APPENDIX E – Construction Noise and Vibration Impact Assessment

Construction Noise and Vibration Impact Assessment

More Trains More Services - Coniston Electrical Works

Prepared for: Transport for Tomorrow

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For and on behalf of

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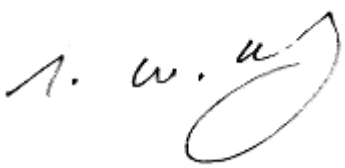
Prepared by:	Reviewed by:	Issued by:
		
David S O'Brien	Stephen Bowley	David S O'Brien
Noise and Vibration Consultant	Principal Environmental Consultant	Noise and Vibration Consultant

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Definitions

Some common terms are provided in the table below.

An **Acoustic Glossary** is provided in **Appendix I**.

Term / Abbreviation	Summary
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed
Attenuation	The reduction in the level of sound or vibration
CEMP	Construction Environmental Management Plan
CNVIA	Construction Noise and Vibration Impact Assessment
CNVMP	Construction Noise and Vibration Management Plan
Construction	Includes all work required to construct the More Trains More Services infrastructure, includes commissioning trials of equipment and temporary use of any part of the Project
dBA	Decibels using the A-weighted scale measured according to the frequency of the human ear
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DPIE	Department of Planning, Industry and Environment
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
Environmental aspect	Defined by AS/NZS ISO 14001:2015 as an element of an organisation's activities, products or services that can interact with the environment
Environmental impact	Defined by AS/NZS ISO 14001:2015 as any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects
Environmental objective	Defined by AS/NZS ISO 14001:2015 as an overall environmental goal, consistent with the environmental policy, that an organisation sets itself to achieve
Environmental target	Defined by AS/NZS ISO 14001:2015 as a detailed performance requirement, applicable to the organisation or parts thereof, that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives
EPA	NSW Environment Protection Authority
EP&A Act	Environmental Planning and Assessment Act 1979
ER	Environmental Representative
EPL	Environment Protection Licences under the POEO Act
Feasible and reasonable	Consideration of best practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.
Heritage Item	A place, building, work, relic, archaeological site, tree, movable object or precinct of heritage significance that is listed under one or more of the following registers: the State Heritage Register under the Heritage Act 1977 (NSW), a state agency heritage and conservation register under section 170 of the Heritage Act 1977 (NSW), a Local Environmental Plan under the EP&A Act, the World, National or Commonwealth Heritage lists under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth), and an "Aboriginal object" or "Aboriginal place" as defined in section 5 of the National Parks and Wildlife Act 1974 (NSW)
Highly Noise Affected	As defined in the ICNG

Term / Abbreviation	Summary
Highly noise intensive works	Works which are defined as annoying under the ICNG, including: a) use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work; b) grinding metal, concrete or masonry; c) rock drilling; d) line drilling; e) vibratory rolling; f) bitumen milling or profiling; g) jackhammering, rock hammering or rock breaking; h) rail tamping and regulating; and i) impact piling.
ICNG	Interim Construction Noise Guideline (DECC, 2009)
$L_{Aeq,15\ min}$	The A-weighted equivalent continuous (energy average) sound pressure level of the construction works under consideration over a 15-minute period and excludes other noise sources such as from industry, road, rail and the community. Sometimes tabulated as L_{eq} or dBA Leq.
MTMS	More Trains More Services
NPfI	Noise Policy for Industry (EPA, 2017)
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
Planning Secretary	Planning Secretary of the Department (or nominee, whether nominated before or after the date on which this approval was granted)
RBL	The Rating Background Level for each period is the medium value of the ABL (Assessment Background Level) values for the period over all of the days measured. There is therefore an RBL value for each period (day, evening and night)
Sensitive Land Uses	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres and passive recreation areas (including outdoor grounds used for teaching). Receivers that may be considered to be sensitive include commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, and retail spaces), and industrial premises as identified by the Planning Secretary Note: For the purpose of determining appropriate mitigation, a multi-storey residential flat building must not be counted as a single sensitive receiver.
SHR	State Heritage Register
Sleep Disturbance	Where the subject development / premises night-time L_{Amax} noise levels at a residential location exceed $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater
SPL SWL	Sound Pressure Level Sound Power Level
TAHE	Transport Asset Holding Entity
TfNSW	Transport for NSW
TfNSW CNVS	Transport for New South Wales Construction Noise and Vibration Strategy, Version 4.2 dated 23 April 2019, Program Management Office, Planning, Environment and Sustainability
TfT	Transport for Tomorrow
VML	Vibration Management Level

1 Introduction

1.1 Background

ADE Consulting Group Pty Ltd (ADE) was commissioned by Transport for Tomorrow (TfT, the 'Client') to undertake a Construction Noise and Vibration Impact Assessment (CNVIA) for proposed construction activities along the rail corridor between Wollongong Train Station and an area approximately 500 m south of Coniston Railway Station under the More Trains More Services (MTMS) Program.

This Construction Noise and Vibration Impact Assessment (CNVIA) aims to achieve the following:

- Describe the proposed electrical works at Coniston
- Identify noise and vibration sensitive receivers adjacent to the proposals site location
- Assign construction noise and vibration criteria
- Assess the potential noise and vibration impacts to the surrounding receivers within the community
- Establish and identify feasible and reasonable mitigation
- Establish project-specific mitigation measures per-receiver based on the predicted impact during each period of the proposed works schedule.

1.2 Project description

The More Trains More Services (MTMS) Program is a series of staged investments designed to progressively deliver service improvements across the network, as part of a broader transformation from a complex, constrained network, to a modern, simplified operation utilising world-class technology.

As part of the MTMS Program integrated infrastructure, fleet and operational changes will deliver service improvements on the T4 Eastern Suburbs & Illawarra (T4), T8 Airport & South (T8) and South Coast line.

The NSW Government is delivering the New Intercity Fleet (NIF) to replace the trains carrying customers from Sydney to the Central Coast, Newcastle, the Blue Mountains and the South Coast. Currently the majority of intercity trains operate as eight car trains however the NIF program would introduce 10-car trains.

The proposed electrical upgrades are required at the Coniston site to support the operation of the NIF trains on the south coast.

1.3 Proposed Works

The works proposed at Coniston comprises of various activities proposed to be undertaken in order to complete the Electrical Works package of the MTMS program.

The anticipated works are as follows:

- Vegetation Management and clearing at locations near to Coniston Railway Station
- Installation of 11 new Overhead Wiring (OHW) Footings
- Installation of 5 new OHW structures
- The installation of a twin link from the Catenary insulator to accommodate twin catenary wires

- The installation of a new 270 mm^2 catenary wire
- The replacement of all OHW cantilever insulators impacted by the works
- The adjustment of OHW cantilevers or replacement where required
- The replacement of worn or life expired Catenary and Contact wires
- Adjustment of feeding and potential jumpers or replacement where required
- Adjustment of existing OHW crossover wires and overlaps
- Works to existing feeding points to support an additional catenary wire
- Structural/durability assessments of all OHW Structures and replacement or modification of all required elements
- Replacement of OHW bridge attachments on the Bridge St Over-Bridge with double insulation bridge attachments

1.4 Site location

The site is located within the rail corridor between Wollongong Train Station and concludes approximately 500 m southwest of Coniston train station. Wollongong train station and Coniston train stations are located approximately 83 km and 84 km south of Sydney CBD, respectively.

Figure 1 below provides an aerial overview of the site's location and anticipated alignment.

Figure 1 Site location and alignment

1.5 Guidelines and standards

Relevant documents pertaining to the measurement, assessment, and management of noise and vibration in Australia are provided below in **Table 1**.

Table 1 Summary of relevant documents

Guideline / Standard	Published by	Relevance
AS 1055:2018 Acoustics – Description and measurement of environmental noise	Australian Standards	Measurement of noise
AS 2659.1-1998 Guide to the use of sound measuring equipment – Portable sound level meters	Australian Standards	Measurement of noise
AS 2436:2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites	Australian Standards	Management of Noise and Vibration on Construction Sites
AS/NZS 2107-2016: Acoustics - Recommended design sound levels and reverberation times for building interiors	Australian Standards	Internal sound level design for Management of Noise
Interim Construction Noise Guideline	Department of Climate Change, 2009	Management of Noise on Construction Sites
Noise Policy for Industry	Environment Protection Authority, 2017	Management of Industry Noise, measurement of noise
Transport for New South Wales Construction Noise and Vibration Strategy	Transport for New South Wales (TfNSW), 2019	Management of Noise and Vibration on Construction Sites
Road Noise Policy	Department of Energy, Climate Change and Water, 2011	Management of Road Traffic Noise, Construction Traffic, and Sleep Disturbance
Accessing Vibration: A Technical Guideline	Department of Conservation, 2006	Management of Vibration
BS 7385: Part 2-1993 Evaluation and measurement of vibration in buildings	British Standards	Management of Vibration
DIN4150-2016: Structural vibration Part 3: Effects of Vibration on Structures	German Standards	Management of Vibration

2 Existing Environment

The project's locality is considered a mixture of Suburban/Urban, Urban, and Urban/Industrial. The dominant ambient noise environment is considered to be natural fauna, road traffic noise from the nearby Princes Motorway, rail traffic along the South Coast (SCO) rail line, and the nearby Pacific Ocean. Some ambient noise from nearby industrial land use may also be present within the area.

Background noise levels have been derived from AS1055.3:1997 *Acoustics – Description and measurement of environmental noise Part 3: Acquisition of data pertinent to land use*, reproduced from the TfNSW CNVS (2019) and presented below in **Table 2**.

Table 2 Typical background noise levels for different areas

Area type	Description	Rating Background Level (RBL) dBA L_{90}		
		Day	Evening	Night
Rural	Areas with negligible transportation	40	35	30
Suburban/Urban	Areas with low density transportation	45	40	35
Urban	Areas with medium density transportation OR some commerce or industry	50	45	40
Urban/Industrial	Areas with dense transportation OR with some commerce or industry	55	50	45

Note: AS1055:1997 is superseded and this table does not appear in the revised 2018 version of this Australian standard. Its use here is based on the TfNSW CNVS reproduction of this information for assessment purposes in lieu of noise monitoring or establishing of ambient noise levels for the purpose of establishing relevant construction noise management levels

Note: Day, Evening and Night-time as defined in the NPfI

2.1 Sensitive land uses

The project is surrounded by a diverse community of various sensitive receiver types and land uses. These include:

- Residential, including high-rise apartment, villas, homes, and townhouses
- Commercial
- Places of worship
- Aged-care, Childcare and early-learning centers
- Educational facilities
- Medical clinics
- Some light industry
- Heritage listed structures

The project is divided into two Noise Catchment Areas (NCAs), surrounding the project boundaries. The NCA boundaries represent logical boundaries based on topography and the type of receivers applicable for that location.

An overview of the NCAs is provided below in **Table 3**, and an illustration is provided in **Figure 2**.

Table 3 Noise Catchment Area overview

NCA	Area type	Locality
NCA01	Suburban/Urban	Coniston – West of the rail line. Predominantly medium density residential
NCA02	Urban	Coniston – East of the rail line. Predominantly medium density residential, high rise apartment buildings, and some commercial or industrial premises

Figure 2 below provide an overview of the surrounding sensitive receivers within the locality of Wollongong and Coniston.

A more detailed illustration of the proposed works and alignment location is provided in **Figure 1**.

Figure 2 Overview of Coniston sensitive receivers. Source: Nearmaps

2.1.1 Heritage

The projects alignment is understood to pass by some heritage structures. These are as follows:

- Wollongong Train Station (State, Transport Asset Holding Entity (TAHE) Section 170 and Local)
- Coniston Train Station (TAHE Section 170)
- TAFE New South Wales Wollongong Campus (Local)
- 18 Bridge Street – The Phoenix Theatre (Local)
- Houses (Bungalows) 69 – 91 Gladstone Avenue (Local).

An aerial overview of the heritage structures is provided below in **Figure 3**.

Figure 3 Aerial overview of heritage structures

3 Noise and Vibration Criteria

The EPA recommends management levels and goals when assessing the potential impacts of construction related noise and vibration.

Works under Transport for New South Wales reference relevant guidelines, policies, and standards tabulated in **Table 1** which provide the framework for management of noise and vibration from construction sites in New South Wales.

This section summarises the noise and vibration goals relevant to the construction works. The noise and vibration criteria varies over the different time periods defined throughout any one 24 hour period and generally more stringent criteria applies in more sensitive evening and night-time periods.

3.1 Airborne construction noise management levels

3.1.1 Residential receivers

Airborne construction noise which impacts residences and other sensitive land uses is assessed and managed through the Department of Environment and Climate Change Interim Construction Noise Guideline (2009).

Project Specific Noise Management Levels (NMLs) are established based on estimated noise level derived from the AS1055.3:1997 Standard, and the TfNSW CNVS Appendix B. The estimated background noise levels are considered conservative and are used for assessment purposes only.

Where noise levels are predicted (or measured) to exceed the NMLs, construction noise minimisation practices are recommended to be investigated.

Table 4 below describes the noise management levels pertaining to residential receivers and how to apply them.

Table 4 Noise at residences using quantitative assessment (ICNG, 2009)

Time of Day	NML dB $L_{Aeq,15min}$	How to apply
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	RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted (or measured $L_{Aeq(15\ minute)}$ is greater than the noise affect level, the proponent should apply all feasible and reasonable work practises 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 a strong community reaction to noise. • Where noise is above the 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 + 5 dB	• 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.

Note: RBL refer to the NPfi defined *Rating Background Level*, assumed background levels are presented in **Table 2**

The resulting Noise Management Levels (NMLs) for all residential noise-sensitive receivers is tabulated below in **Table 5**. These levels represent the noise levels in which projects potential impact, and subsequent noise monitoring (during works) is to be assessed against.

Table 5 Noise Management Level (dBA $L_{Aeq,15\ minute}$) for Residential Receivers

NCA	Area Usage	Standard	Out of Hours (RBL +5)			Sleep Disturbance
		Day	Day	Evening	Night-time	
NCA01	Suburban / Urban	55	50	45	40	50 (RBL+15)
NCA02	Urban	60	55	50	45	55 (RBL+15)

Note: Sleep Disturbance screening is based on RBL+15 noise levels (refer to **Definitions**)
Note: NMLs based on TfNSW CNVS and AS1055 estimated noise levels

3.1.1.1 Sleep disturbance and awakening

The TfNSW CNVS assessment process requires an assessment of Sleep Disturbance and Sleep Awakening events as part of the impact assessment process.

Where construction works are planned to extend over more than two consecutive nights, the ICNG recommends that an assessment of sleep disturbance impacts should be completed. A method for assessing

sleep disturbance is contained in the EPA's Noise Policy for Industry (NPfI) with further guidance sourced from the EPA Road Noise Policy (RNP, 2011).

Although the NPfI sleep disturbance criteria relates to industrial noise, it is also considered relevant for reviewing potential impacts from construction noise as a screening criterion to identify the need for further assessment.

The CNVS recommends that a detailed maximum noise level assessment should be undertaken where a project results in night-time $L_{A1,1\ minute}$ (L_{Amax}) noise levels which exceed a noise level of the prevailing background level (RBL) plus 15 dB.

The RNP indicates that internal noise levels between 50 and 55 dB L_{Amax} are unlikely to cause sleep awakenings, however above this threshold a sleep awakening event is considered likely to occur. To assess external noise levels, a conservative +10 dB outside-to-inside correction is applied as outlined in the ICNG, hence an external noise level screening of 65 dB L_{Amax} is adopted to assess the likelihood of a sleep awakening event occurring.

Resultant sleep disturbance criterion for each NCA is tabulated in **Table 5** above.

3.1.2 Other sensitive land uses and commercial receivers

The project is surrounded by a number of non-residential land uses. **Table 6** below outlines the NMLs for other sensitive receivers.

Table 6 Noise at sensitive land uses (other than residential) using quantitative assessment

Land use	Management level $L_{Aeq,15\ minute}$ (applicable when properties are in use)
Industrial Premises	External noise level 75 dBA
Offices, retail outlets and other commercial properties	External noise level 70 dBA
Classrooms at school and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Community centres	Refer to the recommended 'maximum' internal levels outlined in AS2107 for specific uses

Other noise-sensitive receivers not defined in the ICNG require noise level criteria derived from AS 2107:2016.

The AS 2107 noise level criteria are generally provided as internal levels, and an internal-to-external correction of +10 dB has been applied to assume a conservative noise level with an open window for ventilation.

Table 7 NMLs for 'Other Sensitive Receivers' based on AS2107

Land use	Noise Management Level $L_{Aeq,15\ minute}$	
	Internal	External
Childcare Centre	60 dBA play area 40 dBA sleeping area	70 dBA play area 50 dBA sleeping area
Public Buildings	50 dBA	60 dBA
Café/Bar or Restaurant	50 dBA	60 dBA
Hotel	40 dBA	50 dBA

3.1.3 Maximum allowable Sound Power Levels

The Transport for New South Wales (TfNSW) Construction Noise and Vibration Strategy (CNVS) provides guidance's for the maximum allowable sound power levels from plant equipment. These noise levels are not used for assessment purposes, only when undertaking sound power level testing for plant equipment on site if necessary or as required.

All plant and equipment used on site during construction activities must be below or equal to the allowable noise levels to achieve compliance.

These guidelines are replicated below in **Table 8**.

Table 8 Maximum Allowable noise levels from plant equipment, TfNSW CNVS

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Asphalt – Truck & Sprayer		106	81
Backhoe		111	86
Chainsaw – petrol[4]	4-5hp	114	89
Compactor		106	81
Compressor		109	84
Crane – Fixed		113	88
Crane – Franna	20 tonne	98	73
Crane – Mobile		113	88
Crane – Truck mounted	20 to 60 tonne	108	83
Crusher – Rock[4]		118	93
Dozer	CAT D9	116	91
Dozer	CAT D10	121	96
Elevated work platform – scissor lift		98	73
Elevated work platform		97	77
Excavator – tracked	3 tonne	90	65
Excavator – tracked	6 tonne	95	70
As above + hydraulic hammer[4]		115	90
Excavator – tracked	10 tonne	100	75
As above + hydraulic hammer[4]		118	93
Excavator – tracked	20 tonne	105	80
Excavator – tracked	30 tonne	110	85
As above + hydraulic hammer[4]		122	97
Excavator – tracked	40 tonne	115	90

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Grader		113	88
Generator – diesel/ petrol	6kW	103	78
Generator – attenuated	30kW	92	67
Grinder[4]		105	80
Jackhammer		113	88
Lighting Tower		80	55
Lighting – Daymakers		98	73
Light Vehicle – 4WD		103	78
Line Marking Truck		108	83
Loader – Front-end (wheeled)	23 tonne	112	87
Loader – Skidsteer	1/2 tonne	107	82
Loaders – Skidsteer	1 tonne	110	85
Loader – Tracked	0 to 50 kW	115	90
Loaders – Tracked	200 to 300 kW	121	96
Pavement Laying Machine		114	89
Pavement Profiler		117	92
Pile Driver – Vibratory[4]		121	96
Piling Rig – Bored		112	87
Piling Rig – Impact[4]		134	109
Pump – Concrete		109	84
Rattle gun (hand held)		104	79
Roller – smooth drum		107	82
Roller – large pad foot		109	84
Roller – Vibratory[4]	10 tonne	109	84
Saw – Concrete[4]		118	93
Scraper		113	88
Truck – Concrete		109	84
Truck – Dump	15 tonne	110	85
Truck – Medium rigid	20 tonne	103	78
Truck – road truck/ truck & dog	30 tonne	108	83
Truck – Vacuum (NDD or non-destructive digger)		109	84
Tub Grinder/Mulcher	40-50hp	116	91
Vibrator – Concrete[4]		113	88
Water Cart		107	82
Welding equipment		110	85

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level Leq dBA [1,2,3]	Highest Permissible Sound Pressure Level Leq dBA at 7 m
Wrench – Impact		111	86

Note 1 The Sound Power Level (SWL) represents the total noise output of the plant of equipment. The SWL is normally used in computer noise models to predict the Sound Pressure Levels (SPLs) at nearby receivers. When undertaking site compliance measurements, it is normally the SPL that is measured at a specified distance (typically 7 m) from the plant or equipment

Note 2: The SWLs presented in the above table have been compiled from a selection of field measurements conducted by Heggies Pty Ltd between 2004 and 2006 of plant and equipment operating on construction projects throughout NSW, as well as various TfNSW Noise & Vibration impact assessments and the RMS Construction Noise & Vibration Guideline (August, 2016)

Note 3: Plant and equipment with SWLs higher than those presented in the table would be deemed to be emitting an excessive level of noise and should not be permitted to operate on construction sites

Note 4: Equipment with special audible characteristics.

3.1.4 Construction related traffic

Some heavy truck usage may be used to haul equipment to and from the site to facilitate the activities associated with the Program. Guidance for construction related traffic on TfNSW project is taken from the CNVS which outlines that "*additional traffic on existing roads generated by land use developments (in this case the construction area), any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario".*

Noise monitoring has not been undertaken, therefore the existing ambient traffic noise has not been established. To assess the potential impact of truck haulage, a screening assessment has been undertaken to determine if any potential impact to the sensitive receivers is likely.

Referring to **Table 9** below, screening noise levels for construction traffic.

Table 9 Target construction road traffic noise

Existing road category	Target noise level, dB	
	Day 07:00 hrs to 22:00 hrs	Night 22:00 hrs to 07:00 hrs
Local Road	$L_{Aeq,\ 1\ hour}$, 55 (external)	$L_{Aeq,\ 1\ hour}$, 50 (external)

Should the road traffic noise levels increase by more than 2 dB due to construction traffic, additional mitigation options should be considered and investigated.

3.2 Construction vibration guidelines

Generally, construction which produces vibration may be group into three categories:

- Human Comfort – in which the occupants of a building are disturbed
- Building Contents – in which highly sensitive equipment or other machinery may be affected
- Structural or cosmetic damage – in which the integrity of the buildings structure may be compromised, or weak non-structural components may be damaged.

3.2.1 Effects of vibration on structures

The levels of vibration required to cause cosmetic damage to buildings is significantly higher than the vibration levels in which humans would find tolerable.

Damage caused as a result of vibration can occur due to short-term vibration (vibration which does not occur often enough to cause structural fatigue nor produce resonance) or long-term vibration (all other types of vibration).

Where the potential for structural damage may occur, dilapidation assessments may be necessary to be undertaken prior to and during, or following, construction.

Structural damage vibration guidelines are provided below, derived from British Standard BS 7385 for transient vibration.

3.2.1.1 Transient vibration

BS 7385 provides recommendations in vibration limitations regarding transient vibration. The limits outlined below in **Table 10** are conservative and are judged to give a minimum risk to which vibration may cause damage to buildings.

Table 10 Transient vibration, British Standard BS 7385-3: 1993

Type of Building	Peak component particle velocity (PPV) in frequency range of predominant pulse	
	4 Hz – 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Note: Values referred to are at the base of the building

3.2.1.2 Safe working distances

As a guide, minimum working distances for typical items of vibration intensive plant are listed below in **Table 11**. This data is provided by TfNSW's Construction Noise and Vibration Strategy (CNVS, v4.2 2019).

The minimum working distances are quoted for both cosmetic damage (BS 7385 and DIN4150) and human comfort (Assessing Vibration – A Technical Guideline).

The minimum working distances for cosmetic damage are recommended to be complied with at all times, unless otherwise approved by the relevant authority.

The distances provided in **Table 11** are indicative and would vary depending on the plant or item used for the works, as well as the geotechnical conditions within the surrounding earth.

Table 11 Recommended minimum working distances from vibration intensive plant (TfNSW CNS)

Plant Item	Approximate Size / Weight / Model	Minimum Distance for Cosmetic Damage (BS7385)	Minimum Distance for Human Response (DEC Assessing Vibration)	Heritage (DIN4150)
Vibratory Roller	1-2 tonne	5 m	15 – 20 m	11 m
	2-4 tonne	6 m	20 m	14 m
	4-6 tonne	12 m	40 m	27 m
	7-13 tonne	15 m	100 m	33 m
	13-18 tonne	20 m	100 m	44 m
	>18 tonne	25 m	100 m	55 m
Small Hydraulic Hammer	300 kg (5 to 12texcavator)	2 m	7 m	5 m
Medium Hydraulic Hammer	900 kg (12 to 18t excavator)	7 m	23 m	16 m
Large Hydraulic Hammer	1600 kg (18 to 34t excavator)	22 m	73 m	49 m
Pile Driver – Vibratory	Sheet piles	2 to 20 m	20 m	15 m
Piling Rig - Bored	≤ 800 mm	2 m (nominal)	N/A	6 m
Piling Rig – Hammer	12 t down force	15 m	50 m	45 m
Jackhammer	Hand held	1 m	Avoid contact with structure	3 m

Note: Distances are indicative only, where heavy machinery falls within safe working distances, attended vibration monitoring should be undertaken to confirm vibration levels

Note: Heritage safe working distances are conservative

Generally, vibration monitoring is recommended where construction works within these distances to particular sensitive structures are to occur. The monitoring would verify the minimum working distances at specific locations, which then may be applied to establish a buffer zone surrounding the proposed alignment.

Where the vibration monitoring demonstrates exceedances of the structural/cosmetic damage criteria (refer to **Section 3.2.1.1**), alternative construction methodology may be required, such as selection of equipment designed to produce less vibration (where feasible and reasonable).

In such case, construction works are not recommended to continue until attended vibration measurements confirm any risk of cosmetic damage, particularly to heritage structures found to be structurally unsound.

3.2.1.3 Vibration screening

With the guideline values from BS7385 outlined in **Table 10**, conservative vibration damage screening levels per receiver type have been established based on the potentially worst-case scenario of any vibration intensive plant equipment being in use at any point along the works alignment within the rail corridor.

- Reinforced or framed structures: 25 mm/s
- Unreinforced or light framed structures: 7.5 mm/s.

At locations where the predicted and/or measured vibration levels are greater than those listed above, a more detailed condition assessment of the structure and the construction activities near the structure would be required to determine the applicable safe vibration level for that structure.

3.2.2 Human comfort

Construction activities which have the potential to create ground-borne vibrations may impact sensitive receivers near the project works. Humans are responsive to vibration and some discomfort may arise due to various activities, their intensity and duration.

Structural or cosmetic damage to buildings due to vibration only occur at extreme levels, relative to what humans find tolerable.

For human comfort and exposure to vibration, the NSW document *Assessing Vibration: A Technical Guideline* (DEC, 2006) provides the relevant guidance's derived from British Standards.

Table 12 below tabulates the Vibration Dose Values for human comfort. These values represent a guideline for the total accumulation of vibration energy during a 16 hour day-time period.

Table 12 Vibration Dose Values (VDV) for Intermittent Vibration ($m/s^{1.75}$)

Location	Period	Preferred value, VDV $m/s^{1.75}$	Maximum value VDV $m/s^{1.75}$
Critical areas	Day or Night	0.1	0.2
Residences	Day	0.2	0.4
	Night	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or Night	0.4	0.8
Workshops	Day or Night	0.8	1.6

Note: Daytime is 07:00 hrs to 22:00 hrs

The significance of calculated or predicted VDV at the relevant places of interest can be assessed in terms of human response. **Table 13** below tabulates guideline VDV ranges in residential buildings at which a human response or adverse comment to construction vibration may be likely.

Table 13 Vibration Dose Value ranges which might result in various probabilities of adverse comment within residential buildings

Place and time	Low probability of adverse comment 1 $m/s^{1.75}$	Adverse comment possible $m/s^{1.75}$	Adverse comment probable 2 $m/s^{1.75}$
Residential buildings 16 hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Note 1: Below these ranges adverse comment is not expected
Note 2: Above these ranges adverse comment is very likely
Note 3: For offices and workshops, multiplying factors of 2 and 4 respectively should be applied to the above vibration dose ranges for 16 h day

Table 14 below reproduces the preferred and maximum weighted rms **α** acceleration vibration for continuous and impulsive vibration.

Table 14 Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2)

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y- axis	z-axis	x- and y-axis
Continuous Vibration, m/s^2					
Critical areas	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.010	0.0071	0.020	0.014
	Night	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night	0.020	0.014	0.040	0.028
Workshops	Day or night	0.04	0.029	0.080	0.058
Impulsive Vibration, m/s^2					
Critical areas	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.30	0.21	0.60	0.42
	Night	0.10	0.071	0.20	0.14
Offices, schools, educational institutions, and places of worship	Day or night	0.64	0.46	1.28	0.92
Workshops	Day or night	0.64	0.46	1.28	0.92

3.3 Ground-borne noise

Ground-borne noise impacts are generally caused by high-vibration intensive plant equipment such as tunneling machines. The ICNG provides guidance for the management of ground-borne noise (GNML), these recommendations are tabulated below in **Table 15** applicable only to residential receivers.

Table 15 Ground-borne noise management levels

Evening 18:00 hrs to 22:00 hrs	Night-time 22:00 hrs to 07:00 hrs
40 dB $L_{Aeq,15min}$	35 dB $L_{Aeq,15min}$

Note: During the Daytime period (07:00 hrs to 18:00 hrs), the human comfort vibration objectives only apply

The internal noise levels are to be assessed at the centre of the most-affected habitable room. For a limited number of discrete, ongoing ground-borne noise events, such as drilling or rock-hammering, the L_{Amax} noise descriptor using a slow response on the sound level meter may be better than the L_{Aeq} noise descriptor (15 min) in describing the noise impacts.

The level of mitigation of ground-borne noise would depend on the extent of impacts and also on the scale and duration of works. Any restriction on the days when construction work is allowed would take into account whether the community:

- Has identified times of day when they are more sensitive to noise (for example Sundays or public holidays)
- Is prepared to accept a longer construction duration in exchange for days of respite.

The proposed methodology at Coniston or any other part of the South Works program do not have any tunnelling machines or subjectively high-vibration intensive equipment.

4 Construction Noise and Vibration Impact Assessment

A range of small and large plant equipment is proposed to be utilised in order to undertake the appropriate constructions activities associated with the Project. This section summarises the anticipated construction scenarios and associated predicted noise and vibration impacts.

4.1 Noise

4.1.1 Proposed activities

The proposed construction activities have been divided into 8 construction scenarios in which the works are anticipated to be completed in over multiple railway possessions throughout 2022 and into 2023.

The potential impacts associated with these key activities are assessed based on the type of work that is being carried out, and the time of day/week the works are scheduled to occur over.

Construction works are anticipated to be completed in various stages with the construction activities expected to be completed by December 2023.

It is expected that the activities proposed may be required to work outside the standard daytime hours. The anticipated hours of works are as follows.

Monday to Friday Saturday	Daytime Standard Hours	07:00 hrs to 18:00 hrs 08:00 hrs to 13:00 hrs
Saturday	Daytime Out of Hours	07:00 hrs to 08:00 hrs 13:00 hrs to 18:00 hrs
Sunday Public Holidays	Daytime Out of Hours	08:00 hrs to 18:00 hrs
Monday to Sunday	Evening	18:00 hrs to 22:00 hrs
Monday to Sunday	Night-time	22:00 hrs to 07:00 hrs

Out of hours works and weekend rail Possessions are proposed for works which cannot reasonably be undertaken throughout the normal working-week.

An illustrative overview is provided below in **Table 16**.

Table 16 Periods of works, including out of hours

Hour Commencing	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Monday																								
Tuesday																								
Wednesday																								
Thursday	OOWH Period 2								Standard Hours										OOWH Period 1 (Evening)					
Friday																								
Saturday																								
Sunday									OOWH Period 1 (Day)										OOWH Period 2					
Public Holidays																								

Note: OOWH – Out of Working Hours

Table 17 below provides a general outline of the construction scenarios and their corresponding activity.

Table 17 Work Scenarios for assessment purposes

Scenario ID	Scenario	Activity	Tentative Duration	Proposed Hours of Work				
				Day	Out of Hours Period 1		Out of Hours Period 2	
					Day	Evening	Evening	Night
SN.001	Site Establishment and Mobilisation	Typical Impact	One week at commencement of the project. Then prior to each possession July 2022 to December 2023	✓	✓	✓	✓	✓
SN.002	Footings	Typical Impact	One weekend possession July 2022	✓	✓	✓	✓	✓
SN.003	Vegetation Management	Typical Impact	One weekend possession July 2022	✓	✓	×	×	×
SN.004	Steelworks	Typical Impact	Two weekend possessions July 2022 to November 2022	✓	✓	✓	✓	✓
SN.005	Bridge Street Overbridge Screen Replacement	Typical Impact	One weekend possession July 2022 to December 2023	✓	✓	✓	✓	✓
SN.006	Wiring Preparation Works	Typical Impact	One weekend possession February 2023	✓	✓	✓	✓	✓
SN.007	Run Catenary Wire	Typical Impact	Weekend possessions 7 June to December 2023	✓	✓	✓	✓	✓

Scenario ID	Scenario	Activity	Tentative Duration	Proposed Hours of Work				
				Day	Out of Hours Period 1		Out of Hours Period 2	
					Day	Evening	Evening	Night
SN.008	Site Compound - Operation / Laydown / Stockpile	Typical Impact	12 Months Activity principally concentrated around possessions July 2022 to December 2023	✓	✓	✓	✓	✓

Note: Subject to change or alterations

4.2 Noise model

4.2.1 Calculation methodology

Noise levels have been predicted using 3D predictive software SoundPLAN ver8.2. The prediction model was undertaken using the Industrial Noise ISO 9613 algorithms.

Buildings and the local terrain have been digitised within the model to represent the land surrounding the Project's alignment boundaries.

Data was sourced from Geoscape building footprint database, NSW Spatial Services, and aerial imaging sourced via Nearmaps.

4.2.2 Source noise levels

The Sound Power Levels (SWL) for general and typical construction equipment is provided in **Table 18**. The levels tabulated below are derived from global standard databases.

Construction scenarios, locations, and proposed equipment were provided to us, and confirmed with the Construction manager and Transport for Tomorrow prior to running the assessment. The percentage of on-time is based on standard practices and experience.

Table 18 Sound Power Levels (SWL) for the construction equipment

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.001	Site Establishment and Mobilisation	Typical Impact	Vehicle (light commercial)	1	47%	103	104
			Ute (Light)	1	47%	95	
			Hand Tools	1	47%	91	

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.002	Footings	Typical Impact	Excavator (14 tonne)	1	47%	94	106
			Suction Truck	1	33%	95	
			Concrete Mixer Truck	1	33%	98	
			Dump Truck (≈15 tonne)	1	20%	93	
			Concrete Pump	1	67%	104	
SN.003	Vegetation Management	Typical Impact	Chainsaw	1	33%	109	110
			Mulching machine	1	67%	103	
SN.004	Steel works	Typical Impact	Excavator (14 tonne)	1	33%	92	101
			Flatbed Truck	1	33%	95	
			Telehandler	1	67%	90	
			Elevated Working Platform	1	33%	92	
			Welding Equipment	1	47%	94	
			Ute (Light)	1	33%	93	
SN.005	Bridge Street Overbridge Screen Replacement	Typical Impact	Suction Truck	1	67%	98	102
			Ute (Light)	1	47%	95	
			Hand Tools	1	67%	92	
			Mobile Crane - Franna	1	67%	96	
SN.006	Wiring Preparation Works	Typical Impact	Ute (Light)	1	47%	95	100
			Flatbed Truck	1	33%	95	
			Telehandler	1	67%	90	
			Elevated Working Platform	1	33%	92	

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.007	Run Catenary Wire	Typical Impact	Flatbed Truck	1	67%	98	102
			Telehandler	1	100%	92	
			Elevated Working Platform	1	67%	95	
			Hand Tools	1	67%	92	
			Ute (Light)	2	33%	96	
SN.008	Site Compound - Operation / Laydown / Stockpile	Typical Impact	Truck	1	20%	100	104
			Mobile Crane - Franna	1	33%	93	
			Ute (Light)	1	67%	96	
			Lighting - Diesel Generator	1	100%	98	

Note: Subject to change or alterations
The CNVIA may be updated at anytime to reflect new and updated information regarding the equipment proposed for use during the proposed works

4.2.3 Results overview

The predicted noise levels are analysed in accordance with the policies, guidelines and standards outlined in **Table 1**, and are presented below.

The following tables and figures provide the maximum worst-case $L_{Aeq,15min}$ noise level predicted from the most impacted sensitive receiver for each NCA during all approved construction hour periods.

During most of the construction works, it is reasonable to expect that the noise levels would be lower than the predicted noise levels, as the noise model does not take into account any implemented mitigation measures.

4.2.3.1 Noise management level exceedances (project wide)

Table 19 summarises the number of residential receivers and other sensitive land use which are predicted to experience noise levels which exceed their relevant Noise Management Level, including receivers which would experience noise levels exceeding 75 dBA ($L_{Aeq,15min}$).

Table 19 Project wide overview of NML exceedances

Works Scenario	Number of Receivers exceeding relevant Noise Management Level									
	Number of Receivers	Standard Daytime		Out of Hours Works					
				Out of Hours Period 1		Out of Hours Period 2			
		Daytime	HNA	Day	Evening	Sunday Evening	Night	Sleep Disturbance	Sleep Awakening
SN.001	2636	97	1	161	313	313	659	151	32
SN.002		72	-	175	395	395	786	353	33
SN.003		88	1	225	-	-	-	-	-
SN.004		3	-	13	30	30	70	24	1
SN.005		37	-	83	211	211	467	216	14
SN.006		48	1	112	213	213	430	190	19
SN.007		71	-	135	290	290	569	189	19
SN.008		97	-	155	307	307	748	670	98

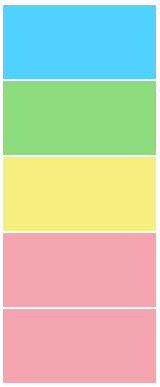
Note: The predicted NML exceedances include all noise sensitive receivers except OOHW which applies to residential
Note: HNA (Highly Noise Affected) only applies to residential receivers
Note: NML Exceedances for residential land use is based on assumed background noise levels discussed in **Section 3.1**

4.2.3.2 Extent of NML exceedances

The results are broken down into four (4) subsets as follows:

NML
- Noise levels 1 to 10 dB above NML (1 – 5 for out of hours)
- Noise levels 11 to 20 dB above NML (5 – 15 for out of hours)
- Noise levels 21 to 30 dB above NML (15 – 25 for out of hours)
- Noise levels greater than 30 dB above NML (>25 for out of hours)

>75 dBA
- Highly Noise Affected, Noise levels exceed 75 dBA ($L_{Aeq,15min}$) (Residential land use only)



Note: The above color code is an arbitrary scheme and not designed to flag exceedances based on their range, rather a category highlight.

The extent and distribution of the NML exceedances are tabulated and illustrated below in **Table 20**.

Daytime and Daytime out-of-hours includes all receivers. Evening and Night-time only include residential as there is no reasonable assumption the local commercial premises would not operate during these periods.

Table 20 Distribution of NML exceedances

Scenario	Number of Receivers															
	Total	HNA >75 dBA	Distribution of NML exceedances													
			Day				Day OOH				Evening (Residential only)				Night time (Residential only)			
			0 - 10	10 - 20	20 - 30	>30	1 - 5	5 – 15	15 – 25	>25	1 - 5	5 – 15	15 – 25	>25	1 - 5	5 – 15	15 – 25	>25
SN.001	2636	2	52	20	-	-	46	50	19	-	116	102	31	3	194	205	48	19
SN.002			49	4			60	52	4		122	136	19	1	227	305	54	2
SN.003			64	7	3	-	83	64	8	2	-	-	-	-	-	-	-	-
SN.004			1	2	-	-	3	3	-	-	14	10	1	-	21	29	1	-
SN.005			23	3	-	-	27	25	1	-	81	67	4	-	140	167	23	1
SN.006			35	5	-	-	30	40	3	-	61	82	8	1	127	159	37	2
SN.007			52	4	-	-	44	53	2	-	85	96	20	-	146	211	50	1
SN.008			49	27	-	-	33	50	25	-	104	84	41	3	269	206	47	25

Note: HNA refers to Highly Noise Affected, based on the ICNG definition
Note: All exceedances are considered conservative worst-case

A bar graph illustration of the above table is provided below in **Figure 4** and tabulates the spread of the exceedances across all work periods, and all receivers during the daytime, residential exceedances during out of hours works.

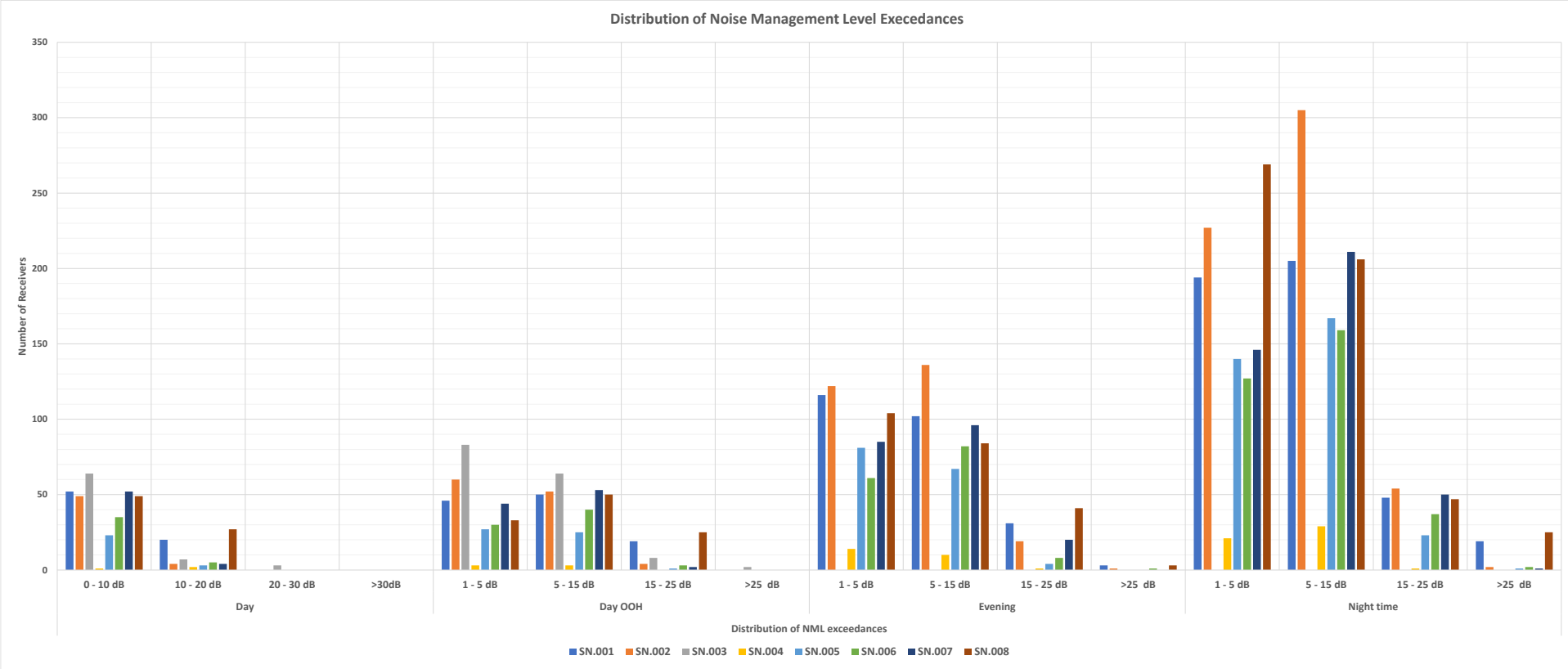


Figure 4 Extent of NML exceedances (all periods, all receivers Day, residential only Day OOH, Evening and Night-time)

Figure 5 below tabulates the number of receivers predicted to exceed their relevant NML during standard working hours.

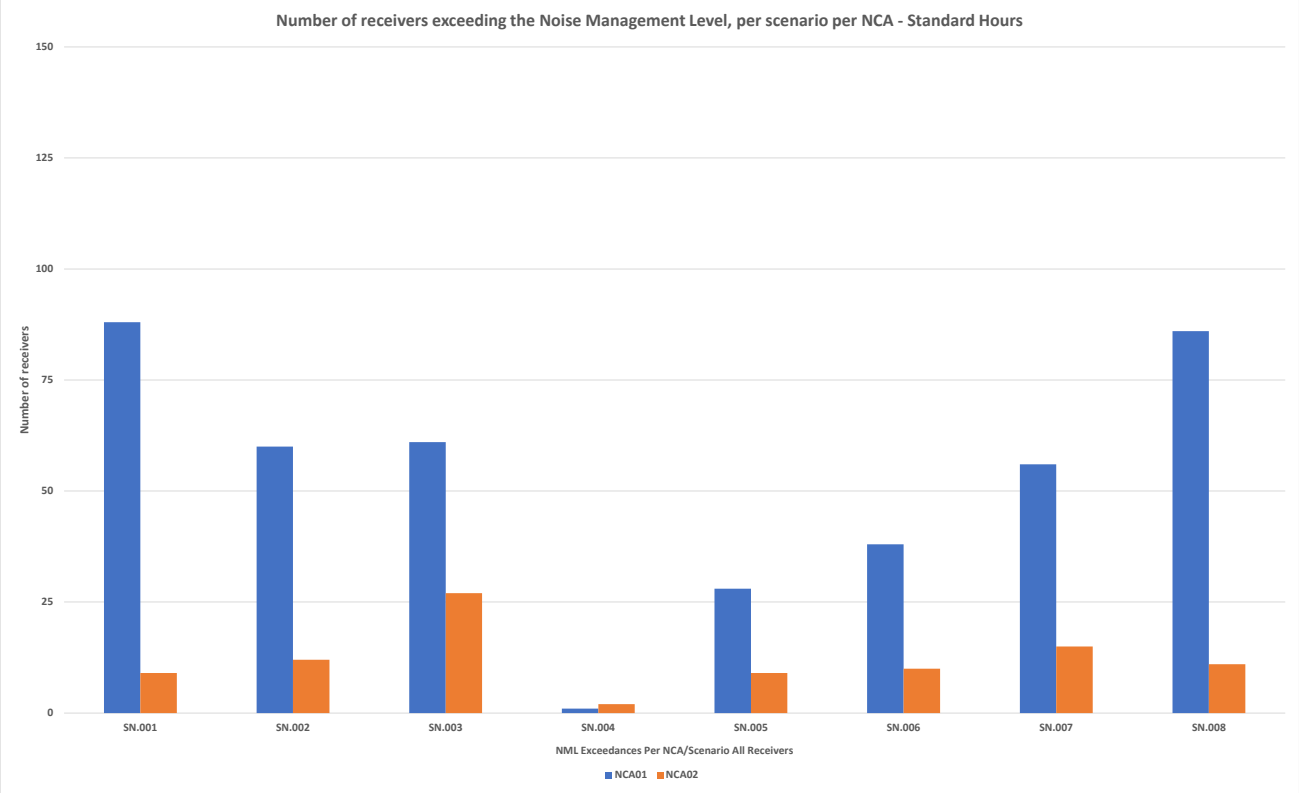


Figure 5 All sensitive receivers exceeding their relevant NML – standard hours

Figure 6 below tabulates day-time out of hours NML exceedances for all receivers.

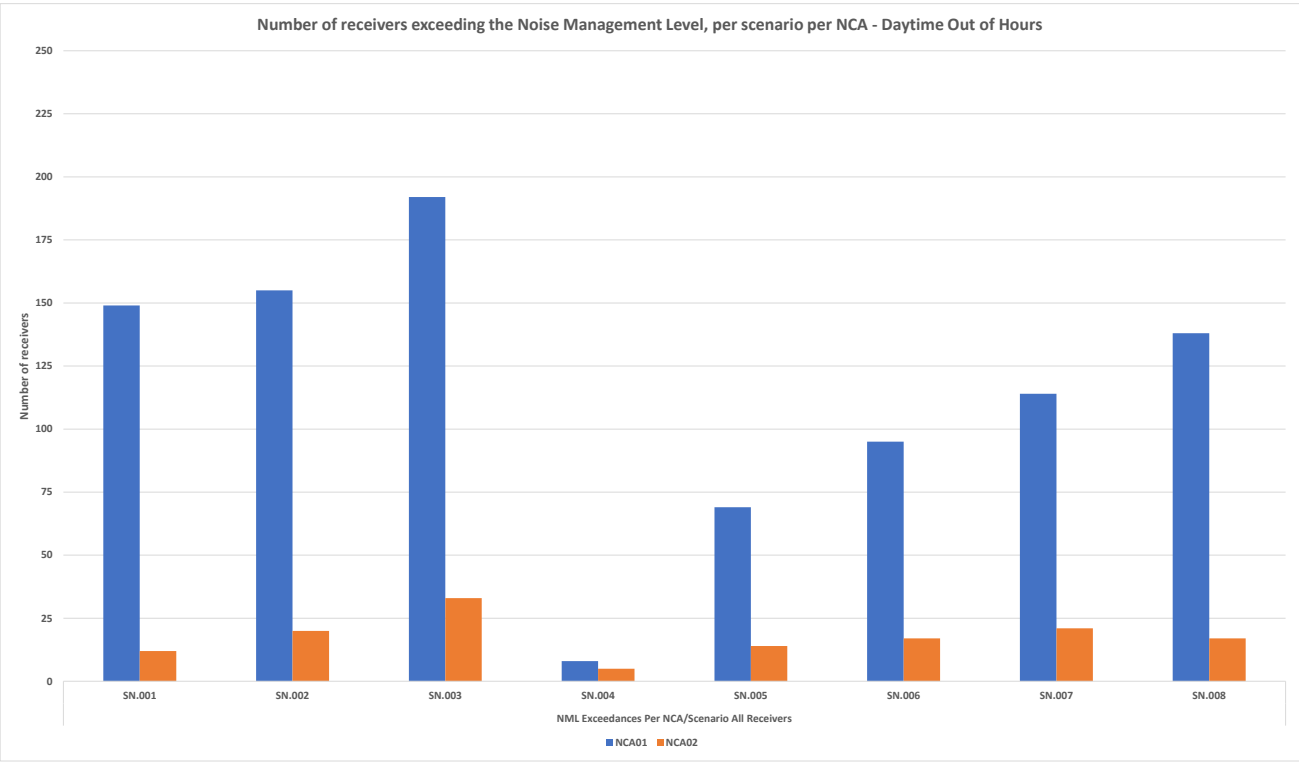


Figure 6 All sensitive receivers predicted to exceed their relevant NML during daytime out of hours

Figure 7 below tabulates evening-time out of hours residential NML exceedances.

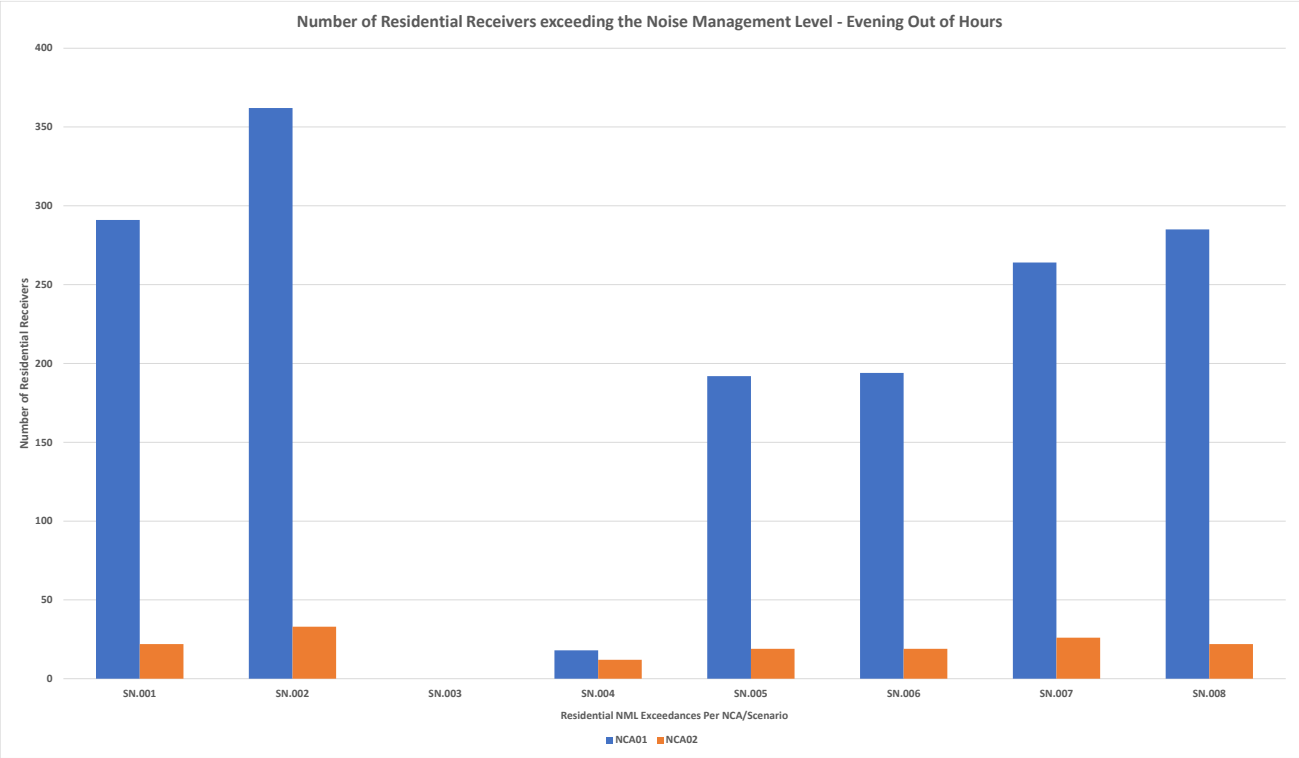


Figure 7 Residential receivers predicted to exceed their relevant NML during evening out of hours

Figure 8 below tabulates night-time out of hours residential NML exceedances.

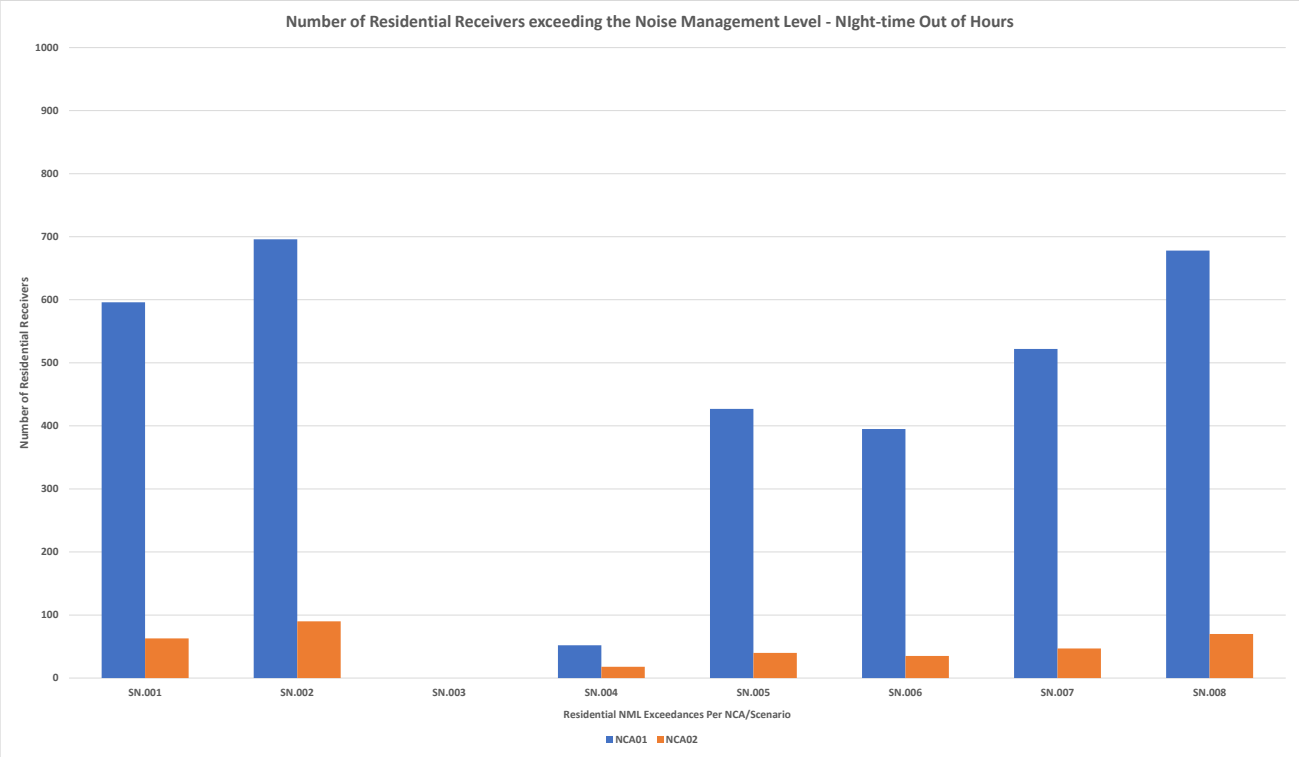


Figure 8 Residential receivers predicted to exceed their relevant NML during night-time out of hours

4.2.3.3 Highly noise affected

A total of two (2) residential receivers are predicted to exceed noise levels of 75 dB $L_{Aeq,15min}$ (highly noise affected). The predicted maximum noise level for any one residential noise sensitive receiver is 88 dB $L_{Aeq,15min}$ for the southern receiver along Bridge Street (refer to **Figure 9**). This noise level is expected during vegetation management activities (Scenario ID SN.003).

Relatively high noise levels (worst-case) would also be experienced at residential premises close to the corridor during SN.001 and SN.006.

Residential land use located on Miller Street is anticipated to exceed the Highly Noise Affected noise goals by 1 dB during site establishment and mobilization activities (SN.001) in close proximity to this receiver within the rail corridor (the cul-de-sac area may also be used as entrance to the corridor).

The residential land uses predicted to exceed the highly noise affected noise goals are presented below in **Figure 9**.

Figure 9 Highly Noise Affected residential land use — standard hours

4.2.4 Worst-case average noise levels

This section provides a tabulated and illustrative overview of the noise models predicted worst-case scenario noise levels, project-wide.

The noise model predictions for each building present the maximum noise level at any level or facade. As noise models account for reflection orders as noise may bounce off buildings, the closest facade facing towards the noise source may not necessarily be the most impacted facade, due to the calculation algorithm.

Table 21 below presents the worst-case scenario noise level (dBA $L_{eq,15min}$) for each NCA per each scenario for residential receivers during all periods of work.

Table 21 Residential worst-case noise level overview, per NCA per scenario

NCA / Scenario	Residential - Worst Case Predicted Noise Levels, dBA Leq,15min							
	SN.001	SN.002	SN.003	SN.004	SN.005	SN.006	SN.007	SN.008
Daytime, and Daytime OOH								
NCA01	73	71	72	53	67	66	68	74
NCA02	76	74	88	69	70	78	70	68
Evening and Night-time periods								
NCA01	73	71	n/a	53	67	66	68	74
NCA02	76	74	n/a	69	70	78	70	68

Note: Shaded red indicates Highly Noise Affected during standard construction hours
Note: SN.003 Vegetation Management not anticipated during the evening/night-time period

Table 22 below presents the worst-case scenario noise level (dBA $L_{eq,15min}$) for each NCA per each scenario for commercial premises receivers during standard hours, and daytime out of hours period 1.

Table 22 Commercial worst-case noise level overview, per NCA per scenario

NCA / Scenario	Commercial - Worst Case Predicted Noise Levels, dBA Leq,15min							
	SN.001	SN.002	SN.003	SN.004	SN.005	SN.006	SN.007	SN.008
Daytime and Daytime OOH								
NCA01	81	64	76	59	60	69	71	72
NCA02	75	75	88	69	73	84	86	81

Note: Shaded red indicated NML exceedances

Table 23 below presents the worst-case scenario noise level (dBA $L_{eq,15min}$) for each NCA per each scenario for other sensitive premises receivers during standard hours.

Table 23 Other Sensitive worst-case noise level overview, per NCA per scenario

NCA / Scenario	Other Sensitive - Worst Case Predicted Noise Levels, dBA $L_{eq,15min}$							
	SN.001	SN.002	SN.003	SN.004	SN.005	SN.006	SN.007	SN.008
Educational								
NCA01	57	46	46	30	42	40	42	58
NCA02	49	53	56	46	47	47	49	50
Child Care								
NCA01	-	-	-	-	-	-	-	-
NCA02	51	49	55	44	45	45	47	51
Industrial								
NCA01	-	-	-	-	-	-	-	-
NCA02	45	56	48	38	52	55	57	45
Public Building								
NCA01	48	37	39	-	33	31	33	55
NCA02	56	65	76	60	65	66	66	53
Hotel								
NCA01	56	66	74	61	62	64	62	55
NCA02	-	-	-	-	-	-	-	-
Aged Care								
NCA01	-	66	74	61	62	64	62	55
NCA02	-	-	-	-	-	-	-	-
Medical								
NCA01	53	43	43	28	39	37	39	55
NCA02	-	-	-	-	-	-	-	-
Place of Worship								
NCA01	-	-	-	-	-	-	-	-
NCA02	41	43	46	28	39	39	41	44

Note: Shaded red indicated exceedances of relevant sensitive land use NML
Note: Noise levels based on standard hours only, as other sensitive land use is not anticipated to be in operation during OOH periods as defined in this assessment

Figure 10 provides an overview of the per-receiver worst-case scenario maximum noise levels dBA L_{eq},15min project wide during the daytime and daytime out of hours works where Vegetation Management would be anticipated to be operational.

Figure 11 below provides an overview of the per-receiver worst-case scenario maximum noise levels dBA L_{eq},15min project wide during the most sensitive time period (night-time).

Figure 10 Daytime and Daytime OOH maximum worst-case noise level dBA $L_{eq,15min}$

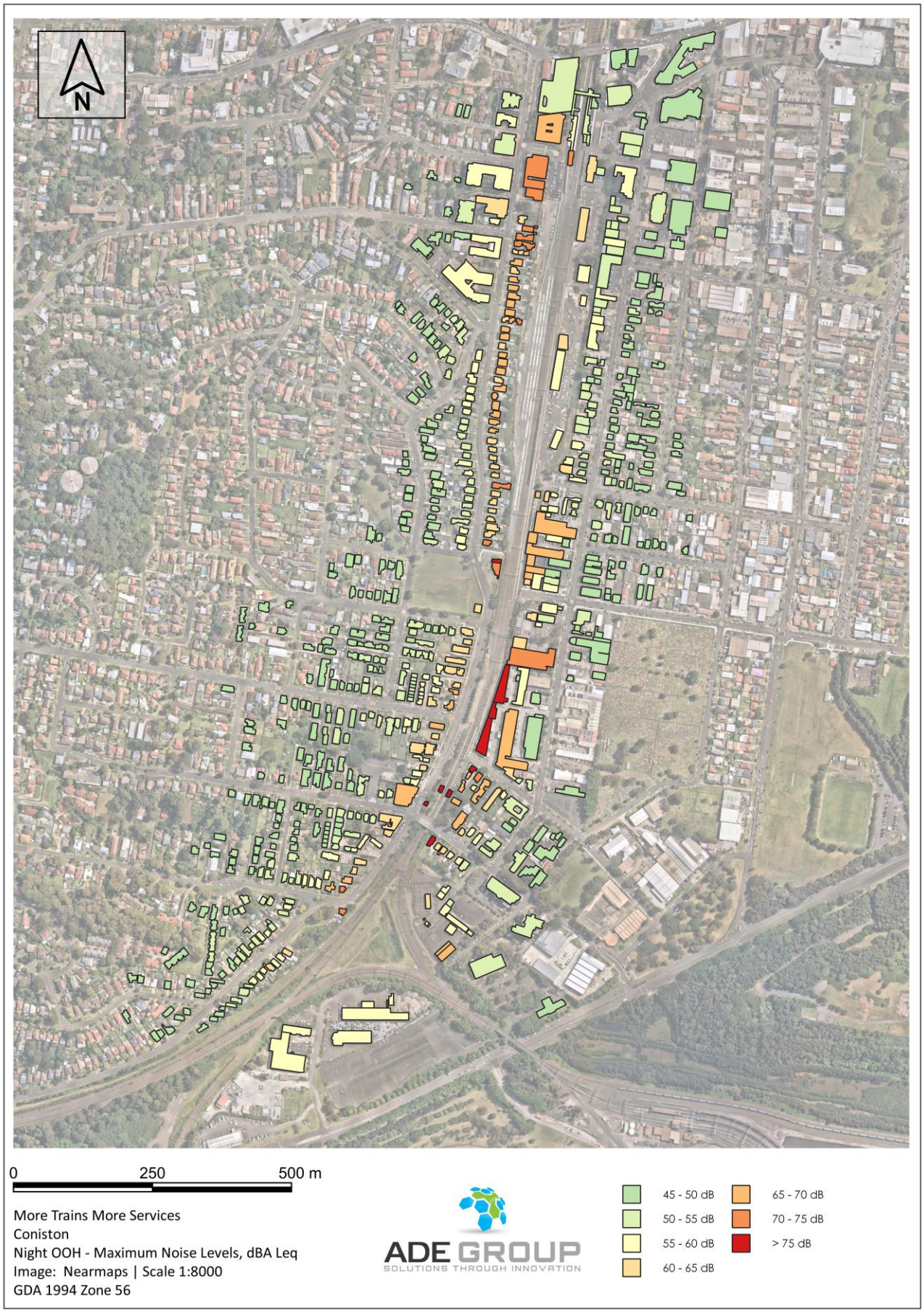


Figure 11 Out of hours – Evening and Night-time worst-case noise levels dBA $L_{eq,15min}$

4.2.5 Discussion

The length of the works alignment exceeds 1,500 m from Wollongong Train Station, to approximately 500 m southwest of Coniston Station towards Spring Hill/Mount Thomas. Over 2,500 sensitive receivers are situated along this alignment, as works move along the rail corridor it is anticipated that the noise impacts would dissipate for some receivers as others would experience increases over time.

NCA01 is comprised predominately of residential low to medium density housing with little to no natural barriers (such as topography benefits or large commercial buildings) to disrupt any line-of-sight noise the works are anticipated to produce.

This results in a wider spread of the potential noise impact, as the terrain naturally slopes up away from the rail corridor; residential properties more towards the west do not benefit from the other dwellings as shields due to this more noise is diffracted, triggering NML exceedances over most of the alignments length.

NCA02 comprises of a mixture of commercial, industrial, other sensitive, and residential premises (predominately high-density apartment blocks with some low-medium density housing). Large commercial buildings along the rail corridor block most of the transmission path of the works' anticipated noise impacts, lowering the impact to these receivers east of the corridor.

Further, noise management level exceedances are considered worst-case scenario as ambient noise monitoring or background noise levels were not established to facilitate this assessment. Assumed background noise levels have been derived and used for assessment purposes to establish the potential impacts of the project.

As the existing ambient noise environment has not been ascertained, this assessment is considered conservative and representative of potential impacts on a worst-case basis.

4.2.6 Sleep Disturbance and Awakening

An L_{max} noise assessment was undertaken for all plant equipment proposed for use during the nighttime period to assess the likely hood of noise events causing sleep disturbance.

Approximately **693** residential properties are anticipated to experience L_{max} noise levels which are predicted to exceed the sleep disturbance criterion of the assumed rating background noise level +15 dB.

This is likely due to the topography sloping up westward from the project site, allowing less built environment to act as shields to the houses further up the hill westward, and the low assumed background noise levels.

Residential properties predicted to experience noise levels resulting in sleep disturbance is provided in **Figure 12** below.

Approximately **115** residential receivers are predicted to experience external $L_{A1,1minute}$ noise levels exceeding 65 dBA L_{max} resulting in the probability of at least one (1) sleep awakening event per night is presented in **Figure 13**.

Figure 12 Residential receivers exceeding sleep disturbance screening criterion

Figure 13 Residential receivers predicted to experience at least one (1) sleep awakening event per night

4.2.7 Construction Traffic

A screening assessment was carried out to assess the potential impact of truck usage on local roads near to the project site along Gladstone Avenue.

The estimation of one haulage truck per hour along Gladstone Avenue with an estimated sound power level of 108 dB (SWL) may have impact noise levels up to 54 dBA $L_{eq,9\ hour}$, or 63 dBA $L_{eq,1\ hour}$.

The predicted traffic noise level from the truck indicates exceedances of the local road traffic noise targets, however the existing traffic noise levels have not been ascertained, therefore it's difficult to determine if the predicted level exceeds the existing level by 2 dB.

The presence of the existing rail line which includes cargo and freight rolling stock from industry and local coal mines would have already existing relatively higher noise levels for receivers along Gladstone Avenue.

Therefore, it is reasonable to conclude that the predicted truck noise levels are not anticipated to have any impact to the receivers along Gladstone Avenue in which a 2 dB increase above existing noise levels would be noticeable.

The screening assessment is considered worst-case, however inconclusive as to the potential impact from any additional construction traffic and cannot be confidently carried out.

The works proposed to be undertaken at the Coniston Works location are not anticipated to use many heavy construction vehicles such as dump trucks or large tippers which would be used during types of construction activities not proposed at the Coniston site, such as activities involving earth works or haulage of high volume Bank Cubic Meter (BCM) waste soils.

Construction traffic would be anticipated to deliver plant equipment and personnel to and from the site infrequently (ie several times per day). It is accepted that the proposed route is the most feasible route. An alternative route is not considered reasonable due to the low frequency of the construction traffic.

4.2.7.1 Recommendations

A noise monitoring program may be implemented or carried out to confirm the anticipated impact, with additional operator attended monitoring prior to site occupation to establish the existing ambient noise environment, and, determine if the predicted traffic noise levels are below the existing ambient.

Any background/ambient noise monitoring should be undertaken in the daytime, evening and night-time period to supplement the assumed background noise levels per the NPfI, AS1055, and industry best practice. Long term noise logging is not required.

4.2.7.2 Noise Monitoring

Ambient noise monitoring prior to site occupation may demonstrate existing ambient noise levels (L_{eq}) exceeding the predicted traffic noise levels. In this case, no further action would be required or necessary as the predicted truck noise levels would be equal to or less than the existing ambient noise environment, hence no impact.

Where the predicted traffic noise exceeds the measured ambient noise by 2.1 dB or greater, additional mitigation should be considered where feasible and reasonable. Such measures may include but are not limited to:

- Noise monitoring to confirm predicted noise impacts
  - Where monitoring of the construction traffic shows impact lower than predicted, no further action would be necessary

- Alternative route or access points to the corridor
- Community notifications (ie letterbox drops)
- No local road use during the night-time period (ie only daytime access)
- Deliveries and truck use scheduled during daytime period.

The purpose for undertaking ambient noise monitoring is to establish a supplementary assessment background level (ABL) and average noise levels for the daytime and night-time period to assess the predicted noise levels of construction traffic against the existing ambient environment. This measurement would facilitate the screening assessment outlined **in Section 4.2.7**.

Where measurement of traffic noise levels is undertaken, the measured dBA $L_{eq,1\ hour}$ (or estimated L_{eq} based on an L_{AE} assessment) would be used to directly compare against the supplemental background and ambient noise level. During the measurement, construction related traffic is required to be present. The engaged acoustic consultant would liaise with the construction contractor to determine the anticipated delivery time frame of any plant equipment during the sensitive time period under assessment (likely the night-time period).

4.3 Vibration

The safe working distances outlined in **Section 3.2.1.2** and presented in **Table 11** are considered to be conservative for continuous vibration. Works within the safe working distances does not guarantee that any impact would occur, rather that consideration regarding methodology and potential impacts may be required.

The distances provided in **Table 11** are generally estimations for vibration intensive equipment such as rollers and piling equipment. The works outlined within this assessment are not anticipated to include any vibration intensive plant.

A subjective risk assessment is provided below in **Table 24** which outlines the most vibration sensitive structures in close proximity to the Project.

Table 24 Potential vibration impacts

Item	Approximate Distance (m) to works	Type of structure	Risk assessment			
			Cosmetic	Structural	Human Comfort	Vibration Monitoring
Wollongong Train Station	≈10	Railway Station	Low	Nil	n/a	No
Coniston Train Station	≈1	Railway Station	Low	Nil	n/a	No
Row of Bungalows 69 – 93 Gladstone Avenue	≈25	House / Residential	Low	Nil	Low	No
18 Bridge Street – The Phoenix Theatre	≈25	Theatre, Auditorium	Low	Nil	Low	No
TAFE 38 -46 Gladstone Avenue	≈100	Educational	Nil	Nil	n/a	No

Note: Risk assessment is subjective and not formulated from any structural engineering advice
Note: Heritage structure is not considered more sensitive unless it is structurally unsound

Vibration intensive plant equipment are not proposed to be operated near any of the sensitive structures. There are no anticipated Ground-Borne vibration impacts from the works as no vibration intensive plant are proposed for use.

Human comfort is considered for this assessment. For humans to be affected by vibration, long durations of consistent vibration would be required for any impact to be noticeable.

The most vibration intensive plant proposed for use would be the rolling of excavation equipment, truck haulage (light trucks and 15T dump trucks are anticipated, no heavy rigs are expected to be employed). The average distance between the works location and a sensitive dwelling with a habitable room is approximately 25 m. The proposed plant equipment are not anticipated to cause any vibration impacts which would affect human comfort.

Should any vibration intensive plant equipment be introduced during the works which is not addressed in this CNVIA, this report is recommend to be updated prior to the plant equipment's deployment to address any potential human comfort, or cosmetic damage concerns.

5 Environmental Mitigation Measures

5.1 Standard mitigation

The Transport for New South Wales CNVS provides a base framework for all feasible and reasonable noise management and mitigation practices.

The strategies outlined below in **Table 25** describe various work practices to minimise noise on work sites. These items summarise the most effective measures, designed to manage and lower noise impacts from construction works.

Table 25 Standard Mitigation Measures

Action Required	Applies to	Details
Management Measures		
Implementation of any project specific mitigation measurement required	Airborne Noise Ground-borne noise and vibration	In addition to the measures set out in this table, any project specific mitigation measures identified in the environmental assessment documentation (e.g. EA, REF, submissions or representations report) or approval or licence conditions must be implemented
Operation of plant equipment	Airborne Noise	All plant and equipment on site to be operated in a proper and efficient manner by an appropriately qualified and competent operator
Implement community consultation measures	Airborne Noise Ground-borne noise and vibration	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: • Project Specific Website • Project Infoline • Construction Response Line • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings and • Community Based Forums (if required by approval conditions)
Register of noise sensitive receivers	Airborne Noise Ground-borne noise and vibration	A register of all noise and vibration sensitive receivers (NSRs) would be kept on site. The register would include the following details for each NSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan

Action Required	Applies to	Details
Construction Respite Periods	Airborne Noise Ground-borne noise and vibration	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Site Inductions	Airborne Noise Ground-borne noise and vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on high noise generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures
Behavioural practices	Airborne Noise	• No swearing or unnecessary shouting or loud stereos/radios; on site. • No dropping of materials from height; throwing of metal items; and slamming of doors. • No excessive revving of plant and vehicle engines • Controlled release of compressed air.
Monitoring	Airborne Noise Ground-borne noise and vibration	A noise monitoring program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne noise and vibration	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria further vibration site law investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity.

Action Required	Applies to	Details
		Continuous vibration monitoring with audible and visible alarms would be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the applicable safe-working distances
Update Construction Environmental Management Plans	Airborne Noise Ground-borne noise and vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies
Building Condition Surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage
Source Controls		
Construction hours and scheduling	Airborne Noise Ground-borne noise and vibration	Where feasible and reasonable, construction would be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods
Construction respite periods	Airborne Noise Ground-borne noise and vibration	High noise and vibration generating activities may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block
Equipment selection	Airborne Noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods 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.
Maximum noise levels	Airborne Noise	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the criteria in **Table 8**
Rental plant and equipment	Airborne Noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in **Table 8**
Plan worksites and activities to minimise noise and vibration	Airborne Noise Ground-borne noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site
Non-tonal reversing alarms	Airborne Noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work
Minimise disturbance arising from delivery of goods to construction sites	Airborne Noise	• Loading and unloading of materials/deliveries is to occur as far as possible from NSRs • Select site access points and roads as far as possible away from NSRs • Dedicated loading/unloading areas to be shielded if close to NSRs • Delivery vehicles to be fitted with straps rather than chains for unloading, wherever feasible and reasonable

Action Required	Applies to	Details
Use and siting of plant	Airborne Noise	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Construction related traffic	Airborne Noise	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
Silencers on mobile plant	Airborne Noise	Where possible reduce noise from mobile plant through additional fittings including: • Residential grade mufflers • Damped hammers such as "City" Model • Rammer Hammers • Air Parking brake engagement is silenced.
Prefabrication of materials off-site	Airborne Noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression brakes	Airborne Noise	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.
Path Controls		
Shield stationary noise sources such as pumps, compressors, fans etc	Airborne Noise	Stationary noise sources would be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding
Shield sensitive receivers from noisy activities	Airborne Noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant

5.1.1 Additional noise mitigation measures

In accordance with the TfNSW CNVS, the implementation of standard mitigation measures, and compliance with maximum sound power levels for plant and equipment, construction hour management, and standard community consultation measures outlined within the CNVS should reduce the noise and any potential vibration impacts on nearby sensitive receivers.

The TfNSW CNVS provides guidance for Transport Projects where exceedances of the construction noise and vibration management levels are likely to, or are predicted to, occur. These measures are summarised from the CNVS and presented below in **Table 26**.

Table 26 Description of Additional Mitigation Measures

Measure	Description	Abbreviation
Periodic Notification	For each IP project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications 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 (e.g. 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 on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the IP Community Engagement Team in cases where AMM are not triggered as shown in **Table 27**, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the IP 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 may 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 (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. 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 CNVIS amended.	V

Measure	Description	Abbreviation
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders 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 • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	SN
Respite Offer	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. The offer could comprise pre- purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all IP projects.	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 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 impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week, except where there is a Duration Respite. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6). Note; this management measure does not apply to OOHW Period 1 – Days.	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to 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. This measure is determined on a project-by-project basis, and may not be applicable to all IP projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with IP Community Engagement Representatives.	DR

5.1.2 Applying additional mitigation measures

Additional Mitigation Measures (AMM) are recommended to be considered to offset impacts where the application of standard and project-specific mitigation measures (outlined in **Table 25**) are taken into consideration when assessing the potential noise and vibration impacts, however the relevant NMLs are still predicted to be exceeded.

Table 27 below tabulates the thresholds for each time period and range of noise above the predicted L_{eq} impact to the surrounding sensitive receivers.

Table 27 Additional Mitigation Measures

Construction Hours	Receiver perception	Predicted dBA (L_{eq}) above RBL		Predicted dBA (L_{eq}) above ANML		Additional management measures
		Range (dB)		Range (dB)		
Standard Hours Monday to Friday – 7 am to 6 pm Saturday – 8 am to 1 pm	Noticeable	5	10	0		-
	Clearly audible	>10	20	<10		-
	Moderately intrusive	>20	30	>10	20	PN, V
	Highly Intrusive	>30		>20		PN, V
	>75 dBA Leq	n/a		n/a		PN, V, SN
OOHW Period 1 Monday to Friday - 6 pm to 10 pm Saturday – 7 am to 8 am, 1 pm to 10 pm Sunday/PH – 8 am – 6 pm	Noticeable	5	10	<5		-
	Clearly audible	>10	20	>5	15	PN, RP, DR
	Moderately intrusive	>20	30	>15	25	PN, V, SN, RO, RP, DR
	Highly Intrusive	>30		>25		PN, V, SN, RO, RP, DR
OOHW Period 2 Monday to Saturday – 12 am to 7 am, 10 pm to 12 am Sunday/PH – 12 am to 8am, 6 pm to 12 am	Noticeable	5	10	<5		PN
	Clearly audible	>10	20	>5	15	PN, V, SN, RO, RP, DR
	Moderately intrusive	>20	30	>15	25	PN, V, SN, RO, RP, DR
	Highly Intrusive	>30		>25		PN, V, SN, RO, RP, DR, AA

Notes PN = Project Notification SN = Specific Notification, Individual Briefings, or phone call
V = Verification Monitoring AA = Alternative Accommodation RP = Respite Period
DR = Duration Reduction RO = Project Specific Respite Offer

Additional notes to **Table 27** include the following:

- SWLs used for the purpose of estimating noise impact shall be increased by 5 dBA where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics.
- Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 7 am-8 am and 1 pm-6 pm, Sundays / Public Holidays 8 am-6 pm)
- Respite offers during OOHW Period 2 are only applicable for evening periods (i.e. Sundays / Public Holidays 6 pm-10 pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1.

5.1.2.1 Overview of additional mitigation measures

Under the TfNSW CNVS, noise levels predicted to exceed the Noise Management Levels (NMLs) require specific additional mitigation measures, summarised above in **Table 27**.

The extent of the additional noise mitigations (AMM) is broken down per each scenario in the following figures.

Figure 14 below provides an overview of the AMM per scenario during standard construction hours during the day.

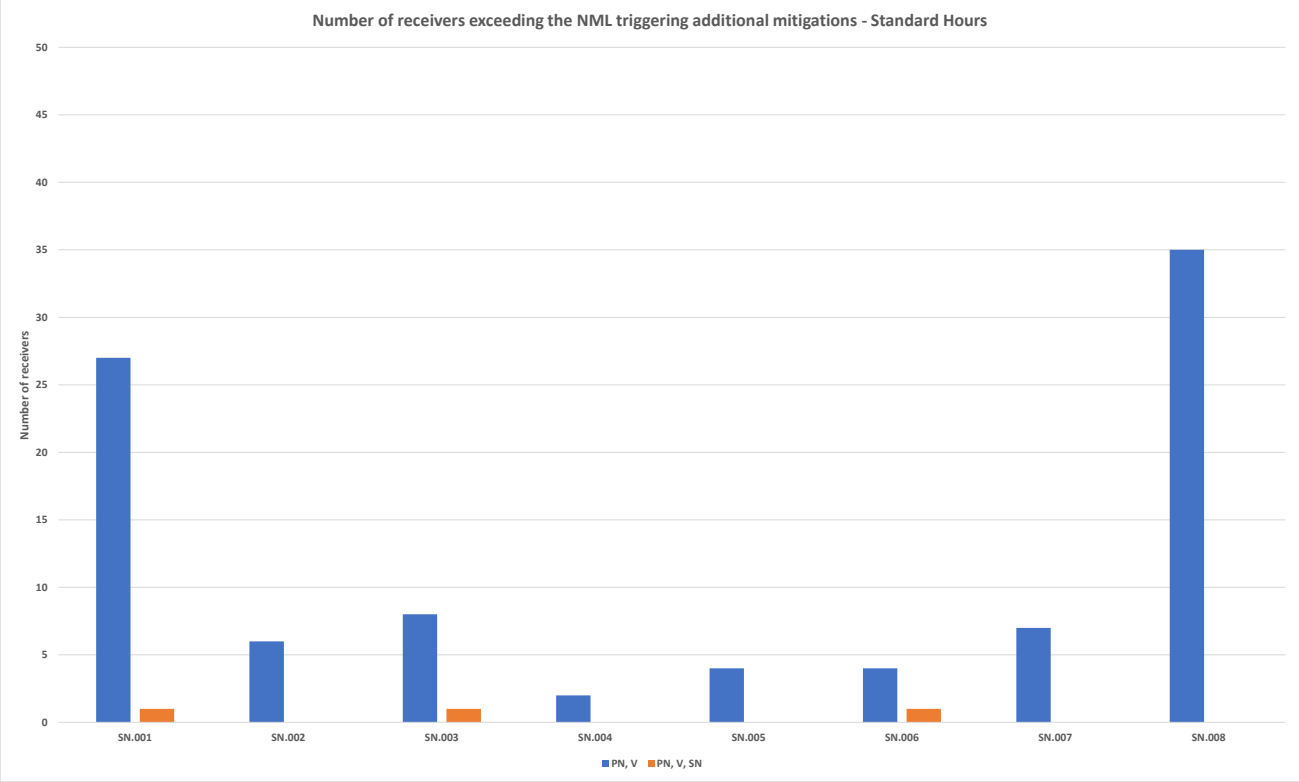


Figure 14 AMM Standard Construction Hours

Figure 15 below provides an overview of the AMM per scenario during the out of hours day-time period.

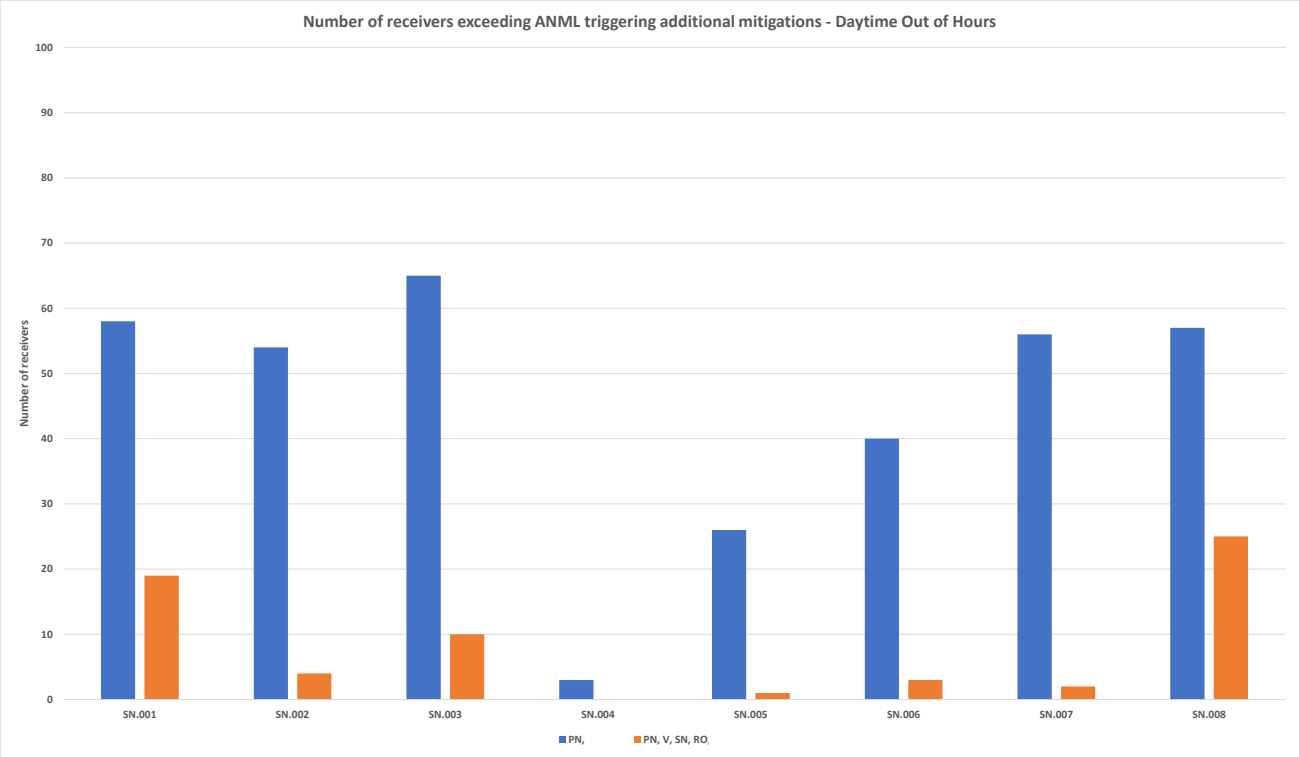


Figure 15 AMM Day – out of hours

Figure 16 below provides an overview of the AMM per scenario during the evening-time period.

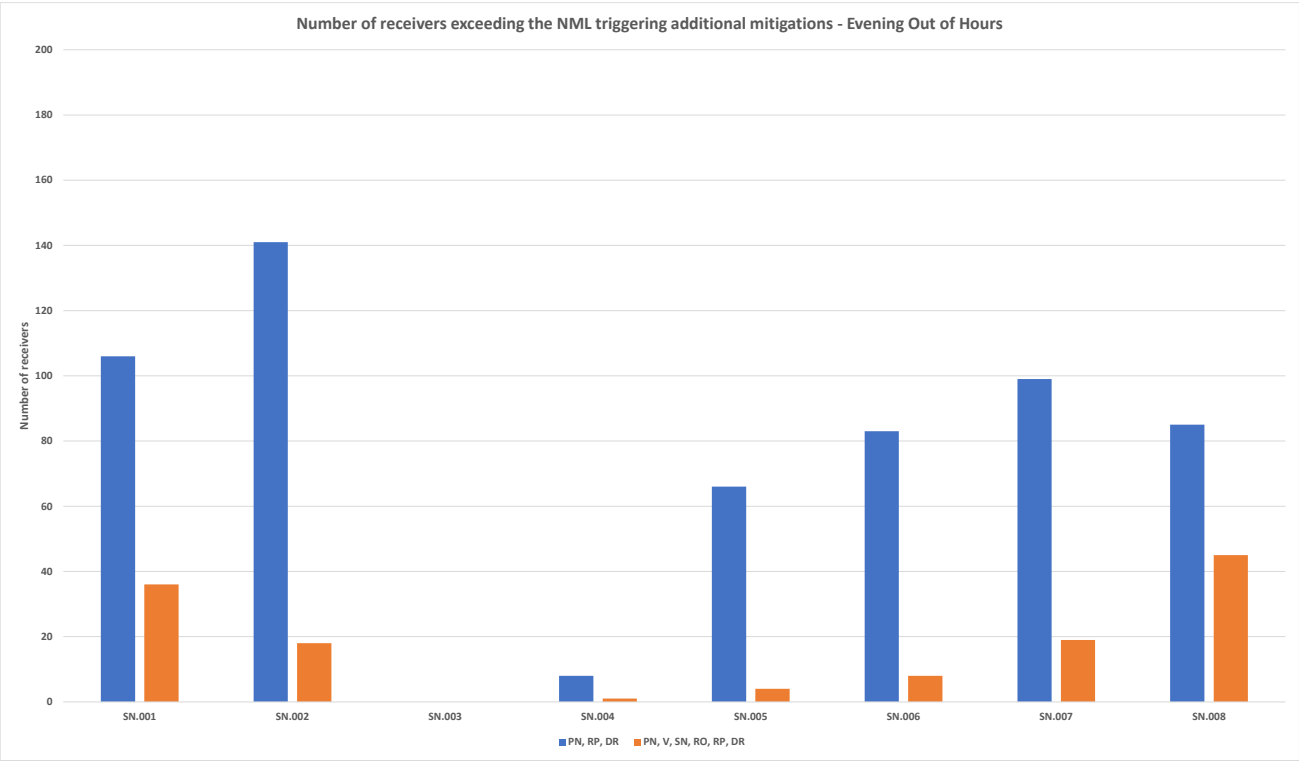


Figure 16 AMM Evening

Figure 17 below provides an overview of the AMM per scenario during the Sunday evening time period.

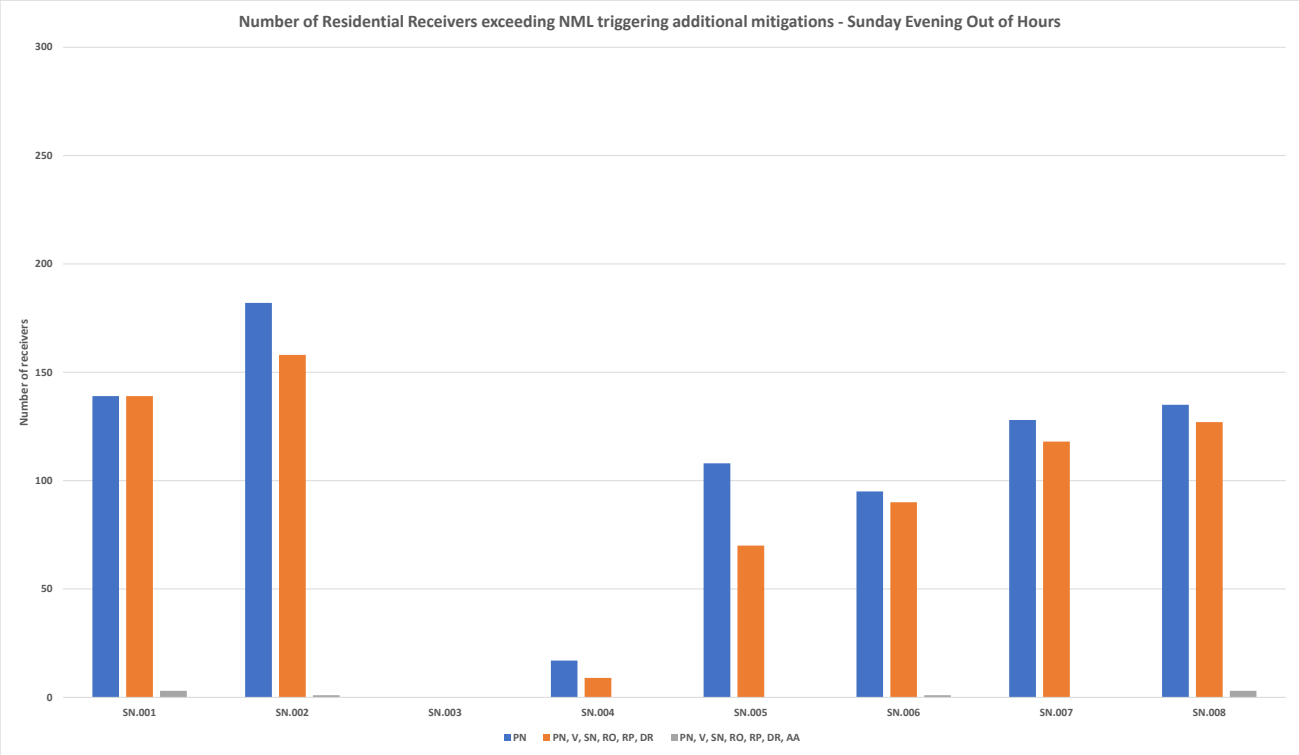


Figure 17 AMM Sunday Evening

Figure 18 below provides an overview of the AMM per scenario during the night-time period.

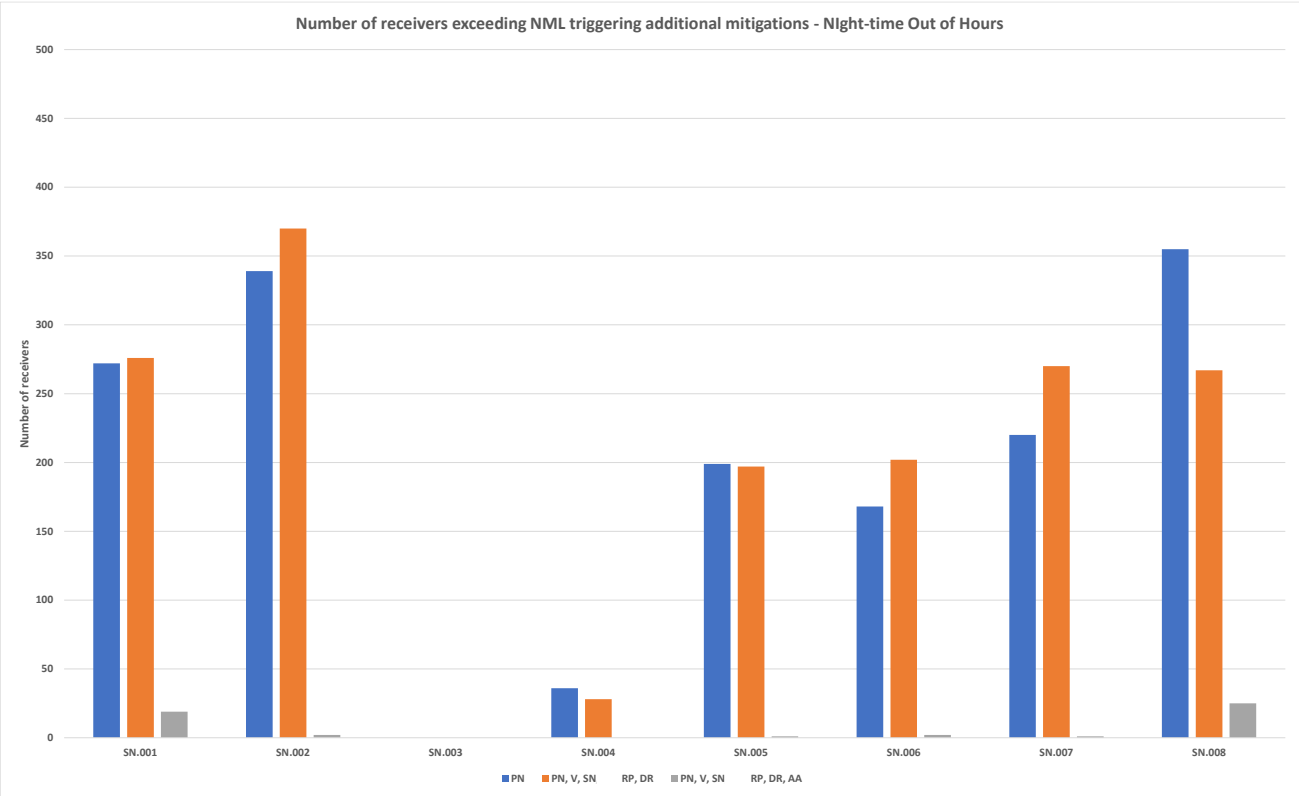


Figure 18 AMM Night-time

5.1.2.2 Extent of additional mitigation measures

Figure 19, **Figure 20**, **Figure 21**, **Figure 22**, and **Figure 23** over the following pages provide an illustrative overview of the extent of the recommended and appropriate airborne Additional Mitigations Measures (AMM). These properties trigger for additional mitigation in accordance with the TfNSW CNVS due to the relatively low assumed background noise management levels during the night-time period, the works proposed during this period, and, the proximity of the receivers to the works along the corridor alignment.

The extent of the additional mitigations are triggered on a project-wide worst-case scenario basis driven by the predicted worst-case average noise levels. The mitigations are likely due to proximity of sensitive land uses to the works locations. Stockpiles, compounds, and the overall length of the works alignment over the duration of the projects anticipated construction timeframe (estimated to be completed by December 2023).

The topography of the encompassing environment allows for greater noise diffraction as less of the western residential built environment are shielding due to the natural up-hill incline westward.

The most noise intensive work activities during the most sensitive time periods are anticipated to be operation of the compounds and stockpile locations, and the general wiring and cable works which extend through the alignment.

Figure 19 Additional Noise Mitigation Measures, Daytime extent (all receivers)

Figure 20 Additional Noise Mitigations, Daytime Out of hours

Figure 21 Additional Noise Mitigation Measures, Evening extent (Monday to Saturday)

Figure 22 Additional Noise Mitigation Measures, Sunday evening extent

Figure 23 Additional Noise Mitigation Measures, Night-time extent

5.2 Discussion

The spread of noise is influenced by the local topography as sensitive land uses west of the rail corridor are located on an incline, increasing in altitude westward. This allows the noise to diffract over houses and reach houses behind, any barrier effect these houses would have is minimal, triggering the additional mitigation presented over **Figure 19**, **Figure 20**, **Figure 21**, **Figure 22**,and **Figure 23**.

Approximately **33** residential properties are triggered for Alternative Accommodation (AA) during most of the night-time assessed works, however most of the properties are triggered during activities SN.001 and SN.008. This is due to the close proximity of the works locations to the facades of these properties.

5.2.1 Spread of Alternative Accommodation

During the initial site establishment phases of the project's timeline, works occurring along the proposed alignment may have impacts reaching the length of the proposed alignment.

During this phase of works, approximately **19** residential premises are triggered for AA. These properties are presented in **Figure 24**.

Figure 24 Residential properties triggered for AA during site establishment and mobilisation activities (SN.001)

Most of the AA triggering is during **SN.008** where the northern and central most compounds proposed for use may include the use of trucks, excavators, lighting generators or other equipment with no barriers or natural hording to shield the path of transmission, resulting in the noise model triggering these properties for alternative accommodation.

These areas are in close proximity to sensitive receivers situated along Gladstone Avenue.

During these works, **25** residential properties are triggered for AA due to the nature of the works, line of distance, and proximity to the receivers facades as stockpile and compound locations include areas in close proximity to the railway station at Wollongong and Coniston.

These properties are presented below in **Figure 25**.

Figure 25 Residential properties triggered for AA during compound and stockpile activities (SN.008)

Alternative Accommodation is not triggered for any one residential premises during SN.003 (daytime vegetation works) or SN.004 (localised steel works).

Other night-time proposed works which trigger residential land use for AA are SN.002 (2 properties), SN.005 (1 property), SN.006 (2 properties), and SN.007 (1 property). The two residential land use triggered during these works are illustrated below in **Figure 26**.

Figure 26 Residential land use triggered for AA during SN.002, SN.005, SN.006, and SN.007 works

During these works, distance limitations for these properties triggered for AA apply.

5.2.2 Respite Offer (RO)

Up to 217 properties are triggered for RO mitigations during evening out of hours period 1 and 2 (ie Monday to Sunday 18:00 – 22:00).

Figure 21 and **Figure 22** provides an illustrative overview.

5.2.2.1 Reasonable distance for respite offer and alternative accommodation

Table 28 below describes the distance (in meters) limitation for each scenarios work activity where residential properties are triggered and eligible for Respite Offer (RO) during Sunday Evening and Evening works (defined in **Section 5.1.2**)

Properties outside of this distance in any direction from the works area would not be eligible for Respite Offers during that activity.

Table 28 Distance limitation to receivers eligible for RO

Activity	Noise level triggering Respite Offer (dBA L_{eq})	Conservative distance limit from works triggering RO NCA01 / NCA02
Site Establishment and Mobilisation (SN.001)	NC01 - 45 (40 NML) NC02 - 50 (45 NML)	310 m / 160 m
Footings (SN.002)		400 m / 220 m
Vegetation Management (SN.003)		**Not Applicable**
Steel Works (SN.004)		230 m / 120 m
Bridge Street Overbridge Works (SN.005)		230 m / 140 m
Wiring Works (SN.006)		200 m / 110 m
Run Catenary Wire (SN.007)		250 m / 150 m
Compound Operation and Utilisation / Laydown Stockpile (SN.008)		290 m / 160 m

Note: Distances presented are conservatively based, and do not include natural barriers or topography. Properties not triggered in **Section 5.1.2.2** are not automatically eligible based on this distance. This table only demonstrates the distances from the works at any specific location and which properties triggered in **Section 5.1.2.2** would be eligible at the time of those works if those properties are located within the distances presented above
Properties triggered for RO in **Section 5.1.2.2** however located further than the distances provided above to the works in the evening period, are not eligible for RO during that activity

Note: *Left* distance refers to residential land use within NCA01, *right* distance refer to residential land use within NCA02. Refer to **Section 2.1** and **Figure 2** for NCA definition and categorization

Where works are proposed and scheduled to be in one localised area, the RO spread would be limited to the distances outlined above for that activity.

The distance for all residential land uses within NCA01 where Alternative Accommodation is triggered and would be eligible is ≈50 m. Properties within NCA01 and are further than 50 m away from night-time works area boundaries would not be eligible for AA.

The distance for all residential land uses within NCA02 where Alternative Accommodation is triggered and would be eligible is ≈30 m. Properties within NCA02 and are further than 30 m away from night-time works area boundaries would not be eligible for AA.

5.2.3 Recommendations

In accordance with the TfNSW CNVS, appropriate mitigation outlined in **Table 25** should be applied where feasible and reasonable. Additional recommendations are formulated as follows:

- Prioritise noise intensive equipment during the daytime period where feasible
- Prioritise all delivery and transport of goods and plant equipment, and, use of stockpile and compounds during the daytime period where feasible
- Undertake attended noise monitoring during the works where works are anticipated to be in close proximity to noise sensitive receivers along Gladstone Avenue
  - In the event that noise levels exceed those tabulated in this report:
    - Noise management level or sleep disturbance exceedances would be responded to through review of equipment on site
    - Review of implemented mitigation (standard and project specific if relevant)
    - Review of sensitive-land use specific mitigation measures (if relevant)
    - Review of feasible and reasonable mitigation
  - Where noise levels do not exceed those tabulated in this report:
    - Apply the AMM mitigations tabulated in **Table 27**
- Vibration monitoring is not anticipated to be necessary unless the following circumstances arise:
  - In the event of any one (1) adverse community comment, complaint, or concern
  - Where any vibration intensive plant equipment no longer operates within the prescribed safe working distances (refer to **Table 11**)
  - Where any dilapidation report outlined conditional concerns for any of the itemized heritage listed structures outlined in this report
  - Where formulated as part of any one inclusive construction noise and vibration management plan (CNVMP) outlining the necessary requirements for monitoring.

It would be anticipated that the application of feasible and reasonable noise and vibration management practices would lower the noise levels presented in this report; noise model analysis does not factor in barriers, hording or other general or specific mitigations, the assessment only assesses the worst-case noise levels at the most reasonably close distance to a sensitive receiver's most habitable room.

6 Conclusion

ADE Consulting Group Pty Ltd (ADE) was commissioned by Transport for Tomorrow (TfT, the 'Client') to undertake a Construction Noise and Vibration Impact Assessment (CNVIA) for works proposed to be undertaken along the rail corridor between Wollongong Station to approximately 500 m southwest of Coniston Station under the More Trains More Services South Works Program.

A 3D noise model was built in SoundPlan to assess the potential impacts of the construction on the nearby noise sensitive receivers. This assessment found the following:

- Noise and Vibration sensitive receivers surrounding the projects location are identified and presented in **Section 2**
- Noise management of construction noise is undertaken in accordance with the ICNG, outlined and described in **Section 3.1**; vibration goals are presented in **Section 3.2**
  - Noise Management Level exceedances are anticipated and outlined in **Section 4.2.3**
- A total of **two** (2) Residences are predicted to exceed ICNG defined Highly Noise Affected criteria of >75 dB $L_{Aeq,15min}$
- Mitigation measures in accordance with the TfNSW Construction Noise and Vibration Strategy are recommended for surrounding sensitive land uses, outlined and described in **Section 5.1.2**
  - Implementation of all relevant AMM and Standard Mitigation Measures (refer to **Table 25**) would have an anticipated positive affect on the overall noise levels predicted in this assessment
    - Lower noise levels would be anticipated where all feasible and reasonable mitigation measures are implemented
- Approximately **693** residential receivers are predicted to exceed sleep disturbance screening criterion during night-time OOH works across the project, and **115** receivers are predicted experience at least one (1) sleep awakening event during night-time works
  - This is due to the natural up-slope of the terrain west of the project's alignment. The low-medium density housing in this area are not benefiting from any natural barriers or topographical conditions, noise is diffracting to the western residential properties as they sit higher than the houses in front of them
- **33** residential properties are triggered for Alternative Accommodation (AA) during works throughout the various stages of construction. This is triggered by site mobilization works in close proximity to residences along Gladstone Avenue, and compound and stockpile areas where anticipation of non-stop work throughout the night-time period would be anticipated at these locations
  - **Section 5.2.2.1** describes the distance limitation for AA eligibility:
    - Residential land use within NCA01 further than ≈50 m away from work boundaries are not eligible for AA
    - Residential land use within NCA02 further than ≈30 m away from work boundaries are not eligible for AA
- Up to **217** properties are triggered for respite offers during Sunday evening works throughout the project's duration and along the length of the proposed alignment assessed in this CNVIA
  - **Section 5.2.2.1** describes the properties eligible for RO where the residential premises triggered for RO falls within a specific distance of a specific activity
    - Where works occurring on Sunday Evening period are localized to one area, the distances provided in **Section 5.2.2.1** limit the spread of RO eligibility for that activity

- Construction related traffic noise impacts may exceed the RNP local road traffic noise target levels, however the existing traffic noise levels have not been established therefore the screening assessment to establish if construction traffic increases the existing traffic noise levels by 2 dB cannot be confidently carried out
  - There are no anticipated impacts from the increase in traffic due to the construction
  - The existing rail line which includes freight and cargo rolling stock would impact the ambient noise environment
  - Assumed 'average noise levels' have not been adopted for this assessment
    - Noise monitoring prior to occupation is recommended to supplement the assumed background noise levels and establish the existing ambient noise environment to facilitate the screening assessment
    - Noise monitoring during route use is recommended to establish the impact of construction traffic where ambient monitoring shows exceedances of the screening criteria (ie existing ambient + 2.1 dB). More information is presented in **Section 4.2.7**
- A vibration assessment is outlined in **Section 4.3**
  - No vibration impacts are anticipated due to the lack of vibration-intensive machinery or plant proposed for use
    - The likelihood of any adverse comment from within the community is not anticipated
    - There are no anticipated vibration impacts to the nearest vibration-sensitive structures
      - None of the structures are considered structurally unsound
    - There are no regenerated noise impacts anticipated due to the lack of vibration intensive equipment used during the night-time period.

Additional recommendations are formulated:

- Prioritise noise intensive equipment during the daytime period where feasible
- Prioritise all delivery and transport of goods and plant equipment, and, use of stockpile and compounds during the daytime period where feasible
- Noise monitoring is recommended where identified within this report, and, during site occupation / mobilization and operation of compound/stockpile areas occurring during the night-time period in the event of noise or vibration complaints or adverse community comments or concerns:
  - Attended noise/vibration monitoring in accordance with the relevant standards, policies and guidelines
  - Noise management level or sleep disturbance exceedances would be responded to through review of equipment on site
  - Review of implemented mitigation (standard and project specific)
  - Review of sensitive-land use specific mitigation measures
  - Review of feasible and reasonable mitigation
    - Further mitigation measures may be necessary should any attended noise monitoring noise levels measure greater $L_{Aeq,15min}$ noise levels than those predicted and presented in **Section 4.2.4**.
- Vibration monitoring may be necessary under the following conditions:
  - In the event of any one (1) adverse community comment, complaint, or concern

- Where any vibration intensive plant equipment no longer operate within the prescribed safe working distances (refer to **Table 11**)
- Where any dilapidation report outlined conditional concerns for any of the itemized heritage listed structures outlined in this report
- Where formulated as part of any one inclusive construction noise and vibration management plan (CNVMP) outlining the necessary requirements for monitoring.

Appendix I – Glossary

1 Sound Pressure Level

Defined as:

$$L_p = 10log_{10}\left(\frac{p^2}{p_{ref}^2}\right)dB$$

In the above equation, p is the sound pressure fluctuation relative to atmospheric pressure, and *pref* is 20 microPascals (2 x 10-5 Pa), the approximate threshold of hearing.

Sound or noise is the sensation produced at the ear by small fluctuations in atmospheric pressure. Human ears are sensitive to changes to sound pressure over a wide range, from 20 microPascals to 60 Pascals, in lieu of using a linear scale to represent this range, a logarithmic scale is adopted to better handle

2 Sound Power Level

Sound power level cannot be directly measured using a microphone, it does not change with distance and is not influenced by atmospheric conditions. The sound power level refers to the total energy of the sound, and is reference to 1 Pico Watt.

3 Weighting and Loudness

The overall level of a sound is usually expressed as dB(A) and not dB. Weighting refers to the human ear's frequency response to sound. Typically, sound is measured with an A-weighted filter which reduces the significance of lower frequencies and very high frequencies, increasing the importance of mid-frequencies (500 Hz to 4 kHz), and being a good measure of the "loudness" of a sound.

A change of 1 to 2 dB(A) is difficult to detect, whilst a change of 3 to 5 dB(A) corresponds to a small but noticeable change. A 10 dB(A) change corresponds to a doubling or halving in apparent loudness.

4 Noise Metrics and Statistical Noise Levels

i) L_{Aeq} - The time averaged A-weighted sound pressure level for the interval, as defined in AS1005.1. It is generally described as the equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time. It can be considered as the average sound pressure level over the measurement period.

ii) L_{Amin}/L_{Amax} - Minimum or Maximum A-weighted noise level detected during the measuring period. It refers to the minimum background noise detected or the maximum L*p* measured.

iii) L_{A90} - A-weighted noise level which is exceeded for 90% of the measuring period. It is usually used as the descriptor for background noise level during the measurement period.

iv) L_{A1} - Noise level which is exceeded for 1% of the measurement period.

v) L_{A10} - Noise level which is exceeded for 10% of the measurement period. The L_{A10} is often referred to as the average *maximum* noise level.

5 Background Noise

The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed.

6 Ambient Noise

Ambient noise of an environment: the all-encompassing sound associated with that environment, being a composite of sounds from many sources.

7 Vibration

The mechanical oscillations occurring about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random. Vibration is most commonly expressed in terms of displacement, velocity, acceleration and frequency, all of which are related

8 Displacement

The change in position of an object, is a vector quantity. (Stress indicator).

9 Velocity

The rate of change of displacement, is a vector quantity. (Fatigue indicator).

10 Acceleration

The rate of change of velocity, is a vector quantity. (Indicator of force).

11 Frequency

The number of times a periodic function or vibration occurs or repeats itself in a specified time, often 1 second – cycles per second. Frequency is measured in Hertz.

12 Hertz

The unit of frequency or pitch of a sound. One hertz equals one cycle per second.

13 Peak Particle Velocity (PPV)

The greatest instantaneous particle velocity during a given time interval if measurements are made in 3-axis. The resultant Peak Particle Velocity (PPV) is the vector sum i.e. the square root of the summed squares of the maximum velocities, regardless of when in the time history those occur.

14 Root Mean Square rms

The rms value of a set of numbers is the square root of the average of their squares. Best used when assessing building damage.

15 **Vibration Dose Value VDV**

The Vibration Dose Value (VDV) is used for assessing intermittent vibration. A cumulative measurement of the vibration level received over an 8-hour or 16-hour period. Best used when the structure is occupied.

16 **Peak**

The peak is the maximum amplitude during a measurement period.

17 **Peak to Peak P-P**

The peak-to-peak (P-P) is the difference between the maximum positive and maximum negative amplitudes of a waveform.

18 **Logarithmic Scale**

Comparing frequency with large amplitude differences be accomplished using a logarithmic scale. Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale, however a logarithmic scale shows prominent vibration components equally well at any amplitude.

19 **Zero Crossing Frequency**

Determining the apparent dominate frequency of a given sample can be achieved by using the Zero Crossing Frequency.

20 **Primary Waves P Waves**

Alternating compressions ('pushes') and dilations ('pulls') in the same direction as the wave is propagating. P waves are the first arriving energy, smaller and higher frequency than S waves.

21 **Secondary Waves S Waves**

Alternating transverse motions perpendicular to the direction of propagation. Slower than P waves.

22 **Rayleigh Waves R Waves**

Motion is both in the direction of propagation and perpendicular (in a vertical plane). R waves are also dispersive, and amplitudes decrease with depth.

23 **Accelerometer**

A vibration sensor whose electrical output is directly proportional to the acceleration component of the vibration. The two most common accelerometer types are the traditional charge type and the IEPE, integrated electronic piezoelectric type with a built-in line-drive amplifier to enable the output signal to be transmitted over 'longer cable runs'.

24 **Geophone**

Geophones measure velocity by means of a magnetic core surrounded by an electrical coil. When the surface vibrates, the geophone housing moves however the coil stays stationary, thus the movement of the magnet in the coil causes an electrical current which is calibrated to velocity of vibration.

25 **Filter**

A device for separating components of a signal on the basis of their frequency. It allows components in one or more frequency bands to pass relatively unattenuated, and it attenuates components in other frequency bands. Modifies the frequency spectrum of a signal usually while it is in electrical form.

26 **Short-term vibration**

Vibration which does not occur often enough to cause structural fatigue, and which does not produce resonance in the structure being evaluated.

27 **Long-term vibration**

All types of vibration not covered by the definition of 'short-term vibration'

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Further details regarding ADE's Services are available via

info@ade.group www.ade.group

ADE Consulting Group Pty Ltd

Sydney
Unit 6/7 Millennium Court,
Silverwater, NSW 2128 Australia

Newcastle
Unit 9/103 Glenwood Drive
Thornton, NSW 2322, Australia

ADE Consulting Group (QLD) Pty Ltd

Brisbane
Unit 3/22 Palmer Place
Murarrie, QLD 4172, Australia

ADE Consulting Group (VIC) Pty Ltd

Melbourne
Unit 4/95 Salmon Street
Port Melbourne, VIC 3207, Australia