

CrossRiver*Rail*



16. Noise and Vibration

Cross River Rail

CHAPTER 16

NOISE AND VIBRATION

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16 Noise and vibration

This chapter addresses Part B, Section 3.8 of the Terms of Reference (ToR). Technical studies on which the chapter is based are reported in *Technical Report No.8 – Noise and Vibration*.

The ToR requires the existing noise and vibration environment within the study corridor to be described in the context of environmental values defined by the *Environmental Protection (Noise) Policy 2008* (EPP (Noise)). Sensitive receivers near significant Project components have been identified along with typical background noise and vibration levels, based on surveys of representative sites. Noise and vibration goals relevant to construction and operation are also defined.

Noise and vibration impacts of construction activities, including tunnelling, surface construction, spoil haulage management and placement and construction traffic, have been identified and assessed. Impacts of noise and vibration generated during operation of the Project, including from underground and surface operations and tunnel ventilation shafts, are assessed against relevant criteria including the criteria stated in Queensland Rail's *Code of Practice for Rail Noise Management, 2007* and against current typical background levels. Potential impacts on sensitive receivers of low frequency noise and vibration from construction and operation are also considered.

16.1 Introduction

The Project has the potential to generate noise and vibration impacts during both construction and operation. Aspects of the Project that are of interest with respect to the existing noise and vibration environment include worksites, upgraded surface track corridors, tunnel portals, the surface of the tunnel alignment, mechanical ventilation plant at stations and emergency tunnel ventilation.

To address the requirements of the ToR for noise and vibration, this chapter:

- sets out the methodology, terminology, criteria and goals
- describes the existing noise and vibration conditions within the study corridor
- provides an assessment of the potential noise and vibration impacts during construction and operation
- outlines mitigation measures to avoid or minimise potential noise and vibration impacts.

16.1.1 Methodology

Introduction

The focus of this assessment is the study corridor identified in **Chapter 1**. The methodology used to undertake this assessment involved:

- assessment of the existing noise and vibration conditions in the study corridor, including monitoring at representative sites
- identification of sensitive receivers, such as residential, health and medical facilities, child care, schools and heritage buildings
- identification of noise and vibration sources during the construction and operation
- modelling of predictive noise and vibration levels associated with the construction and operation, including the use of SoundPLAN, which is a software suite that specialises in computer simulation of noise
- identification of management and mitigation strategies, as required.

Further detail on the methodology is provided in *Technical Report No.8 – Noise and Vibration*.

A summary of the approach to assessing noise and vibration during construction and operation is provided below.

Approach to construction noise and vibration

Goals for construction noise have been established to measure Project performance in relation to the environmental objectives. These aim to minimise disruption to normal urban activities by seeking to avoid sleep disturbance and maintain reasonable acoustic conditions within buildings used for education, commerce, worship and community activities. Potential impacts of long-term construction noise sources have been assessed by comparison with the following noise goals:

- Sleep disturbance criteria contained in Brisbane City Council's Noise Impact Assessment Planning Scheme Policy (NIAPSP) and Queensland Department of Environment and Resource Management (DERM) EcoAccess Guideline Planning for Noise Control (EcoAccess PNC).
- Recommended internal noise levels for various building uses, as specified in Australian/New Zealand Standard (AS/NZS) 2107: 2000 Acoustics – Recommended design sound levels and reverberation times for building interiors.
- Low frequency noise has been assessed in accordance with the DERM Draft EcoAccess Guideline Assessment of Low Frequency Noise (EcoAccess ALFN).
- The criterion for airblast overpressure has been evaluated in accordance with the cosmetic damage limits in United States Bureau of Mines (USBM) Report of Investigation RI 8507, 1980.
- Construction noise from surface track worksites has been assessed in accordance with Queensland Rail's Code of Practice – Railway Noise Management, 2007.
- Noise from construction-related vehicle traffic has been examined using the Calculation of Road Traffic Noise (CoRTN) prediction algorithms.
- Goals for construction vibration have been established to maintain human comfort, protect the integrity of building contents and services and prevent cosmetic damage.

A community's reaction to noise from construction will depend on the time of day that works are undertaken. People can be adversely affected by construction work, especially at night-time as it has the potential to disturb sleep. Accordingly, the extent of construction noise and vibration impacts has been examined as being representative of activities potentially having the greatest noise impact on sensitive receivers ie the worst case. The equipment selected, the distances to sensitive receivers and the duration of noisy activities can also combine to have some noise and/or vibration impacts.

Well considered construction planning has been developed to minimise potential impacts. The measures proposed in this chapter have been designed to achieve the environmental objectives for nearby sensitive receptors, while permitting construction activities to proceed at a reasonable rate of progress. Practical noise management measures have been developed, with a particular emphasis on community engagement. Where exceedances of noise and vibration goals have been predicted, a hierarchy of controls have been proposed in order to maintain compliance with construction noise and vibration goals, including:

- barriers and/or acoustic enclosures
- noise and vibration monitoring
- pre-condition surveys
- ongoing spot checks of noise intensive plant and equipment
- site inspections, to ensure appropriate controls are implemented and effective.

Approach to operation noise and vibration

Goals for noise and vibration during operation have also been established to measure performance in relation to the environmental objectives. Noise goals for railway surface track airborne noise emissions have been examined in accordance with Queensland Rail's *Code of Practice – Railway Noise Management, 2007*.

Ground-borne vibration goals have been evaluated in accordance with International and Australian standards, including AS 2670.2 1990 (*Evaluation of Human Exposure to Whole Body Vibration – Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*).

Ground-borne noise from rail operations have also been assessed in accordance with International and Australian standards, including *International Standard ISO 14837-1:2005(E) (Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1: General Guidance, First Edition 2005)*.

Noise from operational mechanical plant has been assessed in accordance with EPP (Noise), EcoAccess PNC and Brisbane City Council's NIAPSP.

Road traffic noise from realigned roads within the study corridor have been evaluated against the planning noise levels outlined in the *Transport and Main Roads (TMR) Code of Practice – Road Traffic Noise Assessment, 2007 (TMR CoP)*.

Where exceedances of noise and vibration operation goals have been predicted, mitigation measures have been proposed in order to maintain compliance with noise and vibration goals.

16.1.2 Noise and vibration terminology

This section provides an overview of noise and vibration terminology relevant to this assessment.

Noise

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbol LA represents A-weighted sound pressure level¹. Noise level descriptors used in this report are illustrated in **Figure 16-1** and described as:

- LA_{max} – The maximum A-weighted noise level associated with a sampling period
- LA₁ – The A-weighted noise level exceeded for 1% of a given measurement period. This parameter is often used to represent the typical maximum noise level in a given period
- LA₁₀ – The A-weighted noise level exceeded 10% of a given measurement period and is utilised normally to characterise average maximum noise levels
- LA_{eq} – The A-weighted average noise level, is defined as the steady noise level that contains the same amount of acoustical energy as a given time-varying noise over the same measurement period

¹ A-weighted sound pressure level is a measure of sound intensity for environmental and industrial noise. The A-weighting filter de-emphasizes the very low and very high frequency components of sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.

- LA90 – The A-weighted noise level exceeded 90% of a given measurement period and is representative of the average minimum background noise level (in the absence of the source under consideration), or simply the “background” level.

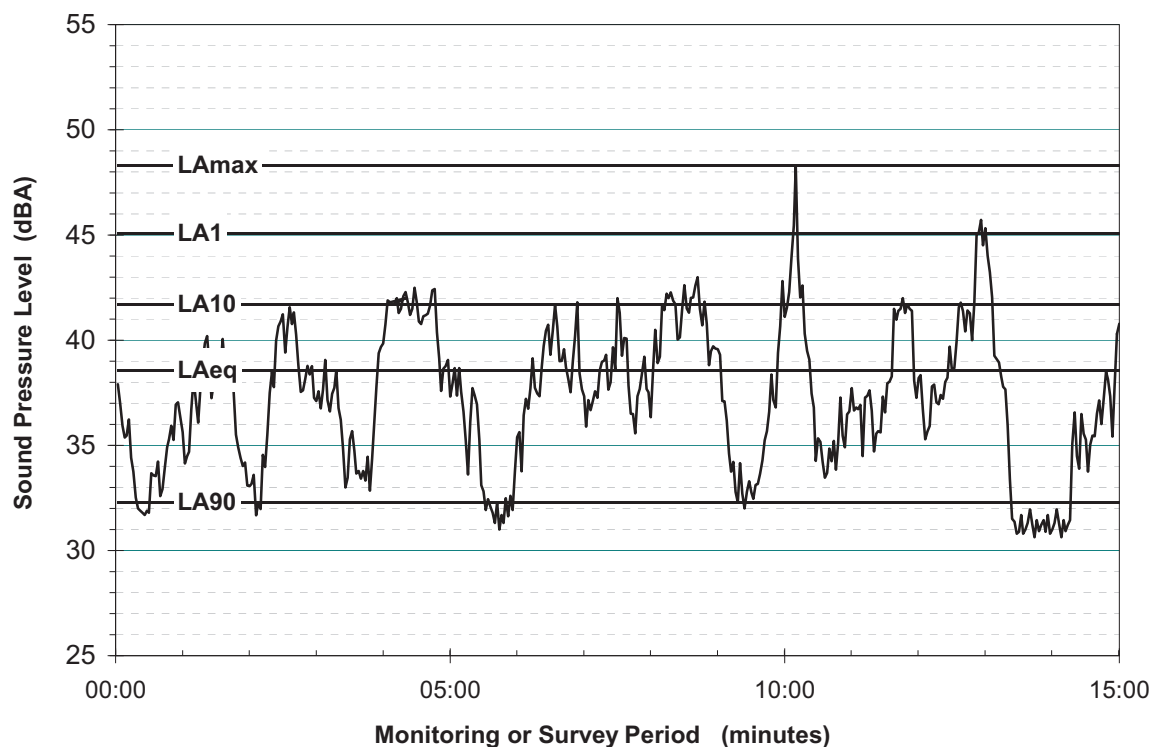


Figure 16-1 Graphical display of typical noise indices

Examples of typical noise levels are provided in **Table 16-1**.

Table 16-1 Typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerb side of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to
50	General Office	Quiet
40	Inside private office	Quiet to
30	Inside bedroom	Very quiet
20	Unoccupied recording studio	Almost silent

When dealing with statistical noise data for a number of days, it is sometimes necessary to define the typical noise levels at a given location for a time of day. A standardised method is used to determine these representative levels, which produces a level representing the “average minimum” background (LA90) noise level over the relevant day-time, evening and night-time periods. This is referred to as the Rating Background Level (RBL).

A change of up to 3 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

Vibration

Vibration is the term used to describe the oscillating or transient motions in physical bodies. This motion can be described in terms of vibration displacement, vibration velocity or vibration acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity, expressed in terms of “peak” velocity or “rms” velocity. Peak velocity is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as “peak particle velocity” (PPV). “Rms” velocity incorporates “root mean squared” averaging over a defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse. The common units for velocity are millimetres per second (mm/s).

As with noise, decibel units can also be used for measuring vibration and the m/s reference level should always be stated. Usually, the vibration velocity level is expressed in dBV (ref 10^{-9} m/s). The character of vibration emissions can be continuous, intermittent or impulsive.

Vibration can be described with the same level descriptors as presented and explained for noise. The corresponding vibration descriptors are Vmax, V1, V10, Veq and V90.

Figure 16-2 provides examples of typical vibration levels associated with surface and underground railway projects together with the approximate sensitivities of buildings, people and precision equipment.

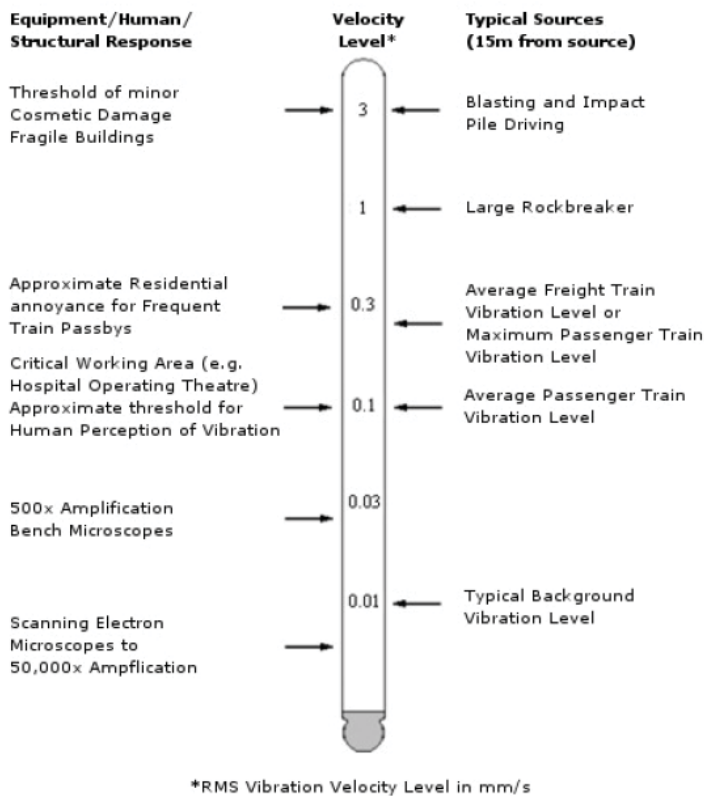


Figure 16-2 Typical vibration levels

Vibration and sound are intimately related. Vibrating objects can generate (radiate) sound and, conversely, sound waves (particularly lower frequencies) can also cause objects to vibrate.

Ground-borne noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall, ceiling and floor surfaces is termed “ground-borne noise”, “regenerated noise”, or sometimes “structure borne noise”. Ground-borne noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne noise include tunnelling construction works, underground railway operation, excavation plant (eg rockbreakers) and building services plant eg fans, compressors and generators.

Figure 16-3 presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.

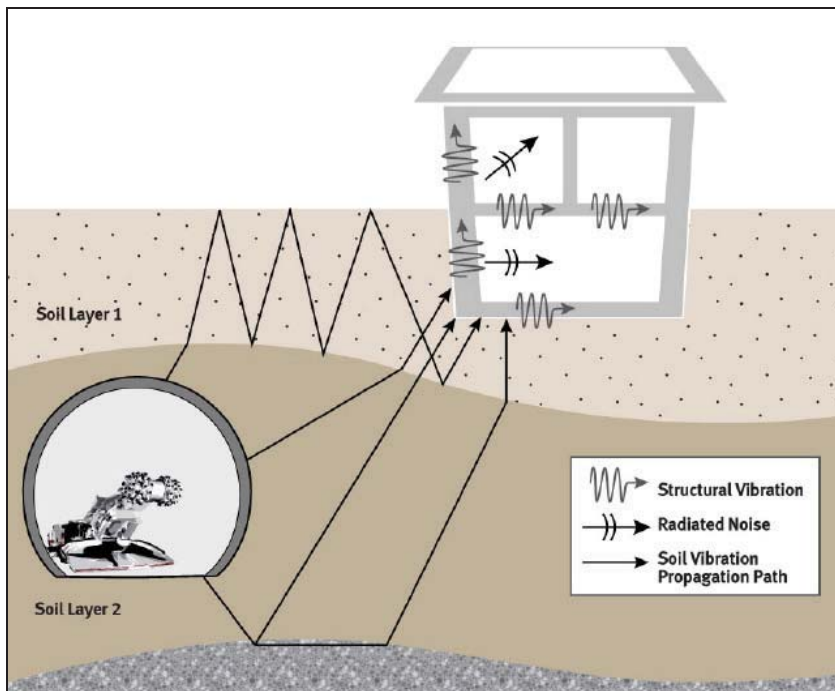


Figure 16-3 Vibration and ground-borne noise transmission paths

For surface rail operations, airborne noise would be significantly higher than ground-borne noise for most situations.

Identification of noise and vibration sensitive buildings

Apart from residential dwellings, a number of other noise and/or vibration sensitive receivers have been identified and factored into the impact assessment. These have been considered in this chapter when assessing the potential for impacts arising from airborne or ground-borne noise and vibration. These include the following types of facilities:

- medical facilities
- child care and educational
- places of worship
- heritage places
- commercial
- hotels.

16.2 Assessment criteria

16.2.1 Community values relating to noise and vibration

The EPP (Noise) defines community values as the qualities of the acoustic environment that are conducive to:

- protecting the health and biodiversity of ecosystems
- human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following
 - sleep: a person's ability to sleep is perhaps the most important value that can be impacted by noise and vibration. Adverse noise and vibration effects on sleep are generally referred to as sleep disturbance.
 - study or learning: the needs for education and work in relation to the acoustic environment relate to the ability to communicate effectively either face-to-face or by telephone, and the ability to think or focus on auditory information without undue intrusion from other sources of noise.
 - be involved in recreation, including relaxation and conversation: recreation is an important aspect of a healthy lifestyle. Recreation may include time spent both indoors and outdoors. In terms of acoustic function, recreation may involve communication with others in verbal conversation or simple enjoyment of an outdoor or indoor soundscape.
- protecting the amenity of the community.

The impact of a project on community values relating to noise and vibration is normally evaluated using statutory regulations and policies which describe acceptable levels of noise and vibration from various sources.

For types of noise for which specific levels are not listed in statutory regulations or policies, it is common to refer to relevant Australian or internationally recognised standards that define acceptable levels of noise and vibration in various human and structural contexts. Such standards can serve an advisory function to regulatory organisations and may be adopted by statutory authorities for the purpose of defining regulatory levels.

16.2.2 Noise impact assessment goals

Standard statutory construction noise regulations

State and Local Government noise policies and regulations do not specify noise limits for construction activity.

The *Environmental Protection Act 1994* (EP Act), Section 440R states the following for building works:

A person must not carry out building work in a way that makes an audible noise –

(a) on a business day or Saturday, before 6.30 am or after 6.30 pm; or

(b) on any other day, at any time.

Construction activity between the hours of 6.30 am to 6.30 pm Monday to Saturday, excluding public holidays, is not normally subject to numerical noise limits, other than those which apply to blasting, providing the machinery being used is in good working condition. The EP Act is summarised in **Table 16-2**.

Table 16-2 Standard noise regulations for construction activity

Day	Operating Constraint
Monday to Saturday	6.30 am – 6.30 pm – no numerical noise limits
Sunday, Public Holidays and all other times	Construction must be inaudible at noise sensitive locations

Construction of the Project would involve some instances where surface construction activity would be required to be undertaken on a 24 hour basis and that such activities would likely be audible outside of the regulated construction hours (for proposed hours of work, refer to **Chapter 24 Draft Outline EMP**).

Noise impact assessment goals – construction phase

The Project would involve the operation of some noise sources in worksites, eg temporary ventilation and spoil extraction to surface from tunnelling, on a 24 hour basis, 7 days per week over varying time periods, depending on the location and nature of construction works (for proposed hours of work, refer to **Chapter 24 Draft Outline EMP** and **Chapter 4 Project Description**).

To address the impacts of these construction noise sources upon the community values described in **Section 16.2.1**, numerical noise goals have been identified to limit or manage the adverse impacts on the community for both the day and night period. These noise goals may need to be exceeded at times in order to construct the Project, with occasional periods of higher noise levels. In those circumstances, arrangements would be made with the individuals and organizations affected to determine agreed appropriate mitigations to deal with these limited periods of higher noise levels.

There are no established noise criteria in Queensland for the assessment of impacts associated with long-term construction noise sources, especially at night. The potential impacts of long-term construction noise sources should be assessed by comparison with numerical noise goals for:

- **sleep disturbance** – criteria contained in Brisbane City Council's *Noise Impact Assessment Planning Scheme Policy (NIAPSP)* and Queensland DERM *EcoAccess Guideline Planning for Noise Control (EcoAccess PNC)*
- **building functions and uses** – recommended internal noise levels specified in *AS/NZS 2107: 2000 Acoustics – Recommended design sound levels and reverberation times for building interiors (AS 2107)*
- **environmental amenity** – comparison with the existing ambient background noise environment specified in *EcoAccess PNC*.

The specific noise goals for sleep disturbance, recommended noise levels for various building functions and comparison with existing ambient background noise levels are discussed in the following sections.

Sleep preservation

Recommended maximum internal noise levels in sleeping areas to avoid sleep disturbance (NIAPSP and EcoAccess PNC) are summarised in **Table 16-3**.

Table 16-3 Guidelines for avoidance of noise-induced sleep disturbance

Guideline	Recommended Maximum Internal L _{Amax}	Recommended Maximum Number Of Occurrences per Night
NIAPSP (Brisbane City Council) AS1055.2 Appendix A R1-R3 Categories AS1055.2 Appendix A R4-R6 Categories	45 dBA 50 dBA	"must not regularly exceed" "must not regularly exceed"
EcoAccess PNC (DERM)	"Approximately 45 dBA"	"no more than 10 to 15" events

With regard to the “R-category” descriptions in AS1055.2, R3 is described as “areas with medium density transportation or some commerce or industry” whereas R4 is described as “areas with dense transportation or with some commerce or industry” and R5 to R6 are described as “areas with very dense to extremely dense transportation or in commercial districts or bordering industrial districts within predominantly industrial districts”.

The NIAPSP approach to assessing sleep disturbance is proposed, as it includes some recognition that sleep disturbance is a function of the background noise level in addition to the level of the intrusive sound.

Acceptable levels of steady or near-steady (“quasi-steady”) noise for sleeping environments are recommended in Australian Standard AS 2107.

The applicable noise goals for the typically short term ground-borne noise from driven tunnelling (a week’s impact during the tunnel boring machine (TBM) passby) is the sleep disturbance criteria (in **Table 16-3**) and also the low frequency criteria according to the draft *EcoAccess Guideline Assessment of Low Frequency Noise* (EcoAccess ALFN).

Building functions and uses

The maximum recommended internal noise levels in AS 2107 are shown in **Table 16-4** for a selection of building uses that may be represented near construction works or tunnelling works.

Table 16-4 Guidelines for internal noise levels to maintain building functions and uses

Type of Building Occupancy		Recommended Internal Design Sound Level LAeq,adj(15 minute) (dBA)	
		Satisfactory	Maximum
Residential buildings (sleeping areas)	Near major roads ¹	30	40
	Near minor roads ²	30	35
Residential buildings (living areas)	Near major roads ¹	35	45
	Near minor roads ²	30	40
Hospitals	Wards	35	40
	Operating theatres, nurses stations consulting rooms and the like	40	45
Place of Worship (with speech amplification)		35	40
School music rooms		40	45
School teaching area		35	45
School library		40	50
School gymnasium		45	55
Commercial buildings – office space		40	45
Commercial Buildings – retail space		45	50

Source: Australian Standard AS 2107

Notes:

1. eg motorway and arterial roads, as per the Brisbane City Council City Plan.
2. eg suburban and district roads, as per the Brisbane City Council City Plan.

Due to the extended duration of construction works in some locations, the maximum design levels in **Table 16-4** are proposed as appropriate construction noise goals for steady state construction noise during the day-time period (6.30 am to 6.30 pm on Monday to Saturday) at these locations.

To assess non-steady state construction noise, the $LA_{10(15\text{minute})}$ parameter with a tolerance of 10 dB above the maximum design levels according to AS 2107 is proposed during the day-time period (6.30 am to 6.30 pm on Monday to Saturday). Non-steady state noise sources are commonly assessed according to the LA_{10} parameter to appropriately assess the louder periods in a fluctuating noise level. The LA_{Aeq} would average out the acoustic energy over the whole assessment period. Due to the non-steady state (or intermittent) nature of the noise source(s), an allowance of 10 dB above the steady-state noise sources is considered appropriate.

For night-time steady state construction noise, the maximum design levels according to AS 2107 are used as appropriate night-time noise goals.

Environmental amenity

The use of existing background noise levels for the assessment of noise impacts is a common impact assessment practice. The DERM EcoAccess PNC refer to the short term specific (intrusive) noise levels (SNL) criteria presented in **Table 16-5**.

Table 16-5 Intrusive ‘background plus’ noise criteria

Criterion	Noise Limit
Specific (Intrusive) Noise Levels (EcoAccess PNC)	$RBL^1 + 3 \text{ dBA } LA_{\text{Aeq}}(1\text{hour})$

Note:

1. Measured Rating Background Level LA_{90} according to DERM EcoAccess PNC. This is representative of the average minimum background noise level.

Adjustments are normally made to the source levels as per AS1055.1-1997, in order to account for the increased subjective loudness associated with noises that are particularly tonal or impulsive.

The DERM EcoAccess PNC is normally applicable for long-term industrial (operation) noise emissions during day time, evening and night-time assessed external to the dwelling. The purpose of this section is to propose applicable noise goals for assessment of long term construction noise emissions during extended work hours (night-time). During the night-time period, the primary objective would be to protect the internal noise amenity of surrounding residences. It is therefore proposed that the internal noise goals according to AS 2107 take precedence over the external noise goals.

Construction road traffic noise

Where the construction phase is adding heavy vehicles to the existing road network, it is appropriate to consider the incremental change in noise levels due to the changes in traffic volume.

A change of up to 3 dBA in the level of a dynamic noise, such as passing vehicles, is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

For assessment purposes, it is common to set the threshold of significance in relation to changes in noise emission levels from roads at 2 dBA. For the impact assessment of construction traffic noise, the noise goal in **Table 16-6** is proposed.

Table 16-6 Construction road traffic noise goal

Type of Road	Goal
Existing Road	$\leq 2 \text{ dBA change in existing } LA_{10} (1\text{hour}), LA_{10}(12\text{hour}) \text{ and } LA_{10} (18\text{hour})$

Summary of construction noise goals

A summary of the proposed noise goals at noise sensitive receivers for the assessment and subsequent management of noise associated with construction of the Project is shown in **Table 16-7**.

Table 16-7 Summary of construction noise goals

	Monday – Saturday 6.30 am – 6.30 pm (internal noise)	Monday – Saturday 6.30 pm – 10.00 pm (internal noise)	Monday – Saturday 10.00 pm – 6.30 am Sundays, Public Holidays (internal noise) ²	Low Frequency LpA,LF ³	Surface Track Works Queensland Rail CoP	Monday – Saturday 7.00 am 6.00 pm ¹ Blasting ¹ (airblast)	Construction Road Traffic
Continuous (LA eq adj)(1hr)	AS 2107 Maximum design level	AS 2107 Maximum design level	AS 1055.2 (App A) R1 – R3: 35dBA R4 – R6: 40dBA	25 dBA LpA, LF (Low frequency assessment in accordance with DERM EcoAccess ALFN)	87 dBA L _{Amax,adj} 65 dBA L _{Aeq,adj} (24hour)	130dB linear peak	≤ 2 dBA change in existing LA10(1hour), LA10(12hour) and LA10(18hour)
Intermittent (LA10 adj)(1hr) (LA Max)	AS 2107 Maximum design level +10dBA	AS 2107 Maximum design level +10dBA	AS 1055.2 (App A) R1 – R3: 45dBA R4 – R6: 50dBA				

Notes:

The adjustment (designated by the 'adj' subscript) is applied to tonal and/or impulsive characteristics of a noise and is intended to counteract any increase in the perceived subjective loudness of the noise resulting from the tonal or impulsive characteristics of the noise.

All noise levels for construction work, other than low frequency noise, surface track works, construction road traffic and blasting, are internal noise levels.

¹ Blasting is proposed to be undertaken only during the hours of 7.00 am to 6.00 pm, Monday to Saturdays

² Sleep disturbance in accordance with AS2107 and Brisbane City Council NIAPSP. Internal noise levels in bedroom.

³ Low frequency assessment in accordance with DERM EcoAccess Assessment of Low Frequency Noise (ALFN). The A-weighted 1/3rd octave band data for indoors is summed to yield the A-weighted noise level in the frequency range 10 Hz to 160 Hz. The resulting level is called LpA,LF.

Noise assessment goals – operation phase

Surface rail operation

The applicable noise criteria for the railway surface track airborne noise emissions are provided in Queensland Rail's *Code of Practice – Railway Noise Management 2007*. The Code of Practice has been endorsed by the Queensland Minister for Sustainability, Climate Change and Innovation. The operation “planning levels” from the Code of Practice relevant to the Project are:

- 65 dBA, evaluated as the 24 hour average equivalent continuous A-weighted sound pressure level, LAeq(24hour)
- 87 dBA, evaluated as a Single Event Maximum sound pressure level for surface track worksites.

The criteria refer to an assessment location one metre in front of the facade of an affected noise sensitive building.

Ground-borne noise – rail operations

In the absence of an Australian Standard specifically addressing ground-borne noise from railway operations, guidance has been taken from the literature:

- International Standard ISO 14837-1:2005(E) *Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1: General Guidance, First Edition 2005*
- American Public Transit Association (APTA), *Guidelines for Design of Rapid Transit Facilities, 1991*
- Federal Transit Administration (FTA), *United States Department of Transportation, Transit Noise and Vibration Impact Assessment, May 2006*
- The Association of Noise Consultants, *Measurements and Assessment of Groundborne Noise and Vibration, 2001*
- Harris Miller Miller and Hanson Inc., *Transit Noise and Vibration Impact Assessment, 1995 (a guideline prepared for the United States Department of Transportation)*
- Department of Environment and Climate Change (DECC) NSW, *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects (IGANRIP), April 2007.*

The ground-borne noise goals for residential receivers are based on the ground-borne noise trigger levels in the NSW interim guideline. This guideline recommends a ground-borne noise “trigger level” of L_{Amax} (slow) 35 dBA during the night-time period. At other sensitive receiver locations, ground-borne noise goals have been based on the interim guidelines (for educational facilities and places of worship) and confirmed by national and international experience on other underground railways.

The international standards and guidelines referenced take into account the intermittent nature and low frequencies characteristic of ground-borne noise generated by underground rail operations. These guidelines are proposed to the more general EcoAccess Draft Guideline ALFN, which does not address underground rail operations.

ISO 14837 provides guidance in relation to the prediction of ground-borne noise levels and factors that need to be considered in the prediction process. Acceptability criteria are not included in Part 1 of the ISO Standard, but are anticipated to be included as Part 4 (yet to be released).

Table 16-8 provides a summary of the proposed ground-borne noise goals for the Project derived from the referenced guidelines.

Table 16-8 Ground-borne noise goals (rail operations)

Receiver	Time of Day	Noise Trigger Level (dBA) ¹
Residential	Day (7.00 am to 10.00 pm)	40 dBA
	Night (10.00 pm to 7.00 am)	35 dBA
Schools, educational institutions, places of worship ²	When in use	40 dBA to 45 dBA
Retail Areas ³	When in use	50 dBA to 55 dBA
General Office Areas	When in use	45 dBA
Private Offices and Conference Rooms	When in use	40 dBA
Theatres	When in use	35 dBA

Notes:

1. Evaluated as the internal L_{Amax} "Slow" response noise level (interpreted as applicable to the 95th percentile train passby event ie typically the highest 1 in 20 event).
2. The lower value of the range is primarily applicable where low internal noise levels are expected, such as in areas assigned to studying, listening, quiet contemplation and praying.
3. The higher end of the range is applicable for larger department stores and supermarkets. The lower end of the range is applicable for small retail stores and speciality shops.

Mechanical plant and ventilation

The applicable statutory requirement for noise emissions associated with fixed mechanical plant is the EPP (Noise). The EPP (Noise) nominates long term acoustic quality objectives and a background creep criterion² applicable to stationary mechanical plant.

The background creep criteria according to the EPP (Noise) are identical to the background creep criteria according to Brisbane City Council's NIAPSP. The EcoAccess PNC includes more complex background noise criteria. In determining the appropriate background creep goals, the statutory and Brisbane City Council criteria have been proposed.

Relevant assessment criteria for operational mechanical plant noise can be found in the following:

- EPP (Noise)
 - Background Creep – Existing LA90 + 0 dBA
 - Acoustic Quality Objectives – Refer to Schedule 1 in EPP (Noise)
- EcoAccess PNC
 - Background Creep – Refer to Table 1 and Table 2 of EcoAccess PNC
 - Planning Noise Levels (PNL) – Refer to Table 3 and Table 4 of EcoAccess PNC
 - Specific (Intrusive) Noise Levels (SNL) – Existing Background (RBL) + 3 dBA (assessed as LAeq)
- Table 3 of the EcoAccess Draft Guideline Assessment of Low Frequency Noise (EcoAccess ALFN)

² The background creep criteria are specific criteria to prevent the background noise level from progressively increasing over time, due to the introduction of new noise sources, one after another, in an area.

- Brisbane City Council NIAPSP
 - Background Creep – Existing LA90 + 0 dBA (for noise categories R3 to R6 as per Appendix A of AS 1055.2)
 - Comparison of Like Parameters – Existing LA90 + 0 dBA
 - AS/NZS 2107: 2000 Acoustics – Recommended design sound levels and reverberation times for building interiors (Table 1).

Mechanical ventilation noise is generally steady state (ie the noise emission varies very little with time in the short term) and therefore the difference between the LA90 the LAeq will be small. As a result, based on the criteria discussed above, the LA90 based background creep criteria will be stricter than the LAeq based intrusive noise criterion. In determining the appropriate goal, a conservative approach has been adopted and thus only a background creep goal has been used.

The EcoAccess ALFN guideline provides for assessment of infrasound and low frequency noise. The mechanical ventilation noise associated with the Project is not anticipated to generate any infrasound or distinctly low frequency noise and therefore does not require a specific assessment.

The proposed noise goals for mechanical plant and ventilation are presented in **Table 16-9**.

Table 16-9 Operation mechanical plant noise goals

Receiver	Time of Day	Background (b/g) Noise Creep ¹ dBA LA90(1hour)	Acoustic Quality Objectives ² dBA LAeq(1hour)
Residential (for outdoors)	7.00 am to 10.00 pm	b/g + 0 ³	50 ³
	10.00 pm to 7.00 am	b/g + 0	–
Residential (for indoors)	7.00 am to 10.00 pm	–	35
	10.00 pm to 7.00 am	–	30
Library and educational institution (including a school, college and university) (for indoors)	when open for business or when classes are being offered	–	35
Commercial and retail activity (for indoors)	when the activity is open for business	–	45

Notes:

1. Background creep criteria in accordance with the EPP (Noise) and NIAPSP for continuous noise sources, adopting the Rating Background Level in accordance with the EcoAccess PNC. Applicable for noise contribution from the source only.
2. Long term acoustic quality objectives according to EPP (Noise)
3. The lower of the background creep LA90(1hour) and Acoustic Quality Objectives LAeq(1hour) is applicable.

Road traffic noise

The Project will require the realignment of a few nearby sections of roadway. Road traffic noise emissions from realigned road sections within the study corridor have been assessed against the planning noise levels outlined in the TMR CoP – *Road Traffic Noise Management 2007*. The relevant planning noise levels for the realigned road sections is that of Category 2 Upgrading Existing Roads, of the TMR CoP, as shown in **Table 16-10**.

Table 16-10 TMR Code of Practice – Road noise goal for existing residences

Description	Noise Description	Goal
Category 2 Upgrading Existing Roads	LA10(18hour) ¹ - external	68 dBA

Note:

1. Arithmetic average of the 18-hourly LA10 levels over the consecutive hours from 6.00 am to midnight.

The external assessment location (for existing residences) is 1 m from the most exposed facade of the “noise sensitive” building and 0.5 m below the surveyed eaves height of the “noise sensitive” building.

16.2.3 Vibration impact assessment goals

With a sufficiently high vibration level, potential adverse effects of vibration in buildings generated by construction activities can be categorised as follows:

- human comfort
- effects on building contents
- safe levels for common services
- structural damage.

Vibration criteria are also differentiated between short transient vibrations, such as those induced by blasting (of the order of one to two seconds), and more sustained vibrations such as those associated with tunnel boring, roadheading or rockhammering. The risk of human discomfort is generally lower for short duration vibrations. The risk of cosmetic building damage is also lower for short duration vibrations compared to continuous vibrations of the same magnitude. This is because short duration vibrations would be less likely to fully ‘excite’ resonant vibration responses in a building structure.

Human comfort

Humans are sensitive to vibration than is commonly understood. People can detect and possibly even be annoyed by 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, in itself, 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.

The degrees of human perception of vibration suggested by the continuous vibration level categories given in **Table 16-11** are derived from German Standard *DIN 4150 Part 2 1975*.

Table 16-11 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 frequency content in the range of 8 Hz to 80 Hz.

Table 16-11 suggests that people would just be able to feel continuous floor vibration at levels of about 0.15 mm/s and that the motion becomes “noticeable” at a level of approximately 1 mm/s.

Vibration goals for human comfort

Guidance in relation to assessing the potential human disturbance from ground-borne vibration inside buildings and structures is contained in Australian Standard AS 2670.2-1990 *Evaluation of Human Exposure to whole-body vibration Part 2 Continuous and shock induced vibrations in buildings (1 Hz to 80 Hz)*.

According to AS 2670.2, levels of peak vibration velocity below which the probability of “adverse comment” from people is low are shown in **Table 16-12** (for generally sinusoidal vibration³).

Table 16-12 Satisfactory level or peak vibration velocity (8 Hz to 80 Hz)

Type of Space Occupancy	Time of Day	Satisfactory Peak Vibration Levels in mm/s Over the Frequency Range 8 Hz to 80 Hz			
		Continuous or Intermittent Vibration		Transient Vibration Excitation with Several Occurrences per Day	
		Vertical	Horizontal	Vertical	Horizontal
Critical working areas (eg some hospital operating theatres, some precision laboratories, etc)	Day Night	0.14	0.4	0.14	0.4
Residential	Day	0.3 to 0.6	0.8 to 1.5	0.4 to 13	13 to 36
	Night	0.2	0.6	0.2 to 3	0.6 to 8.4
Offices	Day	0.6	1.7	8 to 18	24 to 52
	Night				

As can be seen from the last two columns of **Table 16-12**, vibration magnitudes above those generally corresponding to a low probability of reaction can be tolerated, particularly for temporary or intermittent events such as blasting. With effective consultation, experience suggests occupants of potentially affected properties, could often tolerate higher levels of short-term vibration. In many instances there is a trade-off between the magnitude and duration of construction-related vibration, eg rockbreaking versus blasting, with some people preferring shorter periods of more intense activity.

There is no definitive level of vibration that would disturb sleep at night, as people’s perceptions vary. Furthermore, there is not a significant body of research that specifically investigates this issue. In practice, vibration in buildings that disturbs sleep is often perceived as structure-borne regenerated noise, that is, noise generated by rattling objects or through visual cues such as movement of wall hangings, rather than through tactile perception only.

A guide level of 0.5 mm/s (peak) has been used as a threshold of vibration that may disturb sleep for some people, so as to identify geographical areas where specific mitigation measures may be required. Some people may be comfortable with much higher levels of night vibration than the guide level, depending on their understanding of the causes of vibration and the likely (or unlikely) effects, and their awareness of the Project construction methods and timeframe.

³ A sinusoidal vibration is a smooth, cyclical variance in the vibration pattern.

The guide level is based on consideration of vibration levels commonly associated with the on-set of movement and rattling of building contents, vibration guide values based on human perception nominated in AS2670-1990, and the qualitative perception scale for continuous vibration outlined in German Standard *DIN 4150 Part 2-1975*.

Effects of vibration on building contents

Over the frequency range typical of vibration in buildings from construction and excavation activities, industrial vibration, road and rail traffic (approximately 8 Hz to possibly 100 Hz), the likely thresholds for a range of common experiences are:

- visible movement of susceptible building contents ie plants, hanging pictures, blinds, etc – approximately 0.5 mm/s
- windows rattling in some buildings – less than 0.9 mm/s, if combined with sound pressure waves
- audible rattling of loose objects ie crockery – generally 0.9 mm/s
- day-to-day activities eg footfalls, doors closing, etc – generally above 1 mm/s and sometimes by considerable margins.

Potentially vibration-susceptible building contents include sensitive instrumentation, computers and other electronic equipment. Apart from robust personal computers, such items are not usually kept in residences. Typical maximum floor vibration levels for satisfactory operation of such sensitive items are:

- 0.5 mm/s to 2 mm/s – precision balances and some optical microscopes
- 1 mm/s to 5 mm/s – large computer disk drives and sensitive electronic instrumentation.

Very short duration vibration events, for example vibration from infrequent impulsive vibration, could be permitted at higher levels, depending on vibration frequency, the susceptibility of particular objects and their location.

A Transmission Electron Microscope (TEM) is understood to be located in the basement of the Ecosciences Precinct at Boggo Road. A technical paper received from the tenant for this specific TEM (JEOL type JEM-1400) has provided a vibration deflection tolerance and vibration velocity criteria, based on evenly distributed vibration energy within each of the specified frequency ranges.

Safe vibration levels for common services

Vibration due to construction has the potential to effect services such as buried pipes, electrical and telecommunication cables.

German Standard DIN 4150-3 1999 *Structural Vibration – Part 3: Effects of vibration on structures* provides guidance on safe vibration levels for buried pipe work. The levels assume “current technology” as special considerations must be applied for systems associated with older structures such as might occur in the vicinity of heritage-listed buildings.

Table 16-13 details the DIN 4150-3 limits for short-term vibration. The levels apply at the wall of the pipe. For long-term vibration, the guideline levels presented in **Table 16-13** should be halved.

Table 16-13 DIN 4150 Part 3 – Damage to buried pipes – guidelines for short-term vibration

Pipe Material	Peak Wall Vibration Velocity
Steel (including welded pipes)	100 mm/s
Clay, concrete, reinforced concrete, prestressed concrete, metal with or without flange (other than steel)	80 mm/s
Masonry, plastic	50 mm/s

Note:

For gas and water supply pipes within 2 m of buildings, the levels given in Table 16-14 should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

Recommended vibration goals for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s.

Although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not. Should such equipment be encountered during construction, an individual vibration assessment should be carried out.

Building damage

For vibration-related structural damage, British Standard 7385: Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* is a definitive standard against which the likelihood of building damage from ground vibration can be assessed.

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. Sources of vibration addressed in the standard include blasting, demolition, piling, ground treatments (ie compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The guide values from this standard for transient vibration likely to result in a minimal risk of cosmetic damage to residential buildings and industrial buildings are presented numerically in **Table 16-14**.

Table 16-14 BS 7385 – Transient vibration guide values for cosmetic damage

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	
Non-reinforced or light framed structures 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

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for some building types are reduced. Generally, the guide values in **Table 16-14** should not be reduced for fatigue considerations. As the guide values in **Table 16-14** relate predominantly to transient vibration, a reduction of up to 50% may be required for continuous vibration, especially at lower frequencies where lower guide values apply. This would apply particularly to historic buildings⁴.

⁴ Historic buildings in the UK would be significantly older than those in the Project study corridor and are likely to be constructed of different materials and to different designs.

The TMR *Technical Standard MRTS51* (TMR 2009), provides ground vibration limits as presented in **Table 16-15**.

Table 16-15 Ground vibration criteria for construction activities – MRTS51

Type of Receptor	Ground Vibration, mm/s PPV ¹
Historical buildings, monuments and buildings of special value or significance.	2 mm/s PPV
Houses and low rise residential buildings, commercial buildings not included below	5 mm/s PPV
Commercial and industrial buildings or structures of reinforced concrete or steel construction including bridges.	5 mm/s PPV

Note:

1. Peak Particle Velocity (PPV)

Based on the above discussion, a structural damage criterion of 5 mm/s PPV is proposed.

Vibrations from blasting

Vibration criteria for blasting events can be found in the EP Act, EcoAccess Noise and Vibration from Blasting (EcoAccess Blasting) and TMR Technical Standard MRTS51. The blasting vibration criteria are summarised in **Table 16-16**.

Table 16-16 Blasting vibration criteria – construction

Reference	Ground Vibration, mm/s PPV ¹
EP Act	25 mm/s PPV (> 35 Hz)
	10 mm/s PPV (≤ 35 Hz)
EcoAccess Blasting	5 mm/s PPV for 9 out of any 10 consecutive blasts
	not exceed 10 mm/s PPV for any blast
TMR MRTS51	2 mm/s PPV (Historical buildings, monuments and buildings of special value)
	10 mm/s PPV (Houses and low rise residential buildings, commercial buildings not included below)
	25 mm/s PPV (Commercial and industrial buildings or structures of reinforced concrete or steel construction including bridges)

Note:

1. Peak Particle Velocity (PPV)

The EcoAccess Blasting guideline advises that blasting should generally only be permitted during the hours 9.00 am to 3.00 pm, Monday to Friday, and from 9.00 am to 1.00 pm on Saturdays. Blasting should not generally take place on Sunday or public holidays. Limiting blasting to these hours is impractical for the Project due to the variable land use and activity patterns along the study corridor. The principle of limiting the hours of blasting to the “least sensitive” times of the day, however, is relevant. Therefore, blasting is proposed to be limited between 7.00 am and 6.00 pm Monday to Saturday, ie “day-time”, as defined in the EcoAccess guidelines.

For the impact assessment of airblast overpressure from blasting, it is proposed not to exceed 130 dB linear peak.

Vibration assessment criteria – operation phase

There are several sources from which relevant vibration criteria may be drawn. These include:

- Australian Standard AS 2670.2 1990 *Evaluation of Human Exposure to Whole Body Vibration – Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*
- The United States Federal Transit Administration (FTA) Guideline *Transit Noise and Vibration Impact Assessment*, May 2006
- British Standard BS 6472-1992 *Evaluation of Human Exposure Vibration in Buildings (1 Hz to 80 Hz)*
- Department of Environment and Conservation NSW, document *Assessing Vibration: a technical guideline*, February 2006.

The vibration goals have been expressed both in terms of vibration velocity (mm/s) and decibels (dBV ref 10^{-9} m/s). A level of 100 dBV corresponds to 0.1 mm/s (rms) and a level of 120 dBV corresponds to 1 mm/s (rms).

Based on the above references, the proposed vibration goals for the operations phase of the Project are listed in **Table 16-17**. For assessment purposes, these goals may be regarded as applicable to the maximum one second rms vibration level, not to be exceeded by more than 5% of train passbys.

Table 16-17 Ground-borne vibration goals – operation

Receiver Type	Period	Vibration Goal ^{1, 2} (Vibration Velocity)
Residential	Day/Night	106 dBV (0.2 mm/s)
Commercial (including schools and places of worship)	When in use	112 dBV (0.4 mm/s)
Industrial	When in use	118 dBV (0.8 mm/s)
Sensitive equipment within medical or research facilities	When in use	82 dBV (0.013 mm/s) ³

Notes:

1. The vibration goals are based on the maximum 1 second rms vibration level, not to be exceeded by more than 5% of train passbys
2. dBV ref 10^{-9} m/s
3. Unless actual equipment manufacturer data are available

In the case of railway tunnels, the ground-borne noise goals almost always dictate lower vibration emission levels than the ground-borne vibration goals indicated in **Table 16-17**. Hence, other than at specific facilities with equipment which is particularly highly sensitive to vibration, compliance with the ground-borne noise goals (refer to **Table 16-8**) ensures that the vibration goals would also be achieved.

16.3 Description of existing environment

This section describes the existing noise and vibration conditions within the study corridor.

16.3.1 Noise monitoring

To obtain a representative sample of the acoustic conditions along the study corridor, external noise monitoring was conducted at twenty residential and special use (eg educational or medical) locations adjacent to the rail corridor. Both operator attended and unattended noise measurements were conducted in order to characterise the existing noise environment. The monitoring method was consistent with DERM's EcoAccess PNC.

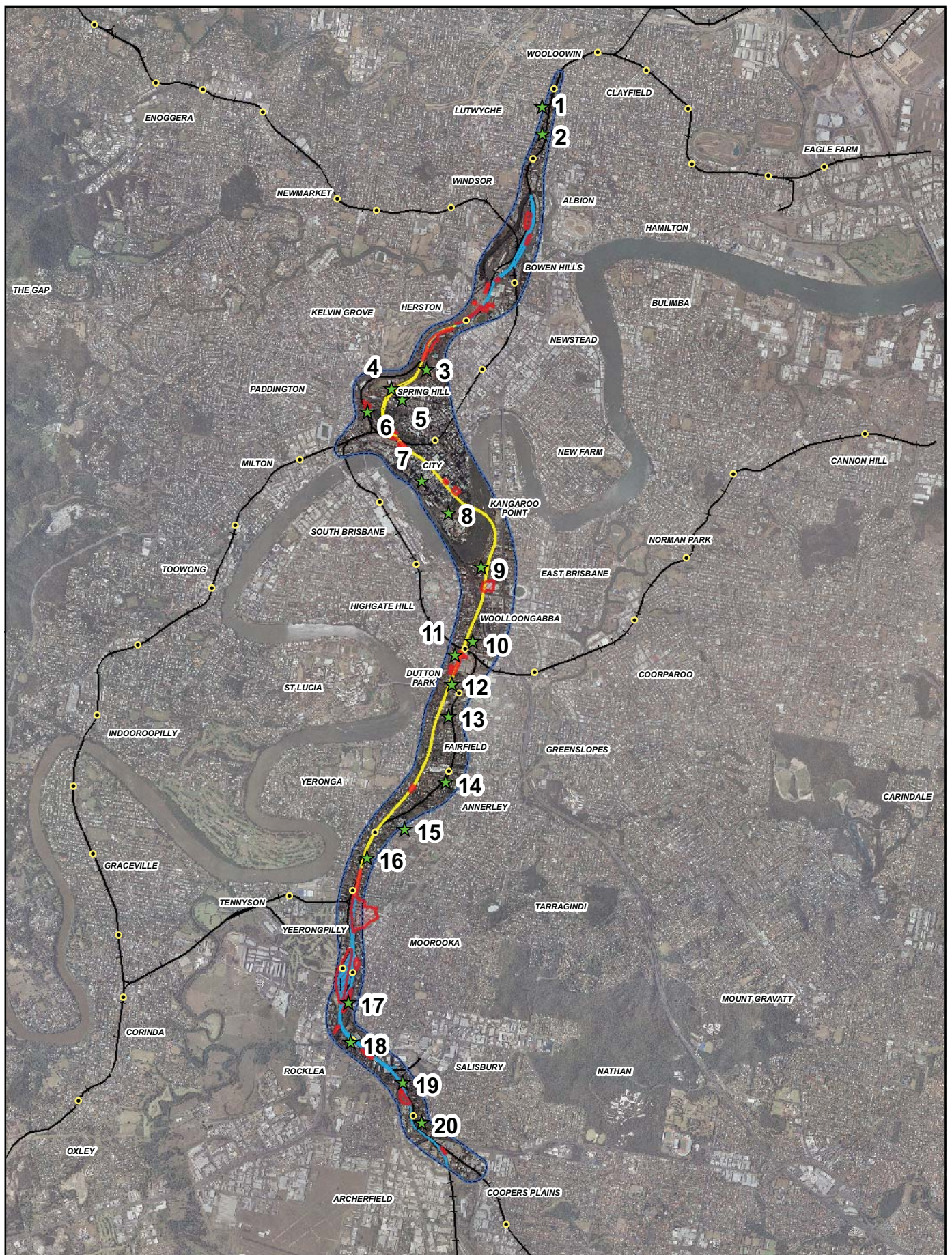
The unattended ambient noise measurements were recorded to determine the Rating Background Levels (RBL) for the day-time (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods at each location. The median of the 90th percentile background (LA90) noise levels is reported for each period (day, evening and night) over the duration of the monitoring as defined in the EcoAccess PNC. **Table 16-18** presents the determined RBL for each measurement location. Monitoring locations are shown on **Figure 16-4**.

Table 16-18 Measured rating background levels

Monitoring Location	Location Relative to Key Project Features	Background Levels LA90 (dBA) (external)		
		Day	Evening	Night
1. 1/19 Chalk Street, Woolloowin	Surface rail tracks	54	45	38
2. 28 Bridge Street, Albion	Surface rail tracks	49	45	38
3. St Josephs College, Gregory Terrace	Road header tunnel, near northern portal	50	48	40
4. Brisbane Girls Grammar, Gregory Terrace	TBM tunnel	61	60 ³	46
5. St Andrew War Memorial Hospital, Spring Hill	TBM tunnel	55	53	51
6. Parkland Crescent	Roma Street Station	54	50	47
7. 191 George Street	Albert Street Station	58	57 ³	54
8. Queensland University of Technology, Gardens Point	Albert Street Station	49	48	46
9. 58 Leopard Street, Woolloongabba	Woolloongabba Station	53	50	46
10. 143 Park Road, Woolloongabba	Woolloongabba Station	43	39 ¹	34
11. Dutton Park State School, Dutton Park	Boggo Road Station	44	40	35
12. 19 Dutton Street, Dutton Park	Boggo Road Station	43	42	37
13. 4 Fenton Street, Fairfield	TBM tunnel	39	38	34
14. 17 Lagonda Street, Annerley	Near existing Fairfield Station	42	41	39
15. Yeronga State High School	TBM tunnel	43 ²	41 ²	36 ²
16. 3 Cardross Street, Yeronga	Southern portal	42	37	33
17. 1223 Ipswich Motorway	Ipswich Motorway on-ramp	53	48	46
18. 2/59 Brook Street	Rocklea Station	50	43	42
19. Nyanda State High School, Salisbury	Surface rail tracks Salisbury Rail Station	54	50	46
20. 14 Bellevue Avenue	Surface rail tracks	45	45	44

Notes:

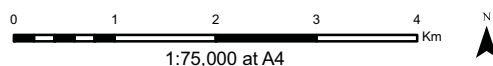
1. Has been adjusted for elevated noise levels due to insect noise
2. Background noise level representative of only one day of noise data, due to vandalism of the noise logger
3. Background noise levels reaching or exceeding construction noise goals



- LEGEND**
- Study Corridor
 - Station
 - Track
 - ★ Noise Monitoring Locations
- Project Alignment**
- Above Ground
 - Underground
 - Construction Worksite

CROSS RIVER RAIL ENVIRONMENTAL IMPACT STATEMENT

Figure 16-4
Overview of
Noise Monitoring Locations



CrossRiverRail

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There would be periods during the year when ambient and background noise levels along the study corridor could be higher than those shown in **Table 16-18** due to the presence of insect noise.

Brisbane Girls Grammar School has high ambient noise levels and is representative of a location close to a transport corridor (Inner City Bypass, Exhibition railway) with no existing noise barriers. High noise levels have also been monitored at St Andrew Hospital and 191 George Street. These are representative of typical inner city locations with high density road traffic, pedestrian activity and nearby mechanical noise.

Compared with these inner city locations, monitoring between Fairfield and Yeerongpilly showed lower ambient noise levels and are representative of suburban settings. For most locations in the study corridor, including monitoring locations distant to major roads, road traffic noise still dominates background noise levels. Monitoring locations near major connector roads show higher ambient noise levels.

Typically, the noise level difference outside a dwelling to inside a habitable room is a nominal 10 dBA for older type dwellings that rely predominantly on natural ventilation through windows, and 20 dBA for modern residential apartments with close-fitting sliding windows that would normally be equipped with air conditioning.

The measured ambient noise levels have been used to inform the development of noise goals for the impact assessment. The façade adjustment methodology applied to the Project is described in **Section 16.4.1**.

16.3.2 Vibration monitoring

Vibration goals and impacts have been assessed based on absolute criteria. Nonetheless, measurement of the existing ambient vibration levels along the study corridor were monitored to compare with potential vibration levels during construction. Ambient vibration monitoring was conducted at eleven residential and special use (for example educational/ research or medical facilities) locations along the study corridor.

The unattended ambient vibration measurements were used to determine the Average Minimum Background Level (V90), Average Maximum Level (V10) and Maximum Level (V1) for the day-time (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods at each location. Vibration measurements are expressed as peak particle velocities (PPV in mm/s).

Table 16-19 contains the determined vibration levels for each measurement location. Vibration monitoring locations are shown on **Figure 16-5**.

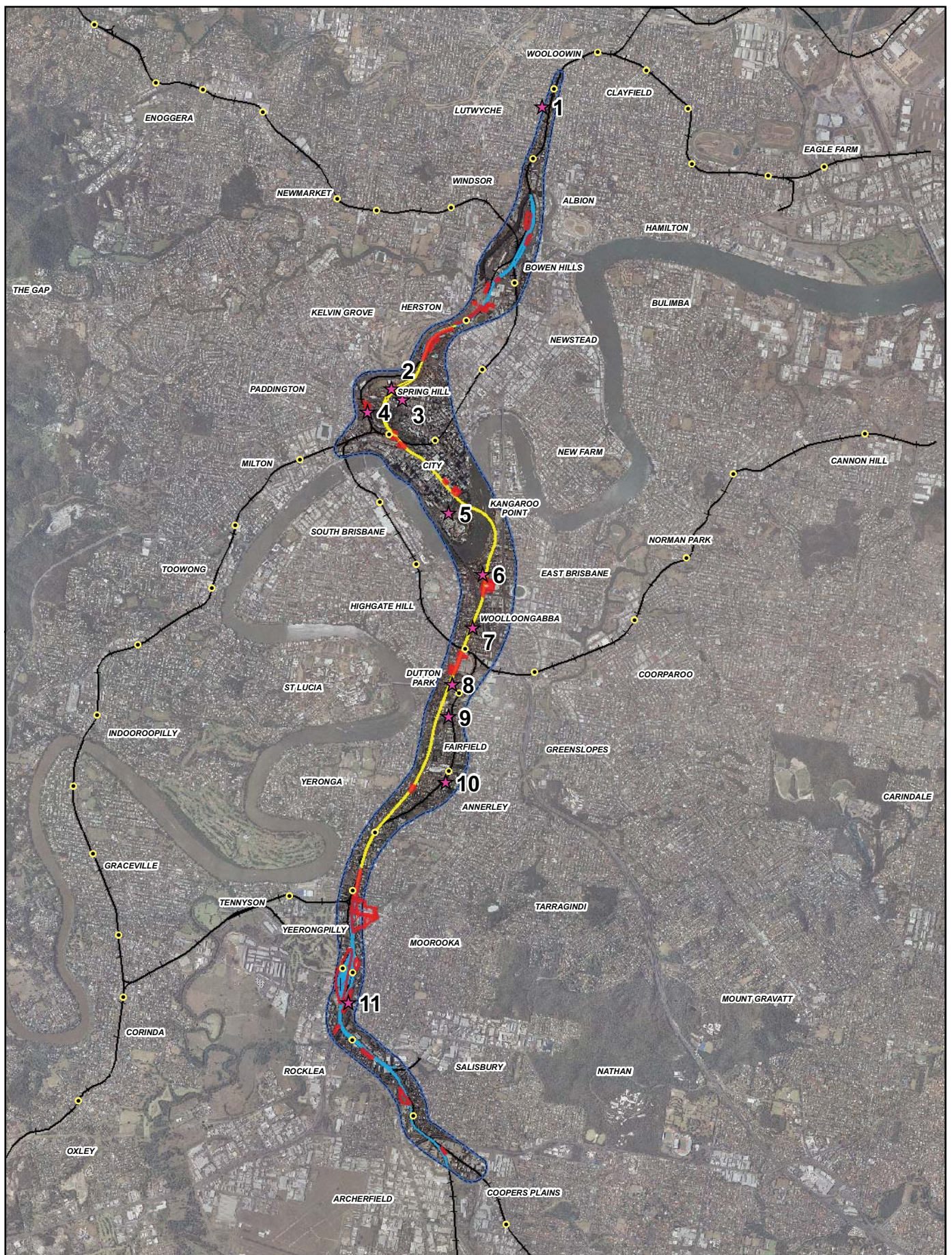
Table 16-19 Measured existing ambient vibration

Monitoring Location	Location relative to key Project features	Nature of Environment Monitored	Average Minimum Background Vibration V90 (mm/s) ¹			Average Maximum Vibration V10 (mm/s) ²			Maximum Vibration V1 (mm/s) ³		
			Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
1. 19 Chalk Street, Woolloowin	Surface rail tracks	Living room on first floor, wooden floor	0.07	0.04	0.02	0.66	0.20	0.14	2.31	0.82	0.49
2. Brisbane Girls Grammar School	TBM tunnel	Ground level in science laboratory preparation room	0.04	0.04	0.04	0.05	0.05	0.05	0.08	0.05	0.05
3. St Andrews War Memorial Hospital, Spring Hill	TBM tunnel	Level 2 next to room with vibration sensitive equipment (MRI system)	0.03	0.03	0.02	0.08	0.05	0.04	0.17	0.08	0.06
4. 3 Parkland Crescent	Roma Street Station	Small office	0.04	0.04	0.03	0.06	0.05	0.04	0.07	0.07	0.06
5. Queensland University of Technology (QUT), City Centre	Albert Street Station	Ground level next to vibration sensitive equipment (electron microscope)	0.02	-	-	0.02	-	-	0.03	-	-
6. 58 Leopard Street, Kangaroo Point	Woolloongabba Station	Ground floor of Queenslander	0.01	0.01	0.01	0.04	0.14	0.02	0.16	0.57	0.16
7. 46 Ross Street, Woolloongabba	TBM tunnel	First floor on wooden floor	0.04	0.04	0.04	0.06	0.10	0.05	0.19	0.49	0.10
8. 19 Dutton Street, Dutton Park	Boggo Road Station	Under staircase on ground floor	0.03	0.03	0.03	0.04	0.04	0.03	0.31	0.04	0.04
9. 4 Fenton Street, Fairfield	TBM tunnel	First floor, wooden floor	0.04	0.06	0.04	0.70	0.84	0.23	2.69	1.61	0.71

Monitoring Location	Location relative to key Project features	Nature of Environment Monitored	Average Minimum Background Vibration V90 (mm/s) ¹			Average Maximum Vibration V10 (mm/s) ²			Maximum Vibration V1 (mm/s) ³		
			Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
10. 17 Lagonda Street, Fairfield	Near existing Fairfield Rail Station	Bedroom on ground floor, polished concrete floor	0.04	0.04	0.04	0.05	0.05	0.04	0.11	0.08	0.13
11. 1223 Ipswich Motorway, Rocklea	Ipswich Motorway on-ramp	First floor. Linoleum matt on wooden floor	0.10	0.04	0.03	0.30	0.22	0.21	1.50	0.50	0.35

Notes:

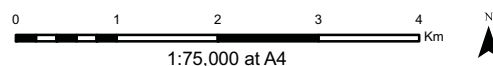
1. The V90 is the vibration velocity exceeded for 90% of a given measurement period and is representative of the average minimum background vibration.
2. The V10 is the vibration velocity exceeded for 10% of a given measurement period and is utilised normally to characterise average maximum vibration.
3. The V1 is the vibration velocity exceeded for 1% of a given measurement period. This parameter is sometimes used to represent the maximum vibration in a given period. The absolute maximum Peak Particle Velocity can be higher than V1.



- LEGEND**
- Study Corridor
 - Station
 - Track
 - ★ Vibration Monitoring Locations
- Project Alignment**
- Above Ground
 - Underground
 - Construction Worksite

CROSS RIVER RAIL ENVIRONMENTAL IMPACT STATEMENT

**Figure 16-5
Overview of
Vibration Monitoring Locations**



CrossRiverRail

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The background vibration level (V90) varies between 0.01 mm/s to 0.1 mm/s during day-time and evening. During the night-time, the background vibration level (V90) varies between 0.01 mm/s to 0.04 mm/s. Maximum vibration levels (V1) for the residential monitoring locations were in the range of 0.11 mm/s to 2.69 mm/s during day-time and evening. During night-time, maximum vibration levels (V1) of 0.04 mm/s to 0.71 mm/s were measured.

High vibration levels were monitored at locations 1, 9 and 11 which are on wooden floors in residential dwellings. This shows that normal activities (eg closing doors, drawers and cupboards, walking, moving and sitting on furniture etc) in these residential dwellings with light-weight (wooden) floors generate vibration levels significantly above the vibration goals presented in **Section 16.2.3**.

For receivers with vibration sensitive equipment (location 3 – St Andrews War Memorial Hospital, Spring Hill and location 5 – QUT, City Centre), background vibration levels (V90) of 0.02 mm/s to 0.03 mm/s and maximum vibration levels (V1) of 0.03 mm/s to 0.17 mm/s, were measured. Vibration sensitive equipment such as electron microscopes typically have vibration criteria of around 0.01 mm/s to 0.02 mm/s. The measured vibration levels are low compared to threshold of perception, however the levels are in the expected range for foundations supporting vibration sensitive equipment.

16.4 Construction impact assessment and mitigation measures

16.4.1 Introduction

This section provides an overview of the Project's construction elements that are relevant to noise and vibration. It outlines the potential noise and vibration levels that would be generated by the Project during construction and outlines mitigation measures to avoid or minimise potential impacts.

In order to quantify noise emissions from construction, a three-dimensional computer noise model was prepared for the major worksites. This was undertaken using the CONCAWE industrial noise algorithm as implemented in SoundPLAN acoustic modelling software. The output from the SoundPLAN noise model is a predicted noise level external to the receiver building of interest. In order to compare the relevant internal noise criteria with the external predicted noise levels, the internal criteria were adjusted (ie increased) to an external free-field level. The adjustment was determined by the type of facade through which noise transmission would occur. For the Project, the façade adjustment methodology applied was consistent with the methodology contained in EcoAccess PNC including:

- for residential type receivers, a +10 dBA inside to outside adjustment for windows partially open (7 dBA in the free-field)
- for commercial type receivers, a +20 dBA inside to outside adjustment for single glazed closed windows (17 dBA in the free-field).

For the worksites, there are negligible existing barriers between the worksite and noise sensitive receivers. Therefore, it is anticipated that the construction of minor noise barriers to fully enclosed structures would result in the following reductions in noise levels:

- minor noise barrier (acoustic hoarding indicative height 3 m) 5 dBA to 10 dBA reduction
- major noise barrier (acoustic hoarding indicative height 6 m) 10 dBA to 15 dBA reduction
- acoustic enclosure 15 dBA to 25 dBA reduction (based on the medium performance transmission loss data).

Correctly designed and constructed barriers (of solid construction using appropriate materials, such as 25 mm timber without gaps) would be expected to result in reductions at the upper end of the range provided. For the calculations at nearby receivers 'mid-range' noise reductions of 8 dBA, 13 dBA and 20 dBA have been assumed for the minor, major barriers and acoustic enclosure respectively.

The effective noise reductions that would be achieved by alternative enclosure designs are summarised in **Table 16-20**. These estimates account for the spectral characteristics of noise sources, enclosure constructions and internal reverberant characteristics.

Table 16-20 Effective noise reductions achieved by an acoustic enclosure

Plant Type	Effective Noise Reduction (dBA)		
	1 – Low Performance Enclosure	2 – Medium Performance Enclosure	3 – High Performance Enclosure
Air compressor	0	7	18
Diesel powered mobile plant	4	12	24
Electric conveyor drive	7	16	28
Rock drill	4	12	23

The indicative acoustic enclosure construction would consist of metal cladding with internal insulation faced with sisalation⁵ on the walls and roof. Where increased noise insulation is required, this can be achieved by upgrading the enclosure elements by using for example, double skins with infill similar to that used on Airport Link.

16.4.2 Noise and vibration data

Machinery noise – tunnelling worksites

A wide range of mechanical plant items are anticipated to be utilised during the construction phase. Typical items of plant have been selected based on observations of similar tunnelling activities at existing worksites in the Brisbane region and on indicative sizing of materials handling equipment that would be required to transport the spoil at the anticipated rates of tunnel excavation. Indicative source sound power levels have been obtained from *AS 2436:2010 Guide to noise and vibration control on construction, demolition and maintenance sites*.

Further details on the selected plant items, including the number of plant required at each worksite and indicative sound power levels is provided in *Technical Report No.8 – Noise and Vibration*.

Machinery noise – surface track worksites

Noise from the surface track construction works will generally depend upon the number of plant items and equipment operating at any one time and on their precise location relative to noise sensitive receivers. A receiver will therefore experience a range of values representing “minimum” and “maximum” construction noise emissions depending upon:

- the location of the particular construction activity ie if the plant of interest were as close as possible or further away from the receiver of interest
- the likelihood of the various items of equipment of interest operating simultaneously.

While noise from diesel-powered mobile plant will generally form the major part of noise emissions during construction, the highest noise levels are expected to occur during the use of specialised track laying plant eg ballast regulator, tamper.

⁵ Sisalation is a reinforced aluminium foil insulation material, made from a lamination of aluminium foil, Kraft paper, reinforced synthetic fibre and polyethylene.

Typical items of surface track construction plant have been selected based on typical Queensland Rail track construction and maintenance plant. *Technical Report No.8 – Noise and Vibration* provides a summary of the plant items, together with indicative sound power levels.

Acoustic properties and enclosure materials

Acoustic enclosures can be built around construction activities in order to reduce noise. The effectiveness of an acoustic enclosure can be significantly improved by adding an acoustically absorptive internal lining, or by using a double layer construction for walls and ceiling elements. Plant emissions that are dominated by high frequency noises, such as rockbreaking, would benefit most from an acoustic enclosure.

The effective noise reductions that would be achieved by alternative enclosure designs are examined in *Technical Report No.8 – Noise and Vibration*.

Indicative effectiveness of noise barriers

The effectiveness of noise barriers typically ranges from 5 dBA if line-of-sight between the noise source and receiver location is just obscured, up to around 15 dBA where the barrier provides optimal blocking of the sound transmission path.

The effective height of noise sources will vary depending on the type of machinery in use and the exhaust height. For a pile-boring rig as an example, this height may be typically 3 m to 4 m. For a frontend loader or excavator, the effective source height may be typically in the range of 2 m to 3 m.

Technical Report No.8 – Noise and Vibration provides further details on worksite barriers.

Vibration – drill and blast

Vibration levels from blasting do not represent a constant vibration source. To a greater degree than mechanical excavation methods, the design of a blast can be controlled to ensure that vibration levels remain within specified bounds. The extraction rate of advance is therefore dependent on the size and design of blasts.

Indicative blast vibration levels associated with tunnelling have been sourced from measurements carried out during the trial blasting for Brisbane Rail Tunnel Duplication (Heggies Q02-R1, 1990). These trials were conducted at the Creek Street tunnel portals that were excavated in hard rock. A second estimate of blast vibration levels has been obtained from the *ICI Explosives Blasting Guide* (ICI Explosives, 1995) for tunnel blasts.

In recent years, Penetrating Cone Fracture (PCF) blasting technology has been developed for rock excavation where vibration (and/or airblast) constraints are critical. In suitable rock formations, the more efficient fracture mechanism employed by PCF allows vibration levels to be approximately half that of conventional explosives for the same volume of broken rock. The PCF technique also dramatically reduces flyrock issues and airblast. PCF may therefore have advantages where blasting is required close to the surface, eg excavation of tunnelling access shafts at worksites, as well as for tunnel blasting beneath sensitive areas.

Further details on drilling and blasting are provided in *Technical Report No.8 – Noise and Vibration*.

Vibration – mechanical tunnel excavation

The two single track tunnels for the Project would be constructed by TBM. The TBMs for the Project tunnels are approximately 7 m in diameter. These TBMs are significantly smaller in diameter than those previously employed in Brisbane for the road tunnels. Due to a smaller drilling surface, the Project TBMs are predicted to generate less ground-borne vibration and noise (compared to the road tunnel TBMs).

Measurements of ground-borne vibration from TBMs and roadheaders during the construction of Clem Jones tunnel have been used to verify the source levels used for the EIS's of the previous road tunnels in Brisbane (which were based on international data). The measurements showed lower ground-borne vibration levels than previously predicted for the TBMs and higher for the roadheaders. It was also found that the ground-borne noise levels at the Government Land Centre Building with footings constructed directly into the bedrock had approximately 5 dBA higher ground-borne noise levels than expected. The ground-borne noise and vibration predictions have therefore been updated to include a 5 dB increase where the buildings are likely to have footings connected directly into the bedrock (ie all buildings within the CBD and some large buildings outside the CBD).

It has been assumed that the ground-borne noise and vibration from the TBM is related to the surface area of the TBM drill head. This means that the smaller (7 m diameter) TBMs generate approximately 4.7 dB less ground-borne noise and vibration.

The likely ground-borne vibration levels for the Project TBMs are presented in *Technical Report No.8 – Noise and Vibration*.

The frequency content of the ground-borne vibration associated with TBMs, roadheaders, rockbreaking and blasting is normally concentrated below 100 Hz.

Ground-borne noise – mechanical tunnel excavation

Ground-borne noise refers to noise that is first transmitted to the ground by machinery as vibration which then travels to a sensitive location (such as a house) through the ground and foundations, where the walls, floor and ceiling then radiate this vibration as audible noise.

Measurements of ground-borne noise from TBMs during the construction of Clem Jones tunnel have been used to verify the source levels used for the EIS's of previous road tunnels in Brisbane (which were based on international data).

As discussed above, the Clem Jones tunnel measurements resulted in a 5 dB increase for buildings that are likely to have footings connected directly into the bedrock (ie all buildings within the CBD and some large buildings outside the CBD). Ground-borne noise levels from the road tunnel EIS's for typical residential properties (not founded in the bedrock) have been maintained for TBMs, roadheaders and rockbreakers for the Project.

Also as discussed above, it has been assumed that the ground-borne noise from the smaller (7 m diameter) TBMs generate approximately 4.7 dBA less ground-borne noise compared to the (12 m diameter) TBMs used for the previous road tunnels in Brisbane.

Further details of ground-borne noise levels anticipated from mechanical tunnel excavation methods are presented in *Technical Report No.8 – Noise and Vibration*.

16.4.3 Worksite descriptions

The locations of the major Project worksites shown in **Figure 16-6** are located at Victoria Park (northern portal), Roma Street Station, Albert Street (Albert Street Station), Vulture Street at Woolloongabba (TBM launch site), Boggo Road (Boggo Road Station), Fairfield Road (ventilation and emergency access building) and Yeerongpilly Station (southern portal, TBM launch site). Details of the main worksites are provided in **Chapter 4 Project Description**.

Surface track worksites would also be located at Mayne Rail Yard, Clapham Rail Yard, Ekka Station (RNA Showgrounds), Yeerongpilly Station, Moorooka Station, Rocklea Station and the Ipswich Motorway on-ramp at Rocklea. Significant noise generating construction activities would involve demolition of existing buildings, excavation using rockbreakers and other construction plant, earthworks, removal of spoil and station construction.

Satellite worksites are proposed at the following locations:

- Bowen Hills, including
 - RNA Showgrounds – two construction material storage areas
 - near Clem Jones tunnel portal – two construction material storage areas
 - Mayne Rail Yard – construction material storage area
- Roma Street Parkland – office, store, workshop and carpark
- Moorooka, off Ipswich Road – construction material storage area
- Clapham Rail Yard – two material storage areas, opposite rail yard
- Rocklea, including
 - adjacent to Rocklea Station – three construction material laydown areas
 - off Fairfield Road – construction material storage area
- Salisbury, including
 - at track bifurcation south of Riawena Road – material stockpile area
 - south of Salisbury Station – early material storage area
 - north of Salisbury Station – long term material storage area
 - opposite Fairlie Terrace – prefabrication area for footbridge
 - off Annie Street – use of sheds as site offices.

As the satellite worksites would be primarily utilised as material laydown areas, it is anticipated that construction noise and vibration emissions from these worksites would be of a temporary nature. Therefore, no further noise and vibration assessment has been carried out.

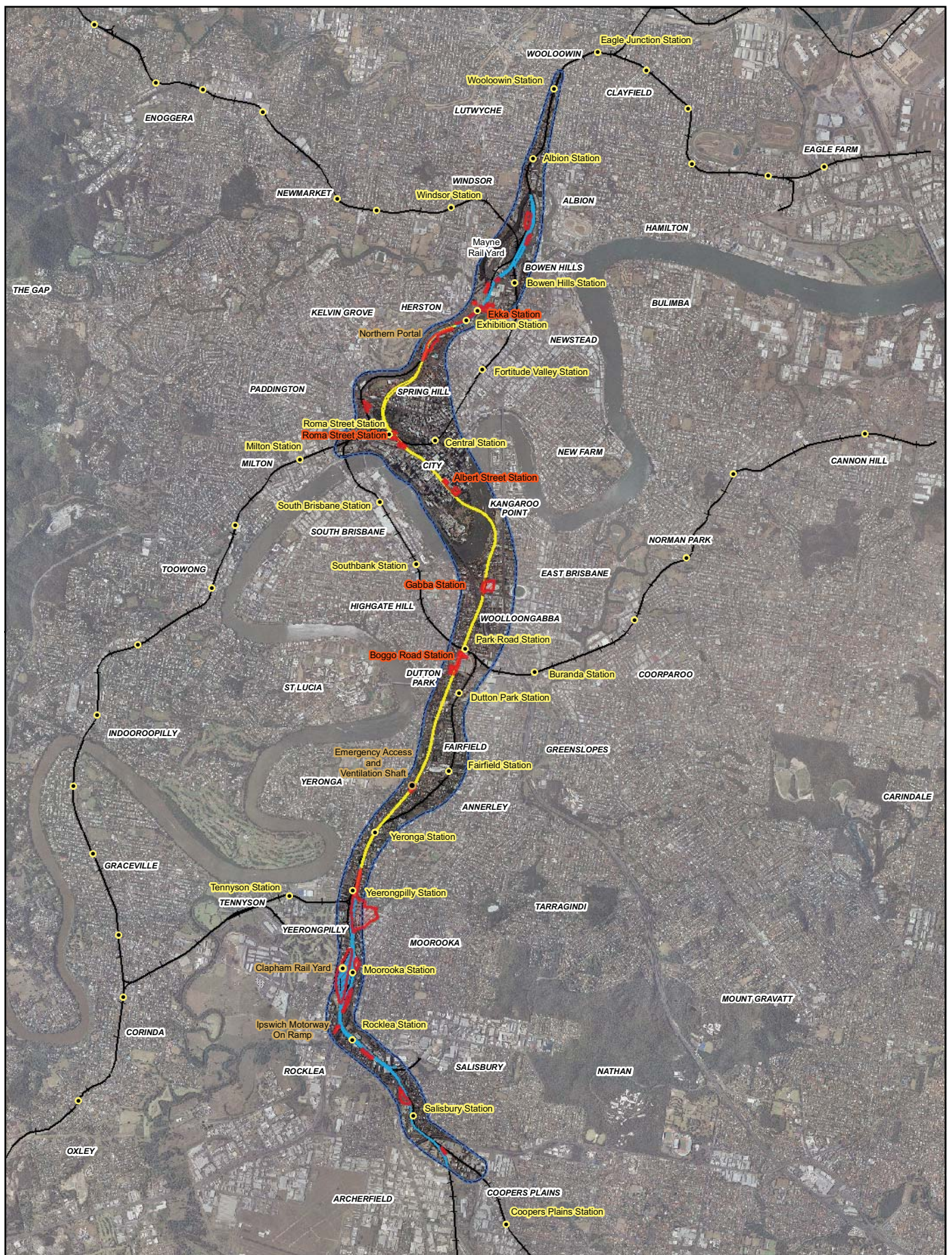
Roadworks which are not directly connected to a major worksite would be required to accommodate the Project as follows:

- realignment of Dollis Street
- Beaudesert Road and Lillian Avenue intersection upgrade
- realignment of Heaton Street under the existing span of Beaudesert Road overpass
- realignment of Fairlie Terrace under the existing span of Beaudesert Road overpass
- new traffic signals at Gladstone Street and Muriel Avenue intersection.

Further details of the roadworks are provided in **Chapter 5 Transport**.

The tunnel machinery, including TBMs and roadheaders, are proposed to operate 24 hours per day, 7 days a week, with usually one day a week and often four hours each day devoted to maintenance. Construction activities such as spoil handling and segment handling would largely occur below ground or within acoustic sheds and would be required through the night to support continuous tunnelling works. The tunnel construction program is outlined in **Chapter 4 Project Description**.

Night-time construction works, potentially including surface works, are anticipated at most worksites at some stage during the construction phase to maintain rail network operations and minimise disruptions to surface traffic (road and rail).

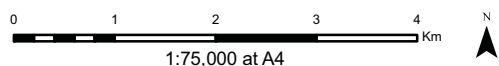


- LEGEND**
- Study Corridor
 - Station
 - Track
 - Project Alignment**
 - Above Ground
 - Underground
 - Associated Infrastructure
 - Construction Worksite

CROSS RIVER RAIL ENVIRONMENTAL IMPACT STATEMENT

Figure 16-6

Cross River Rail Major Worksites Overview



CrossRiverRail

SKM **aurecon**
CRR JOINT VENTURE

16.4.4 TBM launch worksites

The TBM launch worksites are situated at Woolloongabba and Yeerongpilly (**Section 16.4.5**). Generally, the launch worksites would be constructed using 'cut and cover' methodology. Tunnel spoil would be taken back to the main worksites at Woolloongabba and Yeerongpilly. Pre-cast, reinforced concrete segments would be delivered to these worksites to support the TBM drives north to Woolloongabba worksite and Victoria Park respectively.

Woolloongabba

The nearest noise and vibration sensitive receivers to the Woolloongabba worksite are identified on **Figure 16-7** and in **Table 16-21**.

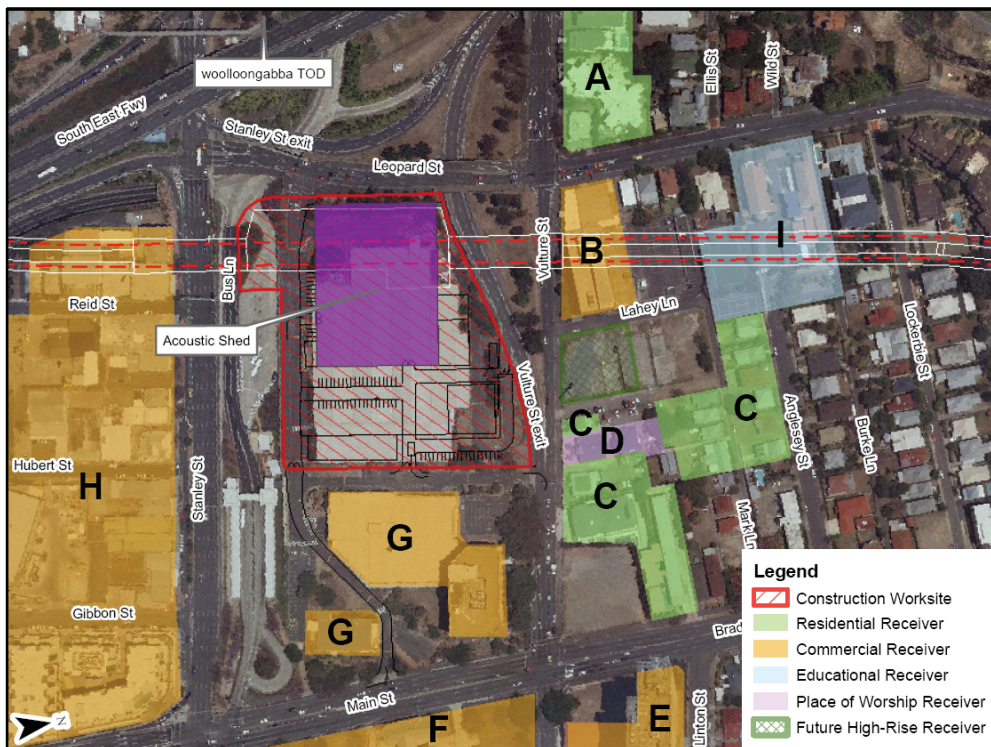


Figure 16-7 Woolloongabba worksite and receiver areas

Table 16-21 Nearest sensitive receivers – Woolloongabba

Worksite/Excavation	Receiver Area	Distance to Worksite (m)
Woolloongabba	A – Vulture Street Residential	125
	B – Vulture Street Commercial	60
	C – Vulture Street Residential	25
	D – St Nicholas Cathedral	25
	E – Main Street Commercial	150
	F – Main Street Commercial	150
	G – Vulture Street Commercial	15
	H – Stanley Street Commercial	60
	I – St Josephs Primary School	180

Phases were identified for construction at the Woolloongabba worksite, being representative of activities having potentially the greatest noise impact on the surrounding receivers (ie worst case). Worst case scenarios were developed based on all plant items, including haul trucks where applicable, operating simultaneously. These phases are:

- Phase 1 – demolition of Goprint building (day-time):
 - duration approximately 6 weeks
 - dominant noise sources include four rockbreakers and excavators
 - day-time construction only
- Phase 2 – installation of perimeter piles:
 - duration approximately 7 weeks
 - dominant noise sources include four piling rigs
 - day-time construction only
- Phase 3 – shaft excavation in hard rock and spoil removal:
 - duration approximately 7 weeks
 - dominant noise sources include three jumbo drill rigs, excavators and front end loaders
 - potentially 24 hour per day construction if acoustic enclosure is in place
- Phase 4 – TBM support operations, including on-site spoil movements:
 - duration approximately 61 weeks
 - dominant noise sources include tunnel ventilation, front end loaders and haul trucks
 - 24 hour per day construction with night-time works carried out inside an acoustic enclosure.

Typical construction noise levels were developed as follows:

- Phases 1 and 2 – worksite provided with either a 3 m or 6 m high hoarding surrounding the site
- Phases 3 and 4 – works completely contained inside an acoustic enclosure.

Construction noise levels have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-22**, as outdoor values. Internal goals for residential or commercial receivers have been adjusted, ie increased, to represent external free-field noise levels. An assessment of noise goal compliance is also provided with indicative noise level reductions based on acoustic hoarding for all phases and works carried out inside an acoustic enclosure for Phases 3 and 4. Note hatching (\\) indicates compliance, whilst “n/a” is not applicable for the assessment period. Exceedances are worst case as they assume the highest predicted noise levels.

Table 16-22 Woolloongabba worksite – predicted ‘worst case’ construction noise levels

Receiver Area	Phase	Period	Noise Goal (dBA) ^{1, 2, 3, 4}	Predicted Noise Level (dBA) ⁵ (calculated with 3 m Hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With ‘Medium Performance’ Acoustic Enclosure ⁶
A – Vulture Street Residential	1	Day	LA10,adj – 62	68 – 72	10	5	n/a
	2	Day	LA10,adj – 62	65 – 70	8	3	n/a
	3	Day	LA10,adj – 62	71 – 77	15	10	3
	4	Day	LAeq,adj – 52	59 – 65	13	8	1
	3	Night	LAmx,adj – 57	66 – 71	14	9	2
	4	Night	LAeq,adj – 47	58 – 64	17	12	5
B – Vulture Street Commercial	1	Day	LA10,adj – 72	78 – 80	8	3	n/a
	2	Day	LA10,adj – 72	73 – 76	4	-	n/a
	3	Day	LA10,adj – 72	81 – 82	10	5	
	4	Day	LAeq,adj – 62	70 – 72	10	5	
C – Vulture Street Residential	1	Day	LA10,adj – 62	69 – 77	15	10	n/a
	2	Day	LA10,adj – 62	57 – 73	11	6	
	3	Day	LA10,adj – 62	65 – 74	12	7	
	4	Day	LAeq,adj – 52	57 – 65	13	8	1
	3	Night	LAmx,adj – 57	60 – 72	15	10	3
	4	Night	LAeq,adj – 47	52 – 62	15	10	3
D – St Nicholas Cathedral	1	Any	LA10,adj – 57	75 – 77	20	15	n/a
	2	Any	LA10,adj – 57	70 – 73	16	11	n/a
	3	Any	LA10,adj – 57	74 – 76	19	14	7
	4	Any	LAeq,adj – 47	63 – 65	18	13	6
E – Main Street Commercial	1	Day	LA10,adj – 72	48 – 67			n/a
	2	Day	LA10,adj – 72	45 – 61			
	3	Day	LA10,adj – 72	44 – 64			
	4	Day	LAeq,adj – 62	50 – 54			
F – Main Street Commercial	1	Day	LA10,adj – 72	47 – 58			n/a
	2	Day	LA10,adj – 72	43 – 56			
	3	Day	LA10,adj – 72	46 – 59			
	4	Day	LAeq,adj – 62	36 – 47			

⁶ A medium performance enclosure provides an acoustically absorptive internal lining (refer to Section 16.4.1 for details).

Receiver Area	Phase	Period	Noise Goal (dBA) ^{1, 2, 3, 4}	Predicted Noise Level (dBA) ⁵ (calculated with 3 m Hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With 'Medium Performance' Acoustic Enclosure ⁶
G – Vulture Street Commercial	1	Day	LA10,adj – 72	68 – 77	5		
	2	Day	LA10,adj – 72	47 – 72	-		
	3	Day	LA10,adj – 72	63 – 74	2		
	4	Day	LAeq,adj – 62	58 – 62	-		
H – Stanley Street Commercial	1	Day	LA10,adj – 72	64 – 76	4		n/a
	2	Day	LA10,adj – 72	59 – 73	1		
	3	Day	LA10,adj – 72	72 – 78	6	1	
	4	Day	LAeq,adj – 62	62 – 68	6	1	
I – St Josephs School	1	Day	LA10,adj – 62	46 – 62			n/a
	2	Day	LA10,adj – 62	45 – 56			n/a
	3	Day	LA10,adj – 62	45 – 57			
	4	Day	LAeq,adj – 52	40 – 54	2		

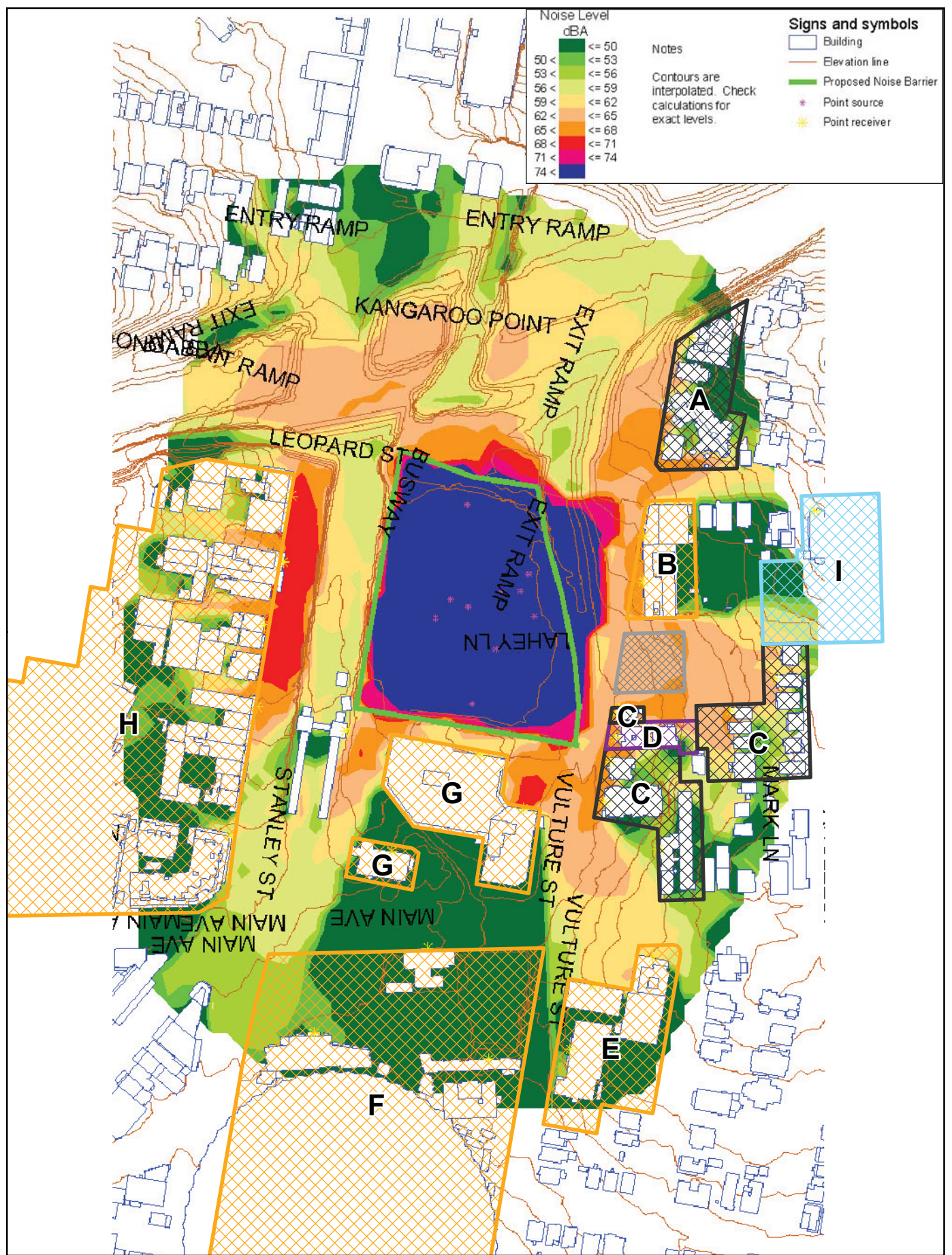


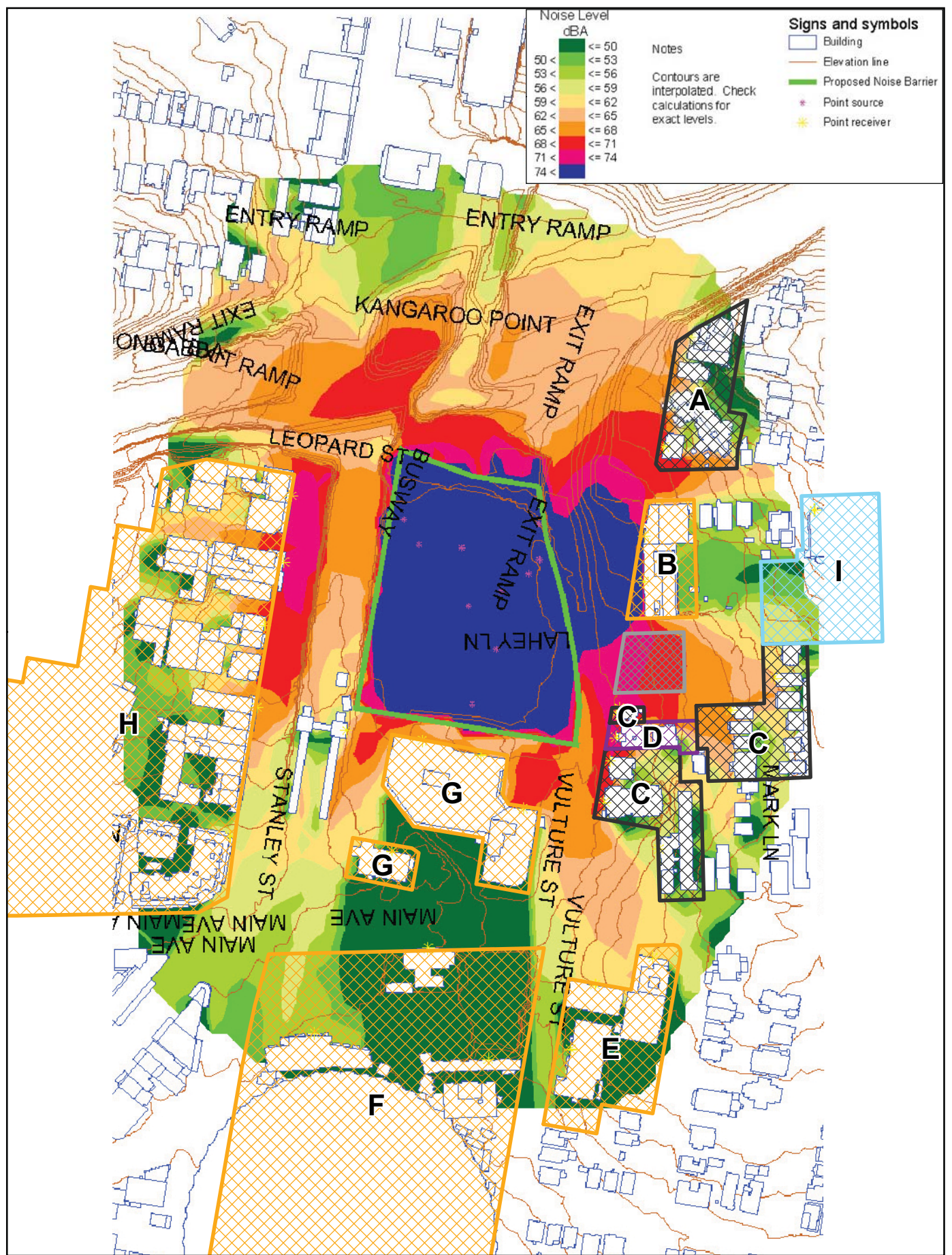
Noise compliance achieved at receiver

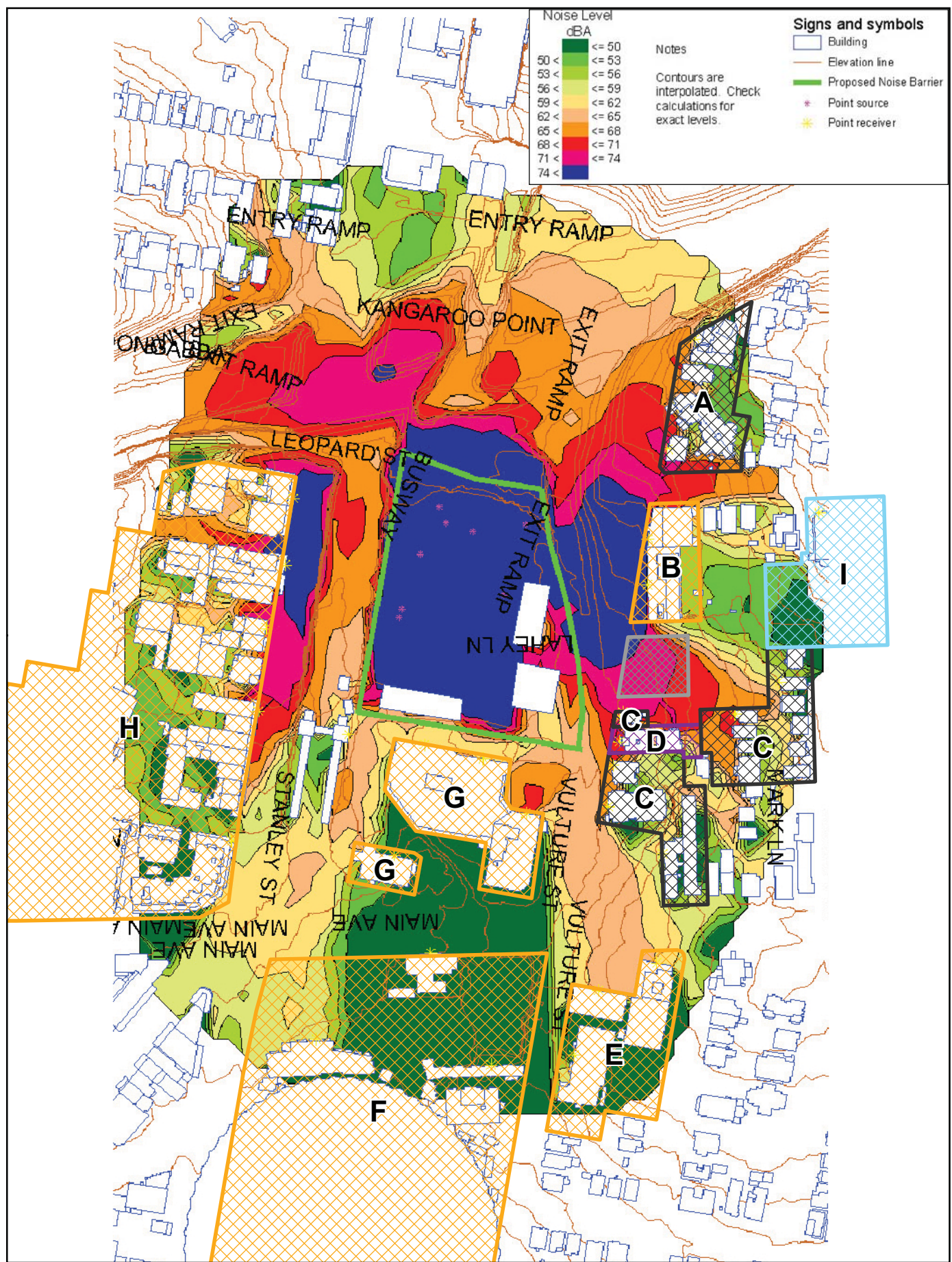
Notes:

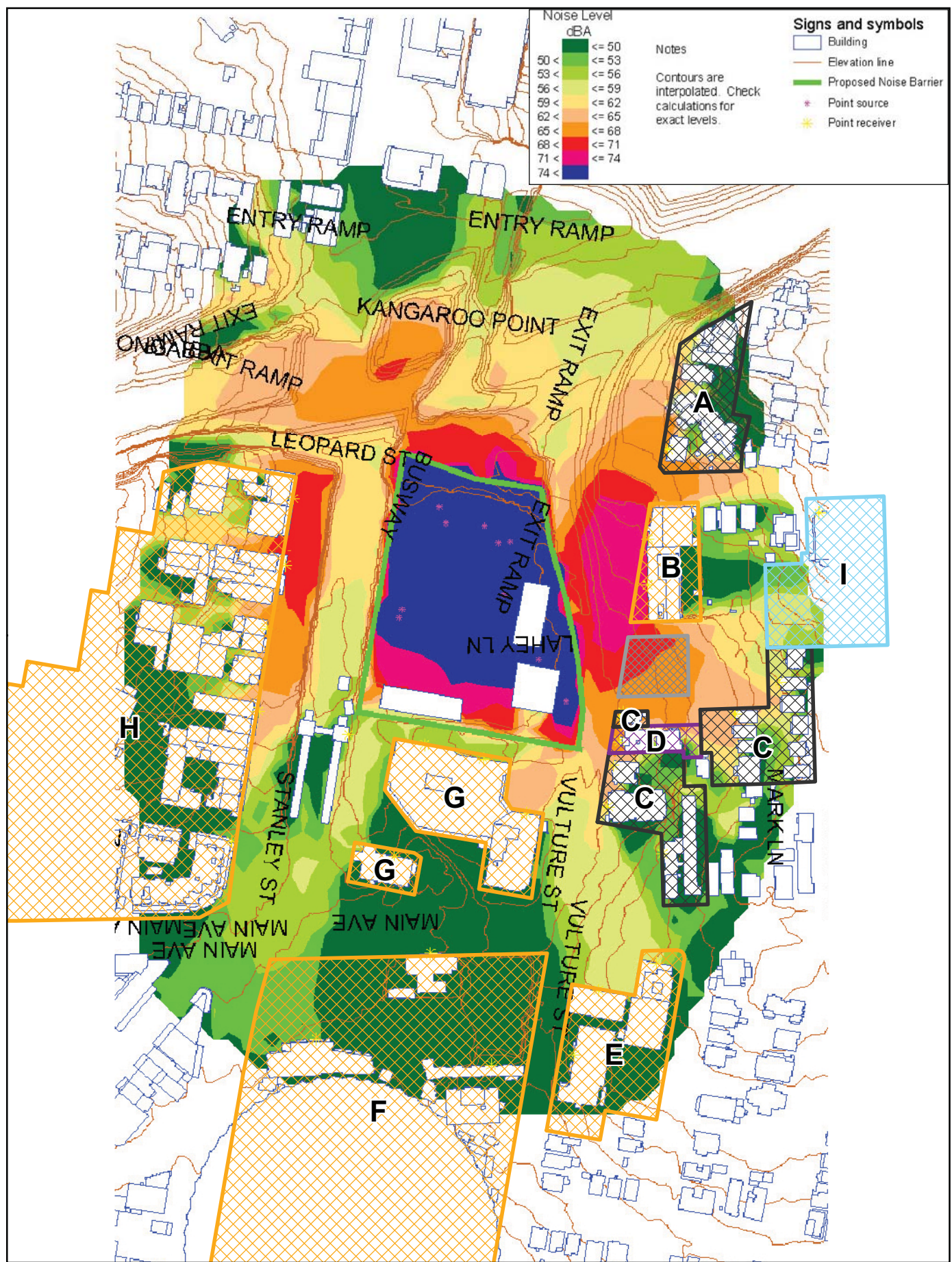
1. Phase 1 – dominant construction noise during Goprint building demolition likely to be non-steady state. Therefore, the LA10,adj assessment parameter is most relevant.
2. Phase 2 – dominant construction noise during pile installation likely to be non-steady state. Therefore, the LA10,adj assessment parameter is most relevant.
3. Phase 3 – dominant construction noise during shaft excavation likely to be non-steady state and intermittent. Therefore, the LA10,adj and LAmax,adj (night-time) assessment parameters are most relevant.
4. Phase 4 – dominant construction noise during long term TBM support operations (ie spoil removal, ventilation etc) likely to be steady state and continuous. Therefore, the LAeq,adj assessment parameter is most relevant.
5. Predicted noise levels include 3 m acoustic hoarding between noise sources and receivers.

Figure 16-8, Figure 16-9, Figure 16-10 and Figure 16-11 show noise contours for the phases examined with 3 m high acoustic hoarding.









The predicted noise levels for demolition of the existing Goprint building at the Woolloongabba worksite, which is anticipated to occur over a six week period, indicate exceedances of up to 15 dBA of the noise goal for day-time operations at the nearest residential receivers along Vulture Street. Higher exceedances are expected at St Nicholas Cathedral due to the lower noise goal. Similar exceedances are predicted during the pile installation works (ie Phase 2) which are anticipated to occur over a seven week period.

Initial predictions in **Table 16-22** indicated that the predicted noise levels for shaft excavation and spoil storage (ie Phase 3) and TBM drives, ie Phase 4, will still be exceeded at three receiver locations with the mitigation described. Therefore, an acoustic enclosure is likely to be required, subject to detailed design and consultation. The Phase 3 works occurring inside a medium performance acoustic enclosure at the Woolloongabba worksite indicate exceedances of up to 3 dBA during the day and 3 dBA during the night-time period at the nearest residential receivers. The predicted noise levels indicate that a minor, eg 1 mm thick metal cladding rather than 0.62 mm thick cladding, upgrade on the medium performance acoustic enclosure would be required to achieve compliance with the day-time and night-time noise goals.

Longer-term activities at this worksite are associated with the TBM drives (ie Phase 4) are also predicted to exceed the night-time residential noise goal at the nearest receivers. A further 5 dBA reduction in noise emission could be achieved through the following mitigation measures:

- highest performance acoustic enclosure over the shaft
- quietest available mobile plant operating at the worksite (ie fitted with appropriate exhaust silencers, mufflers or acoustic covers)
- temporary tunnel ventilation noise sources to be located down in the shaft with appropriate ducting to the surface. Silencers may be required depending on the type of ventilation used
- acoustic louvres at enclosure ventilation points.

Detailed design of a high performance acoustic enclosure would need to include double skinned walls, a roof lined with sound absorptive material, minimised openings and acoustic louvres to ventilation openings. The acoustic enclosure could be constructed with a retractable/removable roof to allow for delivery of large TBM components.

With these mitigation measures in place, combined with careful management of all heavy vehicle movements on the worksite, eg limiting the use of reversing alarms or providing alarms which actively vary their volume, rather than constant volume (tonal) “beeping” alarms, compliance with the noise goals during all time periods could be achieved at the Woolloongabba worksite with the exception of initial demolition works, which are anticipated to occur over a six week period, which cannot be reasonably and feasibly mitigated to achieve compliance with the day-time noise goal.

Construction activities would be undertaken in accordance with the hours of work provided in **Chapter 24 Draft Outline EMP**. Noise monitoring would be conducted at residential premises near the worksite eg north of Vulture Street.

Predicted ground-borne noise and vibration impacts for the excavation of the Woolloongabba shaft are presented in **Table 16-23**.

Table 16-23 Woolloongabba shaft excavation (Phase 3) – predicted ‘worst case’ ground-borne noise and vibration levels

Receiver Area	Period	Noise and Vibration Goals			Predicted Ground-borne Noise and Vibration Levels (Rockbreaking)		Maximum Allowed Blast MIC (kg) to meet Noise and Vibration Goal	
		Vibration PPV (mm/s) Blasting ¹	Vibration PPV (mm/s) Construction	Ground-borne Noise (dBA) ²	Ground-borne Vibration (mm/s)	Ground-borne Noise (dBA)	Vibration	Airblast Over-pressure
A – Vulture Street Residential	Day	10	5	LA10,adj – 55	0.04	34	43 kg	56 kg
	Night	n/a	0.5	LAmx,adj – 50	0.04	39	n/a	n/a
B – Vulture Street Commercial	Day	10	5	LA10,adj – 65	0.07	43	22 kg	20 kg
C – Vulture Street Residential	Day	10	5	LA10,adj – 55	0.02	30	74 kg	126 kg
	Night	n/a	0.5	LAmx,adj – 50	0.02	35	n/a	n/a
D – St Nicholas Cathedral (heritage listed)	Day	2	2	LA10,adj – 50	0.02	29	12 kg	175 kg
E – Main Street Commercial	Day	10	5	LA10,adj – 65	0.01	24	446 kg	1852 kg
F – Main Street Commercial	Day	10	5	LA10,adj – 65	0.01	24	430 kg	1753 kg
G – Vulture Street Commercial	Day	10	5	LA10,adj – 65	0.03	33	100 kg	197 kg
H – Stanley Street Commercial	Day	10	5	LA10,adj – 65	0.08	44	18 kg	16 kg
I – St Josephs Church and School (heritage listed)	Day	2	2	LA10,adj – 50	0.01	25	23 kg	439 kg

Notes:

1. Blasting only during day-time.

2. Dominant construction noise during shaft excavation likely to be non-steady state and intermittent. Therefore, the LA10,adj and LAmx,adj (night-time) assessment parameters are most relevant. For the ground-borne noise, all noise levels are internal levels.

Ground-borne noise and vibration are primarily associated with Phase 3. In terms of this shaft excavation, the predicted ground-borne noise and vibration levels in **Table 16-23** indicate compliance with the relevant goals, primarily due to the Woolloongabba worksite being bordered by existing roads and therefore set back from sensitive receivers.

The estimated Maximum Instantaneous Charge (MIC) blast limits (ie the maximum amount of explosive in kilograms on any one specific delay detonator in any one blast hole) indicate that blasting of the station shaft could be carried out with minimal risk of impact. Therefore, blasting would be a suitable excavation technique for this location.

With respect to construction noise impacts on future urban developments at Woolloongabba, predicted construction noise levels have not been assessed, as building layouts are yet to be finalised. Construction noise emission levels for future ground floor receivers at these developments can be interpreted from the noise contours presented in **Figure 16-8** to **Figure 16-11**.

16.4.5 Tunnel portals

Northern portal

The nearest noise and/or vibration sensitive receivers to the northern portal worksite are identified on **Figure 16-12** and in **Table 16-24**.

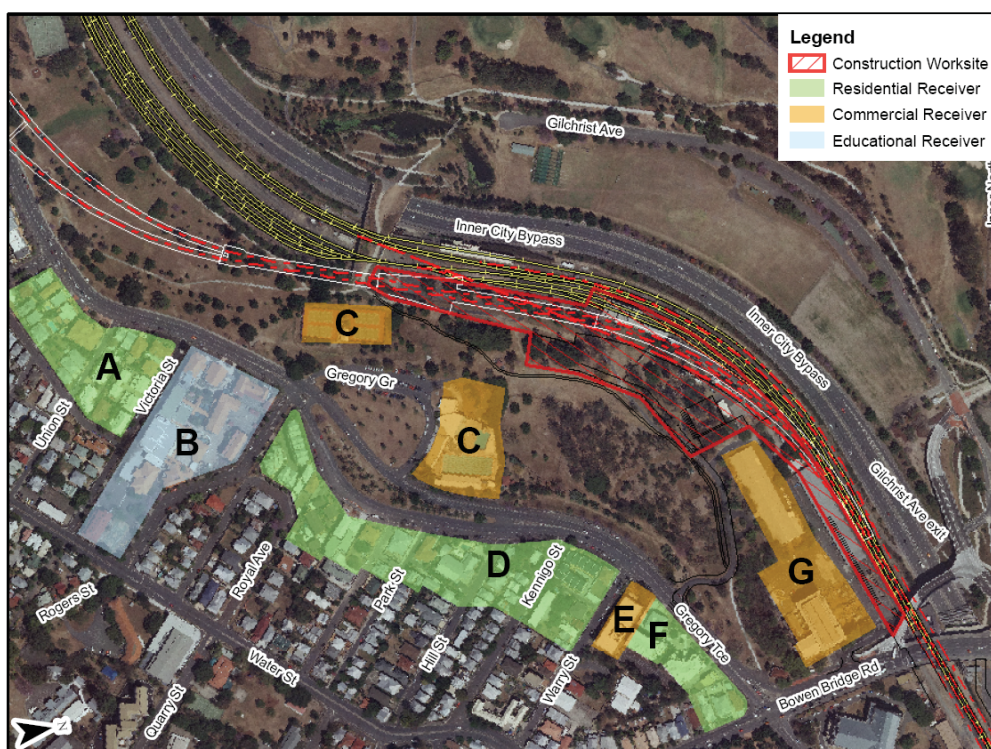


Figure 16-12 Northern portal worksite and receiver areas

Table 16-24 Nearest sensitive receivers – northern portal

Worksite/Excavation	Receiver Area	Location Relative to Works (m)
Northern Portal	A – Gregory Terrace Residential	230
	B – St Josephs College	150
	C – Centenary Aquatic Centre	25
	D – Gregory Terrace Residential	130
	E – Gregory Terrace Commercial	150
	F – Gregory Terrace Residential	170
	G – Bowen Bridge Road Commercial	20

The assessment of ground-borne noise and vibration associated with roadheading the initial section of northern portal is covered in the assessment of mechanical tunnel excavation (refer to **Section 16.4.11**).

‘Worst case’ phases were identified for construction of the northern portal being representative of activities having potentially the greatest noise impact on the surrounding receivers. Worst case scenarios have been developed based on all plant items, including haul trucks where applicable, operating simultaneously.

These phases are:

- Phase 1 – site establishment:
 - duration approximately 4 weeks
 - dominant noise sources include excavators and front end loaders
 - day-time construction only
- Phase 2 – trough excavation and spoil removal:
 - duration approximately 5 weeks
 - dominant noise sources include jumbo drill rigs and excavators
 - day-time construction only
- Phase 3 – TBM disassembly:
 - duration approximately 15 weeks
 - dominant noise sources include cranes and heavy vehicles
 - day-time construction only.

Construction noise levels surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-25**, as outdoor values. Internal goals for residential or commercial receivers have been adjusted, ie increased, to represent external free-field noise levels. An assessment of noise goal compliance is also provided with indicative noise level reductions based on acoustic hoarding for all phases and works carried out inside the cut and cover structure for Phase 3. Note hatching (///) indicates compliance, whilst “n/a” not applicable for the assessment period.

Table 16-25 Northern portal – predicted ‘worst case’ construction noise levels

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) (calculated with 3 m Hoarding) ²	Noise Goal Exceedance with level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With ‘Medium Performance’ Acoustic Enclosure ³
A – Gregory Terrace Residential	1	Day	LA10,adj – 57	56 – 59	2		n/a
	2	Day	LA10,adj – 57	54 – 58	1		n/a
	3	Day	LA10,adj – 57	48 – 54			
B – St Josephs College	1	Day	LA10,adj – 62	48 – 62			n/a
	2	Day	LA10,adj – 62	48 – 60			n/a
	3	Day	LA10,adj – 62	44 – 57			
C – Centenary Aquatic Centre	1	Day	LA10,adj – 72	64 – 83	11	6	n/a
	2	Day	LA10,adj – 72	67 – 74	2		n/a
	3	Day	LA10,adj – 72	66 – 72			
D – Gregory Terrace Residential	1	Day	LA10,adj – 57	59 – 64	7	2	n/a
	2	Day	LA10,adj – 57	59 – 64	7	2	n/a
	3	Day	LA10,adj – 57	53 – 61	4		
E – Gregory Terrace Commercial	1	Day	LA10,adj – 72	46 – 58			n/a
	2	Day	LA10,adj – 72	49 – 61			n/a
	3	Day	LA10,adj – 72	47 – 58			
F – Gregory Terrace Residential	1	Day	LA10,adj – 62	47 – 56			n/a
	2	Day	LA10,adj – 62	50 – 60			n/a
	3	Day	LA10,adj – 62	45 – 57			
G – Bowen Bridge Road Commercial	1	Day	LA10,adj – 72	54 – 72			n/a
	2	Day	LA10,adj – 72	57 – 70			n/a
	3	Day	LA10,adj – 72	53 – 61			

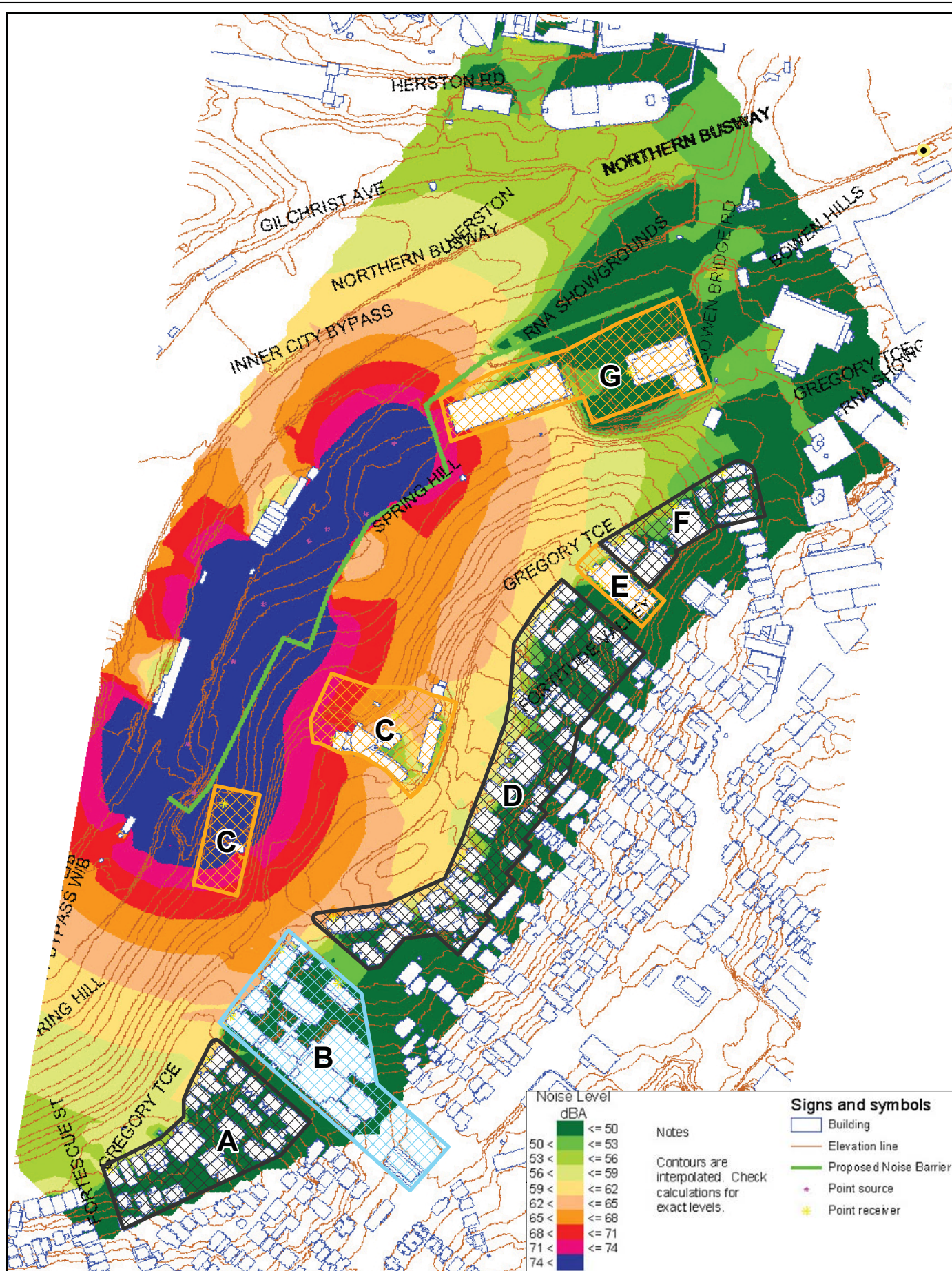


Noise goal achieved at receiver

Notes:

1. Dominant construction noise likely to be non-steady state. Therefore, the LA10,adj assessment parameter is most relevant.
2. Predicted noise levels include 3 m acoustic hoarding between noise sources and receivers.
3. A medium performance enclosure provides an acoustically absorptive internal lining (refer to **Section 16.4.1**).

Noise contours with noise mitigation (3 m high acoustic hoarding) for the phases examined are shown in **Figure 16-13**, **Figure 16-14** and **Figure 16-15**.



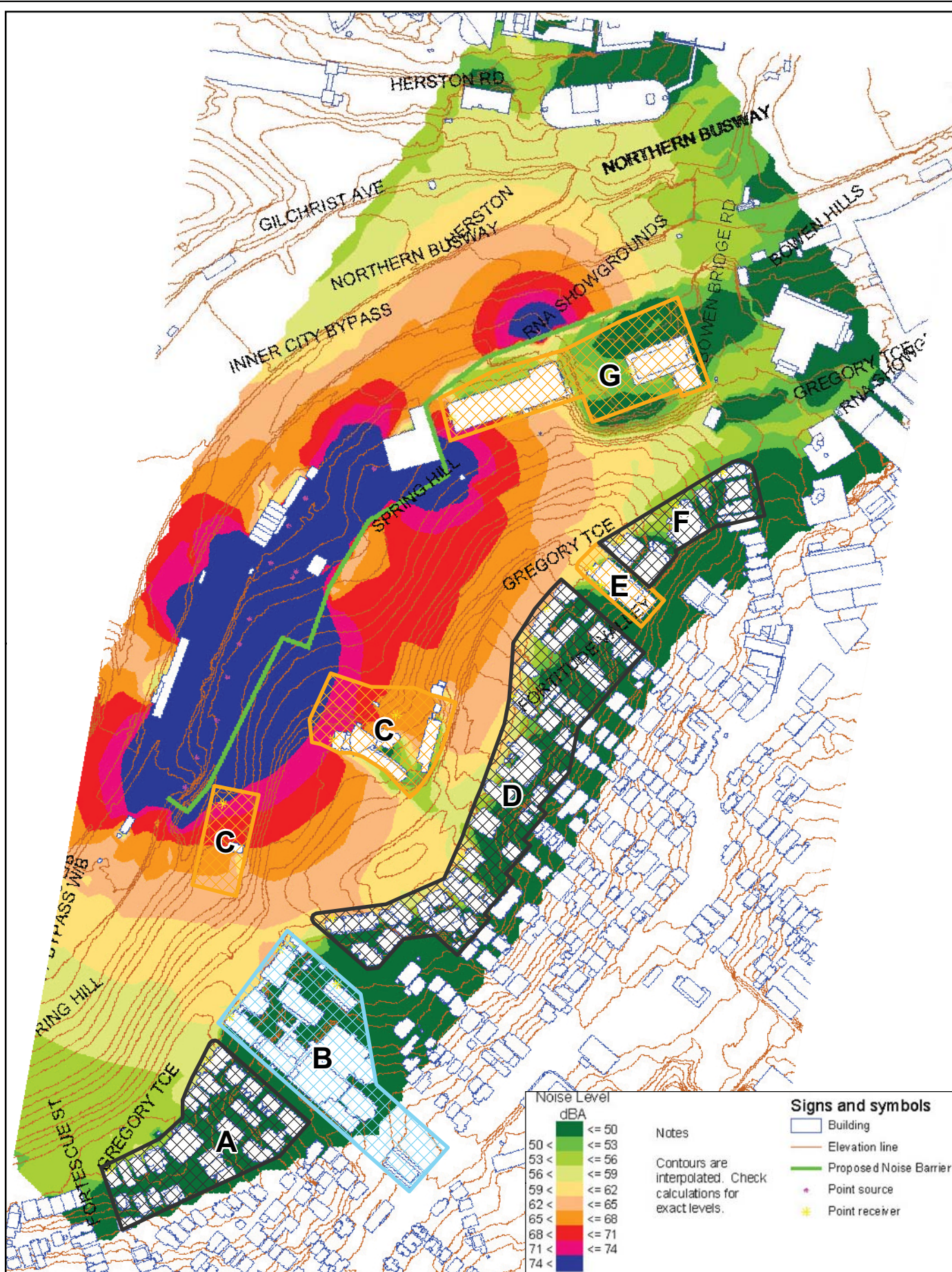
CROSS RIVER RAIL ENVIRONMENTAL IMPACT STATEMENT

Figure 16-13
Northern Portal - Phase 1 Establishment
Daytime

0 50 100 150 200 Meters
1:4,500 at A4

CrossRiverRail

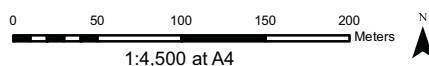
SKM aurecon
CRR JOINT VENTURE



CROSS RIVER RAIL ENVIRONMENTAL IMPACT STATEMENT

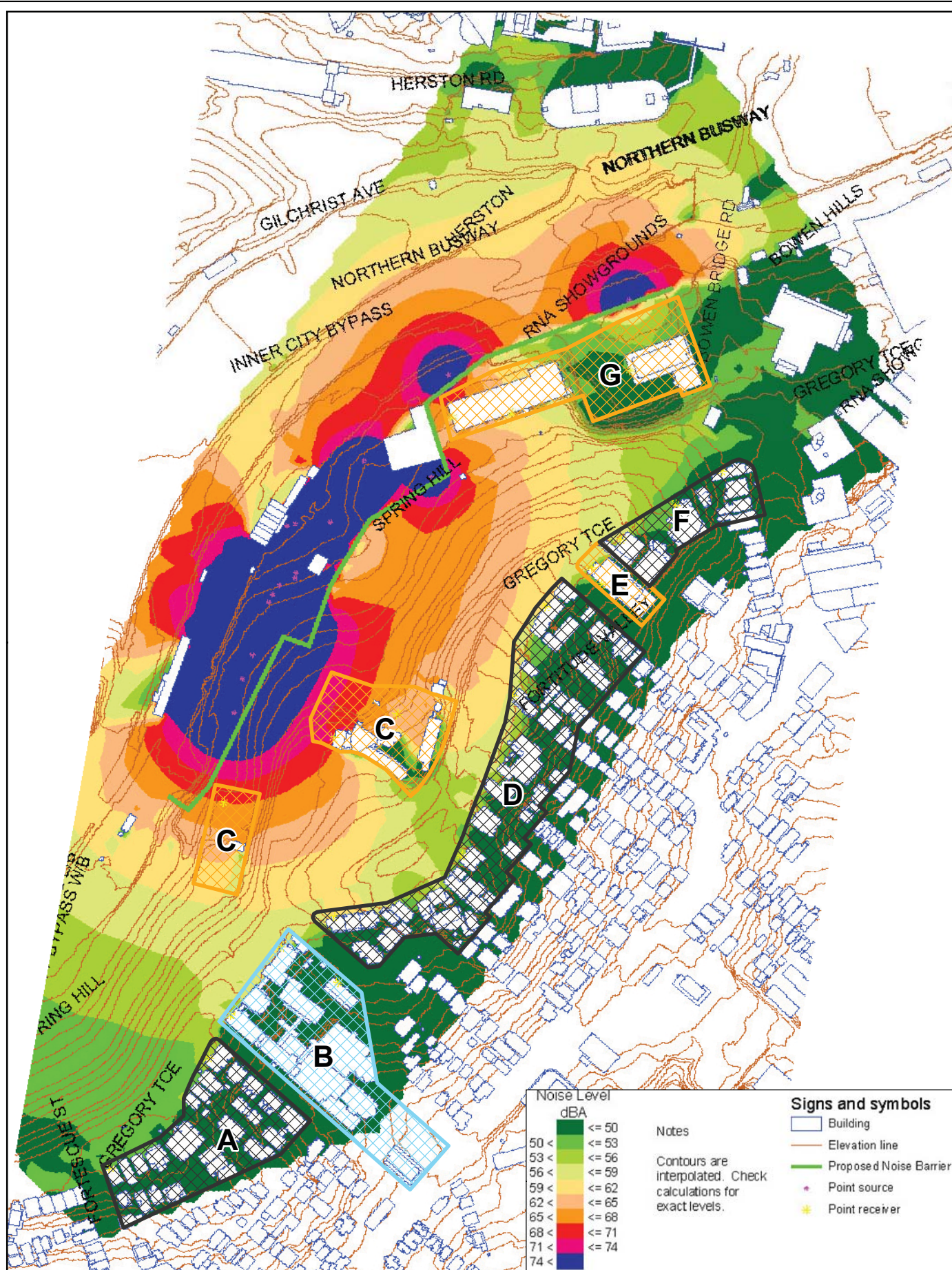
Figure 16-14

Northern Portal - Phase 2 Trough Excavation
Daytime



CrossRiverRail

SKM aurecon
CRR JOINT VENTURE



CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 16-15
Northern Portal - Phase 3 TBM Assembly Daytime

0 50 100 150 200 Meters
1:4,500 at A4

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

The predicted 'worst case' noise levels for the three construction phases at the northern portal worksite indicate exceedances of the relevant noise goals at the nearest residential receivers. The scale of the predicted exceedances is reduced by the separation distance and topography between the worksite and residences. Higher noise goal exceedances are expected at commercial receivers located on the western side of Gregory Terrace, eg Centenary Aquatic Centre, during the worksite establishment phase, over a period of approximately 4 weeks.

The predicted 'worst case' noise levels in **Table 16-25** suggest that increasing the proposed 3 m high worksite hoarding along the eastern boundary to 6 m in height would achieve compliance with the noise goals at all sensitive receivers except for the Centenary Aquatic Centre (6 dBA exceedance) and the nearest Gregory Terrace residences (marginal 2 dBA exceedance). Impacts to these receivers would be minimised through use of quietest available construction plant, ie fitted with appropriate exhaust silencers, mufflers or acoustic covers, and consultation. With respect to Phase 2 impacts, as the excavation plant progresses deeper into the portal structure, construction noise emission levels at Gregory Terrace (residential receivers) would be anticipated to approach compliance with the noise goal.

No exceedances are predicted for the Bowen Bridge Road commercial receiver, as the close proximity of the building to the worksite is effectively shielded by the 3 m high site hoarding.

The movement of trucks within the worksite would be managed to limit the need for reversing and the consequential activation of reversing alarms. Where issues with reversing alarms occur, consideration would be given to the use of broadband "buzzer" reversing alarms or alarms which actively vary their volume according to the ambient noise levels during activation – rather than constant volume (tonal) "beeping" alarms. Truck movements at this worksite are anticipated to be low in number in comparison to the major worksites.

Construction activities at the northern portal worksite would be undertaken in accordance with the hours of work provided in **Chapter 24 Draft Outline EMP**. Assessment of ground-borne noise and vibration associated with roadheading the initial section of the northern portal is presented in **Section 16.4.11**.

Southern portal and Yeerongpilly worksite

The nearest noise and/or vibration sensitive receivers to the southern portal worksite are identified on **Figure 16-16** and in **Table 16-26**.

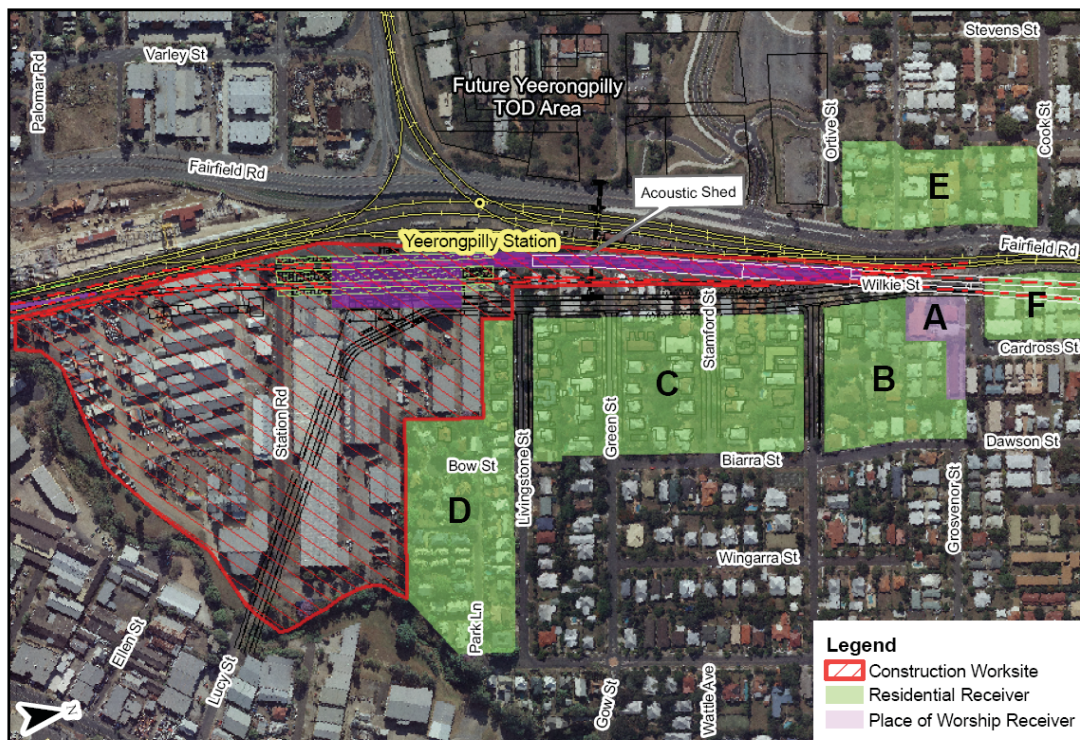


Figure 16-16 Southern portal worksite and receiver areas

Table 16-26 Nearest sensitive receivers – southern portal

Worksite/Excavation	Receiver Area	Location Relative to Works (m)
Southern Portal	A – St Fabian's Church	20
	B – Tees Street Residential	30
	C – Wilkie Street Residential	30
	D – Livingstone Street Residential	35
	E – Fairfield Road Residential	50
	F – Cardross Street Residential	80

Assessment of ground-borne noise and vibration associated with roadheading the initial section of southern portal is covered in the assessment of mechanical tunnel excavation (refer to **Section 16.4.11**).

Phases were identified for southern portal construction works being representative of activities having potentially the greatest noise impact on the surrounding receivers. Worst case scenarios were developed based on all plant items, including haul trucks where applicable, operating simultaneously. These phases are:

- Phase 1 – demolition of existing buildings:
 - duration approximately 6 weeks
 - dominant noise sources include rockbreakers and excavators
 - day-time construction only
- Phase 2 – pile installation within cut and cover section of the trough:
 - duration approximately 6 weeks

- dominant noise sources include three piling rigs
- mostly day-time construction and potentially weekend (and night-time) work during track possessions
- Phase 3 – TBM support including spoil removal:
 - duration approximately 68 weeks
 - dominant noise sources include spoil trucks, front end loaders and tunnel ventilation
 - 24 hour per day construction with night-time works carried out inside an acoustic enclosure
- Phase 4 – night-time truck (eg spoil, delivery etc) movements within the worksite near the entrance:
 - duration approximately 125 weeks
 - dominant noise sources include trucks prior to exiting the worksite at Lucy Street
 - 24 hour per day movements through the worksite.

Construction noise levels surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-27**, as outdoor values. Internal goals for residential receivers have been adjusted, ie increased, to represent external free-field noise levels. An assessment of noise goal compliance is also provided with indicative noise level reductions based on acoustic hoarding for all phases and works carried out inside an acoustic enclosure for Phase 3. Note hatching (\\) indicates compliance and “n/a” not applicable for the assessment period. Exceedances are worst case as they assume the highest predicted noise levels.

Table 16-27 Southern portal – predicted ‘worst case’ construction noise levels

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) ² (calculated with 3 m hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With ‘Medium Performance’ Acoustic Enclosure ⁴
A – St Fabian’s Church ³	1	Day	LA10,adj – 57	76 – 86 ⁵	29	24	n/a
	2	Day	LA10,adj – 57	67 – 70	13	8	n/a
	3	Day	LAeq,adj – 47	47 – 51	4	\\	\\
B – Tees Street Residential	1	Day	LA10,adj – 57	73 – 86	29	24	n/a
	2	Day	LA10,adj – 57	58 – 72	15	11	n/a
	3	Day	LAeq,adj – 47	42 – 52	5	\\	\\
	2	Night	LAmx,adj – 52	51 – 68	16	11	n/a
	3	Night	LAeq,adj – 42	42 – 52	10	5	\\
	4	Night	LAmx,adj – 52	31 – 34	\\	\\	n/a
C – Wilkie Street Residential	1	Day	LA10,adj – 57	69 – 84	27	22	n/a
	2	Day	LA10,adj – 57	56 – 69	12	7	n/a
	3	Day	LAeq,adj – 47	40 – 62	15	10	3
	2	Night	LAmx,adj – 52	52 – 63	11	6	n/a
	3	Night	LAeq,adj – 42	40 – 62	20	15	8
	4	Night	LAmx,adj – 52	24 – 37	\\	\\	n/a

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) ² (calculated with 3 m hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With 'Medium Performance' Acoustic Enclosure ⁴
D – Livingstone Street Residential	1	Day	LA10,adj – 57	52 – 76	19	14	n/a
	2	Day	LA10,adj – 57	41 – 62	5		n/a
	3	Day	LAeq,adj – 47	44 – 61	14	9	2
	2	Night	LAmaj,adj – 52	40 – 48			n/a
	3	Night	LAeq,adj – 42	44 – 61	19	14	7
	4	Night	LAmaj,adj – 52	31 – 53	1		n/a
E – Fairfield Road Residential	1	Day	LA10,adj – 62	69 – 76	14	9	n/a
	2	Day	LA10,adj – 62	62 – 72	10	5	n/a
	3	Day	LAeq,adj – 52	47 – 53	1		
	2	Night	LAmaj,adj – 57	58 – 70	13	8	n/a
	3	Night	LAeq,adj – 47	47 – 53	6	1	
F – Cardross Street Residential	1	Day	LA10,adj – 57	61 – 68	11	6	n/a
	2	Day	LA10,adj – 57	48 – 62	5		n/a
	3	Day	LAeq,adj – 47	36 – 47			
	2	Night	LAmaj,adj – 52	43 – 58	6	1	n/a
	3	Night	LAeq,adj – 42	36 – 47	5		



Noise goal achieved at receiver

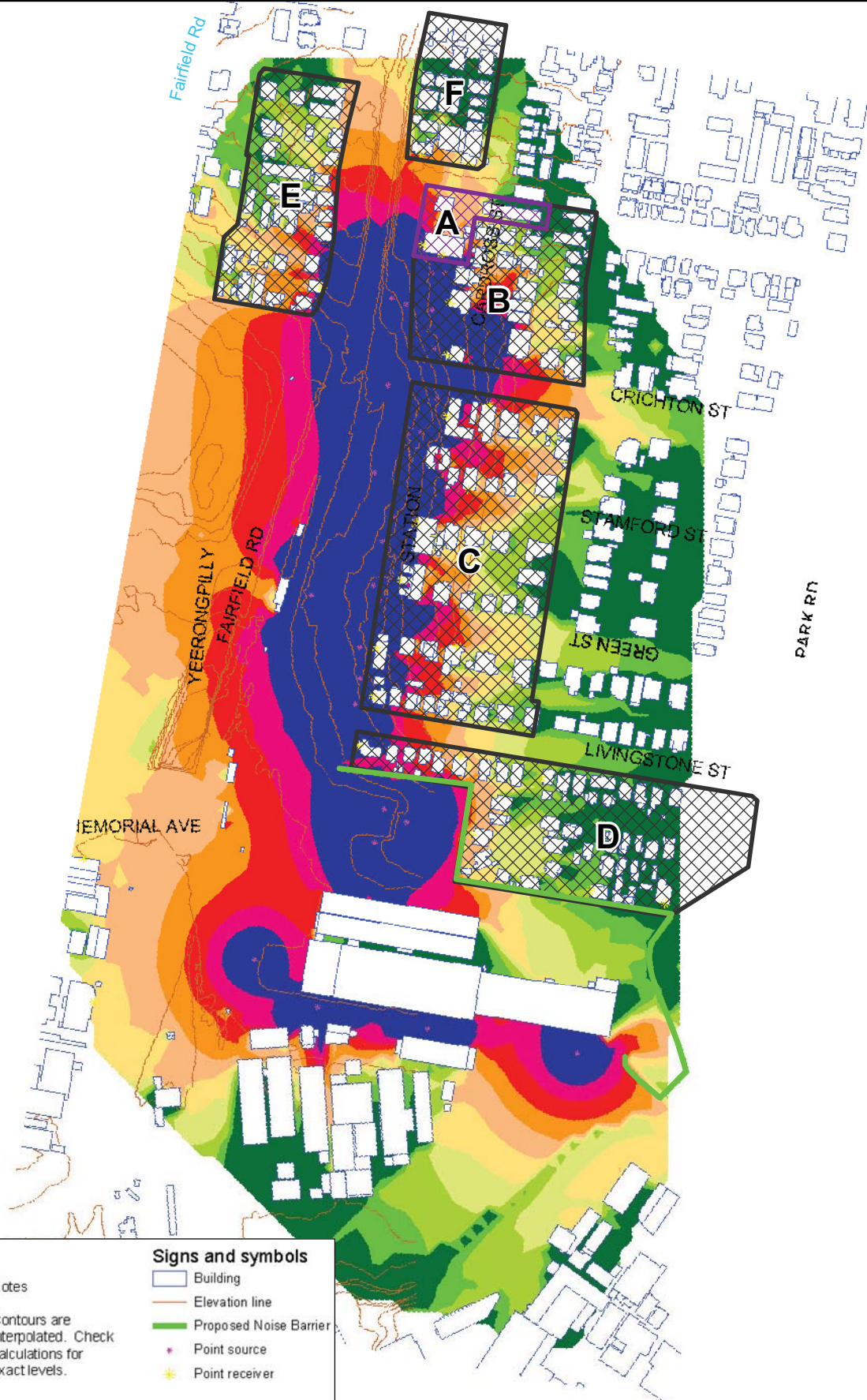
Notes:

1. LA10,adj and LAmaj,adj (night-time) assessment parameters applicable for non-steady state and intermittent noise sources. LAeq,adj assessment parameter applicable to steady state or continuous (night-time) noise sources.
2. Predicted noise levels include 3 m acoustic hoarding between noise sources and receivers.
3. St Fabian's Church is not used during night-time. Therefore, night-time construction noise levels have not been assessed
4. A medium performance enclosure provides an acoustically absorptive internal lining (refer to Section 16.4.1).
5. The large range is due to the short distance nature of construction activity (ie demolition of buildings). Worst case takes the higher of the predicted noise levels.

Figure 16-17, Figure 16-18, Figure 16-19, Figure 16-20 and Figure 16-21 show noise contours for the phases examined with 3 m high acoustic hoarding.

The predicted 'worst case' noise levels for Phase 1, including realignment of Wilkie Street and adjacent residences at the southern portal worksite indicate exceedances of up to 29 dBA of the noise goal for the day-time period with 3 m hoardings. The predicted exceedances would result from the use of rockbreakers in close proximity to sensitive receivers for approximately 6 weeks. To further mitigate construction noise, demolition of residences nearest to the railway line are proposed to occur first, so that the buildings closest to the resumption line act as a barrier for residences located beyond the property impact area, particularly if large rock-breakers are required to break up concrete slabs and/or footings.

Short-term night-time work would be required during earthworks immediately adjacent to the operating rail line, to minimise disruption to rail services. The predicted 'worst case' noise levels for Phase 2 reflect this activity, which indicate that exceedances of up to 16 dBA would result with just 3 m hoarding as noise mitigation. It is proposed that these works are carried out during weekend rail possessions and during the day-time only. If night-time construction work is required, consideration would be given to the early installation of part of, if not the entire, acoustic enclosure to provide significant and effective noise attenuation.



Noise Level
dBA

<= 50
50 < <= 53
53 < <= 56
56 < <= 59
59 < <= 62
62 < <= 65
65 < <= 68
68 < <= 71
71 < <= 74
74 <

Notes

Contours are interpolated. Check calculations for exact levels.

- Signs and symbols**
- Building
 - Elevation line
 - Proposed Noise Barrier
 - Point source
 - Point receiver

- LEGEND**
- Residential Receiver
 - Place of Worship Receiver

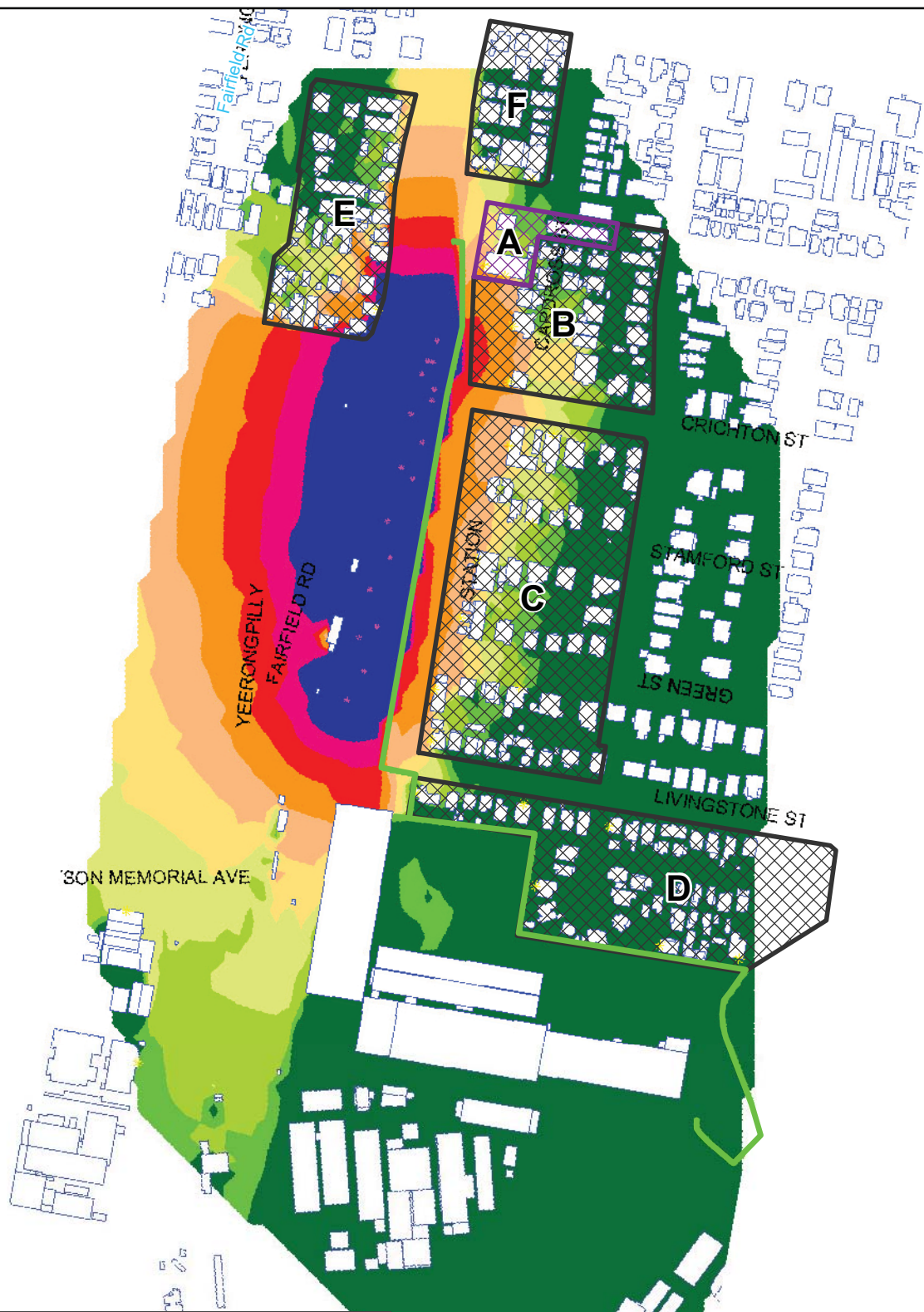
CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 16-17
Southern Portal - Phase 1 Demolition
Daytime

0 50 100 150 200 Meters

1:5,000 at A4





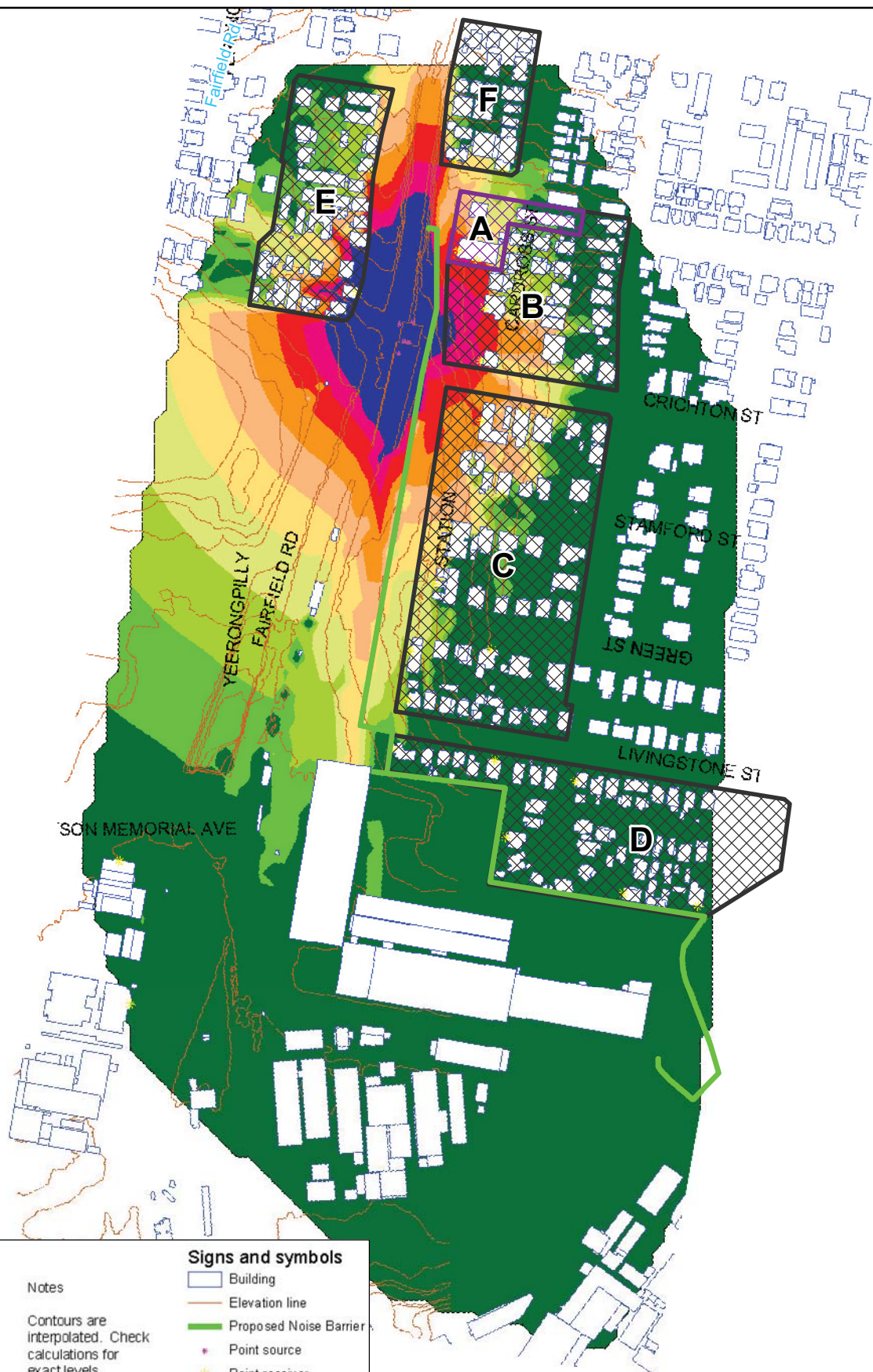
CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 16-18
Southern Portal - Phase 2 Pile Installation
Daytime

0 50 100 150 200 Meters
1:5,000 at A4

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE



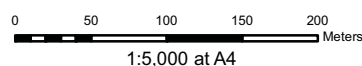
LEGEND

- Residential Receiver
- Place of Worship Receiver

CROSS RIVER RAIL ENVIRONMENTAL IMPACT STATEMENT

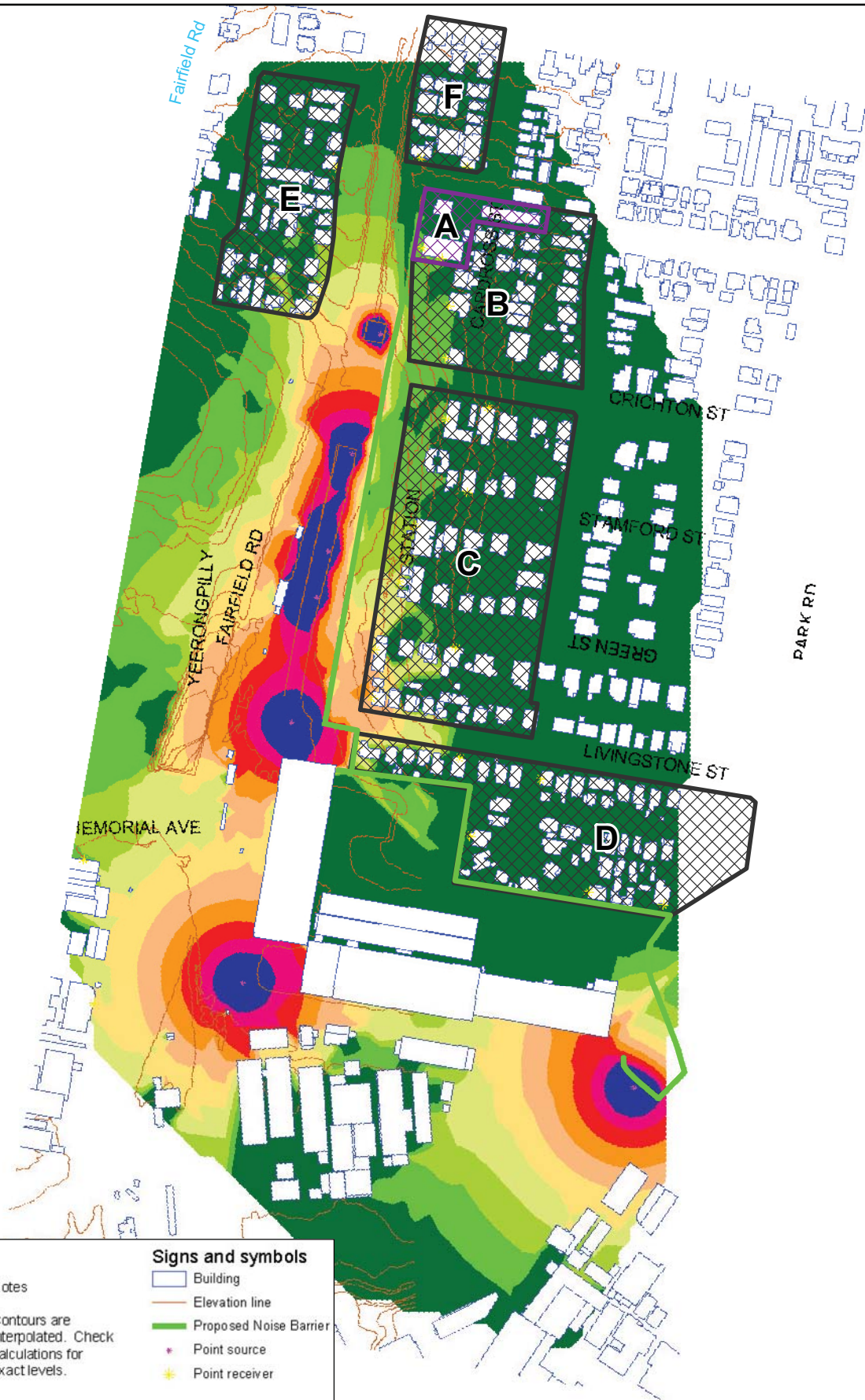
Figure 16-19

Southern Portal - Phase 2 Pile Installation Night-time



CrossRiverRail

SKM aurecon
CRR JOINT VENTURE



Noise Level
dBA

<= 50
50 < <= 53
53 < <= 56
56 < <= 59
59 < <= 62
62 < <= 65
65 < <= 68
68 < <= 71
71 < <= 74
74 <

Notes

Contours are interpolated. Check calculations for exact levels.

Signs and symbols

[Building symbol]	Building
[Elevation line symbol]	Elevation line
[Proposed Noise Barrier symbol]	Proposed Noise Barrier
[Point source symbol]	Point source
[Point receiver symbol]	Point receiver

LEGEND

[Residential Receiver symbol]	Residential Receiver
[Place of Worship Receiver symbol]	Place of Worship Receiver

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 16-20

Southern Portal - Phase 3 TBM Support
Day and Night-time

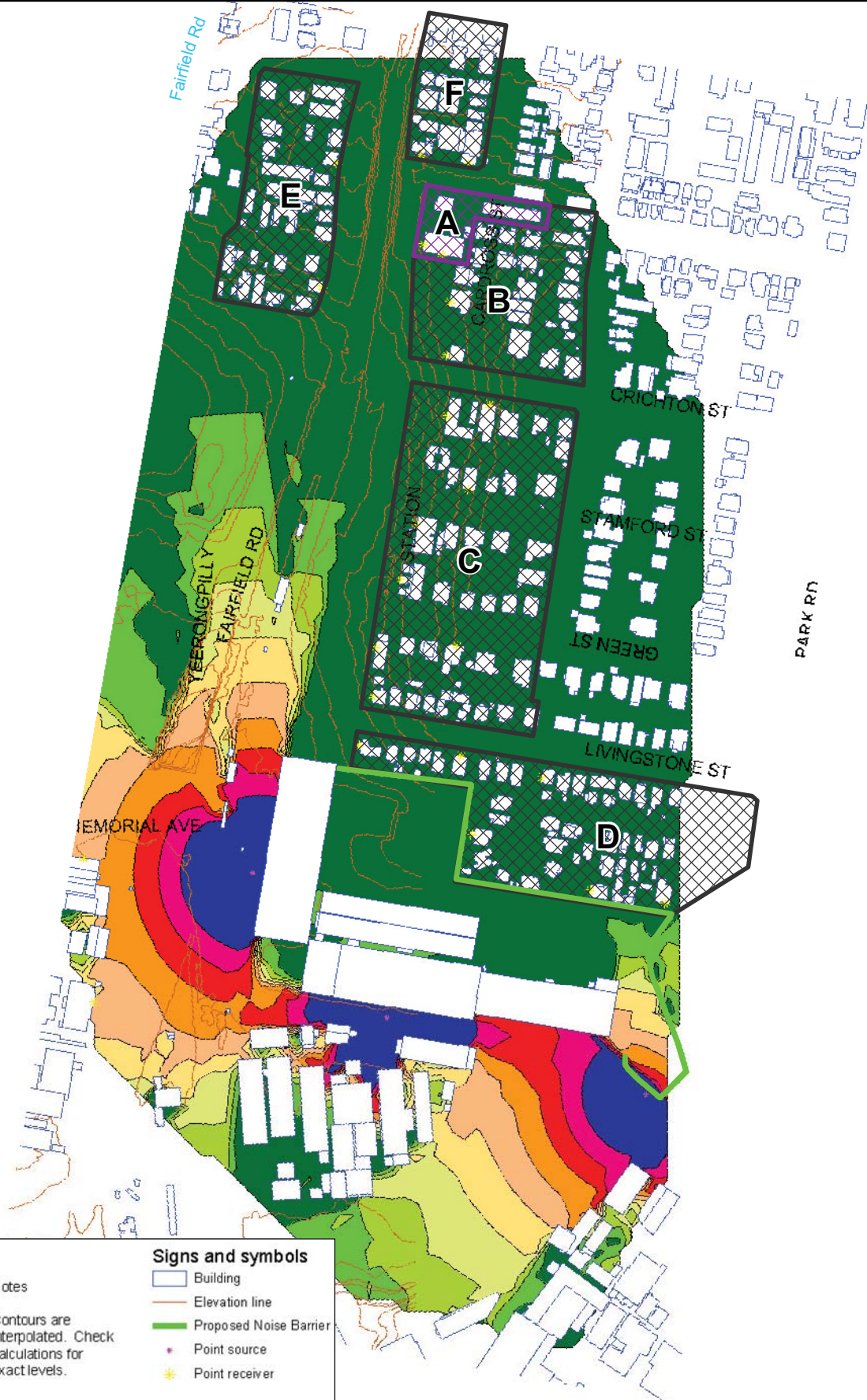
0 50 100 150 200 Meters

1:5,000 at A4

N

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE



Noise Level
dBA

<= 50
50 < <= 53
53 < <= 56
56 < <= 59
59 < <= 62
62 < <= 65
65 < <= 68
68 < <= 71
71 < <= 74
74 <

Notes

Contours are interpolated. Check calculations for exact levels.

Signs and symbols

[Building symbol]	Building
[Elevation line symbol]	Elevation line
[Proposed Noise Barrier symbol]	Proposed Noise Barrier
[Point source symbol]	Point source
[Point receiver symbol]	Point receiver

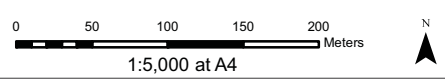
LEGEND

[Residential Receiver symbol]	Residential Receiver
[Place of Worship Receiver symbol]	Place of Worship Receiver

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 16-21

Southern Portal - Phase 4 Spoil Trucks Movements
Night-time



Initial predictions in **Table 16-27** indicated that the predicted noise levels for TBM support including spoil removal (ie Phase 3) will still be exceeded at 2 receiver locations with the mitigation described. Exceedances of up to 20 dBA are predicted during the night-time period at the nearest residential receivers with 3 m high acoustic hoarding. The predicted noise levels indicate that a high performance acoustic enclosure or individual property mitigations are likely to be required, subject to detailed design and consultation⁷. The effectiveness of the enclosure materials in reducing noise is provided in **Section 16.4.1**.

The results of the SoundPLAN noise modelling for this worksite indicate that a hierarchy of noise controls would be required in order for the worksite to operate continuously whilst complying with the noise goals for the duration of the Project (refer to *Technical Report No. 8 Noise and Vibration*). The hierarchy of controls would likely be in the form of:

- early and on-going consultation with affected residents and St Fabian's Church to inform them of the works program and to address concerns and complaints
- where practicable to do so, relocate plant inside the cut and cover tunnel or within the acoustic shed
- selection of quietest available and noise mitigated plant (ie fitted with appropriate exhaust silencers, mufflers or acoustic covers)
- mitigating each acoustically significant item of plant required to operate within the enclosure (eg residential grade mufflers on all front end loaders)
- subsequent to the above measures, detailed design of a high performance acoustic enclosure, which may include double-skin walls and a ceiling lined with sound absorptive material, minimising openings and fitting acoustic louvres to ventilation openings. Access and ventilation openings would be constructed on the western facade of the enclosure away from residences
- if necessary, mitigating noise at individually affected receivers through property treatments (eg mechanical ventilation, glazing upgrades).

Noise monitoring would be conducted at residential premises near the worksite eg Livingstone Street, Park Lane and east of Wilkie Street. Construction activities at the southern portal worksite would be undertaken in accordance with the hours of work provided in **Chapter 24 Draft Outline EMP**.

Spoil movements by trucks within the main Yeerongpilly worksite during the night-time period achieve compliance with the sleep disturbance noise goal as a result of the shielding being afforded by the existing warehouses and other structures on Lucy Street, in combination with 4 m high hoarding adjacent to the worksite entrance at Lucy Street. In order to achieve compliance, the Project would be required to retain the warehouses and other structures. Average spoil truck movements per day and peak hourly truck movements per day at the worksite (24 hour, two-way trips) are predicted to be 86 vehicles and 9 vehicles respectively. Truck deliveries of materials and machinery are predicted to average 23 trucks per day (24 hour, one-way volumes) (refer to *Section 9.4 of Technical Report No. 8 – Noise and Vibration* for details of construction traffic movements).

The movement of trucks within the main worksite would be managed to limit the need for reversing and use of reversing alarms.

⁷ a high performance acoustic enclosure provides double skin walls and roof lined with sound absorptive material and acoustic louvres to ventilation openings

With these mitigation measures in place, combined with careful management of all heavy vehicle movements on the worksite, eg limiting the need for reversing and use of reversing alarms, compliance with the noise criteria during all time periods could be achieved at the southern portal worksite with the exception of initial demolition works during day-time hours and work requiring a rail possession. The latter works could not be reasonably and feasibly mitigated to achieve compliance with the day-time noise goal. Early consultation with affected residents would be required.

Cumulative construction noise impacts from the Yeerongpilly Transit Oriented Development (TOD) site have not been assessed as the construction programs for both projects are yet to be finalised. Should construction works for these projects coincide, it would be anticipated that cumulative construction noise impacts (day-time only) would be mostly limited to receivers located on the western side of the rail corridor north of the Yeerongpilly TOD site, ie Ortive Street. A large number of noise sensitive receivers located on the eastern side of the rail corridor would be shielded from the TOD site by the Projects acoustic enclosure. If required, mitigation of cumulative construction noise from the two projects would be considered during the detailed design stage.

16.4.6 Underground station construction

Roma Street

The nearest noise and vibration sensitive receivers to the Roma Street Station worksite are identified on **Figure 16-22** and in **Table 16-28**.

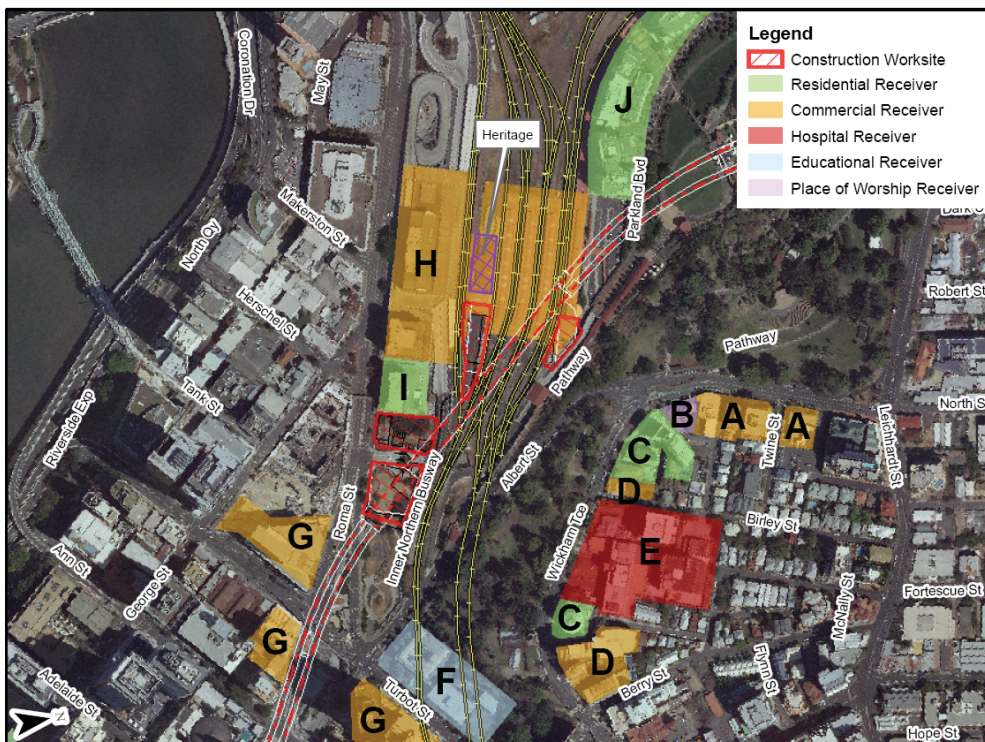


Figure 16-22 Roma Street Station worksite and receiver areas

Table 16-28 Nearest sensitive receivers – Roma Street Station

Worksite/Excavation	Receiver Area	Location Relative to Works (m)
Roma Street Station	A – Wickham Terrace Commercial	150
	B – St Alban Liberal Catholic Church	125
	C – Wickham Terrace Residential	120
	D – Wickham Terrace Commercial	140
	E – Brisbane Private Hospital	130
	F – Brisbane Dental Educational	100
	G – Turbot Street Commercial	40
	H – Roma Street Station Commercial ¹	10
	I – Holiday Inn Residential	50
	J – Parkland Crescent Residential	150

Note:

1. Receiver includes Brisbane Transit Centre and Roma Street Station platforms of which the southern building is heritage listed.

Phases were identified for construction works at Roma Street Station being representative of activities having potentially the greatest noise impact on the surrounding receivers. Worst case scenarios were developed based on all plant items, including haul trucks where applicable, operating simultaneously. The construction phases are:

- Phase 1 – site establishment including demolition:
 - North shaft duration approximately 6 weeks
 - Central shaft duration approximately 10 weeks
 - South shaft duration approximately 6 weeks
 - Dominant noise sources include excavators and cranes
 - Mostly day-time construction works with potential for night-time work to avoid impact on existing rail operations for the central shaft
- Phase 2 – piling of access shafts:
 - North shaft duration approximately 8 weeks
 - Central shaft duration approximately 6 weeks
 - South shaft duration approximately 4 weeks
 - Dominant noise sources include piling rigs
 - Mostly day-time construction works with potential for night-time work to avoid impact on existing rail operations for the central shaft
- Phase 3 – shaft excavation:
 - North shaft duration approximately 12 weeks
 - Central shaft duration approximately 20 weeks
 - South shaft duration approximately 10 weeks
 - Dominant noise sources include jumbo drill rigs, excavators and front end loaders
 - 24 hour per day construction with night-time works carried out inside an acoustic enclosure at the south shaft.

Construction noise levels surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-29**, as outdoor values.

Internal goals for residential or commercial receivers have been adjusted, ie increased, to represent external free-field noise levels. An assessment of noise goal compliance is also provided with indicative noise level reductions based on 6 m acoustic hoarding for all phases and works carried out inside a medium performance acoustic enclosure (southern worksite only) for Phase 3. Note hatching (\\\\) indicates compliance, and "n/a" not applicable for the assessment period. Exceedances are worst case as they assume the highest predicted noise levels.

Table 16-29 Roma Street Station – predicted ‘worst case’ construction noise levels

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level ² (dBA) (calculated with 3 m hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With ‘Medium Performance’ Enclosure ³
A – Wickham Terrace Commercial	1	Day	LA10,adj – 72	49 – 51	\\\\	\\\\	n/a
	2	Day	LA10,adj – 72	51 – 52	\\\\	\\\\	n/a
	3	Day	LA10,adj – 72	48 – 50	\\\\	\\\\	\\\\
B – St Alban Liberal Catholic Church	1	Day	LA10,adj – 57	46 – 50	\\\\	\\\\	n/a
	2	Day	LA10,adj – 57	49 – 52	\\\\	\\\\	n/a
	3	Any	LA10,adj – 57	45 – 49	\\\\	\\\\	\\\\
C – Wickham Terrace Residential	1	Day	LA10,adj – 62	47 – 57	\\\\	\\\\	n/a
	2	Day	LA10,adj – 62	49 – 58	\\\\	\\\\	n/a
	3	Day	LA10,adj – 62	46 – 57	\\\\	\\\\	\\\\
	1	Night	LAmaj,adj – 57	52 – 62	5	\\\\	n/a
	2	Night	LAmaj,adj – 57	54 – 63	6	1	n/a
	3	Night	LAmaj,adj – 57	51 – 62	5	\\\\	\\\\
D – Wickham Terrace Commercial	1	Day	LA10,adj – 72	46 – 57	\\\\	\\\\	n/a
	2	Day	LA10,adj – 72	45 – 64	\\\\	\\\\	n/a
	3	Day	LA10,adj – 72	44 – 57	\\\\	\\\\	\\\\
E – Brisbane Private Hospital	1	Any	LA10,adj – 67	46 – 55	\\\\	\\\\	n/a
	2	Any	LA10,adj – 67	48 – 56	\\\\	\\\\	n/a
	3	Any	LA10,adj – 67	45 – 55	\\\\	\\\\	\\\\
F – Brisbane Dental Educational	1	Day	LA10,adj – 62	45 – 54	\\\\	\\\\	n/a
	2	Day	LA10,adj – 62	45 – 55	\\\\	\\\\	n/a
	3	Day	LA10,adj – 62	44 – 53	\\\\	\\\\	\\\\
G – Turbot Street Commercial	1	Day	LA10,adj – 72	51 – 70	\\\\	\\\\	n/a
	2	Day	LA10,adj – 72	54 – 72	\\\\	\\\\	n/a
	3	Day	LA10,adj – 72	54 – 71	\\\\	\\\\	\\\\
H – Roma Street Station Commercial	1	Day	LA10,adj – 65	62 – 79	14	9	n/a
	2	Day	LA10,adj – 65	64 – 77	12	7	n/a
	3	Day	LA10,adj – 65	63 – 76	11	6	\\\\

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level ² (dBA) (calculated with 3 m hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With 'Medium Performance' Enclosure ³
I – Holiday Inn Residential	1	Day	LA10,adj – 62	62 – 72	12	7	n/a
	2	Day	LA10,adj – 62	63 – 72	10	5	n/a
	3	Day	LA10,adj – 62	62 – 71	9	4	
	1	Night	LAmaj,adj – 57	67 – 77	20	15	n/a
	2	Night	LAmaj,adj – 57	68 – 77	20	15	n/a
	3	Night	LAmaj,adj – 57	67 – 76	19	14	7
J – Parkland Crescent Residential	1	Day	LA10,adj – 62	52 – 58			n/a
	2	Day	LA10,adj – 62	54 – 58			n/a
	3	Day	LA10,adj – 62	52 – 57			
	1	Night	LAmaj,adj – 57	57 – 63	6	1	n/a
	2	Night	LAmaj,adj – 57	59 – 63	6	1	n/a
	3	Night	LAmaj,adj – 57	57 – 62	5		



Noise goal achieved at receiver

Notes:

1. LA10,adj and LAmaj,adj (night-time) assessment parameters applicable for non-steady state and intermittent noise sources. LAeq,adj assessment parameter applicable to steady state or continuous (night-time) noise sources. All presented noise levels are external free-field. The noise goals include a correction for facade noise reduction, 7 dBA (residential) and 17 dBA (commercial), to represent external free-field noise goals.
2. Predicted noise levels include 3 m acoustic hoarding between noise sources and receivers.
3. A 'medium performance' enclosure provides an acoustically absorptive internal lining (refer to Section 16.4.1).

The predicted 'worst case' construction noise levels for Roma Street Station works would exceed the noise goals for a number of receivers during the day-time and night-time period with the 3 m hoardings. The highest predicted noise goal exceedances during the three phases occur at the Roma Street Station and the Holiday Inn hotel. Consequently, a temporary hoarding of 6 m around the three worksites would be required to mitigate day-time impacts.

For the predicted 'worst case' construction noise levels, a 6 m hoarding around each worksite (where practicable), would keep night-time construction noise levels within 1 dBA of the sleep disturbance noise goal. This outcome would be unlikely to interfere with people's sleep. Facade noise reductions for residential buildings located within the CBD are likely to be substantially higher than the 10 dBA assumed for this assessment (refer to **Section 16.4.1**).

For construction works required in the Brisbane City precinct, it may prove onerous to apply absolute noise goals in locations characterised by relatively constant high ambient noise levels. For example, ambient night-time noise levels measured over a week at monitoring location 6 (ie Parkland Crescent) in **Figure 16-4** ranged between 75 to 80 dBA LAmaj and 59 to 63 dBA LAeq. Comparison of predicted night-time construction noise levels in **Table 16-29** with a medium performance acoustic enclosure (eg residential receiver I-Holiday Inn LAmaj,adj – 64 dBA) indicates that worst case construction noise levels would be below the range of existing night-time ambient (LAmaj) noise levels.

Furthermore, the existing Brisbane City high-rise building worksites operate on a daily basis with no noise limits. It is likely that noise sensitive receivers in the vicinity of Roma Street Station worksites would associate initial construction work involving site establishment, demolition and piling with typical high-rise building construction works, particularly at the major southern worksite adjacent the station precinct. Where construction differs from typical inner city high-rise construction work is the subsequent long-term underground excavation of station caverns by roadheaders. The long-term phases would primarily occur below surface to minimise noise impacts. **Figure 16-23, Figure 16-24 and Figure 16-25** show noise contours for the above phases, with noise mitigation (3 m high acoustic hoarding surrounding the worksite).

Predicted ground-borne noise and vibration levels presented in **Table 16-30** for rockbreaking activities, indicate the relevant criteria could be achieved, resulting in no disturbance to occupiers of the Holiday Inn, residential and commercial properties on Wickham Terrace, the Brisbane Private Hospital and Brisbane Dental Centre, the St Alban Liberal Catholic Church or the heritage listed Old Train Station.

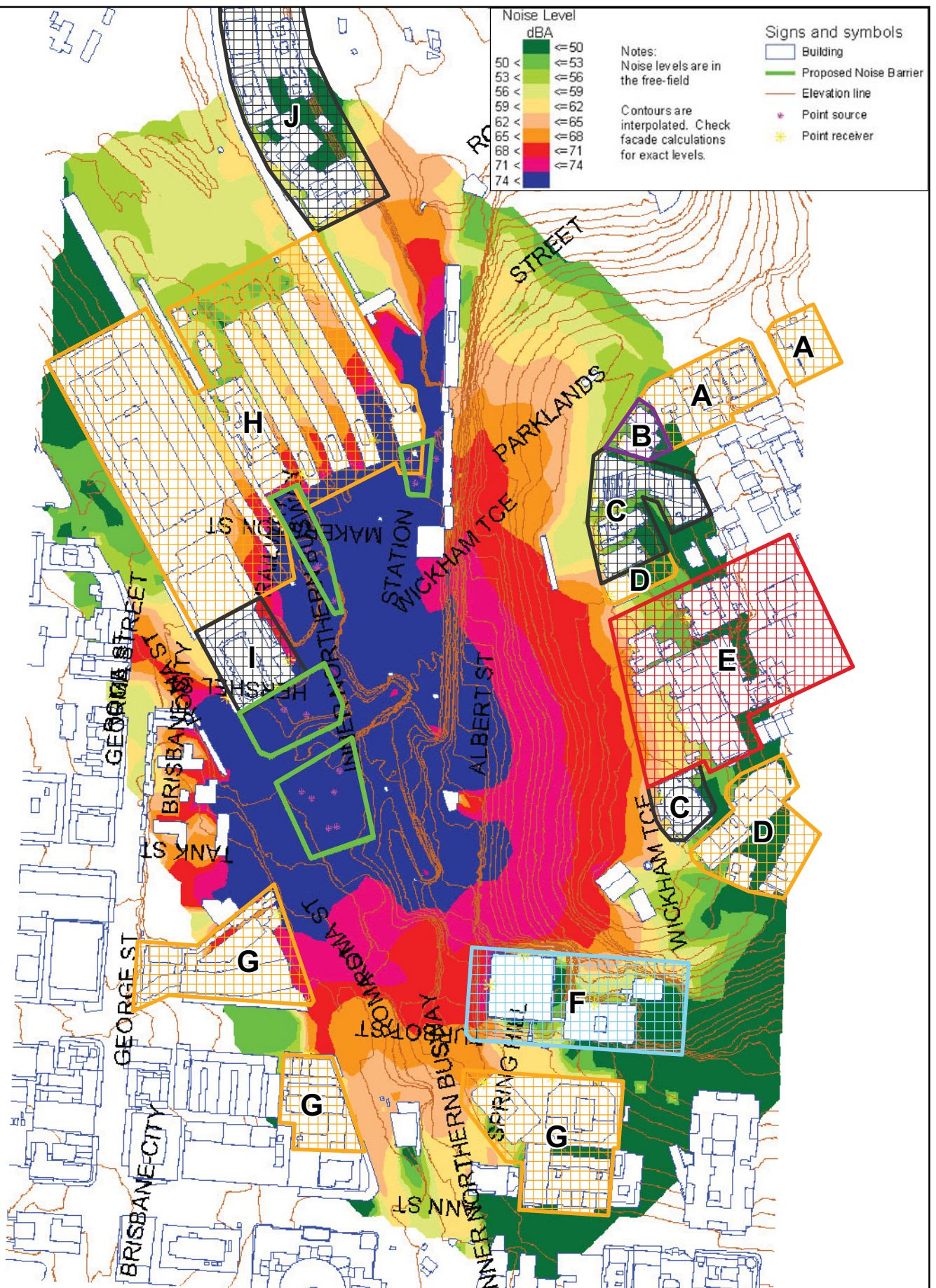
Table 16-30 Roma Street Station – predicted ‘worst case’ ground-borne noise and vibration levels

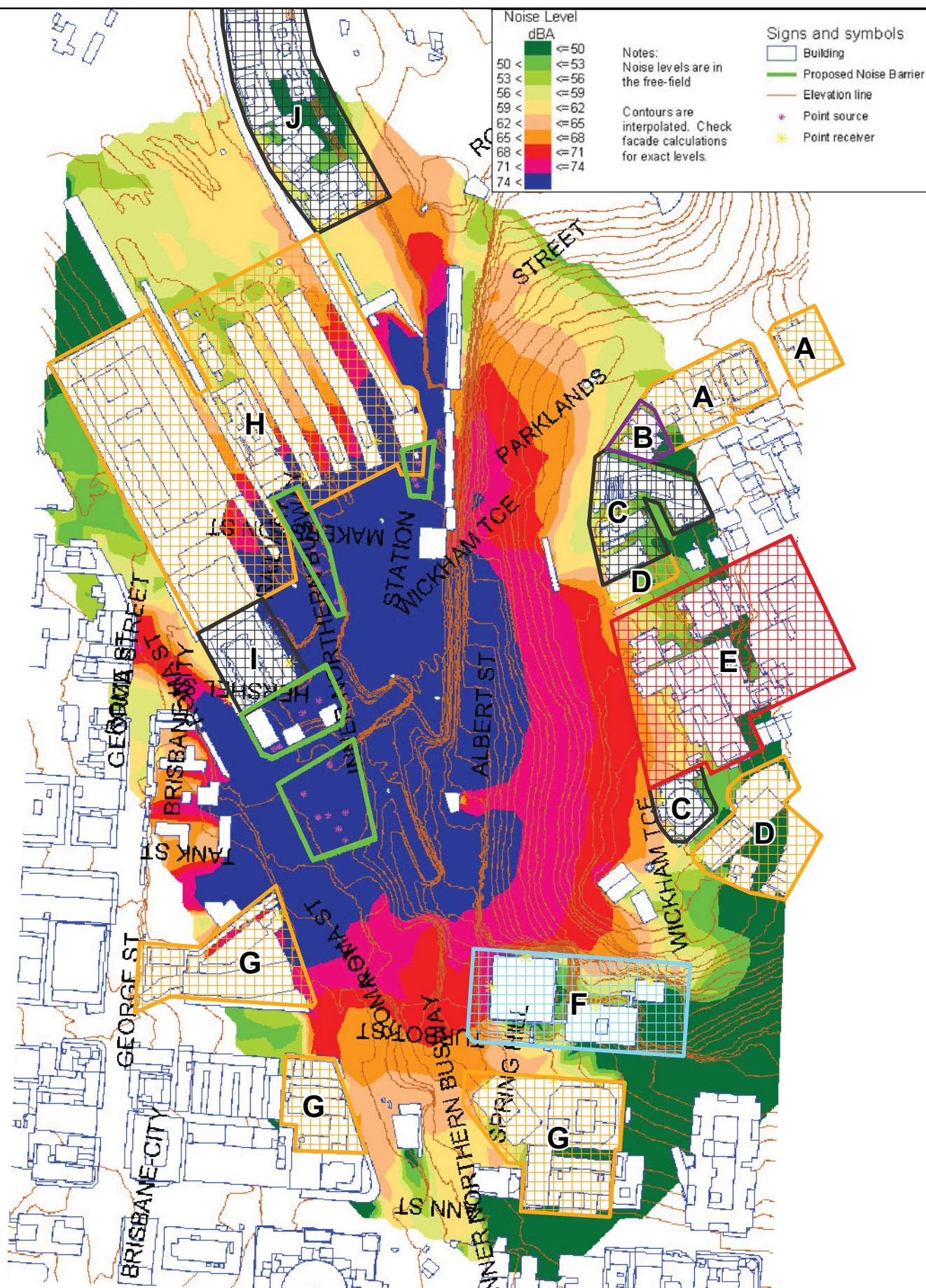
Receiver Area	Period	Noise and Vibration Goals		Predicted Ground-borne Noise and Vibration Levels (Rockbreaking)	
		Vibration PPV (mm/s)	Ground-borne Noise (dBA) ¹	Ground-borne Vibration (mm/s)	Ground-borne Noise (dBA)
A – Wickham Terrace Commercial	Day	5	LA10,adj – 65	0.02	26
B – St Alban Liberal Catholic Church	Day	2	LA10,adj – 50	0.03	28
C – Wickham Terrace Residential	Day	5	LA10,adj – 55	0.04	29
	Night	0.5	LAmx,adj – 50	0.04	34
D – Wickham Terrace Commercial	Day	5	LA10,adj – 65	0.03	27
E – Brisbane Private Hospital	Any	5	LA10,adj – 60	0.02	24
F – Brisbane Dental Educational	Day	5	LA10,adj – 55	0.04	29
G – Turbot Street Commercial	Day	5	LA10,adj – 65	0.14	39
H – Roma Street Station Commercial	Day	5	LA10,adj – 65	0.37	47
H – Old Train Station (heritage listed)	Day	2	LA10,adj – 65	0.53	49
I – Holiday Inn Residential	Day	5	LA10,adj – 55	0.14	39
	Night	0.5	LAmx,adj – 50	0.14	44
J – Parkland Crescent Residential	Day	5	LA10,adj – 55	0.03	26
	Night	0.5	LAmx,adj – 50	0.03	31

Note:

¹ Dominant construction noise during shaft excavation likely to be non-steady state and intermittent. Therefore the LA10,adj and LAmx,adj (night-time) assessment parameters are most relevant. For ground-borne noise, all noise levels are internal levels.

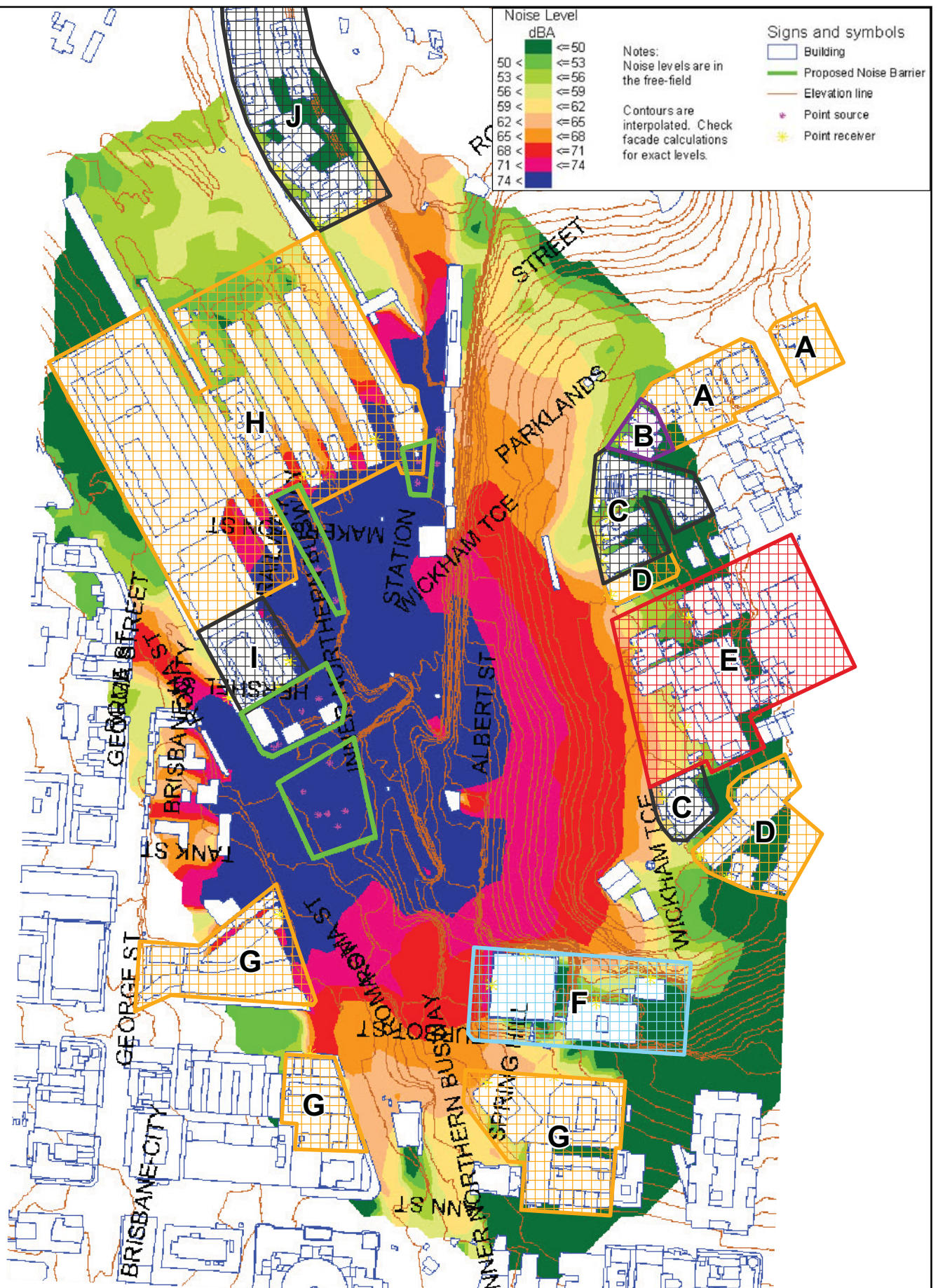
Assuming airblast overpressure can be sufficiently mitigated at the worksite, eg blast mat, enclosure, drill and blast excavation at Roma Street Station would need to be constrained by low MICs (ie the maximum amount of explosive in kilograms on any one specific delay detonator in any one blast hole). The estimated charges would need to be limited to 0.5 kg to protect the heritage listed station building, subject to a detailed survey of the structure, monitoring during construction and adjustments to the excavation works implemented, if required (refer to **Section 16.4.14**).





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Should drill and blast be required for this worksite, the following management measures would be required:

- early and on-going consultation with building owners and occupants
- use of latest available blasting technology (eg PCF)
- pre-blasting condition survey of the heritage station building and adjacent buildings
- appropriate attention to blast design and commence blasting with a low MIC to develop a site law (ie blast design model) based on measurement data from the worksite
- monitoring of the blast emissions.

Approximately 40 worker car park spaces would be provided on a satellite worksite off Parkland Boulevard. On-street car parking would be discouraged through Brisbane Central traffic area. Workforce parking and management of noise, safety, access and amenity would be fully addressed in the construction traffic management plans prepared by the construction contractor. Construction activities at the Roma Street Station worksite would be undertaken in accordance with the hours of work which are provided in **Chapter 24 Draft Outline EMP**.

Albert Street Station

The nearest noise and vibration sensitive receivers to the Albert Street Station worksites are identified on **Figure 16-26** and in **Table 16-31**.

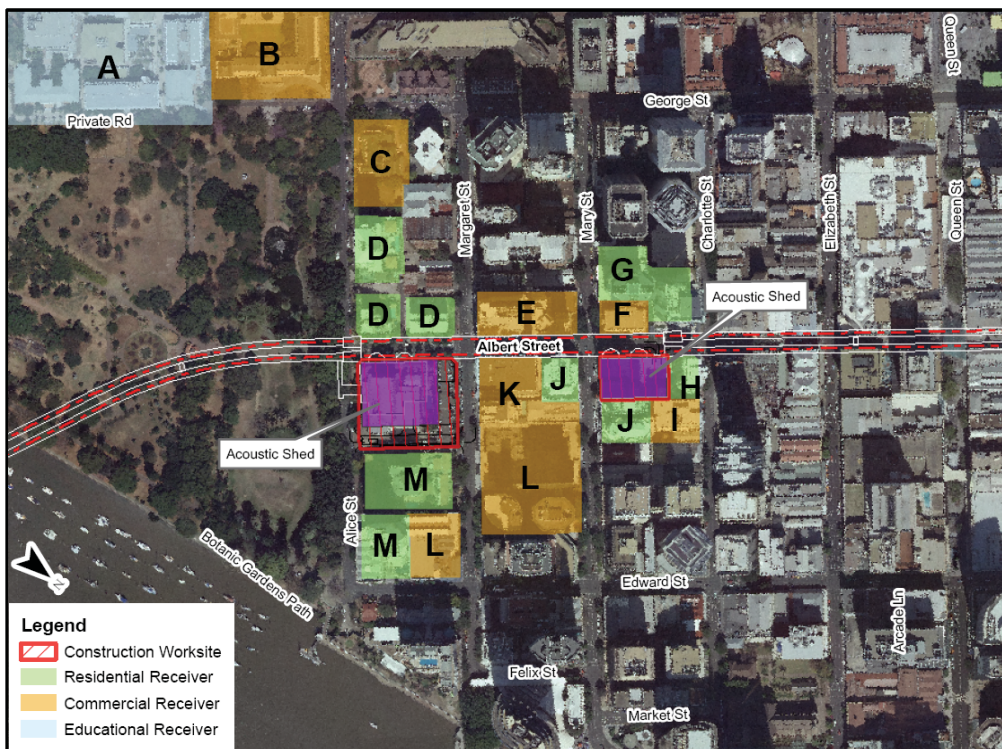


Figure 16-26 Albert Street Station worksite and receiver areas

Table 16-31 Nearest sensitive receivers – Albert Street Station

Worksite/Excavation	Receiver Area	Location Relative to Works (m)
Albert Street Station	A – Queensland University of Technology	270
	B – Parliament House	260
	C – Alice Street Commercial	170
	D – Alice Street (high rise) Residential	25
	E – Albert Street Commercial	25
	F – Albert Street Commercial	20
	G – Albert Street Residential	25
	H – Albert Street Residential	5
	I – Charlotte Street Commercial	5
	J – Mary Street Residential	20
	K – Albert Street Commercial	20
	L – Margaret Street Commercial	45
	M – Alice Street Residential	25

Phases were developed for Albert Street Station construction works being representative of activities having potentially the greatest noise impact on the surrounding receivers. Worst case scenarios have been developed based on all plant items, including haul trucks where applicable, operating simultaneously. The construction phases are:

- Phase 1 – demolition of existing buildings
 - north shaft duration approximately 10 weeks
 - south shaft duration approximately 20 weeks
 - dominant noise sources include rockbreakers, excavators and spoil trucks
 - mostly day-time construction works, noting that the night-time period in the CBD currently experiences higher noise levels than suburban areas and as such it would seem “reasonable” for construction (eg spoil removal) to extend into the night-time period
- Phase 2 – piling around shaft perimeter
 - north shaft duration approximately 10 weeks
 - south shaft duration approximately 4 weeks
 - dominant noise sources include piling rigs
 - mostly day-time construction works, noting that the night-time period in the CBD currently experiences higher noise levels than suburban areas and as such it would seem “reasonable” for construction (eg spoil removal) to extend into the night-time period
- Phase 3 – shaft excavation within an acoustic enclosure
 - north shaft duration approximately 20 weeks
 - south shaft duration approximately 10 weeks
 - dominant noise sources include jumbo drill rigs, excavators and front end loaders
 - 24-hour per day construction with night-time works carried out inside acoustic enclosures.

Construction noise levels with 3 m or 6 m high acoustic hoarding surrounding the site have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-32**, as outdoor values. Internal goals for residential or commercial receivers have been adjusted, ie increased, to represent external free-field noise levels.

An assessment of noise goal compliance is also provided with indicative noise level reductions based on acoustic hoarding for all phases and works carried out inside an acoustic enclosure for Phase 3. Note hatching (\\) indicates compliance and “n/a” not applicable for the assessment period. Exceedances are worst case as they assume the highest predicted noise levels.

Table 16-32 Albert Street Station – predicted ‘worst case’ construction noise levels

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) (calculated with 3 m Hoarding) ²	Noise Goal Exceedance with Level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With ‘Medium Performance’ Enclosure ³
A – QUT	1	Day	LA10,adj – 62	58 – 63	1	\\	n/a
	2	Day	LA10,adj – 62	52 – 54	\\	\\	n/a
	3	Day	LA10,adj – 62	53 – 58	\\	\\	\\
B – Parliament House	1	Day	LA10,adj – 72	60 – 63	\\	\\	n/a
	2	Day	LA10,adj – 72	51 – 54	\\	\\	n/a
	3	Day	LA10,adj – 72	55 – 58	\\	\\	\\
C – Alice Street Commercial	1	Day	LA10,adj – 72	52 – 55	\\	\\	n/a
	2	Day	LA10,adj – 72	47 – 49	\\	\\	n/a
	3	Day	LA10,adj – 72	45 – 48	\\	\\	\\
D – Alice Street Residential	1	Day	LA10,adj – 62	61 – 85	23	18	n/a
	2	Day	LA10,adj – 62	64 – 78	16	11	n/a
	3	Day	LA10,adj – 62	55 – 79	17	12	5
	1	Night	LAmaj,adj – 57	66 – 90	33	28	n/a
	2	Night	LAmaj,adj – 57	69 – 83	26	21	n/a
	3	Night	LAmaj,adj – 57	60 – 84	27	22	15
E – Albert Street Commercial	1	Day	LA10,adj – 72	78 – 80	8	3	n/a
	2	Day	LA10,adj – 72	68 – 72	\\	\\	n/a
	3	Day	LA10,adj – 72	71 – 77	5	\\	\\
F – Albert Street Commercial	1	Day	LA10,adj – 72	84 – 85	13	8	n/a
	2	Day	LA10,adj – 72	74 – 77	5	\\	n/a
	3	Day	LA10,adj – 72	79 – 81	9	4	\\
G – Albert Street Residential	1	Day	LA10,adj – 62	59 – 84	22	17	n/a
	2	Day	LA10,adj – 62	54 – 75	13	8	n/a
	3	Day	LA10,adj – 62	60 – 79	17	12	5
	1	Night	LAmaj,adj – 57	64 – 89	32	27	n/a
	2	Night	LAmaj,adj – 57	59 – 80	23	18	n/a
	3	Night	LAmaj,adj – 57	65 – 84	27	22	15

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) (calculated with 3 m Hoarding) ²	Noise Goal Exceedance with Level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With 'Medium Performance' Enclosure ³
H – Albert Street Residential	1	Day	LA10,adj – 62	81 – 89	27	22	n/a
	2	Day	LA10,adj – 62	72 – 74	12	7	n/a
	3	Day	LA10,adj – 62	76 – 79	17	12	5
	1	Night	LAmx,adj – 57	86 – 94	37	32	n/a
	2	Night	LAmx,adj – 57	77 – 79	22	17	n/a
	3	Night	LAmx,adj – 57	81 – 84	27	22	15
I – Charlotte Street Commercial	1	Day	LA10,adj – 72	82 – 85	13	8	n/a
	2	Day	LA10,adj – 72	76 – 79	7	2	n/a
	3	Day	LA10,adj – 72	79 – 82	10	5	
J – Mary Street Residential	1	Day	LA10,adj – 62	69 – 84	22	17	n/a
	2	Day	LA10,adj – 62	62 – 83	21	16	n/a
	3	Day	LA10,adj – 62	62 – 82	20	15	8
	1	Night	LAmx,adj – 57	74 – 89	32	27	n/a
	2	Night	LAmx,adj – 57	67 – 88	31	26	n/a
	3	Night	LAmx,adj – 57	67 – 87	30	25	18
K – Albert Street Commercial	1	Day	LA10,adj – 72	69 – 75	3		n/a
	2	Day	LA10,adj – 72	62 – 68			n/a
	3	Day	LA10,adj – 72	62 – 77	5		
L – Margaret Street Commercial	1	Day	LA10,adj – 72	56 – 74	2		n/a
	2	Day	LA10,adj – 72	49 – 67			n/a
	3	Day	LA10,adj – 72	51 – 68			
M – Alice Street Residential	1	Day	LA10,adj – 62	56 – 84	22	17	n/a
	2	Day	LA10,adj – 62	48 – 76	14	9	n/a
	3	Day	LA10,adj – 62	49 – 77	15	10	3
	1	Night	LAmx,adj – 57	61 – 89	32	27	n/a
	2	Night	LAmx,adj – 57	53 – 81	24	19	n/a
	3	Night	LAmx,adj – 57	54 – 82	25	20	13



Noise goal achieved at receiver

Notes:

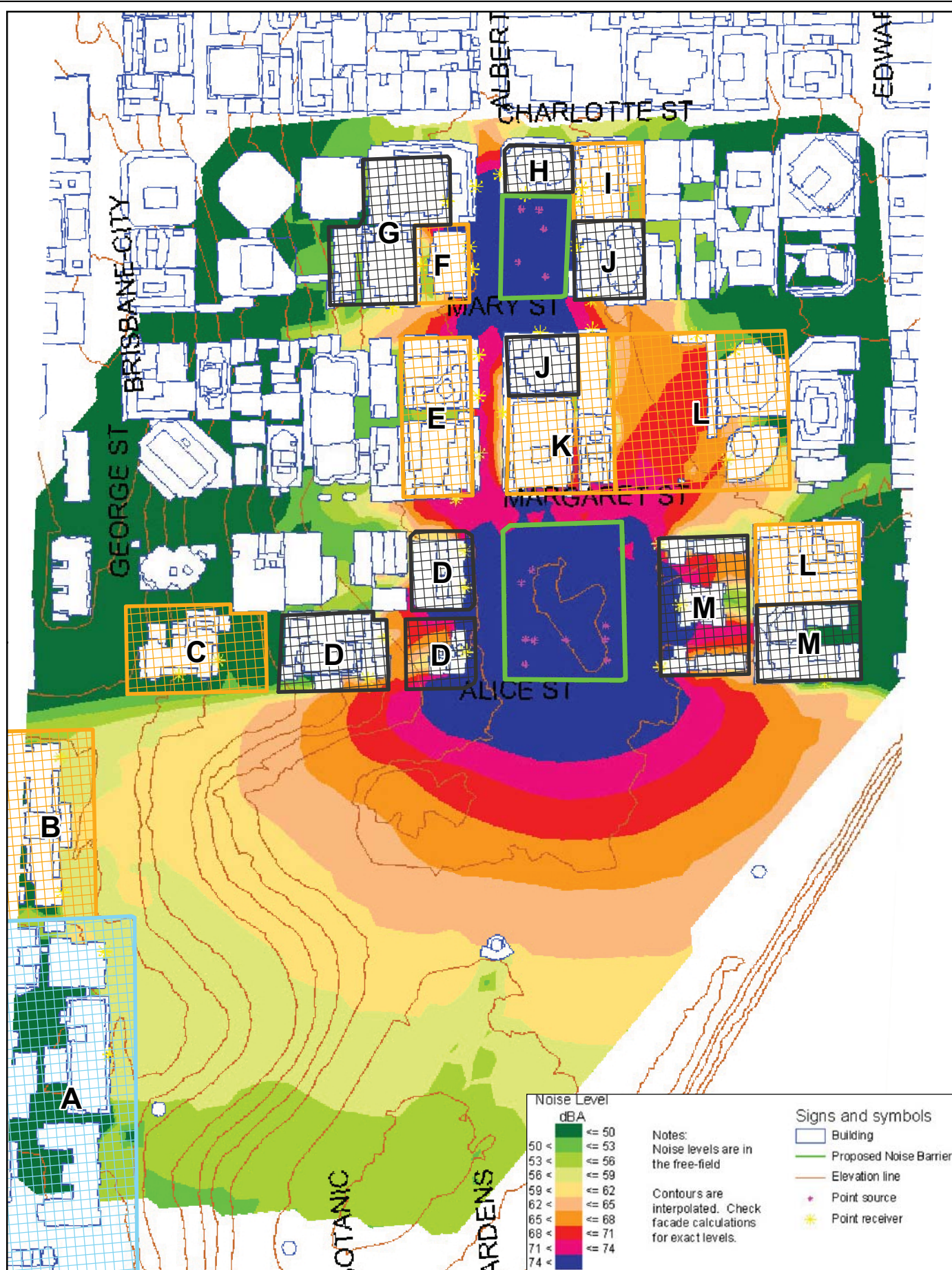
1. LA10, adj and LAmx,adj (night-time) assessment parameters applicable for non-steady state and intermittent noise sources. LAeq,adj assessment parameter applicable to steady state or continuous (night-time) noise sources. All presented noise levels are external free-field. The noise goals include a correction for facade noise reduction, 7 dBA (residential) and 17 dBA (commercial), to represent external free-field noise goals (refer to Section 16.4.1).
2. Predicted noise levels include 3 m acoustic hoarding between noise sources and receivers.
3. A medium performance enclosure provides an acoustically absorptive internal lining (refer to Section 16.4.1).

The predicted 'worst case' noise levels for worksite establishment, including demolition of the existing buildings at the two Albert Street Station worksites indicate exceedances of up to 27 dBA of the noise goal for day-time operations and up to 37 dBA above the night-time noise goal at the nearest residential receivers with 3 m hoardings. Noise goal exceedances of these orders would be unacceptable during the night-time period. The type of machinery used during worksite establishment and piling would not be completely obscure the proposed barriers and would therefore not produce significant noise attenuation. Since an acoustic enclosure would also not be feasible during the site establishment and piling activities, such works would need to be restricted to the day-time period. It is noted that a number of inner city constructions have progressed, or are in progress in proximity to the two Albert Street worksites. Construction at these sites is generally limited to day-time hours.

Buildings in the CBD are assumed to have façade noise reductions greater than 10 dBA (refer to **Section 16.4.1** for the façade adjustment methodology). The assumed facade noise reductions of 10 dBA (7 dBA in the free-field) would be likely to perform significantly better at residential receiver buildings located within the CBD and in proximity to the Albert Street worksites. Predicted noise levels have been considered with respect to existing ambient noise levels in the vicinity of the two Albert Street Station worksites. Ambient night-time noise levels measured over a week at monitoring location 7, ie 191 George Street, in **Figure 16-4** ranged between 70 to 78 dBA L_{Amax} and 58 to 68 dBA L_{Aeq}. Comparison of the predicted night-time construction noise levels in **Table 16-32** with a medium performance acoustic enclosure (eg residential receiver J-Mary Street L_{Amax,adj} – 75 dBA) indicates that worst case construction noise levels would be within the range of existing night-time ambient noise levels. Construction activities at the Albert Street worksites would be undertaken in accordance with the hours of work provided in **Chapter 24 Draft Outline EMP**.

Once excavation of the station shafts has progressed far enough to allow for installation of acoustic enclosures, noise levels would decrease significantly. A high performance acoustic enclosure would be required in combination with the quietest available construction plant, ie fitted with appropriate exhaust silencers, mufflers or acoustic covers. The design and construction of the high performance acoustic enclosure would need to address and achieve the noise goals for the scheduled construction activities.

Figure 16-27, Figure 16-28, Figure 16-29 and Figure 16-30 show noise contours for the phases examined with 3 m high acoustic hoarding.



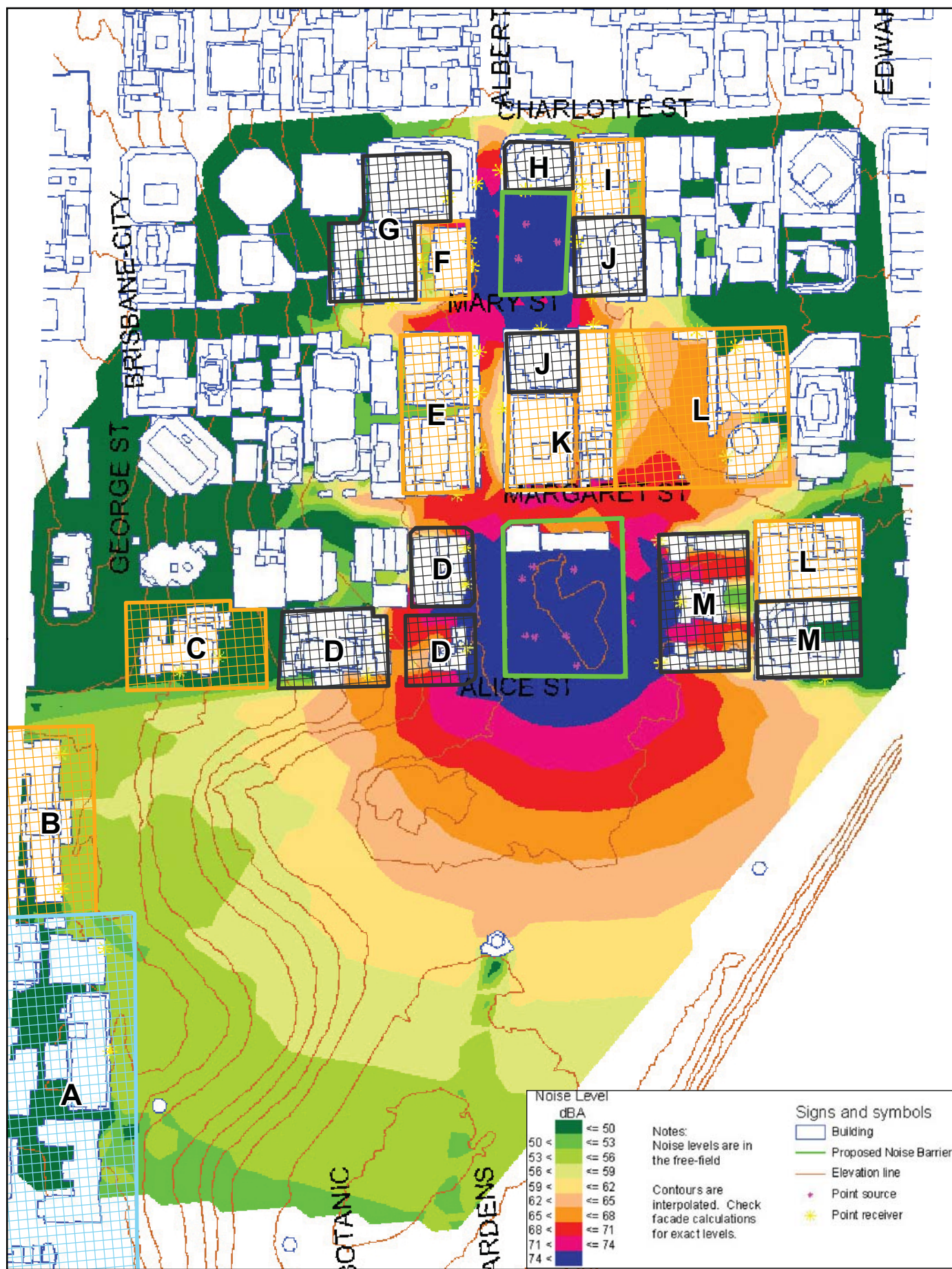
CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 16-27
Albert Street Station - Phase 1 Demolition
Daytime

0 25 50 75 100 125 Meters
1:3,000 at A4

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ENVIRONMENTAL IMPACT STATEMENT

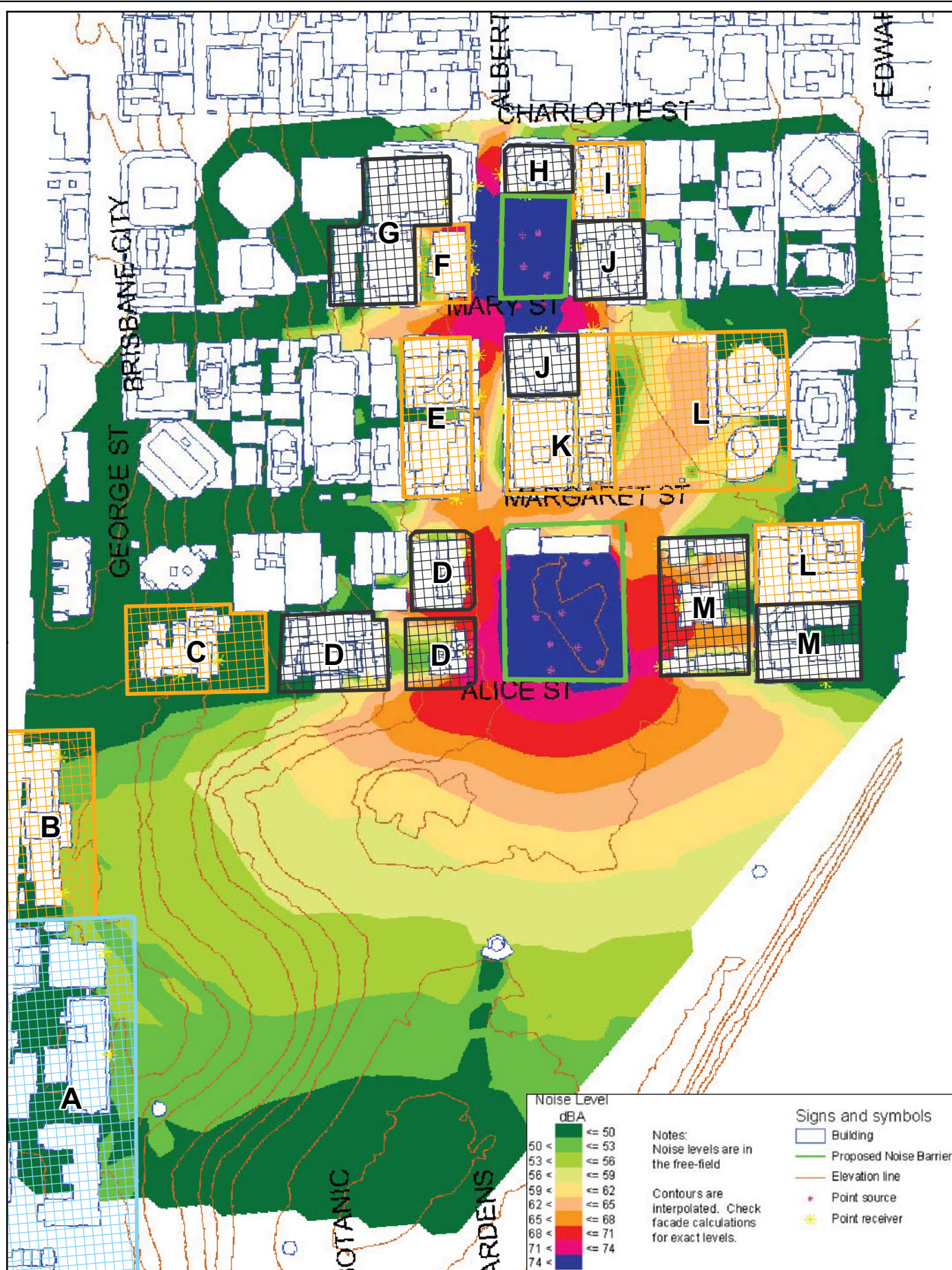
Figure 16-28

Albert Street Station - Phase 2 Piling
Daytime

0 25 50 75 100 125 Meters
1:3,000 at A4

CrossRiverRail

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CROSS RIVER RAIL ENVIRONMENTAL IMPACT STATEMENT

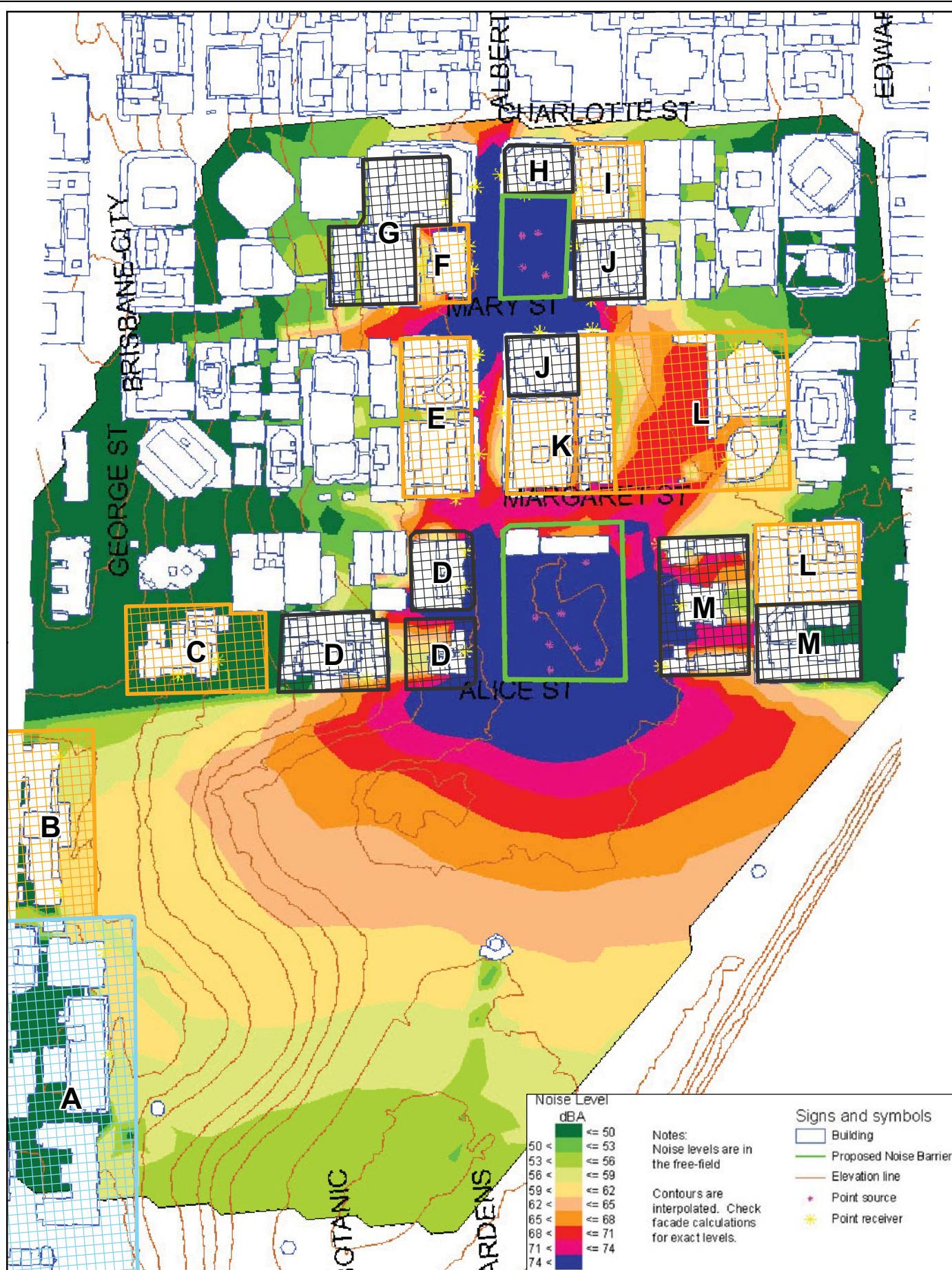
Figure 16-29

Albert Street Station - Phase 3 Shaft Excavation
Daytime

0 25 50 75 100 125 Meters
1:3,000 at A4

CrossRiverRail

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CROSS RIVER RAIL ENVIRONMENTAL IMPACT STATEMENT

Figure 16-30
Albert Street Station - Phase 3 Shaft Excavation
Night-time

0 25 50 75 100 125 Meters
1:3,000 at A4

CrossRiverRail

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Predicted ground-borne noise and vibration impacts for the excavation of Albert Street Station access shafts are presented in **Table 16-33**.

Table 16-33 Albert Street Station – predicted ‘worst case’ ground-borne noise and vibration levels

Receiver Area	Period	Noise and Vibration Goals		Predicted Ground-borne Noise and Vibration Levels (Rockbreaking)	
		Vibration PPV (mm/s)	Ground-borne Noise (dBA) ¹	Ground-borne Vibration (mm/s)	Ground-borne Noise (dBA) (ground level)
A – QUT (heritage listed)	Day	2	LA10,adj – 55	0.01	23
B – Parliament House (heritage listed)	Day	2	LA10,adj – 65	0.01	24
C – Queensland Club (heritage listed)	Day	2	LA10,adj – 65	0.02	29
D – Alice Street Residential	Day	5	LA10,adj – 55	0.57	55
	Night	0.5	LAmx,adj – 50	0.57	60
E – Albert Street Commercial	Day	5	LA10,adj – 65	0.23	48
F – Albert Street Commercial	Day	5	LA10,adj – 65	0.31	50
G – Albert Street Residential	Day	5	LA10,adj – 55	0.19	46
	Night	0.5	LAmx,adj – 50	0.19	51
H – Albert Street Residential	Day	5	LA10,adj – 55	0.25	49
	Night	0.5	LAmx,adj – 50	0.25	54
I – Charlotte Street Commercial	Day	5	LA10,adj – 65	0.67	56
J – Mary Street Residential	Day	5	LA10,adj – 55	1.56	63
	Night	0.5	LAmx,adj – 50	1.56	68
K – Albert Street Commercial	Day	5	LA10,adj – 65	0.59	55
L – Margaret Street Commercial	Day	5	LA10,adj – 65	0.23	48
M – Alice Street Residential	Day	5	LA10,adj – 55	0.29	50
	Night	0.5	LAmx,adj – 50	0.29	55

Note:

1. Dominant construction noise during shaft excavation is likely to be non-steady state and intermittent. Therefore the LA10,adj and LAmx,adj (night-time) assessment parameters are most relevant. For ground-borne noise, all noise levels are internal levels.

The ground-borne noise levels presented in **Table 16-33** for rockbreaking during excavation of Albert Street Station shafts are predicted to exceed the night-time noise goals for five residential receivers and one residential receiver during the day-time period. The Mary Street residential receiver would be located less than 10 m from the northern shaft and approximately 13 m slant distance from the inferred rock level. Exceedance of the day-time internal noise goal of 55 dBA LA10 would be anticipated until rockbreaking had progressed beyond approximately 20 m slant distance from the receiver building.

As a guide, ground-borne noise levels attenuate by approximately 2 dB per floor for the first four floors and by approximately 1 dB per floor thereafter. On this basis, receivers located on the first five floors of the building may require temporary relocation until a slant distance of approximately 20 m has been reached. The temporary relocation of people is a possible mitigation option included as part of a hierarchy of noise controls for the construction phase.

Monitoring of ground-borne noise and vibration would be conducted at several places representative of sensitive receptors along Albert Street, including the City Hall, residential premises and any commercial premises containing sensitive office equipment. Assuming airblast overpressure can be sufficiently mitigated at the worksite, eg blast mat, enclosure etc, drill and blast excavation at both Albert Street Station shafts would need to be constrained by low MICs estimated to be:

- north shaft – 1.0 kg to comply with the vibration criterion at Mary Street residences
- south shaft – 4.3 kg to comply with the vibration criterion at Alice Street residences.

Should drill and blast be required for either of these worksites, the following management measures would be required:

- early and on-going consultation with affected property owners and occupants
- use of latest available blasting technology (eg PCF)
- pre-blasting condition survey of adjacent buildings
- appropriate attention to blast design and commence blasting with a low MIC to develop a site law (ie blast design model) based on measurement data from the worksite
- monitoring of the blast emissions.

It is anticipated that the initial stages of shaft excavation would be carried out by rockbreaker due to the closeness of sensitive receiver buildings. The point at which drill and blast excavation could be safely and efficiently carried out within the shaft would be determined as part of detailed investigations for the worksite. Acoustically, exposure to a short-term blast event would be proposed to long term rockbreaking where ground-borne noise impacts have been identified.

Boggo Road Station

The nearest noise and vibration sensitive receivers to the Boggo Road Station worksite are identified on **Figure 16-31** and in **Table 16-34**.

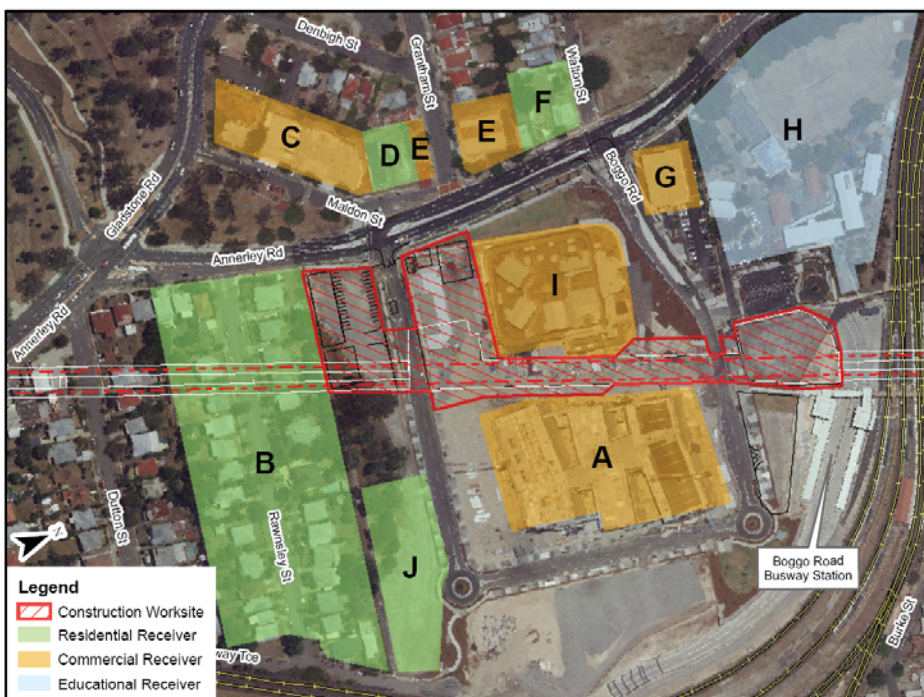


Figure 16-31 Boggo Road Station worksite and receiver areas

Table 16-34 Nearest sensitive receivers – Boggo Road Station

Worksite/Excavation	Receiver Area	Location Relative to Works (m)
Boggo Road Station	A – Ecosciences Building Commercial	5
	B – Rawnsley Street Residential	15
	C – Maldon Street Commercial	45
	D – Maldon Street Residential	40
	E – Grantham Street Commercial	35
	F – Annerley Road Residential	75
	G – Boggo Road Police Station	90
	H – Dutton Park State School	40
	I – Boggo Road Gaol	15 (from buildings) 5 (from wall)
	J – Leukemia Support Village ¹	100

Note:

1. Future development for Boggo Road Urban Village.

Phases were developed for Boggo Road Station construction works being representative of activities having potentially the greatest noise impact on the surrounding receivers. Worst case scenarios were developed based on all plant items, including haul trucks where applicable, operating simultaneously. These Phases are:

- Phase 1 – installation of piles
 - north entrance duration approximately 12 weeks
 - south entrance duration approximately 12 weeks
 - platform box (ie middle section) approximately 9 weeks
 - dominant noise sources include piling rigs, excavators and front-end loaders
 - day-time construction only
- Phase 2 – excavation to slab level and deck construction
 - excavation 1 m below capping beam duration approximately 3 weeks
 - construction of top slab duration approximately 12 weeks
 - dominant noise sources include jumbo drill rig, excavators, concrete trucks and front- end loaders
 - day-time construction only
- Phase 3 – north and south shaft excavation
 - duration approximately 25 weeks
 - dominant noise sources include jumbo drill rigs, excavators, front end loaders and spoil trucks
 - 24-hour per day construction with night-time works carried out inside an acoustic enclosure (spoil trucks day-time only).

Construction noise levels with 3 m high acoustic hoarding surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-35**, as outdoor values. Internal goals for residential or commercial receivers have been adjusted, ie increased, to represent external free-field noise levels. An assessment of noise goal compliance is also provided with indicative noise level reductions based on 6 m high acoustic hoarding and works carried out inside a medium acoustic enclosure or top slab for Phase 3. Note hatching (▨) indicates compliance and “n/a” not applicable for the assessment period. Exceedances are worst case as they assume the highest predicted noise levels.

Table 16-35 Boggo Road Station – predicted ‘worst case’ construction noise levels

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) (calculated with 3 m hoarding) ²	Noise Goal Exceedance with level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With Medium Performance Enclosure ³
A – Ecosciences Building Commercial	1	Day	LA10,adj – 72	76 – 80	8	3	n/a
	2	Day	LA10,adj – 72	70 – 81	9	4	n/a
	3	Day	LA10,adj – 72	62 – 72			
B – Rawnsley Street Residential	1	Day	LA10,adj – 57	64 – 76	19	14	n/a
	2	Day	LA10,adj – 57	61 – 73	16	11	n/a
	3	Day	LA10,adj – 57	59 – 67	10	5	
	3	Night	LAmaj,adj – 52	64 – 72	20	15	8
C – Maldon Street Commercial	1	Day	LA10,adj – 72	49 – 67			n/a
	2	Day	LA10,adj – 72	45 – 65			n/a
	3	Day	LA10,adj – 72	40 – 60			
D – Maldon Street Residential	1	Day	LA10,adj – 62	63 – 66	4		n/a
	2	Day	LA10,adj – 62	57 – 60	-		n/a
	3	Day	LA10,adj – 62	55 – 58			
	3	Night	LAmaj,adj – 52	60 – 63	11	6	
E – Grantham Street Commercial	1	Day	LA10,adj – 72	58 – 63			n/a
	2	Day	LA10,adj – 72	55 – 58			n/a
	3	Day	LA10,adj – 72	49 – 55			
F – Annerley Road Residential	1	Day	LA10,adj – 62	52 – 58			n/a
	2	Day	LA10,adj – 62	55 – 58			n/a
	3	Day	LA10,adj – 62	48 – 51			
	3	Night	LAmaj,adj – 52	53 – 56	4		
G – Boggo Road Police Station	1	Day	LA10,adj – 72	57 – 62			n/a
	2	Any	LA10,adj – 72	59 – 64			n/a
	3	Any	LA10,adj – 72	42 – 50			
H – Dutton Park State School	1	Day	LA10,adj – 62	61 – 69	7	2	n/a
	2	Day	LA10,adj – 62	60 – 65	3		n/a
	3	Day	LA10,adj – 62	44 – 56			
I – Boggo Road Gaol	1	Day	LA10,adj – 72	69 – 76	4		n/a
	2	Day	LA10,adj – 72	71 – 79	7	2	n/a
	3	Day	LA10,adj – 72	59 – 73	1		

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) (calculated with 3 m hoarding) ²	Noise Goal Exceedance with level of Noise Mitigation (dBA)		
					With 3 m Hoarding	With 6 m Hoarding	With Medium Performance Enclosure ³
J – Leukemia Support Village	1	Day	LA10,adj – 57	67 – 72	15	10	n/a
	2	Day	LA10,adj – 57	68 – 71	14	9	n/a
	3	Day	LA10,adj – 57	60 – 65	8	3	
	3	Night	LAmaj,adj – 52	65 – 70	18	13	6



Noise goal achieved at receiver

Notes:

1. LA10,adj and LAmaj,adj (night-time) assessment parameters applicable for non-steady state and intermittent noise sources. LAeq,adj assessment parameter applicable to steady state or continuous (night-time) noise sources. All presented noise levels are external free-field. The noise goals include a correction for facade noise reduction, 7 dBA (residential) and 17 dBA (commercial), to represent external free-field noise goals.
2. Predicted noise levels include 3 m acoustic hoarding between noise sources and receivers.
3. A medium performance enclosure provides an acoustically absorptive internal lining (refer to Section 16.4.1).

The predicted worst case noise levels for site establishment works at the Boggo Road Station worksite indicate exceedances of up to 19 dBA of the noise goal for day-time operations with 3 m hoardings at the nearest residential receivers in Rawnsley Street. Other sensitive receivers, such as the Maldon Street residential and the Dutton Park State School, are also predicted to experience exceedances of the day-time noise goal in a 'worst case' noise exposure.

The predicted worst case noise levels during the initial stages of shaft excavation (ie prior to installation of the top slab) at the Boggo Road Station worksite indicate exceedances of up to 16 dBA during the day at the nearest residential receivers on Rawnsley Street. Further reductions in noise levels may be achieved through the following mitigation measures:

- early and on-going consultation with residents on Rawnsley Street
- operating the quietest available mobile plant at the worksite, ie fitted with appropriate exhaust silencers, mufflers or acoustic covers
- careful placement of fixed plant eg compressors, gensets etc, at the worksite to maximise shielding or separation from sensitive receivers
- programming works to ensure the shortest time practicable between commencing excavation works and installing the 'cut-and-cover lid' over the station box (or installing an acoustic enclosure or acoustic shed over the excavation, immediately on completion of piling works)
- monitoring construction noise at residential premises in Rawnsley Street.

Construction activities at the Boggo Road worksite would be undertaken in accordance with the hours of work provided in **Chapter 24 Draft Outline EMP**. The acoustic hoarding would not attenuate noise at elevated receivers, such as the occupants of the Ecosciences building which 'overlooks' the worksite. Consequently, early consultation with the occupants of the Ecosciences building is proposed.

Initial predictions in **Table 16-35** indicated that noise levels will still be exceeded at two receiver locations (receiver B – Rawnsley Street Residential and receiver J – Leukemia Support Village) for the shaft excavation works (ie Phase 3) with the mitigation described. Therefore, a high performance acoustic enclosure or individual property mitigations are likely to be required, subject to detailed design and consultation. Noise exposure for other sensitive receivers, although potentially less impacted than Rawnsley Street, would be within the relevant noise goals as a consequence of installing a high performance acoustic enclosure or individual property mitigations.

The movement of trucks within the worksite would be managed to limit the need for reversing and the use of reversing alarms.

Predicted ground-borne noise and vibration impacts for the excavation of Boggo Road Station access shafts are presented in **Table 16-36**.

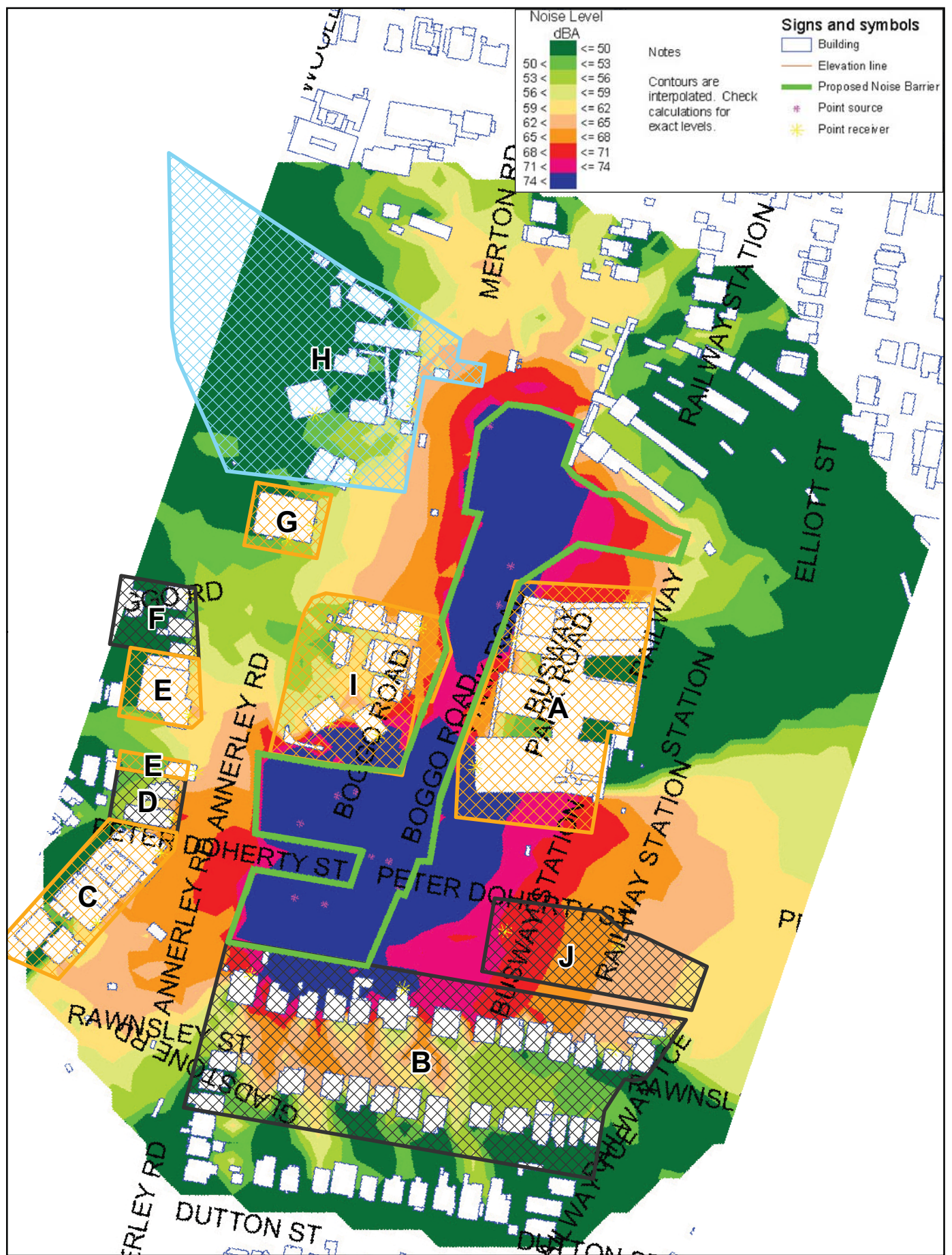
Table 16-36 Boggo Road Station – predicted ‘worst case’ ground-borne noise and vibration levels

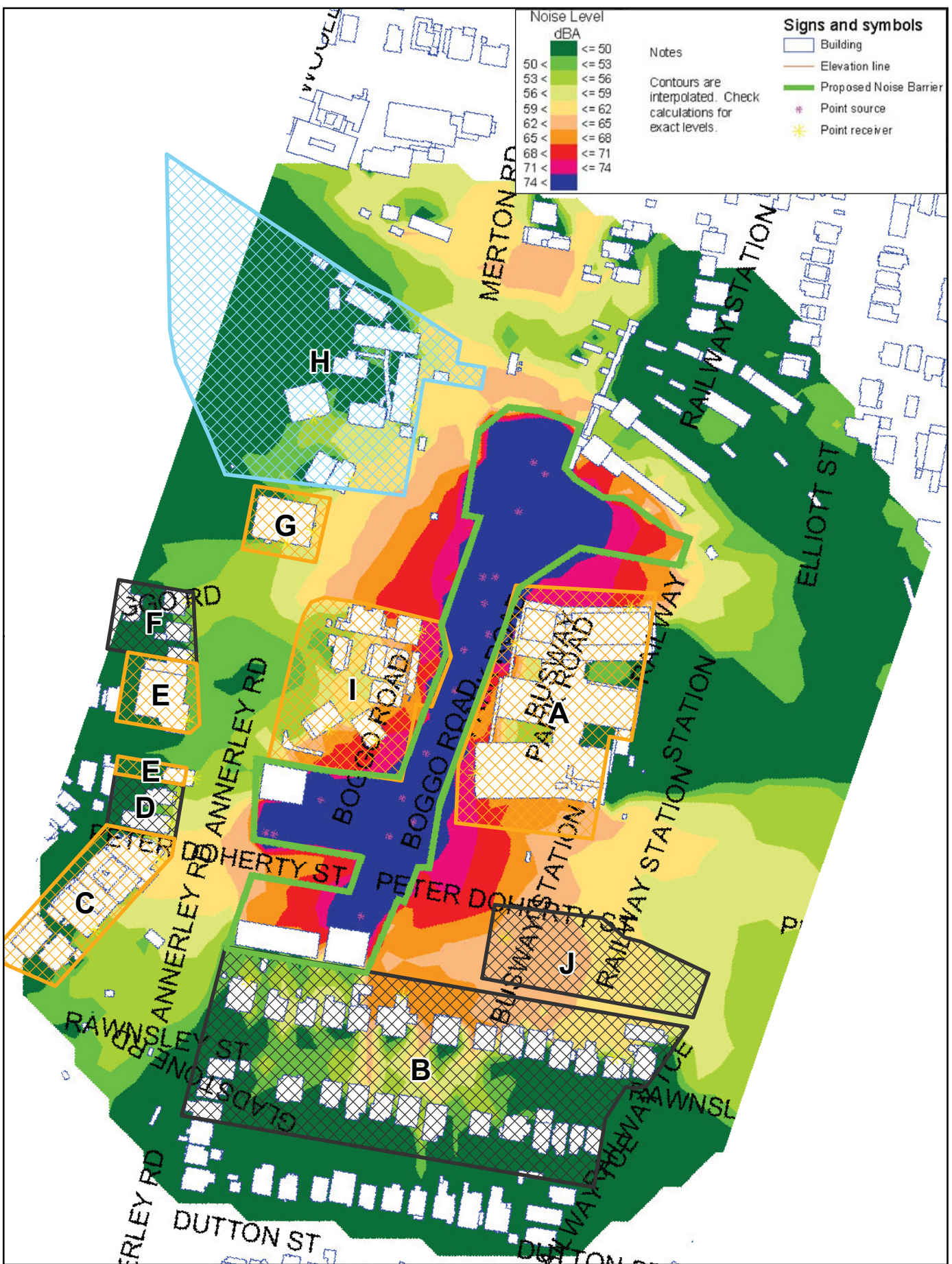
Receiver Area	Period	Noise and Vibration Goals		Predicted Ground-borne Noise and Vibration Levels (Rockbreaking)	
		Vibration PPV (mm/s)	Ground-borne Noise (dBA) ¹	Ground-borne Vibration (mm/s)	Ground-borne Noise (dBA)
A – Ecosciences Building Commercial	Day	5	LA10,adj – 65	0.48	54
A – Ecosciences Building TEM	Day	0.02	LA10,adj – 65	0.11	42
B – Rawnsley Street Residential	Day	5	LA10,adj – 55	0.06	37
	Night	0.5	LAm _{ax} ,adj – 50	0.06	42
C – Maldon Street Commercial	Day	5	LA10,adj – 65	0.03	32
D – Maldon Street Residential	Day	5	LA10,adj – 55	0.03	32
	Night	0.5	LAm _{ax} ,adj – 50	0.03	37
E – Grantham Street Commercial	Day	5	LA10,adj – 65	0.03	32
F – Annerley Road Residential	Day	5	LA10,adj – 55	0.02	29
	Night	0.5	LAm _{ax} ,adj – 50	0.02	34
G – Boggo Road Police Station	Day	5	LA10,adj – 65	0.04	33
H – Dutton Park State School	Day	5	LA10,adj – 55	0.13	43
I – Boggo Road Gaol (heritage listed)	Day	2	LA10,adj – 65	1.23	50
J – Leukemia Support Village	Day	5	LA10,adj – 55	0.03	32
	Night	0.5	LAm _{ax} ,adj – 50	0.03	37

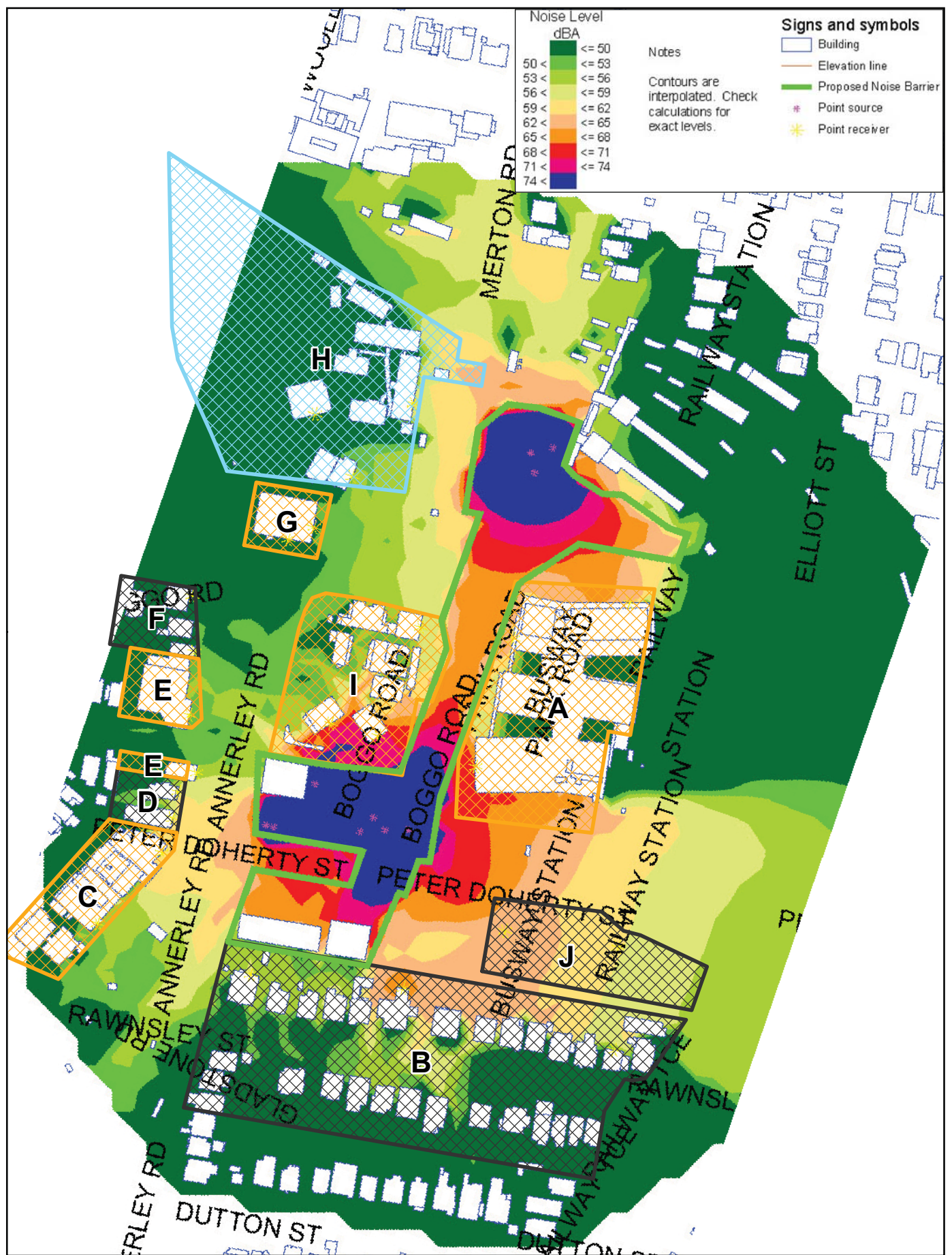
Note:

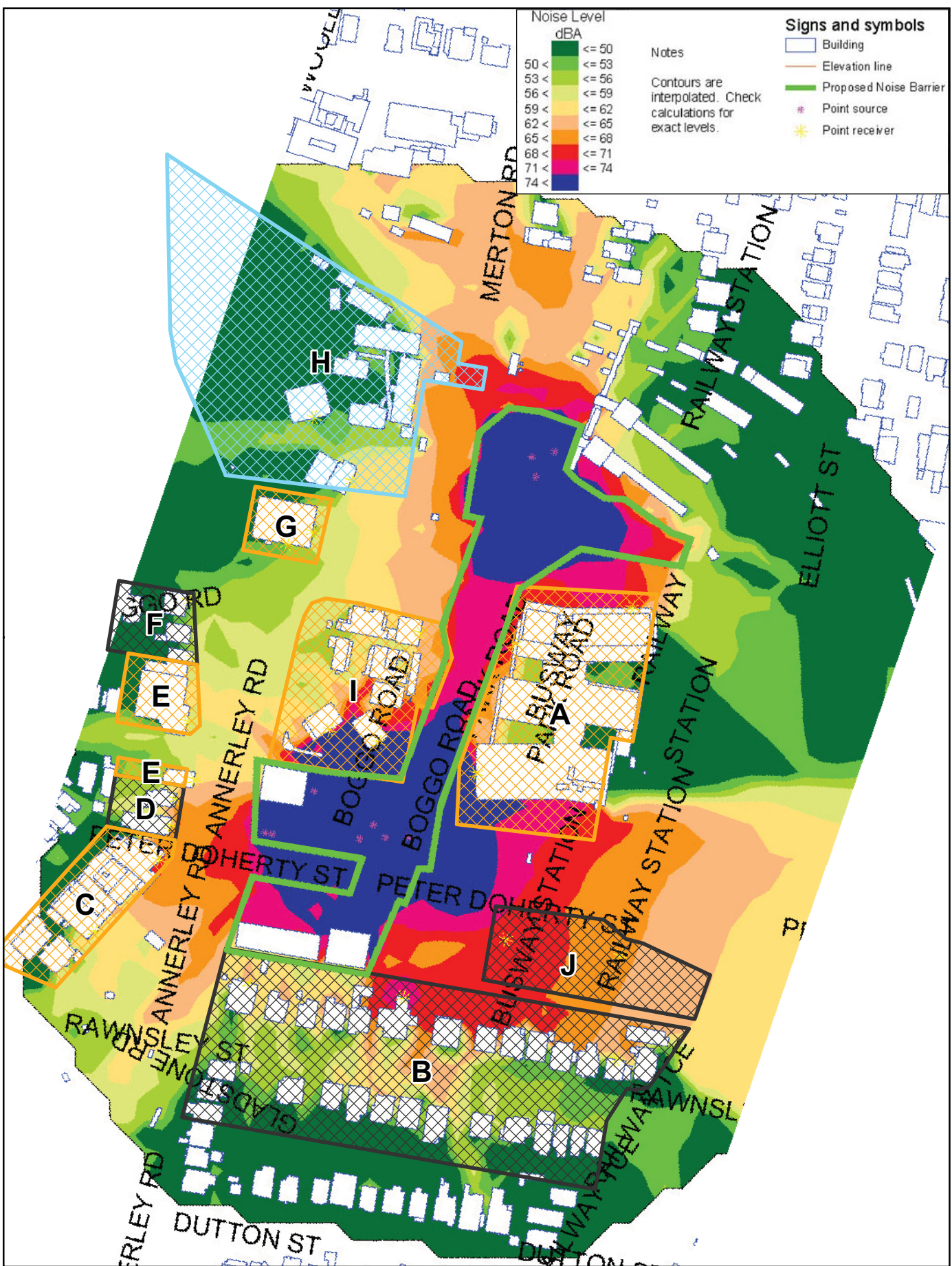
1. Dominant construction noise during shaft excavation is likely to be non-steady state and intermittent. Therefore, the LA10,adj and LAm_{ax},adj (night-time) assessment parameters are most relevant. For ground-borne noise, all noise levels are internal levels.

Figure 16-32, Figure 16-33, Figure 16-34 and Figure 16-35 show noise contours for the phases examined, with 3 m high perimeter acoustic hoarding.









Predicted 'worst case' ground-borne noise and vibration levels in **Table 16-36** from rockbreaking indicate compliance with the relevant criteria for all sensitive receivers with the exception of the TEM located at the Ecosciences Precinct. Further, the estimated blast MIC limits for Boggo Road Station indicate that the allowable MIC for the worksite would be determined by the TEM requirements. Because of the sensitivity of this equipment, ground-borne vibration limits would be well below those likely to impact on the heritage-listed Boggo Road Gaol.

As rockbreaking and drill and blasting would be required for this worksite, the following management measures would be required:

- early and on-going consultation with the occupants of the Ecosciences Precinct, including those operating the TEM, as well as with near neighbours and the Dutton Park State School
- scheduling of rockbreaking and blasts outside of typical TEM operating times. If this is not practicable without impacting on normal (Ecosciences Precinct) TEM operations, a special arrangement would need to be established so that blasting can be scheduled at a specific time
- appropriate attention to blast design and commence blasting with a low MIC to develop a site law (ie blast design model) based on measurement data from the worksite
- monitoring of the blast emissions.

If blasting could be scheduled outside of TEM operating times, the MICs would then be limited by the heritage listed Boggo Road Gaol (ie MIC of 0.2 kg), subject to a detailed survey of the structure, monitoring during construction and adjustments to the excavation works implemented, if required (refer to **Section 16.4.14**). Consequently, blasting may not be feasible until the shaft has deepened sufficiently to allow for efficient blasting.

Vibration levels for bored piling adjacent the heritage listed Boggo Road Gaol are predicted to be below 2 mm/s, based on data obtained from measurements carried out on the Northern Busway project adjacent to the Royal Brisbane and Women's Hospital (RBWH). Notwithstanding this, vibration measurements would be carried out during the commencement of bored piling at the worksite to determine the risk of exceeding the Gaol and TEM vibration limits when piling in close proximity to the buildings.

A detailed building condition survey for Boggo Road Gaol, undertaken for construction of the Boggo Road busway would provide the baseline for the heritage structures situated adjacent to the station shaft. The Boggo Road busway survey included 'post-busway' conditions and would be sourced during the detailed design phase and construction planning.

Cumulative construction noise impacts from the Boggo Road Urban Village development have not been assessed as the construction program is unknown. The new development would be subject to the requirements of EPP (Noise) and local laws pertaining to construction noise. In practice, construction work would be limited to day-time hours (6.30 am – 6.30 pm Monday to Saturday). Any cumulative impacts arising from coincidental construction would occur during those hours. Out of hours work for the Project would be managed to achieve the environmental objectives. Consequently, there would be little potential for overlap, and therefore cumulative effects of construction works out of hours. Coincident construction works would need to be reviewed during the detailed design stage with consultation between all stakeholders to determine all practicable measures to minimise impacts.

With respect to construction noise impacts on the Boggo Road Urban Village development, predicted noise levels have not been assessed as the masterplan for the entire site is yet to be finalised. However, construction noise emission levels for future ground floor receivers at the development site can be interpreted from the noise contours presented in **Figure 16-32** to **Figure 16-35**.

16.4.7 Ventilation and emergency access building and shaft

The nearest noise and/or vibration sensitive receivers to the ventilation and emergency access building and shaft worksite are identified on **Figure 16-36** and in **Table 16-37**.



Figure 16-36 Ventilation and emergency access building and shaft worksite and receiver areas

Table 16-37 Nearest sensitive receivers – Ventilation and emergency access building and shaft

Worksite/Excavation	Receiver Area	Location Relative to Works (m)
Ventilation and emergency access building and shaft	A – Railway Road Residential	15
	B – Sunbeam Street Residential	50
	C – Baptist Union of QLD Church	60
	D – Railway Road Commercial	15
	E – Venner Road Residential	15
	F – Fairfield Road Residential	30
	G – Byrnes Street Commercial	25
	H – Fairfield Road Residential	40
	I – Love Street Residential	90

Phases were developed for the ventilation and emergency access building and shaft construction works being representative of activities having potentially the greatest noise impact on the surrounding receivers. Worst case scenarios were developed based on all plant items, including haul trucks where applicable, operating simultaneously.

These phases are:

- Phase 1 – site establishment
 - duration approximately 6 weeks
 - dominant noise sources include an excavator and front end loader
 - day-time construction only
- Phase 2 – piling of access shaft
 - duration approximately 5 weeks
 - dominant noise sources include a piling rig, excavator and front end loader
 - day-time construction only
- Phase 3 – shaft excavation
 - duration approximately 12 weeks
 - dominant noise sources include excavators and front end loaders
 - day-time construction only.

For all phases, construction noise levels with 3 m high acoustic hoarding surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-38**, as outdoor values. Internal goals for residential or commercial receivers have been adjusted, ie increased, to represent external free-field noise levels. An assessment of noise goal compliance is also provided with indicative noise level reductions based on 6 m high acoustic hoarding for all phases. Note hatching (\\) indicates compliance with the relevant noise goal. Exceedances are worst case as they assume the highest predicted noise levels.

As the shaft is anticipated to remain open during the excavation phase, ground-borne noise impacts would likely be insignificant compared with airborne noise from the worksite. Therefore, no ground-borne noise modelling has been undertaken.

Table 16-38 Ventilation and emergency access building and shaft – predicted ‘worst case’ noise levels

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) (calculated with 3 m hoarding) ²	Noise Goal Exceedance with level of Noise Mitigation (dBA)	
					With 3 m Hoarding	With 6 m Hoarding
A – Railway Road Residential	1	Day	LA10,adj – 62	59 – 67	5	\\
	2	Day	LA10,adj – 62	67 – 74	12	7
	3	Day	LA10,adj – 62	64 – 73	11	6
B – Sunbeam Street Residential	1	Day	LA10,adj – 62	62 – 67	5	\\
	2	Day	LA10,adj – 62	72 – 75	13	8
	3	Day	LA10,adj – 62	68 – 73	11	6
C – Baptist Union of QLD Church	1	Day	LA10,adj – 57	63 – 66	9	4
	2	Day	LA10,adj – 57	70 – 73	16	11
	3	Day	LA10,adj – 57	67 – 70	13	8

Receiver Area	Phase	Period	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) (calculated with 3 m hoarding) ²	Noise Goal Exceedance with level of Noise Mitigation (dBA)	
					With 3 m Hoarding	With 6 m Hoarding
D – Railway Road Commercial	1	Day	LA10,adj – 72	67 – 70		
	2	Day	LA10,adj – 72	75 – 78	6	1
	3	Day	LA10,adj – 72	70 – 73	1	
E – Venner Road Residential	1	Day	LA10,adj – 62	58 – 71	9	4
	2	Day	LA10,adj – 62	66 – 76	14	9
	3	Day	LA10,adj – 62	61 – 73	11	6
F – Fairfield Road Residential	1	Day	LA10,adj – 62	49 – 69	7	2
	2	Day	LA10,adj – 62	53 – 73	11	6
	3	Day	LA10,adj – 62	52 – 71	9	4
G – Byrnes Street Commercial	1	Day	LA10,adj – 72	64 – 70		
	2	Day	LA10,adj – 72	68 – 75	3	
	3	Day	LA10,adj – 72	65 – 74	2	
H – Fairfield Road Residential	1	Day	LA10,adj – 62	54 – 67	5	
	2	Day	LA10,adj – 62	60 – 74	12	7
	3	Day	LA10,adj – 62	56 – 71	9	4
I – Love Street Residential	1	Day	LA10,adj – 62	49 – 61		
	2	Day	LA10,adj – 62	55 – 68	6	1
	3	Day	LA10,adj – 62	54 – 65	3	



Noise goal achieved at receiver

Notes:

1. Dominant construction noise during site establishment likely to be non-steady state. Therefore the LA10,adj assessment parameter is most relevant. All presented noise levels are external free-field. The noise goals include a correction for facade noise reduction, 7 dBA (residential) and 17 dBA (commercial), to represent external free-field noise goals.
2. Predicted noise levels include 3 m acoustic hoarding between noise sources and receivers.

The predicted 'worst case' noise levels for the three modelled phases at the ventilation and emergency access building and shaft worksite indicate significant exceedances of the relevant day-time construction noise goals due to the close proximity of sensitive receivers.

Increasing the 3 m perimeter hoarding to 6 m decreases construction noise levels, however several noise goal exceedances would still be expected. The predicted worst case shaft excavation noise levels in **Table 16-38** have been modelled with the excavation plant operating close to existing ground level. During this phase of the works, initial excavations would take place in soil, 5-10 m in depth. Construction noise emission levels would progressively decrease over time as the excavation plant progressed deeper into the shaft. Further reductions in noise emission levels may be achieved through the following mitigation measures:

- early and on-going consultation with near neighbours, particularly the church community
- operating the quietest available mobile plant at the worksite, ie fitted with appropriate exhaust silencers, mufflers or acoustic covers

- temporary tunnel ventilation noise sources to be located either down in the shaft with appropriate ducting to the surface or within a dedicated enclosure at the surface
- drill and blast in place of the rockbreaking to expedite the works and minimise exposure to receivers of prolonged significantly high construction noise
- careful placement of fixed plant (for example, compressors, gensets etc) at the worksite to maximise shielding or separation from sensitive receivers.

An acoustic enclosure over the shaft has not been considered at this location, as the shaft excavation works would be completed within a relatively short timeframe, ie three months, and restricted to the day-time period. However, individual arrangements with residents and businesses may be required and would be considered at detailed design stage.

Noise monitoring would be conducted at residential premises eg Railway Road. Construction activities at the ventilation shaft worksite would be undertaken in accordance with the hours of work provided in **Chapter 24 Draft Outline EMP**.

Road traffic noise levels on Fairfield Road were predicted for Year 2016 at residences adjacent to Fairfield Road, Railway Road and Sunbeam Street, nearest to the ventilation and emergency access building and shaft worksite, for comparison with the predicted construction noise levels. The road traffic noise predictions were carried out using CORTN (1998) prediction algorithms.

In Year 2016, traffic noise levels on Fairfield Road are predicted between 64 dBA to 74 dBA LA10 during the am and pm peak periods, ie 7.00 am to 9.00 am and 4.00 pm to 6.00 pm respectively, and between 62 dBA to 72 dBA LA10 during the day-time off peak period, ie 9.00 am to 4.00 pm. Comparison with predicted worst case day-time construction noise levels indicates that, at times, road traffic noise from Fairfield Road would be higher and potentially dominate the acoustic environment in the vicinity of the worksite for the receivers closest to Fairfield Road.

The estimated blast MIC limits for the ventilation and emergency access building and shaft worksite indicate that a maximum MIC of 0.9 kg would be permitted to achieve compliance with the airblast overpressure goal of 130 dB Linear Peak at the nearest receivers. Assuming the airblast overpressure can be mitigated eg blast mat, enclosing etc, blasting would be a suitable excavation technique for this worksite.

16.4.8 Surface track work sites

Mayne Rail Yard

The nearest sensitive receivers to the Mayne Rail Yard and viaduct worksite are identified on **Figure 16-37** and in **Table 16-39**.

Table 16-39 Nearest sensitive receivers – Mayne rail yard

Worksite	Receiver Area	Location Relative to Works (m)
Mayne Rail Yard	A – Residential West	300
	B – Residential East	180

Note: Other nearby receivers comprise industrial units

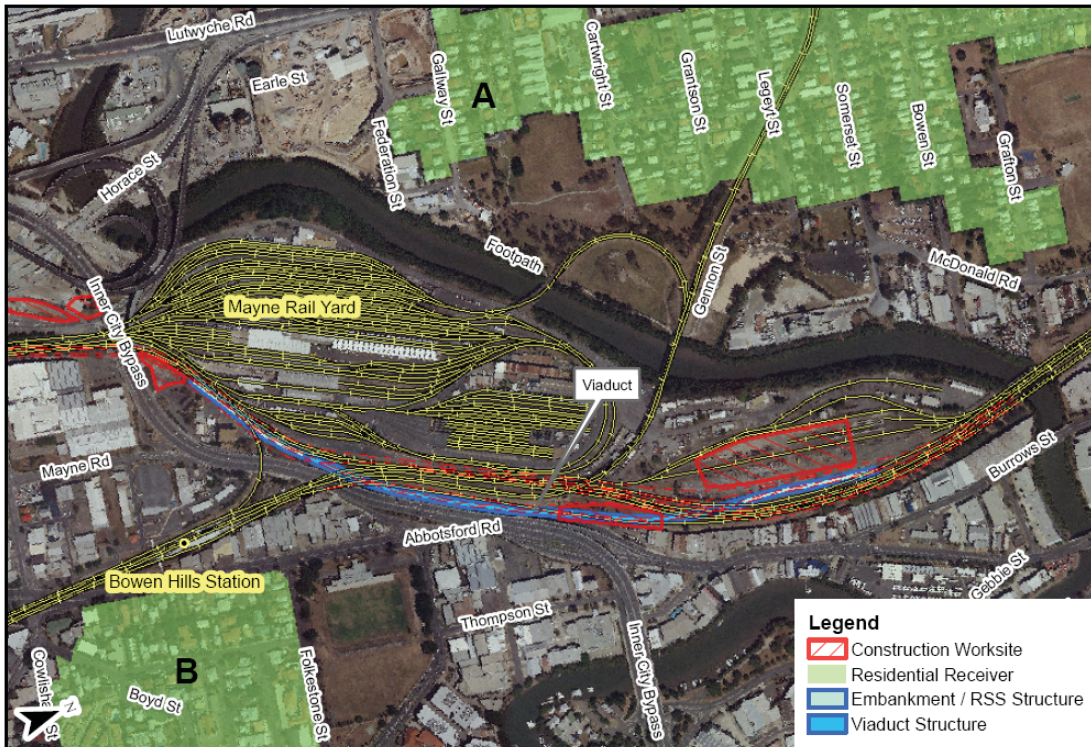


Figure 16-37 Mayne rail yard worksite and receiver areas

Phases were developed for the construction works at Mayne Rail Yard being representative of activities having potentially the greatest noise impact on the surrounding receivers. These phases are:

- Phase 1 – piling for viaduct piers
- Phase 2 – viaduct construction (duration of viaduct works, including Phase 1 piling for viaduct piers is approximately 96 weeks).

The typical construction noise levels without noise controls implemented on site and with 3 m hoarding surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-40** as outdoor values. Internal goals for residential receivers have been adjusted, ie increased, to represent external free-field noise levels. Note hatching (\\) indicates compliance with the relevant noise goal.

Table 16-40 Mayne Rail Yard – predicted ‘worst case’ noise levels

Receiver Area	Phase	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) ² (Without Acoustic Hoarding)	Noise Goal Exceedance with level of Noise Mitigation (dBA)	
				No Acoustic Hoarding	With 3 m Hoarding
A – Residential	1	LAeq(24hour) – 62	48 – 50		
	1	LAm _{ax,adj} – 84	56 – 59		
	2	LAeq(24hour) – 62	44 – 46		
	2	LAm _{ax,adj} – 84	52 – 54		
B – Residential	1	LAeq(24hour) – 62	48 – 52		
	1	LAm _{ax,adj} – 84	56 – 60		
	2	LAeq(24hour) – 62	44 – 46		
	2	LAm _{ax,adj} – 84	52 – 54		



Noise goal achieved at receiver

Notes:

1. Noise goals based on Queensland Rail's Code of Practice planning levels adjusted to a free-field level.
2. Predicted noise levels without acoustic hoarding.

The predicted ‘worst case’ noise levels for the two modelled phases associated with the Mayne Rail Yard viaduct construction works indicate compliance with the Queensland Rail noise goals without specific noise mitigation measures in place. Given that Mayne Rail Yard is offset from the operation “through tracks”, if night-time construction works are required at Mayne Rail Yard, reasonable and practicable mitigation measures would be considered to comply with the 57 dBA L_{Amax} sleep disturbance criterion applicable to other elements of the Project. Examples of mitigation measures include:

- selection of quietest available plant and techniques
- careful orientation of piling plant to take advantage of intervening structures
- noise monitoring at the commencement of construction works to refine noise mitigation measures.

At a distance in excess of 180 m to the nearest residential receiver, vibration impacts from the construction works would not be anticipated.

Clapham Rail Yard

The nearest sensitive receivers to the Clapham Rail Yard worksite are identified on **Figure 16-38** and in **Table 16-41**.

Table 16-41 Nearest sensitive receivers – Clapham rail yard

Worksite	Receiver Area	Location Relative to Works (m)
Clapham Rail Yard	A – Residential East	100
	B – Residential West	250

Note: Other nearby receivers comprise industrial units

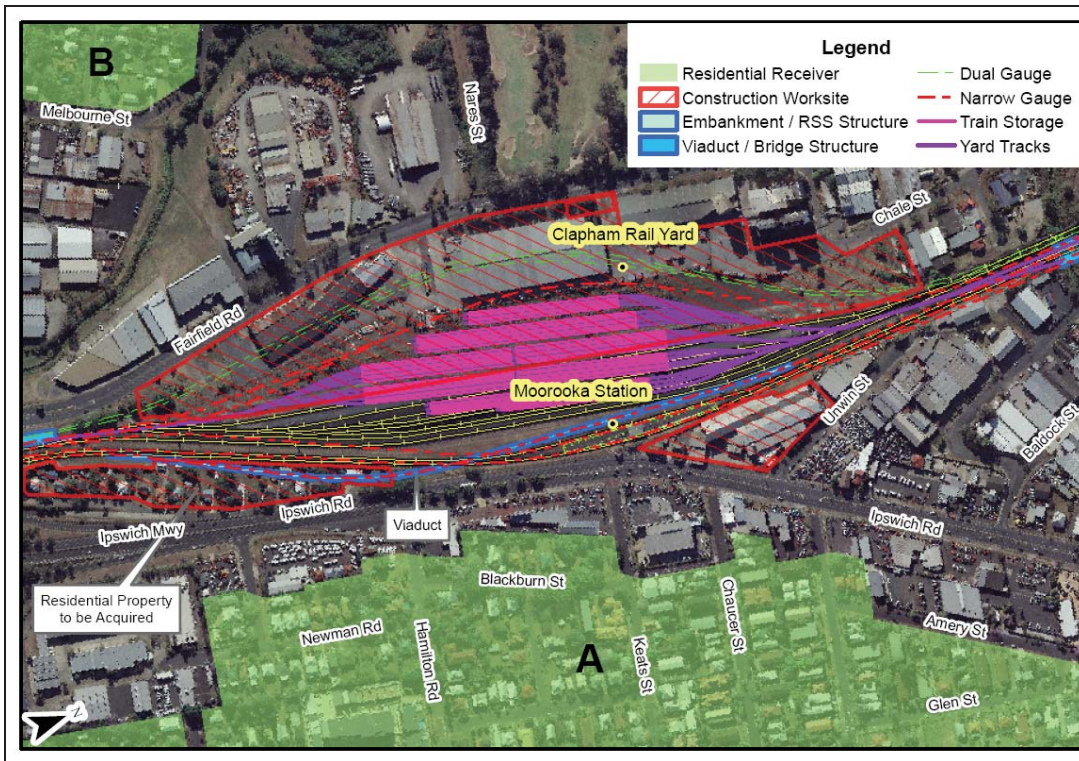


Figure 16-38 Clapham rail yard worksite and receiver areas

Phases were developed for the construction works at Clapham Rail Yard being representative of activities having potentially the greatest noise impact on the surrounding receivers. These phases are:

- Phase 1 – earthworks: duration approximately 36 weeks
- Phase 2 – track construction: duration approximately 36 weeks
- Phase 3 – single track flyover construction: duration approximately 36 weeks for structural works, followed by approximately 12 weeks for track works.

The typical construction noise levels without noise controls implemented on site and with a 3 m high hoarding surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-42** as outdoor values. Internal goals for residential receivers have been adjusted (ie increased) to represent external free-field noise levels. Note hatching (///) indicates compliance with the relevant noise goal.

Table 16-42 Clapham rail yard – predicted ‘worst case’ noise levels

Receiver Area	Phase	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) ² (Without Acoustic Hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)	
				No Acoustic Hoarding	With 3 m Hoarding
A – Residential	1	LAeq(24hour) – 62	48 – 56		
	1	LAmx,adj – 84	56 – 64		
	2	LAeq(24hour) – 62	55 – 62		
	2	LAmx,adj – 84	63 – 71		
	3	LAeq(24hour) – 62	58 – 70	8	
	3	LAmx,adj – 84	66 – 78		
B – Residential	1	LAeq(24hour) – 62	50 – 53		
	1	LAmx,adj – 84	58 – 61		
	2	LAeq(24hour) – 62	45 – 51		
	2	LAmx,adj – 84	53 – 59		
	3	LAeq(24hour) – 62	48 – 51		
	3	LAmx,adj – 84	56 – 59		



Noise goal achieved at receiver

Notes:

1. Noise goals based on Queensland Rail's Code of Practice planning levels adjusted to a free-field level.
2. Predicted noise levels without acoustic hoarding.

The predicted ‘worst case’ noise levels for Phases 1 and 2 indicate compliance with the Queensland Rail noise goals without specific noise mitigation measures in place. Construction of the single track flyover (ie Phase 3) is predicted to exceed the 62 dBA LAeq(24hour) planning level with no noise mitigation measures in place. A 3 m high acoustic barrier adjacent to the east of the piling work area is proposed to achieve compliance with the noise goal.

It is understood that the majority of the work at Clapham Rail Yard could be staged in a way to avoid construction work outside of normal day-time hours. Given that Clapham Rail Yard is mostly offset from the operation “through tracks”, if night-time construction works are required at Clapham Rail Yard, all reasonable and practicable mitigation measures would be required to comply with the 57 dBA LAmx sleep disturbance criterion applicable to other elements of the Project. Examples of mitigation measures include:

- selection of quietest available plant and techniques
- careful orientation of piling plant to take advantage of intervening structures.
- noise monitoring at the commencement of construction works to refine noise mitigation measures eg residential premises to the south-west (Melbourne Street, Rocklea) and to the east (Blackburn Street, Moorooka) (refer to **Chapter 24 Draft Outline EMP**).

Construction noise from works occurring on the bridge over Moolabin Creek has not been specifically assessed for Clapham Rail Yard, as they are anticipated to be less than the impacts associated with the Clapham Rail Yard construction. The assessment of construction noise for the flyover adjacent Clapham Rail Yard presented in **Table 16-42** would be representative of noise emissions from the Moolabin Creek rail bridge works.

At a distance in excess of 100 m to the nearest residential receiver, vibration impacts from the construction works, including vibratory rollers and rockbreakers (if required), would not be anticipated and has not been modelled for this EIS.

16.4.9 Surface station construction/upgrades

Ekka Station (including O'Connell Terrace Road Bridge)

The nearest sensitive receivers to the Ekka Station worksite are identified on **Figure 16-39** and in **Table 16-43**.

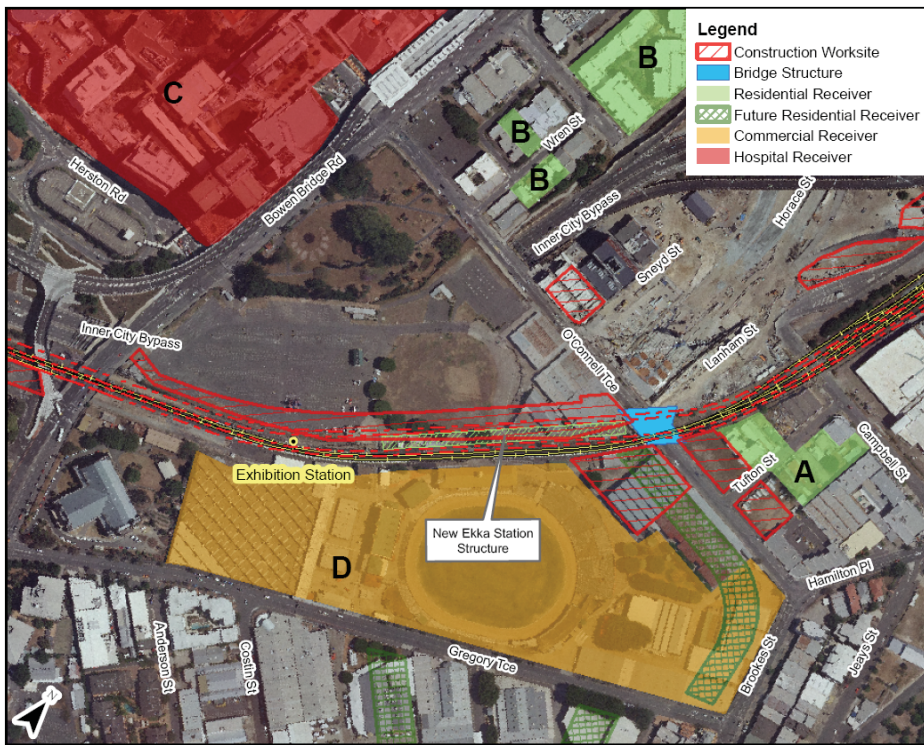


Figure 16-39 Ekka Station worksite and receiver areas

Table 16-43 Nearest sensitive receivers – Ekka Station

Worksite	Receiver Area	Location Relative to Works (m)
Ekka Station	A – Residential North-east	60
	B – Residential North-west	220
	C – RBWH	300
	D – RNA Showgrounds	10

Phases were identified for the construction works at the Ekka Station site being representative of activities having potentially the greatest noise impact on the surrounding receivers. These phases are:

- Phase 1 – piling/foundation works for O'Connell Terrace bridge piers approximately 4 weeks
- Phase 2 – station construction: duration approximately 48 weeks for Ekka Station West; approximately 24 weeks for Ekka Station East.

Typical construction noise levels without acoustic hoarding surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-44** as outdoor values. Internal goals for receivers have been adjusted (ie increased) to represent external free-field noise levels.

An assessment of noise goal compliance is also provided in **Table 16-44** with indicative noise level reductions based on 3 m high acoustic hoarding for Phases 1 and 2. Note hatching (\\) indicates compliance with the relevant noise goal. Exceedances are worst case as they assume the highest predicted noise levels.

Table 16-44 Ekka Station construction – predicted ‘worst case’ noise levels

Receiver Area	Phase	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) ² (Without Acoustic Hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)	
				No Acoustic Hoarding	With 3 m Hoarding
A – Residential	1	LAeq(24hour) – 62	49 – 72	10	2
	1	LAm _{ax,adj} – 84	57 – 80	\\	\\
	2	LAeq(24hour) – 62	39 – 57	\\	\\
	2	LAm _{ax,adj} – 84	47 – 65	\\	\\
B – Residential	1	LAeq(24hour) – 62	35 – 54	\\	\\
	1	LAm _{ax,adj} – 84	43 – 62	\\	\\
	2	LAeq(24hour) – 62	38 – 52	\\	\\
	2	LAm _{ax,adj} – 84	46 – 60	\\	\\
C – RBWH	1	LAeq(24hour) – 62	51 – 54	\\	\\
	1	LAm _{ax,adj} – 84	57 – 60	\\	\\
	2	LAeq(24hour) – 62	51 – 53	\\	\\
	2	LAm _{ax,adj} – 84	59 – 61	\\	\\

 Noise goal achieved at receiver

Notes:

1. Noise goals based on Queensland Rail’s Code of Practice planning levels adjusted to a free-field level.
2. Predicted noise levels without acoustic hoarding.

The predicted ‘worst case’ noise levels for the two modelled phases associated with the Ekka Station construction works indicate compliance with the Queensland Rail noise goals with the exception of the nearest residences to the east of the worksite in Tufton Street. Acoustic hoarding of 4 m in height around the piling worksite would likely result in compliance with the proposed noise goal based on the predicted exceedance in **Table 16-44**.

Night-time construction works at Ekka Station would be avoided insofar as possible.

The redevelopment of the RNA Showgrounds is intended to be implemented with staged construction from 2012 to 2020 (refer to **Chapter 9 Land Use and Tenure**). Cumulative impacts from the RNA Showgrounds redevelopment are described in **Chapter 23 Cumulative Impacts**. The redevelopment of the RNA Showgrounds would be subject to the requirements of EPP (Noise) and local laws pertaining to construction noise. In practice, construction work at the RNA Showgrounds would be limited to day-time hours (6.30 am – 6.30 pm Monday to Saturday) and is in accordance with the advice given in the ULDA approval of the RNA Showgrounds redevelopment. Any cumulative impacts arising from coincidental construction would occur during those hours. Out of hours work for the Project would be managed to achieve the environmental objectives. Consequently, there would be little potential for overlap, and therefore cumulative effects of construction works out of hours. Careful coordination with RNA and ULDA will be required with respect to construction timeframes, construction sites, demolition, spoil removal and construction material haulage in order to minimise potential cumulative impacts of construction noise (refer to **Chapter 24 Draft Outline EMP**).

The TMR Technical Standard MRTS51 provides ground vibration limits for construction activities adjacent to historical, residential, commercial and industrial buildings. For historical buildings, monuments and buildings of special value or significance, a ground vibration goal of 2 mm/s PPV has been utilised. Where construction works are in close proximity to heritage-listed buildings within the RNA Showgrounds, the reference design provides offset distances to heritage structures which would comply with the vibration goal of 2 mm/s. If vibration intensive construction works are required to occur within 10 m of heritage structures, pre-construction condition surveys and monitoring would be undertaken during construction. The Project cosmetic damage vibration goal does not apply to heritage listed structures located further than 10 m from construction activities.

Yeerongpilly Station

The nearest sensitive receivers to the Yeerongpilly Station worksite are identified on **Figure 16-40** and in **Table 16-45**.



Figure 16-40 Yeerongpilly Station worksite and receiver areas

Table 16-45 Nearest sensitive receivers – Yeerongpilly Station

Worksite	Receiver Area	Location Relative to Works (m)
Yeerongpilly Station	A – Residential North-east	35
	B – Residential South-west	300

Only one phase (station construction, with a duration of approximately 48 weeks) was identified for noise modelling of the construction works at Yeerongpilly Station, being representative of the activity having potentially the greatest noise impact on the surrounding receivers. Construction of the southern portal (including cut and cover construction and final realignment of Wilkie Street) would be completed by mid-2016. Construction of Yeerongpilly Station would commence in early 2018.

The typical construction noise levels without acoustic hoarding surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-46** as outdoor values. Internal goals for residential receivers have been adjusted (ie increased) to represent external free-field noise levels. An assessment of noise goal compliance is also provided in **Table 16-46** with indicative noise level reductions based on 3 m high acoustic hoarding. Note hatching (▨) indicates compliance with the relevant noise goal.

Table 16-46 Yeerongpilly Station – predicted ‘worst case’ construction noise levels – station construction

Receiver Area	Phase	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) ² (Without Acoustic Hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)	
				No Acoustic Hoarding	With 3 m Hoarding
A – Residential	1	LAeq(24hour) – 62	49 – 65	3	▨
	1	LAm _{ax,adj} – 84	57 – 73	▨	▨
B – Residential	1	LAeq(24hour) – 62	31 – 40	▨	▨
	1	LAm _{ax,adj} – 84	39 – 48	▨	▨



Noise goal achieved at receiver

Notes:

1. Noise goals based on Queensland Rail's Code of Practice planning levels adjusted to a free-field level.
2. Predicted noise levels without acoustic hoarding.

The predicted ‘worst case’ noise levels for the modelled phase associated with the Yeerongpilly Station construction works indicate compliance with the Queensland Rail noise goals with the exception of the nearest residences to the east of the worksite adjacent to Livingstone Street. Hoarding of 3 m in height along the eastern boundary of the worksite would likely result in compliance with the proposed noise goal, based on the marginal exceedance in **Table 16-46**.

The Yeerongpilly Station worksite would be remote from the operating track. If night-time construction works are required at Yeerongpilly Station, all reasonable and practicable mitigation measures would be required to minimise exceedance of the 57 dBA LAm_{ax} sleep disturbance criterion. Part, or all, of the acoustic shed at Yeerongpilly would be retained to protect the acoustic amenity of the area during the station construction phase.

At a distance in excess of 35 m to the nearest residential receiver, vibration impacts from construction activities would not be anticipated at this worksite.

Moorooka Station upgrade

The nearest sensitive receivers to the Moorooka Station worksite are identified on **Figure 16-41** and in **Table 16-47**.

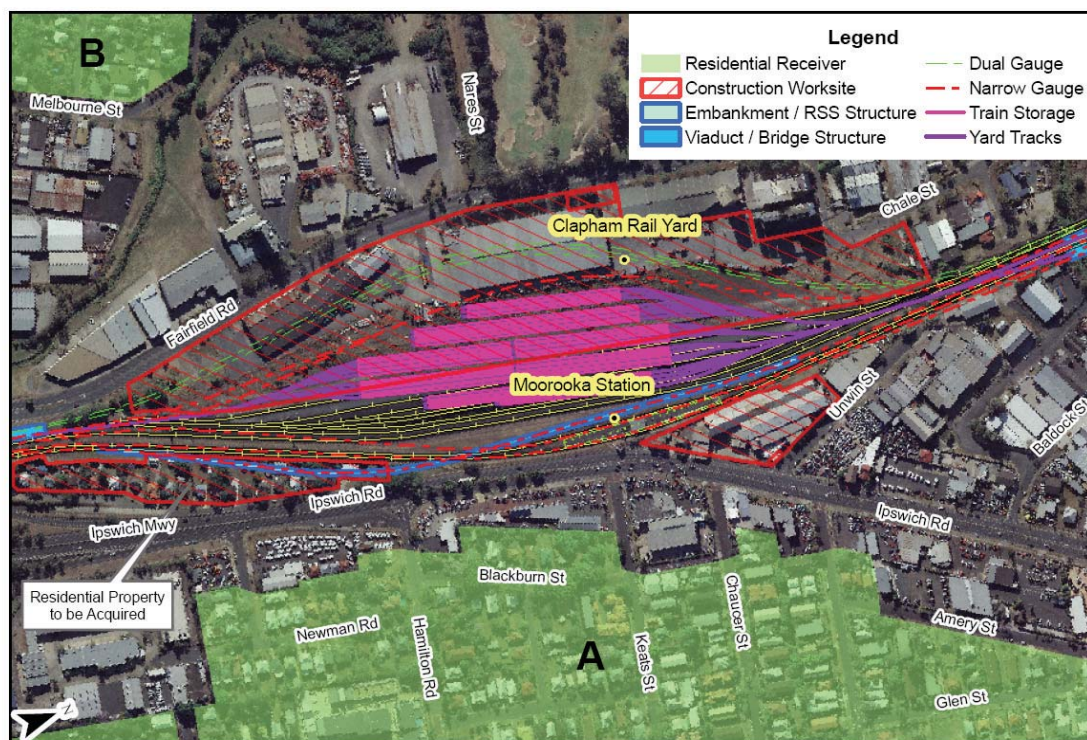


Figure 16-41 Moorooka Station worksite and receiver areas

Table 16-47 Nearest sensitive receivers – Moorooka Station

Worksite	Receiver Area	Location Relative to Works (m)
Moorooka Station	A – Residential East	130
	B – Residential West	500

The provision of additional surface tracks and stabling facilities at Moorooka would require widening of the existing rail corridor and works within Clapham Rail Yard. These works would require full or partial acquisition of properties, including properties along Ipswich Road (refer to **Figure 16-41**).

Only one phase (station construction, with a duration of approximately 24 weeks) was identified for noise modelling of the construction works at Moorooka Station, being representative of the activity having potentially the greatest noise impact on surrounding receivers.

The typical construction noise levels without acoustic hoarding surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-48** as outdoor values. Internal goals for residential receivers have been adjusted (ie increased) to represent external free-field noise levels. An assessment of noise goal compliance is also provided in **Table 16-48** with indicative noise level reductions based on 3 m high acoustic hoarding. Note hatching (▨) indicates compliance with the relevant noise goal.

Table 16-48 Moorooka Station – predicted ‘worst case’ construction noise levels – station construction

Receiver Area	Phase	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) ² (Without Acoustic Hoarding)	Noise Goal Exceedance with level of Noise Mitigation (dBA)	
				No Acoustic Hoarding	With 3 m Hoarding
A – Residential	1	LAeq(24hour) – 62	47 – 63	1	
	1	LAmx,adj – 84	55 – 71		
B – Residential	1	LAeq(24hour) – 62	27 – 37		
	1	LAmx,adj – 84	35 – 45		



Noise goal achieved at receiver

Notes:

1. Noise goals based on Queensland Rail’s Code of Practice planning levels adjusted to a free-field level.
2. Predicted noise levels without acoustic hoarding.

The predicted ‘worst case’ noise levels for the modelled phase of the upgrade works at Moorooka Station indicate compliance with the Queensland Rail noise goals with the exception of a marginal 1 dBA noise goal exceedance at the nearest residences east of the worksite. Every effort would be made to use the quietest available equipment (ie fitted with appropriate exhaust silencers, mufflers or acoustic covers) and optimise the use of plant to ensure that the worst case noise levels presented in **Table 16-48** do not occur.

At a distance in excess of 130 m to the nearest residential receiver, vibration impacts from the construction works would not be anticipated.

Rocklea Station upgrade

The nearest sensitive receivers to the Rocklea Station worksite are identified on **Figure 16-42** and in **Table 16-49**.

Only one phase (station construction, with a duration of approximately 24 weeks) was identified for noise modelling of the construction works at Rocklea Station, being representative of the activity having potentially the greatest noise impact on surrounding receivers.

Typical construction noise levels without acoustic hoarding surrounding the worksite have been predicted at the nearest noise sensitive receivers (at ground floor level) and are presented in **Table 16-50** as outdoor values. Internal goals for residential receivers have been adjusted (ie increased) to represent external free-field noise levels. An assessment of noise goal compliance is also provided in **Table 16-50** with indicative noise level reductions based on 3 m high acoustic hoarding. Note hatching (///) indicates compliance with the relevant noise goal. Exceedances are worst case as they assume the highest predicted noise levels.

Table 16-49 Nearest sensitive receivers – Rocklea Station

Worksite	Receiver Area	Location Relative to Works (m)
Rocklea Station	A – Residential West	40
	B – Residential East	170

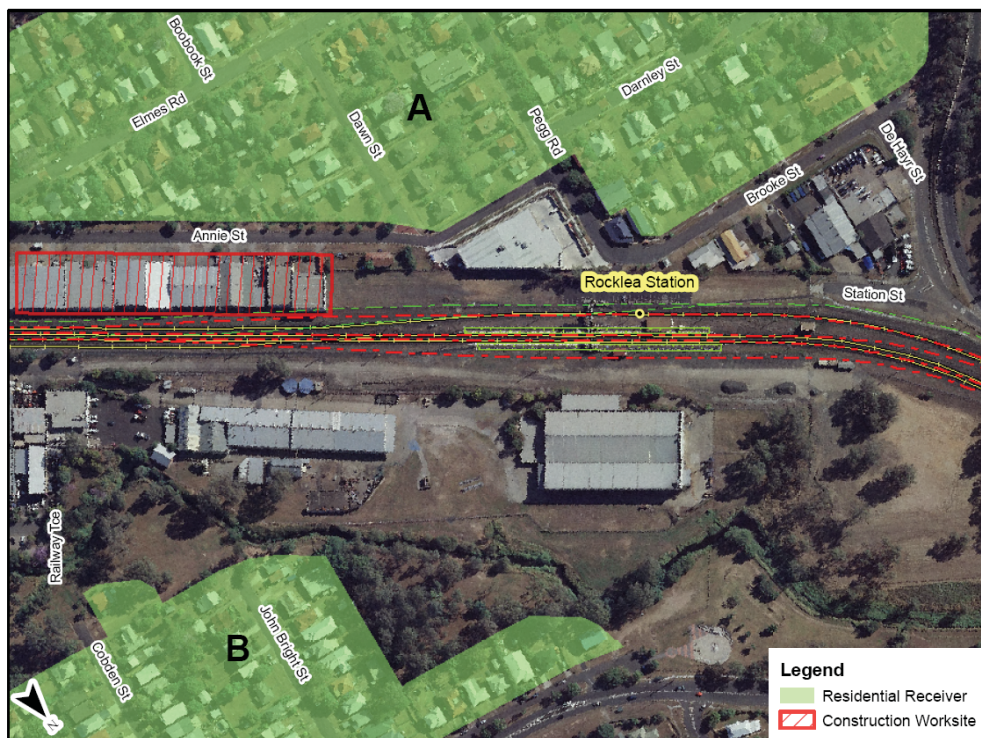


Figure 16-42 Rocklea Station worksite and receiver areas

Note: Other nearby receivers comprise industrial units

Table 16-50 Rocklea Station – predicted ‘worst case’ construction noise levels – station construction

Receiver Area	Phase	Noise Goal (dBA) ¹	Predicted Noise Level (dBA) ² (Without Acoustic Hoarding)	Noise Goal Exceedance with Level of Noise Mitigation (dBA)	
				No Acoustic Hoarding	With 3 m Hoarding
A – Residential	1	LAeq(24hour) – 62	47 – 73	11	3
	1	LAm _{ax,adj} – 84	55 – 81		
B – Residential	1	LAeq(24hour) – 62	46 – 54		
	1	LAm _{ax,adj} – 84	54 – 62		



Noise goal achieved at receiver

Notes:

- Noise goals based on Queensland Rail's Code of Practice planning levels adjusted to a free-field level.
- Predicted noise levels without acoustic hoarding.

The predicted ‘worst case’ noise levels for the modelled phase of upgrade works at Rocklea Station indicate compliance with the Queensland Rail noise goals, with the exception of the nearest residences to the west of the site on Brooke Street. Acoustic hoarding of 4 m in height along the western boundary of the worksite would likely result in compliance with the proposed noise goal, based on the marginal exceedance in **Table 16-50**.

Spot checks of noise intensive plant and equipment would be undertaken during the works. Noise levels would be monitored at locations where predictions indicate exceedance of the noise goals. Supplementary noise monitoring may also be conducted to identify issues of concern in response to any complaints.

At a distance in excess of 40 m to the nearest residential receiver, vibration impacts from minor construction works are not anticipated. A 10 m buffer zone would be maintained between rockbreaking and sensitive structures. Where rockbreakers are required to be used within 10 m of Queensland Rail heritage structures, pre-construction condition surveys and monitoring would be carried out.

16.4.10 Surface structures

Ipswich Motorway on-ramp

The nearest sensitive receivers to the Ipswich Motorway on-ramp worksite are identified on **Figure 16-43** and in **Table 16-51**.

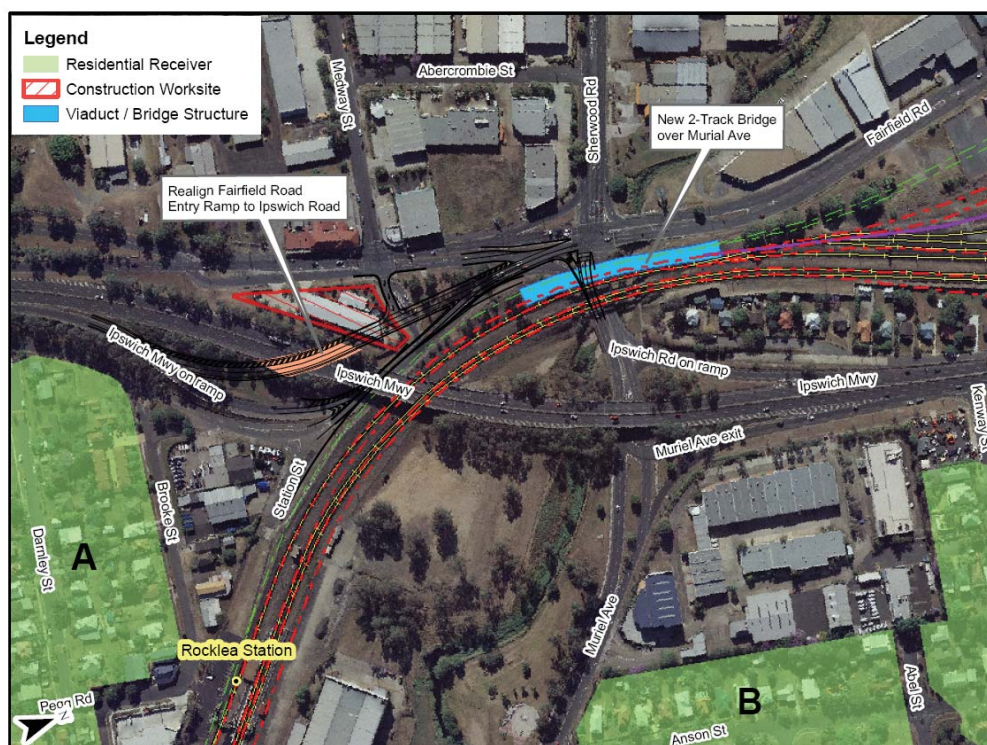


Figure 16-43 Ipswich motorway on-ramp worksite and receiver areas

Table 16-51 Nearest sensitive receivers – Ipswich motorway on-ramp

Worksite	Receiver Area	Location Relative to Works (m)
Ipswich Motorway on-ramp	A – Residential South	50
	B – Residential North-east	350

As the Ipswich Motorway on-ramp worksite would be outside the rail corridor, the Queensland Rail Code of Practice noise goals applied to other surface worksites would not be suitable. Furthermore, it is acknowledged that under certain circumstances, numerical noise limits are often not applied to road construction works, particularly where the works are required within the road reserve of major roads (eg Ipswich Motorway), construction personnel and public safety is a priority and where disruption to major road networks can be avoided by careful scheduling of work hours. Conditions of this nature have been applied to existing major road projects, including Northern Link (Legacy Way) and Airport Link.

On this basis, numerical noise goals have not been proposed for the Ipswich Motorway on-ramp roadworks. Although temporary disruption to normal amenity of the nearest residential receivers is an inevitable consequence of roadworks of this nature, all practicable noise management measures would be employed, eg early community engagement, selecting inherently quiet plant and construction methods and switching off mobile plant when not in use.

At a distance in excess of 50 m to the nearest residential receiver, vibration impacts from the Ipswich Motorway on-ramp works would not be anticipated.

Surface track construction noise

Track work required for the Project would include the use of typical Queensland Rail rolling stock for delivery of both rail and concrete sleepers to the worksite, specialised plant including switch tampers, mainline tampers, ballast regulators, rail grinders and overhead wiring plant etc. Due to the large extent of the Project surface track, it is not practicable to identify all noise sensitive receivers potentially affected by surface track construction noise within (narrow) the operating rail corridors. Consequently, construction noise levels from activities/plant listed in **Table 16-52** have been calculated in **Table 16-53** for various setback distances. The calculated noise emission levels in **Table 16-53** do not take into consideration effects from topographical shielding.

Table 16-52 Surface track construction plant

Plant Item	Sound Power Level (L _A max dBA)
Flat bed truck with crane	110
Ballast truck (rail)	110
Ballast truck (road)	110
Speed swing (360)	114
Locomotive	111
Ballast regulator	122
Tamper	115
Hand held compactor	114
CWR welding plant	93
Cherry picker	104
Wiring equipment	111
Engineers train	111

It should be noted that work associated with construction of new rail track or the upgrading of existing rail track is relatively short in duration (eg less than 2 days) particularly because the work is often confined to shut down periods (eg night-time, weekend, Christmas holidays etc).

Table 16-53 Surface track construction – plant noise emissions

Plant Item	Sound Power Level (dBA)	Noise Level at Setback Distance				
		10 m	25 m	50 m	100 m	250 m
Flat bed truck with crane	110	82	74	68	62	54
Ballast truck (rail)	110	82	74	68	62	54
Ballast truck (road)	110	82	74	68	62	54
Speed swing (360)	114	86	78	72	66	58
Locomotive	111	83	75	69	63	55
Ballast regulator	122	94	86	80	74	66
Tamper	115	87	79	73	67	59

Plant Item	Sound Power Level (dBA)	Noise Level at Setback Distance				
		10 m	25 m	50 m	100 m	250 m
Hand held compactor	114	86	78	72	66	58
CWR welding plant	93	65	57	51	45	37
Cherry Picker	104	76	68	62	56	48
Wiring equipment	111	83	75	69	63	55
Engineers train	111	83	75	69	63	55

As indicated by the construction noise levels in **Table 16-53**, high noise levels, potentially in excess of Queensland Rail's 87 dBA L_{Amax} planning level, may result from the Project trackworks over short setback distances. In addition to limiting, where practicable, the duration of track construction works near any sensitive receiver, all reasonable and feasible noise mitigation measures would need to be applied consistent with the measures listed in Queensland Rail's Code of Practice.

Construction planning would limit works predicted to exceed the Queensland Rail planning level to day-time periods, with suitable arrangements in place to maintain rail network functions. Where such functions cannot be achieved, alternative mitigations for potentially affected properties would be required.

Where track construction is predicted to exceed the Queensland Rail noise goal, consultation with near neighbours would be required to inform them of approaching work, the character and duration of such work, and the potential impacts such work is predicted to have on the acoustic amenity of their locality. Such consultation would be taken into account in construction planning and programming to avoid, where possible, particularly sensitive periods in the year, and to devise mitigation measures which achieve a reasonable acoustic amenity for people living and working near to the works.

16.4.11 Mechanical tunnel excavation

Approximately 10 km of driven tunnelling would be required to construct each of the Project tunnels. Albert Street and Roma Street Station caverns would be constructed by roadheader, whilst Woolloongabba would be excavated by a combination of cut and cover methods and roadheader.

TBM tunnelling works

The nearest receivers from the tunnels have been identified and the corresponding ground-borne vibration and noise levels have been predicted. There are no exceedances predicted in respect of the vibration goals for damage to residential or heritage buildings.

Exceedances of the night-time residential vibration goal are predicted in some locations where the cover between the tunnel crown and the depth below surface is reduced by topographical variations (vibration levels generated at the surface of the ground during tunnel excavation is a function of many variables, including the excavation method, advance rate, depth below surface, ground (rock) hardness and the structure of surface strata).

These exceedances are predicted to occur only for a relatively short period, being less than one week for each TBM passby. At six locations, the predicted vibration levels from TBM tunnelling would extend beyond the theoretical threshold for human perception (0.15 mm/s PPV) and could be noticeable (0.5 to 1.0 mm/s PPV) at 10 locations and even 'easily noticeable' (1.0 to 2.0 mm/s PPV) for some people at three locations. Predicted vibration from TBM tunnelling would be below the 'strongly noticeable' level (> 2.0 mm/s PPV) at all residential properties.

Table 16-54 Summary of TBM ground-borne vibration levels at the nearest point to sensitive receivers

Tunnel Section	Type of Building	Minimum Slant Distance from Tunnel Crown to Sensitive Receiver	Indicative Maximum Vibration Level ¹	Possible Impact ²	Mitigation Options ³
Southern portal to ventilation and emergency access building and shaft	Residential	13 m – 115 m	0.1 to 1.0 mm/s	N	P, M
	Commercial	31 m – 80 m	0.1 to 0.4 mm/s	BN	
	Educational	76 m	0.2 mm/s	TP	
	Worship	21 m – 86 m	0.1 to 0.6 mm/s	N	
	Medical	31 m	0.4 mm/s	BN	
Dutton Park Cemetery	Cemetery	22.5 m – 45 m	0.5 to 1.0 mm/s	-	-
Ventilation and emergency access building and shaft to Boggo Road Station	Residential	13 m – 114 m	0.1 to 1.0 mm/s	N	P, M
	Commercial	13 m – 133 m	0.1 to 1.0 mm/s	N	
	Worship	21 m – 59 m	0.2 to 0.6 mm/s	N	
	Heritage	85 m – 140 m	0.08 to 0.14 mm/s	TP	
	Medical	22.5 m – 38 m	0.3 to 0.6 mm/s	N	
Boggo Road Station to Gabba Station	Residential	10 m – 92 m	0.1 to 1.4 mm/s	EN	P, BSS, M
	Commercial	26 m – 123 m	0.1 to 0.5 mm/s	BN	
	Educational	82 m – 110 m	0.11 to 0.14 mm/s	TP	
	Heritage	56 m – 95 m	0.1 to 0.2 mm/s	TP	
	Hotel	48 m	0.3 mm/s	BN	
Gabba Station to Albert Street Station	Residential	34 m – 200 m	0.1 to 0.4 mm/s	N	P, M
	Commercial	25.5 m – 167 m	0.1 to 0.5 mm/s	BN	
	Educational	35 m – 233 m	0.1 to 0.4 mm/s	BN	
	Worship	36 m – 190 m	0.1 to 0.3 mm/s	BN	
	Medical	200 m	0.1 mm/s	TP	
	Hotel	24 m – 153 m	0.1 to 1.0 mm/s	N	
Albert Street Station to Roma Street Station	Commercial	12 m – 177 m	0.1 to 2.0 mm/s	EN	P, M
	Educational	50 m – 153 m	0.1 to 0.4 mm/s	BN	
	Worship	49 m – 80 m	0.3 to 0.4 mm/s	BN	
	Heritage	28 m – 65 m	0.3 to 0.8 mm/s	N	
	Medical	26.5 m – 96 m	0.2 to 0.8 mm/s	N	
	Hotel	18 m – 141 m	0.1 to 1.3 mm/s	EN	
Roma Street Station to Northern Portal	Residential	33 m – 120 m	0.1 to 0.4 mm/s	BN	P
	Commercial	45 m – 281 m	0.04 to 0.3 mm/s	BN	
	Educational	38 m – 135 m	0.1 to 0.3 mm/s	BN	
	Medical	136 m	0.1 mm/s	TP	
	Hotel	46 m – 107 m	0.1 to 0.3 mm/s	BN	

Notes:

1. Ground-borne vibration goals: Cosmetic damage of 5 mm/s (2 mm/s for heritage listed sites) Residential (hotel) sleep disturbance of 0.5 mm/s
2. NF – Not felt, TP – Threshold of perception, BN – Barely noticeable, N – Noticeable, EN – Easily noticeable, SN – Strongly noticeable, VSN – Very strongly noticeable
3. P = pre notification (vibrations are noticeable), BSS = building sensitive study (vibrations exceed Project cosmetic damage vibration goal), M = monitoring (vibrations exceed sleep disturbance goal)

Predicted 'worst case' ground-borne noise levels from TBM tunnel excavation at residential and commercial receivers along the Project alignment are presented in **Table 16-55**.

In the 'worst case' assessment, there are predicted exceedances of the ground-borne noise goals related to TBM tunnelling, for internal living areas. Such exceedances generally coincide with sections of the route where the distance between the tunnels and the surface are reduced as a consequence of

the surface terrain. While the predicted 'worst case' ground-borne noise would not exceed normal conversation, eg 60 – 70 dB, noise levels at any place, the predicted noise levels would be noticeable and would exceed background noise in most circumstances. Effective mitigation strategies would be required to maintain a reasonable acoustic amenity along the study corridor during TBM passbys.

Based on the average tunnelling speed of a TBM ranging between 90 m to 140 m per week, the maximum number of days exceeding the ground-borne noise goal for the most adversely affected residential receiver would be seven days for each TBM passby, with the majority of sensitive receivers experiencing predicted exceedances of no more than a four to six day period. Beyond these periods, TBM construction would not exceed the night-time noise goals.

There are five hotels in the CBD for which the night-time ground-borne noise goal is predicted to be exceeded for up to 10 days. Such ground-borne noise predictions relate to the ground floor and would diminish with height in each of the buildings.

The following management strategies are proposed to address the predicted exceedances of ground-borne noise from TBM construction:

- Comprehensive advance notice as well as educating the public of intended tunnelling activities in the localities near the tunnel alignment. Part of the consultation process would include information regarding the monitoring program which may require involvement from residences located above the tunnel alignment and the system for dealing with concerns and complaints. An effective construction education program would assist to reduce fears of the tunnelling process.
- Ground-borne noise and vibration monitoring to be undertaken at the commencement of tunnelling to confirm that the source data utilised for this assessment is applicable to the TBM works, including the low frequency noise assessment inputs and findings (ie model validation).
- Conduct pre-condition building surveys in accordance with Brisbane City Council requirements where it is considered there may be potential risk for cosmetic (superficial) building damage from TBM excavation.
- Through consultation, provide direct support to potentially impacted properties, such as temporary relocation of residents impacted by ground-borne noise from TBM tunnelling. Such support would be negotiated between the contractor and the resident on a case-by-case basis, within the context of a framework agreed beforehand with the residents.

Table 16-55 Summary of TBM ground-borne noise levels at the nearest point to sensitive receivers

Tunnel Section	Type of Building	Minimum Slant Distance from Tunnel Crown to Sensitive Receiver	Indicative Maximum Ground-borne Noise Level (dBA) ¹	Possible Impact ²	Mitigation Options ³
Southern Portal to ventilation and emergency access building and shaft	Residential Commercial Educational Worship Medical	13 m – 115 m 31 m – 80 m 76 m 21 m – 86 m 31 m	24 dBA to 53 dBA 29 dBA to 42 dBA 30 dBA 28 dBA to 47 dBA 31 dBA to 42 dBA	Very Low to High Very Low to Mod. Very Low Very Low to High Very Low to Moderate	P, M, R
Ventilation and emergency access building and shaft to Boggo Road Station	Residential Commercial Worship Heritage Medical	13 m – 114 m 13 m – 133 m 21 m – 59 m 85 m – 140 m 22.5 m – 38 m	25 dBA to 53 dBA 25 dBA to 53 dBA 33 dBA to 47 dBA 22 dBA to 28 dBA 39 dBA to 46 dBA	Very Low to High Very Low to High Very Low to High Very Low Low to High	P, M, R

Tunnel Section	Type of Building	Minimum Slant Distance from Tunnel Crown to Sensitive Receiver	Indicative Maximum Ground-borne Noise Level (dBA) ¹	Possible Impact ²	Mitigation Options ³
Boggo Road Station to Woolloongabba	Residential Commercial Educational Heritage Hotel	10 m – 92 m 26 m – 123 m 82 m – 110 m 56 m – 95 m 48 m	27 dBA to 57 dBA 28 dBA to 44 dBA 25 dBA to 29 dBA 27 dBA to 34 dBA 36 dBA	Very Low to High Very Low to Mod. Very Low Very Low Low	P, M, R
Woolloongabba to Albert Street Station	Residential Commercial Educational Worship Medical Hotel	34 m – 200 m 25.5 m – 167 m 35 m – 233 m 36 m – 190 m 200 m 24 m – 153 m	17 dBA to 40 dBA 19 dBA to 44 dBA 20 dBA to 40 dBA 18 dBA to 39 dBA 17 dBA 21 dBA to 50 dBA	Very Low to Low Very Low to Mod. Very Low to Low Very Low to Low Very Low Very Low to High	P, M, R
Albert Street Station to Roma Street Station	Commercial Educational Worship Heritage Medical Hotel	12 m – 177 m 50 m – 153 m 49 m – 80 m 28 m – 65 m 26.5 m – 96 m 18 m – 141 m	24 dBA to 59 dBA 26 dBA to 40 dBA 34 dBA to 40 dBA 37 dBA to 48 dBA 32 dBA to 49 dBA 27 dBA to 54 dBA	Very Low to High Very Low to Low Very Low to Low Very Low to High Very Low to High Very Low to High	P, M, R
Roma Street Station to Northern Portal	Residential Commercial Educational Medical Hotel	33 m – 120 m 45 m – 281 m 38 m – 135 m 136 m 46 m – 107 m	24 dBA to 41 dBA 13 dBA to 37 dBA 22 dBA to 39 dBA 22 dBA 25 dBA to 36 dBA	Very Low to Mod. Very Low to Low Very Low to Low Very Low Very Low to Low	P, M, R

Notes:

- Ground-borne noise goals:
Commercial – 40 to 50 dBA
Residential night-time – 35 dBA
- Very Low: <35 dBA, Low: 35 – 40 dBA, Moderate: 40 to 45 dBA, High: > 45 dBA
- P = pre-notification, M = monitoring, R = temporary relocation (ground-borne noise exceeding Project ground-borne noise goals for residential (night-time))

Roadheader tunnelling works

Cross passages

The nearest receivers from the cross passages between the tunnels have been identified and the corresponding ground-borne noise and vibration levels have been predicted (refer to **Section 9.2** of *Technical Report No. 8 – Noise and Vibration*).

There are no exceedances of the cosmetic damage vibration goal, neither the residential nor the stricter cosmetic damage to heritage buildings vibration goal (refer to **Table 16-15**). All residential receivers comply with the night-time vibration perceptibility goal of 0.5 mm/s PPV during the tunnelling works for the cross passages.

There are 22 exceedances of the night-time ground-borne noise goal for residential receivers above or close to the cross passages (13 of these are within a marginal 2 dBA exceedance). It should be noted that the ground-borne noise and vibration from the excavation of cross passages will be short duration works (ie 2-3 days). All commercial receivers comply with the relevant 45 dBA (office spaces) and 50 dBA (retail) ground-borne noise goals.

Portals and underground stations

A short section adjacent to the northern portal (after the TBM recover site) as well as the station caverns (except at Boogo Road), are proposed to be constructed by roadheader tunnelling.

The nearest receivers from the sections next to the portals and at the underground stations have been identified and the corresponding predicted ground-borne vibration levels are presented in **Table 16-56** and ground-borne noise levels are presented in **Table 16-57**.

As shown in **Tables 16-56** and **16-57**, exceedances of the ground-borne noise and vibration goals are predicted for two hotels (Carrington/Sunland and Oaks Festival Towers) near Albert Street Station. However, it should be noted that the predicted levels are for ground floor and ground-borne noise and vibration levels attenuate by approximately 2 dB per floor for the first four floors and by approximately 1 dB per floor thereafter. This results in exceedances of the ground-borne noise and vibration goals only for hotel rooms on the Ground Floor and Floor 1.

Predicted vibration levels for all other residential receivers would comply with the ground-borne noise and vibration goals during the roadheader tunnelling works at the portals and station locations.

Table 16-56 Summary of roadheader ground-borne vibration levels at underground station locations and close to the portals

Tunnel Section	Type of Building	Minimum Slant Distance from Tunnel Crown to Sensitive Receiver	Indicative Maximum Vibration Level ¹	Possible Impact ²	Mitigation ³
Woolloongabba	Residential Commercial Educational Worship Hotel	47 m – 195 m 21 m – 192 m 90 m – 149 m 115 m 40 m	0.01 to 0.05 mm/s 0.01 to 0.15 mm/s 0.01 to 0.02 mm/s 0.02 mm/s 0.06 mm/s	NF TP NF NF NF	
Albert Street Station	Commercial Educational Hotel	27 m – 194 m 33 m – 277 m 8 m (24 m ⁴) – 107 m	0.01 to 0.2 mm/s 0.01 to 0.15 mm/s 0.01 to 1.0 mm/s (0.2 mm/s ⁴)	TP TP N	P, M
Roma Street Station	Residential Commercial Heritage Medical Hotel	114 m – 148 m 51 m – 169 m 62 m 137 m 45.5 m – 78 m	0.01 to 0.02 mm/s 0.02 to 0.08 mm/s 0.04 mm/s 0.02 mm/s 0.05 to 0.1 mm/s	NF NF NF NF NF	
Northern Portal	Residential Commercial Educational Hotel	109 m – 213 m 136 m – 152 m 100 m – 120 m 141 m – 150 m	0.01 to 0.02 mm/s 0.01 to 0.01 mm/s 0.01 to 0.02 mm/s 0.01 to 0.01 mm/s	NF NF NF NF	

Notes:

1. Cosmetic damage (CD) of 5 mm/s (2 mm/s for heritage listed sites) Residential (hotel) sleep disturbance of 0.5 mm/s
2. NF – Not felt, TP – Threshold of perception, BN – Barely noticeable, N – Noticeable, EN – Easily noticeable, SN – Strongly noticeable, VSN – Very strongly noticeable
3. P = pre notification, BSS = building sensitive study, M = monitoring
4. Minimum distance of 8 m to lowest level underground parking, 24 m to ground floor (first occupied floor). Vibration levels on ground floor 0.2 mm/s barely noticeable.

Table 16-57 Summary of roadheader ground-borne noise levels at underground station locations and close to the portals

Tunnel Section	Type of Building	Minimum Slant Distance to Tunnel Crown	Indicative Maximum Ground-borne Noise Level ¹ (dBA)	Possible Impact ²	Mitigation ³
Woolloongabba	Residential	47 m – 195 m	<10 dBA to 28 dBA	Very Low	
	Commercial	21 m – 192 m	<10 dBA to 38 dBA	Low to Mod.	
	Educational	90 m – 149 m	13 dBA to 19 dBA	Very Low	
	Worship	115 m	16 dBA	Very Low	
	Hotel	40 m	30 dBA	Very Low	
Albert St Station	Commercial	27 m – 194 m	<10 dBA to 40 dBA	Very Low to Mod.	P, M, R
	Educational	33 m – 277 m	<10 dBA to 37 dBA	Very Low to Low	
	Hotel	(8 m ⁴) 24 m – 107 m	22 dBA to 42 dBA	Very Low to Mod.	
Roma St Station	Residential	114 m – 148 m	13 dBA to 16 dBA	Very Low	
	Commercial	51 m – 169 m	16 dBA to 32 dBA	Very Low	
	Heritage	62 m	24 dBA	Very Low	
	Medical	137 m	19 dBA	Very Low	
	Hotel	45.5 m – 78 m	26 dBA to 33 dBA	Very Low	
Northern Portal	Residential	109 m – 213 m	<10 dBA to 17 dBA	Very Low	
	Commercial	136 m – 152 m	12 dBA to 14 dBA	Very Low	
	Educational	100 m – 120 m	15 dBA to 18 dBA	Very Low	
	Hotel	141 m – 150 m	12 dBA to 13 dBA	Very Low	

Notes:

1. Ground-borne noise goals: Commercial of 40 to 50 dBA, Residential night-time of 35 dBA
2. Very Low: <35 dBA, Low: 35 – 40 dBA, Moderate: 40 to 45 dBA, High: > 45 dBA
3. P = pre notification, M = monitoring, R = temporary relocation
4. 8 m to lowest level underground parking, 24 m to ground floor (first occupied floor)

16.4.12 Low frequency noise assessment

The low frequency noise assessment based on the EcoAccess ALFN Guideline includes an assessment of annoyance due to infrasound (dBG) and low frequency noise (LpA,LF) (refer to Section 9.3 of *Technical Report No. 8 – Noise and Vibration*). The assessment indicates that annoyance limits would likely be exceeded during driven tunnelling works associated with the Project for offset distances of up to 100 m. Low frequency noise would manifest a low rumble in the background, and in some circumstances, may become annoying for the duration of the TBM passbys.

The proposed noise and vibration management sub-plan would cover the potential for low frequency noise impacts, with the following recommendations as a minimum:

- A comprehensive notification and education program to assist in allaying community concerns regarding tunnelling. Part of the education process would include an indication of tunnelling progress and subsequent likely (temporary) exposure periods.
- Infrasound and low frequency noise measurements in accordance with the ALFN guideline at the commencement of tunnelling operations and in the event of a “low frequency” noise complaint (where required).
- An option for temporary relocation of people pending the outcome of an assessment of the impact against the EIS goals and ALFN Guideline, in relation to actual monitoring data as each TBM advances.

16.4.13 Construction traffic

Spoil removal

Spoil from the TBMs would be removed via a spoil conveyor behind the TBM in the tunnel out to the acoustic enclosures at the Woolloongabba and Southern Portal worksites to a site in Swanbank. Movements of spoil by heavy goods vehicles would be restricted to operating on designated haulage routes (refer to **Chapter 5 Transport**). Since the proposed spoil destination route does not pass residential receiver locations after vehicles exit the Cunningham Highway, no further assessment of road traffic noise impact is required. Anticipated average and peak frequencies of spoil trucks from each worksite are summarised in **Table 16-58**.

Table 16-58 Summary of spoil truck movements

Worksite	Average Truck Movements per day ¹	Peak Truck Movements per day ¹
Tunnel Worksites		
Northern Portal	30	75
Roma Street Station	64	160
Albert Street Station	55	137
Woolloongabba Station	86	214 (hourly peak = 9)
Boggo Road Station	36	89
Ventilation and emergency access building and shaft	12	29
Southern Portal	86	214 (hourly peak = 9)
Surface Worksites		
O'Connell Terrace	n/a	60 ²
Mayne Stabling Yard	n/a	143 ²
Clapham Stabling Yard	n/a	143 ²

Notes:

1 – Truck movements = 2 trips

2 – Includes delivery vehicles.

Construction traffic noise impacts

Movements of construction materials by heavy goods vehicles would be restricted to designated haulage routes. The effect of construction related heavy vehicle traffic on noise emissions from roadways has been assessed by calculating how the additional truck traffic would alter the LA10(12hour) level of noise emission from roadways using the Calculation of Road Traffic Noise (CoRTN) prediction algorithms. For the purpose of this analysis, the LA10(12hour) is the average LA10 traffic noise level between the hours of 6.30 am and 6.30 pm. However, for Woolloongabba and the southern portal worksites, the change in road traffic noise levels was assessed over the following time periods to cover the 24 hour tunnelling operations from these worksites:

- LA10(18hour) for between 6.00 am and 12.00 midnight
- LA10(1hour) for the peak number of heavy vehicle movements during any hour between 12.00 midnight and 6.00 am.

At this planning stage of the Project, hourly peak heavy vehicle movements between 12.00 midnight and 6.00 am are unknown. As a conservative assessment approach, the day-time hourly peak movements were combined with traffic volumes calculated during the quietest hour between 12.00 midnight to 6.00 am period.

On any given roadway, the essential modelling inputs that the additional construction traffic would alter are the percentage of heavy vehicles and total vehicle numbers using that roadway. For the assessment of typical construction truck volumes, the peak daily frequencies have been used as being representative of total truck movements. This conservative assessment is summarised in **Table 16-59**.

For this analysis, the existing annual average daily traffic (AADT) road traffic predictions on all roads is consistent with information included in **Chapter 5 Transport**.

Table 16-59 Effect of construction truck movements on traffic noise levels along spoil routes

Worksite	Road Segment	Change in Road Traffic Noise Level due to the Project (dBA)	
		LA10 (12hr)	LA10 (1hr)
Tunnel Worksites			
Northern Portal	Gregory Terrace to Bowen Bridge Road	+0.3	n/a
Roma Street Station	Roma Street adjacent to existing station	+0.3	n/a
Albert Street Station	Alice Street west of Albert Street	+0.3	n/a
Woolloongabba	Ipswich Road south of Stanley Street	+0.3 ¹	+0.8
Boggo Road Station	Annerley Road south of Boggo Road	0	n/a
Ventilation and emergency access building	Fairfield Road south of Brougham Street	0	n/a
Southern Portal	Lucy Street ²	+1.5 ¹	n/a
	Ipswich Road south of Lucy Street	+0.2 ¹	+0.5
Surface Worksites			
O'Connell Terrace	Bowen Bridge Road north of O'Connell Terrace	0	n/a
Mayne Rail Yard	Inner City Bypass	0	n/a
Clapham Rail Yard	Fairfield Road south of Chale Street	+0.2	n/a

Notes:

1. LA10 (18 hour)

2. Road adjacent to industrial/commercial receivers only.

From this analysis, spoil traffic would not increase average traffic noise levels on spoil routes that pass residential receivers by more than 0.3 dBA for existing road corridors between 6.30 am and 6.30 pm.

For Woolloongabba, an increase in road traffic noise level of 0.8 dBA was predicted for the (12.00 midnight to 6.00 am) night-time peak. At the southern portal, an increase of up to 0.5 dBA was predicted for the LA10(1hour) night-time peak for residential receivers adjacent to Ipswich Road. A 1.5 dBA increase is predicted for Lucy Street, however this does not impact on residential receivers. It is generally recognised in acoustics that changes in noise levels of 2 dBA or less are undetectable to the human ear and therefore negligible.

The absolute maximum noise levels associated with vehicle pass-bys would not be altered by construction vehicles, however the frequency of such events would increase. Fully loaded trucks travelling on maintained public roadways would not generate significant levels, ie able to be clearly felt, of ground vibration at buildings adjacent to spoil routes.

16.4.14 Construction noise and vibration management

The extent of any construction noise and vibration impact would depend on the construction phases finally adopted. The equipment selected, the distances to residences and the duration of noisy activities would result in some noise and/or vibration impacts. Careful construction planning accompanied by early and on-going consultation with people living and working in the path of construction works, can significantly reduce potential impacts.

The following typical noise control and impact mitigation measures would be implemented where surface construction compounds are situated near a sensitive receiver locality:

- Comprehensive advance notice as well as educating the public of intended tunnelling activities in the localities near the tunnel alignment. Part of the consultation process would include information regarding the monitoring program which may require involvement from residences located above the tunnel alignment. A thorough education program would assist to allay fears of the tunnelling process.
- Constant review of alternative construction methods aimed at reducing the extent of potential impacts.
- Selection of the quietest plant and equipment that can economically undertake the work, wherever possible (ie fitted with appropriate exhaust silencers, mufflers or acoustic covers).
- Regular maintenance of equipment to ensure that it remains in good working order.
- Where possible, avoidance of the coincidence of plant and equipment working simultaneously close together near sensitive receivers.
- Fitting mobile plant such as excavators, front end loader and other diesel powered equipment with residential class mufflers.
- Use of localised noise screens/barriers or enclosures for particular noisy operations such as pile boring, rockbreaking, blasting etc. An example of utilising the built environment to mitigate noise could be achieved at Wilkie Street during the demolition of existing buildings, whereby the last row of buildings to be removed could remain in place until the final stage of demolition.
- Conducting pre- and post construction building condition surveys where it is considered there may be potential for cosmetic (superficial) building damage from the Project's construction activities, eg TBM, roadheader and drill and blast etc.
- Noise and vibration monitoring at the commencement of tunnelling to confirm that the source data utilised for this assessment is applicable to this Project (including the low frequency noise assessment inputs and findings). Monitoring of both tunnelling and surface works would be undertaken to inform and refine environmental performance and management, and to avoid or minimise the extent of potential impacts on sensitive receivers.
- Minimisation of night-time surface construction activities and spoil removal where predicted noise and vibration levels would exceed goals related to the environmental objectives.

Construction noise and vibration monitoring procedures would be developed to address the initial and ongoing monitoring of noise and vibration from construction to assist in planning and management of construction works. This would be of particular importance where work activities are close (ie less than 100 m) to residences or other noise sensitive receivers.

Pre-condition surveys would be conducted for buildings and historical items in vibration sensitive zones prior to commencement of construction. Arrangements would be put in place with property owners prior to commencement, to address any damage to buildings caused by the Project works.

On-going spot checks of noise intensive plant and equipment would be undertaken to ensure performance continues to match specifications. Construction noise and vibration levels would be monitored throughout the construction phase to verify compliance with the design goals.

Monitoring would be undertaken at locations where the goals and criteria are predicted to be exceeded. Further monitoring may be required to address specific complaints.

Regular inspections by the Project site supervisor would ensure that appropriate noise and vibration controls are being implemented and are effective. Any issues identified during the weekly inspections would be documented in regular monitoring reports. Further details of these management measures are provided in **Chapter 24 Draft Outline EMP**.

A detailed monitoring program would be prepared prior to the commencement of construction and would be informed by and updated as detailed design progresses. **Table 16-60** provides an outline construction noise monitoring program and **Table 16-61** provides an outline construction vibration monitoring program, both of which would be adopted as minimum requirements for the Project.

Table 16-60 Construction noise monitoring – minimum mitigation measures

Construction Noise Monitoring	Schedule	Locations	Procedures and Instrumentation
Operator Attended Noise Monitoring – Worksites	Commencement of noise intensive construction activities; then weekly.	At the nearest receiver in each direction for: ■ worksite activities (site preparation works, day and night tunnelling), ■ surface trackworks.	Attended measurements to quantify and qualify construction noise emissions using a calibrated sound level meter capable of measuring LA90, LAeq, LA10 and LA1 statistical noise levels in 15 minute intervals. One 15 minute sample per survey location is generally sufficient. Extraneous noise (eg cars, trains etc) would be excluded from the measurements. Sources contributing to the noise levels are to be noted.
Unattended Noise Monitoring – Worksites	Continuous or as required. Regular (weekly or fortnightly).	Continuous noise logging at nearest noise sensitive receiver adjacent to tunnel worksites.	A calibrated noise logger for LA90, LAeq, LA10 and LA1 statistical noise levels in 15 minute intervals. Consider noise loggers capable of recording audio samples by means of preset trigger level exceedances to identify source of any exceedance.
Plant Noise Audits	As required, for noisy plant items such as piling rigs, hydraulic hammer, haul trucks etc.	On site, typically at 7 m from the item of plant (for surface equipment) in the direction of dominant noise emission. Closer to the source if other sources prevent measurement at this distance.	Attended measurements using calibrated sound level meter for LAeq, LA10, LA1 and LMax levels. Select most dominant sources of noise. Measure maximum noise normally occurring for that source. A one minute sample will be satisfactory, may extend to 15 minutes for variations. Haul trucks to be checked against <i>Vehicle Standard Australian Design Rule 28/01 – External Noise of Motor Vehicles</i> , before commencing works and at 12 month intervals.
Regenerated Noise Monitoring	Commencement of driven tunnelling works at each worksite.	10 receiver locations per working face of short-term operator attended regenerated noise measurements at varying slant distances from the working face.	Calibrated sound level meter for LA90, LAeq, LA10, LA1 and LMax and one-third octave noise levels in 15 minute intervals.
Response to Complaints	Within 24 hours of complaint.	To address complaint.	Attended or unattended measurements as appropriate to identify and measure the source.

Table 16-61 Construction vibration monitoring mitigation measures

Construction Vibration Monitoring	Schedule	Locations	Procedures and Instrumentation
Driven Tunnelling	Minimum of 1 vibration logger per working face for first 3 months for each tunnel section. After initial 3 months, a minimum of 1 vibration logger for each tunnel section where: ■ exceedance of vibration goals are predicted. ■ complaints have been received.	Tunnel sections include: ■ 2 x mainline tunnels ■ 2 x portals At the nearest receiver to the cutting face where predictions indicate exceedances. As appropriate to address complaint.	Operator attended measurements using a calibrated instrument for peak particle velocity in 3 axes (ie vertical, longitudinal and transverse).
Blasting	Minimum of 2 vibration and blast overpressure monitoring locations during each blast.	At the nearest receivers to the blast site. At heritage listed structure if close to blasting.	Measurements using a calibrated instrument for peak particle velocity in 3 axes (ie vertical, longitudinal and transverse) and blast overpressure.
Buffer distance tests for: ■ Worksite activities ■ Surface track works	Commencement of all vibration intensive activities for each worksite and surface track works. To address complaints where exceedances are predicted.	At foundation of potentially affected structure.	Attended measurements using a calibrated instrument for peak particle velocity in 3 axes.

16.5 Operation impact assessment and mitigation measures

This section provides an overview of the Project's operation elements that are relevant to noise and vibration. It outlines the potential noise and vibration levels that would be generated by the Project during operation and outlines mitigation measures to avoid or minimise potential impacts.

16.5.1 Ground-borne noise assessment – train operations

Train noise in buildings adjacent to rail tunnels is caused by the transmission of ground-borne vibration rather than the direct transmission of noise through the air. The vibration is initially generated by wheel-rail interaction and is transmitted from the trackbed, through the tunnel structure, via the ground and into the adjacent building structures. After entering a building, this vibration causes the walls and floors to vibrate faintly and then to radiate noise (commonly termed “ground-borne noise”).

If audible, such noise has a low frequency rumbling character, which increases and decreases in level as a train approaches and departs the site. This type of noise can be experienced in buildings adjacent to many urban underground rail systems.

For most new railways, the standard track design incorporates resilient rail fasteners to reduce the dynamic forces that occur at the wheel-rail interface. This resilience also serves to isolate some ground-borne vibration, which in turn reduces the ground-borne noise levels in buildings near the railway.

In the ground-borne vibration assessment, the following three trackform options have been evaluated:

- “direct fixation” trackform, with standard “stiff” rail fasteners
- “resilient” trackform, with moderately resilient rail fasteners
- “highly resilient” trackform, incorporating highly resilient rail fasteners.

A summary of the reference vibration levels for the three forms of track systems are provided in **Figure 16-44**.

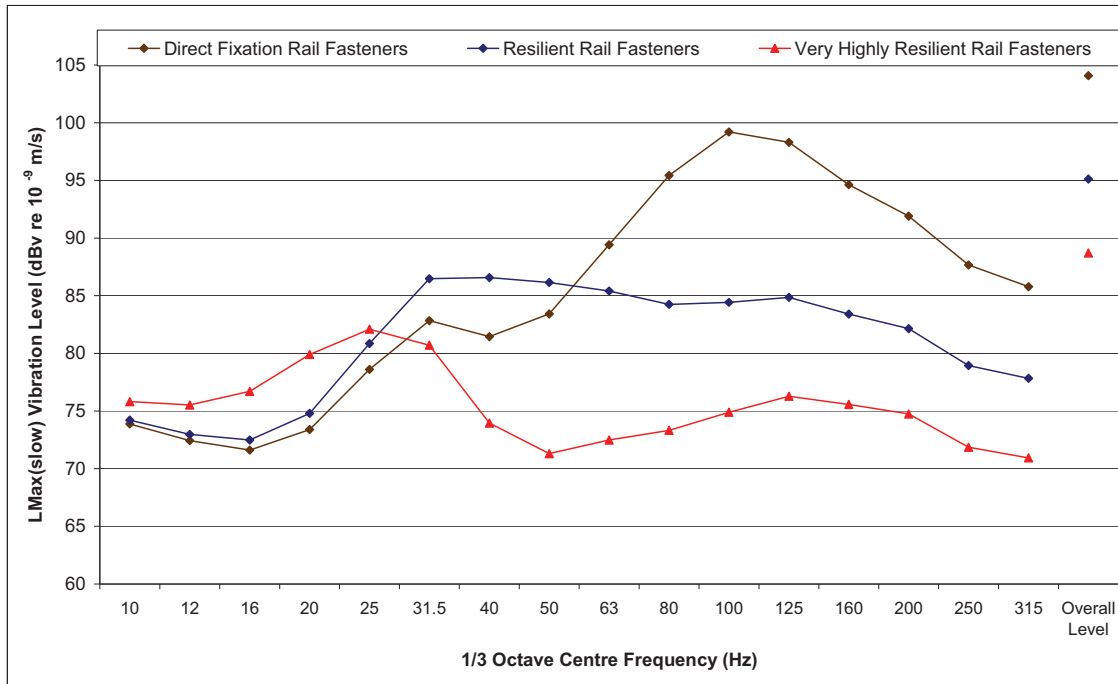


Figure 16-44 Reference source vibration levels for trains (tunnel wall vibration levels at reference speed of 80 km/h) – Lmax,Slow

Note:

The LMax noise levels are for the 95th percentile train passby event. The absolute maximum event is not used for predictions, as it cannot be precisely defined and would be a highly infrequent event. The source vibration levels assume wheel and rail roughness within the limit spectrum in Annex C of ISO 3095. Acoustics: Measurement of Noise Emitted by Rail Bound Vehicles, 2005.

At critical locations, a “resilient” or “highly resilient” trackform will be required to achieve the ground-borne noise goals. Two additional track sections incorporating the “highly resilient” trackform are proposed, compared to the combination of trackforms proposed for the reference design. With the proposed combination of trackforms, compliance with the ground-borne noise goals are predicted at all sensitive receiver locations. In total, 6.9 km of resilient rail fasteners and 1.19 km of highly resilient rail fasteners are required for the tunnels.

A summary of the predicted ground-borne noise levels with the proposed trackform configuration is provided in **Table 16-62** and shows ground-borne noise levels with mitigation in place.

16.5.2 Ground-borne vibration assessment – train operations

During train operations within the Project tunnels, vibration generated at the wheel-rail interface would be transferred via the rail mounts into the track support system and surrounding ground. It then would travel through the ground or structures and sometimes be felt as tactile vibration by the occupants of buildings.

For the ground-borne noise and vibration modelling, no readily available commercial modelling software is available. Therefore, a Project model was developed. The algorithms incorporated into the Project model are well documented in authoritative references. In accordance with ISO 14837-1 *Mechanical Vibration – Ground-Borne Noise and Vibration arising from Rail Systems – Part 1* (2005), the ground-borne noise and vibration modelling considers all of the parameters that are critical in determining the absolute levels of ground-borne noise and vibration, and the benefits (or otherwise) of different design and mitigation options. The key parameters are listed under the following headings:

- source – route alignment, rolling stock design, rail type, trackform design, tunnel design, construction tolerances, operations and maintenance
- propagation path – ground type and vibration propagation wave types
- receiver – building construction.

A description of this method and the references is provided in *Technical Report No.8 – Noise and Vibration*. A brief summary of the modelling algorithms that have been proposed for the Project assessment is provided following.

This model was validated using measurement data collected from the Epping to Chatswood Railway Line (ECRL) in Sydney which opened in February 2009. The ECRL and the Project share similar design characteristics in relation to the circular tunnel cross section and the slab track design. The differences between the ECRL and the Project (eg ground conditions, rolling stock and track/rolling stock maintenance practices) have been accounted for in the ground-borne noise and vibration predictions. To ensure ground conditions along the Project alignment were taken into account, borehole vibration testing at three locations was undertaken to determine the ground vibration attenuation versus distance characteristics. Vibration testing was performed on three boreholes between Albert Street Station and Boggo Road Station using a special vibration sensor lowered to different depths in the boreholes and measuring the vibration attenuation. The tested boreholes have ground types consisting of Neranleigh-Fernvale Beds, Brisbane Tuff, and at Boggo Road Station a combination of Brisbane Tuff with Mudstone and Tingalpa Formation underneath.

The modelling approach was based on the guidelines contained in *International Standard ISO 14837 1 2005 Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1: General Guidance*, taking into account the source vibration levels, the propagation in the ground between the source and receiver and the vibration propagation within the building.

Table 16-62 Summary of predicted ground-borne noise levels during operation with proposed trackforms

Chainage (km)	Type of Building	Min. Slant Distance to Track Level	Predicted Ground-borne Noise Level (dBA) ¹	Ground-borne Noise Goal (dBA)	Mitigation Measures
0.36 – 0.95 Southern Portal to Christensen Street, Yeronga	Residential Commercial Educational/Heritage Worship	18 m – 108 m 57 m – 81 m 77 m 24 m – 26 m	<10 dBA to 27 dBA <10 dBA <10 dBA 20 dBA to 21 dBA	35 dBA (night) 40 dBA 40 dBA 40 dBA	Highly resilient rail fasteners
0.95 – 2.0 Christensen Street, Yeronga to ventilation and emergency access building and shaft (Bledisloe Street)	Residential Commercial Worship Medical	25 m – 117 m 34 m – 80 m 88 m 35 m	<10 dBA to 33 dBA 12 dBA to 28 dBA <10 dBA 28 dBA	35 dBA (night) 40 dBA 40 dBA 40 dBA	Resilient rail fasteners
2.0 – 2.75 Ventilation and emergency access building and shaft (Bledisloe Street) to Glenside Street, Fairfield	Residential Commercial Worship Medical	24 m – 115 m 26 m – 85 m 29 m – 61 m 41 m	<10 dBA to 33 dBA 10 dBA to 32 dBA 17 dBA to 31 dBA 25 dBA	35 dBA (night) 40 dBA 40 dBA 40 dBA	Resilient rail fasteners
2.75 – 3.15 Glenside Street, Fairfield to Fenton Street, Fairfield	Residential Commercial	18 m – 106 m 18 m – 21 m	<10 dBA to 29 dBA 27 dBA to 29 dBA	35 dBA (night) 40 dBA	Highly resilient rail fasteners
3.15 – 3.95 Fenton Street, Fairfield to Boggo Road Station	Residential Commercial Heritage Medical	23 m – 108 m 20 m – 110 m 28 m – 63 m 28 m – 29 m	<10 dBA to 32 dBA <10 dBA to 28 dBA <10 dBA to 35 dBA 27 dBA to 28 dBA	35 dBA (night) 40 dBA 40 dBA 40 dBA	Resilient rail fasteners
3.95 – 4.15 Boggo Road Station to Existing Park Road Station	Commercial Educational	22 m 76 m – 111 m	25 dBA <10 dBA	40 dBA 40 dBA	Resilient rail fasteners
4.15 – 4.35 Existing Park Road Station to Abingdon St, Woolloongabba	Residential	15 m – 79 m	<10 dBA to 28 dBA	35 dBA (night)	Highly resilient rail fasteners
4.35 – 5.1 Abingdon Street, Woolloongabba to Woolloongabba	Residential Commercial Worship Hotel	18 m – 94 m 26 m – 89 m 60 m – 97 m 43 m	<10 dBA to 34 dBA <10 dBA to 29 dBA <10 dBA to 15 dBA 20 dBA	35 dBA (night) 40 dBA 40 dBA 35 dBA (night)	Resilient rail fasteners

Chainage (km)	Type of Building	Min. Slant Distance to Track Level	Predicted Ground-borne Noise Level (dBA) ¹	Ground-borne Noise Goal (dBA)	Mitigation Measures
5.1 – 6.85 Woolloongabba to Albert Street Station	Residential	38.5 m – 202 m	<10 dBA to 26 dBA	35 dBA (night)	Resilient rail fasteners (chainage 5.95 – 6.55 km rail section under the Brisbane River with direct fixation rail fasteners)
	Commercial	26 m – 168 m	<10 dBA to 25 dBA	40 dBA	
	Educational	37 m – 234 m	<10 dBA to 23 dBA	40 dBA	
	Worship	42 m – 192 m	<10 dBA	40 dBA	
	Medical	201 m	<10 dBA	40 dBA	
	Hotel	19 m – 146 m	<10 dBA to 27 dBA	35 dBA (night)	
6.85 – 7.9 Albert Street Station to Roma Street Station	Commercial	17 m – 91 m	<10 dBA to 36 dBA	40 dBA	Resilient rail fasteners
	Educational	52 m – 58 m	13 dBA to 23 dBA	40 dBA	
	Worship	52 m – 82 m	16 dBA to 30 dBA	40 dBA	
	Heritage	33 m – 67 m	21 dBA to 34 dBA	40 dBA	
	Medical	32 m – 98 m	13 dBA to 35 dBA	40 dBA	
	Hotel	22.5 m – 82 m	<10 dBA to 33 dBA	35 dBA (night)	
7.9 – 9.55 Roma Street Station to Northern Portal	Residential	38 m – 121 m	<10 dBA to 25 dBA	35 dBA (night)	Resilient rail fasteners (chainage 9.05 – 9.55 km rail section with direct fixation rail fasteners)
	Commercial	50 m – 113 m	<10 dBA to 21 dBA	40 dBA	
	Educational	43 m – 122 m	<10 dBA to 24 dBA	40 dBA	
	Medical	138 m	<10 dBA	40 dBA	
	Hotel	51 m – 108 m	<10 dBA to 20 dBA	35 dBA (night)	

Notes:

The proposed reference design trackform is detailed in Table 15 of Technical Report No. 8 Noise and Vibration – operation.

The L_{max} Slow noise level refers to the 95th percentile train passby event. The ground-borne noise level of the “average” or median train event would typically be approximately 3 dB lower than the 95th percentile event.

1. Assumes the proposed mitigation measures (ie resilient or highly resilient rail fasteners)

The predicted ground-borne vibration levels with the reference design trackform are below the residential vibration goal at the nearest sensitive receiver locations by more than a factor of three as shown in **Table 16-63**. On this basis, vibration levels from train passbys are not likely to be perceptible within nearby buildings.

However, the CBD 7 Day Medical Centre has predicted vibration levels exceeding the generic vibration goal for highly vibration sensitive equipment. At the detailed design stage, investigations would ascertain whether any highly vibration sensitive equipment is present at the CBD 7 Day Medical Centre and whether it would be necessary to include a section of highly resilient trackform past this building.

The predicted ground-borne vibration levels comply with the instrument-specific vibration criteria given for the electron microscope at the Ecosciences Precinct located at Boggo Road Urban Village. More detailed measurements and predictions would be performed at this site to ensure that operations would remain undisturbed.

The predicted vibration levels associated with train operations in the tunnels are less than 0.06 mm/s at any buildings near the tunnels and therefore the risk to any heritage buildings is negligible. Similarly, the potential for damage to other key utilities or infrastructure is also negligible, on the basis that the tunnel wall vibration levels are anticipated to be approximately 0.1 mm/s (100 dBV).

16.5.3 Airborne noise assessment – train operations

Train operations – upgraded rail alignments

Additional surface tracks are located:

- north of the northern portal, between Victoria Park and Breakfast Creek, within the existing rail corridor for the Exhibition loop, RNA Showgrounds and Mayne Rail Yard
- south of the southern portal, between Yeerongpilly and Salisbury, including narrow gauge tracks generally on the eastern side of the corridor and dual gauge track(s) on the western side of the corridor.

The noise assessment for the surface train operations have been performed for future Year 2021 and Year 2031 train operations. The SoundPLAN model was created from topography, rail alignments, existing buildings, resumption plans and traffic volumes and characteristics for the Project. Existing noise barriers within the model area were taken into account. The model assumes freight traffic travelled at a speed of 60 km/h and suburban trains travelled at a maximum speed of 80 km/h within the modelling area. Suburban trains were modelled as a mixture of six-car Suburban Multiple Unit (SMU)/ Interurban Multiple Unit (IMU) and nine-car SMU, based on the service plans. Freight trains were assumed to comprise a double header current generation locomotive with 620 m long trains for the existing scenario (model verification) and 1,500 m long trains for both future scenarios (this provides a worst case scenario).

Noise source levels from all trains except the new nine-car passenger trains are based on Queensland Rail's standard table of noise emissions. The nine-car passenger train noise levels were extrapolated from the six-car SMU noise levels.

Corrections for curves, bridges and turnouts have been modelled based on features identified in the reference design, existing track alignments and aerial photography. Plans and coordinates of existing noise barriers between Southbank and Salisbury were supplied by Queensland Rail. These have been included in the noise modelling as fully reflective noise barriers.

Table 16-63 Summary of predicted ground-borne vibration levels along the tunnel alignment during operation (reference design trackform)

Chainage (km)	Type of Building	Min. Slant Distance to Track Level	Predicted Ground-borne Vibration Level (mm/s) ¹	Residential Night-time Vibration Goal (mm/s) ^{1,2}	Reference Design Mitigation Measure ³
0.36 – 0.95 Southern Portal to Christensen Street, Yeronga	Residential Commercial Education/heritage Worship	18 m – 108 m 57 m – 81 m 77 m 24 m – 26 m	0.001 to 0.027 mm/s 0.003 to 0.006 mm/s 0.002 mm/s 0.006 mm/s	0.2 mm/s	Highly resilient rail fasteners
0.95 – 2.0 Christensen Street, Yeronga to ventilation and emergency access building and shaft (Bledisloe Street)	Residential Commercial Worship Medical	25 m – 117 m 34 m – 80 m 88 m 35 m	0.002 to 0.039 mm/s 0.003 to 0.015 mm/s 0.002 mm/s 0.008 mm/s	0.2 mm/s	Resilient rail fasteners
2.0 – 2.95 Ventilation and emergency access building and shaft (Bledisloe Street) to Stimpson Street, Fairfield	Residential Commercial Worship Medical	21 m – 115 m 26 m – 85 m 26 m – 61 m 41 m	0.003 to 0.047 mm/s 0.002 to 0.011 mm/s 0.014 to 0.034 mm/s 0.007 mm/s	0.2 mm/s	Resilient rail fasteners
2.95 – 3.15 Stimpson Street, Fairfield to Fenton Street, Fairfield	Residential Commercial	18 m – 82 m 18 m – 21 m	0.003 to 0.038 mm/s 0.012 to 0.014 mm/s	0.2 mm/s	Highly resilient rail fasteners
3.15 – 3.95 Fenton Street, Fairfield to Boggo Road Station	Residential Commercial Heritage Medical	23 m – 108 m 20 m – 110 m 28 m – 63 m 28 m – 29 m	0.002 to 0.035 mm/s 0.002 to 0.025 mm/s 0.005 to 0.017 mm/s 0.023 to 0.024 mm/s	0.2 mm/s	Resilient rail fasteners
3.95 – 5.1 Boggo Road Station to Woolloongabba	Residential Commercial Educational Worship Hotel	15 m – 94 m 22 m – 89 m 76 m – 111 m 60 m – 97 m 43 m	0.002 to 0.038 mm/s 0.003 to 0.031 mm/s 0.003 to 0.005 mm/s 0.005 to 0.010 mm/s 0.014 mm/s	0.2 mm/s	Resilient rail fasteners

Chainage (km)	Type of Building	Min. Slant Distance to Track Level	Predicted Ground-borne Vibration Level (mm/s) ¹	Residential Night-time Vibration Goal (mm/s) ^{1,2}	Reference Design Mitigation Measure ³
5.1 – 6.85 Woolloongabba to Albert Street Station	Residential Commercial Educational Worship Medical Hotel	38.5 m – 202 m 26 m – 168 m 37 m – 234 m 42 m – 192 m 201 m 19 m – 146 m	0.001 to 0.025 mm/s 0.002 to 0.023 mm/s 0.002 to 0.015 mm/s 0.001 to 0.008 mm/s 0.002 mm/s 0.001 to 0.023 mm/s	0.2 mm/s	Resilient rail fasteners (chainage 5.95 – 6.55 km rail section under the Brisbane River with direct fixation rail fasteners)
6.85 – 7.9 Albert Street Station to Roma Street Station	Commercial Educational Worship Heritage Medical Hotel	17 m – 91 m 52 m – 58 m 52 m – 82 m 33 m – 67 m 32 m – 98 m 22.5 m – 82 m	0.004 to 0.059 mm/s 0.009 to 0.025 mm/s 0.015 to 0.029 mm/s 0.023 to 0.056 mm/s 0.012 to 0.058 mm/s 0.006 to 0.044 mm/s	0.2 mm/s	Resilient rail fasteners
7.9 – 9.55 Roma Street Station to Northern Portal	Residential Commercial Educational Medical Hotel	38 m – 121 m 50 m – 113 m 43 m – 122 m 138 m 51 m – 108 m	0.002 to 0.023 mm/s 0.003 to 0.018 mm/s 0.003 to 0.021 mm/s 0.003 mm/s 0.005 to 0.017 mm/s	0.2 mm/s	Resilient rail fasteners (chainage 9.05 – 9.55 km rail section with direct fixation rail fasteners)

Notes:

1. The predicted vibration levels and vibration goal are based on the maximum 1 second rms vibration level, not to be exceeded by more than 5% of train passbys.
2. The residential night-time vibration goal is the most stringent operations vibration goal.
3. The proposed reference design trackform is detailed in Table 15 of Technical Report No. 8 Noise and Vibration – operation.

An assessment of the effects of the Project on freight movement by rail has been undertaken and reported in **Chapter 5 Transport**. This examined future rail freight demand, volumes and train movements on the network with and without the Project. Rail freight train paths were tested using the train operating model for consistency with passenger operations. Surface track upgrades between Salisbury and Yeerongpilly will separate freight and passenger services and allow more services to operate between Yeerongpilly and the Port of Brisbane and Bowen Hills.

Portal noise emissions have been modelled as a vertical area noise source across the tunnel portal openings. A sound power level has been assigned to these portal noise sources based on in tunnel noise measurements in rail tunnels in Sydney. The source level has for the Project assumed no absorption in the tunnel, resulting in a higher reverberant build up noise level in the tunnels. The average LAeq(24hour) sound power level for the portals have been calculated adopting Probst's methodology (Wolfgang Probst 2010).

The predicted noise levels include contributions from the through traffic, stabling yards and tunnel portals and include shielding from any existing noise barriers. All predicted levels include a +2.5 dBA facade correction.

In the northern section, all sensitive locations are predicted to comply with Queensland Rail's operations noise criteria in both 2021 and 2031. Therefore, no mitigation measures would be required in this section.

With regard to noise impacts of the Project on future urban development in and around the RNA Showground precinct, no mitigation measures are required in this section as all sensitive locations are predicted to comply with Queensland Rail's operation planning levels in both Year 2021 and Year 2031.

In the southern section, 28 sensitive locations are predicted to experience noise in excess of Queensland Rail's operations noise criteria in 2021 whilst 37 sensitive locations are predicted to experience noise in excess of the criteria in 2031 at Salisbury, Rocklea, Yeronga and Yeerongpilly, if additional mitigation measures are not implemented. Both the 2021 and 2031 assessments include existing noise barriers. Noise barriers would be required for these locations to achieve compliance with Queensland Rail's noise criteria (refer to mitigation measures below for the locations of proposed noise barriers).

Train operations – existing rail alignments (no upgrade) between portals

The surface rail tracks between the portals in Yeerongpilly and Victoria Park would not change due to the Project. However, the Project would free-up capacity on these surface tracks by redirecting a significant portion of the passenger rail operation through the rail tunnels. This increased capacity would be available for both passenger and freight services on the surface tracks.

The existing and future freight and passenger train numbers on the surface tracks between the portals are shown in **Table 16-64**.

Table 16-64 Existing and future train numbers on surface tracks between portals

Section	Number of Freight Trains	Number of Passenger Trains	Train Lines/Termini
Existing 2009			
Yeerongpilly – Park Road	28 ¹	202	All southern lines (Beenleigh, Varsity, Gold Coast)
Park Road – Roma Street	5	313	All southern lines plus Cleveland (Beenleigh, Varsity, Cleveland)
Roma Street – Bowen Hills	-	616	All lines
Roma Street – Bowen Hills (via Normanby)	29	-	-
Year 2021			
Yeerongpilly – Park Road	39 ¹	160	Kuraby
Park Road – Roma Street	7	352	Kuraby, Cleveland
Roma Street – Bowen Hills	-	724	All lines (except CRR)
Roma Street – Bowen Hills (via Normanby)	38	-	-
Year 2031			
Yeerongpilly – Park Road	47 ²	171	Loganlea
Park Road – Roma Street	7	352	Loganlea, Cleveland
Roma Street – Bowen Hills	-	742	All lines (except CRR)
Roma Street – Bowen Hills (via Normanby)	46	-	-

Source: Systemwide Pty Ltd, 2010, 2011

Notes:

1. Freight trains between Salisbury and Park Road have been assumed to be 620 m long for the existing and future modelling year 2021. All other freight lines through Brisbane assume 1,500 m long freight trains for both the existing and future modelling years.
2. Freight trains between Salisbury and Park Road have been assumed to be 1,500 m long for the future year 2031 as a “worst case” scenario.

The passenger and freight train data for existing and modelling Year 2021 and Year 2031 have been sourced from Systemwide’s *Rail Operations Report and Addenda (2010, 2011)*. Based on information received from Queensland Rail, the existing freight trains between Salisbury to Park Road are currently 620m long and are proposed to be increased to 1,500m by 2031. This change has been incorporated in the modelling as a “worst case”. All freight trains on the other freight lines have been assumed to be 1,500 m long for both existing and future modelling years.

The incremental change to the daily averaged LAeq(24hour) noise levels from the existing surface rail tracks between the portals due to change in freight and passenger train numbers as a result of the Project has been assessed. The predicted LAeq(24hour) noise levels would increase by up to 2.0 dBA due to the change in passenger and freight train traffic for the modelling Year 2031. It is generally recognised in acoustics that changes in noise levels of 2 dBA or less are undetectable to the human ear and therefore negligible.

The maximum noise level during train passbys would not change due to the change in passenger and freight train numbers. There would only be a change to the number of train passby events, as shown in **Table 16-63**. Over time, it is likely that the maximum noise levels from train passbys would be reduced as new generation rolling stock is progressively introduced into Queensland Rail’s operation.

Train stabling operations

Moving rolling stock within the stabling yard has been modelled in accordance with Queensland Rail's noise emissions data with trains modelled at 30 km/h. Switch points have been modelled with a 5 dBA increased noise emission in accordance with Queensland Rail's Network Noise Management Plan (NNMP) Development Standard Gauge Line. The noise emission levels used for the stationary trains auxiliary systems and air conditioning units are based on measurement results for Queensland Rail rolling stock.

A 'worst case' phase has been modelled for the stationary trains in the stabling yard. The 'worst case' phase consists of trains with auxiliary systems and air conditioning units operating, on tracks closest to the sensitive receivers. Other trains on stabling tracks would be significantly shielded. This "worst case" phase has assumed a period of approximately two hours during parking and two hours during pick-up.

The noise contribution from the stabling yard operations to the overall rail noise emissions is negligible. The noise emitted from through-traffic dominates the single event maximum and LAeq(24hour) noise levels. There are no predicted exceedances of Queensland Rail's operations criteria adjacent to either the Mayne or Clapham Rail Yards.

There is some risk of sleep disturbance impacts for stationary trains at the stabling yards due to the steady-state character of the noise sources and the duration (two hours) that train air conditioning could operate. The predicted "worst case" noise levels from the stabling yards during parking and pick-up would exceed The World Health Organisation's internal sleep disturbance criterion of 30 dBA LAeq for stationary noise sources. Therefore, even though the Queensland Rail noise criteria are achieved, there is a risk that the noise emissions from the air conditioning units after parking and before pick up may cause sleep disturbance.

The possible sleep disturbance caused by the noise emission from the air conditioning units after parking and before pick-up would be mitigated by careful management of the stabling yards. It is proposed that trains would be stabled on the outer tracks in the yards (closest to the homes) first during day-time hours and then successively fill the inner tracks and conversely for pick-up (ie the outer tracks would be picked up last). This would result in the trains on the outer tracks acting as noise barriers for the trains stabled on the inner tracks and also ensure maximum distance between noise source and receivers during the night-time. This operations management sub-plan would most likely result in night-time external noise levels less than 40 dBA LAeq (refer to **Chapter 24 Draft Outline EMP**).

Mitigation measures

As all sensitive locations within the northern section are predicted to comply with Queensland Rail's operations noise criteria, no mitigation measures are required for that section of the Project.

The Year 2031 operations noise levels are predicted to exceed Queensland Rail's noise criteria in four areas of the southern section. Noise barriers would be required to reduce operation noise levels to achieve compliance with Queensland Rail's criteria.

Noise Barrier 1 (Salisbury), a 375 m long existing noise barrier of 1.5 to 4.5 m in height south of the Salisbury Station would be upgraded to 6 to 7 m in height. North of Salisbury Station, a 214 m long barrier 5 m in height is required. The total barrier area is approximately 3,415 m².

Noise Barrier 2 (Rocklea), would be approximately 88 m in length and 4.5 m in height south of Rocklea Station. North of Rocklea Station, a noise barrier 43 m in length and 5 m in height is proposed. The total barrier area would be approximately 612 m².

Noise Barrier 3 (Yeronga), would be approximately 165 m in length and 4.5 m in height. The total barrier area required would be approximately 735 m².

Noise Barrier 4 (Yeerongpilly), would be approximately 155 m in length and 4 m in height immediately north of the new Yeerongpilly Station. The total barrier area required would be approximately 625 m².

For safety reasons, Queensland Rail's Code of Practice does not permit the construction of noise barriers adjacent to existing train stations. Ten sensitive receivers are located adjacent to the Salisbury Station and one sensitive receiver is sited adjacent to Rocklea Station which exceed Queensland Rail's operation planning levels taking into account the proposed noise barriers. There are exceedances adjacent to the Salisbury Station of up to 7 dBA for the LAeq(24hour) planning level. Adjacent to the Rocklea Station, there is only one marginal 1 dBA exceedance of the L_Amax) planning level.

Noise contours for Year 2031 with the proposed and existing (ie retained) noise barriers for the southern section are shown in **Figure 16-45, Figure 16-46, Figure 16-47, Figure 16-48, Figure 16-49 and Figure 16-50**. The noise contours include contributions from through traffic, stabling yards, tunnel portals and a +2.5 dBA facade correction. The proposed and existing (retained) noise barriers included in the modelled noise levels are shown on the noise contour figures.

The possible sleep disturbance caused by the air conditioning units after parking and before pick-up of trains from the stabling yards would be mitigated by careful management of the stabling yards involving the staged parking of trains from the outside-in and pick-ups from the inside-out as described above.

16.5.4 Airborne noise assessment – ancillary facilities

Electricity feeder stations

Three 25 kV feeder stations are proposed and would be located at Mayne Rail Yard, near the northern portal at the Ekka Station grounds and near the southern portal at Yeerongpilly (refer to *Figures 21, 22 and 23* in *Technical Report No. 8 – Noise and Vibration – Operation*). Each feeder station would provide approximately 18 Mega Volt Amperes (MVA).

The Australian Standard AS 2374.6-1994 *Power Transformers – Part 6; Determination of transformer and reactor sound levels*, gives generic sound power levels as a function of the power requirement. For a power transformer of 18 MVA capacity, the sound power levels provided in Appendix AA of AS 2374.6-1994 are presented in **Table 16-65**.

Table 16-65 Sound power level for transformers according to AS 2374.6-1994

Power Transformer	LWA(standard maximum) (dBA)	LWA(reduced maximum) (dBA)
18 MVA	92	84

Note:

1. If there are components with tonal character, an adjustment to the measured noise level of +5 dBA is required in accordance with AS 1055.1-1997.

The Project feeder stations typically would consist of a 110 kV switchgear building, three 110/25 kV transformer enclosures, a 25 kV control building, and three 25 kV harmonic filter enclosures. All components would be enclosed in buildings with the transformer building partially open towards the direction of the tracks.

The nearest sensitive receiver is more than 200 m from the proposed feeder station at Mayne Rail Yard, approximately 160 m from the proposed feeder station at the Ekka and 65m to 100 m from the proposed feeder station at Yeerongpilly. A noise reduction through the feeder station building facades of approximately 20 dBA has been assumed.



Signs and symbols

- Area source
- Building
- Designed Noise Barrier
- Elevation line
- Existing Noise Barrier
- Point source
- Point receiver
- Railway

Noise Level
dBA

- ≤ 47
- 47 <
- ≤ 50
- 50 <
- ≤ 53
- 53 <
- ≤ 56
- 56 <
- ≤ 59
- 59 <
- ≤ 62
- 62 <
- ≤ 65
- 65 <
- ≤ 68
- 68 <
- ≤ 71
- 71 <

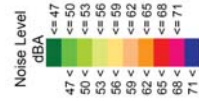
Notes:
Noise levels
include a 2.5 dBA
fade correction.
Contours are
interpolated. Check
calculations for
exact levels.



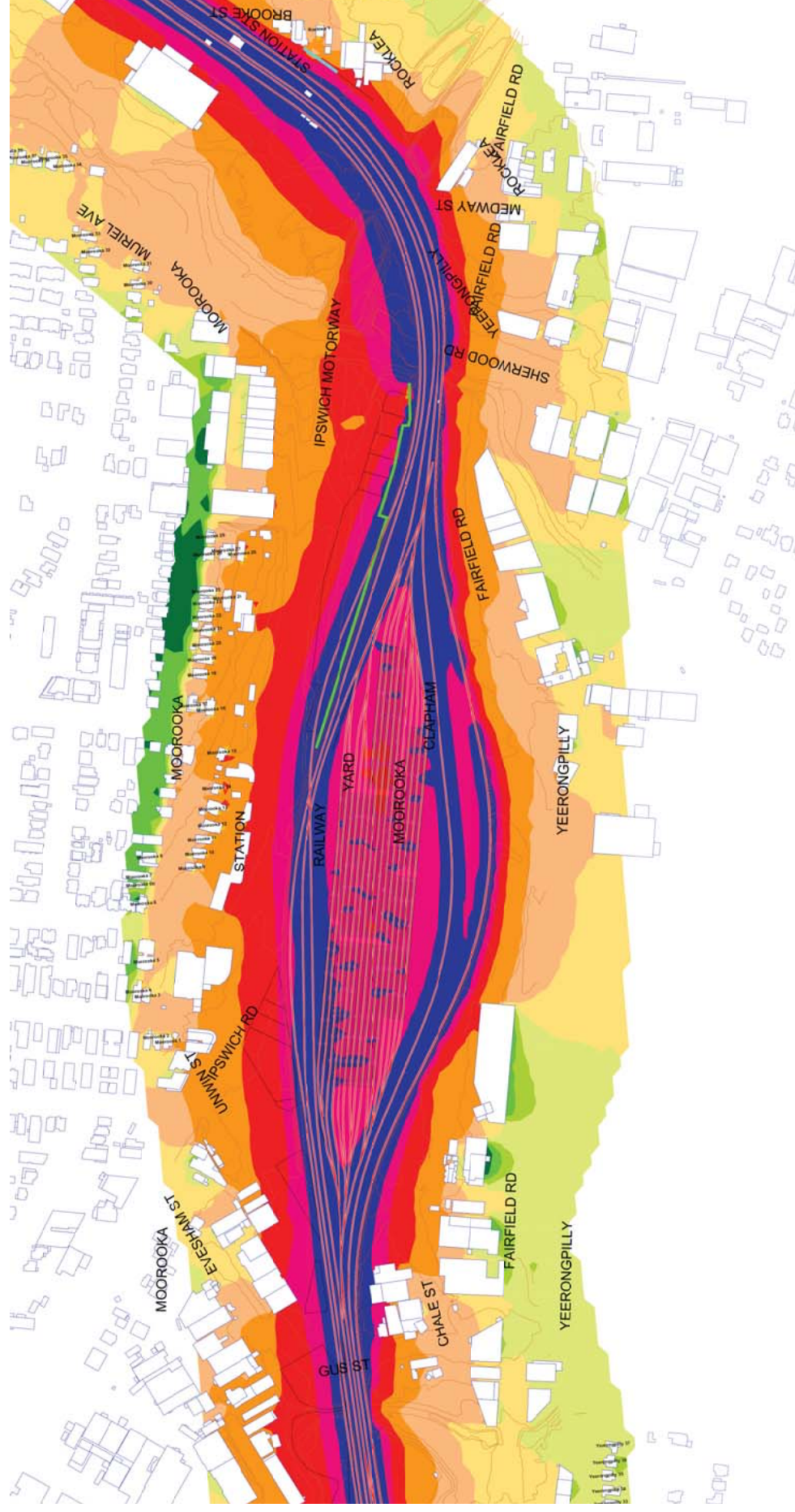


Signs and symbols

- Area source
- Building
- Designed Noise Barrier
- Elevation line
- Existing Noise Barrier
- Point source
- Point receiver
- Railway



Notes:
Noise levels include a 2.5 dBA facade correction.
Contours are interpolated. Check calculations for exact levels.



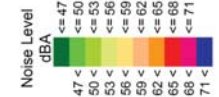
Notes:
 Noise levels include a 2.5 dBA facade correction.
 Contours are interpolated. Check calculations for exact levels.

- Signs and symbols
- Area source
 - Building
 - Designed Noise Barrier
 - Elevation line
 - Existing Noise Barrier
 - Point source
 - Point receiver
 - Railway



CROSS RIVER RAIL
 ENVIRONMENTAL IMPACT STATEMENT

Figure 16-47
 Operational Rail Noise – Predicted L_{Aeq} (24 hour) Rail Noise Levels (4.5m Above Ground Level) Year 2031 - Sheet 3 of 6



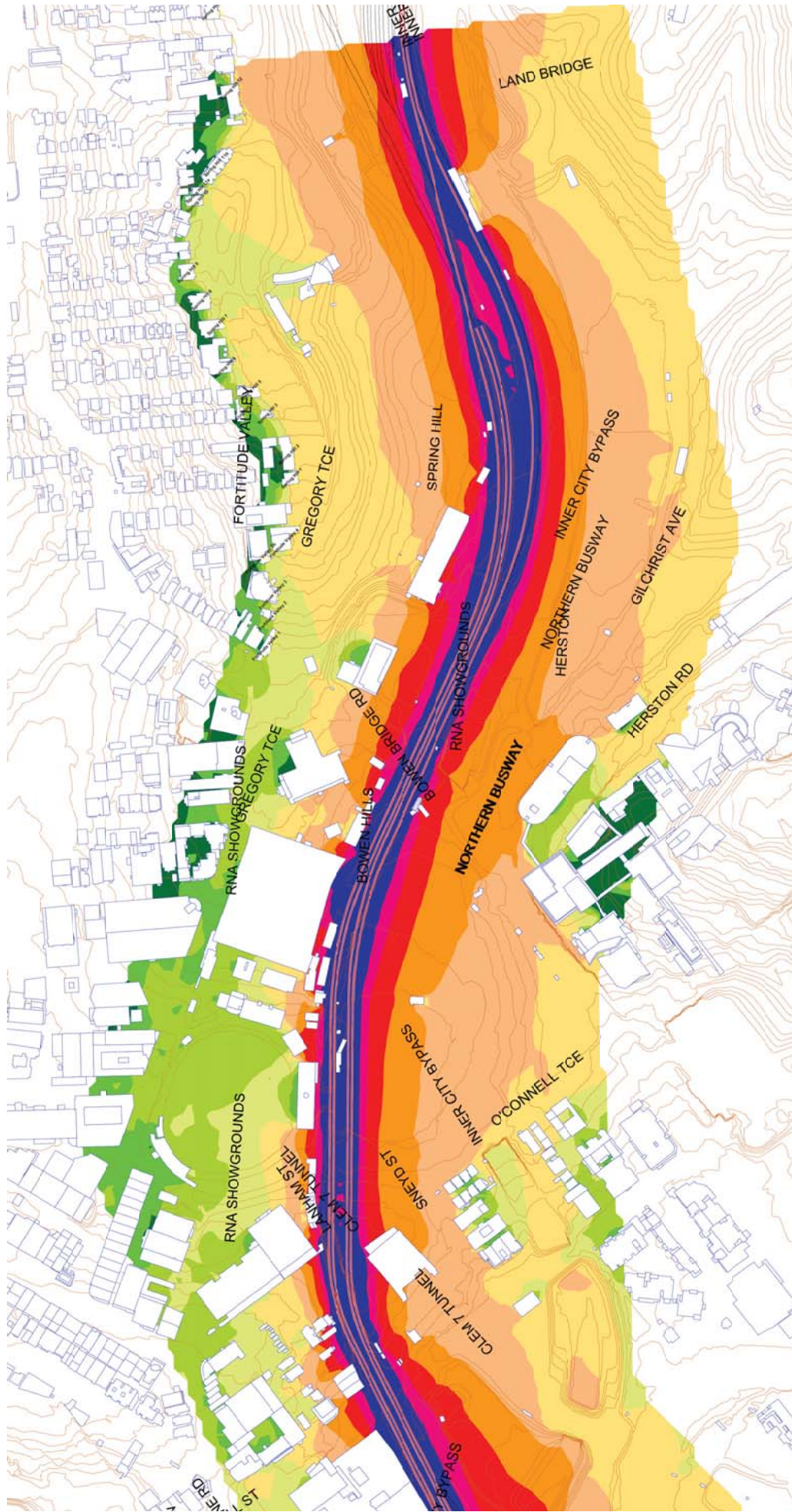
Notes:
Noise levels include a 2.5 dBA facade correction.
Contours are interpolated. Check calculations for exact levels.

- Signs and symbols
- Area source
 - Building
 - Designed Noise Barrier
 - Elevation line
 - Existing Noise Barrier
 - Point source
 - Point receiver
 - Railway



CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

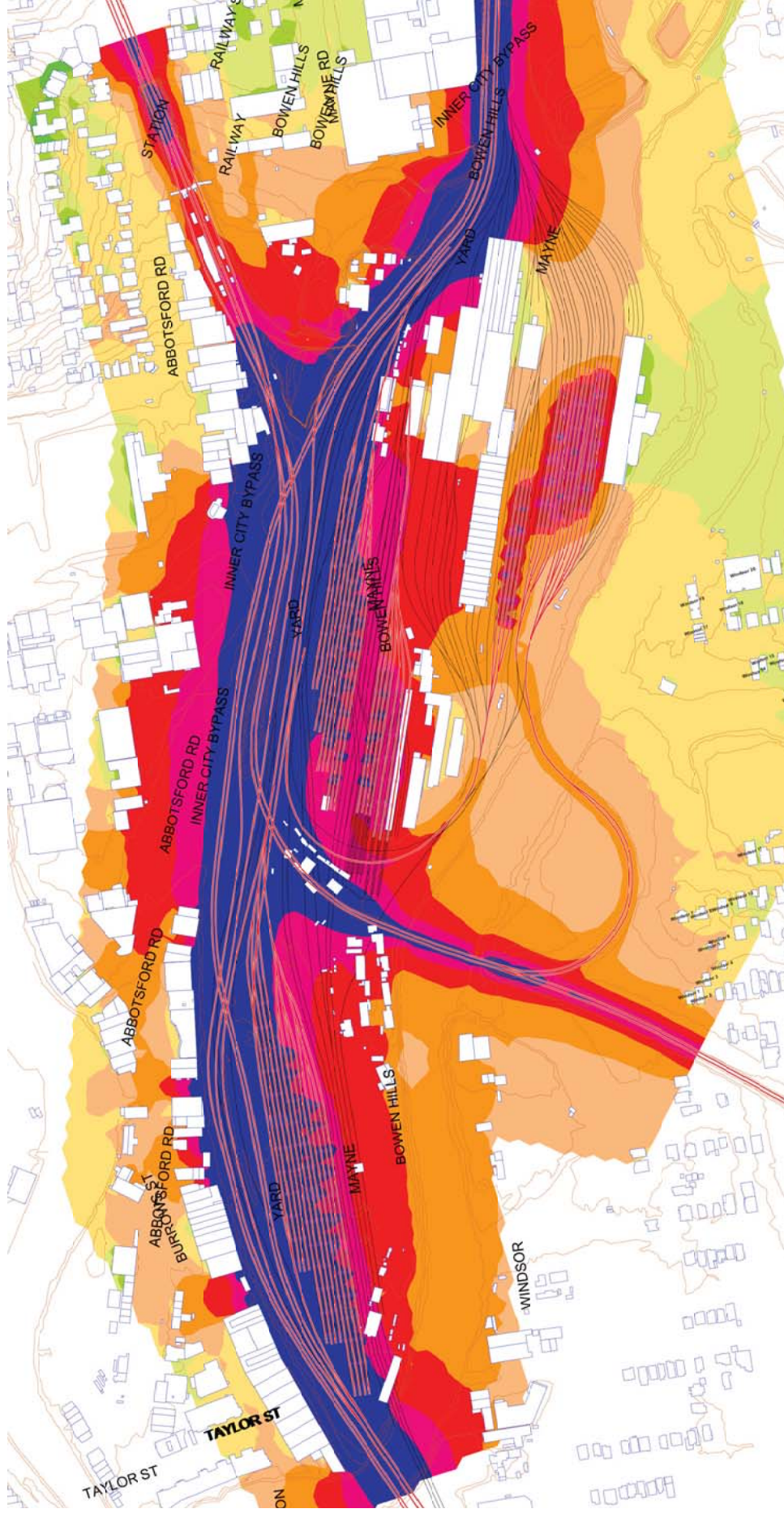
Figure 16-48
Operational Rail Noise – Predicted L_{Aeq} (24 hour) Rail Noise Levels (4.5m Above Ground Level) Year 2031 - Sheet 4 of 6



Signs and symbols

- Area source
Building
Designed Noise Barrier
Elevation line
Existing Noise Barrier
Point source
Point receiver
Railway
- Notes:
Noise levels include a 2.5 dBA facade correction.
Contours are interpolated. Check calculations for exact levels.
- Noise Level
dBA
47 < 50
50 < 53
53 < 56
56 < 59
59 < 62
62 < 65
65 < 68
68 < 71





CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 16-50
Operational Rail Noise – Predicted LAeq (24 hour) Rail Noise Levels (4.5m Above Ground Level) Year 2031 - Sheet 6 of 6

The feeder stations have been assessed against the background creep criterion in accordance with EPP (Noise). Using the sound power levels adjusted for tonality (ie +5 dB), the predicted noise levels at the sensitive receiver nearest to each of the feeder station locations would be below the existing background noise level for all sensitive receivers.

Noise predictions with detailed equipment sound power levels and final designs of feeder station buildings would be undertaken during the detailed design phase to confirm these predictions.

Ventilation and emergency access building

The noise emission for ventilation and emergency access building has not been assessed as part of this EIS due to its sporadic use in exceptional circumstances, ie fire events. It is assumed that the ventilation and emergency access building would have only forced ventilation during emergency events.

Noise generated during underground train passbys has the potential to escape from the tunnels via the ventilation shaft.

An in-tunnel maximum reverberant noise level of 102 dBA L_{Amax} was used to predict train passby noise levels from tunnel shaft break-out noise. Based on the in-tunnel maximum noise level and assumed concrete-lined air ducts, ie no significant acoustic absorption, maximum noise levels at the nearest sensitive receiver (approximately 35 m) from a train passby is predicted to be 50 dBA L_{Amax}. This would comply with the operation planning levels in accordance with the Queensland Rail's Code of Practice.

Train noise break-out through the tunnel ventilation shaft from trains operating within the tunnel is not expected to exceed the noise goals and is expected to be comparable (or quieter) than car passby noise levels from Fairfield Road.

Underground stations mechanical plant and ventilation

The maximum allowable sound power levels emitted by industrial-type noise sources have been predicted for each location in order to meet the noise goal (refer to **Table 16-9**) at nearby sensitive receivers. The results are presented in **Table 16-66**.

Table 16-66 Station ancillary facilities – maximum acceptable noise emissions

Site Location	Ancillary Location	Distance to Nearest Sensitive Receiver (m)	Noise Goal (dBA LA90) ¹	Maximum Acceptable Sound Power Level emitted from the Ancillary Facility (dBA)
Boggo Road Station	South of Boggo Road Gaol	~90	37	84
	Northern entry supply and exhaust outlets towards Boggo Road busway	~90	34	82
Woolloongabba Station	Central station box is open to natural light and ventilation. Ventilation supply and exhaust outlets east and west of the station building.	~100	46	94
Albert Street Station	Alice Street Entry	~45	46	87
	Mary Street Entry	~25	54	90
Roma Street Station	Southern Entry	~80	47	93
	Parkland Crescent plant and ventilation shaft	~130	47	97

Note:

1. Background creep noise goal in accordance with EPP (Noise) refer to Table 16-9. The background creep is the RBL + 0 assessed as the LA90 parameter. Existing background noise levels (RBLs) as presented in Table 16-18.

The locations and designs of the mechanical plants and air exhausts and intakes for the Project would need to be assessed further during the detailed design phase. The maximum allowable mechanical services and ventilation shaft sound power levels emitted at each location have been calculated for detailed design purposes and range from 82 dBA to 97 dBA.

Mitigation measures are likely to be required for some station mechanical plant and ventilation shafts in order to comply with the proposed noise goals. Mitigation measures that may need to be considered at some locations include appropriate equipment selection, in-duct attenuators, noise barriers, acoustic enclosures and the strategic positioning of critical plant away from sensitive receivers.

Airborne noise assessment – road traffic

The Project will require the realignment of a number of roads adjacent to the railway corridor. The potential road traffic noise impact associated with the realignment of these roads has been assessed at nearby residential properties. The existing AADT road traffic predictions on all roads are consistent with information included in **Chapter 5 Transport**.

Table 16-10 presents the TMR CoP road traffic noise goals. For the realigned road sections, the noise goal for “upgrading Existing Roads” of 68 dBA LA10(18hour) is applicable.

Noise modelling was carried out using CORTN prediction algorithms incorporated into the SoundPLAN noise software. The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, reflections off building surfaces, ground absorption and shielding from ground topography and physical noise barriers.

Roads have been realigned in four locations as follows:

- Dollis Street near Salisbury Railway Station – the Dollis Street realignment moves the road traffic marginally closer to residences on Olivia Avenue as a result of road straightening
- Heaton Street and Fairlie Terrace at the Beaudesert Road overpass – the realignment of Heaton Street and Fairlie Terrace at this location is minor and the distance from the road carriageways to the nearest residences will be unchanged. The acoustic impacts will be negligible and therefore have not been assessed
- Fairfield Road entry ramp to Ipswich Road – the nearest residences are located to the south-east in Brooke Street
- Wilkie Street east of Yeerongpilly Railway Station – Wilkie Street has been realigned to the east to allow for the southern portal and station location. The nearest residences are located in the Wilkie Street cross streets, adjacent to the new Wilkie Street alignment.

Predicted road traffic noise levels at the nearest sensitive receivers from the realigned road sections are presented in **Table 16-67**. The range corresponds to predicted noise levels at the nearest row or group of residences to the realigned roads.

Table 16-67 Realigned roads – predicted traffic noise levels (dBA)

Realigned Road	Residential Receivers	Predicted LA10(18hr) Noise Level
Dollis Street	Olivia Avenue	48 dBA to 51 dBA
Fairfield Road entry ramp	Brooke St	54 dBA to 60 dBA
Wilkie Street	Crighton St, Stamford St, Green St, Livingston St	58 dBA to 64 dBA

Note:

The predicted noise levels include a +2.5 dBA facade noise reflection.

As presented in **Table 16-67**, for each of the three realigned road sections, the highest predicted noise levels are 51 dBA at Olivia Avenue, 60 dBA at Brooke Street and 64 dBA at Green Street. All residences adjacent to the realigned road sections comply with the TMR CoP road traffic noise goal of 68 dBA LA10(18hr) for the design Year 2031.

16.6 Findings of noise and vibration assessment

16.6.1 Construction

General

The analysis of noise and vibration impacts associated with the construction phase provides an understanding of the potential impacts and the mitigation measures that may be necessary to mitigate any impacts during construction.

The potential noise and vibration impacts can vary greatly depending on factors such as the proximity of noise-sensitive receivers, the duration of the construction works, the intensity of the noise and vibration emissions, the time at which the construction works are undertaken and the character of the noise or vibration emissions.

The construction methodology will evolve and be refined as detailed construction plans are developed for the Project, with consequential implications for the refinement of mitigation strategies. Detailed construction noise and vibration management sub-plans, provided as a draft outline in **Chapter 24 Draft Outline EMP**, will be refined for the Project as the detailed construction plans are developed.

Woolloongabba worksite

The assessment of construction noise and vibration impacts from the Woolloongabba worksite and associated TBM launching operations indicated that site establishment works, including demolition of the existing Goprint building, would lead to exceedances of up to 15 dBA of the noise goal for day-time operations at the nearest residential receivers along Vulture Street with a 3 m acoustic hoarding surrounding the worksite. Higher exceedances are expected at St Nicholas Cathedral due to the lower noise goal for the church.

The predicted noise levels for shaft excavation and spoil handling at the Woolloongabba worksite indicate exceedances of up to 3 dBA during the day and 3 dBA during the night-time period at the nearest residential receivers occurring within a medium performance acoustic enclosure. The assessment shows that a minor upgrade, eg 1 mm thick metal cladding rather than 0.62 mm thick cladding, on the medium performance acoustic enclosure in combination with quietest available mobile plant would be required to comply with the day-time and night-time noise goals.

Table 16-68 presents a summary of particular activities at the Woolloongabba worksite where construction noise is anticipated along with approximate duration of these activities. While some construction activities may generate high levels of noise, the durations of such activities would be considerably shorter than the overall construction program or operation of the worksite.

The proposed noise mitigation measures for this worksite are listed in **Table 16-69**.

Table 16-69 Noise mitigation measures – Woolloongabba worksite

No.	Mitigation measures – Woolloongabba worksite
1	Early and on-going consultation with potentially affected properties to address concerns and mitigation measures.
2	Highest performance acoustic enclosure over the worksite.
3	Quietest available mobile plant operating at the worksite (ie fitted with appropriate exhaust silencers, mufflers or acoustic covers).
4	Temporary tunnel ventilation noise sources to be located down in the shaft with appropriate ducting to the surface. Silencers may be required depending on the type of ventilation used.
5	Acoustic louvres at enclosure ventilation points.

With the mitigation measures in place, combined with careful management of all heavy vehicle movements within the worksite, eg limiting the need for reversing and use of reversing alarms, compliance with the noise criteria during all time periods could be achieved, with the exception of initial demolition works which are anticipated to occur over a six week period and pile installation works which are anticipated to occur over a seven week period. For such works, direct mitigation to achieve compliance with the day-time noise goal is constrained by the nature of the work.

Existing night-time background noise levels in the vicinity of the Woolloongabba worksite are typical of a city environment (e.g. rating background level of 46 dBA at Leopard Street). It would be expected that night-time construction noise originating from the high performance enclosure at the Woolloongabba worksite would not be discernable to the majority of residential receivers surrounding the worksite, as the night-time noise goal is only 1 dBA above the rating background level.

The use of drill and blast as an excavation technique at the Woolloongabba worksite would be limited to a 12 kg MIC to comply with the 2 mm/s peak particle velocity vibration limit at St Nicholas Cathedral. A MIC limit of 12 kg indicates that blasting of the station shaft could be carried out with minimal risk of impact. Therefore, blasting would be a suitable excavation technique for this location.

Northern portal worksite

The predicted noise levels for the northern portal worksite indicate relatively small exceedances of the relevant noise goals at the nearest residential receivers due to the separation distances involved. Greater exceedances are expected at commercial receivers located on the western side of Gregory Terrace, eg Centenary Aquatic Centre.

The predicted construction noise levels suggest that a hoarding of 6 m should achieve compliance with the noise goals at all sensitive receivers except for the Centenary Aquatic Centre and the nearest Gregory Terrace residences. Impacts to these receivers would be managed through use of quietest available construction plant and consultation. With the cut and cover excavation, the predicted impacts would diminish as the plant and equipment progress deeper into the portal structure. Construction noise levels at Gregory Terrace (residential receivers) would comply with the noise goal.

Table 16-70 presents a summary of particular activities at the northern portal worksite where construction noise is anticipated along with approximate duration of these activities. While some construction activities may generate high levels of noise, the durations of such activities would be considerably shorter than the overall construction program or operation of the worksite.

Table 16-70 Northern portal worksite – summary of construction activities

Element	Estimated durations (weeks)	Year 1																											
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52		
A	Site clearance and establishment																												
B	Establish piling rigs on site																												
C	Install piles																												
D	Excavate north portal shaft																												
E	Install piles for cut and cover box structure																												
F	Excavate trough for dive structure and cut and cover box																												
G	TBM disassembly																												



Construction activities with no predicted exceedences of the relevant construction noise goals

Specific noise mitigation measures will be adopted to comply with noise goals where exceedences of the relevant construction noise goals are predicted

Construction activities with predicted exceedences of the relevant construction noise goals (with mitigation) - further options for mitigating construction noise impacts would be developed for each worksite, prior to construction

Notes:

A: Dominant noise sources include excavators and front end loaders (day-time construction only)

F: Dominant noise sources include jumbo drill rigs and excavators (day-time construction only)

G: Dominant noise sources include cranes and heavy vehicles (day-time construction only)

Southern portal worksite

The predicted noise levels for site establishment works including demolition of Wilkie Street and adjacent residences and the cut and cover of the southern portal would exceed the day-time noise goal by up to 29 dBA with 3 m acoustic hoarding surrounding the worksite. The large noise goal exceedances result from the use of rockbreakers in close proximity to receivers. It is anticipated that rockbreakers would be used intermittently during the six week site clearing phase of the Project.

Demolition of buildings nearest to the railway line would occur first, so that the buildings closest to the resumption maintain a barrier for residences located beyond the property impact area, particularly if large rockbreakers are required.

Short-term night-time work would be required during earthworks immediately adjacent to the operation rail line. The predicted noise levels for this activity indicate exceedances of up to 16 dBA would be anticipated with a 3 m hoarding as noise mitigation. Where practicable, these works would be carried out during weekend rail possessions and during the day-time. If night-time construction work is required, consideration would be given to the early installation of part of if not the entire acoustic enclosure to provide significant noise attenuation.

The predicted noise levels for spoil removal during TBM operation at the southern portal worksite indicate exceedances of up to 20 dBA during the night-time period (with 3 m high acoustic hoarding) at the nearest residential receivers. The predicted noise levels indicate that a high performance acoustic enclosure or individual property mitigations are likely to be required, subject to detailed design and consultation, to comply with the night-time noise goals.

Table 16-71 presents a summary of particular activities at the southern portal worksite where construction noise is anticipated along with approximate duration of these activities. While some construction activities may generate high levels of noise, the durations of such activities would be considerably shorter than the overall construction program or operation of the worksite.

Table 16-71 Southern portal worksite – summary of construction activities

Element	Estimated durations (weeks)	Year 1	Year 2	Year 3
A Site clearance	6	2-6		
B Demolition works	6	6-12		
C Wilkie Street realignment (construction arrangement only)	6	14-20		
D Establish piling rigs on site	4	18-22		
E Install piles alongside live rail corridor	6	22-28		
F Excavate open trough	10	24-34		
G Soil nail installation in open trough excavation	2	30-32		
H Excavate in piled trough	16	32-48		
I Installation of anchors and shotcrete lagging	10	40-50		
J TBM support, including spoil removal by trucks	68	52-68	68-102	102-118
K Night-time truck movements within worksite	125			118-144



Construction activities with no predicted exceedences of the relevant construction noise goals

Specific noise mitigation measures will be adopted to comply with noise goals where exceedences of the relevant construction noise goals are predicted

Construction activities with predicted exceedences of the relevant construction noise goals (with mitigation) - further options for mitigating construction noise impacts would be developed for each worksite, prior to construction

Notes:

B: Dominant noise sources include rock breakers and excavators (daytime construction only)

E: Dominant noise sources include pilling rigs. Mostly daytime construction and potentially weekend and night-time work during track possessions

J: Dominant noise sources include spoil trucks, front end loaders and tunnel ventilation (24 hour per day construction with night-time works carried out inside an acoustic enclosure)

K: Dominant noise sources include trucks prior to exiting the worksite at Lucy Street (24 hour movements through the worksite).

The likely hierarchy of noise controls are provided in **Table 16-72**.

Table 16-72 Noise mitigation measures – southern portal worksite

No.	Mitigation measures – Southern portal worksite
1	Where practicable to do so, relocate plant inside the cut and cover tunnel.
2	Selection of quietest available plant (ie fitted with appropriate exhaust silencers, mufflers or acoustic covers).
3	Mitigating each acoustically significant item of plant required to operate within the enclosure (eg residential grade mufflers on all front end loaders).
4	Provide a high performance acoustic enclosure or individual property mitigations, sufficient to achieve the noise goals at the nearest receivers, as soon as practicable after commencement of site establishment works.
5	If necessary, mitigating noise at individually affected receivers through property treatments (eg mechanical ventilation, glazing upgrades etc).

Spoil movements within the worksite during the night-time period achieve compliance with the sleep disturbance noise goal as a result of the shielding afforded by the existing warehouses, in combination with 4 m high hoarding adjacent to the worksite entrance at Lucy Street.

With appropriate mitigation measures in place, combined with careful management of all heavy vehicle movements within the worksite, eg limiting the need for reversing and use of reversing alarms, compliance with the noise criteria at all times could be achieved, with the exception of initial demolition works which are anticipated to occur over a six week period and installation of piles alongside the live rail corridor which are predicted to create noise exceedances for approximately six weeks. These initial demolition works would be unlikely to achieve compliance with the day-time noise goal. Early and on-going consultation with near neighbours would be required to address concerns.

Roma Street Station worksite

The predicted noise levels for Roma Street Station construction works would exceed the noise goals for a small number of receivers during the day-time and night-time period. The highest predicted noise goal exceedances would occur at Roma Street Station and the Holiday Inn. Consequently, the height of temporary hoarding around each of the three worksites will need to be sufficient to mitigate daytime impacts. A high performance acoustic enclosure would be required to achieve compliance with the external noise goal for the night-time period at the Holiday Inn.

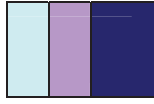
The predicted construction noise levels indicate that with provision for a 6 m hoarding around each worksite, night-time construction noise levels would be within 1 dBA of the sleep disturbance noise goal and therefore unlikely to interfere with people's sleep.

Predicted ground-borne noise and vibration levels from rock breaking indicate compliance with the relevant goals.

Table 16-73 to Table 16-75 present a summary of particular activities at the Roma Street Station worksites where construction noise is anticipated along with approximate duration of these activities. While some construction activities may generate high levels of noise, the durations of such activities would be considerably shorter than the overall construction program or operation of the worksites.

Table 16-73 Roma Street worksite (south shaft) – summary of construction activities

Element	Estimated durations (weeks)	Year 1																									
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
A Site clearance and establishment	6																										
B Establish piling rigs on site	4																										
C Install piles	4																										
D Construct acoustic shed	6																										
E Excavate to formation level	10																										



Notes:

- A: Dominant noise sources include excavators and cranes (mostly daytime construction works)
- C: Dominant noise sources include piling rigs (mostly daytime construction works)
- E: Dominant noise sources include jumbo drill rigs, excavators and front end loaders (potential for 24 hour per day construction with night-time works carried out inside an acoustic enclosure at the south shaft)

Table 16-74 Roma Street worksite (central shaft) – summary of construction activities

Element	Estimated durations (weeks)	Year 1																											
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52		
A Site clearance and establishment	10																												
B Establish piling rigs on site	4																												
C Install piles	6																												
D Excavate to formation level	20																												

Notes:

A: Dominant noise sources include excavators and cranes (mostly daytime construction works with potential for night-time works to avoid impact on existing rail operations)

C: Dominant noise sources include piling rigs (mostly daytime construction works with potential for night-time work required to avoid impact on existing rail operations)

D: Dominant noise sources include jumbo drill rigs, excavators and front end loaders

Table 16-75 Roma Street worksite (northern shaft) – summary of construction activities

Element	Estimated durations (weeks)	Year 1																											
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52		
A Site clearance and establishment	6																												
B Establish piling rigs on site	4																												
C Install piles	8																												
D Excavate to formation level	12																												

Notes:

A: Dominant noise sources include excavators and cranes (mostly daytime construction works)

C: Dominant noise sources include piling rigs (mostly daytime construction works)

D: Dominant noise sources include jumbo drill rigs, excavators and front end loaders

Assuming airblast overpressure can be sufficiently mitigated at the worksite, eg blast mat, enclosure etc, drill and blast excavation at Roma Street Station would be constrained by low MIC (0.5 kg) controlled by the heritage listed station building, subject to a detailed survey of the structure, monitoring during construction and adjustments to the excavation works implemented, if required.

Should drill and blast be required for this worksite, the management measures listed in **Table 16-76** would be required.

Table 16-76 Noise mitigation measures – Roma Street Station worksite

No.	Mitigation measures – Roma Street Station
1	Use of latest available blasting technology (e.g. penetrating cone fracture).
2	Pre-blasting condition survey of adjacent buildings.
3	Appropriate attention to blast design and commence blasting with a low MIC to develop a site law (ie blast design model) based on measurement data from the worksite.
4	Monitoring of the blast emissions.

Albert Street Station worksite

The predicted noise levels for site establishment works including demolition of the existing buildings at the two Albert Street worksites would exceed, at the nearest residential receivers, the goal for day-time works by up to 27 dBA and up to 37 dBA above the night-time noise goal. An exceedance of this magnitude would be unacceptable during the night-time period. Since an acoustic enclosure would not be feasible during the site establishment and piling activities, these works would need to be restricted to the day-time period.

Once excavation of the station shafts had progressed far enough below the surface to allow for installation of the acoustic enclosures, noise levels would decrease significantly. Subject to detailed design and construction planning, a high performance acoustic enclosure would be required to achieve the noise goals for these worksites.

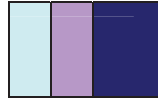
The ground-borne noise levels for rockbreaking during excavation of the Albert Street shafts would exceed the night-time noise goals for several residential receivers and one residential receiver during the day-time period. The Mary Street residential receiver would be located less than 10 m from the northern shaft and approximately 13 m slant distance from the inferred rock level. Exceedance of the day-time internal noise goal of 55 dBA LA10 would be anticipated at ground level, until rock breaking had progressed beyond approximately 20 m slant distance from the receiver building.

Generally, ground-borne noise levels attenuate by approximately 2 dB per floor for the first four floors and by approximately 1 dB per floor thereafter. On this basis, receivers located on the first five floors of the Mary Street residential building may require temporary relocation until a slant distance of approximately 20 m has been reached.

Table 16-77 and Table 16-78 present a summary of particular activities at the Albert Street Station worksites where construction noise is anticipated along with approximate duration of these activities. While some construction activities may generate high levels of noise, the durations of such activities would be considerably shorter than the overall construction program or operation of the worksites.

Table 16-77 Albert Street Station worksite (south) – summary of construction activities

Element	Estimated Durations (weeks)	Year 1																											
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52		
A Site clearance and establishment	6																												
B Demolition works	20																												
C Establish piling rigs on site	4																												
D Install piles	4																												
E Construct acoustic shed	6																												
F Excavate to formation level	10																												



Construction activities with no predicted exceedences of the relevant construction noise goals

Specific noise mitigation measures will be adopted to comply with noise goals where exceedences of the relevant construction noise goals are predicted

Construction activities with predicted exceedences of the relevant construction noise goals (with mitigation) - further options for mitigating construction noise impacts would be developed for each worksite, prior to construction

Notes:

- B: Dominant noise sources include rock breakers, excavators and haulage trucks (day-time construction only)*
- D: Dominant noise sources include piling rigs (day-time construction only)*
- F: Dominant noise sources include jumbo drill rigs, excavators and front end loaders (24 hour per day construction with night-time works carried out inside an acoustic enclosure)*

Table 16-78 Albert Street Station worksite (north) – summary of construction activities

[illegible]

Notes:

C: Dominant noise sources include rock breakers, excavators and haulage trucks (day-time construction only)

E, G, J: Dominant noise sources include piling rigs (day-time construction only)

M: Dominant noise sources include jumbo drill rigs, excavators and front end loaders (24 hour per day construction with night-time works carried out inside an acoustic enclosure)

Assuming airblast overpressure can be sufficiently mitigated at the worksite (eg blast mat, enclosure etc), drill and blast excavation at both Albert Street Station shafts would be constrained by low MIC estimated to be:

- north shaft – 1.0 kg to comply with the vibration criterion at Mary Street residences
- south shaft – 3.4 kg to comply with the vibration criterion at Alice Street residences.

Should drill and blast be required for this worksite, the management measures listed in **Table 16-79** would be required.

Table 16-79 Noise mitigation measures – Albert Street Station worksite

No.	Mitigation measures – Albert Street Station worksite
1	Use of latest available blasting technology (eg penetrating cone fracture).
2	Pre-blasting condition survey of adjacent buildings.
3	Appropriate attention to blast design and commence blasting with a low MIC to develop a site law (ie blast design model) based on measurement data from the worksite.
4	Monitoring of the blast emissions.

It is anticipated that the initial stages of shaft excavation would be carried out by rockbreaker due to the closeness of sensitive receiver buildings. The point at which drill and blast excavation could be safely and efficiently carried out within the shaft would be determined as part of detailed investigations for the worksite. Acoustically, exposure to a short-term blast event would be proposed to long term rock-breaking where ground-borne noise impacts have been identified.

Boggo Road worksite

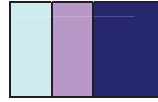
The predicted noise levels for site establishment works at the Boggo Road worksite indicate exceedances of up to 19 dBA of the noise goal for day-time construction at the nearest residential receivers in Rawnsley Street.

The predicted noise levels for the south entry shaft excavation, ie Phase 3 indicate that a high performance acoustic enclosure or individual property mitigations would be required, subject to detailed design and consultation, to comply with the day-time and night-time noise goals at the nearest residential receivers in Rawnsley Street and the Leukemia Support Village. No acoustic enclosure is predicted to be required for the north entry shaft excavation.

The movement of trucks within the worksite would be managed to limit the need for reversing and therefore reversing alarms.

Table 16-80 present a summary of particular activities at the Boggo Road worksite where construction noise is anticipated along with approximate duration of these activities. While some construction activities may generate high levels of noise, the durations of such activities would be considerably shorter than the overall construction program or operation of the worksite.

Table 16-80 Boggo Road worksite – summary of construction activities

[illegible]

Construction activities with no predicted exceedences of the relevant construction noise goals

Specific noise mitigation measures will be adopted to comply with noise goals where exceedences of the relevant construction noise goals are predicted

Construction activities with predicted exceedences of the relevant construction noise goals (with mitigation) - further options for mitigating construction noise impacts would be developed for each worksite, prior to construction

Notes:

* Rock excavation = 9 weeks (K)

E, F, G: Dominant noise sources include piling rigs, excavators and front end loaders (day-time construction only)

I, J: Dominant noise sources include jumbo drill rig, excavators, concrete trucks and front end loaders (day-time construction only)

K: Dominant noise sources include jumbo drill rigs, excavators, front end loaders and spoil trucks (24 hour per day construction with night-time works carried out inside an acoustic enclosure (spoil trucks day-time only)).

Predicted ground-borne noise and vibration levels from rock breaking indicate compliance with the relevant goals for all sensitive receivers with the exception of the TEM located at the Ecosciences Precinct. Further, the estimated blast MIC limits for Boggo Road Station indicate that the allowable MIC for the worksite would be controlled by the TEM, rather than by the heritage listed Boggo Road Gaol. As rock breaking, and drill and blasting would be required for this site, the management measures listed in **Table 16-81** would be required.

Table 16-81 Noise mitigation measures – Boggo Road worksite

No.	Mitigation measures – Boggo Road worksite
1	Scheduling rockbreaking and blasts outside of typical TEM operating times. If this is not practicable without impacting on normal (Ecosciences Precinct) TEM operations, a special arrangement would need to be established so that blasting can be scheduled at a specific time.
2	Appropriate attention to blast design and commence blasting with a low MIC to develop a site law (ie blast design model) based on measurement data from the worksite.
3	Monitoring of the blast emissions.

If blasts could be scheduled outside of TEM operating times, the MICs would then be limited by the heritage listed Boggo Road Gaol, ie MIC of 0.2 kg, subject to a detailed survey of the structure, monitoring during construction and adjustments to the excavation works implemented, if required. Consequently, blasting may not be feasible until the shaft has deepened sufficiently to allow for efficient blasting.

Vibration levels for bored piling adjacent the heritage listed Boggo Road Gaol are predicted to be below 2 mm/s peak particle velocity. Vibration measurements would be carried out during the commencement of bored piling at the worksite to determine the risk of exceeding the TEM vibration limit when piling in close proximity to the Ecosciences Precinct building.

Ventilation and emergency access building and shaft worksite

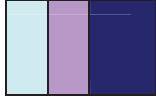
The predicted noise levels for the three modelled phases at the ventilation and emergency access building and shaft worksite indicate significant exceedances of the relevant day-time goals due to the close proximity of sensitive receivers to the north of the worksite.

Increasing the proposed hoarding to 6 m would reduce noise levels, however some exceedances of the goals would still be expected. The predicted worst case shaft excavation noise levels have been modelled for the excavation plant operating close to existing ground level. During shaft excavation, which is anticipated to occur over a 12 week period, construction noise emission levels would progressively decrease over time as the excavation plant progresses deeper into the shaft.

Table 16-82 present a summary of particular activities at the ventilation and emergency access building and shaft worksite where construction noise is anticipated along with approximate duration of these activities. While some construction activities may generate high levels of noise, the durations of such activities would be considerably shorter than the overall construction program or operation of the worksite.

Table 16-82 Ventilation and emergency access building and shaft worksite – summary of construction activities

Element	Estimated durations (weeks)	Year 1																									
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
A	Site clearance and establishment																										
B	Establish piling rigs on site																										
C	Piling of access shaft																										
D	Excavate shaft																										



Construction activities with no predicted exceedences of the relevant construction noise goals

Specific noise mitigation measures will be adopted to comply with noise goals where exceedences of the relevant construction noise goals are predicted

Construction activities with predicted exceedences of the relevant construction noise goals (with mitigation) - further options for mitigating construction noise impacts would be developed for each worksite, prior to construction

Notes:

A: Dominant noise sources include an excavator and front end loader (day-time construction only)

C: Dominant noise sources include a piling rig, excavator and front end loader (day-time construction only)

D: Dominant noise sources include excavators and front end loaders (day-time construction only)

Further reductions in noise emission levels may be achieved through the mitigation measures described in **Table 16-83**.

Table 16-83 Noise mitigation measures – ventilation and emergency access building and shaft worksite

No.	Mitigation measures – ventilation and emergency access building and shaft worksite
1	Quietest available mobile plant operating at the worksite (ie fitted with appropriate exhaust silencers, mufflers or acoustic covers).
2	Temporary tunnel ventilation noise sources to be located either down in the shaft with appropriate ducting to the surface or within a dedicated enclosure at the surface.
3	Drill and blast in place of the rockbreaking to expedite the works and minimise exposure to receivers of prolonged significantly high construction noise.
4	Careful placement of fixed plant (e.g. compressors, gensets etc) at the worksite to maximise shielding or separation from sensitive receivers.

Traffic noise levels on Fairfield Road in Year 2016 are predicted to be in the order of 64 dBA to 74 dBA LA10 during the am and pm peak periods (ie 7.00 am to 9.00 am and 4.00 pm to 6.00 pm respectively) and 62 dBA to 72 dBA LA10 during the day-time off peak period (ie 9.00 am to 4.00 pm). Comparison with predicted worst case day-time construction noise levels indicates that, at times, road traffic noise from Fairfield Road would be higher and potentially dominate the acoustic environment in the vicinity of the worksite for the receivers closest to Fairfield Road.

The estimated blast MIC limits for the ventilation and emergency access building and shaft worksite indicate that blasting could be carried out with minimal risk of impact to surrounding receivers. A MIC of 3 kg would comply with the airblast overpressure limit of 130 dB Linear Peak at the residential receiver. With appropriate management of airblast overpressure eg blast mat, enclosing etc, blasting would be a suitable excavation technique for this worksite.

Surface track worksites

Noise

Construction noise levels at surface track worksites are predicted to comply with the Queensland Rail Code of Practice noise goals, with no specific mitigation at Mayne Rail Yard, Clapham Rail Yard and Moorooka Station, due to the large buffer distance between the worksites and sensitive receivers.

At the surface track worksites where receivers are in close proximity, small noise goal exceedances have been identified with 3 m hoarding. The exceedances include:

- Ekka Station during piling of O'Connell Terrace (ie 2 dBA)
- Rocklea Station during station construction (ie 3 dBA).

Work associated with construction of new rail track or the upgrading of existing rail track is relatively short in duration particularly because the work is often confined to shut down periods (eg night-time, weekend, Christmas holidays etc). Noise emission levels from typical rail construction plant have been provided over various setback distances. Significant short duration noise impacts would be expected from the trackwork over small setback distances. In addition to limiting, where practicable, the duration of track construction works near any sensitive receiver, effective noise mitigation measures (consistent with the measures listed in Queensland Rail's Code of Practice) would need to be applied.

Vibration

During surface track construction activities, the major potential sources of vibration include rockbreakers and vibratory rollers. The majority of the surface track worksites do not require significant work and hence would not be anticipated to result in any impact on vibration sensitive receivers outside the rail corridor.

For the sites that require substantial work, including Clapham Rail Yard, Ekka Station and Mayne Rail Yard viaduct, the location at which vibration intensive plant would likely be operating within these worksites is far enough from sensitive residential receivers to avoid any impact. For example, substantial earthworks and compaction would be required at Clapham Rail Yard, with the nearest residential receivers located approximately 100 m to the east of the worksite. At this distance, compliance with both building damage and human comfort limits would be readily achieved during operation of vibratory rollers or rockbreakers.

For construction works in close proximity to heritage-listed buildings, including the Ekka Station, Yeerongpilly Station and Rocklea Station, a detailed investigation would be required to determine the risk of exceeding the 2 mm/s vibration goal. Notwithstanding this, the reference design at these worksites results in offset distances to heritage structures which would comply with the vibration goal of 2 mm/s.

TBM tunnelling between portals

The predicted ground-borne vibration levels would not exceed the structural damage vibration goal or the stricter cosmetic damage goal to heritage buildings. However, at six locations, the predicted vibration levels from TBM tunnelling would extend beyond the theoretical threshold for human perception (0.15 mm/s PPV) and could be noticeable (0.5 to 1.0 mm/s PPV) at 10 locations and even 'easily noticeable' (1.0 to 2.0 mm/s PPV) for some people at three locations. These exceedances would occur during a relatively short period (less than one week for each TBM passby).

In the 'worst case' assessment, there are predicted exceedances of the ground-borne noise goals related to TBM tunnelling, for internal living areas. Such exceedances generally coincide with sections of the route where the distance between the tunnels and the surface are reduced as a consequence of the surface terrain. Whilst the predicted 'worst case' ground-borne noise would not exceed normal conversation (eg 60 – 70 dB) noise levels at any place, the predicted noise levels would be noticeable and would exceed background noise in most circumstances. There are five hotels in the CBD for which the predicted night-time, ground-borne noise may exceed the goal for up to ten days. As the noise predictions are for the ground floor, noise levels would diminish higher up in the buildings.

In response to these predicted exceedances, the management strategies in **Table 16-84** are proposed:

Table 16-84 Noise mitigation measures – TBM tunnelling between portals

No.	Mitigation measures – TBM tunnelling between portals
1	Ground-borne noise and vibration monitoring to be undertaken at the commencement of tunnelling to confirm that the source data utilised for this assessment is applicable to this Project (including the low frequency noise assessment inputs and findings).
2	Comprehensive advance notice as well as educating the public of intended tunnelling activities in the localities near the tunnel alignment. Part of the consultation process would include information regarding the monitoring program which may require involvement from residences located above the tunnel alignment. A thorough education program would assist to allay fears of the tunnelling process.
3	Conduct building condition surveys in accordance with Brisbane City Council requirements where it is considered there may be potential risk for cosmetic (superficial) building damage from TBM excavation.
4	Temporary relocation of residents particularly impacted by ground-borne noise from TBM tunnelling may be required.

Roadheader

Ground-borne noise and vibration levels from roadheader tunnelling works associated with the cross-passages between the two tunnels, station caverns and close to the portals would be lower than the levels predicted for the TBMs.

All residential receivers are predicted to comply with the ground-borne vibration goals during the roadheader tunnelling works.

There are 22 predicted exceedances of the night-time ground-borne noise goal for residential receivers above or close to the cross passages (13 of these are within a marginal 2 dBA exceedance). It should be noted that the ground-borne noise and vibration from excavation of cross passages will be short duration works (ie 2-3 days). All commercial receivers comply with the relevant 45 dBA (office spaces) and 50 dBA (retail) ground-borne noise goals.

Exceedances of the ground-borne noise and vibration goals for two hotels near Albert Street Station have been predicted. Ground-borne noise and vibration levels attenuate by approximately 2 dB per floor for the first four floors and by approximately 1 dB per floor thereafter. This results in exceedances of the ground-borne noise and vibration goals only for hotel rooms on the Ground Floor and Floor 1.

Low frequency noise assessment

The low frequency noise assessment indicates that annoyance limits would likely be exceeded during driven tunnelling works for offset distances of approximately 100 m associated with the Project. The noise and vibration management sub-plan would cover the potential for low frequency noise impacts, with the following listed in **Table 16-85** as a minimum.

Table 16-85 Noise mitigation measures – low frequency noise assessment

No.	Mitigation measures – low frequency noise assessment
1	A comprehensive notification and education program to assist in allaying fears regarding tunnelling. Part of the education process would include an indication of tunnelling progress and subsequent likely (temporary) exposure periods.
2	Infrasound and low frequency noise measurements in accordance with the Assessment of Low Frequency Noise guideline at the commencement of tunnelling operations and in the event of a “low frequency” noise complaint (if required).
3	An option for temporary relocation of people, pending the outcome of an assessment of the impact against the EIS goals and the Assessment of Low Frequency Noise Guideline.

Construction traffic

The increase in road traffic noise due to spoil traffic is predicted to be less than 2 dBA on all spoil roads at adjacent residential receiver locations. It is generally recognised in acoustics that changes in noise levels of 2 dBA or less are undetectable to the human ear and therefore the change in noise levels would be negligible. The absolute maximum noise levels associated with vehicle pass-bys would not be altered by construction vehicles, however the frequency of such events would increase. Best practice noise management practices would be incorporated into the management of spoil removal.

16.6.2 Operation

For new underground railway projects, consideration of the potential noise and vibration impacts during the design stage is critical in order to achieve a cost-effective and acceptable environmental outcome for the surrounding community. The application of add-on mitigation measures after construction is completed is usually very expensive, and in many cases is not feasible after train operations commence.

Ground-borne noise and vibration – train operations

Ground-borne vibration

On the basis of the proposed alignment, operating speeds, and design and maintenance assumptions, the predicted ground-borne vibration levels with the proposed trackform configuration are more than a factor of three below the vibration goal at the nearest sensitive receiver locations. On this basis, vibration levels from train passbys are not likely to be perceptible within nearby buildings.

However, a potential exceedance of the 0.013 mm/s (82 dBV) vibration goal for buildings with highly vibration sensitive equipment has been identified at the 7 Day Medical Centre in the Brisbane CBD. Further investigation of mitigation measures, such as track-fastening systems, would be required during detailed design to ensure that sensitive equipment within this facility would not be adversely affected by train operations.

The predicted ground-borne vibration levels for the electron microscope at the Ecosciences Precinct complies with the instrument specific vibration criteria supplied by the tenant. However, further measurements and more detailed predictions would be performed during the detailed design stage to confirm the electron microscope is not adversely affected by vibration from train operations.

The predicted vibration levels associated with train operations in the tunnels are less than 0.06 mm/s at any buildings near the tunnels and therefore the risk to any heritage buildings is negligible. Similarly, the potential for damage to other key utilities or infrastructure is also negligible, on the basis that the tunnel wall vibration levels are anticipated to be approximately 0.1 mm/s (100 dBV).

Ground-borne noise

Three trackforms have been proposed as part of the reference design to achieve the ground-borne noise goals. These comprise a “direct fixation” trackform with standard “stiff” rail fasteners, a “resilient” trackform with moderately resilient rail fasteners and a “highly resilient” trackform incorporating highly resilient rail fasteners.

The ground-borne noise modelling indicates that at critical locations, a “resilient” or “highly resilient” trackform would be required to achieve the ground-borne noise goals. With the proposed combination of trackforms, the ground-borne noise goals would be achieved at all sensitive receiver locations. In total, 6.9 km of resilient rail fasteners and 1.19 km of highly resilient rail fasteners would be required for the tunnels.

Airborne noise assessment – train operations

The predicted airborne noise levels include contributions from through traffic, stabling yards and tunnel portals and include shielding from any existing noise barriers.

In the northern section, all sensitive locations are predicted to comply with Queensland Rail’s operations noise criteria in both Year 2021 and Year 2031. Consequently, mitigation measures are not required in this section.

In the southern section, 28 sensitive locations are predicted to exceed Queensland Rail’s operations rail noise criteria in Year 2021 and 37 sensitive locations are predicted to exceed the criteria in Year 2031. Four sections with noise barriers are proposed for these locations to achieve compliance with Queensland Rail’s rail noise criteria, as described in **Table 16-86**.

Table 16-86 Proposed noise barriers

Noise Barrier	Location	Length (m)	Height (m)	Area (m ²)
1	South of Salisbury Station	375	6 to 7	2,345
	North of Salisbury Station	214	5	1,070
2	South of Rocklea Station	88	4.5	395
	North of Rocklea Station	43	5	217
3	Yeronga	165	4.5	735
4	Yeerongpilly Station	155	4	625

Note:

1. The southern portion of Noise Barrier 1 south of the Salisbury Station (approximately 375 m) replaces an existing noise barrier of 1.5 to 4.5 m in height.

For safety reasons, Queensland Rail's Code of Practice does not permit the construction of noise barriers adjacent to existing train stations. Ten sensitive receivers located adjacent to the Salisbury Station and one sensitive receiver sited adjacent to Rocklea Station exceed Queensland Rail's operation planning levels, taking into account the proposed noise barriers. There are exceedances adjacent to the Salisbury Station of up to 7 dBA for the LAeq(24hour) planning level.

The noise contribution from the rail stabling yard operations to the overall rail noise emissions is negligible. The through traffic dominates the single event maximum and LAeq(24hour) noise levels. There are no predicted exceedances of Queensland Rail's criteria adjacent to either Mayne Rail Yard or Clapham Rail Yard.

There is a risk that the stationary trains at the stabling yards would lead to a sleep disturbance impact due to the more steady-state character of the noise sources compared to normal rail operations. Even though the Queensland Rail noise criteria would be achieved, there is a risk that noise emissions from the air conditioning units after parking and before pick up may cause sleep disturbance. The possible sleep disturbance caused by the noise emission from the air conditioning units after parking and before pick-up would be mitigated by careful management of the stabling yards. Effective mitigation and management measures would most likely result in night-time external noise levels less than 40 dBA LAeq.

The existing rail tracks between the portals in Yeerongpilly and Victoria Park would not be changed as part of the Project. The Project would however free up capacity on these surface tracks creating an opportunity to increase both passenger and freight traffic on the surface tracks between the portals.

The incremental change to the daily averaged LAeq(24hour) noise levels from the existing surface rail tracks between the portals due to change in freight and passenger train numbers as a result of the Project have been assessed. The predicted noise levels indicate that the LAeq(24hour) noise emission levels between the portals would increase by up to 2.0 dBA due to the change in passenger and freight train traffic for the Year 2031.

The maximum noise level during train passbys would not change due to the change in passenger and freight train numbers. However, there would only be an increase in the number of train passby events.

Airborne noise assessment – ancillary facilities

Three feeder stations are proposed for the power supply to the tunnel section. The feeder stations are proposed to have building enclosures of all components, based on the recently completed Roma Street feeder station. Assuming a 20 dBA facade reduction for the enclosures, all three feeder stations are predicted to comply with the Project noise goals.

Train noise break-out through the ventilation and emergency access building and shaft from trains operating within the tunnel is not expected to exceed the noise goals and is expected to be comparable (or quieter) than car passby noise levels from Fairfield Road.

At the proposed underground train stations, appropriate noise mitigation measures are likely to be required for some station mechanical plant and ventilation shafts in order to comply with the Project noise goals. The maximum total allowable emitted sound power at each location has been calculated, specifying the acoustic emission limit for all equipment (combined operation) at each location. These emission limits would be achievable with appropriate equipment selection and silencing treatments, if required. Mitigation measures that would be considered at detailed design stage include appropriate equipment selection, in-duct attenuators, noise barriers, acoustic enclosures and the strategic positioning of critical plant away from sensitive receivers (refer to Operations EMP within **Chapter 24 Draft Outline EMP**).

Airborne noise assessment – traffic noise

Four sections of road would be realigned adjacent to the southern railway corridor at Dollis Street near Salisbury Station, Heaton Street and Fairlie Terrace at the Beaudesert Road overpass, the Fairfield Road entry ramp to Ipswich Road and at Wilkie Street, east of Yeerongpilly Station. The predicted road traffic noise levels with the realigned roads would comply with the TMR CoP design goals for Year 2031.

16.7 Summary

The noise and vibration assessment has identified the key sources of noise and vibration anticipated during construction and operation of the Project. Noise and vibration modelling has been carried out to predict noise and vibration levels at sensitive receivers during the construction and operation phases.

16.7.1 Construction

Construction noise and vibration is predicted to exceed the goals for varying periods in a number of locations across the study corridor. The duration of the predicted exceedances varies considerably, depending on the different construction activities and locations of sensitive receivers.

During construction, exceedances of the goals for sleep disturbance with respect to construction vibration and regenerated noise are anticipated in sections along the main tunnel alignments where the tunnel is closest to the surface. Some locations between Roma Street and Albert Street, Woolloongabba and Boggo Road, south of Boggo Road are anticipated to be affected for short periods as the TBMs pass by beneath the surface. The duration of these predicted impacts would be up to seven days, although periods of up to ten days could be expected in the CBD where buildings have deep foundations into rock.

A hierarchy of management and mitigation measures are proposed to achieve the environmental objectives for nearby sensitive receptors, while permitting construction activities to proceed at a reasonable rate of progress. The environmental objectives seek to minimise disruption to normal urban activities by seeking to avoid sleep disturbance and maintain reasonable acoustic conditions within buildings used for education, commerce, worship and community activities. Construction vibration would be managed to achieve similar environmental objectives.

16.7.2 Operation

Ground-borne noise and vibration is predicted to fall below the goals during operation at all nearest sensitive receiver locations, except a potential exceedance of the vibration goal for buildings with highly vibration sensitive equipment in the Brisbane CBD.

Potential exceedances of the operations airborne noise criteria established in the Queensland Rail Code of Practice have been identified in the southern end of the study corridor at Yeerongpilly Station, Yeronga, Rocklea and Salisbury. The predicted changes in train traffic, including freight train traffic on the surface tracks between the portals would not lead to exceedances of the Code of Practice requirements. Mitigation measures, such as acoustic barriers are proposed to address noise impacts during operation. Modelling indicates that such measures would be effective in reducing operation noise to satisfy the requirements of the Code of Practice.

Four sections of road would be realigned adjacent to the southern railway corridor. No exceedances of road traffic noise design goals are predicted from the realigned roads.