CABRAMATTA LOOP PROJECT

TECHNICAL REPORT

TECHNICAL REPORT 2 —

NOISE AND VIBRATION IMPACT ASSESSMENT

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Australian Rail Track Corporation

Cabramatta Loop Project

Environmental Impact Statement

Technical Report 2 - Noise and Vibration Impact Assessment

August 2019

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Glossary

Term	Definition
Absolute rail noise	The absolute rail noise refers to noise levels emitted by rail only, that is without the contribution of any other noise source.
Ambient noise	The all-encompassing noise associated with a given environment. It is the composite of sounds from many sources, both near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise is removed. This is described using the L_{A90} descriptor (See also rating background level).
dB	Decibel, which is 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference pressure; used as a unit of sound.
dB(A)	Decibel expressed with the frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at low and high frequencies.
Feasibility	Feasibility (or practicability) relates to engineering constraints such as constructability, safety, maintenance and reliability.
Ground-borne vibration	Ground-borne vibration is vibration transmitted from source to receiver via the medium of the ground.
Kilde report 67/130 (1984)	Nordic rail traffic noise prediction method.
$L_{A90\ (Time)}$	The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise. Eg $L_{A90\ (15\ min)}$.
$L_{AN\ (Time)}$	The A-weighted sound pressure level that is exceeded for N% of the time over which a given sound is measured. Eg L_{A1}.
$L_{Aeq\ (Time)}$	Equivalent sound pressure level: the steady sound level that, over a specified period, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Aeq\ (15\ hr)}$	The L_{Aeq} noise level for the period 7.00 to 22.00 hours.
$L_{Aeq\ (9\ hr)}$	The L_{Aeq} noise level for the period 22.00 to 7.00 hours.
$L_{Aeq\ (1hr)}$	The highest hourly L_{Aeq} noise level during the day and night periods.
L_{AFmax}	The maximum sound level recorded during the measurement period.
Mitigation	Reduction in severity.
Noise sensitive receiver	An area or place potentially affected by noise including residential dwellings, schools, child care centres, places of worship, health care institutions and active or passive recreational areas.
Notch setting	Locomotive throttle control position.
Peak Particle Velocity (PPV)	The maximum vector vibration velocity that occurs in any of the individual x,y or z orthogonal directions. Current practices for assessments of the risk of structural damage to buildings use measurements of PPV in millimetres per second.
Project	The construction and operation of the Cabramatta Loop
Projet site	Refers to the area that would be directly disturbed by construction of the project (for example, as a result of ground disturbance and the construction of foundations for structures). It includes
Rating Background Level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period. This is the level used for construction noise assessment purposes.

Term	Definition
Reasonable	Considers cost, noise impacts, mitigation benefits, community views and state government requirements to determine if a noise mitigation proposal is reasonable.
Receiver	A noise modelling term used to describe a map reference point where noise is predicted. A sensitive receiver would be a home, work place, church, school or other place where people spend time.
RMS or Vrms	Root Mean Square (velocity)
Short-term vibration	Vibration that occurs so infrequently that it does not cause structural fatigue nor does it produce resonance in the structure.
Sound Pressure Level (SPL)	20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level of 20 micro Pascals.
Study area	For the noise assessment, the study area has been defined as a one kilometre buffer from the railway alignment between Cabramatta and Warwick Farm.
Tonality	Noise containing a prominent frequency or frequencies characterised by a definite pitch.
Turnouts	Assemblies of rails, switches and crossings where two tracks converge into one.
Vibration dose value (VDV)	As defined in BS6472 – 1992, the vibration dose value is given by the fourth root of the integral of the fourth power of the frequency weighted acceleration.
Vibration	The variation of the magnitude of a quantity which is descriptive of the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value or reference. Vibration can be measured in terms of its displacement, velocity or acceleration. The common units for velocity are millimetres per second (mm/s).

List of abbreviations

Abbreviation	Definition
AVTG	Assessing Vibration: A Technical Guideline (DEC 2006)
ARTC	Australian Rail Track Corporation
CNVS	Construction Noise and Vibration Strategy (TfNSW 2018)
DEC, DECC, DECCW	See OEH
EPA	Environment Protection Authority of New South Wales
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EIS	Environmental impact statement
ICNG	*Interim Construction Noise Guideline* (DECC 2009)
INP	*Industrial Noise Policy* (EPA 2000)
mm/s	millimetres per second
m/s	metres per second
NCA	Noise catchment area
NML	Noise management level
NPI	*Noise Policy for Industry* (EPA 2017)
NVSR	Noise and vibration sensitive receiver
OEH	The Office of Environment and Heritage (OEH). Formerly the Department of Environment and Conservation (DEC) before becoming the Department of Environment and Climate Change (DECC), later known as the Department of Environment Climate Change and Water (DECCW).
RING	*Rail Infrastructure Noise Guideline*
RBL	Rating Background Level
RNP	*Road Noise Policy* (DECCW 2011)
SEARs	Secretary's Environmental Assessment Requirements
SEL (or L_{AE})	Sound exposure level
SSFL	Southern Sydney Freight Line
TfNSW	Transport for NSW

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Executive summary

Australian Rail Track Corporation proposes to construct and operate a passing loop for up to 1,300 metre length trains on the Southern Sydney Freight Line between Sydney Trains' Cabramatta and Warwick Farm stations. The Cabramatta Loop Project would allow freight trains to pass and provide additional rail freight capacity along the SSFL.

A noise and vibration assessment of construction and operational activities associated with the project has been undertaken.

Baseline noise monitoring was undertaken at seven locations in the project area. The noise monitoring was used to establish rail, ambient and background noise levels in the area. Five locations were used for operational rail noise validation.

Construction activities are proposed to be carried out during and outside standard construction hours and have been modelled based on the construction staging.

The predicted noise levels indicate that the noise management levels would be exceeded during and outside standard hours. Receivers located next to the works are likely to experience levels above the highly noise affected level of 75 dBA.

Construction traffic movements along local roads should be managed with a construction traffic management plan to limit the degree of road traffic noise impacts.

Vibration intensive plant and equipment may be used during construction of the road, noise wall and bridge. Construction equipment should be selected to comply with the vibration safe work buffer distances.

Heritage listed structures have been identified within the construction work areas. A building dilapidation survey would be carried out prior to starting vibration generating works near these structures.

Operational noise modelling was carried out for the existing, year opening and design year scenarios with and without the project operating ('build' and 'no build'). A noise wall similar to the existing, would be constructed along Broomfield Street.

The predicted 'no build' and 'build' design year noise levels indicate that architectural treatments would need to be considered at one sensitive receiver. During detailed design phase, it is recommended that a site visit should be undertaken to determine specific architectural treatments.

Specific operational ground-bore noise and vibration mitigation strategies are not required for the project. A dilapidation survey will be undertaken during construction to assess the structural integrity of heritage bridges located in the study area.

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1. Introduction

1.1 Overview

Australian Rail Track Corporation (ARTC) proposes to construct and operate a passing loop for up to 1,300 metre length trains on the Southern Sydney Freight Line (SSFL) between Sydney Trains' Cabramatta and Warwick Farm stations. The Cabramatta Loop Project ('the project') would allow freight trains to pass and provide additional rail freight capacity along the SSFL.

The project is State significant infrastructure in accordance with Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). As State significant infrastructure, the project needs approval from the NSW Minister for Planning and Public Spaces.

This report has been prepared to accompany the environmental impact statement (EIS) to support the application for approval of the project, and address the environmental assessment requirements of the Secretary of the Department of Planning and Environment (the SEARs), issued on 17 May 2018.

1.2 The project

1.2.1 Location

The project is generally located within the existing rail corridor between the Hume Highway and Cabramatta Road East road overbridges in the suburbs of Warwick Farm and Cabramatta. In addition, the project includes works to Broomfield Street adjacent to the rail corridor in Cabramatta.

The rail corridor is owned by the NSW Government (RailCorp) and leased to ARTC.

The location of the project is shown on Figure 1-1.

1.2.2 Key features

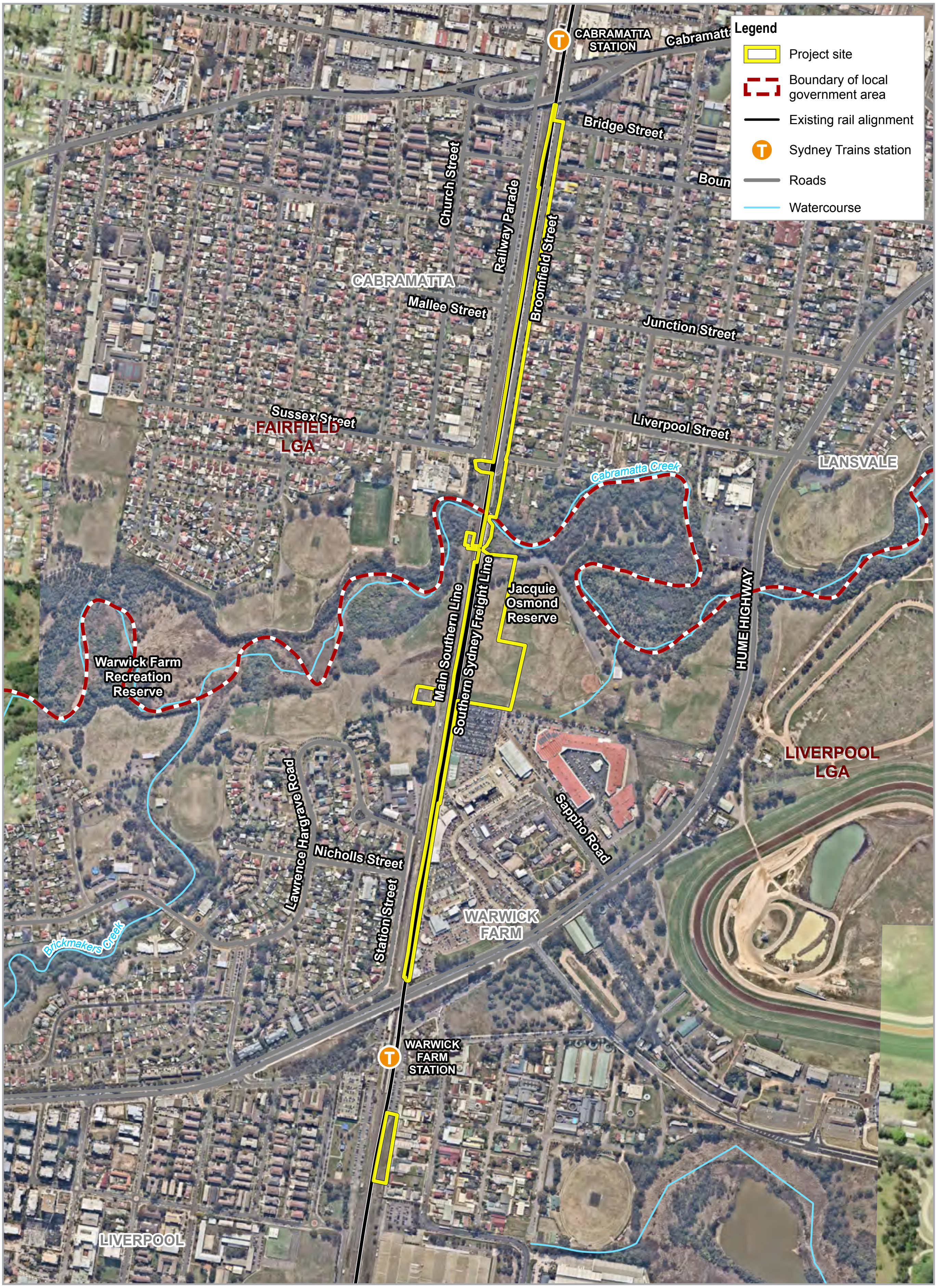
The key features of the project include the following:

- New rail track – providing a 1.65 kilometre long section of new track with connections to the existing track at the northern and southern ends.
- Track realignment – moving about 550 metres of existing track sideways (slewing) to make room for the new track.
- Bridge works – constructing two new bridge structures adjacent to the existing rail bridges over Sussex Street and Cabramatta Creek.
- Road works – reconfiguring Broomfield Street for a distance of about 680 metres between Sussex and Bridge streets.

Ancillary work would include communication upgrades, works to existing retaining and noise walls, drainage work and protecting/relocating utilities. In addition, minor works in the form of new signalling would be installed at a number of locations within the rail corridor (indicative locations provided in the EIS).

The key features of the project are shown on Figure 1-2.

Further information on the project is provided in the EIS.



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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: AGD 1966 ISG 56 1

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GHD

ARTC
Cabramatta Rail Loop
Biodiversity Assessment Report

Project No. 22-19800
Revision No. 0
Date 17/04/2019

Site map

FIGURE 1.1

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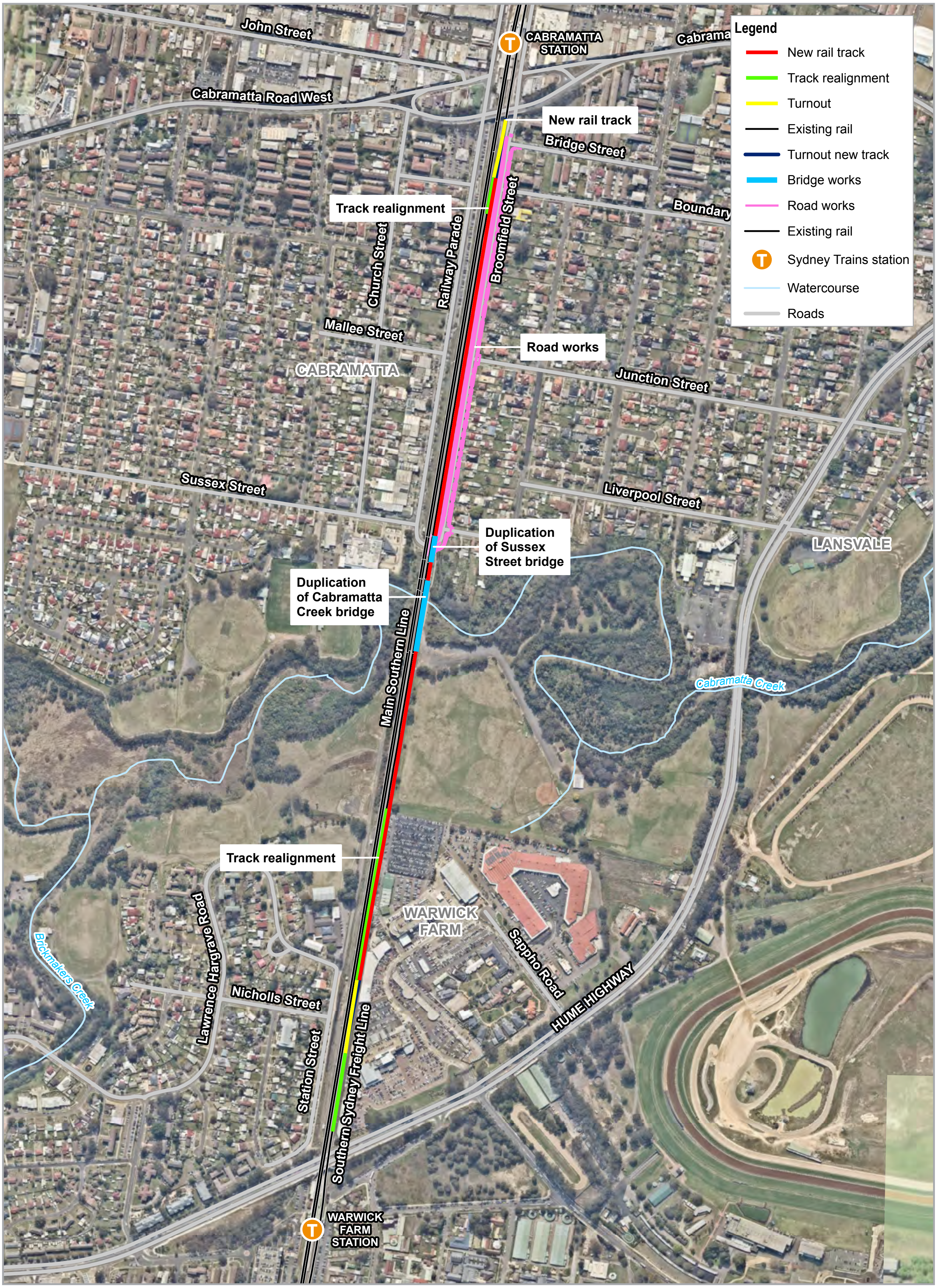
Data source: NearMap: Imagery, 2018. LPI:DCDB/DTDB, 2017LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017 Created by: tmorton



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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: AGD 1966 ISG 56 1

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GHD

ARTC
Cabramatta Rail Loop
Biodiversity Assessment Report

Key features

Project No. 22-19800
Revision No. 0
Date 17/04/2019

FIGURE 1.2

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\2219800_BAR007_KeyFeatures_0
Print date: 17 Apr 2019 - 15:16

Data source: NearMap: Imagery, 2018. LPI:DCDB/DTDB, 2017LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017 Created by: tmorton

1.2.3 Timing

Subject to approval of the project, construction is planned to start in early 2021, and is expected to take about two years. Construction is expected to be completed in early 2023.

It is anticipated that most of the project would be constructed while the existing rail line continues to operate. Other features of the project would need to be constructed during programmed weekend rail possession periods when rail services along the line cease to operate. Possession periods typically occur for 48 hours four times per year.

Furthermore, some construction works may be scheduled outside of standard construction hours to manage impacts to existing road and rail infrastructure in the area. An indicative time for works to take place is included in Table 4-1.

1.2.4 Operation

The project would operate as part of the SSFL and would continue to be managed by ARTC. ARTC is not responsible for the operation of rolling stock. Train services are currently, and would continue to be, provided by a variety of operators.

Following the completion of works, the existing functionality of Broomfield Street would be restored, with one travel lane in each direction, kerb-side parking on both sides and a shared path on the western side of the street.

1.3 Purpose and scope of this report

The purpose of this report is to assess the potential noise and vibration impacts from the operation and construction of the project. This noise and vibration assessment addresses the relevant SEARs and agency requirements for the EIS as outlined in Table 1-1 and Table 1-2.

The report:

- Describes the existing ambient noise environment.
- Describes the relevant applicable operational and construction noise and vibration criteria.
- Assesses the impacts of constructing and operating the project on sensitive receivers.
- Recommends measures to mitigate the impacts identified.

The SEARs key issues, performance outcomes and referenced guidelines for the project are summarised in Table 1-1. The agency comments are summarised in Table 1-2.

Table 1-1 SEARs relevant to this assessment

Environmental Assessment Requirements	Where addressed in this report
Assessment of Key Issues	
1. For each key issues the Proponent must: (a) describe the biophysical and socio-economic environment, as far as it is relevant to that issue (b) describe the legislative and policy context, as far as it is relevant to the issue (c) identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts (d) demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies); (e) detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant)	Section 2 Relevant guidelines are referenced where used throughout the report and listed in section 8 Section 4 & 5 Refer to the EIS Section 6
Key Issue and Desired Performance Outcome: Noise and Vibration–Amenity	
Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on acoustic amenity. Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and wellbeing of the community. ***Requirement*** 1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must cover typical realistic construction and operation activities (such as bringing trains to idle or holding trains in the loop). The assessment must include consideration of: (a) impacts to sensitive receivers including small businesses (b) noise impacts from the removal of the existing noise walls and construction of any new noise walls (permanent or temporary) during construction, including the consideration of implementing permanent noise walls prior to the removal of the existing noise walls (c) noise impacts of out-of-hours works including proposed activities, justification for these activities, estimation of the number of out-of-hours activities required and timeframes for these activities (d) sleep disturbance (e) the characteristics of noise and vibration, as relevant (for example, low frequency noise) 2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Section 4 Section 5
Current guidelines • Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZECC, 1990) • Assessing Vibration: a Technical Guideline (DEC, 2006) • Interim Construction Noise Guideline (DECCW, 2009) • NSW Industrial Noise Policy (EPA, 2000) • Construction Noise Strategy (TfNSW, 2012)	Relevant guidelines are referenced where used throughout the report and listed in section 8

Environmental Assessment Requirements	Where addressed in this report
• Rail Infrastructure Noise Guideline (EPA, 2013) • NSW Road Noise Policy (DECCW, 2011) • Environmental Noise Management Manual (RMS, 2001) • Development Near Rail Corridors and Busy Roads – Interim guideline (DoP, 2008) • Noise Mitigation Guideline (RMS, 2015) • Noise Criteria Guideline (RMS, 2015) • NSW Sustainable Design Guidelines Version 3.0 (TfNSW, 2013)	
Key Issue and Desired Performance Outcome: Noise and Vibration–Structural	
Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on the structural integrity of buildings and items including Aboriginal places and environmental heritage. Increases in noise emissions and vibration affected environmental heritage as defined in the *Heritage Act 1977* during operation of the project are effectively managed. ***Requirement*** 1. The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage). 2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Section 3.1 Section 3.4
Current guidelines *German Standard DIN 4150-3: Structural Vibration – effects of vibration on structures*	Section 3.3

Table 1-2 Agency comments relevant to this assessment

Agency	Requirement	Where addressed in this report
NSW EPA	Noise and vibration impacts should be assessment in accordance with the ICNG and RING and EPA's requirements (as outlined in the EPA letter)	Section 4 Section 5
NSW EPA	The assessment should clearly state what type of rail infrastructure development the project constitutes under the RING	Section 3.2
NSW EPA	The assessment must provide clear justification for construction activities to be conducted outside the recommended standard hours in Section 2.2 of the ICNG, and assess these impacts	Section 4
NSW EPA	Approval to work outside of the recommended standard hours may be required from the EPA	-
Transport for NSW	Detailed acoustic assessment, including noise impacts of holding an Up freighter in the new loop	This report

1.4 Structure of this report

The structure of the report is outlined below:

- Section 1 – provides an introduction to the report.
- Section 2 – describes the study area, sensitive receivers, existing rail infrastructure and operations and existing ambient noise environment.
- Section 3 – details the relevant noise and vibration criteria.
- Section 4 – describes the construction noise and vibration impact assessment.
- Section 5 – describes the operational rail noise and vibration impact assessment.
- Section 6 – describes the recommended mitigation and management measures for the project.
- Section 7 – the report conclusion summarising key outcomes from the report
- Section 8 – the references used in the preparation of this report.

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2. Existing environment

2.1 Study area

The area surrounding the project is primarily suburban, with residential and commercial land uses located directly next to the existing rail and road corridors.

The study area for the operational rail noise and vibration assessment has been defined as a one kilometre buffer either side of the rail corridor between the stations of Warwick Farm and Cabramatta, in accordance with the *ARTC Noise Prediction and Mitigation Guideline* (ARTC, 2018). The operational study area is bounded at each end by the extent of the works within the rail corridor.

The study area for the construction noise and vibration assessment has been defined as a one kilometre buffer from the project boundary in all directions. The construction assessment study area extends slightly to the north of Cabramatta Station and south of Warwick Farm Station.

The operational and construction noise and vibration study areas are shown on Figure 2-1.

The study areas have been further sub-divided into noise catchment areas (NCAs). The noise catchment areas have been created based on the ambient noise characteristics with respect to the major road and rail corridors in the study area. The following NCAs were created:

- NCA01: The area to the north of Jacquie Osmond Reserve and west of the rail corridor. The area comprises of commercial and residential land uses. Rail noise, road traffic noise from Railway Parade and noise from commercial premises along Railway Parade dominate the noise environment in NCA01.
- NCA02: The area to the north of Jacquie Osmond Reserve and east of the rail corridor. The area comprises of residential land uses. Road traffic noise from Broomfield Street and local roads in the area dominate the noise environment. An existing noise wall along Broomfield Street shields the catchment from rail noise.
- NCA03: The area to the south of Jacquie Osmond Reserve and west of the rail corridor. The area comprises of primarily residential land uses. Rail noise and traffic along local roads dominate the noise environment in NCA03.
- NCA04: The area to the south of Jacquie Osmond Reserve and east of the rail corridor. The area comprises of primarily commercial land uses. Rail noise and noise from commercial premises dominate the noise environment in NCA04.

The noise catchment areas are shown on Figure 2-1.

2.2 Sensitive receivers

Noise and vibration sensitive receivers (NVSRs) are defined by the type of occupancy within the structure and the activities performed within the property boundary. NVSRs could include the following:

- residences (including multi-floor dwellings): Each floor of a multi-floor dwelling is considered to be a separate sensitive receiver as each floor could have separate property owners and/or land uses (e.g. commercial ground floor and residential first floor)
- educational institutes (such as schools and universities eg Lawrence Hargrave School)
- hospitals and medical facilities
- places of worship

- commercial or industrial premises eg Peter Warren Automotive
- passive recreational areas
- active recreational areas such as sporting fields, golf courses. Note that recreational areas are only considered sensitive when they are in use or occupied.

For the construction noise and vibration assessment (Section 4), 3604 residential receivers and 283 non-residential receivers have been identified within the construction assessment study area.

For the operational noise and vibration assessment (Section 5), 3321 residential receivers and 283 non-residential receivers have been identified within the operational assessment study area.

All receivers are individually identified in Appendix A and shown in Appendix B. All medical, educational and place of worship sensitive receivers are also summarised in Table 2-1.

In addition to the existing sensitive receivers, a search of the NSW Government major projects online database and the Fairfield and Liverpool council online planning databases was undertaken to identify if any determined projects within 100 metres of the project site would alter the type or sensitivity of existing receivers (i.e. change from a commercial premises into residential). No projects were identified that would require additional consideration.

Table 2-1 Medical, educational and place of worship sensitive receivers

Receiver ID	Address	Receiver Type	NCA
R0218	42 BIGGE STREET LIVERPOOL	Medical facility	NCA03
R0232	26 BIGGE STREET LIVERPOOL	Medical facility	NCA03
R0253	20 BIGGE STREET LIVERPOOL	Medical facility	NCA03
R0257	16 BIGGE STREET LIVERPOOL	Medical facility	NCA03
R0277	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0281	45 GOULBURN STREET LIVERPOOL	Medical facility	NCA03
R0287	41 GOULBURN STREET LIVERPOOL	Medical facility	NCA03
R0291	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0302	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0312	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0322	17 GOULBURN STREET LIVERPOOL	Medical facility	NCA03
R0329	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0340	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0351	LIVERPOOL HOSPITAL CANCER THERAPY CENTRE CAMPBELL STREET LIVERPOOL	Medical facility	NCA03
R0357	17 GOULBURN STREET LIVERPOOL	Medical facility	NCA03
R0363	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0439	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03

Receiver ID	Address	Receiver Type	NCA
R0454	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0469	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0494	27 FORBES STREET LIVERPOOL	Place of worship	NCA03
R0516	95 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R0607	136 JOHN STREET CABRAMATTA	Place of worship	NCA01
R0618	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0619	13 LACHLAN STREET WARWICK FARM	Medical facility	NCA03
R0621	LIVERPOOL HOSPITAL CANCER THERAPY CENTRE CAMPBELL STREET LIVERPOOL	Medical facility	NCA03
R0623	LIVERPOOL HOSPITAL CANCER THERAPY CENTRE CAMPBELL STREET LIVERPOOL	Medical facility	NCA03
R0639	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0641	LIVERPOOL HOSPITAL CANCER THERAPY CENTRE CAMPBELL STREET LIVERPOOL	Medical facility	NCA03
R0679	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0692	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0736	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0744	LIVERPOOL HOSPITAL CANCER THERAPY CENTRE CAMPBELL STREET LIVERPOOL	Medical facility	NCA03
R0767	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0776	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0785	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0806	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0810	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0818	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0842	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0852	LIVERPOOL HOSPITAL CANCER THERAPY CENTRE CAMPBELL STREET LIVERPOOL	Medical facility	NCA03
R0866	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0888	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0892	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0913	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R0970	LIVERPOOL HOSPITAL CANCER THERAPY CENTRE CAMPBELL STREET LIVERPOOL	Medical facility	NCA03
R0975	54 HUGHES STREET CABRAMATTA	Medical facility	NCA01
R0989	LIVERPOOL HOSPITAL CANCER THERAPY CENTRE CAMPBELL STREET LIVERPOOL	Medical facility	NCA03
R1025	120 JOHN STREET CABRAMATTA	Medical facility	NCA01
R1037	18 FORBES STREET LIVERPOOL	Medical facility	NCA03

Receiver ID	Address	Receiver Type	NCA
R1086	18 FORBES STREET LIVERPOOL	Educational institute	NCA03
R1087	18 FORBES STREET LIVERPOOL	Medical facility	NCA03
R1099	18 FORBES STREET LIVERPOOL	Medical facility	NCA03
R1245	119A JOHN STREET CABRAMATTA	Medical facility	NCA01
R1348	117 JOHN STREET CABRAMATTA	Medical facility	NCA01
R1476	42 HILL STREET CABRAMATTA	Medical facility	NCA01
R1641	1 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R1649	1 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R1673	1 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R1683	1 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R1705	1 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R1739	1 LAWRENCE HARGRAVE ROAD WARWICK FARM	Educational institute	NCA03
R1919	PARK ROAD CABRAMATTA	Educational institute	NCA01
R1952	39 PARK ROAD CABRAMATTA	Place of worship	NCA01
R2030	7 MCBURNEY ROAD CABRAMATTA	Place of worship	NCA01
R2035	PARK ROAD CABRAMATTA	Place of worship	NCA01
R2250	1 BARTLEY STREET CANLEY VALE	Place of worship	NCA01
R2368	70 BROOMFIELD STREET CABRAMATTA	Place of worship	NCA02
R2696	60 CUMBERLAND STREET CABRAMATTA	Educational institute	NCA02
R2706	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2724	60 CUMBERLAND STREET CABRAMATTA	Educational institute	NCA02
R2751	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2753	42 CUMBERLAND STREET CABRAMATTA	Place of worship	NCA02
R2789	65 CURTIN STREET CABRAMATTA	Place of worship	NCA02
R2791	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2800	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2810	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2814	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2822	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2824	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2831	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2832	9 NIANGALA STREET COOMA	Educational institute	NCA02
R2862	72 CABRAMATTA ROAD CABRAMATTA	Educational institute	NCA02
R2895	79 CABRAMATTA ROAD CABRAMATTA	Place of worship	NCA02

2.3 Existing rail operations

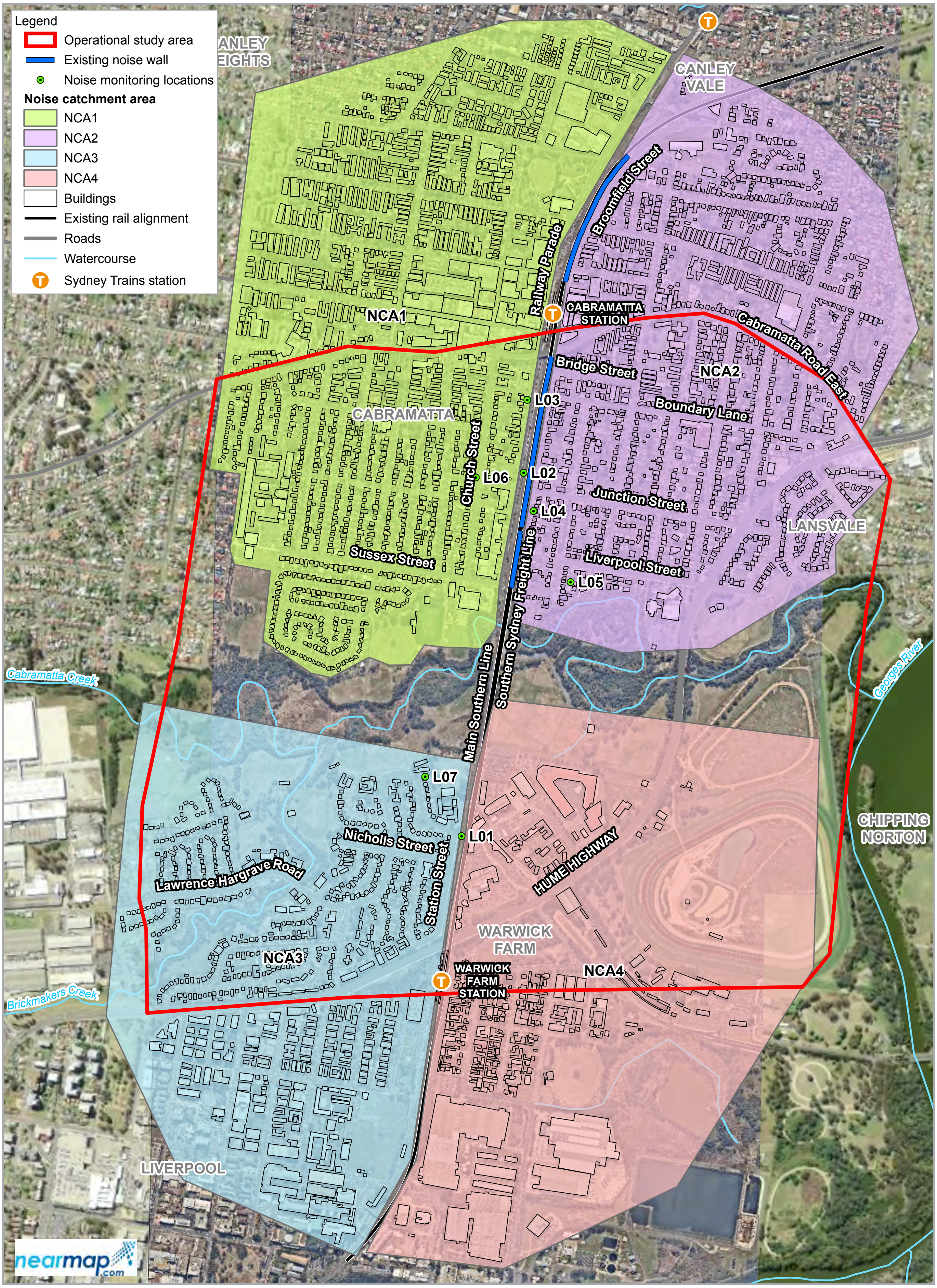
Existing rail operations in the study area include the following:

- Passenger rail operations for the Sydney South Metropolitan Network on the Sydney Trains up and down main lines. The maximum posted passenger train speeds are 80 kilometres per hour (up) and 100 kilometres per hour (down). Train speeds on the up track have been assumed based on the speed board south of Cabramatta Station as this is considered representative of the Warwick Farm to Cabramatta section of the track.
- Freight rail operations on the Sydney Trains up and down main lines. These freight services share the network with the passenger trains. The maximum posted freight train speeds are 70 kilometres per hour (up) and 80 kilometres per hour (down). Train speeds on the up track have been assumed based on the speed board south of Cabramatta Station as this is considered representative of the Warwick Farm to Cabramatta section of the track.
- ARTC bi-directional freight rail operations on the SSFL. The maximum posted speed on the SSFL is 80 kilometres per hour.

2.4 Existing noise wall

An existing noise wall exists along Broomfield Street as shown on Figure 2-1 and would be replaced as part of the project. The existing wall was designed as a part of the original SSFL environmental assessment (*Southern Sydney Freight Line Environmental Assessment*, Parsons Brinckerhoff 2006).

The existing wall height (from top of rail) varies between a minimum of 3.4 metres (CH32237 to CH32380) to a maximum of 5.5 metres (at CH32150). This suggests that the effective minimum height of the wall (from top of rail) is 3.4 metres and the average height of the wall is 3.7 metres. These heights have been calculated from the supplied 559D-SW1500 As-built drawings (Aurecon, 2013) for the existing noise wall.



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Map Projection: Transverse Mercator
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Australia Rail Track Corp Ltd
Cabramatta Rail Loop
Noise and Vibration Impact Assessment

Study area, noise monitoring locations and noise sensitive receivers

Project No. 22-19800
Revision No. 0
Date 17/04/2019

Figure 2-1

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\2219800_NVIA003_Study_Area_Noise_Sensitive_Receivers_0
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Data source: LPI: DTDB\DCDB, 2017. DPE: Land zoning, 2016.LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017. Created by: tmorton

2.5 Baseline monitoring

Existing ambient and background noise monitoring was undertaken at seven locations in the study area between 12 October 2018 and 1 November 2018. A minimum of two weeks of monitoring was carried out at each location.

The objectives of the monitoring were to quantify:

- The existing railway and background noise levels at five locations (two within the rail corridor and three at residential receivers). These locations were used for noise model validation.
- The existing background noise levels (only) at an additional two locations set back from the rail corridor.

Baseline logger location considerations included land topography, distance from rail activities and contribution from other noise activities, such as road noise. The logger locations were considered representative of the existing background and ambient noise environment in the study area.

The noise loggers accumulated L_{AN}, L_{Aeq} and L_{Amax} noise descriptors continuously over sampling periods of 15 minutes for the entire monitoring period.

Prior to deployment, a calibration check was performed on the noise monitoring equipment using a SV 30 sound level calibrator (serial number 29030). At completion of the measurements, the equipment was re-checked to ensure the sensitivity of the noise monitoring equipment had not varied. The noise loggers were found to be within the acceptable tolerance of ± 0.5 dB(A).

The data collected by the loggers was downloaded and analysed, and any invalid data removed. Invalid data generally refers to periods where average wind speeds were greater than five metres per second, or when rainfall occurred in accordance with the *Noise Policy for Industry* (NPI) (EPA, 2017). Concurrent half-hourly weather data was sourced from the Bureau of Meteorology's Bankstown Airport automatic weather station (AWS) to identify any periods of weather, which may have affected the monitoring results. The Bankstown Airport AWS is located about five kilometres east of the project area.

All sampling activities were carried out with consideration to the specifications outlined in AS 1055 (1997) *Acoustics–Description and Measurement of Environmental Noise* and the NPI. Appendix C provides details of the noise loggers utilised for unattended monitoring.

2.5.1 Summary of baseline noise monitoring

A summary of the baseline noise monitoring, including a description of the ambient noise environment at each location is provided in Table 2-2. Detailed noise monitoring tables and charts are provided in Appendix C.

Background noise levels at residential locations L04 to L07 are consistent and within 2 dB across the day (37 to 39 dBA), evening (37 to 39 dBA) and night (30 to 32 dBA) time periods. As per Australian Standard *AS 1055*, these background noise levels are typical of a suburban environment with negligible transportation. Intermittent noise events such as rail passbys do not contribute significantly to the background noise levels.

Background noise levels at L03 (225 Railway Parade) are slightly higher during the day and evening time periods due to higher road traffic noise levels. The noise levels are typical of a suburban area with low density transportation.

Table 2-2 Summary of baseline noise monitoring

Location	NCA	Address	Free-field or façade?	Rating background level (RBL) 90th percentile $L_{A90(15min)}$			Ambient noise levels, $L_{Aeq(period)}$					Ambient noise observations
				Day	Evening	Night	Day	Evening	Night	Day (15 hour)	Night (9 hour)	
L01[2]	-	In rail corridor (North of Warwick Farm Station)	Free field	-	-	-	65	64	63	65	63	Rail noise dominant
L02[2]	-	In rail corridor (South of Cabramatta Station)	Free field	43	41	33	68	68	66	68	66	Rail noise dominant
L03	01	225 Railway Parade, Cabramatta	Free field	45	44	33	61	61	59	61	59	Rail noise dominant, road traffic noise along Railway Parade
L04	02	150 Broomfield Street, Cabramatta	Façade	39	38	31	56	56	52	56	52	Rail noise dominant, road traffic noise along Broomfield Street, construction works at residence along Broomfield street
L05	02	46a National Street, Cabramatta	Free field	38	37	31	53	48	46	51	46	Rail noise faintly audible, road traffic noise along National Street
L06	01	41 Church Street, Cabramatta	Free field	38	39	30	55	53	50	54	50	Road traffic noise along Church Street, rail passbys in background
L07	03	25 Lawrence Hargrave Road, Warwick Farm	Free field	37	38	32	52	50	47	50	47	Rail noise dominant, car passbys and bird noise

Note 1: For the rating background and ambient noise levels, the periods are defined as per the *NPI* (EPA, 2017):

- Day: the period from 7.00 am to 6.00 pm Monday to Saturday or 8.00 am to 6.00 pm on Sundays and public holidays
- Evening: the period from 6.00 pm to 10.00 pm
- Night: the remaining periods.

For the 15 hour and nine hour noise levels, as per the *Rail Infrastructure Noise Guideline* (EPA, 2013), day refers to the 7.00 am to 10.00 pm time period while night refers to 10.00 pm to 7.00 am.

Note 2: The absolute rail noise contributions at L01 were calculated to be 64 dB(A) $L_{Aeq(15\ hour)}$ and 63 dB(A) $L_{Aeq(9\ hour)}$. The absolute rail noise contributions at L02 were calculated to be 68 dB(A) $L_{Aeq(15\ hour)}$ and 66 dB(A) $L_{Aeq(9\ hour)}$.The absolute rail noise contributions were calculated from a detailed analysis of passby data and do not include non-rail noise sources.

2.5.2 Effects of long term noise exposure

The RING states that *"several studies have shown that excessive noise from transport modes can lead to sleep disturbance and other health impacts, not just annoyance"* and that *"longer-term effects on health are more difficult to quantify, although links have been confirmed between noise exposure and health impacts."*

The World Health Organisation (WHO) *Night noise guidelines for Europe* (WHO, 2009) concluded that there is sufficient evidence for *"biological effects of noise during sleep: increase in heart rate, arousals, sleep stage changes and awakening"* and *"that night noise exposure causes self-reported sleep disturbance, increase in medicine use, increase body movements and (environmental) insomnia"* and *"leads to further consequences for health and well-being"*.

Based on these conclusions, the WHO recommends an interim target of 55 dBA $L_{Aeq,\ night\ (outside)}$. However, this is measured over an eight hour night time period and for a duration of one year. Therefore, the results presented in Table 2-2 cannot be directly compared with the WHO interim target. However, it is noted that the night time $L_{Aeq(9\ hour)}$ noise levels over the measurement duration are generally below 55 dBA at all locations except L03 (which is slightly higher at 59 dBA $L_{Aeq(9\ hour)}$).

Roosli et al. (2017) undertook research on the short and long term effects of transportation noise exposure in Sweden. Rail, road and air traffic noise exposure modelling was undertaken for over 54 million façade points of 1.8 million residential dwellings. Average day and night time L_{Aeq} noise levels were modelled for the day and night time periods. These periods were 16 hour (day) and 8 hour (night) which are similar to the 15 hour (day) and 9 hour (night) time periods used in New South Wales.

The modelled noise levels were correlated with a population survey centered around annoyance, self-reported sleep disturbances and coping responses due to transportation noise. The intermittency ratio was used to quantify the long term health effects of noise.

Roosli et al. used the intermittency ratio to quantify health impacts. The intermittency ratio is defined as the total event-based sound pressure level (e.g. from railway noise) compared with the overall ambient sound pressure level. High night time period intermittency ratios correlated with higher arterial stiffness (and potential for cardiovascular disease). Roosli et al. concluded that *"either continous noise or highly intermittent noise with long quiet periods between noise events is less problematic than mid-range intermittency"* and that *"the diurnal pattern of noise exposure is also relevant for cardiovascular mortality"*.

A comprehensive review of the effects of environmental noise on sleep was undertaken by Basner and McGuire in 2018. Fragmentation of sleep was linked to short-term and long-term health impacts. This is shown below in Figure 2-2, with the dashed lines showing potential hypothetical pathways to long-term health effects.

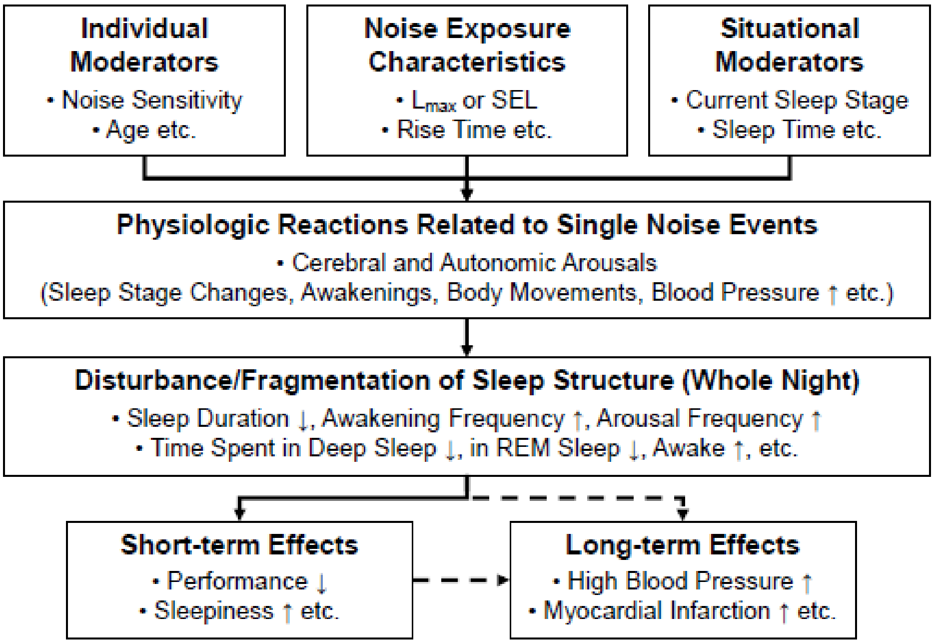

Figure 2-2 Effects of noise on sleep (Figure 1 from Basner and McGuire, 2018)

Based on a review of a number of studies, Basner and McGuire concluded that:

- there was moderate evidence of dose-response between railway noise and cortical awakenings in adults, measured using $L_{AS,max}$
- there was moderate evidence of dose-response between railway noise and self-reported sleep disturbance in adults, measured using $L_{Aeq(9\ hour)}$.

Furthermore, Basner and McGuire derived the following formulas to calculate the percentage of highly sleep disturbed based on $L_{Aeq,9\ hour}$ night time noise levels:

- Difficulty falling asleep:

  $44.4836 – 2.1324^* L_{Aeq(9\ hour)} + 0.0273 (L_{Aeq(9\ hour)})^2$

- Awakenings:

  $38.5819 – 1.8376^* L_{Aeq(9\ hour)} + 0.0234 (L_{Aeq(9\ hour)})^2$

Based on these formulas and the data gathered in the study area, the calculated sleep disturbance percentages for the residential logging locations are provided in Table 2-3.

Table 2-3 Percentage of highly sleep disturbed (Calculated based on Basner and McGuire, 2018)

Location	% (Difficulty falling asleep)	% (Awakenings)
L03	13.7	11.6
L04	7.4	6.3
L05	4.2	3.6
L06	6.1	5.2
L07	4.6	3.9

The percentages are generally lower than 10% at all locations except at L03, which is also influenced by road traffic noise.

Overall, the long term health impacts of rail (and transportation) noise continue to be a research topic. Health effects are generally linked to sleep disturbance which in turn causes short term impacts (such as drowsiness, fatigue, etc.) and potential long-term impacts.

Based on the data gathered at the residential logging locations and current guidance on long-term impacts, the probability of long-term impact is expected to be low due to:

- noise levels during the night time period being generally lower than 55 dBA
- the awakening percentages are generally lower than 10%.

It should also be noted that while noise levels in the future might potentially increase, the aims of the RING are to protect *“approximately 90 per cent of receivers from being highly annoyed by rail noise”*.

2.5.3 Baseline vibration monitoring

Attended and unattended vibration monitoring was also undertaken within and outside the rail corridor. The results of the monitoring indicated 4-5 mm/s peak vibration levels 6 metres from the railway tracks and levels between 0.1 mm/s and 0.3 mm/s at the residence (150 Broomfield Street, 31 metres from the SSFL). The vibration environment was dominated by road traffic noise and intermittent rail passbys.

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3. Noise and vibration criteria

The construction and operational noise and vibration criteria for the project are outlined in this section. The criteria are referenced to the relevant noise and vibration guidelines, as stipulated in the SEARs and agency requirements.

The predicted noise and vibration levels (refer to Section 4 and 5) are compared with the criteria outlined in this section. If the predicted construction and operational noise and vibration levels exceed the criteria, potential noise and vibration mitigation measures need to be considered.

3.1 Construction noise criteria

The *Interim Construction Noise Guideline* (ICNG) (DECC 2009) applies to the management of construction noise in NSW. The guideline provides recommendations on construction noise management levels (NMLs) and standard construction periods.

3.1.1 Construction hours

Construction NMLs for the project are based on the ICNG and the *Construction Noise and Vibration Strategy* (CNVS) (TfNSW, 2018).

The construction periods defined in the CNVS are provided in Table 3-1.

Table 3-1 Construction hours

Construction hours	Monday to Friday	Saturday	Sunday/Public holiday
Standard hours	7.00 am to 6.00 pm	8.00 am to 1.00 pm	No work
Out-of-hours work (OOHW) Period 1 (Day)	-	7.00 am to 8.00 am 1.00 pm to 6.00 pm	8.00 am to 6.00 pm
OOHW Period 1 (Evening)	6.00 pm to 10.00 pm	6.00 pm to 10.00 pm	-
OOHW Period 2	10.00 pm to 7.00 am	10.00 pm to 7.00 am	6.00 pm to 8.00 am

The standard hours for construction periods are not mandatory and the ICNG acknowledges that some activities can be carried out outside standard construction hours, assuming that all reasonable and feasible mitigation measures are implemented to minimise impacts on the surrounding sensitive land uses. These activities may include the following:

- the delivery of oversized plant or structures that police or other authorities determine are required for special arrangements to transport along public roads
- emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours
- works that maintain noise levels at sensitive receivers to below the NMLs outside of the recommended standard construction hours.

3.1.2 Construction noise management levels

Construction NMLs at sensitive residential receivers are provided in Table 3-2. Construction NMLs at non residential receivers are provided in Table 3-3.

The construction NMLs during recommended standard hours represent a noise level that, if exceeded, would require management measures including the following:

- reasonable and feasible work practices
- contact with residences to inform them of the nature of works to be carried out, the expected noise levels and durations and contact details.

The management measures aim to reduce noise impacts on the residential receivers; however, it may not be reasonable and feasible to reduce noise levels to below the noise affected management level.

The construction NMLs during recommended standard hours are not intended as a noise limit but rather a level where noise management is required. The construction NMLs outside of recommended standard hours would be considered as noise limits unless a private agreement has been negotiated with the affected residences.

Table 3-2 Construction NMLs (residential receivers)

Time of day	Management level $L_{Aeq(15min)}$	How to apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm. Saturday 8.00 am to 1.00 pm. No work on Sundays or public holidays.	Noise affected RBL plus 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise Affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences) • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL plus 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Table 3-3 Construction NMLs (non residential receivers)

Receiver Type	Time of day	Management level, $L_{Aeq(15min)}$
Industrial	When in use	75 dBA (external)
Commercial		70 dBA (external)
Educational institutes		45 dBA (internal)
Hospital wards and operating theatres		45 dBA (internal)
Places of worship		45 dBA (internal)
Passive recreation areas		60 dBA (external)
Active recreation areas		65 dBA (external)

3.1.3 Modifying factor adjustments for annoying activities

The ICNG lists a number of activities that have proven to be particularly annoying to sensitive receptors, including the following:

- use of 'beeper' style reversing or movement alarms, particularly at night time
- use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work
- grinding metal, concrete or masonry
- rock drilling
- line drilling
- vibratory rolling
- rail tamping and regulating
- bitumen milling or profiling
- jackhammering, rock hammering or rock breaking
- impact piling.

These activities, if required, would be factored into the assessment by adding five dB to the predicted noise levels.

3.1.4 Sleep disturbance criteria during construction

The ICNG recommends that where construction works are planned to extend over two or more consecutive nights, the project should consider maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL. The potential for both sleep disturbance and awakenings should be considered in the assessment.

The NPI provides the latest Environmental Protection Authority (EPA) guidance for the assessment of sleep disturbance.

The NPI recommends an assessment of maximum noise levels which have the potential to cause sleep disturbance impacts. Sleep disturbance impacts could include awakenings or disturbance to sleep stages. The NPI recommends an initial screening test for maximum noise level events (such as material drop noise or reversing alarms associated with construction machinery), with the following screening levels:

- $L_{Aeq(15\ min)}$ 40 dBA or the prevailing RBL plus five dB, whichever is greater
- L_{AFmax} 52 dBA or the prevailing RBL plus 15 dB, whichever is greater.

A detailed maximum noise level assessment should be carried out if the screening test indicates there is a potential for sleep disturbance. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the RBL, and the number of times this happens during the night time period. The detailed assessment should consider all feasible and reasonable noise mitigation measures with a goal of achieving the maximum noise screening levels.

3.1.5 Construction traffic

Construction traffic relates to light and heavy vehicle movements associated with travel to-and-from construction compounds, transporting construction materials and spoil along defined haulage routes as well as personnel travelling to and from construction sites.

Construction related traffic noise objectives are based on the *Road Noise Policy* (RNP) (DECCW, 2011). The RNP states that an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

The RNP states that any increase in the total traffic noise level should be limited to 2 dB above the existing road traffic noise levels. This applies for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments.

The RNP has been used to identify potential impacts as a result of noise produced by construction traffic. If road traffic noise increases due to construction works within 2 dBA of current levels, then the RNP objectives would be met and no specific mitigation measures required.

Where construction traffic increases the existing road traffic noise levels by more than 2 dBA, then further assessment against the road traffic noise criteria in Table 3-4 is required.

Table 3-4 Road traffic noise criteria, dBA

Type of development	Day 7.00 am to 10.00 pm	Night 10.00 pm to 7.00 am
Existing residence affected by additional traffic on arterial roads generated by land use developments	60 $L_{Aeq(15\ hour)}$	55 $L_{Aeq(9\ hour)}$
Existing residence affected by additional traffic on local roads generated by land use developments	55 $L_{Aeq(1\ hour)}$	50 $L_{Aeq(1\ hour)}$

3.1.6 Project construction noise criteria

A summary of the project construction NMLs for each identified sensitive receiver type is provided in Table 3-5 for residential receivers and Table 3-6 for non-residential receivers (within the study area). The NMLs have been calculated based on the rating background levels provided in Table 2-2 and the calculation procedure outlined in Table 3-2.

Table 3-5 Residential construction NMLs, dBA

NCA	Standard hours, $L_{Aeq,15min}$	OOHW Period 1, $L_{Aeq,15min}$		OOHW Period 2, $L_{Aeq,15min}$	Sleep disturbance, L_{AFmax}
		Day	Evening	Night	Night
NCA01	48	43	42	36	52
NCA02	48	43	43	35	52
NCA03	47	42	42	37	52
NCA04	47	42	42	37	52

Note : The time periods for Standard hours, OOHW Period 1 (Day), OOHW Period 1 (Evening) and OOHW Period 2 (Night) are defined in Table 3-1.

Table 3-6 Non-residential construction NMLs, dBA

Receiver Type	Time of day	Management level
Commercial	When in use	70 dBA (external)
Educational institutes		45 dBA (internal)
Hospital wards and operating theatres		45 dBA (internal)
Places of worship		45 dBA (internal)
Active recreation areas		65 dBA (external)

3.2 Operational noise criteria

3.2.1 Air-borne noise

Operational rail noise criteria are derived from the *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013) and relate to noise generated from rail movements along existing and proposed rail lines within the study area.

The RING applies to both light and heavy rail infrastructure proposals and distinguishes between 'new' or 'redeveloped' heavy rail lines in terms of the applicable noise criteria.

Heavy rail and its associated rolling stock are considered rail infrastructure, which may be electrified or hauled by diesel locomotives, and which operates in dedicated rail corridors for either passenger and/or freight transportation.

A 'new' heavy rail line development is one where rail infrastructure is developed on land that is not currently an operational rail corridor and where more stringent noise criteria apply. According to the RING, a 'redevelopment' of a heavy rail line occurs where a rail infrastructure proposal is developed on land that is either:

- Located within an existing and operational corridor, where a rail line is or has been operational.
- Immediately next to an existing operational rail line which may result in widening of an existing corridor.

The works associated with the 'redevelopment' of an existing rail line would typically increase its capacity to carry rail traffic or alter the alignment through design changes. In such cases, the 'redevelopment of existing rail line' noise criteria apply.

The 'new' and 'redevelopment' rail noise trigger levels for residential land uses are provided in Table 3-7. The trigger levels are both in terms of the absolute L_{Aeq} and L_{Amax} rail noise contributions as well as the relative increase for the case of an existing rail line redevelopment. The increase in noise levels is assessed by considering the difference between the 'no build' (i.e. if the project did not proceed) and the 'build' options for both the year opening and design years (typically, 10 years after year opening) for the project.

Table 3-7 Airborne rail traffic noise trigger levels for residential land uses

Type of development	Noise trigger levels, dBA (external)	
	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
New rail line development	60 $L_{Aeq(15\ hour)}$ or 80 L_{AFmax}	55 $L_{Aeq(9\ hour)}$ or 80 L_{AFmax}
Redevelopment of existing rail line	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dBA or more, or existing L_{Amax} rail noise levels by 3 dBA or more and predicted noise levels exceed	
	65 $L_{Aeq(15\ hour)}$ or 85 L_{AFmax}	60 $L_{Aeq(9\ hour)}$ or 85 L_{AFmax}

Source: *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013).

In accordance with the RING, other non-residential sensitive land uses including hospitals, schools and outdoor recreational areas have their own specific noise trigger levels for heavy rail redevelopments that are applicable when the facility or space is in use. Noise trigger levels for these receivers are applicable as internal or external levels depending on the land use. For internal noise criteria, the acoustic performance of the building façade affects the transmission of noise into the premises. As construction materials and the façade acoustic performance of these buildings is unknown and may vary, a conservative 10 dBA reduction in noise between the external level and internal level has been assumed[1].

The RING criteria for non-residential land uses in the study area are shown in Table 3-8.

Table 3-8 Airborne rail traffic noise trigger levels for non-residential land uses

Sensitive land use	Noise trigger levels, dBA (when in use)	
	New rail line development	Redevelopment of existing rail line
	Resulting rail noise levels exceed	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dBA or more and resulting rail noise levels exceed
Schools, educational institutions and child care centres	40 $L_{Aeq(1h)}$ Internal	45 $L_{Aeq(1h)}$ Internal
Places of worship	40 $L_{Aeq(1h)}$ Internal	45 $L_{Aeq(1h)}$ Internal
Hospital wards	35 $L_{Aeq(1h)}$ Internal	40 $L_{Aeq(1h)}$ Internal
Hospital – other uses	60 $L_{Aeq(1h)}$ External	65 $L_{Aeq(1h)}$ External
Open space – active use	65 $L_{Aeq(15h)}$ External	65 $L_{Aeq(15h)}$ External

Source: *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013).

For this assessment, the project is considered a 'redevelopment of an existing heavy rail line' as the passing loop would be constructed on land within an existing operational rail corridor. As such, the 'redevelopment of existing rail line' criteria listed in Table 3-7 apply to this assessment for the total rail noise levels from both the existing (Sydney Trains and SSFL) lines and the project.

In the event the predicted noise levels exceed the criteria listed in Table 3-7 and Table 3-8, an investigation of potential reasonable and feasible noise mitigation measures needs to be undertaken. The mitigation measures should aim to reduce the noise down towards the relevant absolute trigger levels (refer to section 6).

3.2.2 Ground-borne noise

Ground-borne noise is defined in ISO 14837 Mechanical vibration – ground-borne noise and vibration arising from rail systems as noise generated inside a building by ground-borne vibration generated from the pass-by of a vehicle on rail. Operational ground-borne noise is assessed in accordance with the RING. The ground-borne noise trigger levels are provided in Table 3-9. For an existing railway the ground borne noise levels would need to increase by 3 dBA or more for the trigger levels to be exceeded. Ground-borne noise is assessed internally at the centre of the most affected habitable room.

Ground-borne noise level values are relevant only where they are higher than the airborne noise from railways and where the ground-borne noise levels are expected to be, or are, audible

[1] See RING - Technical notes to tables 1,2 and 3 – Technical note 6. Allows that a window may be opened to provide adequate ventilation.

within habitable rooms. For an existing heavy rail corridor airborne noise is expected to be the dominant noise source from the project and significantly higher than any ground-borne noise contributions. However, a situation can occur for surface rail where airborne noise is mitigated with at-residence treatments, which does not mitigate ground-borne noise.

Table 3-9 Ground-borne noise trigger levels

Sensitive land use	Time of day	Internal noise trigger levels, dBA
	Development increase existing rail noise by 3 dBA or more ***and*** resulting rail noise level exceeds:	
Residential	Day (7am-10pm)	40 L_{ASmax}
	Night (10pm-7am)	35 L_{ASmax}
Schools, educational institutes, places of worship	When in use	40–45 L_{ASmax}

3.3 Vibration criteria (Construction and operational)

The effects of vibration in buildings can be divided into three main categories:

- human comfort impacts
- structural impacts (effects on building contents and structural integrity)
- utility impacts (buried pipework and services).

A description of each category and the vibration criteria for the above are discussed in the following sections.

The construction equipment and activities which may generate vibration are outlined in section 4.7 and the operational acitivities which may generate vibration are outlined in section 5.5.

3.3.1 Human comfort

Construction vibration can adversely affect the amenity of occupants inside buildings as it may affect their quality of life or working efficiency. Human comfort impacts are experienced at levels well below those that can damage of affect a structure and its contents.

Acceptable vibration levels for human comfort have been set with consideration to *Assessing Vibration: a technical guideline* (DEC, 2006) which is based on the guidelines contained in British Standard *BS 6472 – 1992, Guide to Evaluation of Human Exposure to Vibration in Buildings (1 hertz (Hz) to 80 Hz)*. *BS 6472-1:2008* superseded this British Standard in 2008. Although a new version of *BS 6472* has been published, the relevant guideline, the *Assessing Vibration: A Technical Guideline* (AVTG) (DEC, 2006), still references the 1992 version of this standard and the EPA still advises vibration to be assessed in accordance with this version of the standard.

Construction and operational rail activities typically generate ground vibration of an intermittent nature, which is assessed using the vibration dose value. Acceptable values of vibration dose are presented in Table 3-10 for sensitive receivers.

Table 3-10 Human comfort intermittent vibration limits

Receiver type	Period	Intermittent vibration dose value ($m/s^{1.75}$)	
		Preferred value	Maximum value
Residential	Day (7.00 am and 10.00 pm)	0.2	0.4
	Night (10.00 pm and 7.00 am)	0.13	0.26
Offices, schools, educational institutes and places of worship	When in use	0.4	0.8
Workshops	When in use	0.8	1.6

While the assessment of response to vibration in *BS 6472:1992* is based on vibration dose value (refer to Table 3-10) and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of a peak value. This parameter is likely to be routinely measured based on the more usual concern over potential building damage.

Therefore, the peak values recommended by the British Standard, *BS 5228.2 – 2009, Code of Practice Part 2 Vibration for noise and vibration on construction and open sites – Part 2: Vibration* have been adopted for the construction human comfort vibration assessment and are reproduced below in Table 3-11. The degree of human perception associated with each peak vibration level is also provided, noting that humans are capable of detecting vibration at levels which are well below those causing risk of damage to a building.

Table 3-11 Guidance on effects of peak vibration levels for human comfort

Peak vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments will cause complaints, but can be tolerated if warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

3.3.2 Structural damage

Vibration transmission through the ground can cause a structure and structure coupled elements (walls, windows) to radiate. The transmitted vibration energy has the potential to damage and compromise the integrity of a structure as well as increase the risk of damage to building contents.

There is no current Australian Standard that sets criteria for the assessment of building damage caused by vibrations. Guidance on limiting vibration values has been obtained with reference to the following standards:

- standard structures: British Standard BS 7385-Part 2:1993 Evaluation and measurement for vibration in buildings
- heritage structures: German Standard DIN 4150-3:1999 Structural Vibration Part 3: Effects of vibration on structures.

Standard structures

Vibration criteria provided in *BS 7385-Part 2* to determine the effects of transient vibration on standard structures is provided in Table 3-12. The damage classification relating to 'cosmetic', 'minor' and 'major' categories are described in *BS 7385-Part 1* and are presented in Table 3-13.

Table 3-12 Transient vibration guide values

Line	Type of structure	Damage level	Peak component particle velocity in frequency range of predominant pulse – transient vibration (mm/s)		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures[1]	Cosmetic	50		
		Minor	100		
		Major	200		
2	Unreinforced or light framed structures[2]	Cosmetic	15 - 20	20 - 50	50
		Minor	30 - 40	40 -100	100
		Major	60 - 80	80 - 200	200

Note 1: Typical for industrial and heavy commercial buildings
Note 2: Typical for residential or light commercial type buildings.

Table 3-13 Damage classification

Damage classification	Description
Cosmetic	The formation of hairline cracks on drywall surfaces or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in the mortar joints of brick/concrete block construction.
Minor	The formation of cracks or loosening and falling of plaster or drywall surfaces, or cracks through bricks/concrete blocks.
Major	Damage to structural elements of the building, cracks in support columns, loosening of joints, splaying of masonry cracks.

The guide values in Table 3-12 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings. Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at lower frequencies, then the guide values may need to be reduced by up to 50 per cent.

The predominant vibration for most construction activities involving intermittent vibration sources such as piling rigs and excavators occur at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). However, a conservative vibration damage screening level is based on continuous vibration and provided below:

- reinforced or framed structures: 25.0 mm/s
- unreinforced or light framed structures: 7.5 mm/s

The conservative vibration screening level provided above is based on a 'cosmetic' damage level at frequencies between 4 Hz to 15 Hz.

Heritage structures

Vibration criteria provided in *DIN 4150-3* to determine the effects of short-term vibration on heritage structures is provided in Table 3-14 (Line 3).

It should be noted that heritage structures should be considered on a case by case basis, as a heritage listed structure may not necessarily be more sensitive to vibration than a standard structure. Where a historic heritage structure is deemed to be sensitive to damage (following inspection), the more conservative criteria from DIN 4150-3 should be considered (Line 3 from Table 3-14).

Table 3-14 Guideline values for short-term vibration on structures

Line	Type of Structure	Guideline Values for Velocity, $v_i(t)^1$ [mm/s]		
		1 Hz to 10 Hz	10 Hz to 50 Hz	50Hz to 100Hz[2]
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20 to 40	40 to 50
2	Residential dwellings and buildings of similar design and/or occupancy.	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (such as heritage listed buildings under preservation order).	3	3 to 8	8 to 10

Source: German Standard DIN 4150-3: 1999-02 Structural Vibration – Part 3: Effects of vibration on structures
Notes:

1. The term v_i refers to vibration levels in any of the x, y or z axes
2. At frequencies above 100 Hz the values given in this column may be used as minimum values

3.3.3 Guidelines for buried pipework and services

The British Standard *BS 7385-2:1993 Evaluation and measurement for vibration in buildings* notes that structures below ground are known to sustain higher levels of vibration and are very resistant to damage unless in very poor condition.

Guideline values for vibration to evaluate the effects of vibration on buried pipework is provided in *DIN 4150-3*. These values are reproduced in Table 3-15.

Table 3-15 Guideline values for vibration effects on buried pipework

Line	Pipe material	Guideline values for vibration velocity measured on the pipe
1	Steel (including welded pipes)	100 mm/s
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80 mm/s
3	Masonry, plastic	50 mm/s

Note that in general, compliance with the guideline values for structural damage would result in compliance with the guideline values for buried pipework.

3.4 Blasting

No blasting is anticipated during construction of the project and therefore is not discussed further in this assessment.

4. Impact assessment – Construction

4.1 Assessment methodology

The following methodology was utilised to assess the potential noise and vibration impacts associated with the construction of the project to address the SEARs:

- Identifying key NVSRs in the study area.
- Establishing noise and vibration assessment criteria at sensitive receiver locations.
- Establishing key construction scenarios (and operating equipment for each scenario) based on a review of the construction methods described in the EIS.
- Undertaking noise and vibration modelling based on the established construction scenarios.
- Assessing the potential noise and vibration impacts during construction of the project.
- Assessing potential traffic noise impacts during construction of the project.
- Providing recommendations for reasonable and feasible noise and vibration mitigation measures.

4.2 Construction overview

Construction works associated with the project would include activities typically utilised for rail and road construction. Construction works would broadly involve the following key steps:

- enabling works
- main construction works
- testing and commissioning works.

RailCorp owns all land within the existing rail corridor. ARTC manage the freight lines within the corridor which will be impacted by the project. Where Sydney Trains and ARTC freight lines are affected by the project, the works will be conducted in possessions. The majority of construction works will be limited to within the rail corridor.

Additional land requirements (i.e. outside the corridor) include the Broomfield Street road corridor and other areas which relate mainly to the need for construction compounds and four work sites (particularly associated with bridge works).

Construction of the project is anticipated to start in early 2021 and would be completed over a period of about two years.

The methodology and information presented below is indicative and would continue to be modified and refined as the design process continues. The construction contractor, when appointed, would develop a final construction methodology and program.

4.2.1 Staging

Construction inside the project site would generally be carried out in six key stages. A summary of the potential staging is provided in Table 4-1.

It should be noted that the staging may not be sequential but may be undertaken in a different order or with some stages occurring simultaneously. The final staging will be determined by the construction contractor. Establishment and demobilisation of compounds would take place during standard construction hours only.

Table 4-1 Indicative construction staging

Stage	Activity	Duration	Hours of work				
			Standard hours	OOHW	Possession works		
					Day	Evening	Night
Enabling works	Enabling works and relocation of utilities	26 weeks	✓	✓			
Stage 1 – Sussex Street and south abutment of Sussex Street Bridge	Road works Use of compounds C1, C2 and C3 and worksite 1.	65 weeks	✓	✓			
Stage 2 – Broomfield Street and north abutment of Sussex Street Bridge	Road works Retaining walls Noise wall Sussex Street bridge Tie in works Use of compounds C1, C2 and C3 and worksite 1 and 4	65 weeks	✓	✓	✓	✓	✓
Stage 3 – Cabramatta Creek Bridge	Cabramatta Creek bridge Tie in works Use of compounds C1, C2 and C3 and worksite 1. Worksites 2 and 3.	104 weeks	✓	✓	✓	✓	✓
Stage 4 – Jacquie Osmond Reserve and Peter Warren Automotive	Retaining walls Use of compounds C1, C2 and C3 and worksite 1.	78 weeks	✓	✓			
Stage 5 Track works	Track works Signalling Testing and commissioning Use of compounds C1, C2 and C3 and worksite 1.	52 weeks	✓	✓	✓	✓	✓
Stage 6 – Finishing and rehabilitation	Finishing and rehabilitation Use of compounds C1, C2 and C3 and worksite 1.	13 weeks	✓	✓	✓	✓	✓

Additional construction works for the installation of new signalling would be required outside the project site which may be located in proximity to Villawood Station, Liverpool Station and Casula Station. Timing for the signalling works are anticipated to be:

- Installation works: completed in one week
- Commissioning: undertaken during a possession
- Cabling works: up to one month using hand tools.

The construction impacts at these locations are outside the main project study area and have been assessed separately in section 4.3.3.

4.2.2 Timing

The scale and complexity of works required means that works would need to be carried out during and outside recommended standard working hours.

The majority of works would be carried out during recommended standard hours as defined by the ICNG, which are:

- Monday to Friday: 7.00 am to 6.00 pm
- Saturday: 8.00 am to 1.00 pm
- Sundays and public holidays: no work.

A number of works would need to be carried out outside the above mentioned hours. These works would be required due to the physical location of the works within the operational rail and road corridors, which could create a significant safety hazard and to minimise impacts to transport, environment and adjacent properties.

The out of hours works would include the following:

- delivery of certain materials and plant to the fixed facilities, required to be conducted outside of standard hours by authorities for safety reasons, environmental impact reasons or potential impacts to properties
- works required to occur within the operational rail envelope and therefore to manage potential safety or operational considerations, need to be undertaken during track possessions. This might include formation work and track configurations
- relocation of services such as overhead electricity
- some bridge works such as lifting of girders to minimise potential impacts on the surrounding community
- some road works to be carried out at night (generally between 10.00 pm and 4.00 am) to minimise traffic disruptions and to maintain pedestrian and cyclist safety (i.e. traffic realignment, asphalting, linemarking).

The above list of works is not exhaustive and other works would potentially be required outside the recommended standard hours. The construction contractor would determine any additional works required outside standard hours. All OOHW would be carried out in accordance with an OOHW framework developed for the project.

4.2.3 Compounds

Construction compounds are areas used as the base for construction activities, usually for the storage of plant, equipment and materials, and/or construction site offices and worker facilities. The compounds would also contain some of the following:

- site office
- toilets, showers and change rooms
- meal rooms and first aid facilities
- areas for plant, equipment and material storage
- fencing and security facilities
- staff parking.

The main construction compounds are listed in Table 4-2.

Table 4-2 Proposed construction compounds

ID	Location	Existing land use	Proposed use	Duration of use	Principle plant and equipment use
C1	Within rail corridor	Temporary storage	Areas for plant, equipment and material storage	Long term, Full length of construction works	Delivery vehicles
C2	Warwick Farm Recreational Reserve	Public recreation	Areas for plant, equipment and material storage Fencing	Long term, Full length of construction works	Delivery vehicles
C3	Jacquie Osmond Reserve	Public recreation	Site offices and staff facilities Areas for plant, equipment and material storage Fencing and security facilities Worker parking for between 60 to 80 cars.	Long term, Full length of construction works	Delivery vehicles Semi-trailers Light vehicles Grinder / mulcher 20 tonne (T) excavator including rock-breaker Vibratory roller Water cart Compactor Light vehicles Crane

Ancillary work site areas would be established in addition to the main construction compounds, to support short-term works. The ancillary work sites would be used to provide support for construction activities that are not near the main construction compounds. The proposed locations of ancillary work sites and their proposed use are listed in Table 4-3.

Table 4-3 Work site locations

ID	Location	Existing use	Proposed use	Duration of use	Principle plant and equipment use
W1	Access to compound site C3	Unnamed road/ shared path	Truck turning circle	Long term - Full length of construction works	Construction vehicles including light vehicles and heavy vehicles under 3.5 m in height.
W2	Southern side of Cabramatta Creek bridge	Shared path	Crane pads	Short term	Crane Piling rigs
W3	Northern side of Cabramatta Creek bridge	Shared path	Crane pads	Short term	Crane Piling rigs
W4	Sussex Street bridge	Shared path	Crane pads	Short term	Crane Piling rigs

4.3 Construction noise impacts

4.3.1 Noise modelling scenarios

The proposed construction staging described in section 4.2.1 was used to construct the noise modelling scenarios in Table 4-4.

These scenarios have been modelled to estimate the construction noise impacts during each stage of construction. Construction work hours for each modelled scenario has been identified based on the times identified in Table 4-1 for the construction stages.

The activity sound power level for each modelled scenario is provided in Table 4-5 and is based on the following assumptions:

- Construction scenarios have been modelled based on the plant and equipment proposed at the time of undertaking this assessment.
- Construction scenarios assume that the noise wall along Broomfield Street will be completely demolished in the immediate work area. However, in reality, the existing noise wall will be progressively removed and the new noise wall constructed (in sections) as works progress along Broomfield Street. Partial shielding from construction of a new noise wall (during demolition of the existing noise wall) has not been taken into consideration and therefore the predicted modelling results are conservative.

  The new noise wall cannot be fully constructed prior to the demolition of the existing noise wall due to constructability constraints relating to the existing retaining walls in the area and insufficient space. This is further discussed in the EIS.
- All equipment would operate simultaneously at maximum power for 10 minutes out of the 15 minute worst case period. During construction, it is unlikely that all equipment would be operating at any one time. Limiting the period that the equipment is operational applies a degree of realism to the predicted results.

The actual plant and equipment used at each work area would be further refined during the detailed design stage.

Table 4-4 Construction scenarios

Scenario	Scenario description	Activities	Construction work hours					Highly intensive works
			Standard hours	OOHW	Possession works			
					Day	Evening	Night	
CS01	Compound establishment and operations	Install site environment and traffic control devices. Establish site compounds and construction work areas. Install site fencing and hoarding. Compound operations.	✓	✓	-	-	-	-
CS02	Vegetation removal and utility relocation	Vegetation clearance and tree removal. Relocation of sub-surface utilities. Power pole relocation works.	✓	✓	-	-	-	-
CS03	Road earthworks (Stage 1/2)	Earthworks along Broomfield Street and Sussex Street. Embankment, foundation and fill to road formation level.	✓	✓	✓	✓	✓	✓
CS04	Road pavement works (Stage 1/2)	Kerb and gutter installation. Pavement construction and asphalt overlay. Tie-in works to existing roads.	✓	✓	✓	✓	✓	✓
CS05	Road furniture installation (Stage 1/2)	Line-marking and signage installation. Installation of street lights.	✓	✓	✓	✓	✓	-
CS06	Noise wall construction (Stage 2)	Removal of existing noise wall panels. Dismantle existing retaining wall. Construction of new retaining walls. Installation of noise wall structural posts. Insert noise wall panels.	✓	✓	✓	✓	✓	✓
CS07	Bridge construction pre-work (Stage 3)	Construct access ramps for piling rigs and cranes. Construct crane pads and prepare piling location sites.	✓	✓	✓	✓	✓	✓
CS08	Bridge construction works (Stage 3)	Construct pile cap and erect precast pies. Girder installation.	✓	-	✓	✓	✓	✓

Scenario	Scenario description	Activities	Construction work hours					Highly intensive works
			Standard hours	OOHW	Possession works			
					Day	Evening	Night	
CS09	Bridge rail installation (Stage 3)	Ballast, sleeper and rail installation. Finishing works and shared pathway reinstatement.	✓	-	✓	✓	✓	-
CS10	Retaining wall installation (Stage 4)	Excavation for new retaining wall. Concrete pour for footing. Installation of structural wall.	✓	✓	-	-	-	✓
CS11	Track construction (Stage 1-3 and Stage 5)	Realighning existing track (slewing) (Stage 1- 3 or first available possession period) Excavate beside the existing SSFL. Earthworks. Install track drainage.	✓	✓	✓	✓	✓	✓
CS12	Track installation (Stage 5)	Ballast, sleeper and rail installation. Signalling equipment (inside the project area) and infrastructure installation.	✓	-	✓	✓	✓	✓
CS13	Finishing and rehabilitation (Stage 6)	Demobilise construction compounds and work areas. Removal of temporary fencing. Revegetation and area restoration.	✓	-	-	-	-	-

Table 4-5 Construction scenario activity sound power levels, dBA

Construction plant	Sound power level	Construction scenario[1]												
		CS01	CS02	CS03	CS04	CS05	CS06	CS07	CS08	CS09	CS10	CS11	CS12	CS13
Activity sound power level		109	115	121	117	105	121	113	115	106	121	112	119	106
Asphalting machine	106				✓									
Backhoe	111			✓								✓		
Ballast train	115												✓	
Cherry picker	98	✓				✓				✓			✓	✓
Compactor	106		✓	✓										
Concrete pump	102					✓	✓	✓	✓		✓	✓		
Concrete truck	109				✓			✓	✓			✓		
Concrete vibrator	113				✓				✓					
Crane	108	✓	✓	✓						✓				
Crane (franna)	98					✓	✓				✓	✓	✓	✓
Excavator (20 tonne)	105	✓		✓				✓	✓			✓		✓
Excavator (20 tonne) with rock breaker	122			✓			✓				✓			
Front end loader	112								✓					
Grader	113			✓			✓				✓			

Construction plant	Sound power level	Construction scenario[1]												
		CS01	CS02	CS03	CS04	CS05	CS06	CS07	CS08	CS09	CS10	CS11	CS12	CS13
Grinder	105						✓				✓			
Grinder/mulcher	116		✓											
Jack hammer	113						✓		✓		✓			
Light vehicle	103	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Milling machine	117				✓									
Piling rig	112							✓						
Rail regulator	114												✓	
Rail tamper (vibration)	115												✓	
Rail train	115												✓	
Truck	108	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓
Vibratory roller	109		✓	✓								✓		
Water cart	107	✓	✓	✓	✓		✓				✓			

4.3.2 Construction noise prediction method

Noise modelling was carried out using SoundPLAN Version 7.4. SoundPLAN is a computer program for the calculation, assessment and prognosis of noise propagation. Environmental sound propagation was calculated using ISO 9613-2, *Acoustics – Attenuation of sound during propagation outdoors*. The ISO 9613-2 algorithm also takes into account the presence of a well developed, moderate ground based temperature inversion, such as commonly occurs on clear, calm nights or 'downwind' conditions which are favourable to sound propagation.

Ground absorption, reflection, terrain and relevant shielding objects have been taken into account in the calculations.

4.3.2.1 Model configuration

The noise model inputs and assumptions for the construction assessment are provided in Table 4-6.

Table 4-6 Construction noise modelling assumptions

Modelling component	Assumption
Prediction algorithm	*ISO 9613 – 2 Acoustics – Attenuation of sound during propagation outdoors.*
Modelling period	Typical worst case 15 minute period of operation where all the equipment are running at full power for 10 minutes.
Meteorology	ISO 9613 considers the presence of a well developed moderate ground based temperature inversion, such as commonly occurs on clear, calm nights or 'downwind' conditions which are favourable to sound propagation.
Ground absorption coefficient	G = 0.5
Atmospheric absorption	Based on an average temperature of 10°C and an average humidity of 70%.
Receiver heights	1.5 m above building ground level (ground floor).
Operating intensity	Construction scenario sound power levels have been adopted.

4.3.3 Construction noise impacts inside study area

Predicted noise levels for all construction scenarios, outlined in Table 4-4, are presented in Appendix D. Construction noise contours for each modelled scenario are presented in Appendix E. A summary of the construction noise assessment and findings are discussed below.

The following steps have been applied to assess construction noise impacts during and outside standard construction hours:

1. Determine the construction scenarios where the most impacts are expected based on the total number of exceedances (i.e. the predicted noise levels are greater than the construction NMLs).

2. Determine the construction scenarios where the highest impacts are expected based on the maximum exceedance of the NMLs.

Exceedances of the construction NMLs are typical for construction projects of this scale. The predicted noise impacts would be limited to the construction period only and would not have lasting effects on the community.

Impacts during standard hours

The number of receivers inside the construction study area that are predicted to experience noise levels above the construction NMLs are shown in Figure 4-1.

The maximum exceedance of the NML during standard hours are listed in Table 4-7. For each NCA, the range of noise level exceedances for the scenarios with the highest exceedances are shown on Figure 4-2.

Construction noise levels at 102 residential receivers are predicted to exceed the highly noise affected level of 75 dBA. The locations of these receivers are shown in Figure 4-3.

Table 4-7 Highest exceedances, standard hours

NCA	Scenario with highest exceedance	Highest exceedance, dBA
NCA01	CS06	30
NCA02	CS04	52
NCA03	CS02	32
NCA04	CS01	47

Noise levels at some receivers would be considered ‘highly intrusive’ based on the perception categories provided in the TfNSW CNVS. The additional mitigation measures discussed in section 6 should be implemented where feasible and reasonable.

NCA01

Receivers located in NCA01 are expected to be impacted the most, based on the total number of exceedances of the NML. This can be attributed to the high density of receivers located near the construction works. The number of total exceedances of the NML would be highest during the road earthworks (CS03), noise wall construction (CS06) and track installation (CS12) stages of construction.

The highest exceedances of the NML would occur during the noise wall construction (CS06) stage. This exceedance would be due to operation of the excavator with a concrete rock breaker attachment. The majority of NML exceedances during this stage of construction would be between 1.0 and 5.0 dBA and between 6.0 and 10 dBA which represents a minor impact. Receivers located closer to the works would experience moderate to high impacts above 10 dBA.

NCA02

The number of total exceedances of the NML would be highest during the road earthworks (CS03), noise wall construction (CS06) and track installation (CS12) stages of construction. The highest exceedances of the NML would occur due to the use of a milling machine during road pavement works (CS04).

The number of receivers that would exceed the NML between 1.0 and 10 dBA and more than 11 dBA are roughly equal. Construction impacts during road pavement works would be considered moderate as there is a high proportion of receivers that exceed the NML by a significant amount.

NCA03

The number of total exceedances of the NML would be highest during the retaining wall installation (CS10) and track installation (CS12) stages of construction. The highest exceedances of the NML would occur due to the use of a grinder and mulcher during vegetation removal and utility relocation works (CS02).

The majority of receivers that would exceed the NML are between 1.0 and 10 dBA so construction noise impacts during CS02 are considered minor.

NCA04

The number of total exceedances of the NML would be highest during the site establishment (CS01) and track installation (CS12) stages of construction. The highest exceedances of the NML would occur due to the use of a crane and truck site establishment and compound operations (CS01).

The majority of receivers that would exceed the NML are between 1.0 and 10 dBA. Construction noise impacts during site establishment and compound operations are considered minor.

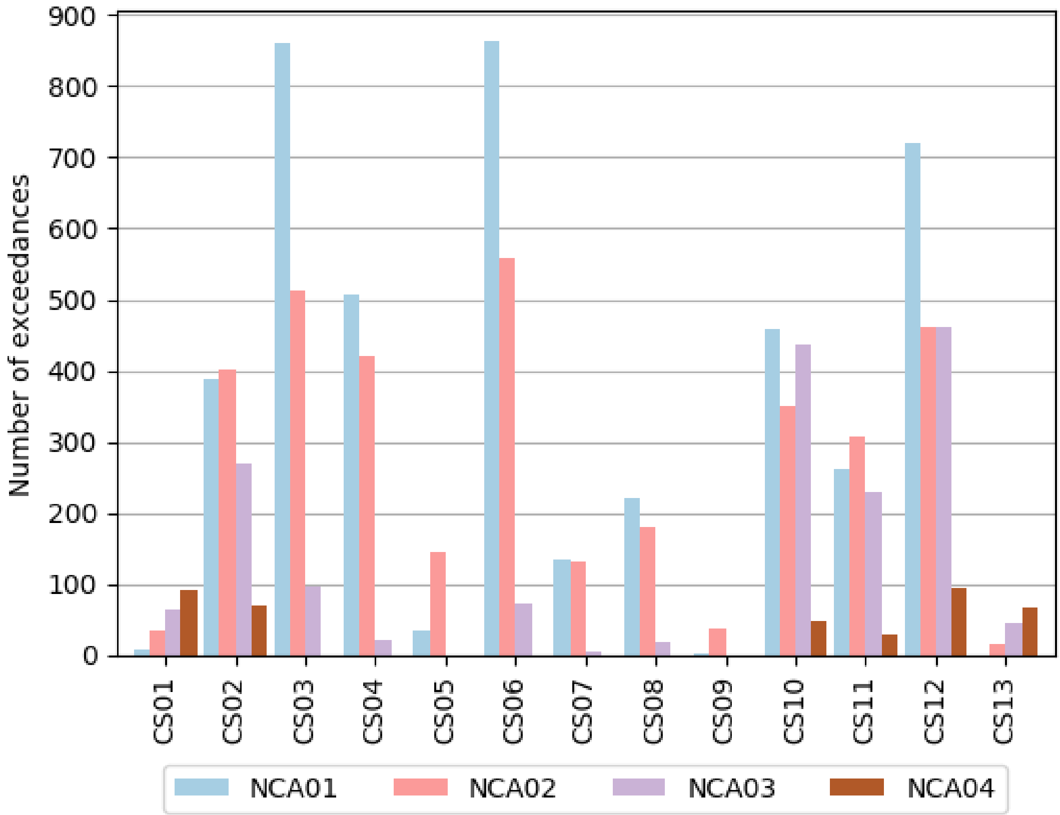

Figure 4-1 Number of exceedances, standard hours

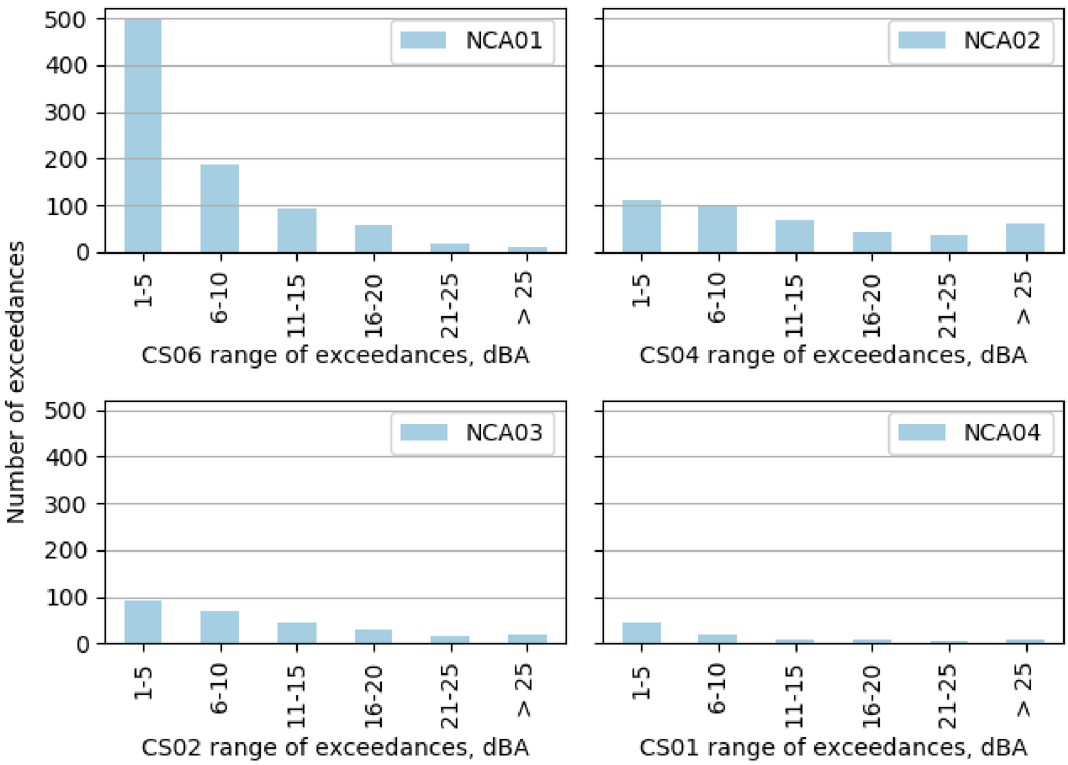

Figure 4-2 Range of noise level exceedances, standard hours

Paper Size ISO A4

0 70 140 210 280

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: AGD 1966 ISG 56 1

N

GHD

Australia Rail Track Corp Ltd
Cabramatta Rail Loop
Noise and Vibration Impact Assessment

Project No.	22-19800
Revision No.	0
Date	17/04/2019

Highly Noise affected receivers (standard hours)

Figure 4-3

G:\22\19800\GIS\Maps\2219800_CabramattaLoop\Noise_Report_0.aprx\2219800_NVIA005_HighNoiseAffected_0
Print date: 17 Apr 2019 - 16:58

Data source: LPI: DTDB\DCDB, 2017. DPE: Land zoning, 2016.LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017. Created by: tmorton

Impacts outside standard hours

The number of receivers that are predicted to experience noise levels above the NMLs for works outside standard construction hours are shown on Figure 4-4 to Figure 4-6 for the day, evening and night assessment periods.

The highest exceedances of the OOHW NMLs and the construction scenario where these levels are predicted are shown on Table 4-8. For each NCA, the range of noise level exceedances for the scenarios with the highest exceedances are shown on Figure 4-7 to Figure 4-9.

Table 4-8 Highest exceedances, OOHW

NCA	Scenario with highest exceedance	Highest exceedance, dBA		
		OOHW Day	OOHW Evening	OOHW Night
NCA01	CS06	35	36	42
NCA02	CS04	57	57	65
NCA03	CS02	37	37	42
NCA04	CS01	52	52	57

NCA01

Receivers located inside NCA01 are predicted to have low to moderate impacts for any works carried out outside standard hours. The highest exceedances of the NML would occur during the noise wall construction (CS06) stage. The majority of NML exceedances would be between 1.0 and 15 dBA during the day and evening periods and 11 to 20 dBA during the nighttime period.

NCA02

Receivers located inside NCA02 are predicted to have low to moderate impacts for any works carried out outside standard hours. The highest exceedances of the NML would occur during vegetation removal and utility relocation works (CS04). The majority of NML exceedances would be between 1.0 and 15 dBA during the day, evening periods and nighttime periods. A significant proportion of receivers located next to the proposed works would experience high impact as the predicted exceedance of the NML is above 20 dBA.

NCA03

Receivers located inside NCA02 are predicted to have low impacts for any works carried out outside standard hours. The highest exceedances of the NML would occur during the road pavement works (CS04). The majority of NML exceedances would be between 1.0 and 10 dBA during the day, evening periods and nighttime periods.

NCA04

Receivers located inside NCA02 are predicted to have low impacts for any works carried out outside standard hours. The highest exceedances of the NML would occur during site establishment and compound operations (CS01). The majority of NML exceedances would be between 1.0 and 10 dBA during the day, evening periods and nighttime periods.

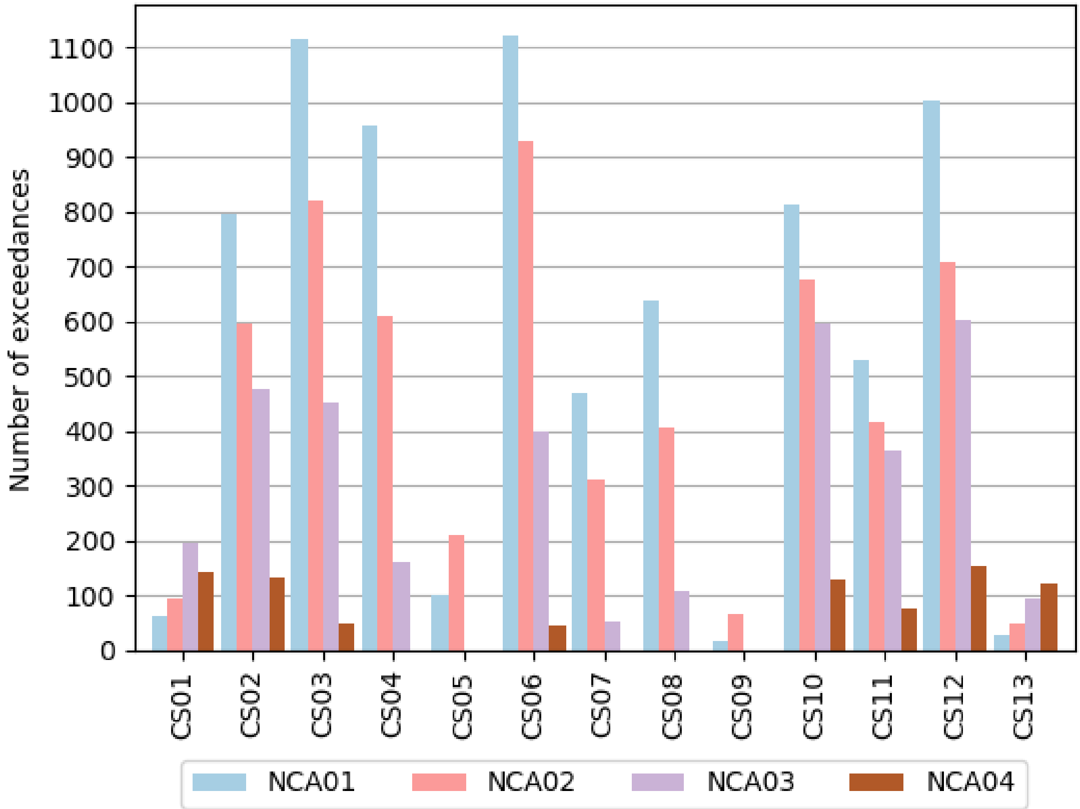

Figure 4-4 Number of exceedances, OOHW (day)

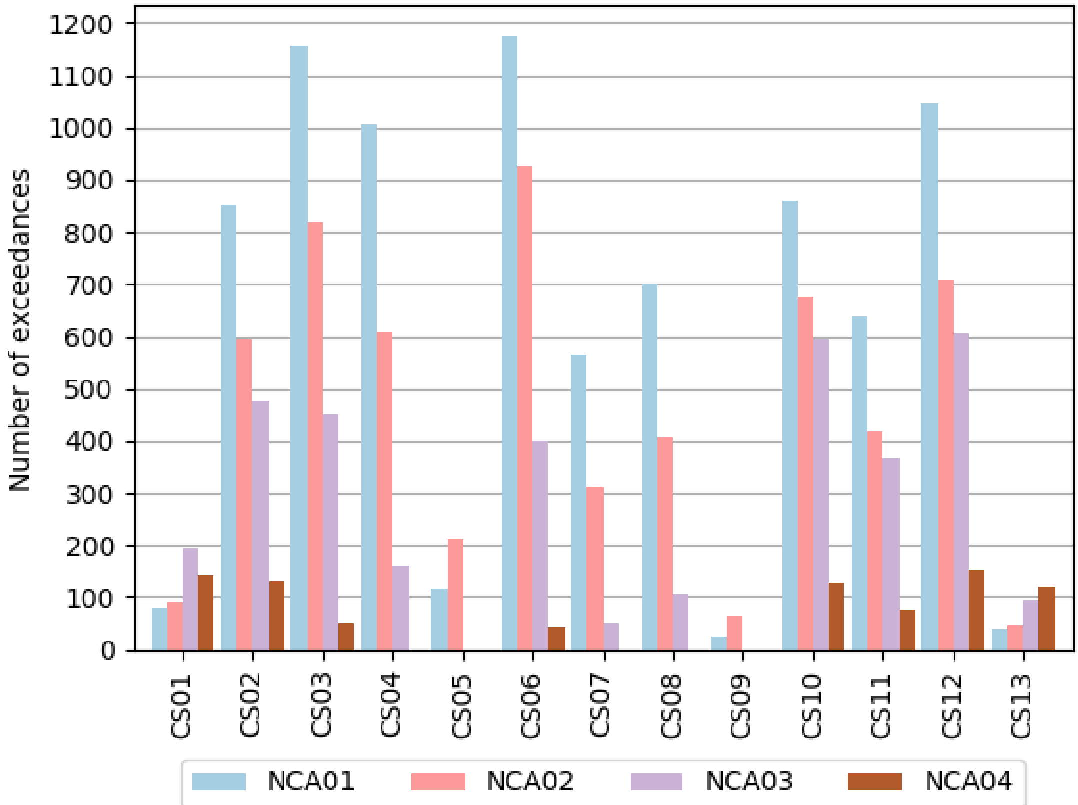

Figure 4-5 Number of exceedances, OOHW (evening)

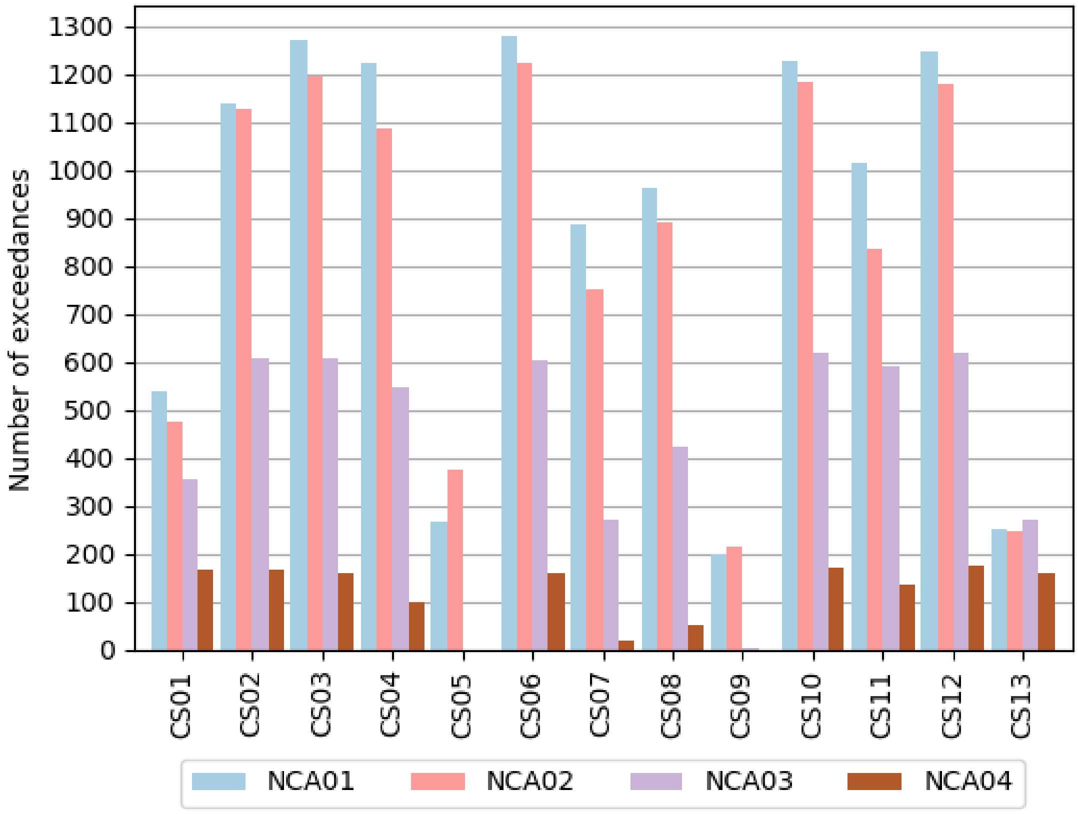

Figure 4-6 Number of exceedances, OOHW (night)

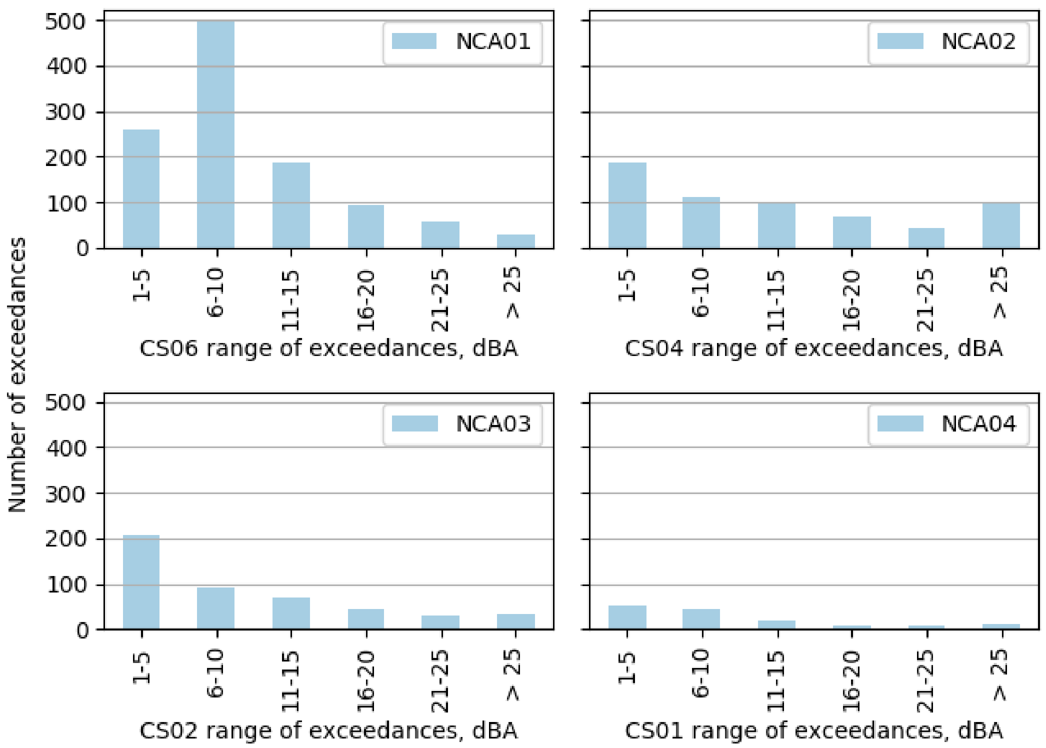

Figure 4-7 Range of noise level exceedances, OOHW (day)

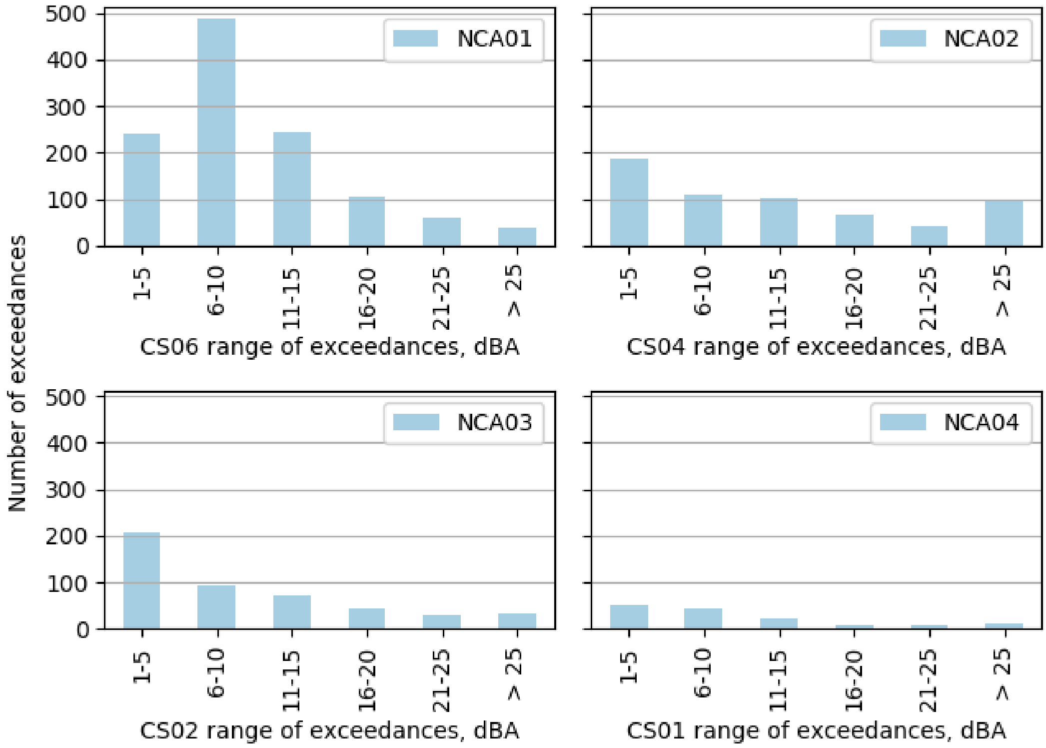

Figure 4-8 Range of noise level exceedances, OOHW (evening)

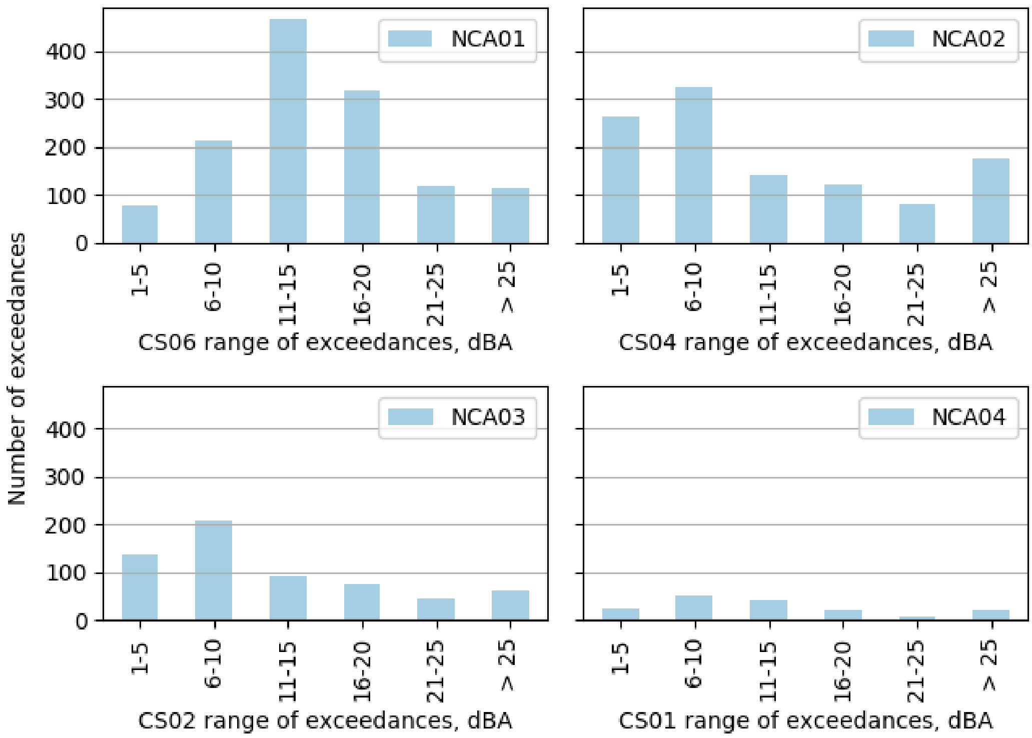

Figure 4-9 Range of noise level exceedances, OOHW (night)

Discussion on construction noise impacts

Construction noise impacts are expected during and outside standard hours. The level of impact is based on the level of exceedance above the NML which depends on the following factors:

- type of construction plant and equipment being operated
- location of the construction machinery relative to the sensitive receiver
- existing background noise levels
- attenuation effects from intervening terrain and structures
- time of day for construction works.

Without the use of supplementary construction noise and vibration controls, the latter three factors are generally fixed. Therefore, the type of operational construction equipment and the distance between the construction works and receiver controls the level of exceedance.

In general, construction activities would move along the construction alignment. Impacted receivers would only experience the predicted worst case noise levels when construction works are located closest to the receiver. At other times, the receivers would experience levels below the worst case noise levels predicted as construction activities would progressively move away from the receiver as works are completed.

The highest construction noise impacts are expected during road earthworks, noise wall construction and track installation. This would be consistent for works during and outside standard construction hours. The mitigation measures identified in section 6.1 should be implemented where considered feasible and reasonable.

Receivers located along the roads identified in Table 4-9 would be expected to experience the worst-case noise impacts as they are located directly adjacent the construction works. Beyond the first row of receivers located adjacent the construction works, the level of exceedance would decrease due to noise levels decreasing with distance and shielding from surrounding structures.

Table 4-9 Most impacted roads from construction vibration

Road	NCA	Affected receiver types
Railway Parade	NCA01	Residential, commercial, industrial
Broomfield Street	NCA02	Residential
Station Street	NCA03	Residential
Lawrence Hargrave Road	NCA03	Residential
Todman Road	NCA04	Commercial, industrial
Sappho Road	NCA04	Commercial, industrial

4.3.4 Construction noise impacts for signalling work

In addition, minor works in the form of new signalling would be installed at a number of locations within the rail corridor. Timing for the signalling works are anticipated to be:

- Installation works: completed in one week
- Comissioning: undertaken during a possession
- Cabling works: up to one month using hand tools.

This work would involve the use of the following equipment:

- Light and heavy vehicles
- Excavators
- Hand tools, including portable generators.

A simple assessment, as defined in the CNVS (TfNSW, 2018), has been undertaken to assess construction noise and vibration impacts for the proposed signalling works :

- Construction works will be completed within 6 weeks. Some works will be undertaken during possession periods.
- Vibration intensive equipment are used outside the minimum working distances for cosmetic damage to buildings or human disturbance.
- Construction traffic impacts are not anticipated.

The nearest residential receivers are located around 30 to 50 m from the proposed signalling works. The exceedance of the NML for various distances is provided in Table 4-10.

Table 4-10 Exceedance of NML, dBA

Period	Distance from work area, m							
	30	40	50	60	70	80	90	100
Standard hours	5	3	1	-	-	-	-	-
OOHW Period 1 (Day)	15	13	11	9	8	7	6	5
OOHW Period 1 (Evening)	15	13	11	9	8	7	6	5
OOHW Period 2 (Night)	20	18	16	14	13	12	11	10

The impact distances based on the exceedances of the NML are:

- Standard hours: 50 metres
- OOHW Period 1 (Day/Evening): 100 metres
- OOHW Period 2 (Night): 170 metres.

The mitigation measures identified in section 6.1 should be implemented where considered feasible and reasonable.

4.4 Construction compound operation

The proposed compound operations have been assessed as part of construction scenario CS01. Three construction compound locations and four work site areas are proposed to provide support for construction activities. The typical activities and locations of the compounds are described in section 4.2.3. The expected impacts due to compound operations is discussed in the following section.

4.4.1 Rail compound (C1) operations

This rail compound (C1) is located within the rail corridor and it is anticipated that it would be operational for across the majority of the construction period. The C1 compound is located south of Warwick Farm Station and is located inside NCA04. This compound would be accessed from Hume Highway and Warwick Street through the Warwick Farm Railway Station at-grade car park. This compound would be primarily used as a storage area for plant, equipment and stockpiling.

Operations at the C1 compound have the potential to impact receivers located inside NCA03 and NCA04. The maximum exceedance of the NML for each time period is provided in Table 4-11. The most affected receivers are as follows:

- NCA03: The nearest residential receivers are located along Hart Street and are around 120 metres from the C1 compound. These receivers have line of sight to the C1 compound. Operations towards the north of the compound have the potential to be slightly shielded from the Warwick Farm Multi-Storey Car Park.
- NCA04: The nearest residential receivers are located directly adjacent the C1 compound These receivers are separated from the railway corridor by a fence which provides a degree of shielding from compound operations.

Table 4-11 C1 Compound operations – maximum exceedances

NCA	Standard hours	OOHW Period 1		OOHW Period 2
		Day	Evening	Night
NCA03	13	18	18	23
NCA04	47	52	52	57

4.4.2 Warwick Farm (C2) and Jacquie Osmond Reserve (C3) operations

The Warwick Farm Recreational Reserve (C2) compound and the Jacquie Osmond Reserve (C3) compound are located on opposing sides of the rail corridor in the same broader area. Therefore, impacts from these compounds have been assessed together.

The C3 compound will be the main compound for the construction of the project and would likely be utilised for the majority of the works.

As the C2 and C3 compounds are located in an existing reserve, they are not entirely contained within any NCA identified. The C2 compound is located north of NCA03 and the C3 compound is located in NCA02 and NCA04.

Access to each compound would be along the following routes:

- C2 compound: Hume Highway, Mannix Parade, Lawrence Hargrave Road, Nicholls Street and Station Street
- C3 compound: Hume Highway and Sappho Road.

A description for the types of activities at each compound is as follows:

- C2 compound: this is an ancillary compound which would be used as a storage area for plant, equipment and stockpiling.
- C3 compound: this is the main compound which would be used to support construction works. The C3 compound would contain the site office and amenity facilities. This compound would support parking for around 60 to 80 cars. Additional uses of this compound would include storage for plant, equipment and stockpiling.

Operations at the C2 and C3 compound would impact receivers located in all NCAs. A discussion on the predicted impacts on the receivers located in each NCA follows. The maximum exceedance of the NML for each time period is provided in Table 4-11 The most affected receivers are as follows:

- NCA01: The nearest residential receivers surround the reserve where the proposed compounds will be located. The roads which would be most affected include Jasmine Crescent, Lunn Court and Sussex Street. These roads are located around 220 metres to 400 metres from the proposed compounds. Dense vegetation along Cabramatta Creek breaks line of sight to the compound and would provide minor shielding effects.
- NCA02: The nearest residential receivers are located immediately north of Cabramatta Creek along Sussex Street and Liverpool Street. These roads are located around 150 metres to 270 metres from the proposed compounds. Dense vegetation along Cabramatta Creek breaks line of sight to the compound and would provide minor shielding effects.
- NCA03: The nearest residential receivers are located along Lawrence Hargrave Road and are around 100 metres from the C2 compound. These receivers have line of sight to the C2 and C3 compound.
- NCA04: The nearest receivers are commercial and industrial and are located directly adjacent the C3 compound. Impacts on residential receivers located in NCA04 are considered unlikely as these receivers are located to the south of Hume Highway which is over 700 metres south of the compound locations.

Table 4-12 C2/C3 Compound operations – maximum exceedances

NCA	Standard hours	OOHW Period 1		OOHW Period 2
		Day	Evening	Night
NCA01	2	7	8	14
NCA02	9	14	14	22
NCA03	13	18	18	23

4.5 Sleep disturbance impacts

Construction activities are expected outside standard construction hours to minimise the impacts on rail and road traffic during construction. There is the potential for maximum noise level events if the predicted maximum noise level is above the screening criteria of 52 dBA.

The screening criteria of 52 dBA is predicted to be exceeded outside the building’s façade at 1284 residential receivers. Therefore a detailed maximum noise level assessment has been undertaken. The RNP states that maximum internal noise levels between 50 to 55 dBA are unlikely to awaken people from sleep. Typically, a window will provide a 10 dBA reduction when partially open and a 20 dBA reduction when closed. For a conservative assessment, the windows have been assumed to be partially open to assess sleep disturbance impacts.

Based on this assessment, 102 sensitive receivers have the potential to experience sleep disturbance impacts. These receivers are shown in Figure 4-10.

Potential sleep disturbance impacts near Warwick Farm Station would be due to operation of the rail compound (C1). This compound would be predominately used for storage and would require material deliveries during the early morning and late evening periods. Continuous impacts throughout the night-time period are considered unlikely.

Community consultation and consideration of the additional mitigation measures in section 6.1.2 should be applied if the sleep disturbance criteria is anticipated to be exceeded for more than two consecutive nights and cannot be avoided due to reasonable and feasible justification.

Paper Size ISO A4

0 70 140 210 280

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: AGD 1966 ISG 56 1

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Noise and Vibration Impact Assessment

Project No. 22-19800
Revision No. 0
Date 11/04/2019

Sleep disturbance impacted receivers

Figure 4-10

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Print date: 11 Apr 2019 - 09:35

Data source: LPI: DTDB\DCDB, 2017. DPE: Land zoning, 2016.LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017. Created by: tmorton

4.6 Construction traffic

Construction vehicle movements would consist of light and heavy vehicles associated with staff movements, plant delivery and material delivery and removal. This has the potential to create construction traffic noise impacts.

Construction traffic impacts are assessed by determining whether the potential noise level increases would be perceptible when compared to existing traffic. The access routes are shown in Figure 4-11 and the estimated peak vehicle numbers per hour are provided in Table 4-13. Existing peak vehicle numbers per hour are provided in Table 4-14.

Table 4-13 Peak number of construction vehicles per hour

Street	Road class	Possession (24 hours)		Non-possession (day time working hours)	
		Heavy vehicle	Light vehicle	Heavy vehicle	Light vehicle
Hume Highway	Arterial	4	60	4	30
Cabramatta Road East	Sub-arterial	2	20	2	15
Junction Street	Local	2	20	2	15
Liverpool Street/ Sussex Street	Local	2	20	2	15
Broomfield Street	Collector	2	20	2	15
Mannix Parade/ Lawrence Hargrave Road/Nicholls Street/ Station Street/Railway Parade	Local	3	60	2	30
Sappho Road	Collector	2	20	2	15
Warwick Street	Local	4	60	4	30

Table 4-14 Existing traffic volumes per hour

Location	Road classification	Direction	AM Peak Hour (veh/h)*	PM Peak Hour (veh/h)*
Hume Highway – between Mannix Road and Sappho Road	Arterial road	Eastbound	2,150	1,890
		Westbound	1,650	1,885
		Total	***3,800***	***3,775***
Cabramatta Road East	Sub arterial	Northbound	390	935
		Southbound	840	800
		Total	***1,230***	***1,735***
Broomfield Street	Local road	Northbound	135	140
		Southbound	150	160
		Total	***285***	***300***
Mannix Parade	Local road	Northbound	125	120
		Southbound	165	135
		Total	***290***	***255***
Lawrence Hargrave Road	Local road	Northbound	80	80
		Southbound	65	65
		Total	***145***	***145***
Sappho Road	Local road	Northbound	205	275
		Southbound	45	200
		Total	***250***	***475***

The noise increase associated with the additional traffic on these roads has been calculated as per the following formula:

$$Increase\ (dB) = 10\log\left(\frac{Total\ traffic\ (existing\ plus\ construction)}{Existing\ traffic}\right)$$

The noise increase associated with the project roads is calculated to be as follows:

- Arterial and sub-arterial roads: <0.2 dB.
- Collector roads: 0.5 to 0.7 dB.
- Local roads: 0.5 to 1.8 dB.

Therefore, construction traffic is not expected to increase noise levels by more than 2 dBA for the roads in the study area. The objectives of the RNP are considered met and further consideration of noise impacts associated with construction traffic is not required. Traffic along local and collector roads would be managed in accordance with a traffic management plan to minimise the potential construction traffic noise impacts.

Paper Size ISO A4

0 0.065 0.13 0.195 0.26

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: AGD 1966 ISG 56 1

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Cabramatta Rail Loop
Noise and Vibration Impact Assessment

Project No.	**22-19800**
Revision No.	**0**
Date	**16/04/2019**

Construction traffic routes

Figure 4-11

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Print date: 17 Apr 2019 - 16:56

Data source: LPI: DTDB/DCDB, 2017. LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017. Created by: tmorton

4.7 Construction vibration assessment

4.7.1 Construction vibration overview

The methodology for the construction vibration assessment included the following:

- Vibration from surface construction plant and equipment was predicted and assessed with consideration to Assessing Vibration: a Technical Guideline and German Standard DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures.
- Where vibration levels were predicted to exceed the vibration criteria, appropriate construction vibration mitigation measures have been provided to minimise impacts from each construction phase.

Energy from equipment is transmitted into the ground and transformed into vibration, which then attenuates with distance. The magnitude and attenuation of ground vibration is dependent on the following:

- the efficiency of the energy transfer mechanism of the equipment (ie impulsive, reciprocating, rolling or rotating equipment)
- the frequency content
- the impact medium stiffness
- the type of wave (surface or body)
- the ground type and topography.

Construction and demolition works have the potential to impact on human comfort and/or cause structural damage to buildings. Potential vibration inducing activities identified during construction and demolition works include the following:

- piling, grinding and cutting would generate impulsive vibration emissions
- bulk earthworks, construction traffic movements and demolition works would be a source of intermittent or continuous vibration.

4.7.2 Predicted vibration levels

Table 4-15 outlines typical vibration levels for different plant activities sourced from the Roads and Maritime *Environmental Noise Management Manual* (ENMM) (RTA, 2001), British Standard *BS 5228.1* and the CNVS (TfNSW, 2018).

Table 4-15 Typical vibration levels for construction equipment

Item	Peak Particle Velocity (PPV) at 10 m (mm/s)
Roller	5–6
15 tonne roller	7–8
7 tonne compactor	5–7
Dozer	2.5–4
Backhoe	1
Pavement breaker	4.5–6
Excavators, Scrapers, Graders etc.	2.5[1]
Piling (impact)	30
Piling (vibratory)[2]	16.8
Piling (bored)[2]	7.4

Note 1: Based on levels derived at 8 m from: Tyan, A. E. *Ground Vibrations. Damaging Effects to Buildings*. Road Research Board 1973

Note 2: Based on levels derived from BS5228-2. *Bored piling through stones or other obstruction*. Vibratory piling based on relationship provided in Table E.1

As stated in the ENMM, it can be assumed that the vibration level of a source is inversely proportional to the distance between the source and receiver. The following equation has been used to predict the construction vibration levels at various distances.

$$PPV_{receiver} = PPV_{reference} \times \left(\frac{d_{reference}}{d}\right)^{0.8}$$

The values used for each parameter are provided in Table 4-16.

Table 4-16 Equation parameters

Parameter	Description	Value
$PPV_{receiver}$	PPV at the receiver	See Table 4-18
$PPV_{reference}$	Measured reference PPV	See Table 4-15
$d_{reference}$	Distance for reference PPV measurement	10 m
d	Predicted safe working distance	Predicted value

Based on the typical vibration levels in Table 4-15, the potential vibration levels due to the construction works at various distances are shown in Table 4-17.

Table 4-17 Predicted construction vibration levels

Vibration source	Distance to Source/Peak Particle Velocity (mm/s)			
	10 m	20 m	50 m	100 m
Roller	6.0	3.4	1.7	1.0
15 tonne vibratory roller	8.0	4.6	2.2	1.3
7 tonne compactor	6.0	3.4	1.7	1.0
Dozer	4.0	2.3	1.1	0.6
Backhoe	1.0	0.6	0.3	0.2
Pavement breaker	6.0	3.4	1.7	1.0
Excavator	2.1	1.2	0.6	0.3
Piling (impact)	30	17.2	8.3	4.8
Piling (vibratory)[1]	16.8	7.3	2.4	1.1
Piling (bored)[1]	7.4	4.3	2.1	1.2

Note 1: Based on levels derived from BS5228-2. *Bored piling through stones or other obstruction*. Vibratory piling based on relationship provided in Table E.1

4.7.3 Buffer distances

Predicted safe working buffer distances were calculated for typical equipment vibration values to determine indicative distances where the structural damage (standard dwelling and heritage structure) and human comfort criteria may be exceeded. These are listed in Table 4-18. The safe working buffer distances are dependent on the equipment that the construction contractor selects and would be refined prior to construction.

Vibration may be amplified in multi-level buildings through the structure to the upper floors. A doubling of the buffer distances provided in Table 4-18 would provide a conservative allowance for this possible effect.

Table 4-18 Vibration safe working buffer distances, m

Equipment	Human comfort	Structural damage	
		Heritage structure	Standard dwellings
Vibration criteria	1 mm/s	3 mm/s	5 mm/s
Criteria source	BS 5228-2	DIN 4150-3	DIN 4150-3
General construction activities			
Roller	90 m	24 m	13 m
15 tonne vibratory roller	140 m	34 m	18 m
7 tonne compactor	90 m	24 m	13 m
Dozer	60 m	14 m	8 m
Backhoe	10 m	3 m	1 m
Pavement breaker	90 m	24 m	13 m
Excavator	25 m	6 m	3 m
Piling (bridges)			
Piling (impact)	700 m	180 m	100 m
Piling (vibratory)[1]	110 m	50 m	30 m
Piling (bored)[1]	120 m	35 m	17 m

Note 1: Based on advice given in British Standard BS 7385:1993 – Evaluation and measurement of vibration in buildings.

Note 2: Based on levels derived from BS 5228-2. *Bored piling through stones or other obstruction*. Vibratory piling based on relationship provided in Table E.1.

Vibration intensive plant that may be used during construction includes the following:

- Road construction: a vibratory roller may be used for compaction and has the potential to affect residential properties along Broomfield Street and Sussex Street.
- Noise wall construction: a vibratory roller may be used for compaction and a piling rig may be required during support structure construction works. This has the potential to affect residential properties along Broomfield Street and Sussex Street.
- Bridge construction: a piling rig may be required during bridge foundation works and has the potential to affect residential properties along Broomfield Street and Sussex Street.

Other work areas may require use of vibration intensive plant and the construction contractor would assess these on a case-by-case basis. The following steps should be carried out for vibration intensive work inside the safe working buffer distances:

1. Carry out a building dilapidation survey and confirm whether the structure is considered structurally unsound. The results of the building dilapidation survey would determine the vibration criteria that would be used for construction vibration monitoring. These are provided below and are based on the criteria provided in section 3.3:
   - Structurally sound reinforced structure: 25.0 mm/s
   - Structurally sound unreinforced structural: 7.5 mm/s
   - Structurally unsound structure: 3.0 mm/s.
2. Perform compliance vibration monitoring to determine the vibration emission levels of the equipment prior to construction works starting. The requirement for compliance vibration monitoring will be dependent on the size of the construction equipment selected by the construction contractor and shall be reviewed be a suitably qualified acoustic consultant prior to construction.
3. Confirm the vibration safe working buffer distances based on the site specific vibration emission levels determined in step 2

4. If structures are still located inside the vibration safe working buffer distances, equipment with lower vibration emissions should be considered. If this is deemed unfeasible then a long term monitoring and alarm system should be installed. This system would warn operators in real time when vibration levels are approaching the allowable limits. If the vibration limit is exceeded, activities triggering the exceedance should cease immediately. A detailed review of work methods would be undertaken. If there are no reasonable or feasible alternative work methods, a structural engineer should be contacted for specialist advice, which may include re-enforcing the structure.

4.7.4 Vibration impacts on structures

The numbers of receivers located inside the minimum working distances for vibration intensive activities are provided in Table 4-19. The safe work buffer distances and the receivers affected are displayed in Figure 4-12 for vibratory roller (15 tonne) works and Figure 4-13 for bored piling works. These figures represent the expected worst-case vibration impacts that would be expected during general construction activities and piling works for bridges.

Table 4-19 Number of vibration affected receivers

Equipment	Human comfort	Structural damage	
		Heritage structure	Standard dwellings
Criteria source	BS 5228-2	DIN 4150-3	DIN 4150-3
General construction activities			
Roller	223	3	51
15 tonne vibratory roller	382	3	53
7 tonne compactor	223	3	51
Dozer	156	3	41
Backhoe	48	3	9
Pavement breaker	223	3	51
Excavator	64	3	12
Piling (bridges)			
Piling (impact)	2580	3	243
Piling (vibratory)[1]	272	3	69
Piling (bored)[1]	296	3	53

Effects on standard structures

Receivers located along Broomfield Street and Sussex Street are set back by around 15 to 25 metres from the road. This would be inside the vibration safe working buffer distance if a 15 tonne vibratory roller is used. The size of the vibratory roller should be limited to below 15 tonnes for any works located within 25 metres of any residential structure.

Bored piling works has the potential to cause cosmetic damage impacts on residential structures along Broomfield Street and Sussex Street located within 17 metres of the works.

Effects on heritage listed structures

The heritage structures listed in Table 4-20 have been identified within 50 metres of the project site. A building dilapidation survey of the heritage structures identified within the vibration safe working distance should be carried out. If the building dilapidation survey indicates that the heritage buildings are structurally unsound, then the conservative criteria of 3.0 mm/s provided by DIN 4150-3 should be used.

Piling works during bridge construction has the potential to cause cosmetic damage on the Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge. The

Federation Cottage has the potential to experience vibration levels above the allowable limits during road construction works if a 15 tonne vibratory roller is used. As such, the vibratory roller should be limited to below 15 tonnes to limit the potential impact on this structure. It should be noted that since the Federation Cottage's listing in 2009, the structure has burnt down. As it is still a listed site however and may include archaeological potential, it remains referenced here.

Table 4-20 Heritage listed items

Site number	Site name	Address / Property description	Listings - Individual item	Significance	Location
I10	Federation cottage	132 Broomfield Street, Lot 11, section 6, DP 1656	Fairfield LEP 2013	Local (Fairfield LEP)	Next to project site
I19	Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge	Railway Parade and Sussex Street (Cabramatta Creek)	Fairfield LEP 2013 RailCorp Section 170 Register	State and local (Fairfield LEP, Section 170 register)	Within project site

In addition the proposed locations for minor works in the form of new signalling are situated close to the following heritage listed items:

- Villawood Railway Station Group (I103), 19 Villawood Road
- Liverpool Railway Station Group, including station building, goods shed and jib crane (72), Bigge Street (off), Lot 31, DP 859887; Part Lot 5, DP 226933.

The proposed signalling works would be located outside of vibration buffer distances to ensure there are no vibraton impacts to these sites.

4.7.5 Human comfort impacts

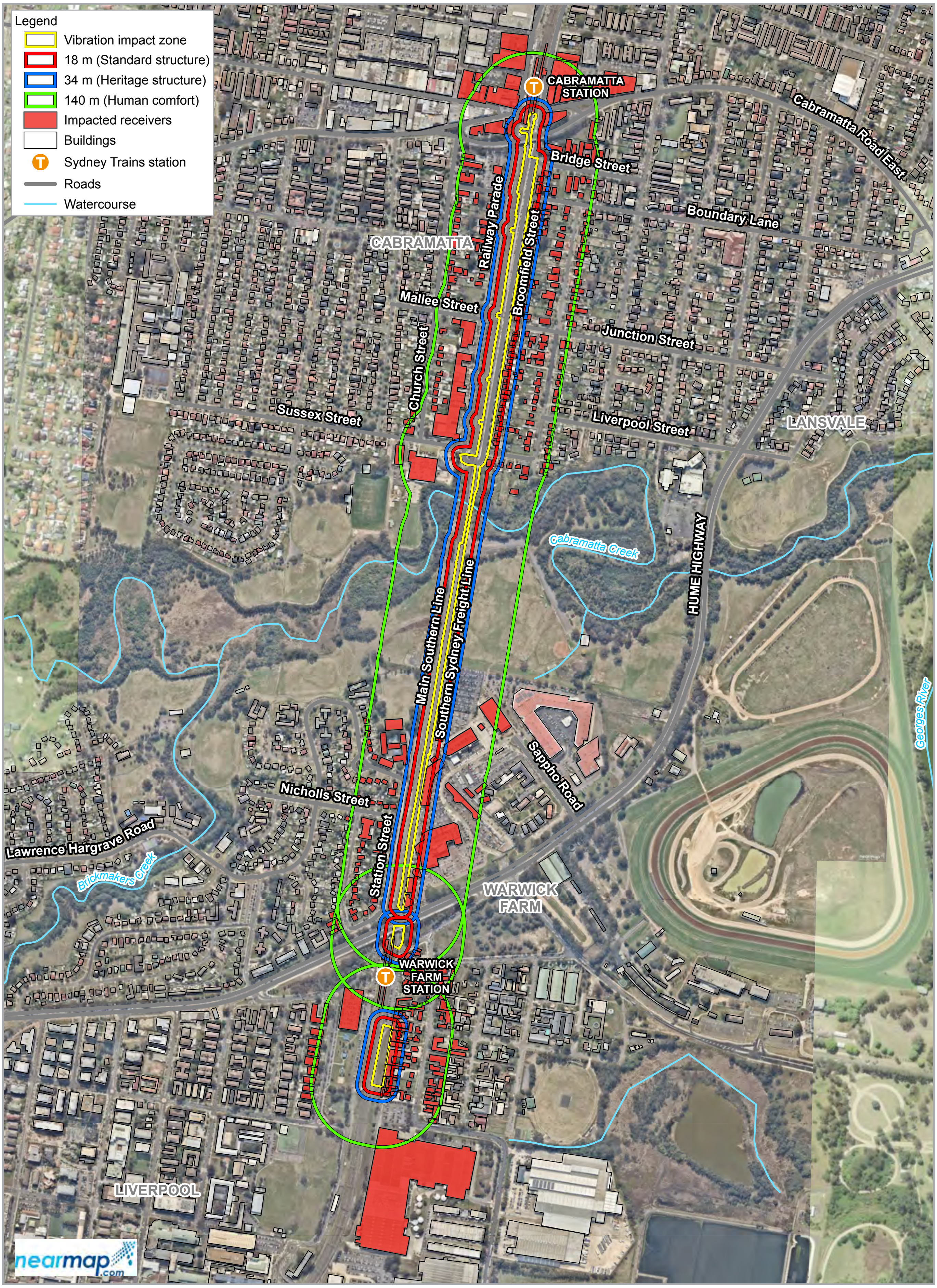
Impact piling has the potential to cause human comfort impacts within 700 metres of the works (2580 sensitive receivers). Impact piling would be extremely short term in duration and may not be required.

A total of 382 residential receivers within 140 metres of the proposed vibration intensive works have the potential to experience impacts on human comfort during operation of the vibratory roller.

Construction vibration would be intermittent and these impacts would not be continuous throughout the construction period. The mitigation measures in section 6 should be implemented where considered feasible and reasonable.

4.7.6 Vibration impacts on buried services

Note that in general, compliance with the guideline values for structural damage would result in compliance with the guideline values for buried pipework. Direct contact between the vibration intensive equipment and the buried pipework shall be avoided.



Paper Size ISO A4

0 80 160 240 320

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: AGD 1966 ISG 56 1

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Australia Rail Track Corp Ltd
Cabramatta Rail Loop
Noise and Vibration Impact Assessment

Vibration impact zones
(15 tonne vibratory roller)

Project No. 22-19800
Revision No. 0
Date 11/04/2019

Figure 4-12

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\2219800_NVIA006_VibrationImpactZones_Roller_0
Print date: 11 Apr 2019 - 09:35

Data source: LPI: DTDB\DCDB, 2017. DPE: Land zoning, 2016.LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017. Created by: tmorton

Paper Size ISO A4

0 25 50 75 100

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: AGD 1966 ISG 56 1

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Australia Rail Track Corp Ltd
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Noise and Vibration Impact Assessment

Vibration impact zones (bored piling)

Project No. **22-19800**
Revision No. **0**
Date **11/04/2019**

Figure 4-13

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\2219800_NVIA007_VibrationImpactZones_Piling_0
Print date: 11 Apr 2019 - 09:36

Data source: LPI: DTDB\DCDB, 2017. DPE: Land zoning, 2016.. Created by: tmorton

4.8 Summary of key findings

4.8.1 Construction noise

The six-staged construction methodology proposed for the project was separated into 13 distinct construction scenarios to assess potential construction noise impacts. All scenarios have been assessed against the NMLs during standard construction hours and for OOHW.

Construction noise impacts were assessed by considering the following:

- The number of expected impacts based on the total number of exceedances of the NMLs.
- The level of impact based on the maximum exceedance of the NML.

The expected impacts are summarised in Table 4-21 for each NCA. Exceedances of the construction NMLs are typical for construction projects and would be limited to the period of construction.

Compound operations at the Jacquie Osmond Reserve (C3) location are predicted to have a minor impact on receivers located in NCA01, NCA02 and NCA03. Receivers in NCA03 and NCA04 are expected to experience a higher degree of impact from the compound within the rail corridor (C1) as the compound is located directly adjacent to some receivers.

Table 4-21 Construction noise impact summary

NCA	Highest number of total exceedances	Highest level of exceedance (Most intrusive plant item)
NCA01	Road earthworks (CS03) Noise wall construction (CS06)	Noise wall construction (CS06) (Excavator with concrete rock breaker)
NCA02	Road earthworks (CS03) Noise wall construction (CS06)	Road pavement works (CS04) (Milling machine)
NCA03	Retaining wall installation (CS10) Track installation (CS12)	Vegetation removal and utility relocation (CS02) (Grinder and mulcher)
NCA04	Site establishment (CS01) Track installation (CS12)	Site establishment (CS01) (Crane, truck)

4.8.2 Construction traffic

Construction traffic along the primary access routes (Hume Highway, Cabramatta Road East) are not expected to generate road traffic noise impacts as these routes would have high existing traffic volumes.

Construction traffic movements along local roads should be managed with a construction traffic management plan to limit the degree of road traffic noise impacts.

4.8.3 Construction vibration

Vibration intensive plant and equipment may be used for construction of the road, noise wall and bridge. Equipment should be selected so that the safe working buffer distances identified in Table 4-20 are complied with.

A building dilapidation survey should be carried out for all structures located within the safe working buffer distances to identify whether the structure is considered structurally unsound.

If the structure is found to be structurally unsound, the vibration levels of the proposed equipment would be measured and used to confirm the buffer distances calculated as part of this assessment. If the structure is still located within the vibration safe working distances, then alternative equipment with lower vibration emissions (such as smaller compactors/rollers) would need to be considered. Construction vibration monitoring would be required if there are still structures located within the vibration safe working distances.

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5. Impact assessment – Operation

5.1 Methodology

5.1.1 Overview

The following methodology was utilised to assess the potential noise and vibration impacts associated with the operation of the project to address the SEARs:

- Identifying key NVSRs in the study area.
- Establishing noise and vibration assessment criteria at sensitive receivers.
- Identify the existing and proposed rail traffic volumes and speeds for the study area.
- Calculating L_{Aeq} and L_{Amax} noise levels using noise logger data obtained at the monitoring locations.
- Validating the operational noise model using the noise monitoring data.
- Modelling operational rail (L_{Aeq} and L_{AMax}) noise for the agreed (year opening 2023 and design year 2033) scenarios.
- Assessing operational rail noise predictions (L_{Aeq} and L_{AMax}) against the relevant RING trigger levels.
- Considering noise mitigation options where exceedances of the trigger levels are predicted.

Note that the predicted rail noise levels (termed the 'absolute rail noise levels') refers to noise levels emitted by rail only, that is without the contribution of any other noise source.

5.1.2 Noise modelling scenarios

Operational rail noise scenarios were developed to clearly identify noise levels resulting from:

- Existing rail operations on both the Sydney Trains and SSFL lines.
- Future rail operations with the inclusion of the project (passing loop).

'No build' scenarios were also developed to identify the likely future operational rail noise levels without the project. This enables the effect of the project to be clearly quantified.

The RING states that noise trigger levels are to be evaluated immediately after operations start and for a design year, typically 10 years later. Consequently, the following two assessment timeframes have been evaluated within the project's operational assessment study area:

1. Opening year: No build and build scenarios for the year in which project operations start following construction completion, 2023.
2. Design year: No build and build scenarios 10 years after project operations start, 2033.

Noise modelling was also completed to examine the existing noise environment and validate predictions. For this project, the existing operations were modelled for the year 2018.

The noise modelling scenarios used for the assessment are summarised in Table 5-1.

Table 5-1 Noise modelling scenarios

Time Frame	Build	No build
2018 – model for calibration against noise logger data	-	L_{Aeq}
2023 – Project opening year	L_{Aeq} and L_{Amax}	L_{Aeq} and L_{Amax}
2033 – Project design year	L_{Aeq} and L_{Amax}	L_{Aeq} and L_{Amax}

5.1.3 Noise modelling assumptions

Noise modelling was carried out in SoundPLAN version 7.4 using the Kilde130 Nordic Rail Traffic Noise prediction method (1984), in accordance with the guidance provided in the *ARTC Noise Prediction and Mitigation Guideline* (ARTC, 2018).

The noise modelling assumptions are detailed below.

Source noise levels and heights

Passenger and maximum freight source noise levels were derived from unattended measurements carried out at Logger L01, located north of the Warwick Farm Station. Individual passbys from the data were correlated with the Sydney Trains Wayside Information Management System (WIMS) at Warwick Farm to establish noise levels for different train types.

Freight rolling and locomotive engine/exhaust noise levels were sourced from the TfNSW rail noise database (RNDB, revision C). Wagons were assumed to be in good condition free of wheel defects while locomotives were assumed to be operating in the high notch setting. This is considered to be conservative as a review of the rail passby data from on-site measurements indicates that freight travelling down is unlikely to be operating in the high notch setting.

The modelled passenger and freight source noise levels are provided in Table 5-2. Source heights were assumed to be 0.5 metres from top of rail for rolling noise and four metres from top of rail for engine/exhaust noise.

Table 5-2 Adopted source noise levels

Train type	Reference conditions	SEL, dBA	$L_{Amax,95^{th}}$ percentile, dBA
Passenger – A-Set	80 km/h, at 15 m from track for a train length of 154.4 m (8 car)	86	81
Passenger – B-Set		86	81
Passenger – C-Set	80 km/h, at 15 m from track for a train length of 163.2 m (8 car)	89	85
Passenger – K-Set		89	87
Passenger – S-Set		88	87
Passenger – M-Set (8 car)	80 km/h, at 15 m from track for a train length of 161.6 m (8 car)	86	81
Passenger – M-Set (4 car)	80 km/h, at 15 m from track for a train length of 80.8 m (4 car)	84	81
Freight (Rolling noise)	80 km/h, at 15 m from track for a train length of 1000 m	97	88
Freight (Engine/exhaust noise) – High notch	80 km/h, at 15 m from track for a train length of 20 m (one locomotive)	90	90

Existing rail volumes, speeds and consists

Existing average daily rail traffic volumes and speeds along the Sydney Trains up and down lines were sourced from the WIMS located at Warwick Farm.

Existing rail volumes along the SSFL were partially provided by ARTC and partially derived from detailed passby analysis of the measured rail data at Cabramatta and Warwick Farm.

A summary of the existing volumes and average speeds on the Sydney Trains up and down lines is provided in Table 5-3 below (with the naming nomenclature of train set and number of carriages).

Passenger trains on the Sydney Train lines are provided in Table 5-2.

Freight train along the Sydney Train lines were calculated from the supplied WIMS data and are as follows:

- Up line: An average of one locomotive (day and night), 25 wagons (day) and 24 wagons (night)
- Down line: An average of one locomotive (day and night), 22 wagons (day) and 29 wagons (night)

Existing average daily volumes of 12 trains (day) and eight trains (night) for the SSFL were calculated from the supplied ARTC data, with an average speed of 60 kilometres per hour (km/h). Freight trains along the SSFL were also calculated from this data and are as follows:

- Day: Train length of 900 metres with two locomotives.
- Night: Train length of 750 metres with two locomotives.

Table 5-3 Existing daily day (15hr) and night (9hr) Sydney Trains up and down line volumes and speeds

Train type	Day (7.00 am to 10.00 pm)				Night (10.00 pm to 7.00 am)			
	Up	Down	Speed (Up, km/h)	Speed (Down, km/h)	Up	Down	Speed (Up, km/h)	Speed (Down, km/h)
A8	50	50	76	75	22	23	76	74
B8	5	6	71	74	4	4	77	77
C8	6	5	70	71	2	1	70	71
K8	14	14	70	70	5	4	67	69
S8	16	16	70	70	5	3	69	73
M8	17	15	76	74	5	7	71	76
M4	21	22	75	74	2	2	75	55
Freight	4	3	46	53	2	4	54	59

Future rail volumes, speeds and consists

Future rail volumes for the Sydney Trains and SSFL lines were based on modelling undertaken by ARTC and Sydney Trains. The volumes were provided by ARTC and are reproduced in Table 5-4.

The ‘no build’ and ‘build’ rail volumes were assumed the same for the Sydney Trains lines.

The ‘no build’ and ‘build’ volumes for the opening year on the SSFL would remain the same; however, a proportion of the trains would be diverted through the passing loop.

Table 5-4 Future daily day (15hr) and night (9hr) Sydney Trains line volumes

Year	Train type	Day 7:00 am to 10:00 pm		Night 10:00 pm to 7:00 am	
		Up	Down	Up	Down
2023	Tangara	6	10	6	-
	SGT (B set)	40	40	11	12
	8 car Waratah	54	49	16	20
	4 car Millennium	22	22	3	3
	8 car Millennium	15	15	4	5
	Freight	5	3	2	5
2033	8 car Waratah	168	168	84	84
	Freight	5	3	2	5

Table 5-5 Future SSFL daily day (15hr) and night (9hr) volumes

Scenario	Train Type	Train Movements Per Weekday Period			
		Day 7:00 am to 10:00 pm		Night 10:00 pm to 7:00 am	
		Up	Down	Up	Down
At opening (No build)	Freight	15	15	9	9
At opening (Build)	Freight	15	15	9	9
10 years after opening (No build)	Freight	15	15	9	9
10 years after opening (Build)	Freight	22.5	22.5	13.5	13.5

Speeds for the opening and design years were modelled at the following speeds:

- Sydney Trains lines: 80 kilometres per hour (up, passenger), 100 kilometres per hour (down, passenger), 70 kilometres per hour (up, freight), 80 kilometres per hour (down, freight).
- SSFL and passing loop: 80 kilometres per hour.

Average future freight trains lengths were constructed from the data provided by ARTC and are as follows:

- Freight trains on the Sydney Trains up and down lines: Train length of 620 metres with one locomotive.
- Freight trains on the SSFL (and the passing loop): Train length of 1110 metres with two locomotives.

Track corrections and other noise sources

Noise modelling algorithms require track corrections for track features such as curves, turnouts, joints and bridges.

Existing bridges were identified in the study area between Warwick Farm and Cabramatta at the Broomfield Street and Sussex Street intersection. The bridges are ballasted concrete span with no side screens, so no source correction has been applied to the tracks for the existing and future scenarios as per *ARTC Noise Prediction and Mitigation Guideline* (ARTC, 2018).

The following additional sources of noise have been considered for the future build scenarios:

- Turnouts at tie-ins from the SSFL to the passing loop: Modelled with a +6 dB track correction over a 10 metre track section as per the *ARTC Noise Prediction and Mitigation Guideline.*

Model configuration

The following assumptions were made with regard to the model configuration:

- A ground absorption coefficient of zero was used.
- Fifty per cent of the total trains on the SSFL were assumed to use the passing loop. The impact of different passing loop volumes is considered in the sensitivity analysis presented in section 5.4.
- Idling noise was modelled with an indicative sound pressure level of 70 dB(A) at 15 metres. The impact of idling noise has been considered at the two tie-in signal locations. A total of four hours of idling (in a 24 hour period) has been assumed in the noise modelling. The impact of different idling durations is considered in the sensitivity analysis presented in section 5.4.
- Stretching/bunching noise may occur at the signal tie-ins when trains are forced to stop and start at the signals. Stretching/bunching noise is associated with wagon couplings and manifests as short-term noise peaks. Stretching/bunching noise was modelled with a LA_{max} sound power level of 121 dB(A) over a length of 150 metres (10 wagons entering/exiting the turnout) as one second duration events between each wagon. The impact of stretching/bunching noise has been considered at the two tie-in signal locations.
- Receivers were modelled at a height of 1.5 metres above ground (ground floor), with each additional floor modelled at an additional three metre height (ie first floor at 4.5 metres, second floor at 7.5 metres, etc.
- Building footprint data (including average building heights) were derived from LiDAR data.

5.2 Existing rail noise levels and model validation

Existing rail noise levels were calculated using the results from the baseline monitoring described in section 2.5. Existing 15 hour and nine hour noise levels were calculated based on the noise logger data obtained at locations L01, L02, L03, L04 and L07. The noise levels at locations L01 and L02 represent the absolute existing rail noise levels while at the remaining locations, the noise comprises both rail and extraneous noise (though dominated by rail noise).

Noise modelling was carried out for the existing 2018 scenario for comparison with the measured existing rail noise levels to confirm the model's accuracy and validity for assessing the subsequent modelling scenarios.

The validation was carried out across the entire monitoring period (two weeks), with rail movement data extracted from a detailed passby analysis at Cabramatta (L02) and Warwick Farm (L01) (in addition to the data supplied by ARTC).

Only the first four days of data from Warwick Farm (L01) was used for validation due to a noise logger malfunction. A detailed passby analysis was undertaken at L01 which indicated 977 passenger and 84 freight rail passbys across the four days. This is considered to be a sufficient number of passbys and does not compromise the quality of the data. Additionally, the overall railway noise levels across the four days were consistent and considered representative of the broader monitoring period. Table 5-6 presents the measured and modelled 2018 rail noise levels.

Table 5-6 Measured absolute existing rail noise levels and model validation

Location	Measured[2]		Modelled		Modelled-Measured	
	LAeq, 15hr	LAeq, 9hr	LAeq, 15hr	LAeq, 9hr	LAeq, 15hr	LAeq, 9hr
L01 – North of Warwick Farm Station[1]	64.0	63.0	64.6	61.3	+0.6	-1.7
L02 – South of Cabramatta Station	67.6	66.1	65.7	62.4	-1.9	-3.7
L03 – 225 Railway Parade	61.0	59.0	61	57.8	0.0	-1.2
L04 – 150 Broomfield Street	58.6	52.3	54.5	52.7	-4.1	+0.4
L07 – 27 Lawrence Hargrave Road	50.4	47.2	50.5	47.3	+0.1	+0.1

Note 1: Based on data gathered over the first four days of monitoring as the equipment malfunctioned after the fourth day.

Note 2: Measured noise levels at L01 and L02 represent the extracted rail noise contribution. Measured levels at L03 and L04 represent the ambient and rail noise contributions.

The modelled noise levels are, on average, within 2 dB of the measured noise levels across all logged locations. Two of the 10 total validation comparisons show poor agreement between the logged and modelled values; however, these outliers are due to extraneous factors:

- L02, nighttime: Modelled noise levels are predicted to be slightly lower at L02 due to the existence of a localised track defect which was observed in the measurement data. However, the effect of this defect is localised and the defect is likely to be removed in future track maintenance. As such, the defect has not been included as part of the opening and design year modelling.
- L04, daytime: Modelled noise levels at 150 Broomfield Street are predicted to be lower during the day time period due to extraneous noise sources such as road traffic noise along Broomfield Street and temporary local construction works in the area.

Overall, the model is considered to be validated and suitable for the prediction of future rail noise levels.

5.3 Operational rail noise results

Predicted operational noise levels at the worst affected façade of all sensitive receivers (all floors) are provided in Appendix J to Appendix L. A summary of these result are discussed below. Noise levels presented in the appendices include the cumulative noise levels from all tracks within the rail corridor as well as noise contributions from the Sydney Trains and ARTC lines.

Operational noise contours for all modelled scenarios are provided in Appendix M to Appendix O. All results include a +2.5 dB façade correction.

The predicted noise levels indicate that the removal of the existing noise wall on Broomfield Street would increase L_{Aeq} noise levels by up to 8 to 9 dB and L_{Amax} noise levels by up to 11 to 12 dB at residences located along Broomfield Street. These noise levels will be experienced by receivers along Broomfield Street during the period when the old noise wall is demolished and the new one is in the process of being constructed.

Therefore, a replacement noise wall has been considered. The location of the replacement noise wall would be slightly set back from the existing noise wall location due to the construction alignment of the project, as shown on Figure 5-1.

The height of the noise wall has been kept the same as the current noise wall.

Implementation of mitigation has been considered when L_{Aeq} noise levels are predicted to exceed the relevant day/night trigger levels and an increase by 2 dB or more from the no build scenario. Mitigation may also be considered where L_{Amax} levels are predicted to exceed 85 dBA and there is a predicted increase of 3 dB or more due to the project.

With a replacement noise wall in place, noise mitigation needs to be considered for one sensitive receiver:

- R2289 (106 Broomfield Street) – second floor only

The predicted noise levels and contributions at R2289 (second floor) for the design year (2033) have been extracted from the appendices and are reproduced in Table 5-7 for the day and night time periods.

Table 5-7 R2289 (Second floor, F2) predicted noise levels, dBA

Time period	Noise trigger level	No build 2033			Build 2033 (with replacement noise wall)			Increase (build minus no build)
		Total (Sydney Trains and ARTC)	Sydney Trains contribution	ARTC contribution	Total (Sydney Trains and ARTC)	Sydney Trains contribution	ARTC contribution	
Day, 15 hour	65 dBA LAeq, 15 hour	64.5	61.0	62.0	67.0	63.9	64.2	2.5
Night, 9 hour	60 dBA LAeq, 9 hour	62.7	59.8	59.6	65.3	62.4	62.1	2.6
24 hour	85 dBA LAmax	84.3	-	-	88.2	-	-	3.9

The predicted total L_{Aeq} rail noise level at R2289 (F2) exceeds the day time noise trigger level by 2 dB and the night time noise trigger level by 5.3 dB. The predicted L_{Amax} rail noise level also exceeds the trigger level by 3.2 dB.

Furthermore, rail noise levels are predicted to increase between the ‘build’ and ‘no build’ scenarios by 2.5 dB ($L_{Aeq,\ 15\ hour}$), 2.6 dB ($L_{Aeq,\ 9\ hour}$) and 3.9 dB ($L_{Amax,\ 24\ hour}$).

A detailed breakdown of sources contributing to the increase in noise levels at R2289 (F2) is presented below in Table 5-8 for the night-time period which has the largest incremental exceedance of the noise trigger level.

Table 5-8 R2289 (F2) noise source contributions – LAeq, 9 hour (night), dBA

Source contribution	No build 2033	Build 2033, with replacement noise wall
Sydney Trains up and down line - passenger (rolling noise)	58.7	61.5
Sydney Trains up and down line - freight (rolling noise)	50.5	53.9
Sydney Trains up and down line - freight (engine/exhaust noise)	49.6	49.6
ARTC SSFL (rolling noise)	54.8	57.6
ARTC SSFL (engine/exhaust noise)	57.9	59.8
ARTC SSFL (idling)	-	46.8
Total	62.7	65.2
Total (with idling)	**62.7**	**65.3**

The table above shows that the increase in noise levels would be due to the following:

- Increase in rolling noise contributions from the Sydney Trains lines as a result of shifting the existing noise wall location
- Increase in rolling and engine/exhaust noise contributions from the ARTC line as a result of the project and shifting the existing noise wall location.

Noise mitigation options for R2289 (F2) are discussed below.

5.3.1 Operational rail noise mitigation

The night time period is considered to be the determining time period for noise mitigation as the night-time period has the largest incremental exceedance (5.3 dB) of the noise trigger level.

The RING states that *"if the trigger levels are likely to be exceeded…Determine the feasible and reasonable mitigation measures that could be implemented to reduce noise to reach the absolute trigger levels"*.

Section 3.3.6 of the RING identifies potential mitigation measures such as at source controls (alternative track alignments, controlling rail traffic, speeds, type of rolling stock, etc.), path controls (e.g. noise barriers) and at receiver controls (e.g. architectural treatment).

Source noise controls such as operational restrictions are not considered to be reasonable and feasible for this project.

Increasing the height of the replacement noise barrier adjacent to receiver R2289 was investigated as a potential path control. An additional increase in barrier height of up to two metres was not sufficient to reduce the noise levels to below the trigger levels at the second floor of R2289. Additional barrier height increases were not considered to be reasonable as they would increase the barrier height above six metres.

Therefore, potential receiver controls such as architectural treatments would need to be considered. The RING acknowledges that *"in the case of multi-level residential buildings, the external point of reference for measurement for the trigger is the two floors of the building most exposed to rail noise. On other floors, an internal noise level value 10 dB below the relevant external noise level value applies on the basis that windows that can be opened can do so sufficiently to provide adequate ventilation"* and *"treating the façade of residential buildings where night-time noise levels are the major concern to reduce internal noise levels in sleeping areas."*

A review of receiver R2289 confirms that it is a multi-storey apartment block with balconies facing Broomfield Street and the rail corridor. During detailed design phase, it is recommended that a site visit should be undertaken to confirm the apartment layout and determine specific architectural treatments.

5.4 Model sensitivity analysis

5.4.1 Sensitivity to passing loop volumes

All trains on the SSFL (45 day and 27 night) were modelled as either on the SSFL or on the passing loop to establish the sensitivity of volume splits between the two.

The results indicate the following:

- The change in noise levels between the two cases (all trains on the SSFL vs. all SSFL trains on the passing loop) ranges between +2.1 dB to -1.4 dB (day) and +2.0 dB to -1.2 dB (night), with an average difference of -0.3 dB (both the day and nighttime periods). As the impacts depend on the location of the receiver, the final modelling has assumed a 50/50 split between the SSFL and the passing loop.

5.4.2 Locomotive idling sensitivity

Idling noise from a locomotive has been considered at the two turnout signals where the passing loop ties into the SSFL.

A sensitivity analysis (average and maximum increase across the study area) was performed to illustrate the contribution from idling to the overall noise levels. The analysis indicates that the contribution from idling to the overall noise levels is negligible.

Table 5-9 Idling duration and sensitivity

Idle time (1 locomotive) (minutes) (nighttime period) (minutes)	Average increase (2033 night), dB	Max increase (2033 night), dB
20	0	0.1
40	0	0.2
60	0	0.3
80	0	0.4
100	0	0.5
120	0	0.6
140	0	0.7
160	0	0.8
180	0	0.9
200	0.1	1
220	0.1	1
240	0.1	1.1

It should be noted that the 240 minutes above implies that a train is idling for four hours of the entire nine hour nighttime period. This is considered extremely unlikely and the final modelling assumes a realistic worst case of four hours of idling time split between the day and nighttime periods. It should also be noted that only one of the two tracks would be in use (likely leading to a reduced number of movements and additional shielding of operational rail noise caused by the stationary train) with a train idling on the SSFL or the passing loop.

In general, the negligible impact of idling occurs due to the existing high noise contributions from the Sydney Trains and SSFL lines in the area. Overall, the impact of idling is not considered to be significant.

5.4.3 Stretching/bunching noise

The predicted maximum noise levels from stretching/bunching are generally lower than the predicted maximum freight locomotive engine/exhaust noise levels at the majority of the modelled sensitive receivers.

However, an additional marginal L_{max} increase of 0 to 1 dB is predicted at some sensitive receivers due to the change in train behaviour and the subsequent stretching/bunching noise generated due to trains slowing down at the passing loop entry and exit points.

Paper Size ISO A4

0 80 160 240 320

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: AGD 1966 ISG 56 1

N

GHD

Australia Rail Track Corp Ltd
Cabramatta Rail Loop
Noise and Vibration Impact Assessment

Existing and proposed noise wall location

Project No.	22-19800
Revision No.	0
Date	12/04/2019

Figure 5-1

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Print date: 12 Apr 2019 - 08:57

Data source: LPI: DTDB\DCDB, 2017. LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017. Created by: tmorton

5.5 Operational ground-borne noise and vibration

Vibration and ground-borne noise from the operation of heavy rail infrastructure can adversely affect sensitive receivers located near a rail line. Vibration can cause buildings, windows and other fixtures to shake; contribute to annoyance and impacts on residents and other land uses; and interfere with vibration-sensitive equipment. Vibration can also be regenerated as ground-borne noise inside a building.

Building damage is not usually likely for operation of rail infrastructure; however, annoyance can occur at significantly lower vibration levels, which are often only slightly higher than the limits of human perception.

Human comfort goals and ground-borne noise trigger levels provide the controlling criteria for operational ground-borne noise and vibration for the project.

The level of vibration at a receiver is usually a function of the energy of the vibration source, the propagation through the ground and the coupling of the ground to the receiver, structure or building.

Vibration generation from rail traffic is generally a function of the following:

- wheel-rail interface including wheel defects, acceleration and braking
- the quality of the rail
- track geometry
- variations in sleepers and ballast
- axle load
- geometry and composition of the train
- Speed.

Soil further influences propagation and perception of vibration, geological conditions and building characteristics including the following:

- soil stiffness
- ground internal damping
- depth of bedrock
- depth of water table
- building mass
- building coupling to the ground
- propagation of vibration through the building.

5.5.1 Operational vibration assessment

The US Federal Transit Administration's '*Transit Noise and Vibration Impact Assessment'* report provides a method for estimating the ground surface vibration levels near rail lines. The process involves selecting a base curve for typical ground surface vibration levels. The base curve assumes rail equipment is in good condition and operating at speeds of 80 km/h. Correction factors are then applied to account for different speeds, geological conditions, etc.

The report notes that vibration levels are about proportional to $20 \log_{10}$ (speed/speed_{ref}), although the relationship can be as low as 10 to 15 $\log_{10}$ (speed/speed_{ref}). A speed relationship of $20 \log_{10}$ (speed/speed_{ref}) has been adopted for this assessment.

Vibration levels may increase slightly for the project due to the passing loop being slightly closer to residential receivers on the eastern side of the corridor.

The Federal Transit Administration's base curve for locomotive-powered freight/passenger trains derived the distance attenuation relationship of ground vibration measurements. Vibration measurements from similar rail projects undertaken by GHD can be seen on Figure 5-2. Note that these values have been adjusted to the reference speed of 80 kilometres per hour, using the 20 $\log_{10}(\text{speed}/\text{speed}_{ref})$ relationship.

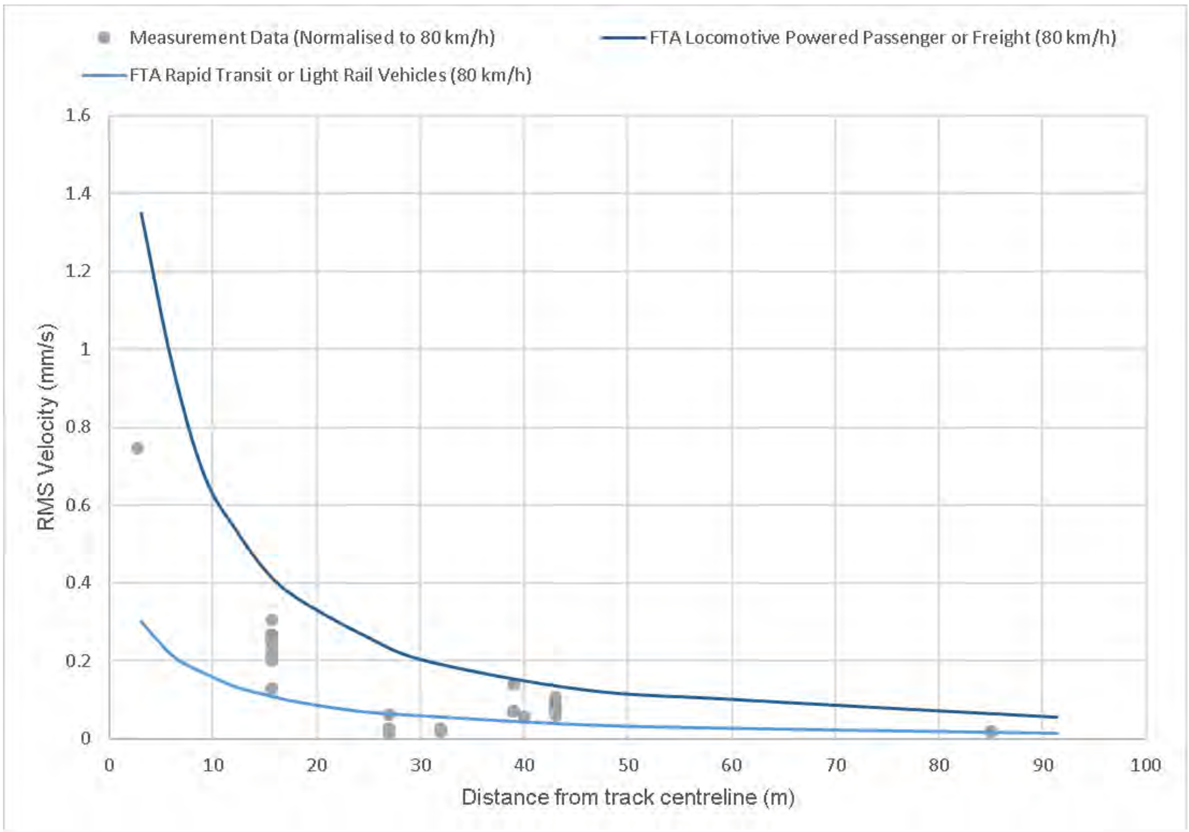

Figure 5-2 Rail ground vibration levels

Vibration measurements are highly variable and are largely dependent on local geological conditions. Track irregularities may also significantly increase vibration levels (for example, at crossovers and joints). A significant variation in vibration levels for similar systems are not uncommon and the FTA curves represent the upper range of measurement data for well maintained systems. The measured vibration data presented on Figure 4-9 are consistently lower than that upper-range vibration curve from the FTA guideline. As such, the use of levels from the FTA locomotive curve are expected to provide a conservative estimate of vibration levels.

For the purposes of this assessment, the track has been assumed to be in good condition and track irregularities have not been assessed. An assessment of these factors would be completed once the detailed design has been finalised and during periodic track inspections and maintenance.

5.5.2 Human comfort assessment

Human comfort for operational vibration has been assessed in accordance with British Standard BS 6742-1:1992. The Vibration Dose Value (VDV) provides a cumulative descriptor of the vibration level received for a given period.

BS 6472 provides a method to calculate the estimated VDV using Root Mean Square (RMS) vibration velocity. The estimated VDV is calculated as:

$$eVDV = 0.07 \times V_{rms} \times t^{0.25} \ (m/s^{1.75})$$

Where t= duration of the event.

The eVDVs for this project have been estimated by adjusting vibration levels for speed, duration and distance from the track.

The following assumptions have been made:

- Maximum train lengths as specified in section 5.1.3
- Maximum train speeds as specified in section 5.1.3
- Track in good condition with no track irregularities
- Train volumes specified in section 5.1.3

These assumptions are expected to provide a conservative estimate of future vibration levels. The predicted future eVDV values for day and nighttime along both the eastern and western sides of the rail corridor, including the respective residential criteria are provided on Figure 5-3 to Figure 5-6. The residential criteria is met at the following distances:

- On the eastern side of the rail corridor, at 13 metres (day) and 18 metres (night).
- On the western side of the rail corridor, at 9 metres (day) and 13 metres (night).

The AVTG does not specify human comfort vibration criteria for commercial sensitive receivers (refer to Table 3-10). This assessment conservatively adopts an intermittent vibration dose value of 0.6 $m/s^{1.75}$ for commercial spaces. This value is the mid point of the values specified in the AVTG for offices (0.4 $m/s^{1.75}$) and workshops (0.8 $m/s^{1.75}$). The adopted commercial criteria is met at the following distances:

- On the eastern side of the rail corridor, at 4 metres (day) and 3.5 metres (night).
- On the western side of the rail corridor, at 3 metres (day) and 2.5 metres (night).

The buffer distances are higher on the eastern side of the rail corridor due to the closer proximity of the SSFL and the passing loop, which carry the majority of the freight trains within the corridor.

No residential or commercial sensitive receivers have been identified within the human comfort vibration buffer distances.

5.5.3 Structural vibration impacts

The human comfort vibration criteria is more stringent than the structural damage criteria. As no residential receivers have been identified within the human comfort vibration buffer distances, structural vibration impacts at residential sensitive receivers are not anticipated as a result of the project.

The structural damage vibration criteria for commercial structures has been adopted as 20 mm/s (refer to Table 3-14) and is significantly higher than the residential structural damage criteria. Vibration from freight trains has been measured at 4-5 mm/s at 6 metres in the study area. Therefore, vibration levels at commercial receivers would be significantly below 20 mm/s and structural impacts on commercial structures are not anticipated as a result of rail operations.

There is the potential for vibration impacts at heritage bridges during operation due to an increase in train volumes. However, given the existing use of the heritage bridges by Sydney Trains and the use of the adjacent SSFL this impact is difficult to quantify. A dilapidation survey would be undertaken during construction to assess the structural integrity of the heritage listed bridges. If this survey notes there is structural damage to the bridges then there may be a need for a structural assessment to be undertaken to assess potential impacts due to vibration from trains.

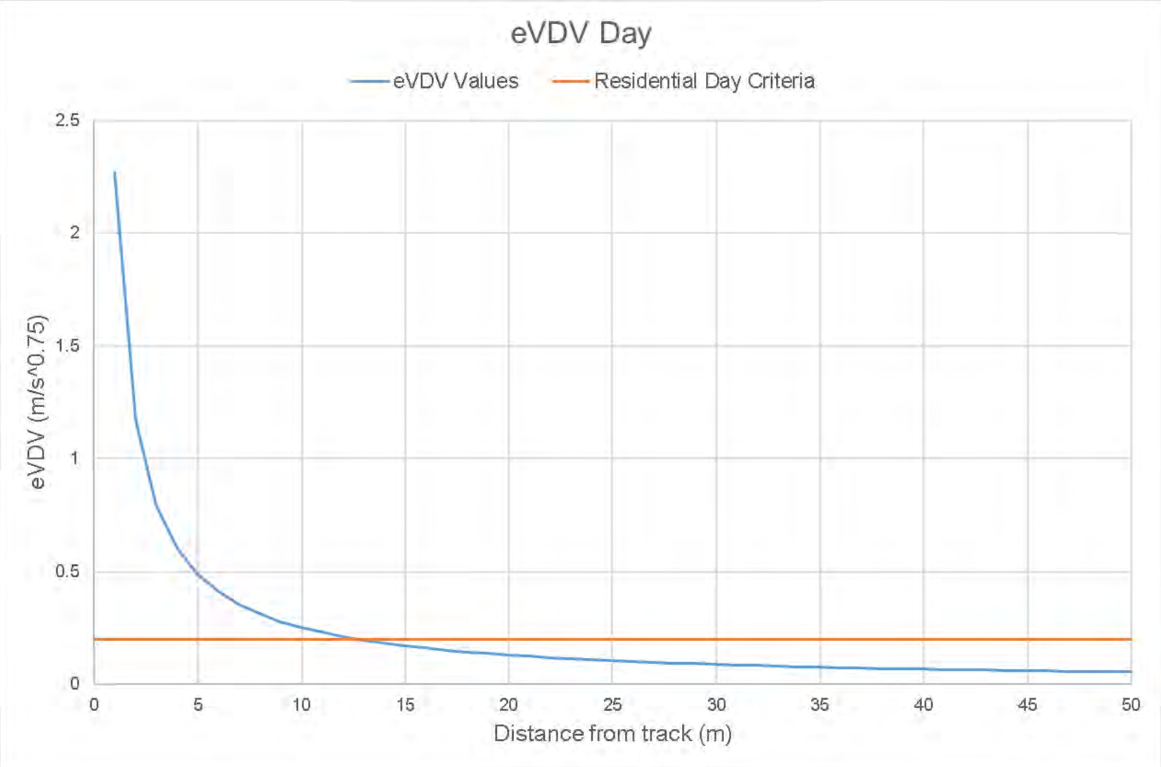

Figure 5-3 Daytime VDV levels (2033) – East of rail corridor

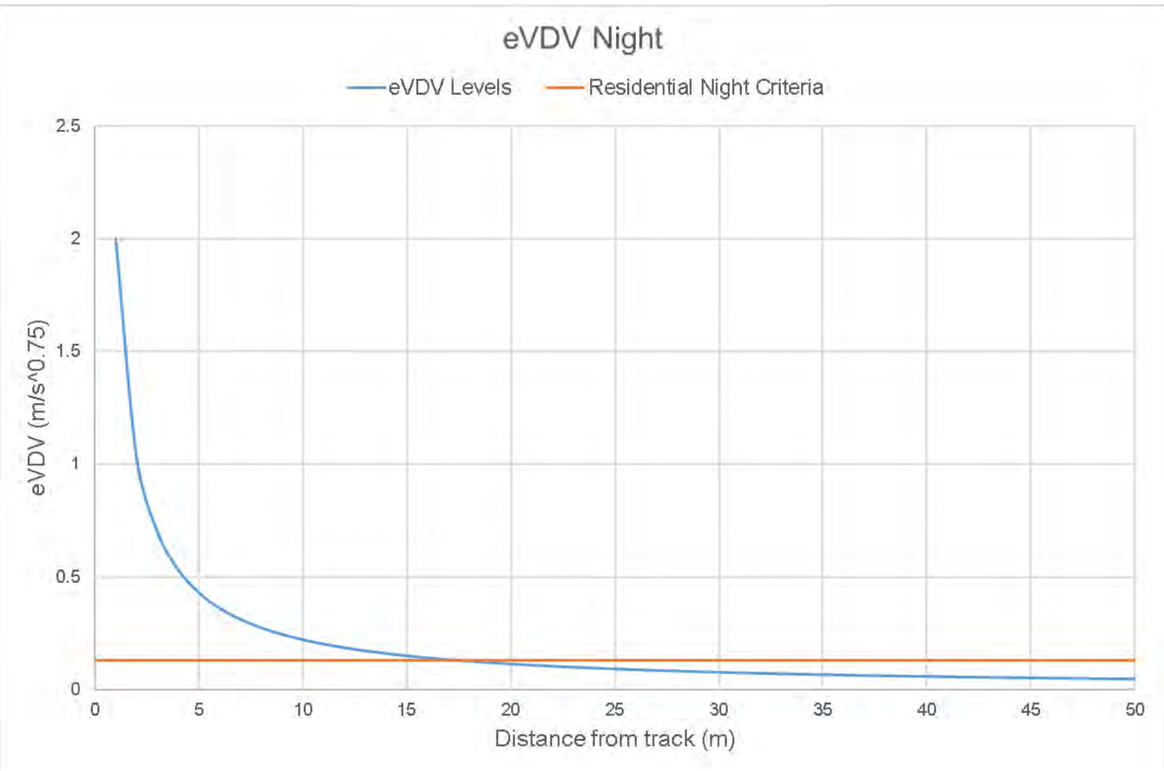

Figure 5-4 Nighttime VDV levels (2033) – East of rail corridor

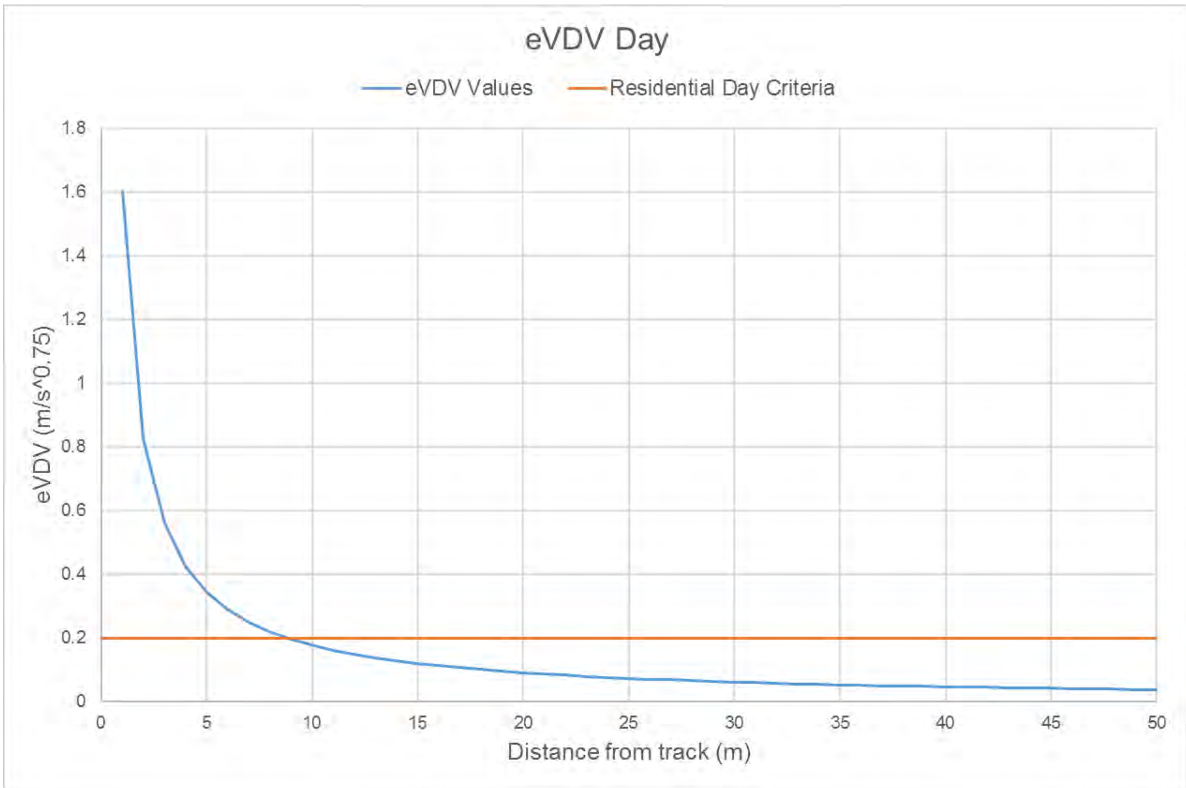

Figure 5-5 Daytime VDV levels (2033) – West of rail corridor

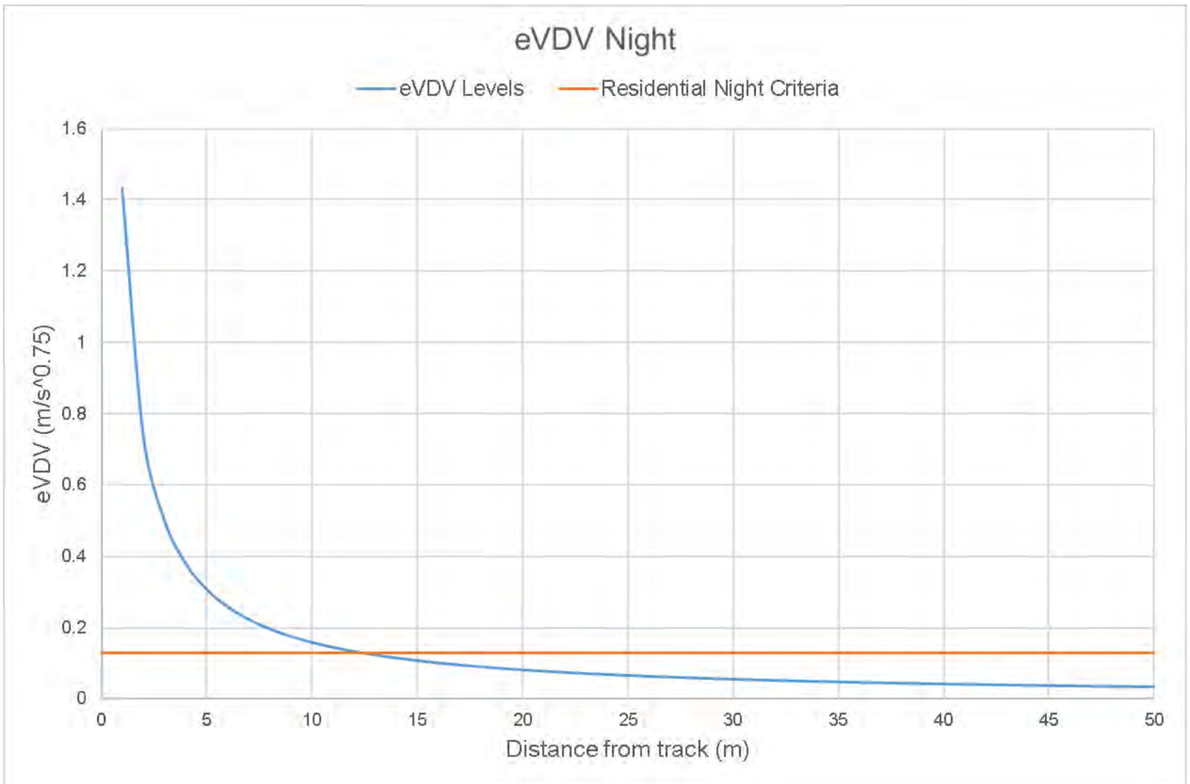

Figure 5-6 Nighttime VDV levels (2033) – West of rail corridor

5.5.4 Ground-borne noise

Ground-borne noise from can be generated nside a building by vibration generated from the pass-by of the rail vehicle. Operational ground-borne noise is assessed in accordance with the RING. The ground-borne noise trigger levels for an existing railway allow an increase of less than 3 dBA assessed as a maximum pass-by event.

A screening level ground-borne noise assessment has been undertaken to confirm if ground-borne noise levels are likely to increase by 3 dBA or more. The passing loop is shifting the SSFL up to 5 m closer to the residential receivers. The RING requires the increase in noise to be calculated to a single decimal place. Note that the criteria is a L_{ASmax} criteria and independent of rail volumes. Based on the FTA curves (Figure 5-2) and the change in distance between the new and existing tracks, the increase in ground-borne noise is predicted to be 2.5 dBA at the nearest sensitive receiver. The largest increase in ground borne noise would occur at the nearest residential receiver where the relative change in distance of the new track is greatest. As such all other receivers further set back are predicted to have an increase in ground-borne noise less than these values.

The predicted increase in ground-borne noise based on the screening assessment is less than 3 dBA therefore there would not be an exceedance of the ground-borne criteria as idefntified in the RING.

Furthermore ground-borne noise levels are relevant only where they are higher than the airborne noise from railways and where the ground-borne noise levels are expected to be, or are, audible within habitable rooms. For an existing heavy rail corridor airborne noise is expected to be the dominant noise source from the project and significantly higher than any ground-borne noise contributions.

5.6 Summary of key findings

5.6.1 Operational noise

Operational noise levels were predicted for the existing (2018), opening (2023) and design years (2033).

The existing noise levels were used to validate the noise model. The modelled noise levels were found to be, on average, within 2 dB of the measured noise levels at all locations. Overall, the model is considered to be validated and suitable for the prediction of opening and design year noise levels.

An existing noise wall exists along Broomfield Street will be replaced with a similar noise wall constructed as part of the project. The predicted ‘no build’ and ‘build’ design year (2033) noise levels (with the reconstructed noise wall) indicate that noise mitigation needs to be considered for one sensitive receiver.

The receiver is located on the second floor of the property at 106 Broomfield Street in NCA02. During detailed design phase, it is recommended that a site visit should be undertaken to confirm the apartment layout and determine specific architectural treatments.

5.6.2 Operational vibration

Operational vibration results indicate that no residential or commercial sensitive receivers fall within the vibration buffer distances, so specific operational vibration mitigation strategies are not required for the project.

A dilapidation survey will be undertaken prior to construction to assess the structural integrity of heritage bridges located in the study area.

5.6.3 Operational ground-borne noise

Operational ground-borne noise results indicate that no residential receivers exceed the trigger noise levels, so specific operational ground-borne noise mitigation strategies are not required for the project.

6. Recommended mitigation measures

6.1 Construction noise

6.1.1 Standard mitigation measures

Table 6-2 provides the standard mitigation recommendations to reduce the noise levels from the construction activities.

Table 6-1 Standard construction noise mitigation measures

Stage	Impact	Measure
Design/pre-construction	General impacts of construction activities on sensitive receivers	A CNVMP will be prepared by the contractor and implemented as part of the CEMP. It will include measures to minimise the potential for noise and vibration impacts on the community, including those listed in this EIS. It will also consider relevant noise mitigation measures and notification procedures outlined in ARTC's EPL #3142. The CNVMP would be developed in consultation with Liverpool City Council, Fairfield City Council Roads and the EPA.
Design/pre-construction	Noise impacts during out of hours work	An out of hours protocol will be developed as part of the CNVP. It will at a minimum: • provide a process for the consideration of out of hours work against the relevant noise and vibration criteria • document procedures to manage potential impacts • identify responsibilities for implementation and management including managing complaints.
Construction	Noise impacts during sensitive periods	Where feasible and reasonable, construction will be carried out during the standard daytime working hours. The use of highly intensive noise and vibration generating equipment (such as jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) less sensitive times (e.g. the middle of the day).
	Noise impacts from continuous activities.	Highly intensive noise and vibration generating equipment (such as jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) will only be used in continuous blocks not exceeding three hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than one hour respite between ceasing and recommencing any of the work. Additionally, this equipment will not be used for more than two consecutive nights over any seven day period adjacent to the same sensitive receivers, unless otherwise approved by the relevant authority.
	Noise impacts from worker activities	All employees, contractors and subcontractors are to receive an environmental induction. The induction will include at least:

Stage	Impact	Measure
		• All relevant project specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) Environmental incident procedures.
	Noise impacts from worker activities	While on site, construction workers will refrain from: • Swearing or unnecessary shouting or loud stereos/radios on site • Dropping of materials from height, throwing of metal items and slamming of doors • Excessive revving of plant and vehicle engines • Uncontrolled release of compressed air.
	Construction traffic noise	Traffic flow, parking and loading/unloading areas will be planned to minimise reversing movements within the site.
	Construction traffic noise	Loading and unloading of materials/deliveries will occur as far as possible from sensitive receivers. Site access points and roads will be selected as far as possible away from sensitive receivers. Dedicated loading/unloading areas will be shielded if close to sensitive receivers, where reasonable and feasible. Delivery vehicles will be fitted with straps rather than chains for unloading, wherever possible.
	Construction traffic noise	Route vehicle movements will be scheduled away from sensitive receivers and during less sensitive times, where possible. The speed of vehicles will be limited within and approaching construction compounds The use of engine compression brakes will be avoided during night time periods, where possible On-site storage capacity will be maximised to reduce the need for truck movements during sensitive times.
	Construction noise and vibration	Quieter and less vibration emitting construction methods and equipment will be used where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
	Construction noise and vibration	Where practicable, materials will be pre-fabricated and/or prepared off-site to reduce noise with special

Stage	Impact	Measure
		audible characteristics occurring on site. Materials can then be delivered to site for installation.
	Noise from construction equipment	The noise of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the allowable noise levels.
	Noise from construction equipment	The offset distance between noisy plant and adjacent sensitive receivers will be maximised. Plant used intermittently will be throttled or shut down. Noise-emitting plant will be directed away from sensitive receivers.
	Noise from construction equipment	Non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work, including delivery vehicles.
	Noise from construction equipment	Noise from mobile plant will be reduced where possible, through additional fittings including: • Residential grade mufflers • Damped hammers such as 'City' Model Rammer Hammers • Air parking brake engagement silenced.
	Noise from construction equipment	The use of engine compression brakes will be limited at night and in residential areas. Vehicles will be fitted with a maintained original equipment manufacturer exhaust silencer that complies with the National Transport Commissions 'in-service test procedure' and standard.
	Noise impact from compound (C1)	Use of the construction compound (C1) near Warwick Farm Station will where practicable, be limited to standard hours only with the exception of plant storage and material delivery.
	Noise from construction compounds	Stationary noise sources will be enclosed or shielded where practicable, to ensure that the occupational health and safety of workers is maintained. Appendix F of AS 2436:1981 lists materials suitable for shielding.
	Noise from construction compounds	Structures will be used to shield residential receivers from noise where practicable such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.
	Construction noise resulting in highly intrusive levels	A noise monitoring program will be carried out for the duration of works at sensitive receivers identified as experiencing highly intrusive noise levels and as a result of complaints received, in accordance with the CEMP and any approval and licence conditions.
	Vibration impacts on heritage sites: Villawood Railway Station Group and	The signalling works will be located outside of vibration buffer distances.

Stage	Impact	Measure
	Liverpool Railway Station Group	
	Vibration impacts on structures.	Attended vibration measurements of vibration generating equipment (e.g. bored piling, vibratory rolling works) will be undertaken. This will confirm the minimum working distances for vibration intensive activities prior to works near the sensitive structures located within the vibration buffer distances identified in Figure 4-12 and Figure 4-13 provided in Technical Report 2.
	Vibration impacts on structures	Building dilapidation surveys will be carried out on all structures located within the vibration buffer distance prior to major project construction activities with the potential to cause property damage.

6.1.2 Additional mitigation measures

Table 6-2 provides the project specific mitigation recommendations to reduce the noise levels from the construction activities.

Table 6-2 Project specific construction noise mitigation measures

Impact	Details
Management measures	
Concern from local residents and stakeholder relating to noise impacts from the project	Refer to Table 6-3 and Table 6-4 and for specific stakeholder consultation measures relevant to the project and the recievers predicted to be impacted.
Construction noise resulting in highly intrusive levels	A noise monitoring program will be carried out for the duration of works at sensitive receivers identified as experiencing highly intrusive noise levels and at complainant properties, in accordance with the CEMP and any approval and licence conditions.
Vibration impacts on heritage sites: Villawood Railway Station Group and Liverpool Railway Station Group	The proposed signalling works will be located outside of vibration buffer distances, where possible.
Vibration impacts on structures	Attended vibration measurements of vibration generating equipment (e.g. bored piling, vibratory rolling works) will be undertaken prior to works near the sensitive structures located within the vibration buffer distances identified in Figure 4-12 and Figure 4-13. This will confirm the minimum working distances for vibration intensive activities.
Vibration impacts on structures including heritage items	Building dilapidation surveys will be carried out on all structures located within the vibration buffer distance prior to major project construction activities with the potential to cause property damage.
Vibration impacts on heritage sites: Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge	Where building dilapidation surveys indicate that the heritage listed bridges are unsound, then the conservative criteria of 3.0 mm/s provided by DIN 4150-3 should be used for equipment used within the vibration buffer distances.

ARTC's *Noise Prediction and Mitigation Guideline* (ARTC, 2018) does not specify specific construction noise mitigation measures. Therefore, the TfNSW CNVS has been adopted to determine potential additional construction noise mitigation measures. It should be noted that the mitigation measures listed in the TfNSW CNVS have also been adopted by the Roads and Maritime Services in *Construction Noise and Vibration Guideline* (RMS, 2016) and are considered the standard for recommending additional construction noise mitigation measures in New South Wales.

The TfNSW CNVS provides the following mitigation measures for certain receivers exceeding NMLs, which are presented in Table 6-3. The Additional Mitigation Measures Matrices (AMMM) will be used to determine the additional measures after the application of standard mitigation measures, where reasonable and feasible. The triggers for impacted recievers to require the additional management measures are outlined in Table 6-4.

Table 6-3 Additional management measures for receivers exceeding NMLs

Measure	Description	Abbreviation
Periodic notification	For each construction stage, a notification entitled 'Project Update' or 'Construction Update' will be produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. Periodic notifications will provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (eg traffic changes or noisy works) can assist in reducing the impact on stakeholders. The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact them. Most projects distribute notifications on a monthly basis. Each notification is designed within a branded template. In certain circumstances, media advertising may also be used to supplement periodic notifications, where considered effective. The Community Engagement Team may be advised in cases where AMMMs are not triggered for periodic notifications, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances, the Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	PN
Verification monitoring	Verification monitoring of noise and/or vibration during construction will be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (ie for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (ie for specific periods of construction noise). The purpose of monitoring is to confirm that: • Construction noise and vibration from the project are consistent with the predictions in the noise assessment • Mitigation and management of construction noise and vibration is appropriate for receivers affected by the works. Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment, then immediate refinement of mitigation measures may be required and the Construction Noise and Vibration Impact Statement (CNVIS) amended.	V
Specific notification	Specific notifications in the form of a personalised letter or phone call to identified stakeholders will be provided no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed. • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs.	SN

Measure	Description	Abbreviation
	• Individual briefings used to inform stakeholders about the impact of noisy activities and the mitigation measures implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. Specific notifications used to support periodic notifications, or to advertise unscheduled works.	
Respite offer	Respite offer may be provided to residents subjected to lengthy periods of noise or vibration. The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. This measure is determined on a case-by-case basis.	RO
Alternative accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative construction methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the vibration management levels (VMLs) for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
Respite period	OOHW during evening and night periods will be restricted so that receivers are not impacted for more than three consecutive evenings and not more than two consecutive nights in the same NCA in any one week. A minimum respite period of four evenings/five nights will be implemented between periods of consecutive evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (eg to minimise impacts on rail operations). Note: this management measure does not apply to OOHW Period 1 – Day.	RP
Duration Reduction	Where respite periods (see management measure above) are considered counterproductive to reducing noise and vibration impacts on the community, it may be beneficial to increase the number of consecutive evenings and/or nights through duration reduction to minimise the duration of the activity. Impacted receivers must be consulted and evidence of community support for the duration reduction provided as justification. A community engagement strategy must be agreed with and implemented in consultation with Community Engagement Representatives.	DR

The CNVS outlines the various trigger levels to warrant these mitigation measures, as presented below in Table 6-4.

The predicted noise levels for each receiver and any additional noise mitigation measures are presented in Appendix D. Construction noise management zones have been mapped and are provided in Appendix F to Appendix I.

The predicted construction noise levels in Appendix D have been categorised into the noise perception categories to determine the additional mitigation measures required in accordance with the CNVS. The number of residential receivers that require additional mitigation measures for each modelled construction scenario is provided in Table 6-5.

Table 6-4 Triggers for additional mitigation measures – Airborne noise

Construction hours	Receiver perception	dBA above RBL	dBA above NML	Additional management measures
Standard hours Monday – Friday (7.00 am – 6.00 pm) Saturday (8.00 am – 1.00 pm)	Noticeable	5 to 10	0	-
	Clearly audible	> 10 to 20	< 10	-
	Moderately intrusive	> 20 to 30	> 10 to 20	PN, V
	Highly intrusive	> 30	> 0	PN, V
	75 dBA or greater	N/A	N/A	PN, V, SN
OOHW Period 1 Monday – Friday (6.00 pm – 10.00 pm) Saturday (7.00 am – 8.00 am, 1.00 pm – 10.00 pm) Sunday/PH (8.00 am – 6.00 pm)	Noticeable	0 to 10	< 5	-
	Clearly audible	> 10 to 20	5 to 15	PN
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO
	Highly intrusive	> 30	> 25	PN, V, SN, RO, RP[1], DR[1]
OHW Period 2 Monday – Saturday (12.00 am – 7.00 am, 10.00 pm – 12.00 am) Sunday/PH (12.00 am – 8.00 am, 6.00 pm – 12.00 am)	Noticeable	0 to 10	< 5	PN
	Clearly audible	> 10 to 20	5 to 15	PN, V
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RP, DR
	Highly intrusive	> 30	> 25	PN, V, SN, AA, RP, DR

Note 1: Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only.

Table 6-5 Number of receivers identified for additional mitigation measures

ID	Description	Standard construction hours			OOHW Period 1						OOHW Period 2			
					Day			Evening			Night			
		MI	HI	HNA	CA	MI	HI	CA	MI	HI	N	CA	MI	HI
		11-20 dBA	> 20 dBA	≥ 75 dBA	6-15 dBA	16-25 dBA	> 25 dBA	6-15 dBA	16-25 dBA	> 25 dBA	0-5 dBA	6-15 dBA	16-25 dBA	> 25 dBA
CS01	Site establishment	26	13	7	157	26	13	164	26	13	925	516	84	20
CS02	Vegetation removal and utility relocation	286	101	28	742	286	101	791	292	105	724	1525	549	272
CS03	Road earthworks (Stage 1/2)	304	154	79	1011	304	154	1056	312	161	590	1652	676	357
CS04	Road pavement works (Stage 1/2)	209	117	59	622	209	117	704	234	121	922	1378	419	257
CS05	Road furniture installation (Stage 1/2)	38	35	11	108	38	35	113	38	35	237	271	81	54
CS06	Noise wall construction (Stage 2)	303	154	71	1033	303	154	1082	314	164	543	1713	700	352
CS07	Bridge construction pre-work (Stage 3)	31	7	3	233	31	7	273	33	7	771	1018	124	28
CS08	Bridge construction works (Stage 3)	38	10	4	370	38	10	449	41	10	920	1199	185	38
CS09	Bridge rail installation (Stage 3)	5	3	0	32	5	3	32	5	3	291	96	24	6
CS10	Retaining wall installation (Stage 4)	107	17	0	1171	107	17	1267	109	17	672	1961	536	64
CS11	Track construction (Stage 5)	190	69	20	565	190	69	580	204	72	910	1137	385	167
CS12	Track installation (Stage 5)	389	172	73	1175	389	172	1235	405	179	456	1642	763	389
CS13	Finishing and rehabilitation (Stage 6)	15	10	7	100	15	10	100	15	10	578	291	46	17

Notes:
N refers to Noticeable
CA refers to Clearly Audible
MI refers to Moderately Intrusive
HI refers to Highly Intrusive
HNA refers to Highly Noise Affected

6.2 Operational noise and vibration

Potential architectural treatments need to be considered for one sensitive receiver (second floor of 106 Broomfield Street) with the reconstructed noise wall in place. During detailed design phase, it is recommended that a site visit should be undertaken to confirm the apartment layout and determine the suitability for specific architectural treatments.

Operational vibration results indicate that no residential receivers fall within the vibration criteria buffer distances. Operational vibration is not expected to adversely impact any commercial receivers.

Vibration impacts from the increase number of trains passing by Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge would be managed by undertaking a dilapidation survey of the structures during construction. If the structures are found to be unsound, then a structural engineer will advise if there is a risk from increasing operational train numbers and identify strategies to avoid risks.

7. Conclusion

7.1 Construction impacts summary

Construction activities have been developed based on the construction staging and are proposed to be carried out during and outside standard construction hours.

Three compounds are proposed and would be used throughout the duration of construction to provide support facilities for staff on site, parking, equipment storage and stockpiling locations for materials.

Four ancillary work areas are anticipated to provide support short-term works including vehicle movements and crane operation. The ancillary work areas would only be used when required and would not be a permanent fixture throughout construction.

The predicted noise levels indicate that the NMLs would be exceeded during and outside standard hours. Receivers located next to the works are likely to experience levels above the highly noise affected level of 75 dBA.

Construction traffic movements along local roads would be managed with a construction traffic management plan to limit the degree of road traffic noise impacts.

Vibration intensive plant and equipment may be used for construction of the road, noise wall and bridge. Plant and equipment would be selected to comply with the vibration safe work buffer distances.

Heritage listed structures have been identified within the construction work areas and a building dilapidation survey would be carried out prior to starting vibration generating works near these structures.

It is typical for construction projects to exceed the construction NMLs. Any impacts caused by construction works are temporary in nature and would not represent a permanent impact on the community and surrounding environment. The predicted noise levels are generally conservative and would only be experienced for limited periods during construction. Impacts may be reduced through the introduction of feasible and reasonable mitigation measures; however, these mitigation measures are unlikely to reduce noise levels below the construction NMLs.

7.2 Operational impacts

The predicted ‘no build’ and ‘build’ design year noise levels indicate that architectural treatments need to be considered at one sensitive receiver with the reconstructed noise wall. During detailed design phase, it is recommended that a site visit should be undertaken to determine specific architectural treatments.

Specific operational ground-borne noise and vibration mitigation strategies are not required for the project. A dilapidation survey will be undertaken during construction to assess the structural integrity of heritage bridges located in the study area.

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8. References

Australian Standards (1997), *AS1055.1:1997 Acoustics – Description and measurement of environmental noise*

Australian Standards (2010), *AS2436:2010 Guide to noise and vibration control on construction, demolition and maintenance sites*

Aurecon (2012), *Sefton to Macarthur Southern Sydney Freight Line Noise Barrier Keystone Drawing No 559D-SW1500-NB-0251*

Basner, M and McGuire, S (2018), *WHO Environmental Noise Guidelines for the European Region: A Systematic Review of Environmental Noise and Effects on Sleep*

British Standards (1993), *BS7385-2:1993 Evaluation and measurement for vibration in buildings*

DEC (2006), *Assessing Vibration: a Technical Guideline*

DECC (2009), *Interim Construction Noise Guideline*

DECCW (2011), *Road Noise Policy*

EPA (2000), *Industrial Noise Policy*

EPA (2017), *Noise Policy for Industry*

EPA (2013), *Rail Infrastructure Noise Guideline*

German Standards (1999), *DIN 4155-3 Structural Vibration Part 3: Effects of vibration on structures*

Parsons Brinckerhoff (2016), *Southern Sydney Freight Line Environmental Assessment Volume 2 Technical Papers*

Roosli, M. et al. (2017), *Short and long term effects of transportation noise exposure (SiRENE): an interdisciplinary approach*

Transport for NSW (2018), *Construction Noise and Vibration Strategy*

WHO (2009), *Night noise guidelines for Europe*

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