. At the upper range, this represents a very significant decrease in traffic noise. All the noise levels at all buildings are predicted to comply with the relevant project noise objectives.
Watsonia Library	Watsonia Library would benefit significantly from the project and its associated noise walls, with reductions in traffic noise of up to 9 dBA. The overall level of traffic noise from the project is predicted to readily comply with the project noise objectives.
Watsonia Uniting Church	Traffic noise at the Watsonia Uniting Church would significantly reduce by up to 8 dBA due to the new noise walls. The overall level of traffic noise from the project is predicted to readily comply with the project noise objectives.

Community building	Overview of project impacts
Holy Spirit Anglican Church	Traffic noise levels at the Holy Spirit Anglican Church would reduce by up to 3 dBA, due to construction of new noise walls along the project roads. Modelling indicated the overall levels of traffic noise from the project roads, would readily comply with the project noise objectives.
St Martin of Tours Primary School	St Martin of Tours Primary School is approximately 200 metres from North East Link tunnels. At this location, the traffic noise is controlled by the traffic on Lower Plenty Road. Calculations indicate the project would marginally reduce traffic (compared with the no-project traffic flows), resulting in a negligible decrease in traffic noise of approximately 1 dBA.

9.5.1.7 Parks and open space

There are three main parks and open space areas in Noise Precinct 1, as discussed in **Table 9-3**.

Table 9-3 Noise Precinct 1 – Discussion of typical impacts to key parks and open spaces

Community building	Overview of project impacts
AK Lines Reserve	The noise levels at this location are predicted to decrease by a slight reduction of 3 dBA due to the introduction of noise walls along the project roads, designed for adjacent residential properties. This represents a small decrease in prevailing traffic noise levels.
Winsor Reserve	The noise levels at this location are predicted to decrease by a negligible 2 dBA due to the introduction of noise walls designed for the adjacent residential properties.
Plenty River Linear Reserve	The traffic noise levels in the northern portion of this park (east of Pinehills Drive) are predicted to reduce by a negligible 2 dBA, due to the noise walls along the Greensborough Bypass.

9.5.2 Noise Precinct 2

Noise Precinct 2 is the area between the Lower Plenty Road and the Manningham Road interchange, where North East Link would be in tunnels. Regenerated noise and vibration impact from the tunnel section are covered in Technical report D – Tunnel vibration.

The only project roads in this noise catchment are the entry/exit ramps at Manningham Interchange. At this location modelling has shown that the traffic noise complies with the project criterion at all locations, and the increase in traffic noise is less than 2 dBA. No further consideration of mitigation is considered warranted.

The most common current access route between North East Link and the M80 Ring Road is between Greensborough Road, Lower Plenty Road, Rosanna Road, Banksia Street and Bulleen Road. Once North East Link is operating, it would provide an underground link for the length of Noise Precinct 2. The traffic noise on these intervening surface roads (in the wider area) is predicted to reduce by between (approx.) 1.5 dBA to 2.5 dBA, representing a negligible reduction in traffic noise levels.

9.5.3 Noise Precinct 3

9.5.3.1 Summary of project road works

Noise Precinct 3 is the area immediately surrounding the Bulleen Road interchange with the Eastern Freeway, extending up to the Manningham Road interchange. The area of interest in this Noise Precinct relating to surface noise impact is south and east of the southern portal.

The proposed ramps to and from the tunnel portals would introduce several flyovers over the Eastern Freeway, increasing the complexity of the interchange over that currently existing. In addition, the Eastern Freeway is proposed to be widened, and the new dedicated busway along the northern part of the Eastern Freeway (the Doncaster Busway) would include a new Park and Ride facility at Bulleen Road.

9.5.3.2 Sensitive receivers

The land-use in Noise Precinct 3 is predominantly residential although there are two schools in the area:

- Belle Vue Primary (south of the Eastern Freeway and east of Bulleen Road)
- Marcellin College (north of the Eastern Freeway and east of Bulleen Road).

9.5.3.3 Noise mitigation recommended to achieve EPR NV01

The proposed mitigation in Noise Precinct 3 includes:

- Low-noise, open-graded asphalt (OGA) on the main carriageway. The use of OGA has been extended to include two of the viaducts at the southern portal (the viaduct transporting vehicles travelling west along the Eastern Freeway into the tunnel, and the viaduct transporting vehicles from the tunnel in an easterly direction on the Eastern Freeway), subject to detailed design acceptance. If the use of OGA proves not to be feasible, several additional dwellings in the surrounding area may qualify for treatment.
- Noise walls on the main carriageway, typically 8 – 10 metres high.
- Noise walls on selected flyovers, are four metres high. The physical extent of these walls is subject to review, having considerations of driver's sight lines, or other design issues.
- Thirteen properties in Noise Precinct 3 are subject of residual impacts, which may qualify for at-property noise mitigation. However, this would be further considered during the detailed phase of the project.

Change in traffic noise levels

Table 9-4 presents the calculated levels of road traffic noise for a selection of locations along the route and includes noise from North East Link and nearby arterial roads in the immediate vicinity.

Table 9-4 Calculated typical road traffic noise levels – Noise Precinct 3

Receiver type	$L_{A10(18hour)}$ Road traffic noise level (dBA)			Difference (dBA)	
	Existing (2018)	Do nothing (2036)	With project (2036)	With/without project (2036)	Change from current (with project)
Residential					
Ursa Street, Balwyn Nth	53 to 63	54 to 64	53 to 61	-4 to -1	-2 to 0
Viewpoint Road, Balwyn North	62 to 65	63 to 66	59 to 60	-6 to -3	-5 to -2
Furneaux Grove, Bulleen	57 to 63	57 to 64	58 to 64	0 to 2	1 to 2
Noise sensitive					
Marcellin College	56 to 59	59 to 62	56 to 60	-3 to -2	0 to 1
Belle Vue Primary School	60 to 69	62 to 70	59 to 70	-3 to 0	-2 to 1

Within Noise Precinct 3, 13 properties are predicted to have traffic levels above the 63 dBA assessment guideline target and will consequently be considered for at-property treatments during detailed design. It is noted that as a result of the project proceeding, there would be a precinct wide change in noise of between an insignificant 1 dBA increase to a noticeable 4 dBA decrease in traffic noise.

9.5.3.4 Discussion: Category A – residential properties

Bulleen

The new noise walls have been designed to achieve the requirements of NV01 at the nearby residential buildings. To protect the amenity of the area the existing noise walls are proposed to be demolished and replaced with taller walls that are eight metres to 10 metres in height. In addition, some viaducts would incorporate four metre high walls. The roadside walls would be positioned close to their current position, having consideration of some widening of the roads to the north. This mitigation associated with the project is predicted to provide up to 5 dBA noise reduction in 2036, representing a noticeable decrease.

Thirteen properties in the Bulleen area are subject to residual impacts and are subject to review during the detailed design phase of the project. This review would include any relevant project design changes.

Balwyn North

The future 2036 traffic noise levels in Balwyn North area are predicted to generally decrease between 2 dBA to 5 dBA compared with the 'without project' scenario. The future change in noise represents a noticeable change in the noise environment. The noise walls would increase from their current heights, up to eight metres to 10 metres tall, with the viaducts incorporating four metre walls.

The location of the new noise walls moves towards the south (closer to the residences), to accommodate the north-bound viaduct and the expansion of the freeway.

9.5.3.5 Discussion: Category B – Community Buildings

Table 9-5 presents a summary of the expected project impacts to key community buildings in this Noise Precinct.

Table 9-5 Noise Precinct 1 – Discussion of typical impacts to key community buildings

Community building	Overview of project impacts
Marcellin College	Traffic noise at Marcellin College is predicted to decrease by up to 3 dBA during operation of North East Link. Traffic noise at the school buildings is heavily influenced by local traffic noise from Bulleen Road. However, the overall modelled traffic levels are predicted to comply with the project noise objectives.
Belle Vue Primary School	Modelling indicates that traffic noise from the project is predicted to comply with the project noise objectives at the school due to the new 8 –10 -metre high noise walls to the north of the school. This would reduce noise from the Eastern Freeway of up to 3 dBA. On the western facades of the closest buildings to Bulleen Road, in insignificant increase of less than 1 dBA in traffic noise is predicted. Although the overall traffic noise level exceeds the 63 dBA criterion, the noise from the project complies with its noise objectives and the increase in noise (between the 'with project' and 'without project' scenarios) would not be more than 2 dBA. Consequently, no further consideration of noise mitigation is warranted in relation to project noise standard, given the noise is attributable to the non-project roads.

9.5.3.6 Parks and open space

There are three main parks and open space areas in Noise Precinct 3: the Carey Grammar oval, Marcellin College ovals and Trinity Grammar School Sporting Complex. At this stage of the design, the modelling indicates an increase in noise levels of up to 5 dBA. These predictions do not include the acoustic benefit of the flood walls (which will act as a noise wall), the design of which are yet to be finalised. When the acoustic shielding benefits of these are accounted for, it is expected they would likely provide sufficient mitigation to areas of the sporting fields, although this requires confirmation during detailed design.

9.5.4 Noise Precinct 4

9.5.4.1 Summary of project road works

The project design of this section would include:

- Upgrades including widening of the Eastern Freeway
- New dedicated busway along the Eastern Freeway (the Doncaster Busway)
- Upgrades to noise walls including new walls in some areas
- New and modified shared use paths
- Changes to waterways and drainage in some areas.

The road widening would principally extend into adjacent parkland, mainly to the south and along the north of the Koonung Creek Linear Park frontage.

9.5.4.2 Sensitive receivers

The area north and south of the Eastern Freeway east of the Bulleen Road interchange is defined as Noise Precinct 4. The corridor is predominantly residential in nature with some intervening parkland in some areas. Some of this parkland has historically been considered as a buffer zone or a form of noise mitigation separating the residential area from the Eastern Freeway. A complete list of noise-sensitive buildings is detailed as part of **Table 6-3**.

9.5.4.3 Noise mitigation recommended to achieve NV01

The proposed mitigation in Noise Precinct 4 includes:

- Low-noise, open-graded asphalt (OGA) on the main carriageway
- Noise walls on the main carriageway, typically 5–10 metres high
- Approximately 128 properties would experience residual impacts above 63 dBA and may qualify for at-property noise mitigation, although this would be further considered during the detailed phase of the project. Those buildings considered for at-property mitigation would be subject to ongoing design refinement, in terms of changes to the road or wall design and tend to be located near the end of noise walls or adjacent to shared path penetrations.

Noise at the residential properties varies along the route depending on the noise wall height, the height of the property relative to the roadway and whether there is a break in the wall (due to features such as cross roads and cycle paths).

9.5.4.4 Change in traffic noise levels

Table 9-6 presents the calculated levels of road traffic noise for a selection of locations along the wider route and road networks and includes noise from North East Link and arterial roads in the immediate vicinity.

Table 9-6 Calculated typical road traffic noise levels – Noise Precinct 4

Receiver type	$L_{A10(18hour)}$ Road traffic noise level (dBA)			Difference (dBA)	
	Existing (2018)	Do nothing (2036	With project (2036)	With/without project (2036)	Change from current (with project)
Residential (Category A buildings)					
Estelle Street, Bulleen	61 to 64	62 to 65	59 to 60	-5 to -3	-5 to -2
Carron Street, Balwyn North	63 to 66	64 to 66	58 to 60	-7 to -5	-6 to -4
Koonung Street, Balwyn Nth	59 to 64	60 to 65	59 to 62	-3 to -1	-2 to 0
Paul Street, Doncaster	60 to 65	61 to 66	61 to 63	-4 to 0	-3 to 0
Hender Street, Doncaster	63 to 66	64 to 67	65 to 67	0 to 2	0 to 3
Jocelyn Avenue, Balwyn North	57 to 61	57 to 62	60 to 67	0 to 5	1 to 5
Stanton Street, Doncaster	56 to 66	56 to 66	62 to 69	2 to 7	2 to 7
Valda Street, Mont Albert North (Lincoln Street to Morris Street)	59 to 62	60 to 62	58 to 60	-3 to -1	-3 to -1
Paul Avenue, Box Hill North	60 to 65	61 to 66	61 to 67	0 to 1	1 to 2
Applewood Retirement Village, Doncaster	62 to 64	62 to 65	65 to 66	1 to 2	2 to 3
Norfolk Circuit, Doncaster	58 to 60	58 to 61	59 to 62	0 to 2	1 to 2
Lyndhurst Crescent, Box Hill North	57 to 61	57 to 61	59 to 63	0 to 2	0 to 2
Eram Road, Box Hill	59 to 64	60 to 64	60 to 66	-1 to 2	0 to 2
Douglas Street, Blackburn North	60 to 63	60 to 63	59 to 60	-4 to -2	-3 to -1
Boronia Grove, Doncaster East	55 to 61	56 to 61	57 to 62	0 to 1	1 to 2
Kett Street, Blackburn North/Nunawading	58 to 61	59 to 61	58 to 62	-2 to 1	-1 to 1
Darvall Street, Doncaster East	57 to 65	58 to 65	58 to 64	-2 to 1	-2 to 1
Noise sensitive (Category B buildings)					
Donvale Primary School	54 to 55	55 to 56	56 to 56	0 to 1	1
Birralee Primary School	58	58	59	1	1
Kalker Montessori Centre	61	62	60	-2	-1

9.5.4.5 Discussion: Category A – residential properties

East of Precinct 3 to Doncaster Road

The widening of the Eastern Freeway in this area would require existing noise walls on the northern side to be demolished with new 8–10-metre high walls constructed. Across all of the properties in this assessment area, the 2036 (with project) noise levels are predicted to be up to a noticeable 4 dBA quieter (compared with the 'without project' scenario), and in houses closer to the project roads, the decrease is up to 7 dBA. Modelling indicates that all properties in this assessment area, would comply with the project's noise objectives, without the need for any at-property treatments.

On the southern side of the Eastern Freeway there are currently no noise walls. It is proposed the project design incorporates new 7–10-metre high noise walls adjacent to the freeway. Modelling indicates that all properties in this area would comply with the project noise objectives, with no property requiring at-property treatments. These new noise walls would reduce noise by up to 7 dBA (compared with the 'without project' scenario) at houses close to the freeway, but more typically up to 5 dBA throughout this area, representing a noticeable decrease in noise.

Doncaster to Station Street/Tram Road

The widening of the freeway in this section is predominantly to the south. Consequently, along the southern portion of the freeway, the noise walls would need to be demolished and replaced with new 5–10-metre high walls. With the project roads, the future noise levels are generally +/- 2 dBA of the 'do-nothing' scenario. At locations closer to the project roads the noise reductions tend to be slightly higher, except for one location that is predicted to experience a clearly noticeable increase of 8 dBA. Seven properties in this assessment area, on the southern side of the Eastern Freeway may qualify for at-property treatment, although this would be further considered during the detailed design phase of the project, in conjunction with any other project design changes in this area.

On the northern side of the freeway many of the existing noise walls would remain, except for any timber noise walls which would be upgraded and replaced. Residents living in buildings behind walls not proposed to be upgraded would experience an increase in noise due to the increase in traffic flows and changes in the project's road configuration. Across this assessment area, the future noise levels are generally +/- 2 dBA of the 'do-nothing' scenario. At some locations the increases are predicted to be clearly noticeable increase of 7 dBA. Ninety three properties in this assessment area, on the northern side of the Eastern Freeway may qualify for at-property treatment. This would be further considered during the detailed design phase of the project, in conjunction with any other project design changes in this area including the multi-level carpark facility at the Doncaster Bus terminus.

Station Street/Tram Road to Middleborough Road

North East Link here would encroach on land mainly to the north of the Eastern Freeway, but also to the south.

Existing noise walls would be replaced where they conflict with the project alignment or where they are constructed from timber. These walls would be generally positioned adjacent to the freeway, although one of the walls would be constructed on a viaduct and so limited to a height of four metres.

On the northern side, residences are set back approximately 200 metres (or more) from the roadway and the current road design does not incorporate any noise walls. With the proposed noise walls, the resulting traffic noise at residences are predicted to comply with the 63 dBA project noise criterion, and no properties will be considered for at-property treatments. There would be a negligible increase of traffic noise of less than 3 dBA.

South of the freeway, some of the existing noise walls would remain. New noise walls would be constructed where changes in the road alignment required their relocation. The change in the traffic noise levels are predicted to vary between reductions up to 2 dBA to increases of less than 2 dBA. Changes of this magnitude are considered to be negligible. This is consistent with expectations, given that some of the noise walls are not changing. Eight properties on the southern side of the freeway are to be considered for noise mitigation during the detailed design phase of the project.

Middleborough Road to Springvale Road

Many of the noise walls in this area are not being upgraded, excepting those which conflict with the new alignment or are constructed from timber.

The expected changes in traffic noise levels (as a result of the project proceeding) vary along the section. Over the assessment area, the traffic noise reductions (relative to the future do-nothing) generally vary between a negligible reduction of 2 dBA to an insignificant increase of 1 dBA. Closer to the noise walls, the noise reductions approach 5 dBA. The higher reductions occur as a result of new noise walls being erected, while the marginal increase is predicted to occur where the existing noise walls are to remain.

Twenty properties are predicted to exceed the project noise objectives, which will be considered during the detailed design phase of the project.

9.5.4.6 Discussion: Category B – Community

Table 9-7 presents a summary of the expected project impacts to key community buildings in Noise Precinct 4.

Table 9-7 Noise Precinct 4 – Discussion of typical impacts to key community buildings

Community building	Overview of project impacts
Kalker Montessori Centre	The introduction of new (and higher) noise walls on the northern side of the Eastern Freeway near the school would reduce noise at the Centre by up to 2 dBA compared with the 'without project' scenario. This represents a small reduction in the future level of traffic noise. The existing and future (with project) traffic noise levels are predicted to comply with the project noise objectives.
Birralee Primary School	The predicted traffic noise levels from North East Link are predicted to readily comply with the project noise objectives. The school is behind a section of noise wall that is not proposed to be upgraded as part of the project. Consequently, the traffic levels may increase by 1 dBA, representing a negligible increase. This is not expected to result in the loss of acoustical amenity at the school.
Wonderland Childcare and Kinder/North Eastern Jewish Centre	The overall predicted levels of traffic noise levels at this location comply with the project noise objectives. The introduction of higher noise walls along the northern side of the Eastern Freeway close to these buildings would slightly decrease traffic noise by up to 1 dBA. No acoustical impacts would be expected at these buildings.
Applewood Retirement Village	Future traffic noise levels with North East Link are predicted to be up to an insignificant 2 dBA higher compared to the project if it did not proceed. Notwithstanding, traffic noise levels are predicted to exceed the project criterion on the southern facades of the building overlooking the Eastern Freeway. During the detailed design phase, this location would be further reviewed for consideration of at-property treatments, with consideration of the use of the space, the extent of noise control already incorporated in the buildings design and any project changes in the vicinity.

Community building	Overview of project impacts
Japara Sydney Williams Apartments – Retirement Village	The predicted traffic noise levels from North East Link are predicted to readily comply with the project noise objectives. The Japara Sydney Williams Apartments are behind a section of noise wall not proposed to be upgraded as part of the project. The increase in noise levels around the perimeter of the development is less than 2 dBA (compared with the 'without project' scenario). Changes of this small a magnitude are considered to have 'no noticeable change' to the noise environment. While the project noise levels are predicted to comply with the project noise objectives, noise from the non-project, Blackburn Road results in levels that exceed the 63 dBA criterion along the most exposed facades. As the change in traffic noise between the with/without project does not exceed 2 dBA, and it is predicted North East Link would comply with the relevant criterion, no further consideration of noise mitigation is warranted.
Heatherwood School	Noise from North East Link is predicted to comply with the project noise objectives here, with a future increase in the traffic noise levels of less than 1 dBA, which would be considered insignificant and would not change the acoustical amenity. The eastern facades of the school are heavily influenced by traffic from the non-project, Springvale Road. As the change in traffic (between the 'with project' and 'without project' scenarios) is less than 2 dBA, no further consideration of noise mitigation is warranted.
Presbyterian Theological College	The Presbyterian Theological College would benefit from new noise walls between the subject building and the Eastern Freeway. The noise walls would provide sufficient noise reduction so that traffic noise complies with the project noise objectives. The western facades of the buildings are influenced by noise from Elgar Road, resulting in levels that exceed the 63 dBA noise objectives. As the change in traffic (between the 'with project' and 'without project' scenarios) is less than 2 dBA, no further consideration of noise mitigation is warranted.

9.5.4.7 Parks and open space

The main parks and open space areas in Noise Precinct 4 are discussed in **Table 9-8.**

Table 9-8 Noise Precinct 4 – Discussion of typical impacts to key parks and open spaces

Community building	Overview of project impacts
Koonung Creek Reserve	The Koonung Creek Reserve currently has no noise walls fronting the Eastern Freeway. The project would incorporate 7–10-metre high noise walls along the Eastern Freeway. This would reduce future noise up to 5 dBA to 6 dBA compared with the 'without project' scenario, representing a moderate decrease in traffic noise.
Manningham Park Reserve	Traffic noise in the Manningham Park Reserve is predicted to decrease by approximately 3 dBA, representing a slight decrease.
Bulleen Cricket Club	Traffic noise levels at the Bulleen Cricket oval are predicted result in no noticeable change when comparing the noise from the project roads to the 'without project' scenario.
Winfield Road Reserve	Traffic noise at the Winfield Road Reserve is predicted to increase an insignificant 2 dBA at locations close the perimeter residents, but decrease by up to 3 dBA, closer to the noise walls.
Katrina Street Reserve Playground	The noise walls along the Eastern Freeway near the Katrina Street Reserve are not being upgraded. Future noise levels may increase by up to 2 dBA if the project proceeded (compared with the 'without project' scenario) and equates to an insignificant change in level of traffic noise.
Elgar Park, Belmore Road	New noise walls along the Eastern Freeway common with Elgar Park would reduce noise levels up to 2 dBA compared with the 'without project' scenario.
Koonung Creek Linear Park	The change in noise along the Koonung Creek Linear Park varies depending on whether an existing noise wall is present or not. For those areas where no existing noise wall is present, slight increases of less than 4 dBA can result (close to the roadway), but closer to the residents in the north of the park, the increase decreases to 2 dBA. Changes of this magnitude would not result in a loss of amenity to users of the park.
Boronia Grove Reserve	Noise walls along the Eastern Freeway near the Boronia Grove Reserve are not being upgraded. Future noise levels may increase by up to 1 dBA if the project proceeds compared with the 'without project' scenario. This represents a negligible change in level of traffic noise.

Community building	Overview of project impacts
Eastern Freeway Linear Reserve	The Eastern Freeway Linear Reserve currently has no noise walls fronting the Eastern Freeway. The project would incorporate 6–8-metre noise walls along the Eastern Freeway. This would reduce future noise by up to 3 dBA compared with the 'without project' scenario, representing a negligible decrease in traffic noise.
North Box Hill Tennis Club/Frank Sedgman Reserve	The North Box Hill Tennis Club/Frank Sedgman Reserve currently has no noise walls fronting the Eastern Freeway. The project would incorporate 5–8-metres high noise walls along the Eastern Freeway. This would reduce noise by up to 1 dBA at the Tennis Club, with lower noise reductions occurring closer to the Eastern Freeway.
Frank Sedgman Reserve	New noise walls adjacent to the freeway at this location are predicted to reduce noise by approximately 3 dBA in the parkland closer to the noise walls. This decreases to there being no noticeable change towards the south of the park (near the residents). This represents a slight noise reduction in the open space, in the northern part of the park.

9.5.5 Noise Precinct 5

9.5.5.1 Summary of project road works

Noise Precinct 5 covers the area north and south of the Eastern Freeway, between Hoddle Street and Bullen Road for a distance of approximately eight kilometres. Project works would include:

- Upgrades to the Eastern Freeway
- A new dedicated busway along the Eastern Freeway (the Doncaster Busway) and an upgrade to the Doncaster Park and Ride facility
- Upgrades to noise walls including new walls in some areas
- New and modified shared use paths
- Changes to waterways and drainage including the diversion and piping of Koonung Creek in some areas.

9.5.5.2 Sensitive receivers

The Eastern Freeway between Dights Falls Reserve and the Yarra Boulevarde is predominantly open recreational parkland, excepting for Melbourne Polytechnic, the Thomas Embling Hospital and the Royal Talbert Rehabilitation Centre. Other buildings and land are used for other purposes, such as the Blind Dog Training facility, although these would not be considered noise-sensitive by the VicRoads Traffic Noise Reduction Policy (2005) and so are non-assessable. A complete list of noise sensitive buildings is detailed in **Table 6-3**.

9.5.5.3 Noise mitigation recommended to achieve NV01

With consideration of the future 2036 (with project) noise levels, the proposed mitigation includes:

- Low-noise, open-graded asphalt (OGA) on the main carriageway.
- Road side noise walls, as detailed in **Appendix I**. Noise walls in this would section from 3–10 in height along the main carriageway. For the elevated viaducts for the busway and lanes from the tunnel heading west (along the Eastern Freeway) and lanes heading west along the Eastern Freeway leading north into the tunnel, the noise walls would typically be 4 metres high.
- The bus lane approach and flyover (across the freeway) would be fitted with three-metre high noise walls on the side of the viaduct closest to the residences, south of the freeway.

- The number of minor impacts at noise sensitive properties would be further considered during the detailed phase of the project, including at-property noise abatement. Buildings considered for at-property mitigation are subject to ongoing design refinement, in terms of changes to the road or noise wall design.

After consideration of low noise pavement and noise walls (4–10 high), approximately seven properties may qualify for at-property noise mitigation, which would be further considered during detailed design along with any other project changes in this area.

9.5.5.4 Change in traffic noise levels

Table 9-9 presents the calculated levels of road traffic noise for a selection of locations along the route and includes noise from North East Link and nearby arterial roads in the immediate vicinity.

Table 9-9 Calculated typical road traffic noise levels – Noise Precinct 5

Receiver type	$L_{A10(18hour)}$ Road traffic noise level (dBA)			Difference (dBA)	
	Existing (2018)	Do nothing (2036	With project (2036)	With/without project (2036)	Change from current (with project)
Residential					
Obrien Court, Kew	56 to 63	57 to 63	56 to 61	-2 to 0	-2 to 0
Kellett Grove, Kew	59 to 61	59 to 61	59 to 60	-1 to 1	0 to 1
Kilby Road, Kew East (west of Windella Avenue)	60 to 64	60 to 65	57 to 61	-7 to -1	-6 to -1
Willow Grove, Kew East	57 to 65	58 to 65	58 to 64	-2 to 0	-1 to 0
Fairway Drive, Kew East	59 to 61	60 to 62	57 to 61	-3 to 0	-2 to 1
Keystone Crescent, Kew East	60 to 61	62 to 66	61 to 65	-2 to -1	1 to 5
Noise sensitive					
Royal Talbot Rehabilitation Centre	54 to 69	54 to 69	54 to 62	-7 to 0	-7 to 1

Noise on non-project roads that intersect with North East Link are not predicted to result in noise from the project which exceeds the 63 dBA (NV01) traffic noise assessment guideline target. At these locations the noise environment is dominated by traffic noise on local (non-project) roads. The cumulative increase of traffic noise from the project and the existing roads were not predicted to increase by more than 2 dBA. Consequently, these properties would not be further considered for noise mitigation.

9.5.5.5 Discussion: Category A – residential properties

West of Merri Creek bridge

North East Link would not involve any substantial works to the alignment in this area, except for works such as minor road lane markings. Notwithstanding, an analysis of the noise emissions was undertaken to assess the need for noise mitigation. The project has incorporated 3–5-metre high noise walls to achieve compliance with the project noise objectives. The design incorporates a new four-metre noise wall on the northern side of the Merri Creek Bridge. This wall is subject to further detailed design to ensure its feasibility and to understand the extent of any implications for other design requirements. Currently, there no properties that require further consideration for at-property treatments. However, if the bridge walls prove not to be viable, some properties may qualify for at-property mitigation.

The new noise walls are predicted to reduce noise at buildings close to the project here by 1 dBA to 7 dBA. The upper range represents a significant reduction in the traffic noise.

Merri Creek bridge to Earl Street

Existing noise walls along Wiltshire Drive (Kew) on the southern side of the Eastern Freeway would be demolished and replaced with a taller five-metre noise wall, reducing noise by up to 2 dBA (compared with the no-project scenario). This is a small reduction, resulting in the project noise objectives being achieved at all residences.

In this area, the westbound bus lane would transfer from the northern to the southern side of the freeway. The viaduct would incorporate a four-metre high wall (on the Kew side) to mitigate noise from the elevated bus corridor to residences located south of the overpass.

One building in the assessment area, may be further considered for at-property treatments during detailed design.

Earl Street to Bulleen Road

New noise walls would be constructed on the southern side of the Eastern Freeway that provide a continuous noise wall (noting breaks for features such as local street thoroughfares and shared use path access) between Earl Street and Bulleen Road. These walls would be 3–9-metres high and would provide coverage for those areas which currently have no noise wall (Kilby Street Kew, The Boulevarde Balwyn North, Columba Street Balwyn North). These new noise walls reduce traffic noise by up to 5 dBA, depending on the exact location. No property would experience any residual impacts that required further consideration of at-property treatments.

On the northern side of the Eastern Freeway the noise wall on the southern side of Kew East would be replaced with higher and longer walls (typically eight metres) which would reduce future traffic noise by up to 5 dBA. A shared use path here would break the noise wall, with six properties identified as qualifying for further consideration of noise mitigation measures. During the detailed design of the noise walls and shared use path, it is possible the exceedance at this one property could be eliminated by adjusting or optimising the noise walls.

9.5.5.6 Discussion: Category B – Community

Table 9-10 presents a summary of the expected project impacts to key community buildings in Noise Precinct 5.

Table 9-10 Noise Precinct 5 – Discussion of typical impacts to key community buildings

Community building	Overview of project impacts
Royal Talbot Rehabilitation Centre	North East Link is predicted to reduce traffic noise levels by up to 7 dBA (compared to the predicted levels, if the project did not proceed) on some buildings, with no change in noise levels on some of the more exposed facades. Notwithstanding, traffic noise levels are predicted to exceed the project criterion on the eastern fade of the building overlooking the Chandler Highway. During the detailed design phase, this location would be further reviewed for consideration of at-property treatments, with consideration including the use of the space, the extent of noise control already incorporated in the building's design and the effects of the Chandler Highway widening works.
Thomas Embling Hospital and Melbourne Polytechnic	These building are more than 200 metres from the Eastern Freeway and predictions of the future 'with project' noise levels indicate compliance with the project noise objectives. Future traffic noise increases of less than 1 dBA are predicted during operation of North East Link which is considered negligible and would not result in the loss of acoustical amenity.

Note: References to the change in noise levels refer to the difference of the 'with project' to 'without project' scenarios; such that a negative number represents a decrease in noise

9.5.5.7 Parks and open space

The key parks and open space areas in Noise Precinct 5 are discussed in **Table 9-11.**

Table 9-11 Noise Precinct 5 – Discussion of typical impacts to key parks and open spaces

Community building	Overview of project impacts
Musca Street Reserve	Musca Street Reserve currently has no noise walls, common with the Eastern Freeway. The project would incorporate new 5–8-metre noise walls between the park and the Eastern Freeway. This would reduce noise by up to 4 dBA compared with the 'without project' scenario, representing a significant decrease in traffic noise.
Freeway Public Golf Course	The Freeway Public Golf course has no noise walls fronting the Eastern Freeway. As a result of natural increase in traffic noise, the noise levels are predicted to increase by 2 dBA along the freeway. An increase of this magnitude is considered to be negligible and would not result in the loss of acoustical amenity.
Jack O'Toole Reserve	The Jack O'Toole reserve has no noise walls fronting the Eastern Freeway. The noise level for the design year is predicted to be less than 3 dBA higher due to the natural increase in traffic. An increase of this magnitude is considered to be minor and would not result in the loss of acoustical amenity.

9.5.6 Comments on at-property treatments

The number of at-property treatments has been conservatively assessed using the upper limit of the predicted traffic range. On this basis, 159 properties have been initially identified as possibly requiring treatment. If the 'actual' or expected traffic flow rate was adopted, this number would decrease to 82.

Of the 159 currently identified properties that require further consideration of at-property treatments, 46% are just over the criterion (within 1 dBA). The model is conservative in that it includes a 'safety factor' and does not include attenuation provided by property boundary fencing, or non-habitable buildings on a property (garden shed or the like). During detailed design, it is reasonable to expect that with more detailed modelling and possible modifications to the road design, the noise predictions would be reviewed and updated. As a consequence of this review, it is also likely that the number of properties requiring treatment would significantly decrease.

9.5.7 Noise contours

A series of noise contours have been generated for the 2036 'with project' and 'without project' scenarios (**Appendix J** to **Appendix L**). The contours are generated from a large number of discrete points spaced at 20 metre intervals across the project and then interpolated to generate the specific contours shown. Consequently, some caution must be used when viewing these plots as they are mainly for visualisation and only provide an estimate of predicted road traffic noise levels. The noise contours are only a visual aid to assist in the assessment.

9.6 Predicted noise levels for 2026 with project

The difference between two time-varying noise environments (as occurs adjacent to a roadway) of 1 dBA is not considered discernible to people. Consequently, it can be concluded there would unlikely be a substantial change in the magnitude of the daytime or night-time level of traffic noise between the year of opening and the design year.

A high-level comparison of the traffic flows along North East Link showed that overall there would be an approximate 6 per cent increase in traffic from the proposed year of opening to the 2036 design year. Considering the overall traffic volume and the expected percentage of heavy vehicles along each of the sections along the main traffic stream of North East Link, calculations indicate that the year of opening would have a level of road traffic noise that is predicted to be approximately 1 dBA lower, compared with the 'without project' traffic noise level predicted for 2036.

9.7 Predicted noise levels for 2036 without project

The impacts arising from the resulting traffic noise levels have been determined. These levels are not used in the assessment of mitigation, but to inform the change in noise levels, as requested in the scoping requirements.

The modelled traffic noise contours for the 2036 'without project' scenario is presented in **Appendix I**. This scenario is sometimes referred to as the future-existing or do-nothing.

The modelling assumes:

- 2036 traffic flows (assuming no project)
- Existing roadside noise walls, noting that residential fences are generally not included as their acoustical qualities tend to be unreliable or poor – this is therefore a conservative assumption and may lead to over-predictions of the traffic noise at some locations.

The traffic noise levels for the 'without project' 2036 scenario are approximately 0.9 dBA higher across the project than the current levels of traffic noise due to the projected growth in traffic. This can be seen in **Figure 9-2,** where the 2018 noise levels are approximately 1 dBA higher in the 2036 'without project' scenario. This increase is generally considered not to be significant nor would result in additional significant impacts.

9.8 WHO night-time noise guidelines

2009 Guidelines

The WHO night-time guidelines have been determined to be an L_{Aeq} night-time level of 58 dBA, when corrected to Australian conditions (refer **Section 4.4.4**).

The relationship between $L_{Aeq,night,}$ and $L_{A10(18hour)}$ that allows for the assessment of the $L_{Aeq,night}$ in terms of the equivalent $L_{A10(18hour)}$ noise index.

Based on the measured difference between the $L_{Aeq(8hour)}$ and the $L_{A10(18hour)}$ indices, the WHO night-time criterion is equivalent to an $L_{A10(18hour)}$ level of 63 dBA.

55 dBA + 2.5 (façade reflection) + 5.6 (measured difference between $L_{A10(18hour)}$ and $L_{Aeq, night}$) = 63 dBA

The $L_{A10(18hour)}$ equivalent of the night-time WHO noise guideline is identical to the project $L_{A10(18hour)}$ noise objectives.

Therefore, there are no additionally impacted properties when assessed to the WHO night-time guidelines; at the lower floors. Examining impacts to the lower floor allows for a direct comparison with the project criterion. If consideration is given to upper level of multi-story buildings, the number of additional residential or other noise sensitive floors of floors (other than the ground floor) that exceed the WHO 2009 interim level is predicted to be 160. In total therefore there are 319 ground and upper level floors, equating to 211 unique buildings, which exceed the objectives detailed in the 2009 Interim WHO Guidelines.

Environmental Noise Guidelines for the European Union (2018 WHO)

The WHO issued a new publication in October 2018 titled *Environmental Noise Guidelines for the European Union*. This document is seen as complimenting the 2009 night-time noise level guidance, issued by the European Regional Office.

The 2018 WHO presents the findings of new research on the effect of noise on health. For road traffic noise an outdoor, free-field, annual average night exposure should not exceed an $L_{Aeq, night}$ level of 45 dBA. Given that all road traffic noise assessed to at a dwelling in Australia is a façade-corrected level, the WHO guideline target can be considered to be 48 dBA, if it is considered in terms of a façade corrected level.

The 2018 WHO are considered to be long-term, aspirational guideline. The 48 dBA night-time L_{Aeq} level is approximately 12 dBA lower than the current, most stringent night-time road traffic noise objective applied by a regulator to a redeveloped road anywhere in Australia. As a result, it would be considered difficult or impossible to achieve compliance with the 48 dBA L_{Aeq} night-time guideline target for residents living near surface highways/freeways, having consideration of commonly used reasonable and feasible mitigation measures.

The 2018 WHO continues to recognise the concept of maintaining an interim guidelines but recommends that this level be set by the relevant local authority. Victoria is yet to set an interim guideline, noting that the Victorian regulators do not have any night-time objectives for road traffic noise. On this basis, it would not be unreasonable to adopt the continued use of the of the 55 dBA free-field, external night-time L_{Aeq} guideline target, for assessment purposes – this is consistent with the redeveloped roads objectives used in NSW (Road Noise Policy, 2011).

The impacts arising from the 2018 WHO guidelines to upper and lower floors of a building is fully discussed in Technical report J – Human health.

9.9 Change in noise level along the North East Link corridor

An analysis of traffic noise levels from the movement of traffic along North East Link to buildings in the study area indicated that:

- Traffic noise levels are predicted to increase by approximately 1 dBA at noise sensitive receivers along the corridor (within the assessment catchment) due to the projected increase in traffic growth along the noise corridor (before mitigation is considered).
- The introduction of North East Link (and associated noise mitigation) tends to reduce the project-wide traffic noise levels by approximately 1 dBA (assuming noise from local roads and project roads). It is noted that for Category A and Category B buildings:
    - 35 buildings along the corridor would experience a very significant noise reductions of 10 dBA or more due to North East Link
    - 382 one buildings along the corridor would experience a significant noise reduction of 5 dBA to 10 dBA
    - 1,883 properties would experience noise reductions by between 2 dBA to 5 dBA
    - 8,287 properties are predicted to experience no noticeable change in their noise environment (-2 dBA to + 2 dBA)
    - 889 properties are predicted to experience an increase of more than 2 dBA.

Figure 9-3 presents a distribution of the predicted change in traffic noise for 2036, with and without the project (adopting the upper limit of the predicted traffic volume range). The number of buildings referred to, includes all properties in the assessment. The high number of properties that fall in the range of +/- 2 dBA (representing no noticeable change to the noise environment) includes those houses that are located sufficiently far from the project alignment, so as not to be adversely affected. **Figure 9-2** highlights that the project provides the most noise reduction to those locations having noise levels higher than approximately 60.5 dBA (compared to the do-nothing scenario).

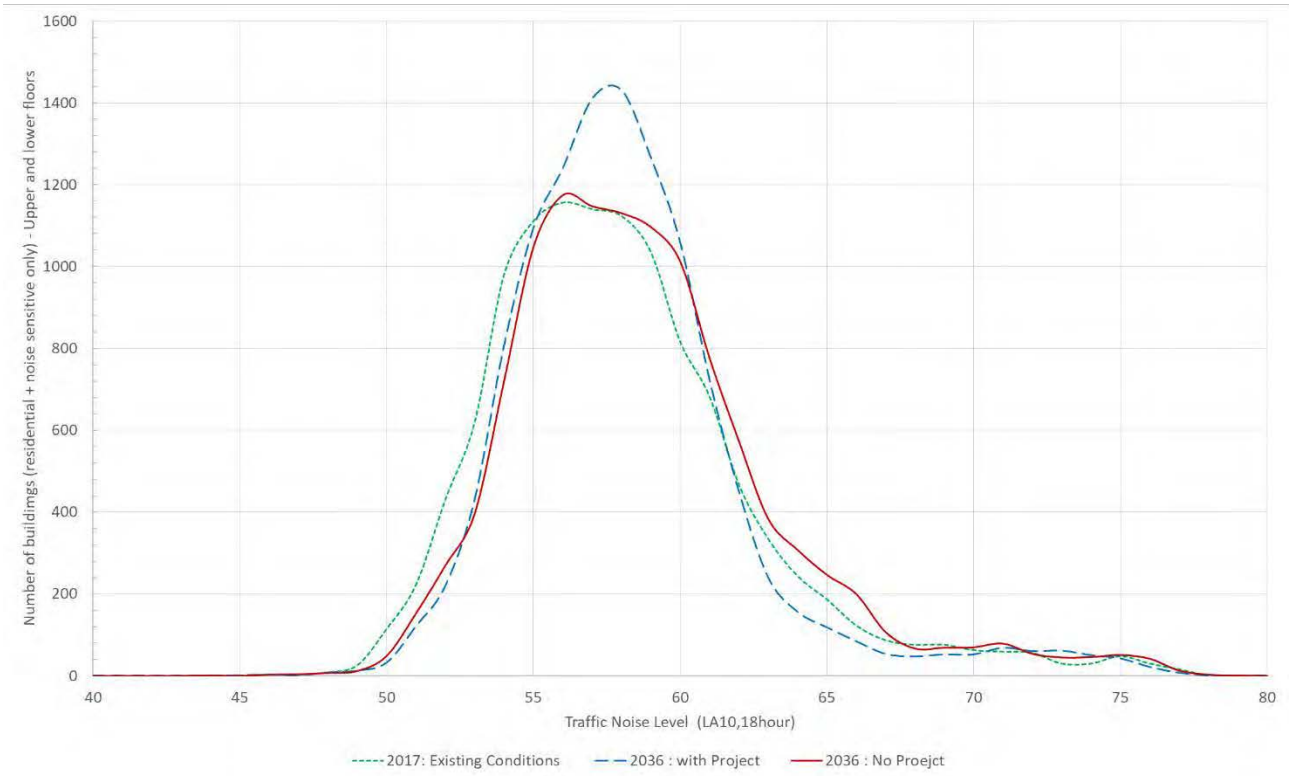


Figure 9-2 Distribution of total traffic noise at noise sensitive buildings along the corridor (total traffic noise)

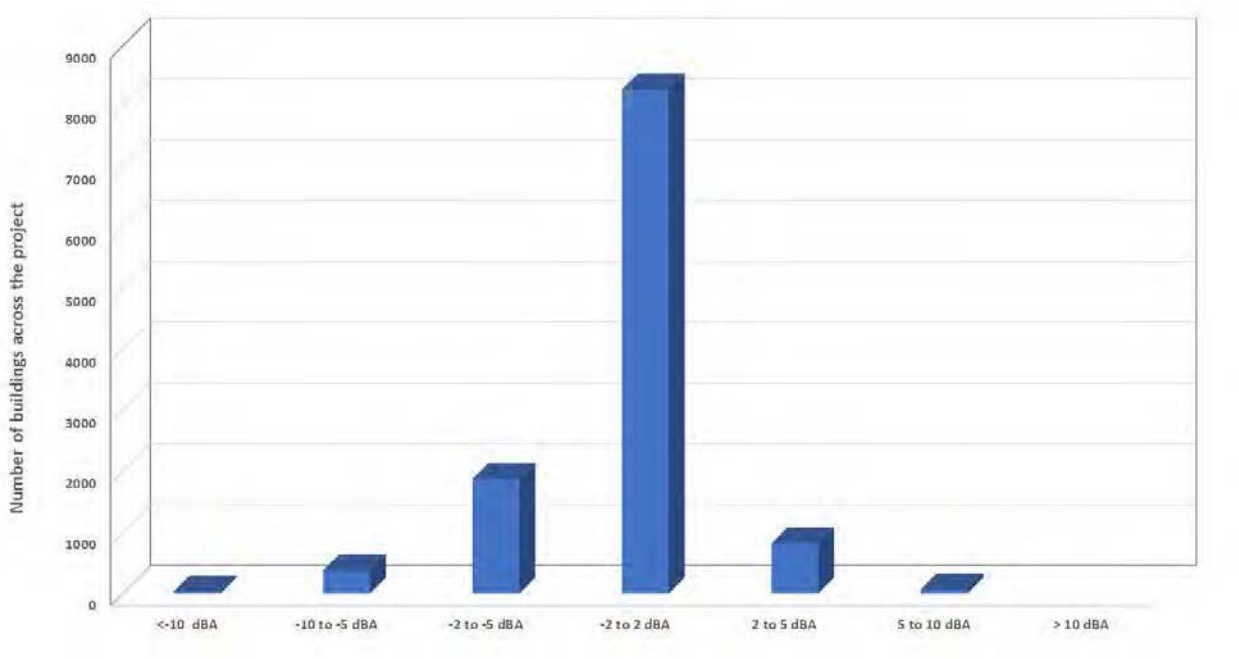


Figure 9-3 Distribution of change noise level in 2036 with/without project (based on total traffic noise)

9.10 Alternative design options

Although the reference project for North East Link has largely been finalised, there are currently two design options being considered for the arrangement of the Manningham Road interchange. For information on the design options, refer to EES Chapter 9 – Project description.

This section explains how the potential impacts associated with the alternative Manningham Road interchange would differ from the impacts associated with the reference project scenario assessed in **Section 9.2** to **Section 9.10** above.

Manningham Road interchange alternative

The potential surface noise and vibration impacts of the alternative design for the Manningham Road interchange have been reviewed.

This alternative design would result in minor changes to the noise environment and would not introduce the need for any additional mitigation, nor changes to the risks or EPRs.

9.11 Comments on impacts on wider road network

North East Link has been designed to provide an effective means of moving traffic between the M80 Ring Road and the Eastern Freeway and beyond. Consequently, it is expected that traffic would be reduced on the current interconnecting roads that commuters now use to move between the M80 Ring Road and the Eastern Freeway.

A high-level estimate of the change in daily traffic noise on the wider road network is presented in **Figure 9-4**. This is based on a simple 'difference in traffic levels' for the traffic flows occurring 2036 with and without the project. It does not account for roads in a cutting or noise reductions due to noise walls. Consequently, for the predictions for areas around and including Greensborough Road, reference should be made to **Section 9.5.1**.

Figure 9-4 shows segments of the road network where the road section was studied as part of the project's overall traffic study (refer to Technical report A – Transport and traffic). It can be reasonably expected that the segments could be simply extrapolated further than that shown.

Figure 9-4 indicates that North East Link would reduce traffic noise on many local roads away from the project compared with the 'no project' scenario. There would be a slight increase in traffic noise in the southern portion of the roads intersecting the Eastern Freeway (such as Station Street and Surry Road in Springvale) and in the west of the site (Childs Road, Dalton Road, Edgars Road and MacDonalds Road). However, the highest increase would be only 1.4 dBA, which is considered negligible and generally unnoticeable.

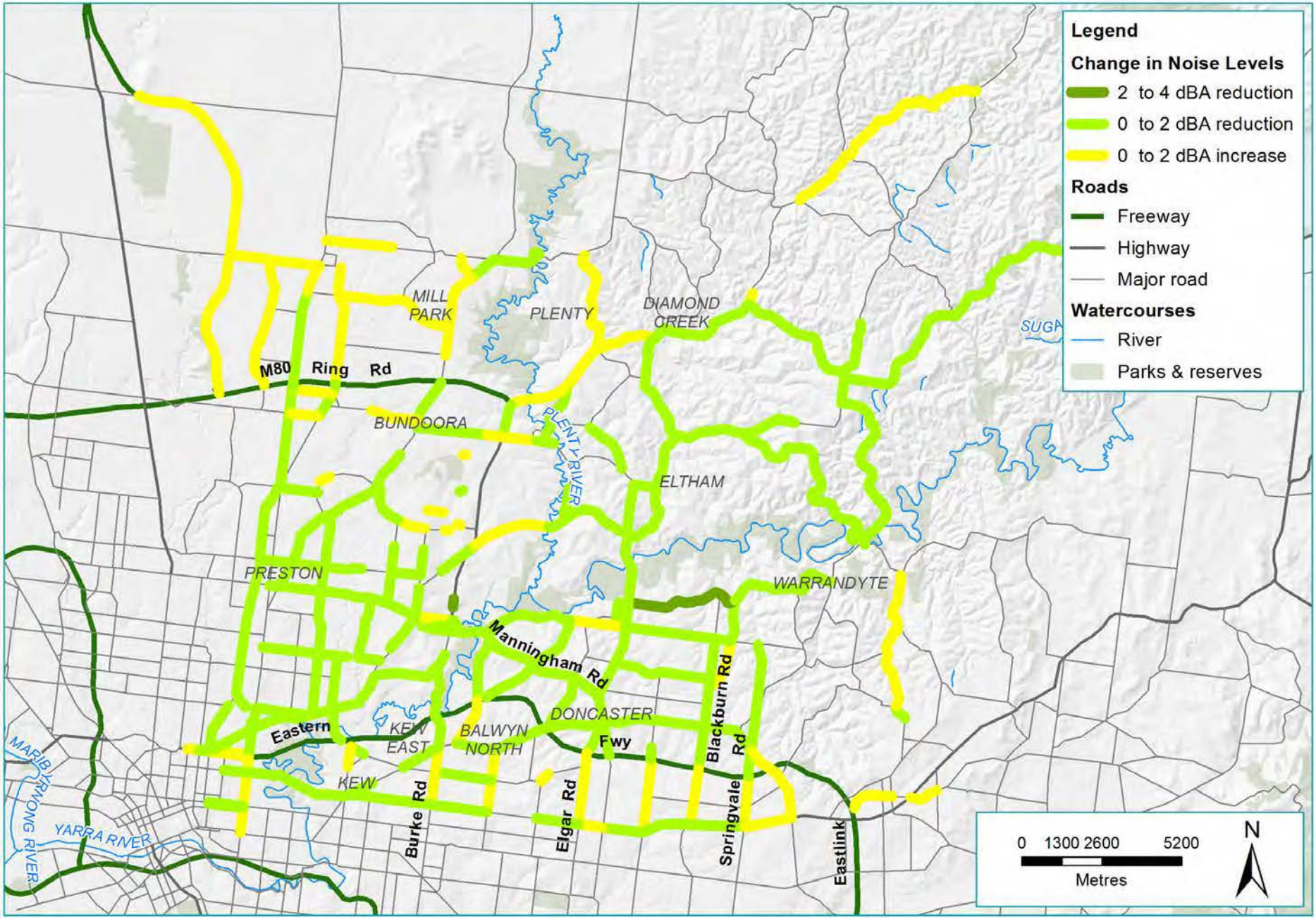


Figure 9-4 Traffic noise reduction on wider road network (2036 $L_{A10(18hour)}$: With-project compared with future-existing noise levels)

9.12 Comments on engine brakes

Engine brakes are one type of secondary braking device fitted to a heavy vehicle intended to assist in slowing it, rather than to stop it.

They are frequently reported as being a source of noise complaint from people who live in the areas around their use, due to the character of the noise rather than the absolute level of the noise. There are no Australian Design Rules associated with the levels of noise that can be emitted from their use, although regulators in Australia have attempted to address the noise issue through measures including Offensive Noise provisions in the regulations. These measures tended to be ineffective and consequently the associated noise emissions are largely unregulated. VicRoads does not provide any guidelines nor requirements to provide noise mitigation to control maximum noise events. Rather, an assessment of the maximum noise levels can be used to assist the planning and design of new roads and ramps.

Engine brakes are predominantly used on the downhill sections of road to slow down but could occasionally be used on flat or up-hill sections if the truck needed to slow down.

The variation in noise levels from engine brakes varies dramatically from vehicle to vehicle and this makes it difficult to predict the future number of events and maximum noise level associated with the use of engine brakes. Potentially, the number of occurrences where engine brakes could be used is proportional to the future increase in percentage of heavy vehicles along the corridor. However, the more free-flowing the traffic stream, the less likely it is for trucks to engage their engine brakes.

Noise emissions from secondary braking devices varies from system to system, and also depends on the prevailing regulations in the country of origin. It is noted that trucks from the European Union have the lowest noise regulations for secondary braking devices, when compared with trucks from the United State or Asia. Some United States trucks are generally recognised as generating higher noise emissions and higher levels of modulations (resulting in the characteristic rapid rise and fall in noise when using the brakes).

The use of secondary braking is entirely at the driver's discretion and depends on the driver's behaviour and attitude. It is noteworthy that a well-maintained muffler could greatly assist in reducing the noise from engine brakes.

Along the majority of the main-line section of the Eastern Freeway, the vertical alignment would not substantially change (although the road is planned to be widened). The road design is therefore considered unlikely to increase the number of engine braking events, acknowledging that the increase in the overall number of trucks on the roadway (commensurate with the increase in capacity) may increase the number of truck breaking events. As the project would allow the traffic travelling on the main corridor to flow at a more consistent speed, this would be expected to lead to less reliance on the need for braking and consequently less use of the engine brakes compared with the existing stop-start traffic environments.

Metered ramps would be introduced to control west-facing traffic connections to the Eastern Freeway. The need for slowing/stopping at the merging of the ramps and the main carriageway (heading east or west along the Eastern Freeway) is a potential source of engine brake noise. However, as the metered ramps would be used mainly during the daytime and road network has been designed to allow for continuous flow traffic, the potential for trucks to engage engine brakes is not considered high.

Residents living along the approaches or near the signalised intersections at the corner of the Greensborough Bypass and the M80 Ring Road and the Greensborough Bypass and Grimshaw Street should benefit with more free-flowing traffic from the elimination of the traffic lights. This should decrease the need to use engine brakes as trucks currently need to slow down for the traffic lights.

Trucks may use their engine brakes to deaccelerate along sections of downhill gradient. An example is the 480-metre length of roadway that leads into the northern portal, south of Somers Avenue. Along this section of North East Link, the average decline would be approximately 3.5 per cent. Considering the project roads are partially enclosed by the three land-bridges over the depressed roadway (total length of 194 metres) and the project road would be 14 to 20 metres below the top of the four-metre noise barriers above the land bridges, noise from the use of truck exhausts would likely be sufficiently mitigated so that significant impacts were minimised (acknowledging that truck exhausts may be audible).

It is not possible to eliminate the noise from engine brakes, given the project cannot mandate that trucks do not use engine brakes on the project roads. To assist in the possible minimisation of truck engine brakes, appropriate signage will be considered during detailed design to encourage drivers not to engage their secondary braking system. It is considered this measure may help reduce engine brake usage.

Currently, the most commonly used truck route to navigate between the M80 Ring Road (at Watsonia) and the Eastern Freeway is:

- Greensborough Road
- Lower Plenty Road
- Rosanna Road
- Banksia Street
- Bulleen Road.

The number of trucks using these surface roads would dramatically decrease during the operation of North East Link as the project would provide a more direct travelling path. The decrease in tuck volumes would vary along each of the roads, but along the above corridor truck volumes are expected to decrease by a median value of 80 per cent. This could be expected to substantially decrease the number of engine brake noise events.

Further reductions in the use of engine brake noise can be expected to occur in future with the continuing progress made in electric cars and trucks. Electric vehicles (cars or trucks) are not factored into the future noise predictions. While it is recognised that electric cars only comprise a small percentage of the current traffic fleet in Melbourne, the establishment of policy incentives in Europe (and other countries) are accelerating the take-up and manufacture of electric vehicles. It is also noted that Volvo (by way of example) has already introduced city-wide trials of electric trucks for delivery of goods (in Europe). There have also been several trials of electric trucks in Australia (including by Australia Post). By the 2036 project design year it can be expected that a measurable percentage of the truck fleet in Melbourne would be electric, further reducing the occurrence of engine brakes in the community.

9.13 Operational vibration

There are no scientific or medical facilities close to the project roads for which specific consideration of vibration is warranted.

Motor vehicles (including cars and trucks) operating on local roads or freeways are unlikely to cause a perceptible level of vibration, assuming the roadway is maintained and free of major potholes. This is supported by the following:

- The results of the baseline vibration measurements undertaken for this project and also from measurements undertaken for the West Gate Tunnel Project
- The vibration predictive model in Section 3.3.4 of the *Transport and Road Research Laboratory, Traffic Induced vibration in buildings* (report 246, 1990) – which predicts a vibration level less than 0.1 mm/s (at 15 metre separation distance)
- Guidance from the *NSW Traffic Noise Policy* (2011), which tends to support the overall conclusion.

Based on the above, the ground-borne vibration from a traffic stream to a dwelling (15 metres away) is not expected to result in perceptible levels of vibration (with reference to **Table 4-9**), as long as the roadway is routinely maintained so that noticeable potholes are repaired once identified.

10 Operation impacts – fixed infrastructure noise

The project would include a number of fixed plant which is assessable under State Environment Protection Policy N-1 (SEPP N-1). This section provides a discussion of the potential for acoustical impact from the operation of the plant and equipment (SNV14).

10.1 Description of plant

The design consists of the following three ventilation stations:

- Northern portal
- Southern portal
- Manningham Road interchange – emergency smoke discharge only.

10.1.1 Tunnel exhaust

10.1.1.1 Ventilation structures

Fresh air supply to the tunnels and ventilation exhaust would be managed by the ventilation system. These would generally consist of jet fans with baffle-type attenuators located within the ventilation building and outlets. It is assumed that the ventilation buildings (intake as well as outlet) would be constructed so the breakout noise (where the noise transmitted externally through the building structure and walls of the ventilation structure) is at least 10 dBA below the noise emanating from the ventilation structure at the nearest most affected receiver location. The ventilation system is assumed to be operational 24-hours per day, seven days per week.

The tunnel exhaust fans would include several variable speed drive (VSD) duty ventilation fans at the tunnel structure. Dampers located at the structure exit would enable the exhaust gas air velocity to be maintained between six to eight metres per second. Ventilation rates from each ventilation structure would be approximately 450 to 1,050 cubic metres per second. The configuration of the dampers would depend on the time of day, vehicle volumes, in-tunnel air quality and maintenance schedules, noting that the duty cycle of the fans may vary throughout a 24-hour period, depending on the vehicle flow ate and the prevailing meteorological conditions.

Low static pressure fans were considered in equipment selection for the reference design, however, were discounted for the following reasons:

- Low pressure fans are larger in size than a high pressure fan (with at least twice the diameter) and are required to be arranged vertically resulting in an increased ventilation structure footprint, leading to increased visual impacts and an increased loss of parklands area
- Low pressure fans are unable to power the smoke extraction system, leading to a requirement for a separate smoke extraction system, further increasing the ventilation structure size and associated visual and land use impacts
- Little change to the energy usage, which is dominated by the use of jet fans to meet requirements for zero portal emissions
- For substantial energy savings to be achieved through the use of low static pressure fans, a large ventilation structures would need to be placed at every each of the exit portal (at least six exit portals) which would further increase impacts on community, visual amenity, land use as well as generating additional costs

- The technology is not new, however a road or rail tunnel using low pressure fans has not yet been constructed and applied in the Australian setting.

In accordance with Principle 1B of the *Environment Protection Act 1970*, the consideration of low static pressure fans has integrated social considerations alongside environmental considerations. In balancing the energy savings which could be achieved through the use of low static pressure fans against the large increase in community impacts which would result from an increase in the number and size of ventilation structures, it is considered that the use of low static pressure fans is not justified.

The northern and southern tunnel ventilation structures can be assumed to be almost identical. The design is based on six, 3,600-millimetre diameter fans. Two sets of noise attenuators are to be installed:

- Between the fans and the tunnel roadway
- Between the fans and the discharge point.

To predict pressure loss, noise attenuators have been assumed to be a rectangular duct straight splitter with a 43 per cent open-area and 3 metres long. These silencers have been included in this acoustic assessment.

For noise modelling purposes, the fans are represented as an area source at each location and set to a height of 40 metres above prevailing terrain. The sound power level at the top of the ventilation structure has been based on the noise from the in-tunnel fans as shown in **Table 10-1** and **Table 10-2** and the in-tunnel fans as detailed in **Table 10-4**. The anticipated noise from the supporting substations, is detailed in **Table 10-5.** Detailed information is currently unavailable, but the assumed levels are considered representative, based on project information.

Indicative sound power level data for the proposed ventilation outlets is presented in **Table 10-1**, for the peak load and non-peak load times, and the nominated insertion loss for the silencer (3000 millimetres, 43 per cent open area) is presented in **Table 10-2**. During detailed design, consideration must be given to:

- The long-term dynamic insertion loss performance of the silencer, having consideration of deterioration due to dust or wear
- Flow noise across the silencer due to the movement of air across the face of the silencer, acknowledging that this effect is dependent on the flow rate of the air.

The net sound power level would be refined during the detailed design phase, in-line with fan/silencer selection and siting. The peak cycle operating conditions are assumed to be operational at any time of the day or night. This conservative assumption would be reviewed during the detailed design stage.

Table 10-1 Indicative sound power level of ventilation outlets (northern and southern portal)

Ventilation exhaust	Octave band frequency (Hz)/sound power level SWL (dBL re 1pW)								Sound power level dBA
	63	125	250	500	1k	2k	4k	8k	
Outlet (peak cycle time)	120	118	120	120	119	116	111	109	123
Outlet (night-time)	110	108	110	110	109	106	101	99	113

Notes:

1. Based on project team indictive fan selection. Equipment and sound power levels are indicative and may change subject to detailed design

Table 10-2 Proposed silencer insertion loss

Ventilation exhaust	Octave band frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Insertion loss (dB)	8	19	38	49	54	39	27	20

Notes: Based on NAP D47/300, subject to detailed design

It is assumed that similar fans (but minimal silencers so as not to restrict airflow during an emergency situation) would be used at the smoke exhaust structure within the Manningham Road interchange. For modelling purposes, the 'peak cycle' noise emissions detailed in **Table 10-1** and the silencer loss detailed in **Table 10-2** have been used at the northern and southern portal ventilation discharge sites, noting that no silencers are incorporated in the Manningham Road emergency discharge.

10.1.1.2 Tunnel jet fans

The nearest in-tunnel jet fans are assumed to be positioned a distance of 50 metres from the nearest jet fans to the various tunnel portals. Three jet fans have been included in the calculation for each assessment location and are assumed to be operational 24-hours per day, seven days per week.

Indicative sound power level data for the proposed tunnel jet fans is presented in **Table 10-3**.

Table 10-3 Indicative sound power level of jet fans in tunnel

Jet fan	Octave band frequency (Hz)/sound power level LW (dBL re 1pW)								Sound power level LWA
	63	125	250	500	1k	2k	4k	8k	
1,250 mm	108	100	94	87	95	91	87	87	98

Notes: Based on SLR database. Equipment and sound power levels are indicative and may change subject to detailed design

The fans would have in-line circular 1,250-millimetre 1D silencers installed on the intake and discharge side of the fan unit.

Table 10-4 In-tunnel jet fans – typical attenuator insertion loss

Fan configuration	Minimum static insertion loss (dB)							
	Octave band centre frequency (Hz)							
	63	125	250	500	1K	2K	4K	8K
Circular (no pod)/1D/1,250 mm	-	4.5	75	9	5.5	4.5	3.5	3

Based on NAP Circular Silencer (no pod) Model number: 1220-1D

10.1.1.3 Substations

There are multiple substations along the tunnelled section of the project. All substations except two will be below ground and consequently would have negligible acoustical influence on the prevailing noise environment, given they have appropriate space for acoustically treated ventilation systems to be incorporated into the scheme (which will be refined during the detailed design phase of the project). The two substations located on the surface, will be housed in new buildings with provisional space for ventilation and noise mitigation.

The two above ground buildings used during the operational phase of the project are located at:

- Northern Portal: incorporating four x 2 MVA and one 20 MVA transformers
- Manningham Interchange: one 20 MVA transformer.

Indicative sound power level data for the proposed transformers used in the noise model is based on previous studies and presented in **Table 10-5**.

Table 10-5 Indicative sound power level of transformers at substations

MVA	Octave band frequency (Hz)/sound power level LW (dBL re 1pW)						Sound power level LWA
	63	125	250	500	1k	2k	
3.15 MVA per unit	75	83	73	67	67	65	73
Northern Portal (ten units)	90	98	88	82	82	80	88
Manningham Interchange: (six units)	88	96	86	80	80	78	86

Notes: Equipment and sound power levels are based on SLR database and are to be considered indicative and may change subject to detailed design.

10.1.1.4 Predicted modifying factors

This assessment has not allowed for modifying factors on the ventilation fan noise. This is based on SLR's previous measurement on other similar facilities, where no penalty was shown to be required. Notwithstanding, it is recommended this is revised during detailed design, when final fan selection has been undertaken. If appropriate, modifying factors are to be included.

The in-tunnel fans and substations both include a 5 dBA tonality penalty within this assessment. This should be reviewed during detailed design.

It is recommended that during detailed design, all plant items (once selected) are assessed for consideration of the tonal, impulsive, or low-frequency modifying factors. Where modifying factors are found to be applicable, they should be added to the assessment and compliance with the criteria checked at all receivers.

10.1.2 Location of equipment

The proposed ventilation facilities and structures, including the emergency ventilation system and the substations are shown in **Figure 10-1** to **Figure 10-3.**

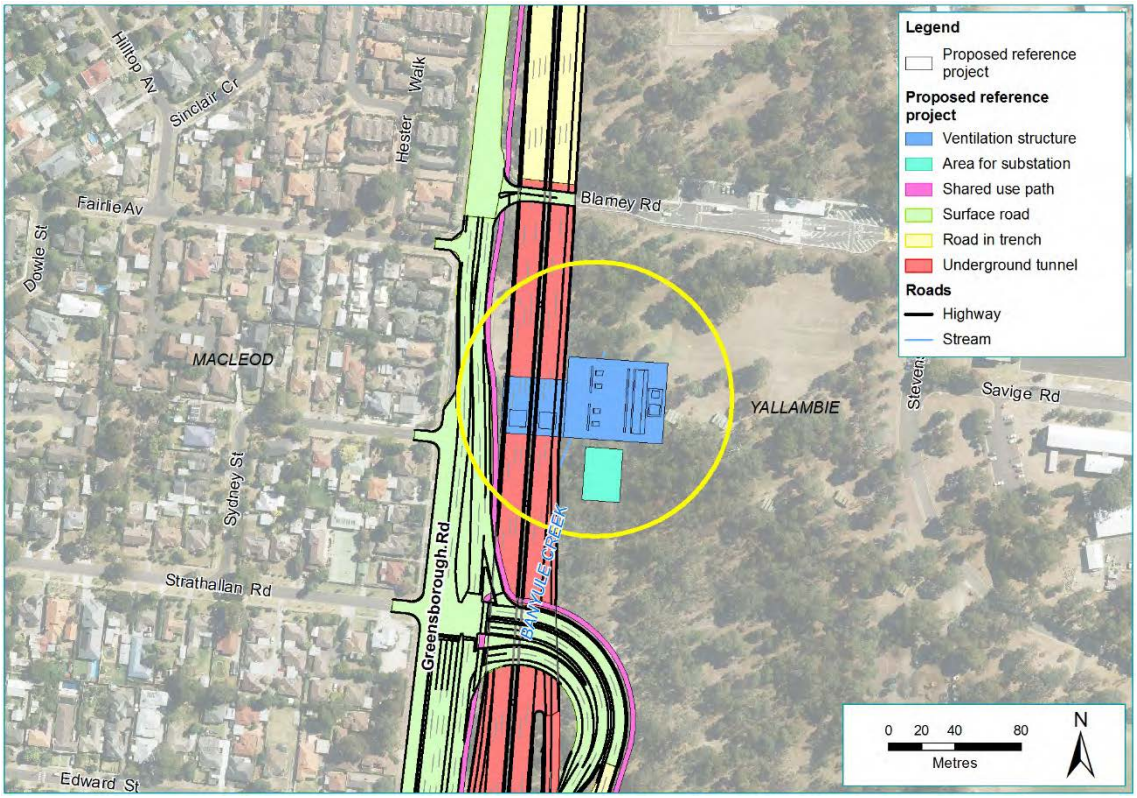


Figure 10-1 Proposed location of ventilation structure and substation – Northern portal

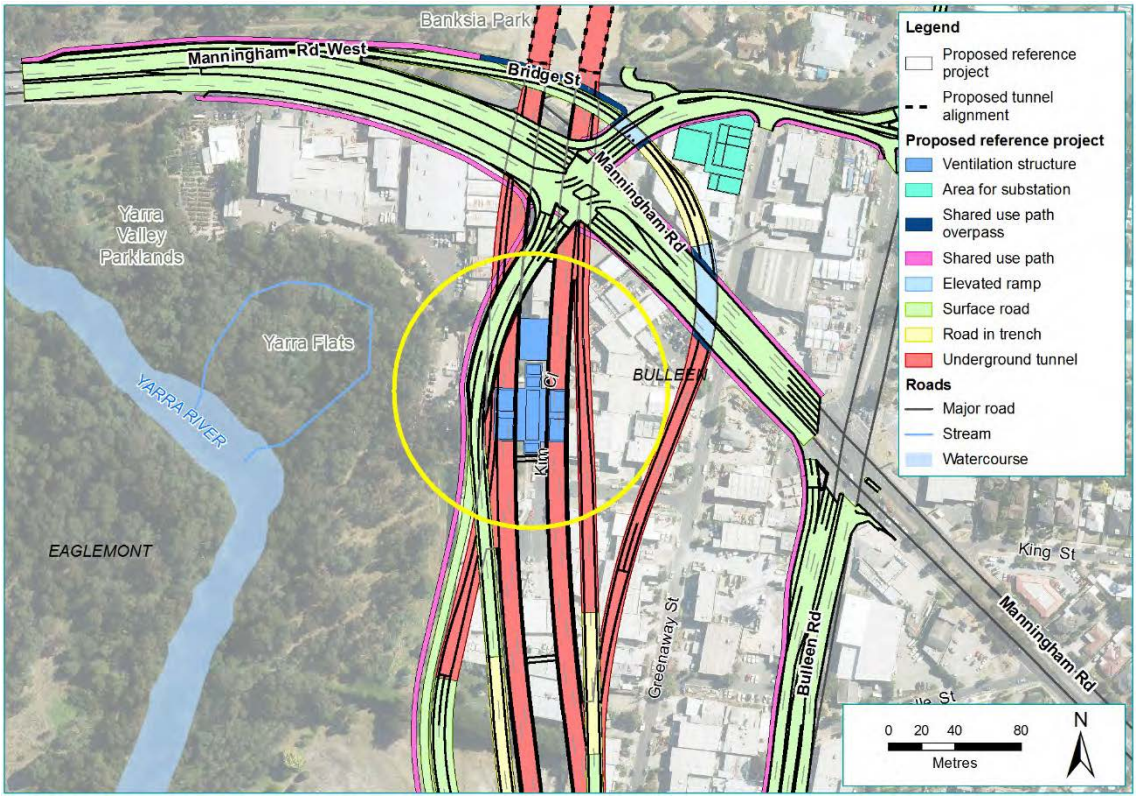


Figure 10-2 Proposed location of emergency ventilation structure and substation – Manningham Road interchange

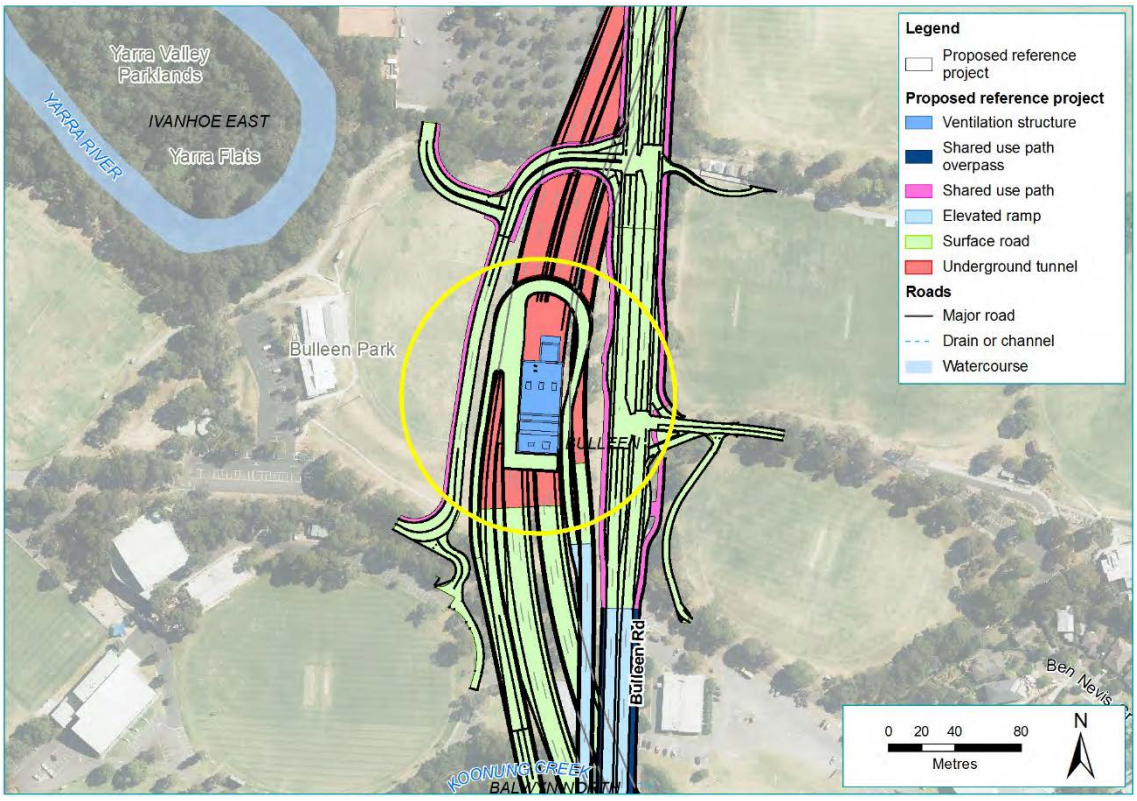


Figure 10-3 Proposed location of ventilation structure – Southern portal

10.2 Noise from commerce, industry and trade

In the Melbourne metropolitan area, noise from commerce, industry and trade is subject to the provisions of the State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1). Under SEPP N-1 the noise limit is the maximum allowable 'level of noise emitted from the commercial, industrial or trade premise', in a 'noise sensitive area' as defined by the Policy. Noise limits are prescribed for residential premises for the day, evening and night periods, as defined in **Table 10-6**. The lowest limits usually apply to the night period.

Table 10-6 SEPP N-1 Definitions of SEPP N-1 day, evening and night-time periods

Period	Day	Time
Daytime	Monday to Friday Saturday	7 am – 6 pm 7 am – 1 pm
Evening	Monday to Friday Saturday Sunday and public holidays	6 pm – 10 pm 1 pm – 10 pm 7 am – 10 pm
Night-time	Monday to Sunday	10 pm – midnight Midnight – 7 am

Noise limits are based on the land-use zoning of the area surrounding the residence, as defined by the relevant authority and on the measured background noise levels when background levels are especially high or low.

Noise from commercial premises can be assessed over any single 30-minute period during which the premises operates.

The measured and predicted noise from a commercial, industrial or trade site is adjusted for character, including tonality, intermittency and duration. The adjusted noise level is compared with the noise limit to determine compliance or otherwise with SEPP N-1.

Noise limits apply to all noise from commercial and industrial activities from all sites contributing to the measured level at a residence. Where multiple activities take place on a site at the same time, the noise limits should be met by all activities at the one time. In such cases, the effective noise limit for each activity may be lower than the overall SEPP N-1 limit.

10.3 Noise-sensitive receivers

The locations for assessment were selected based on:

- The proximity of the receiver to the ventilation structure
- The locations where baseline monitoring was undertaken
- The results of the noise modelling showing the areas where predicted emissions were the highest.

Locations selected for assessment are listed in **Table 10-7**.

Table 10-7 Assessment locations

Assessment area	Address
Northern portal	5 Hester Walk
	183 Greensborough Road
Manningham Road interchange	218 Bulleen Road
	1a Elizabeth Street
	40 – 42 Bridge Street
Southern interchange	11 Ben Nevis Grove

10.4 Background noise survey

Unattended monitoring qualified the longer-term noise environment and is used to set the SEPP N-1 noise criteria for the fixed plant and equipment at the locations where baseline monitoring was undertaken. These monitoring results are summarised in **Table 10-8**. In accordance with the SEPP N-1, an adjustment of -2 dBA has been applied to the measured noise levels as the microphone was positioned one metre from an acoustically reflecting surface (wall or building).

For the purposes of this assessment, the background noise levels at residential areas further away from a main road are assumed to be 5 dBA lower than the nearest monitoring position. An additional 2 dBA has been conservatively subtracted to allow for the predicted future decreases in the levels of ambient noise due to reductions in traffic on the prevailing roads. This has been applied at all locations.

The measured unattended noise levels can be used to determine the applicable SEPP N-1 noise limits for receivers potentially impacted by noise from the various fixed plant.

Table 10-8 Adjusted ambient noise monitoring results

Nearest site	Assessment location	Basis of background noise	Measured average measured L_{A90} noise level, dB(A)[1]		
			Daytime	Evening	Night-time
Northern portal	183 Greensborough Road, Watsonia	179 Greensborough Road, Watsonia	59[1]	56[1]	44[1]
	5 Hester Walk, Watsonia	179 Greensborough Road, Watsonia minus 5 dBA	54[2]	51[2]	39[2]
Manningham Road interchange	218 Bulleen Road, Bulleen	218 Bulleen Road, Bulleen	53[1]	51[1]	46[1]
	1a Elizabeth Street, Bulleen	218 Bulleen Road, Bulleen minus 5 dBA	48[2]	46[2]	41[2]
	40 – 42 Bridge Street	218 Bulleen Road, Bulleen minus 5 dBA	48[2]	46[2]	41[2]
Southern portal	11 Ben Nevis Grove, Bulleen	8 Ben Nevis Grove	46[1]	48[1]	43[1]

Note 1: Measured background minus 2 dBA for façade reflection and -2 dBA for reduced future background noise level, as predicted in the Project wide noise modelling undertaken for the EES

Note 2: Measured background minus 5 dBA for lower background environment (compared to monitoring position), -2 dBA for façade reflection and -2 dBA for reduced future background noise level

10.5 Noise limits

Zoning levels for the nearest residential receivers nearest for each of the ventilation structures have been calculated in accordance with SEPP N-1. Refer to **Figure 10-4** to **Table 10-6** for zone maps showing land use zoning surrounding the residences. The land use classification of areas inside the SEPP N-1 'zoning circles' are considered in the derivation of zoning levels.

The fans would operate day and night, although for most of the night at a lower setting. This assessment assumes the fans could be operational at full capacity for some period during the night period, although this may be revised during detailed design.

10.5.1 Northern portal

For the two receivers selected for assessment near the northern portal, using the ratios of the Type 2/Type 3 land within the zoning circles and the average of the measured background noise levels, the appropriate noise limits were determined for day, evening, and night periods using the procedure prescribed by SEPP N-1. These limits are presented in **Table 10-9.**

The Commonwealth land has a planning zone CA, which is exempt from the provisions of the Banyule Planning Scheme. For this assessment, the Commonwealth land is conservatively treated as general residential.

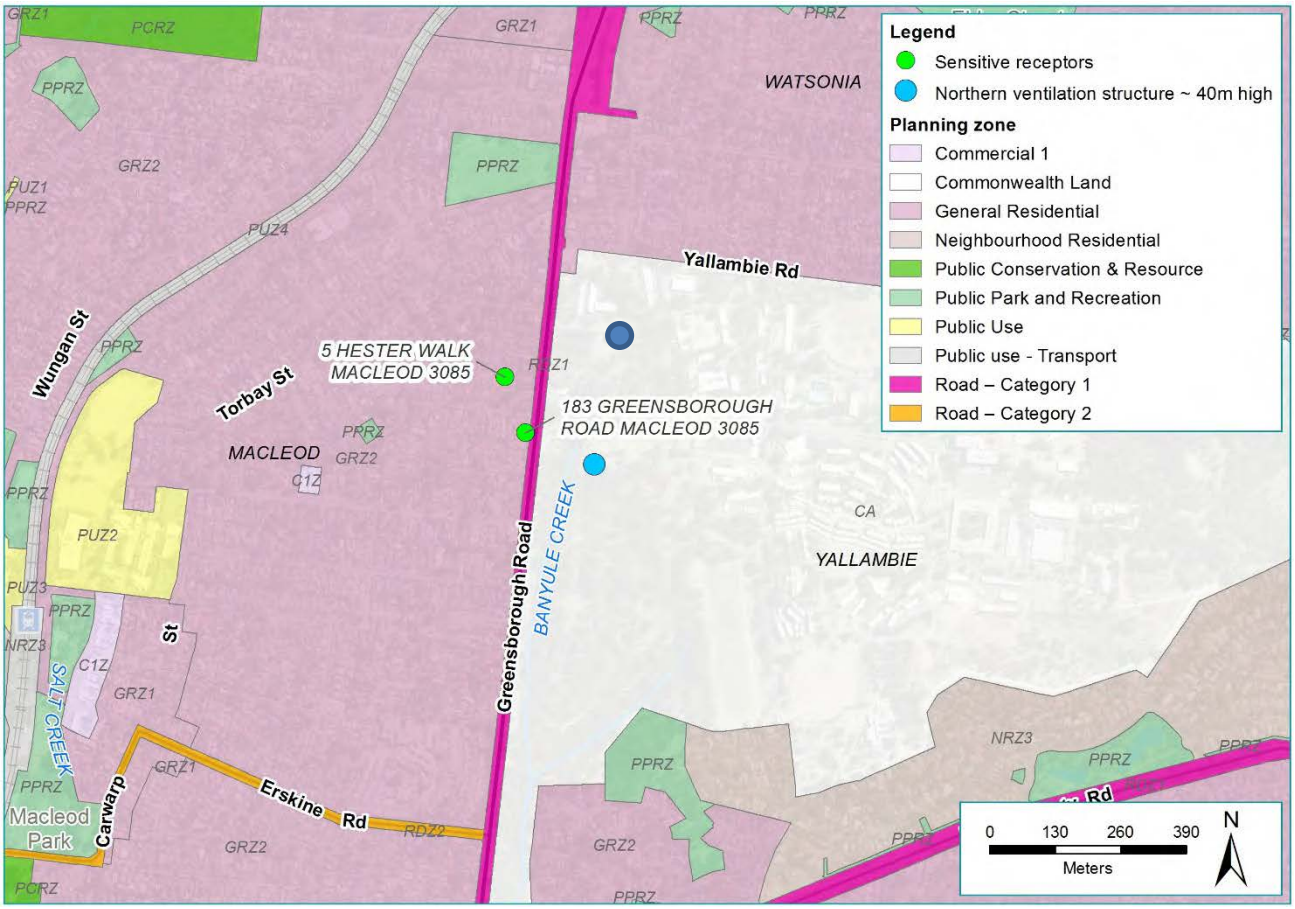


Figure 10-4 Zoning map – northern portal

Table 10-9 SEPP N-1 Noise limits – northern portal

	Day	Evening	Night
183 Greensborough Road, Watsonia			
Zoning level, dBA	53	46	41
Background noise level, dBA L_{90} [1]	59	56	44
Background classification	Neutral	High	Neutral
Noise limit, calculation	Neutral	Background + 3	Neutral
Noise limit, dBA L_{eq}	53	47	41
5 Hester Walk, Watsonia			
Zoning level, dBA	51	45	40
Background noise level, dBA L_{90} [2]	55	52	40
Background classification	Neutral	High	Neutral
Noise limit, calculation	Neutral	Background + 3	Neutral
Noise limit, dBA L_{eq}	51	47	40

Note 1: Measured background minus 2 dBA for façade reflection and -2 dBA for reduced future background noise level

Note 2: Measured background minus 5 dBA for lower background environment (compared with monitoring position), -2 dBA for façade reflection and -2 dBA for reduced future background noise level

It is envisaged these noise limits would be revised and refined during the detailed design phase of the project.

10.5.2 Manningham Road interchange

For the two receivers selected for assessment near the Manningham Road interchange, using the ratios of the Type 2/Type 3 land within the zoning circles and the average of the measured background noise levels, the appropriate noise limits were determined for day, evening, and night periods using the procedure prescribed by SEPP N-1. A zoning map of the area around the Manningham Road interchange is shown in **Figure 10-5**. The noise limits are presented in **Table 10-10**.

The smoke exhaust fans at the Manningham Road interchange would only be used in an emergency situation but would be tested routinely, maybe every three to six months. Testing would be expected to last for approximately an hour or two on each occasion, although it is reasonable to assume testing can be limited to the daytime period only. Consequently, this assessment is based on daytime operation of the fans, with the evening and night-time periods included for completeness.

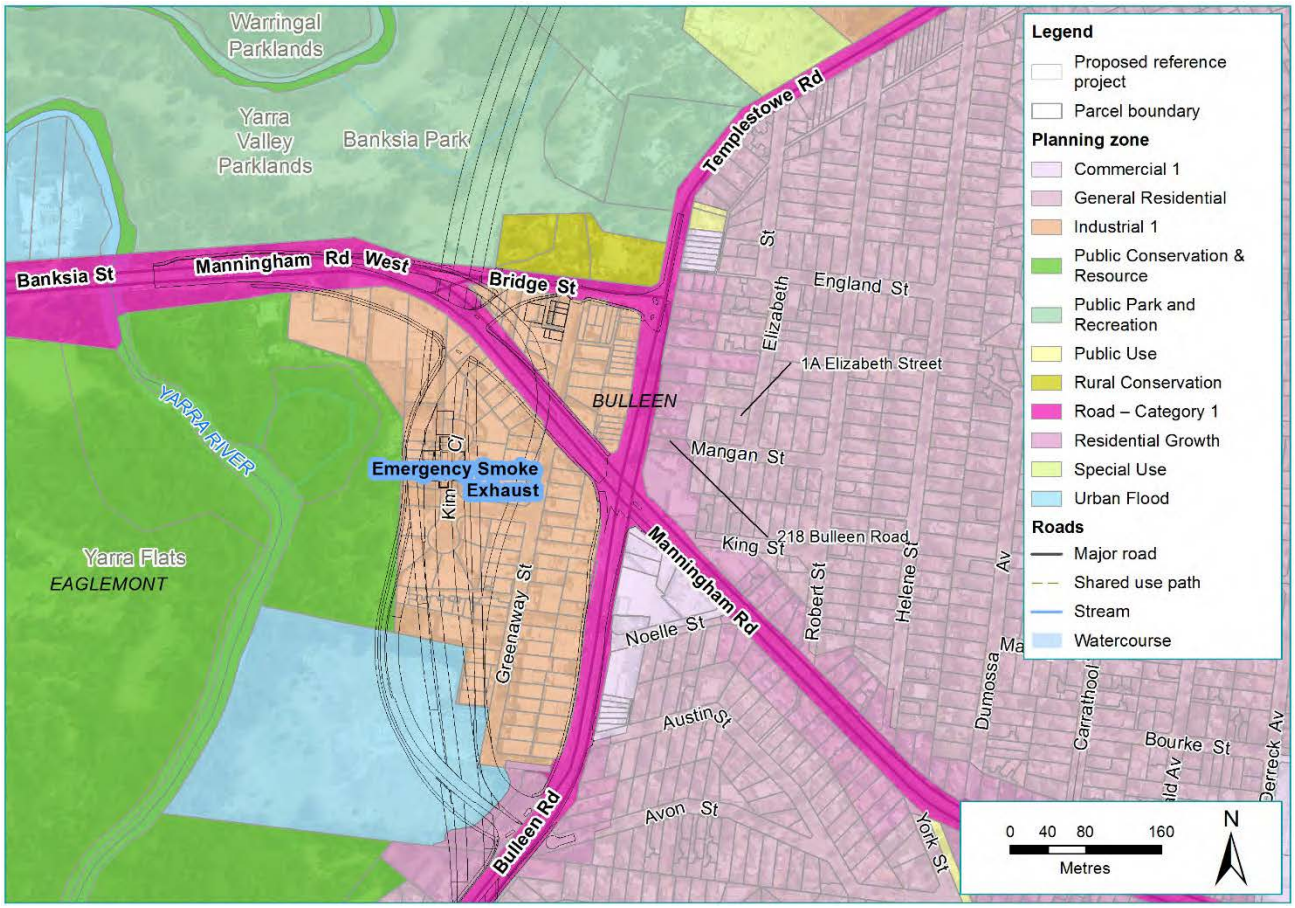


Figure 10-5 Zoning map – Manningham Road interchange

Table 10-10 SEPP N-1 noise limits – Manningham Road interchange

	Day	Evening	Night
218 Bulleen Road			
Zoning level, dBA	57	51	46
Background noise level, dBA L_{90} [1]	53	51	46
Background classification	Low	Neutral	Neutral
Noise limit, calculation	Background +13	Neutral	Neutral
Noise limit, dBA L_{eq}	55	51	46
1A Elizabeth Street and 40 – 42 Bridge Street			
Zoning level, dBA	53	46	41
Background noise level, dBA L_{90} [2]	48	46	41
Background classification	Neutral	Neutral	Neutral
Noise limit, calculation	Neutral	Neutral	Neutral
Noise limit, dBA L_{eq}	53	46	41

Note 1: Measured background minus 2 dBA for façade reflection and -2 dBA for reduced future background noise level

Note 2: Measured background minus 5 dBA for lower background environment (compared with monitoring position), -2 dBA for façade reflection and -2 dBA for reduced future background noise level

There was no significant contribution of industrial/commercial noise in the noise environment measurements taken at the measurement sites. The non-residential buildings west of Bulleen Road (south of Bridge Street) will be demolished as part of the project. No firm decision has been made as the future use of the land. The derived noise limits have been adjusted 3 dBA downwards to allow for the possible future contribution from commercial developments (should that eventuate). The adjusted noise limits are detailed in **Table 10.11**.

Table 10.11 SEPP N-1 Adjusted Noise Limits, Manningham Interchange

	Day	Evening	Night
218 Bulleen Road			
Noise Limit, dBA L_{Aeq}	52	48	43
1A Elizabeth Street and 40 – 42 Bridge Street			
Noise Limit, dBA L_{Aeq}	50	43	38

During the operational phase of the project, the electrical substations used for the emergency smoke exhaust fans at Manningham Interchange are in a dedicated acoustically treated building. Though the noise from the substation has been modelled, it can considered to have a negligible contribution to the overall noise environment. It is envisaged these noise limits would be revised and refined during the detailed design phased of the project.

10.5.3 Southern portal

The nearest assessment point was taken to be the residences at 11 Ben Nevis Grove, with the assessment based on the ambient environment at 8 Ben Nevis Grove, which can be considered representative of residences in the immediate surrounding area. A zoning map of the area around the southern portal is shown in **Figure 10-6**. The noise limits are presented in **Table 10-12**.

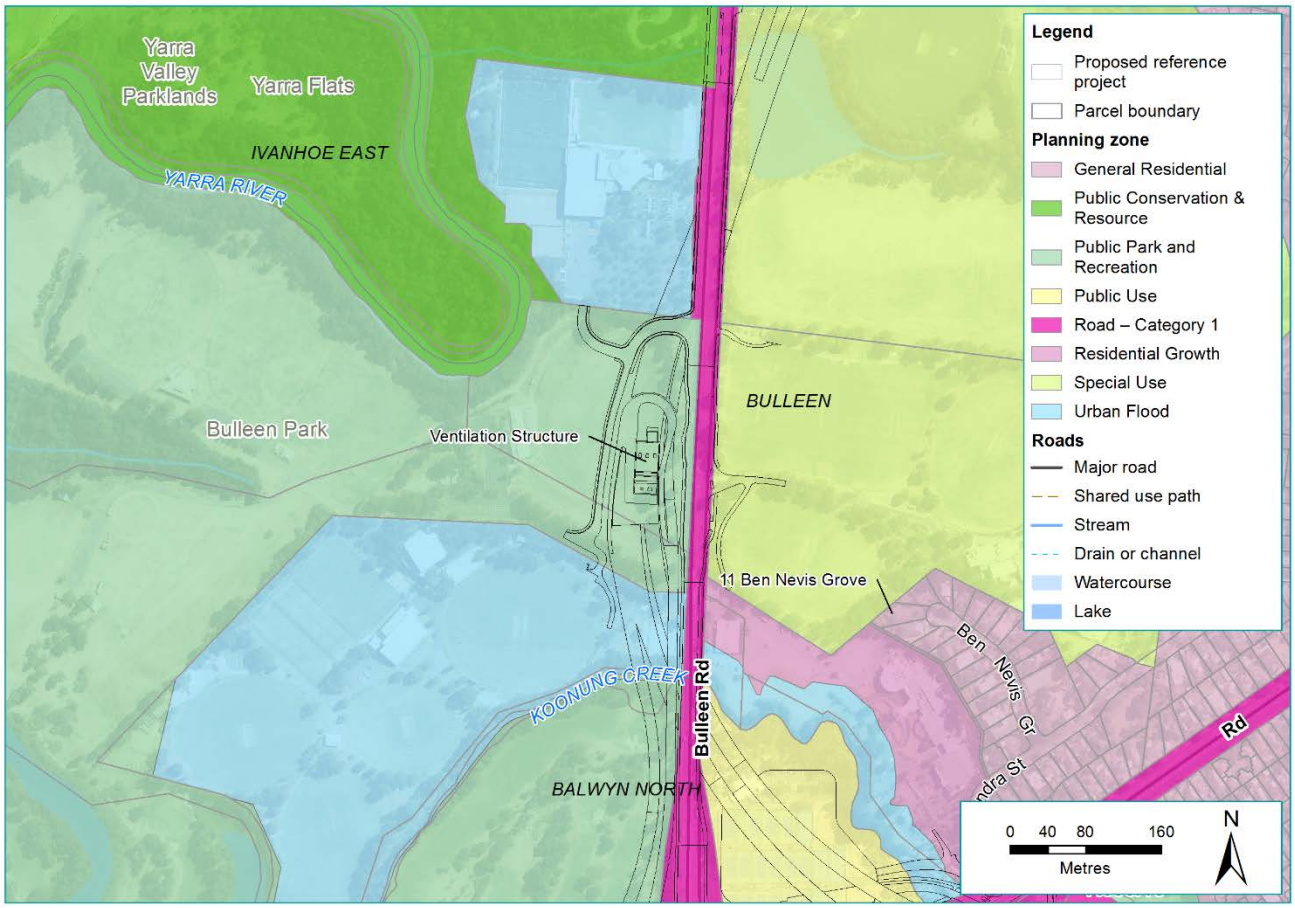


Figure 10-6 Zoning map – southern portal

Using the measured background noise levels, for the day, evening and night-time periods, the appropriate noise limits were determined using the procedure prescribed by SEPP N-1. These limits are presented in **Table 10-12**.

Table 10-12 SEPP N-1 noise limits – Southern interchange

	Day	Evening	Night
11 Ben Nevis Grove			
Zoning level, dBA	50	44	39
Background noise level, dBA L_{90} [1]	46	48	43
Background classification	Neutral	High	High
Noise limit, calculation	Neutral	Background + 3	Background + 3
Noise limit, dBA L_{eq}	50	48	43

Note 1: Measured background minus 2 dBA for façade reflection and -2 dBA for reduced future background noise level

It is envisaged these noise limits would be revised and refined during detailed the design phased of the project.

10.5.4 Assessment

The assessment considers the noise from the fans to the nearest residences.

10.5.4.1 Noise modelling

A computer noise model of the proposed fixed facilities has been undertaken to predict the potential breakout noise impact at the nearest sensitive receivers in reference to the relevant project derived SEPP N-1 noise limits.

The following sections detail the modelling software and the methodology that was adopted and lists the assumptions and parameters used for the calculations.

The general noise model used for road traffic predictions was adapted to determine the noise from the proposed ventilation system and substation. All calculations were conducted using the ISO 9613- 2:1996 prediction method. The ISO 9613- 2:1996 Standard provides a method of calculating environmental noise from fixed plant items, as distinct from the CoRTN method, used the prediction of road traffic noise.

The noise model was created adopting the following assumptions:

- Topographical data within the study area
- Digitised houses in the calculation areas
- Calculations were undertaken using ISO 9613- 2:1996 – this model includes down-wind (noise enhancement) propagation of the noise to each of the calculation points
- While no specific directionality was added to the propagation of noise from the top of the discharge, the fans were located five metres below the top of the ventilation structure, as schematically shown in **Figure 10-7**
- No insulation is included within the air passage of the ventilation structure (though space exists in the ductwork for insulation, if this proves to be necessary)
- Design layouts and drawings of the facilities
- Assumed sound power level information for the various noise-emitting plant and equipment items proposed to be installed as part of the project
- Aerial photography was used to determine the locations of the residential receivers
- Noise from audible warning devices is not assessed under SEPP N-1 and has not been included within the noise model
- Noise mitigation requirements are based on the predicted noise levels at noise sensitive receivers and the required noise reductions to meet the noise limits
- During the detailed design phase, the calculations would be revised considering the noise emission data from the selected fans
- Baseline noise monitoring was conducted under neutral atmospheric conditions, wind less than three metres per second and during periods of no rain.

Note that a works approval under the Victorian *Environment Protection Act 1970* is required for industrial and waste management activities which have the potential for significant environmental impact such as road tunnels and associated ventilation systems.

Potential noise impacts associated with project operations primarily relate to noise emanating from:

- Road tunnel ventilation structure exhaust fans (northern portal)
- Road tunnel jet fans located near the tunnel portals (northern and southern portal)
- Emergency smoke removal fans (Manningham Road interchange)

- Electrical substation (northern and southern portal).

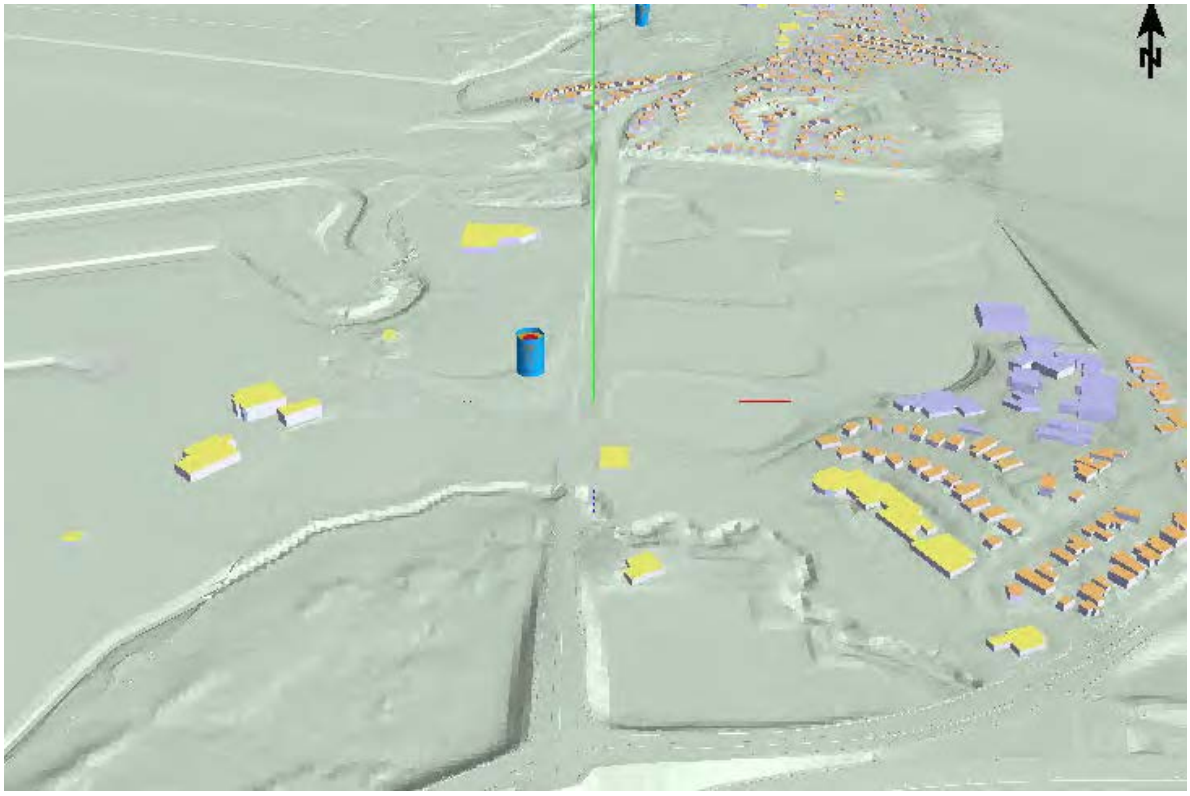


Figure 10-7 Schematic model showing ventilation discharge (southern portal)

The model does not account for the following (within the fan ventilation exhaust), which would further reduce the predicted levels:

- The location of the fans being at the base of the discharge within a fan room
- Reflection losses at duct bends
- Losses along the airflow path of the ventilation structure
- End loss at the point of discharge
- Specific directionality of the noise.

Note that a works approval under the Victorian *Environmental Protection Act 1970* is required for industrial and waste management activities which have the potential for significant environmental impact such as road tunnels and associated ventilation systems.

Potential noise impacts associated with project operations primarily relate to noise emanating from:

- Road tunnels ventilation structure exhaust fans (northern portal)
- Road tunnels jet fans located near the tunnel portals (northern and southern portal)
- Emergency smoke removal fans (Manningham Road interchange).

Noise contours showing the dispersion of noise from the ventilation fans and substations are shown in the following images.

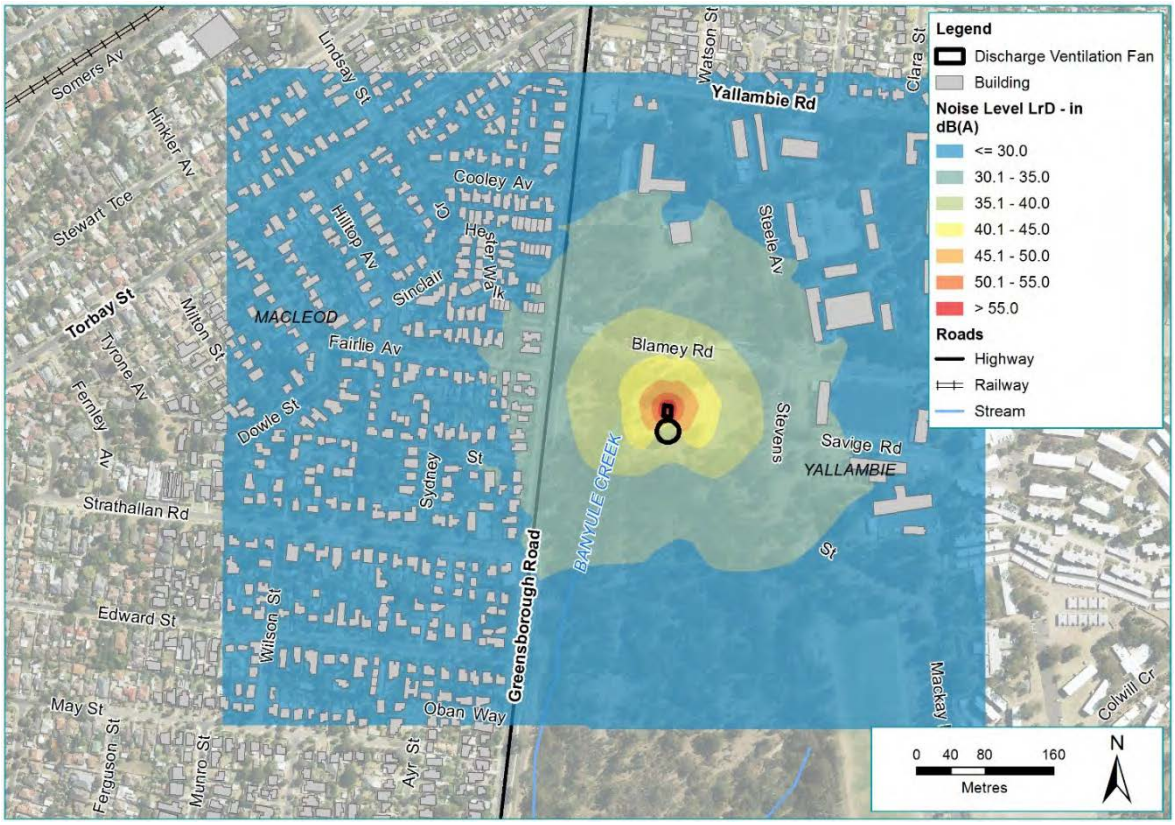


Figure 10-8 Noise contours from fan ventilation discharge at northern portal

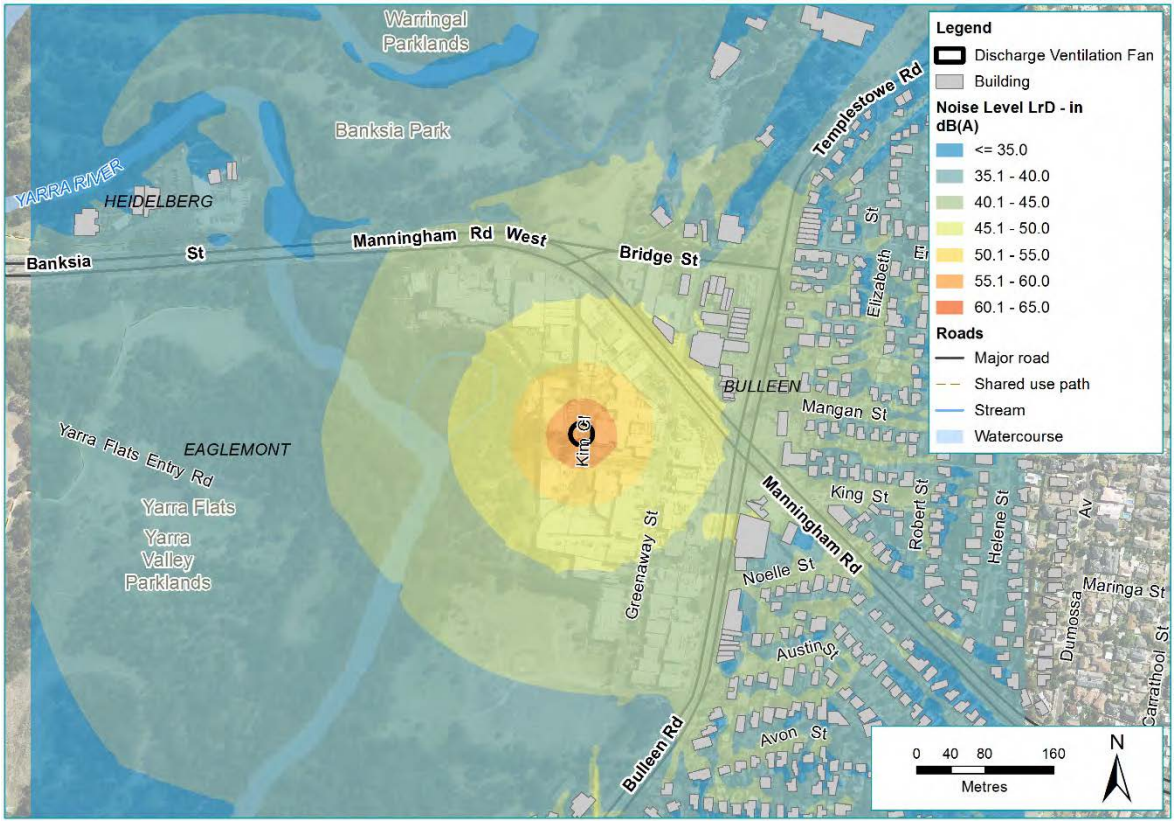


Figure 10-9 Noise contours from fan ventilation discharge at Manningham Road interchange

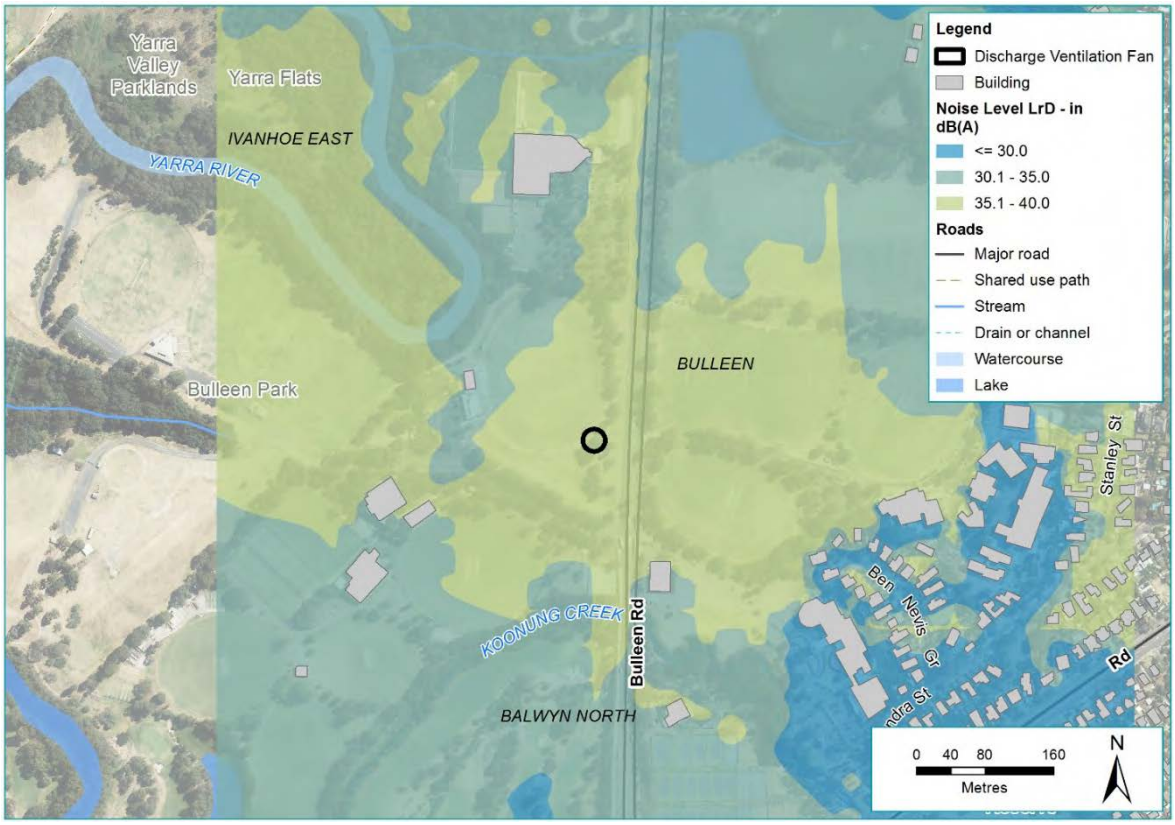


Figure 10-10 Noise contours from fan ventilation discharge at southern portal

10.5.4.2 Mitigation incorporated within the design

Calculations are based on the initial design and incorporate the noise mitigation already identified.

The following in-principle mitigation requirements have been identified for the SEPP-N1 analysis.

Ventilation and smoke fans

The exhaust fans are configured so the intake draws air from within the tunnel, although all fans are designed to be unidirectional. The noise from the fans is dependent on the ratings of the fans, the path the noise travels between the fan and the tunnels/outside space, including the nature of any intervening noise mitigation. During the detailed design, the complete noise path must be considered with respect to noise breakout to the wider community and to noise within the tunnel.

Noise sources in the tunnels including the jet fan noise and road traffic noise could also travel through the intake path to the outside environment. Although the inherent in-line mitigation (required to reduce fan noise) would most likely address this, it must be considered during detailed design on the basis of the finalised equipment selection.

Calculations of the in-tunnel fan jet noise was undertaken using measured field data and ISO 9613 propagation algorithms. To the north of the northern portal a small allowance for the potential reverberant build-up within the depressed roadway.

Calculations include an assumption that the character of the noise would be not be tonal, and no tonality correction has not been applied. The results in **Table 10-13** indicate that for the selected ventilation fans, no additional mitigation would be required to achieve the relevant SEPP N-1 noise limits.

Table 10-13 Assessment of noise emissions from ventilation system

Location	SEPP N1 criteria (dBA)	Predicted emissions (dBA) (1st floor level)	Margin Below criteria (dBA)	Statement of compliance
Northern portal				
183 Greensborough Road	53 (daytime)	33 (fan + substation)	20	Complies with SEPP N-1
	47 (evening)	33 (fan + substation)	14	Complies with SEPP N-1
	41 (night-time)	33 (fan + substation)	8	Complies with SEPP N-1
5 Hester Walk	51 (daytime)	28 (fan + substation)	23	Complies with SEPP N-1
	47 (evening)	28 (fan + substation)	19	Complies with SEPP N-1
	40 (night-time)	28 (fan + substation)	12	Complies with SEPP N-1
Manningham Interchange				
218 Bulleen Road	52 (daytime)	49 (fan + substation)	3	Complies with SEPP N-1
	48 (evening)	19 (substation only)	29	Complies with SEPP N-1
	43 (night-time)	19 (substation only)	24	Complies with SEPP N-1
1A Elizabeth Street	50 (daytime)	46 (fan + substation)	4	Complies with SEPP N-1
	43 (evening)	16 (substation only)	27	Complies with SEPP N-1
	38 (evening)	16 (substation only)	22	Complies with SEPP N-1
40 – 42 Bridge Street	50 (daytime)	48 (fan + substation)	2	Complies with SEPP N-1
	43 (evening)	26 (substation only)	17	Complies with SEPP N-1
	38 (evening)	26 (substation only)	12	Complies with SEPP N-1
Southern portal				
11 Ben Nevis Grove	50 (daytime)	36 (fan only)	14	Complies with SEPP N-1
	48 (evening)	36 (fan only)	12	Complies with SEPP N-1
	43 (night-time)	36 (fan only)	7	Complies with SEPP N-1

During detailed design, the proposed silencers (and other forms of noise mitigation) would be selected to provide an overall insertion loss (under expected operating conditions) considering flow noise due to the movement of air through splitters of the silencers, on the intake and discharge side of each of the fans. The preliminary identified silencers would need be re-verified during detailed design, having consideration of the design of the building and the frequency dependent noise spectra of the selected fans. Consideration should be given to the noise in the tunnels to ensure audibility of any emergency announcements.

10.5.4.3 Acoustic Design Considerations

During detailed design, the selected plant will require re-assessment; having consideration of the final noise levels and location of the plant. At that time the following tasks will need to be considered to further enhance the prediction process:

- The contractor chosen to build the tunnel ventilation system would also be responsible for its ongoing operation. This responsibility would be implemented through contractual documents and the North East Link Environmental Performance Requirements (EPR)s. EPR NV6 gives the contractor responsibility for ensuring the tunnel ventilation system's compliance with all aspects of SEPP N-1, which includes the principle of the application of best practice, at the point of initial operation and on an ongoing basis. EPR NV7 gives the contractor responsibility to monitor noise emissions from the tunnel ventilation system on commencing road operation and post opening to verify compliance with the SEPP N-1. Compliance with these EPRs would be achieved through a potential combination of appropriate initial design choices to be specified during the detailed design process, ongoing noise monitoring and appropriate maintenance, replacement of parts or the addition of extra attenuation as required. It is anticipated that EPA will require the contractor to submit detailed design documentation and updated noise modelling to EPA, that demonstrates that the to be built tunnel ventilation system can achieve compliance with SEPP N-1 at the point of construction and for future operation. This is consistent with the approach taken in West Gate Tunnel Works Approval.
- It is envisaged that the contractor would review current best practices relating to the tunnel ventilation system and justify the design with respect to best practice, as part of the detailed design.
- Silencer insertion loss data should be based on dynamic testing of the product under similar conditions to the operation conditions, where this is feasible. This is to also address flow noise, across the face of the silencer.
- When selecting silencers or other forms of noise mitigation, consideration must be given to the acoustic performance throughout the life of the product. The report shall detail how the potential for acoustic degradation in the performance equipment (such as silencers) through wear, dust build-up etc will be addressed.
- The detailed design shall consider and justify the need for adjustments to the predicted levels, having consideration of the character of the noise (tonal, impulsive or low frequency).
- The current design does not include any silencer for the Manningham emergency smoke discharge fans. Consideration of reducing noise emissions is required under the SEPP and will need to be undertaken for noise from the smoke discharge fans, noting that silencers can impede the performance of the fan.
- Detailed design should document the design uncertainties and ensure that required noise targets (or better) are achieved, by means of:
  - safety factors (ie design to lower targets)
  - minimising noise emissions, consistently with the implementation of best practice noise control measures.
- As a contingency, (but not a direct for of mitigation), noise from the tunnel ventilation system should be measured on commencing road operation and noise from the Tunnel ventilation system monitored as agreed with EPA Victoria to verify compliance with SEPP N-1. Rectification measures will be implemented if noise level criteria are not met. The type and form of possible additional mitigation cannot be determined at this stage (if any), but may include consideration of the some of the following (or other) in-principle measures; the incorporation of acoustic insulation in the duct system, optimisation of turning vanes, removal of possible obstacles in the air flow path, optimisation/lengthening of silencers, incorporation of attenuation in bends, optimisation of the fan speed etc. It is understood that the design of the mechanical services system has allowed some additional space for supplementary noise attenuation, should it be required.

10.5.5 Statement of compliance

With the development and incorporation of the proposed noise mitigation, the predicted noise levels at the potentially most impacted noise sensitive buildings identified for assessment, are predicted to comply with the relevant SEPP N-1 noise limits, based on the assumptions detailed in this report.

The reference design includes a number of potential uncertainties associated with the assessment. These may include the dynamic attenuation of the silencer (compared to the static test results), the potential for regenerated noise across the face of the silencer, the degradation of the silencer due to dust build-up (assuming yearly cleaning and appropriate maintenance) etc. The modelling however, contains some conservatism; the fans are positioned at the base of the discharge within a fan room whereas they were modelled near the top of the ventilation structure, the acoustical losses at bends of ductwork, acoustic losses along the air-flow path, end reflection loss at the point of discharge, or specific directionality of the noise etc are not included in the modelling and will act to lower the predicted emissions. Having considered the balance of uncertainties and the conservatism within the modelling, and the degree to which the predictions are below the criteria; it is considered that the conservatism within the model is sufficient to offset the possible uncertainty.

11 Environmental Performance Requirements

Table 11-1 lists the recommended Environmental Performance Requirements (EPRs) relevant to the noise and vibration assessment.

Table 11-1 Environmental Performance Requirements – Noise and Vibration (NV)

<table>
<tr><th>Applicable Legislation and Policy</th><th>EPR Code</th><th>DRAFT Environmental Performance Requirements</th><th>Phase</th></tr>
<tr><td>State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1)
Australian Standards AS 2187.2, Explosives – Storage and use – Use of explosives
Australian Standard 2436 2010 Guide to Noise Control on Construction, Maintenance and Demolition Site (reconfirmed 2016)
VicRoads Road Design Note RDN 6-1 Interpretation and application of VicRoads traffic noise reduction policy 2005
VicRoads Traffic Noise Measurement Requirements for Acoustic Consultants – September 2011
EPA Publications:
• 480 Best Practice Environmental Management: Environmental Guidelines for Major Construction Sites
• 1254 Noise Control Guidelines
New South Wales Interim Construction Noise Guideline (ICNG) (2009)</td><td>NV1</td><td>Achieve traffic noise objectives
Design and construct the works to meet the following L_{A10} traffic noise objectives.
<table>
<tr><th>Aspect</th><th>External traffic noise levels</th></tr>
<tr><td>External traffic noise levels</td><td>(a) Traffic noise from North East Link Project Roads* must be no greater than:
o 63 dBA measured between 6 am and midnight at Category A buildings**
o 63 dBA measured between 6 am and 6 pm at Category B buildings**.
(b) For Category A and Category B buildings on non-Project Roads which:
o directly intersect with North East Link project roads, and
o where total traffic noise for the design year and with Project exceeds the thresholds listed in paragraph (a)
The combined noise from North East Link Project Roads and non-Project Roads must not be more than 2 dBA higher than the predicted traffic noise level under the design year ‘do nothing’ scenario. Non-Project Roads must be modelled for a distance of 100 m from the intersection with North East Link Project Roads or to the first traffic intersection (whichever is the lesser).</td></tr>
<tr><td>Applies at</td><td>The noise criteria in paragraphs (a) and (b) above are to apply to the lowest habitable level of Category A buildings and Category B buildings at both the year of opening and 10 years thereafter (the design year). For the purposes of this EPR, Category A buildings and Category B buildings to be considered are those that are either existing or known to have planning approval prior to exhibition of the North East Link Environment Effects Statement.
Where external traffic noise cannot be mitigated through project design solutions to meet the criteria outlined in paragraphs (a) and (b), at-property treatments may be required. At-property treatments would be undertaken with reference to section 7.3 of the NSW Road and Maritime Services document ‘Noise Mitigation Guidelines 2015 – Roads and Maritime Services’, and in consultation with the owner of the relevant building.</td></tr>
</table></td><td>Design, operation</td></tr>
</table>

Applicable Legislation and Policy	EPR Code	DRAFT Environmental Performance Requirements	Phase
New South Wales Roads and Maritime Services Construction Noise and Vibration Guideline (CNVG) (2016) New South Wales Roads and Maritime Services Noise Mitigation Guideline (2015) ASHRAE Chapter 48 Sound and Vibration Control Standards German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (2016) British Standard BS6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting.		* Project Roads are defined to be the M80 Ring Road (east of Plenty Road), the Greensborough Bypass (west of the Plenty River bridge and up to the M80 interchange with North East Link), the upgrade of the Eastern Freeway (between Hoddle Street and Springvale Road) and the new North East Link freeway (connecting the M80 Ring Road to the Eastern Freeway), including all access ramps. ** Category A Buildings and Category B Buildings means: o Category A Buildings: – Residential dwellings, aged persons homes, hospitals, motels, caravan parks and other buildings of a residential nature o Category B Buildings: – Schools, kindergartens, libraries and other noise-sensitive community buildings	
	NV2	Monitor traffic noise Traffic noise monitoring must be carried out for at least the following time periods: • Baseline traffic noise must be re-verified after project award and prior to construction works • Traffic noise must be re-measured within six months of project opening during normal traffic flows (outside school or public holidays). For the purpose of determining compliance, the measurements conducted after project opening must be adjusted to the 10 year traffic flows. • Traffic noise must be re-measured 10 years after project opening All traffic noise monitoring must be undertaken in accordance with the VicRoads Traffic Noise Measurement Requirements for Acoustic Consultants – September 2011, to verify conformance with the external traffic noise objectives set out in EPR NV1. Remedial action must be taken as soon as practicable in the event that the measured traffic noise levels demonstrate that the external traffic noise objectives set out in EPR NV1 are not met.	Design, operation
	NV3	Minimise construction noise impacts to sensitive receptors Construction noise and vibration must be managed in accordance with the Construction Noise and Vibration Management Plan (CNVMP) required by EPR NV4. Non-residential sensitive receptors For sensitive land uses (based on AS/NZS 2107:2016) implement management actions as per EPR NV4 if construction noise is predicted to or does exceed the internal and external noise levels below, and a noise sensitive receptor is adversely impacted. If construction exceeds the noise levels below: • Consider the duration of construction noise • Consider the existing ambient noise levels • Consult with the owner or operator of the noise sensitive receptor • Consider any specific acoustic requirements of land uses listed below to determine whether a noise sensitive receptor is adversely impacted.	Construction

<table>
<tr><th>Applicable Legislation and Policy</th><th>EPR Code</th><th>DRAFT Environmental Performance Requirements</th><th>Phase</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><th>Land use</th><th>Construction noise management level, $L_{Aeq\ (15\ min)}$ applies when properties are in use</th></tr>
<tr><td>Classrooms in schools and other educational institutions</td><td>Internal noise level 45 dB(A)</td></tr>
<tr><td>Hospital wards and operating theatres</td><td>Internal noise level 45 dB(A)</td></tr>
<tr><td>Places of worship</td><td>Internal noise level 45 dB(A)</td></tr>
<tr><td>Active recreation areas characterised by sporting activities and activities which generate their own noise, making them less sensitive to external noise intrusion</td><td>External noise level 65 dB(A)</td></tr>
<tr><td>Passive recreation areas characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example reading, meditation</td><td>External noise level 60 dB(A)</td></tr>
<tr><td>Community centres</td><td>Depends on the intended use of the centre. Refer to the recommended maximum internal levels in AS/NZS 2107:2016 for specific uses</td></tr>
<tr><td>Industrial premises</td><td>External noise level 75 dB(A)</td></tr>
<tr><td>Offices, retail outlets</td><td>External noise level 70 dB(A)</td></tr>
<tr><td>Other noise sensitive land uses as identified in AS/NZS 2107:2016</td><td>Refer to the noise levels in AS/NZS 2107:2016</td></tr>
</table>
<u>Residential receptors</u>
For residential dwellings, management actions must be implemented as per EPR NV4 if noise from construction works during normal working hours is predicted to or does exceed the noise management levels for normal working hours below.
Noise from construction works during weekend/evening work hours and the night period must meet the weekend/evening and night period noise guideline targets in the table below unless they are Unavoidable Works.
</td><td></td></tr>
</table>

<table>
<tr><th>Applicable Legislation and Policy</th><th>EPR Code</th><th>DRAFT Environmental Performance Requirements</th><th>Phase</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><th>Time of day</th><th>Construction noise guideline targets</th></tr>
<tr><td>Normal working hours:
7 am – 6 pm Monday to Friday
7 am – 1 pm Saturday</td><td>Noise affected: Background L_{A90}+10 dB
Highly noise affected: 75 dB(A)
Source: NSW Interim Construction Noise Guideline (ICNG) Chapter 4.1.1 Table 2.
The noise affected level represents the point above which there may be some community reaction to noise. The highly noise affected level represents the point above which there may be strong community reaction to noise.</td></tr>
<tr><td>Weekend/evening work hours:
6 pm – 10 pm Monday to Friday
1 pm – 10 pm Saturday
7 am – 10 pm Sunday and public holidays</td><td>Noise level at any residential premises not to exceed background noise (L_{A90}) by:
10 dB(A) or more for up to 18 months
5 dB(A) or more after 18 months
Source: EPA Publication 1254 Section 2</td></tr>
<tr><td>Night period:
10 pm – 7 am Monday to Sunday</td><td>Noise inaudible within a habitable room of any residential premises
Source: EPA Publication 1254 Section 2 and EPA Publication 480 Section 5</td></tr>
</table>
i. Note: Where any reference is made to the rating background level (RBL) or background L_{A90}; the ‘average background’ over the assessment period as per Victorian noise policy practices is to be used. This applies to all receptors and all time periods.
ii.
<u>Unavoidable Works</u>
Unavoidable Works may include:
• The delivery of oversized plant or structures that police or other authorities determine require special arrangements to transport along public roads
• Emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
• Maintenance and repair of public infrastructure where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
• Tunnelling works including mined excavation elements and the activities that are required to support tunnelling works (ie spoil treatment facilities)
• Road and rail occupations or works that would cause a major traffic hazard
• Other works where a contractor demonstrates and justifies a need to operate outside normal working hours and exceed the noise guideline targets such as work that once started cannot practically be stopped.
</td><td></td></tr>
</table>

Applicable Legislation and Policy	EPR Code	DRAFT Environmental Performance Requirements	Phase
	NV4	Implement a Construction Noise and Vibration Management Plan (CNVMP) to manage noise and vibration impacts Prepare, implement and maintain a Construction Noise and Vibration Management Plan (CNVMP) in consultation with EPA Victoria and relevant councils. The CNVMP must comply with and address the Noise and Vibration EPRs, be informed by the noise modelling and monitoring results and must include (but not be limited to): • Identification of noise and vibration sensitive receptors along the project alignment, including habitat for listed threatened fauna, likely to be impacted by the project • Construction noise and vibration targets as per EPRs NV3, NV5, NV8, NV9, NV10, NV11 and NV12, including any details of conversions between alternative metrics • Details of construction activities and an indicative schedule for construction works, including the identification of key noise and/or vibration generating construction activities that have the potential to generate airborne noise and/or surface vibration impacts on surrounding sensitive receivers • How construction noise (including truck haulage) and vibration would be minimised (see EPR T2) • A requirement for preliminary tests using the actual equipment to validate modelling for vibration and regenerated noise and review, with predictions to be remodelled as necessary and confirm prevention/mitigation/remediation measures confirmed • Management actions and notification and mitigation measures to be implemented with reference to the Appendix B and Appendix C of the New South Wales Roads and Maritime Services Construction Noise and Vibration Guideline 2016 (CNVG) • Any processes and measures to be implemented as part of the Communications and Community Engagement Plan including measures concerning complaints management (see EPR SC2) • Requirements to assess and manage vibration impacts to scientific or medical establishments to the higher of ambient levels or ASHRAE VC Standards (as defined in the 2015 handbook), or manufacturers equipment levels (unless by agreement with occupant) • Measures to ensure effective monitoring of noise and vibration associated with construction with consideration to the construction noise and vibration targets • Measures to minimise noise and vibration impacts from temporary traffic diversions and altered access to parking facilities • The Unavoidable Works that would be undertaken, including their location, timing and duration. The CNVMP must include a clear rationale for defining works or a list of the type of planned works that constitute Unavoidable Works and response strategies to mitigate the impacts of these Unavoidable Works, with reference to EPA Victoria Publication 1254 Noise Control Guidelines and Appendix B and Appendix C of the CNVG. The Independent Environmental Auditor must verify that the proposed Unavoidable Works meet the definition of Unavoidable Works for each instance they are undertaken. Details of Unavoidable Works must be made publicly available. For emergency Unavoidable Work, a rationale must be provided to the satisfaction of the Independent Environmental Auditor as soon as practicable.	Construction

<table>
<tr><th>Applicable Legislation and Policy</th><th>EPR Code</th><th>DRAFT Environmental Performance Requirements</th><th>Phase</th></tr>
<tr><td></td><td>NV5</td><td>
Establish vibration guidelines to protect utility assets
Prior to construction undertake condition assessments of above and below ground utility assets (EPR GM3) and consult with asset owners to establish and agree construction vibration guidelines to maintain asset integrity. In all cases the asset owner's criteria takes precedence.
Where construction vibration guidelines are not proposed by the asset owner, reference should be made to the relevant sections of German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (2016) for guideline assessment procedures for buried pipework or underground infrastructure. The integrity of the asset should be reviewed and assessed (by the contractor, in conjunction with the asset owner) to confirm these values are appropriate. If necessary, based on this assessment, limits must be reduced to the level necessary to maintain asset integrity.
Monitor vibration levels during construction to demonstrate compliance with agreed vibration guidelines. Identify contingency measures to be implemented if guidelines are not met. Where necessary rectify any defects that are attributable to the project.
An overview of the key vibration guidelines values is presented below. In all cases, the supporting documentation within the Standard which describes, clarifies and sometimes modifies the tables below must be considered.

Table 2 Guideline values for vi, max, for evaluating the effects of short-term vibration on the lining of underground cavities
<table>
<tr><th>Line</th><th>Lining material</th><th>Guideline values for vi, max in mm/s perpendicular to lining surface</th></tr>
<tr><td>1</td><td>Reinforced or sprayed concrete, tubbing segments</td><td>80</td></tr>
<tr><td>2</td><td>Concrete, stone</td><td>60</td></tr>
<tr><td>3</td><td>Masonry</td><td>40</td></tr>
</table>
Note: The guideline values were measured during nearby mine blasting operations and apply only to the lining of underground structures, but not to any associated installations.

Table 3 Guideline values for vi, max, for evaluating the effects of short-term vibration on buried pipework
<table>
<tr><th>Line</th><th>Lining material</th><th>Guideline values for vi, max in mm/s perpendicular to lining surface</th></tr>
<tr><td>1</td><td>Steel, welded</td><td>100</td></tr>
<tr><td>2</td><td>Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)</td><td>80</td></tr>
<tr><td>3</td><td>Masonry, plastics</td><td>50</td></tr>
</table>
</td><td>Construction</td></tr>
</table>

<table>
<tr><th>Applicable Legislation and Policy</th><th>EPR Code</th><th>DRAFT Environmental Performance Requirements</th><th>Phase</th></tr>
<tr><td></td><td>NV6</td><td>Design permanent tunnel ventilation system to meet EPA requirements for noise
Design and implement the permanent tunnel ventilation system to achieve compliance with State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 and in accordance with the Works Approval. Provide detailed design to the satisfaction of EPA Victoria prior to commencement of the works permitted by the Works Approval.</td><td>Design, construction</td></tr>
<tr><td></td><td>NV7</td><td>Monitor noise from tunnel ventilation system
Measure noise from the permanent tunnel ventilation system on commencing road operation and monitor noise from the tunnel ventilation system post opening of the North East Lin, as agreed with EPA Victoria, to verify compliance with State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1. Identify and implement contingency measures to be implemented if noise level targets are not met.</td><td>Operation</td></tr>
<tr><td></td><td>NV8</td><td>Minimise construction vibration impacts on amenity
Implement management actions if the following guideline target levels for continuous vibration from construction activity to protect human comfort of occupied buildings (including heritage buildings) are not achieved (levels are calculated from the British Standard BS6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting.).

<table>
<tr><th rowspan="3">Type of space occupancy</th><th colspan="4">Vibration Dose Values (m/s$^{1.75}$)</th></tr>
<tr><th colspan="2">Day (7 am to 10 pm)</th><th colspan="2">Night (10 pm to 7 am)</th></tr>
<tr><th>Preferred Value</th><th>Maximum Value</th><th>Preferred Value</th><th>Maximum Value</th></tr>
<tr><td>Residential</td><td>0.2</td><td>0.4</td><td>0.1</td><td>0.2</td></tr>
<tr><td>Offices, schools, educational institutions, places of worship</td><td>0.4</td><td>0.8</td><td>0.4</td><td>0.8</td></tr>
<tr><td>Workshops</td><td>0.8</td><td>1.6</td><td>0.8</td><td>1.6</td></tr>
</table>
Notes
1 The Guideline Targets are non-mandatory; they are goals that should be sought to be achieved through the application of practicable mitigation measures. If exceeded then management actions would be required
2 The Vibration Dose Values may be converted to Peak Particle Velocities within a noise and vibration construction management plan.</td><td>Construction</td></tr>
<tr><td></td><td>NV9</td><td>Minimise construction vibration impacts on structures
Construction vibration targets for structures based on German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (2016) must be adopted. All sections of the German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (2016) standard apply, noting the guideline levels detailed in Section 5 and Section 6 (and any references sections).
An overview of the key vibration guidelines values is presented below. In all cases, the supporting documentation within the Standard which describes, clarifies and sometimes modifies the tables below must be considered.</td><td>Construction</td></tr>
</table>

Applicable Legislation and Policy	EPR Code	DRAFT Environmental Performance Requirements	Phase

Table 1 — Guideline values for vibration velocity, vi, max, for evaluating the effects of short-term vibration on structures

	Type of structure	Guideline values for vi, max in mm/s				
		Foundation, all directions, I = x, y, z, at a frequency of			Topmost floor, horizontal direction, I = x, y	Floor slabs, vertical direction, i = z
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz (a)	All frequencies	All frequencies
Column Line	1	2	3	4	5	6
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (eg listed buildings)	3	3 to 8	8 to 10	8	20 (b)

Note: Even if guideline values as in line 1, columns 2 to 5, are complied with, minor damage cannot be excluded.

(a) At frequencies above 100 Hz, the guideline values for 100 Hz can be applied as minimum values.

(b) Paragraph 2 of 5.1.2 must be observed.

<table>
<tr><th>Applicable Legislation and Policy</th><th>EPR Code</th><th>DRAFT Environmental Performance Requirements</th><th>Phase</th></tr>
<tr><td></td><td></td><td>Table 4 — Guideline values for vi, max, for evaluating the effects of long-term vibration on buildings
<table>
<tr><th></th><th>Type of building</th><th colspan="2">Guideline values for vi, max, in mm/s</th></tr>
<tr><th></th><th></th><th>Topmost floor, horizontal direction, all frequencies</th><th>Floor slab, vertical direction, all frequencies</th></tr>
<tr><td>Column Line</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>1</td><td>Buildings used for commercial purposes, industrial buildings, and buildings of similar design</td><td>10</td><td>10</td></tr>
<tr><td>2</td><td>Residential buildings and buildings of similar design and/or occupancy</td><td>5</td><td>10</td></tr>
<tr><td>3</td><td>Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (eg listed buildings)</td><td>2.5</td><td>10 (a)</td></tr>
</table>
Note: Even if guideline values as in line 1, column 2, are complied with, minor damage cannot be ruled out
(a) section 6.1.2 must be observed</td><td></td></tr>
<tr><td></td><td>NV10</td><td>Minimise impacts from ground-borne (internal) noise
Implement management actions in consultation with potentially affected land owners to protect amenity at residences where the following ground borne noise guideline targets based on Section 4.2 of the New South Wales Interim Construction Noise Guidelines are exceeded during construction.
<table>
<tr><th>Time of Day</th><th>Internal noise level measured at the centre of the most affected habitable room</th></tr>
<tr><td>Evening (6 pm to 10 pm)</td><td>$L_{Aeq(15\ minute)}$ = 40 dBA</td></tr>
<tr><td>Night (10 pm to 6 am)</td><td>$L_{Aeq(15\ minute)}$ = 35 dBA</td></tr>
</table>
Notes
1 Levels are only applicable when ground borne noise levels are higher than airborne noise levels.
2 Management actions include community consultation to determine acceptable level of disruption and provision of respite accommodation in some circumstances.</td><td>Construction</td></tr>
</table>

<table>
<tr><th>Applicable Legislation and Policy</th><th>EPR Code</th><th>DRAFT Environmental Performance Requirements</th><th>Phase</th></tr>
<tr><td></td><td>NV11</td><td>Minimise amenity impacts from blast vibration
Implement management actions if the following vibration values are not achieved. Blasting activities must comply with Australian Standard AS2187.2-2006, Explosives – Storage and use Part 2 – Use of explosives for all blasting.

<table>
<tr><th>Category
(as defined in AS 2187.2-2006)</th><th>Type of
blasting operations</th><th>Peak component particle velocity (mm/s)</th></tr>
<tr><td>Sensitive site</td><td>More than 20 blasts</td><td>5 mm/s for 95% blasts per year
10 mm/s maximum (unless by agreement with occupier)</td></tr>
<tr><td>Sensitive site</td><td>Less than 20 blasts</td><td>10 mm/s maximum (unless by agreement with occupier)</td></tr>
<tr><td>Non-sensitive site (with occupants)</td><td>All blasting</td><td>25 mm/s maximum value (unless by agreement with occupier).</td></tr>
<tr><td>Scientific equipment</td><td>All blasting</td><td>Existing ambient levels or ASHRAE VC Standards (as defined in the 2015 handbook) (whichever is the higher) or manufacturers equipment levels (unless by agreement with occupier)</td></tr>
</table></td><td></td></tr>
<tr><td></td><td>NV12</td><td>Minimise amenity impacts from blast overpressure
Implement management actions if the following overpressure values are not achieved. Blasting activities must comply with Australian Standard AS2187.2-2006, Explosives – Storage and use Part 2 – Use of explosives for all blasting.

<table>
<tr><th>Category (as defined in AS 2187.2-2006)</th><th>Type of blasting operations</th><th>Peak Overpressure Value (dBL)</th></tr>
<tr><td rowspan="2">Sensitive Site</td><td>More than 20 blasts</td><td>115 dBL for 95% blasts
120 dBL maximum (unless by agreement with occupier)</td></tr>
<tr><td>Less than 20 blasts</td><td>120 dBL for 95% blasts
125 dBL maximum (unless by agreement with occupier)</td></tr>
<tr><td>Occupied non-sensitive sites such as factories and commercial premises</td><td>All blasting</td><td>125 dBL maximum (unless by agreement with occupier).
For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturers specification or levels that can be shown to adversely affect the equipment operation</td></tr>
</table></td><td>Construction</td></tr>
</table>

Applicable Legislation and Policy	EPR Code	DRAFT Environmental Performance Requirements	Phase
	NV13	Noise mitigation – noise walls Construction of permanent noise attenuation must, where feasible, be installed in advance of adjacent works.	Construction
	NV14	Reduce impacts from engine brake noise Opportunities to encourage heavy vehicle drivers to reduce use of engine brakes must be considered, where practicable.	Design, construction, operation

12 Conclusion

The purpose of this report is to provide a surface noise and vibration impact assessments to inform the preparation of the EES required for the project.

A summary of the key assets, values or uses potential affected by the project, and the associated impacts assessment are summarised below.

The proposed North East Link runs through a predominantly residential area with a section of the corridor within tunnels. This helps to minimise the airborne noise to the community, by removing traffic from the surface roads.

A detailed baseline noise and vibration investigation was undertaken to document and quantify the existing conditions. These levels helped set the appropriate design goals by which the airborne noise was assessed. The existing conditions measurements were not included in the analysis where there were periods of high wind or rain, or when it was apparent there was evidence of local noise events. The levels recorded were consistent with expectations for a residential area, given the surrounds and the proximity to a transport corridor.

A review of identified relevant policies, standards and guidelines relating to noise and vibration was undertaken and initial risk assessment was conducted early in the project to identify areas of potential concern for this study. That information was shared with other technical studies and helped form the final Environmental Performance Requirements (EPRs) for the project.

A number of key construction scenarios were modelled to determine the expected noise impacts that would occur from key works during the day, evening and night-time period. This initial assessment highlighted a number of potential impacts, that warrant the need for additional mitigation and/or time restrictions to the activity.

The successful contractor to the project, would need to prepare a Construction Noise and Vibration Management Plan (CNVMP) which would need to update the assessment for the specific processes, techniques and plant items adopted. Where appropriate, this could lead to differing impacts and mitigations. The impacts will never-the-less need to comply with the requirements detailed in the EPRs, appropriate to the time of the day.

For a small number of discrete construction works, high impacts could be expected for a period of time. In these cases, the contractor would need to demonstrate that all reasonable and feasible mitigation measures have been adopted, the community has been consulted, and suitable management measures have been implemented.

The project has generally adopted more stringent noise objectives than required by a strict interpretation of the VicRoads *Traffic Nosie Reduction Policy* (2005). Where Victoria has no assessment guidelines (such as daytime construction criteria, human-comfort vibration assessment procedures, building damage guidelines), relevant interstate or accepted international criteria has been adopted.

A traffic noise prediction model was prepared and calibrated to the measured existing conditions measurements. This model was also used to predict future traffic noise levels for the year of opening, the design year (10 years after opening) and for the expected noise levels for the design year, assuming the project did not proceed. This model was then used to tailor the noise walls required to full or near-compliance.

Noise walls up to 10 metres high have been incorporated into the design along the road corridor and up to a maximum of four metres on viaducts. It is currently predicted that compliance would not be achieved at 159 properties even with the proposed noise walls, mainly due to the relative heights of the property with respect to the roadway or because continuous noise walls cannot be included at particular locations (such as at the end of noise walls near cross streets, or due to shared use paths intercepting the noise walls). These properties would be considered for at-property mitigation during the detailed design phase of the project.

The recommendation of noise walls on the existing bridge structures precedes an assessment of the bridge to ensure it can withstand the structural load imposed or other design considerations. If it demonstrates the recommended viaduct walls are not feasible; a small number (nominally three to five properties around each bridge) may qualify for at-property treatments as a means of noise control (in lieu of the bridge wall).

The road widening means that some noise walls would need to be demolished and new walls constructed. The proposed new walls would not be lower in height than the existing walls. Although noise walls would not be provided specifically for noise reduction in parkland areas, many parks would benefit from the noise walls needed for compliance at nearby residential properties.

Fourteen specific EPR requirements based on Victorian, interstate or international limits, standards and guidelines have been collated, which would assist to minimise the impacts of the project to the community along the corridor.

The introduction of North East Link (and associated noise mitigation) tends to reduce the project-wide traffic noise levels by approximately 1 dBA (assuming noise from local roads and project roads). It is noted that for Category A and Category B buildings:

- 35 buildings along the corridor would experience a very significant noise reductions of 10 dBA or more due to North East Link
- 382 one buildings along the corridor would experience a significant noise reduction of 5 dBA to 10 dBA
- 1,883 properties would experience noise reductions by between 2 dBA to 5 dBA
- 8,287 properties are predicted to experience no noticeable change in their noise environment (-2 dBA to + 2 dBA)
- 889 properties are predicted to experience an increase of more than 2 dBA.

The properties referred to above, include all noise sensitive buildings in the study area. An analysis of the distribution of the predicted change in traffic noise for 2036, with and without the project (adopting the upper limit of the predicted traffic volume range) shows that:

- A high number of properties that fall in the range of +/- 2 dBA (representing no noticeable change to the noise environment). Many of these houses are located sufficiently far from the project alignment, so as not to be adversely affected by the project
- The project provides the most noise reduction to those locations having noise levels higher than approximately 60.5 dBA (compared to the do-nothing scenario).; so that more impacted buildings receive the highest benefit from the noise mitigation measures.

The project would substantially reduce the current volume of trucks on the local road network. This would reduce engine brake noise. At other locations along the study corridor, the elimination of intersections and smoother traffic flows would be expected to lead to reduce the frequency-of-use of engine brakes. However, metered ramps would be introduced to control west-facing traffic connections to the Eastern Freeway. It is possible the merging of the ramps on the main carriageway (heading east or west along the Eastern Freeway) could be a source of future engine brake noise (when the metering ramps are active). However, as the road network has been designed to allow for continuous flow traffic, the need for trucks to regularly engage engine brakes is not considered high.

The analysis in the potential change in traffic noise on the wider road network (away from the study corridor) indicates there are many roads traffic noise would reduce during the operation of North East Link. The largest reduction in traffic noise corresponds to those sections of roads currently used to link the M80 Ring Road and the Eastern Freeway, with the highest reductions anticipated to be approximately 4 dBA. However, a small number of other roads on the wider road network are anticipated to experience a negligible increase in traffic numbers and an increase in traffic noise, although the highest increase is only 1.4 dBA which is considered minimal and generally unnoticeable.

Noise from North East Link ventilation systems and substations associated has been shown to comply with the SEPP N-1 noise limits. During detailed design, the assessment would be reviewed, with consideration of the selected fans and updates to the background noise levels at the relevant receiver locations.

13 Bibliography

[1] Austroads, “An approach to the validation of road traffic noise models (AP-T14),” Ausroads Incorporated, Sydney, 2002.

[2] Road and Maritime Services, “Construction Nosie and Vibration Guidelines,” Road and Maritime Services, Sydney, 2018.

[3] Wikipedia, “Simpson Barracks,” 2018. [Online]. Available: https://en.wikipedia.org/wiki/Simpson_Barracks. [Accessed 2 11 2018].

[4] Australian Standards, “Acoustics - Methods for the Measurement of Traffic Noise,” AS2702.

[5] VicRoads Victoria, “Traffic Noise Reduction Policy, VicRoads,” 2005.

[6] VicRoads Victoria, Traffic Noise Measurement Requirements for Acoustic Consultants, Victoria, 2011.

[7] EPA Victoria: Publication 1254, “Noise Publications,” 2017. [Online]. Available: https://www.epa.vic.gov.au/our-work/publications/publication/2008/october/1254. [Accessed 20 07 2018].

[8] EPA Victoria : Publication 480, “Environmental guidelines for major construction sites,” 1996. [Online]. Available: https://www.epa.vic.gov.au/our-work/publications/publication/1996/february/480. [Accessed 20 07 2018].

[9] ASHRAE , ASHRAE Handbook, Chapter 48: Sound and Vibration Control, ASHRAE, USA, 2015.

[10] Australian Standards, Explosives – Storage and Use Part 2: Use of explosives: , AS2187.2-2006, Australia: Standards Australia Online.

[11] Standards Australia, Australian/New Zealand Standard Acoustics-Recommended design sound levels and reverberation times for building interiors :AS2107: 2016, Australia: Standards Australia Online.

[12] Australian Standards, Guide to noise and vibration control on construction, demolition and maintenance sites: AS 2436-2010, Australia: Standards Australia Online.

[13] British Standards, Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting: BS6472-1:2008,, British Standards Institution.

[14] British Standards, Code of practice for noise and vibration control on construction and open sites. Noise: BS 5228-1-2014, British Standards Institution.

[15] British Standards, Code of practice for noise and vibration control on construction and open sites – Vibration: BS5228-2: 2014, British Standards Institution .

[16] EPA Victoria , Noise Control Guidelines Publication 1254, EPA Victoria, 2008.

[17] EPA Victoria , Environmental Guidelines For Major Construction Sites Publication 480, EPA Victoria, 1996.

[18] VicRoads Victoria , Noise Guidelines – Construction and Maintenance Works, EPA Victoria, 2007.

[19] German Standard, Structural Vibration in Buildings – Effects on Structures, DIN 4150 – Part 3: 2016, Beuth publishing DIN.

[20] EPA NSW, Interim Construction Noise Guideline, EPA NSW, 2009.

[21] EPA NSW, Assessing Vibration: A Technical Guideline, EPA NSW, 2006.

[22] Roads and Maritime Services NSW, Construction Noise and Vibration Guideline, RMS NSW, 2016.

[23] Roads and Maritime Services NSW, Environmental Noise Management Manual, RMS NSW, 2001.

[24] VicRoads Victoria , Road Design Note (RDN) 06-01 – Interpretation and application of VicRoads Traffic Noise Reduction Policy, VicRoads Victoria , 2005.

[25] VicRoads Victoria , Traffic Noise Measurement Requirements for Acoustic Consultants, VicRoads Victoria , 2011.

[26] AustRoads, Modelling, Measuring and Mitigating Road Traffic Noise, AustRoads, 2005.

[27] NSW EPA, NSW Road Noise Policy, NSW: NSW EPA, 2011.

[28] Transport Research Board, Supplementary Guideance on the Applpication of FHWA's Traffic Nosie Model (TNM), Washington: TRB, 2014.

[29] WHO, Environmental Noise Guidelines for the European Union, Denmark: WHO, 2018.

[30] WHO, Night Noise Guidelines for Europe, Denmark: WHO, 2009.

[31] Australian Standards, Guide to noise and vibration control on construction, demolition and maintenance sites, AS 2436-2010 (R2016), Australian Standards Online, 2016.

[32] British Standard, Evaluation and Measurement for Vibration in Buildings: BS 7385-2 (1993), British Standard Institution.

[33] EPA NSW , Assessing Vibration, A Technical Guide, EPA NSW , 2006.

[34] British Standards, Guide to evaluation of human exposure to vibration in building: BS 6472:1992, British Standard Institution.

[35] Environmental Protection Act, “SEPP (Control of noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1),” Victoria, 1970.