Australian Government

BUILDING OUR FUTURE

ARTC InlandRail

Inland Rail Programme

Narrabri to North Star Project

Environmental Impact Statement

Technical Report 5: **Noise and Vibration Assessment**

Image: Newell Highway north of Narrabri, NSW

Technical Report 5:
Noise and Vibration Assessment

Image: Railway and Newell Highway north of Narrabri, NSW

Australian Rail Track Corporation

Inland Rail - Narrabri to North Star
Noise and Vibration Assessment

October 2017

This report has been prepared by GHD for ARTC and may only be used and relied on by ARTC for the purpose agreed between GHD and ARTC as set out in section 1.3 of this report. GHD otherwise disclaims responsibility to any person other than ARTC arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

Whilst every care has been taken to prepare the maps included in this report, GHD and ARTC, make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Table of contents

Glossary i

List of abbreviations v

Executive summary vii

1. Introduction 1
   - 1.1 Overview 1
   - 1.2 The proposal 1
   - 1.3 Purpose and scope of this report 5
   - 1.4 Study area 6
   - 1.5 Structure of this report 6
2. Existing environment 7
   - 2.1 Existing operations 7
   - 2.2 Location of study area 8
   - 2.3 Identification of sensitive receivers 9
   - 2.4 Baseline monitoring 13
3. Legislative context 23
   - 3.1 Operational rail noise criteria 23
   - 3.2 Road traffic noise criteria 25
   - 3.3 Construction noise criteria 27
   - 3.4 Construction traffic noise criteria 31
   - 3.5 Vibration criteria 32
   - 3.6 Blasting 33
   - 3.7 Other standards and guidelines 34
4. Operational rail noise and vibration assessment 35
   - 4.1 Methodology 35
   - 4.2 Existing rail noise levels and model validation 41
   - 4.3 Operational rail noise model results 42
   - 4.4 Horn noise 55
   - 4.5 Operational vibration 56
5. Operational road traffic noise assessment 61
   - 5.1 Noise modelling methodology 61
   - 5.2 Traffic data 62
   - 5.3 Noise modelling verification 65
   - 5.4 Predicted noise levels 65
   - 5.5 Assessment of impacts 66

5.6 Maximum noise level/sleep disturbance assessment ... 66
6. Construction noise and vibration assessment ... 69
6.1 Construction methodology ... 69
6.2 Construction noise level prediction ... 83
6.3 Construction traffic noise ... 90
6.4 Sleep disturbance impacts ... 91
6.5 Construction vibration assessment ... 92
7. Mitigation measures ... 99
7.1 Approach to mitigation ... 99
7.2 Operational noise and vibration ... 99
7.3 Construction noise and vibration ... 104
7.4 Operational road traffic noise mitigation ... 108
8. Conclusion ... 111
8.1 Operational rail noise and vibration ... 111
8.2 Operational road traffic noise ... 111
8.3 Construction noise ... 112
8.4 Construction vibration ... 113
8.5 Summary ... 114
8.6 Limitations ... 114

Table index

Table 1.1 Relevant SEARs ... 5
Table 2.1 Non-residential receivers ... 11
Table 2.2 Unattended Noise Logger Details ... 14
Table 2.3 RBL $L_{A90\ (period)}$ and $L_{Aeq\ (period)}$ Noise Monitoring Results, dB(A) ... 18
Table 2.4 Attended Monitoring Results ... 19
Table 2.5 Identified Train Pass-by Summary ... 22
Table 3.1 Airborne rail traffic noise trigger levels for residential land uses ... 24
Table 3.2 Airborne rail traffic noise trigger levels for non-residential land uses ... 24
Table 3.3 NCG assessment criteria for residential land uses, $L_{Aeq(period),}$dBA ... 25
Table 3.4 Road types and classifications ... 26
Table 3.5 ICNG construction noise criteria for residential receivers, dB(A) ... 30
Table 3.6 ICNG construction noise criteria for industrial premises, dB(A) ... 30
Table 3.7 ICNG construction noise criteria for residential receivers, dB(A) ... 31

Table 3.8	Construction traffic noise criteria for residential land uses	31
Table 3.9	Acceptable vibration dose values for intermittent vibration	32
Table 3.10	Guidance on the effects of vibration levels	33
Table 3.11	Guideline values for short term vibration on structures	33
Table 4.1	Noise modelling scenarios	36
Table 4.2	Proposal rail volumes (trains per 24 hours)	37
Table 4.3	Proposal train lengths (metres)	37
Table 4.4	Train type maximum speeds	39
Table 4.5	Train source SELn values	40
Table 4.6	Measured absolute existing rail noise levels and model validation	42
Table 4.7	Predicted rail noise levels for residential receivers exceeding RING trigger levels – Narrabri to North Star (dBA)	44
Table 4.8	Predicted rail noise levels for non-residential receivers exceeding RING trigger levels – Narrabri to North Star (dBA)	54
Table 4.9	Receivers potentially affected by operational vibration	60
Table 5.1	Operational noise model inputs and assumptions	61
Table 5.2	Existing traffic volumes, hourly	62
Table 5.3	Moree projected traffic volumes	63
Table 5.4	Newell Highway projected traffic volumes	64
Table 5.5	Noise model verification, dBA	65
Table 5.6	Summary of maximum noise levels (10 pm to 7 am) - dBA	67
Table 6.1	Site establishment activities	70
Table 6.2	Main upgrading construction activities	71
Table 6.3	Post-construction activities	76
Table 6.4	Construction activities and corresponding equipment	79
Table 6.5	Construction noise modelling assumptions	83
Table 6.6	Activity-based construction noise management level exceedances for residential receivers	84
Table 6.7	Activity-based construction noise management level, number of exceedances for residential receivers	85
Table 6.8	Construction activity, number of exceedances - Non-residential receivers	86
Table 6.9	Construction traffic noise increase	90
Table 6.10	Sleep disturbance, number of exceedances	91
Table 6.11	Typical vibration levels for construction equipment	92
Table 6.12	Predicted construction vibration levels	92

Table 6.13 Vibration buffer distances 93
Table 6.14 Construction vibration activities- number of potentially impacted receivers 94
Table 6.15 Heritage listed items 95
Table 7.1 Potential noise control options 101
Table 7.2 Potential vibration control options 103
Table 7.3 Additional mitigation measures – Airborne construction noise 106
Table 7.4 Additional mitigation measures –Construction vibration 106
Table 7.5 Standard construction noise and vibration management controls 107

Figure index

Figure 1.1 Location of the proposal 3
Figure 1.2 Key features of the proposal 4
Figure 2.1 Existing rail lines in the study area 8
Figure 2.2 Construction and operational sensitive receiver locations 10
Figure 3.1 Noise mitigation flowchart (derived from the NMG) 28
Figure 4.1 Existing track speeds- Down Line 38
Figure 4.2 Existing track speeds- Up Line 38
Figure 4.3 Proposal Design Speeds 39
Figure 4.4 Ground vibration levels 58
Figure 4.5 Daytime VDV levels (2040) 59
Figure 4.6 Night-time VDV levels (2040) 60

Appendices

Appendix A – Unattended noise logger results
Appendix B – Monitoring locations
Appendix C – Study area and noise sensitive receivers
Appendix D – Operational rail noise, table of results
Appendix E – Operational rail noise contours, LAeq
Appendix F – Operational rail noise contours, LAMax
Appendix G – Construction noise, table of results
Appendix H – Road Traffic Noise Results

Glossary

Absolute rail noise	The absolute rail noise refers to noise levels emitted by rail only, that is without the contribution of any other noise source.
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise is removed. This is described using the L_{A90} descriptor. (see also Rating background level).
dB	Decibel, which is 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference pressure; used as a unit of sound.
dB(A)	Unit used to measure 'A-weighted' sound pressure levels.
EPA	Environmental Protection Authority of New South Wales.
Feasibility	Relates to engineering considerations (what can be practically built). These engineering considerations may include: • The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources • Safety issues such as restrictions on road vision • Road or rail corridor site constraints such as space limitations • Floodway and stormwater flow obstruction • Access requirements • Maintenance requirements • The suitability of building conditions for at property treatments.
Groundborne vibration	Groundborne vibration is vibration transmitted from source to receiver via the medium of the ground.
$L_{A90\ (Time)}$	The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise e.g. $L_{A90\ (15\ min)}$.
$L_{Aeq\ (Time)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Aeq\ (15\ hr)}$	The L_{Aeq} noise level for the period 7.00 to 22.00 hours.
$L_{Aeq\ (9\ hr)}$	The L_{Aeq} noise level for the period 22.00 to 7.00 hours.
$L_{Aeq\ (1hr)}$	The highest hourly L_{Aeq} noise level during the day and night periods.
$L_{A90(period)}$	The sound pressure level exceeded for 90% of the measurement period.
L_{Amax}	The maximum sound level recorded during the measurement period.
L_{AFmax}	The maximum sound level recorded during the measurement period using a fast time response.
Mitigation	Reduction in severity.
Noise sensitive receiver	An area or place potentially affected by noise including residential dwellings, schools, child care centres, places of worship, health care institutions and active or passive recreational areas.
Operation	Operation of trains between Melbourne and Brisbane on the completed Inland Rail alignment.

Peak Particle Velocity (PPV)	Current practices for assessments of the risk of structural damage to buildings use measurements of Peak Particle Velocity (PPV) in millimetres per second. The PPV is the maximum speed, in mm/s, that occurs from a vibration at the midpoint between maximum displacements in each direction", the existing statement could be added after the definition to provide context of typical use.
Project	For the purposes of the noise and vibration assessment, the term ‘Project’ is synonymous with ‘Proposal’.
Proposal	The construction and operation of the Narrabri to North Star section of Inland Rail. This is the ‘Project’ for the purposes of the Rail Infrastructure Noise Guideline.
Rating Background Level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period. This is the level used for assessment purposes.
Reasonable	Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measure. To make such a judgement, the following should be considered: • Noise impacts: - Existing and future levels, and projected changes in noise levels - Level of amenity before the project, e.g. the number of people affected or annoyed - Any noise performance criteria for the development, e.g. internal noise levels for certain rooms - The amount by which the triggers are exceeded • Noise mitigation benefits: - The amount of noise reduction expected, including the cumulative effectiveness of proposed mitigation measures - ideally, a noise wall/mound should be able to reduce noise levels by at least 5 dB - The number of people protected • Cost effectiveness of noise mitigation: - The total cost of mitigation measures, taking into account the physical attributes of the site, e.g. topography, geology, and the cost variation to the project given the expected benefit - Noise mitigation costs compared with total project costs, taking into account capital and maintenance costs - Ongoing operational and maintenance cost borne by the community, e.g. running air conditioners or mechanical ventilation • Community views: - Engage with affected land users when deciding about aesthetic and other impacts of noise mitigation measures - Determine the views of all affected land users, not just those making representations, through early community consultation - Consider noise mitigation measures that have majority support from the affected community
Receiver	A noise modelling term used to describe a map reference point where noise is predicted. A sensitive receiver would be a home, work place, church, school or other place where people spend time.
RMS or Vrms	Root Mean Square (velocity).

Short-term vibration	Vibration that occurs so infrequently that it does not cause structural fatigue nor does it produce resonance in the structure.
Sound Pressure Level (SPL)	20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level of 20 micro Pascals.
Tonality	Noise containing a prominent frequency or frequencies characterised by a definite pitch.
Vibration dose value (VDV)	As defined in BS6472 – 1992, the vibration dose value is given by the fourth root of the integral of the fourth power of the frequency weighted acceleration.
Vibration	The variation of the magnitude of a quantity which is descriptive of the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value or reference. Vibration can be measured in terms of its displacement, velocity or acceleration. The common units for velocity are millimetres per second (mm/s).

List of abbreviations

AVTG	Assessing Vibration: A Technical Guideline (DEC 2006)
ARTC	Australian Rail Track Corporation
CNS (Rail projects)	Construction Noise Strategy (TfNSW 2012)
CoRTN	Calculation of Road Traffic Noise (UK Department of Transport Welsh Office 1988)
CNVIS	Construction Noise and Vibration Impact Statement
DEC, DECC, DECCW	See OEH
EPA	Environment Protection Authority of New South Wales
EIS	Environmental impact statement
ICNG	*Interim Construction Noise Guideline* (DECC 2009)
km/h	kilometres per hour
INP	*Industrial Noise Policy* (EPA 2000)
mm/s	millimetres per second
m/s	metres per second
NMT	Nordic Prediction Method for Train Noise (TemaNord 1996:524)
NVRF	Sydney Trains Environmental Management System Guide for Noise and Vibration from Rail Facilities
OEH	The Office of Environment and Heritage (OEH). Formerly the Department of Environment and Conservation (DEC) before becoming the Department of Environment and Climate Change (DECC), later known as the Department of Environment Climate Change and Water (DECCW).
RING	*Rail Infrastructure Noise Guideline*
RNP	*Road Noise Policy* (DECCW 2011)
SEARs	Secretary's Environmental Assessment Requirements
SEL	Sound exposure level
TfNSW	Transport for NSW

Executive summary

The proposal

Australian Rail Track Corporation Ltd (ARTC) is seeking approval to construct and operate the Narrabri to North Star section of Inland Rail ('the proposal').

The proposal would involve upgrading the existing rail line for a distance of 188 kilometres between Narrabri and North Star via Moree, including new crossing loops, track realignment and new sections of rail line, new river crossings, and new road over rail bridges at Jones Avenue and Newell Highway.

Ancillary work would include works to level crossings, signalling and communications, signage, fencing, and services and utilities.

This report

This report provides an assessment of the potential noise and vibration impacts of the proposal. The scope of the assessment has been undertaken in response to the Secretary's Environmental Assessment Requirements (SEARs) issued on 8 November 2016 and guided by relevant legislation and various industry guidelines and standards.

Operational noise

Operational noise has been assessed having regard to the NSW *Rail Infrastructure Noise Guideline* (RING) and included modelled operational scenarios at current and future horizon timeframes for both the 'no-build' case that assumes the proposal does not proceed and the 'build' case that incorporates the proposal and corresponding growth in train movements.

The RING criteria for redeveloped rail lines provide trigger levels for noise at residential receivers (L_{Aeq} and L_{Amax}), as well as an increase in noise levels resulting from the proposal. To qualify for mitigation consideration, the proposal must both increase noise levels at a receiver and exceed the noise trigger levels set out in the guideline.

A total of 152 residential receivers were found to exceed the criteria established by the RING for the 2040 design assessment year. These included:

- 14 receivers in North Star
- 16 receivers in Moree-North Star
- 79 receivers in Moree Town
- 15 receivers in Bellata-Moree
- 19 receivers in Bellata
- 9 receivers in Narrabri-Bellata.

A number of non-residential receivers within the study were also predicted to exceed the internal RING trigger levels for the 2040 design assessment year including three educational receivers, three worship receivers this assumes a 10 dB external to internal reduction. Additionally two passive recreation receivers and one active recreation receiver were predicted to exceed the respective RING trigger level at 2040.

A number of potential mitigation options have been reviewed and may be effective, subject to being shown to be reasonable and feasible for this proposal. Details of potential mitigation options can be found in Section 7.2 of this report.

Operational vibration

Operational vibration impacts with consideration to structural damage are not considered likely to result from the proposal. While an increase in vibration due to increased axle loads and speeds is anticipated, vibration is predicted to remain within acceptable levels considering the distance to most nearby receivers. Additionally, improved ballast/sleeper heterogeneity and rail surface smoothness may also reduce transmitted vibration and assist to offset increases in vibration due to axle loading and speed.

Daytime vibration levels are predicted to be within the acceptable range for human comfort impacts at distances of more than 17 metres from the track, while night time levels are predicted to be acceptable at distances of more than 23 metres from the track. Three receivers are located within these distances and are detailed in Section 4.5.2. Potential mitigation measures to reduce vibration impacts are detailed in Section 7.2.2.

Operational traffic noise

Assessment of the expected noise impacts in accordance with the *Road Noise Policy* (RNP) are as follows:

- The controlling criteria is expected to be exceeded at six receivers during the day-time period. The maximum exceedance of the criteria is 1.4 dBA. It should be noted however that these are due to noise from existing roads or roads not part of the proposal and therefore would not qualify for mitigation treatment.
- The controlling criteria is not expected to be exceeded during the night-time period.
- Noise levels are not predicted to exceed the day-time acute criteria of 65 dBA $L_{Aeq(15\ hr)}$ or night-time acute criteria of 60 dBA $L_{Aeq(9\ hr)}$.
- The increase in noise levels between the no-build and build scenarios are less than 2 dB for the receivers that exceed the controlling criterion during the day-time period, therefore mitigation measures are not warranted.
- The Relative Increase Criterion is not applicable to any receiver due to realignment of the Newell Highway overpass or construction of the Jones Avenue bridge.

The proposed overpass at Newell Highway and the Jones Avenue bridge are not expected to adversely impact any sensitive receiver from a noise perspective within the assessment area.

Construction noise

Noise emissions from construction have been assessed during the primary proposal construction hours and outside the primary proposal construction hours. An assessment has been carried out in accordance with the *Interim Construction Noise Guideline* (ICNG) and with consideration to the Inland Rail NSW Construction Noise and Vibration Management Framework.

- In relation to construction activities:
  - Activities such as pre-possession (construction scenario S1), skim track reconditioning (construction scenario S2), full depth reconditioning (construction scenario S3), and drainage construction, are likely to impact the largest number of receivers due to the higher level of noise emitted by the anticipated equipment.
  - Construction activities undertaken outside of the primary proposal construction hours increase the impacted receivers to those within about 1500 metres for bridge works and 700 metres for other activities.
- In relation to the primary proposal construction hours and construction noise management levels:
  - The highly affected level of 75 dB(A) L_{Aeq} is predicted to be exceeded at three receivers.
  - Rail line redevelopment construction activities are predicted to exceed the noise management level at receivers nearest to the construction footprint. Impacted receivers are within about 700 metres of the works and includes up to 1574 identified noise sensitive residential receiver locations. Noise levels are predicted to exceed the proposal specific construction management level by up to 43 dB.
  - Newell Highway overbridge construction is predicted to exceed the proposal specific construction management level by up to 13 dB at two residential receivers.
  - Jones Avenue overbridge construction is predicted to exceed the proposal specific construction management level by up to 41 dB at 1098 residential receivers.
  - Construction activities during the primary proposal construction hours have the potential to exceed the noise management level at non-residential sensitive receivers including educational, child care and hospital facilities. Construction noise management levels are applicable as an internal level only when the facilities are in use.
  - Construction activities during the primary proposal construction hours have the potential to exceed the noise management level at recreational areas including bushland areas, parks and sporting facilities when these areas are in use.

The noise and vibration mitigation measures detailed in Section 7 should be implemented where feasible and reasonable and all potentially affected receivers should be informed of the nature of the works, expected noise levels, duration of works and a method of contacting site management.

Construction vibration

General construction activities

In relation to vibration from general construction activities, the expected magnitude of ground vibration is not expected to be sufficient to cause structural damage if the equipment operates at distances greater than 18 metres from standard residential buildings or structures of similar construction.

Many heritage structures near to the proposal consist of station buildings, sidings and silos which are directly adjacent to the track and bridges that are on the actual alignment. The expected magnitude of ground vibration is not expected to be sufficient to cause structural damage if the equipment operates at distances greater than 35 metres from heritage buildings and structures. However, many items are potentially within this distance from the works and may therefore be affected.

The noise and vibration mitigation measures detailed in Section 7 should therefore be implemented to manage potential construction vibration impacts.

Piling

Vibration impacts due to piling activities have the potential to exceed structural vibration values for standard dwellings at distances of up to 100 metres from the activity for impact piling, 30 metres for vibratory piling and 17 metres for bored piling.

Piling activities have the potential to exceed structural vibration values for heritage structures at distances of 180 metres from the activity for impact piling, 50 metres for vibratory piling and 35 metres for bored piling.

In the event that sensitive receivers fall within these buffer distances, other methods may need to be investigated such as press-in hydraulic piling or jacked-in piling to reduce the potential for impact. These methods generally exhibit much lower vibration levels compared to impact, vibratory and bored piling.

Bridges

For bridges on the alignment within the buffer distances of vibration generating activities it is recommended that the potential for vibration damage be assessed on a case by case basis at detailed design stage with suitable mitigation measures implemented as part of a construction vibration management plan. This may include measurement of existing vibration levels from trains on these structures to provide an existing baseline and/or review by a suitably qualified structural engineer.

Human comfort

Humans are capable of detecting vibration at levels well below those causing risk of damage to buildings. Based on a conservative assessment, it is possible that construction vibration for general construction activities may be perceptible at distances up to 140 metres from the works.

Piling works are required for bridge construction. About 820 receivers may receive perceptible vibration where impact piling is used. These receivers are within 700 metres of piling locations. They are located mostly within Moree and are near to either the Mehi River rail bridge or the Jones Avenue road overbridge.

Vibration impacts due to boring of the cast in-situ piles has the potential to impact receivers up to 120 metres from the work area. There are 56 receivers located within this buffer distance from proposed piling locations.

To minimise human comfort impacts, alternatives to impact piling are recommended where feasible. The mitigation measures detailed in Section 7 should also be considered where feasible and reasonable to reduce the potential for impact.

1. Introduction

1.1 Overview

The Australian Government has committed to delivering a significant piece of national transport infrastructure by constructing a high performance and direct interstate freight rail corridor between Melbourne and Brisbane. The Inland Rail programme (Inland Rail) involves the design and construction of a new inland rail connection, about 1,700 km long, between Melbourne and Brisbane. Inland Rail is a transformational rail infrastructure initiative that will enhance Australia's existing national rail network and serve the interstate freight market.

Australian Rail Track Corporation Ltd (ARTC) is seeking approval to construct and operate the Narrabri to North Star section of Inland Rail ('the proposal'), which consists of 188 kilometres of upgraded rail track and associated facilities.

The proposal requires approval from the NSW Minister for Planning under Part 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal is also a controlled action under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act), and requires approval from the Australian Minister for the Environment and Energy.

This report has been prepared by GHD Pty Ltd (GHD) as part of the environmental impact statement (EIS) for the proposal. The EIS has been prepared to accompany the application for approval of the proposal, and addresses the environmental assessment requirements of the Secretary of the Department of Planning and Environment (the SEARs), issued on 8 November 2016.

1.2 The proposal

1.2.1 Location

The proposal is generally located in the existing rail corridor between the town of Narrabri and the village of North Star, via Moree. The location of the proposal is shown in Figure 1.1.

1.2.2 Key features

The key features of the proposal involve:

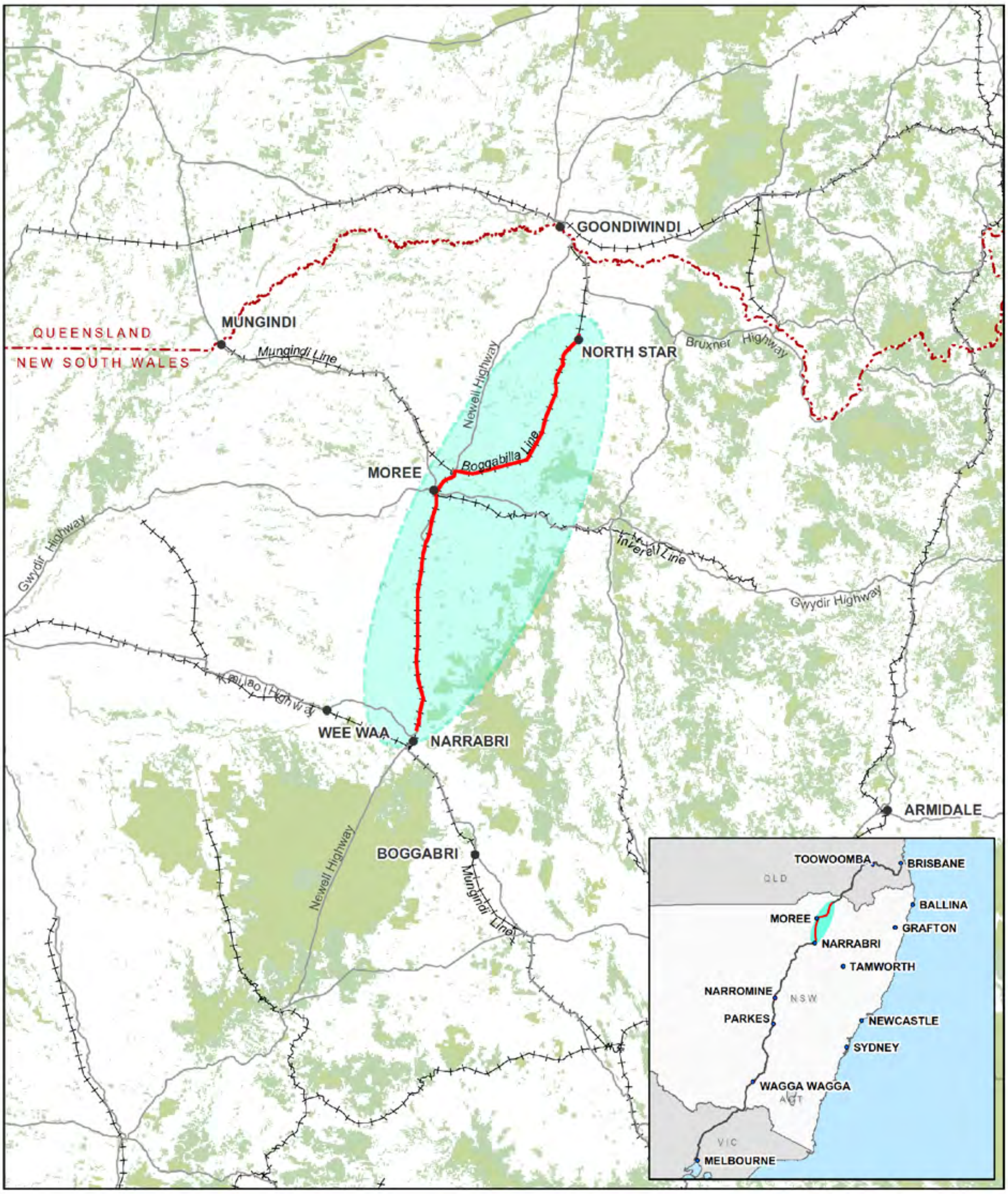
- upgrading the track, track formation, and culverts within the existing rail corridor for a distance of 188 kilometres between Narrabri and North Star via Moree
- realigning the track where required within the existing rail corridor to conform with required platform clearances for Inland Rail trains
- providing five new crossing loops within the existing rail corridor at Bobbiwaa, Waterloo Creek, Tycannah Creek, Coolleearllee and Murgo
- providing a new section of rail line at Camurra about 1.6 kilometres long to bypass the existing hairpin curve ('the Camurra bypass')
- removing the existing bridges and providing new rail bridges over the Mehi and Gwydir rivers and Croppa Creek

- realigning about 1.5 kilometres of the Newell Highway near Bellata and providing a new road bridge over the existing rail corridor (‘the Newell Highway overbridge’)
- providing a new road bridge over the existing rail corridor at Jones Avenue in Moree (‘the Jones Avenue overbridge’).

The key features of the proposal are shown in Figure 1.2.

Ancillary work would include works to level crossings, signalling and communications, signage and fencing, and services and utilities.

Further information on the proposal is provided in the EIS.



LEGEND

- Proposal site
- Proposal location
- Main road
- Railway
- State border

Paper Size A4

0 10 20 40 60

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Australian Rail Track Corporation
Inland Rail Track Alignment

Job Number | 22-17916
Revision | 0
Date | 02 Jun 2017

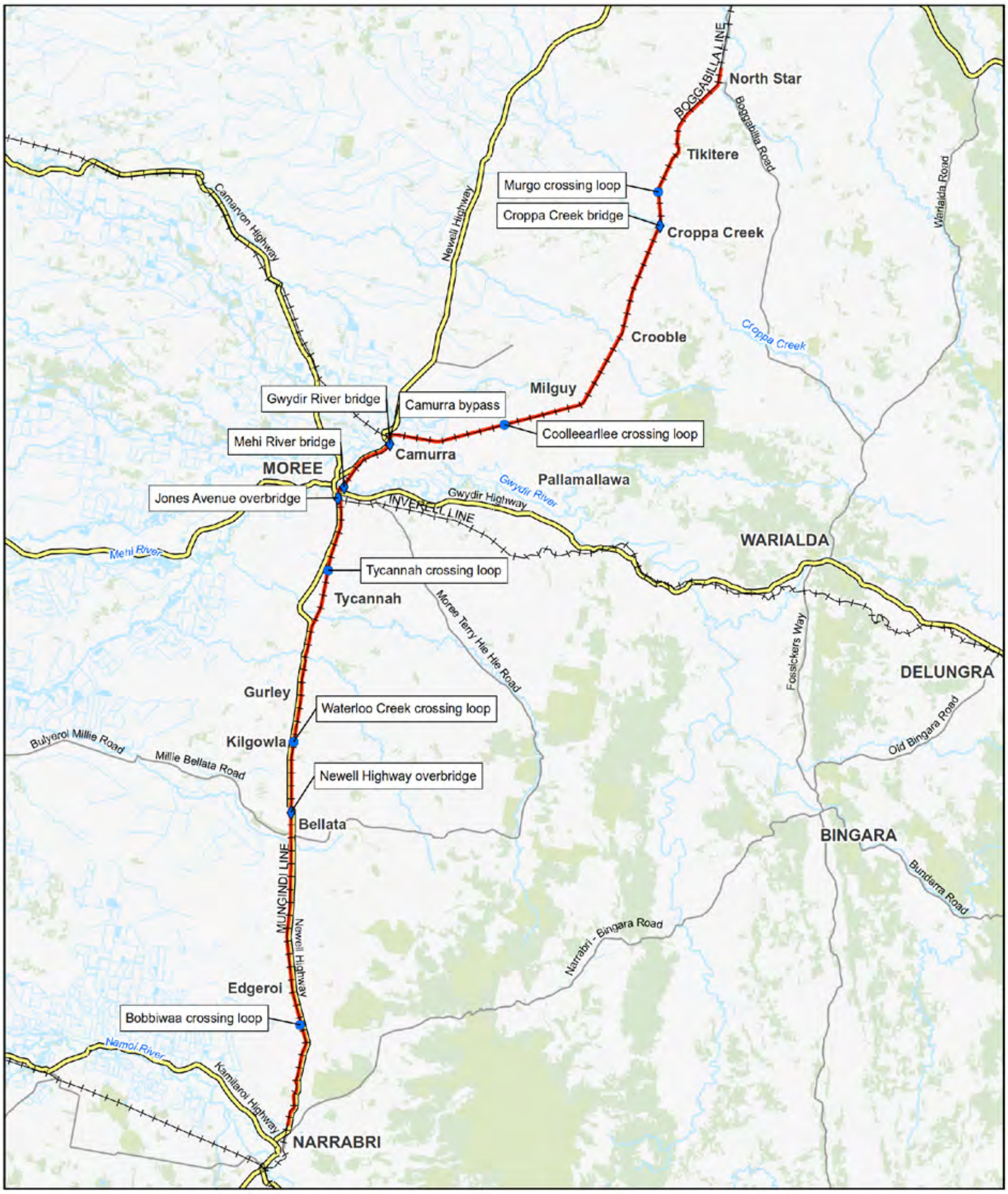
Location of the proposal

Figure 1-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\17916\GIS\Maps\Deliverables\N2NS\EIS\Specialist Reports\2217916_EIS001_NNS_Location_0.mxd

Data source: Commonwealth of Australia (Geoscience Australia), 250K Topographic Data Series 3, 2006. Created by: tmorton, kpsrcba



LEGEND

New bridge	Railway
Crossing loop	Highway
The proposal	Road

Paper Size A4

0 3 6 12 18 24

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Australian Rail Track Corportion
Inland Rail Track Alignment

Job Number | 22-17916
Revision | 0
Date | 01 Aug 2017

Key features of the proposal

Figure 1-2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

G:\22\17916\GIS\Maps\Deliverables\N2NS\EIS\Specialist Reports\2217916_EIS002_NNS_KeyFeatures_0.mxd

Data source: Commonwealth of Australia (Geoscience Australia), 250K Topographic Data Series 3, 2006. Created by: gmcdiarmid, tmorton, kpsroba

1.2.1 Timing

Subject to approval of the proposal, construction is planned to start in early to mid 2018, and is expected to take about 24 months. Existing train operations along the Narrabri to North Star line would continue prior to, during, and following construction. Inland Rail as a whole is expected to be operational in 2025.

1.2.2 Operation

Prior to the opening of Inland Rail as a whole, the proposal would be used by existing rail traffic, which includes trains carrying passengers and grain at an average rate of about four trains per day. It is estimated that the operation of Inland Rail would involve an annual average of about 10 trains per day travelling north of Moree (between North Star and Moree) and 12 trains per day travelling south of Moree (between Moree and Narrabri) in 2025. This would increase to about 19 trains per day north of Moree (between North Star and Moree) and 21 trains per day south of Moree (between Moree and Narrabri) in 2040. The trains would be a mix of grain, intermodal (freight), and other general transport trains.

Once operational in 2020, the proposal would enable increased train running speeds in many areas that are currently the subject of restrictions due to local track conditions. Daily average train volumes are not expected to significantly change until Inland Rail through connection in 2025.

1.3 Purpose and scope of this report

The purpose of this report is to assess potential noise and vibration issues from the operation and construction of the proposal, and where required, identify feasible and reasonable mitigation measures.

This noise and vibration assessment has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs). Table 1.1 outlines the requirements relevant to this assessment.

Table 1.1 Relevant SEARs

Requirements for Noise and Vibration	
Noise and vibration – Amenity Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on acoustic amenity. Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the proposal are effectively managed to protect the amenity and well-being of the community.	1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers including small businesses, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise). 2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.

Requirements for Noise and Vibration	
Noise and vibration – Structural Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on the structural integrity of buildings, items including Aboriginal places and environmental heritage, and nearby road infrastructure. Increases in noise emissions and vibration affecting environmental heritage as defined in the Heritage Act 1977 during operation of the proposal are effectively managed.	1. The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage). 2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.

Specifically, this assessment:

- Identifies key noise and vibration sensitive receivers
- Identifies existing noise and vibration levels in the subject area
- Identifies the likely principal noise sources during operation of the proposal
- Identifies the applicable construction noise and vibration criteria from relevant guidelines and existing background noise levels
- Identification of applicable operational rail noise criteria
- Assesses the potential construction noise and vibration impacts of the proposal on the surrounding environment based on indicative construction methodology and equipment
- Assesses of the potential operational noise and vibration impacts of the proposal on the surrounding environment
- Identifies and discusses potential noise and vibration mitigation measures with consideration to the proposal noise and vibration criteria

1.4 Study area

The study area subject to this noise and vibration assessment is the rail corridor and adjacent land between Narrabri and North Star. The study area encompasses the operational and construction footprints, including areas which could be indirectly impacted by the Project. The study area including sensitive receiver locations is described further in section 2.3.

1.5 Structure of this report

The structure of the report is outlined below.

- Section 1 - provides an introduction to the report
- Section 2 - describes the existing ambient noise environment
- Section 3 - details the relevant noise and vibration criteria
- Section 4 - describes the operational rail noise and vibration assessment
- Section 5 - described the operational road assessment
- Section 6 - describes the construction noise and vibration assessment
- Section 7 - describes the mitigation assessment
- Section 8 - the report conclusion summarising key outcomes from the report

2. Existing environment

2.1 Existing operations

Narrabri and Moree are located on the Mungindi (North West) line, which branches from the Main North Line at Werris Creek Station and heads north-west through the towns of Gunnedah and Narrabri to Moree.

Narrabri Station opened in 1897, which was when the Mungindi line was extended from Boggabri to Moree. The existing Moree Station opened in 1904, replacing the original station (located to the north of the existing station), which opened in 1897 when the line was extended from Boggabri.

From Moree, the Mungindi line travels north-west to Mungindi on the NSW-Queensland border. The line was closed between Weemelah and Mungindi in 1974 when rail services were withdrawn following flooding. The Inverell line is located between the Mungindi line (at Moree Station) and Inverell to the west. The Inverell line, which was completed in 1902, was progressively closed between 1987 and 1994.

North Star is located on the disused Boggabilla line, which branches from the Mungindi line at Camurra (about 10 kilometres north-west of Moree). North Star Station was opened in 1932 with the opening of the Boggabilla line. From Camurra, the Boggabilla line travels north for about 130 kilometres to Boggabilla on the Queensland border. In 1987 the line was truncated at North Star. The remainder of the line was closed to normal operations in 2013 but is still used occasionally.

Figure 2.1 provides a schematic drawing of the rail network in the study area.

Track characteristics

The existing track is a mixture of track weights (47 and 53 kilograms) mainly supported on steel sleepers. The track was originally constructed for light traffic on the existing sub-grade materials. Over time, the track has been re-ballasted and maintained, but no significant improvements have been made to the track formation.

Sections of track pass through low lying flood prone areas, and wash-aways have occurred in the past after heavy rain events. The maintenance access track along the existing rail corridor is not continuous and can be impassable during and after wet weather.

There are about 12 sidings between Narrabri and North Star that provide access to and from the main line for private operations.

2.1.1 Rail operations

Passenger services

The Northern Tablelands Xplorer, run by NSW TrainLink, travels between Sydney and Moree via Werris Creek and Narrabri. In the proposal site, trains stop at Bellata and Moree twice a day (to and from Sydney Central).

Freight services

Occasional grain/goods trains operate on an as needs basis. Annually, there is an average of two grain trains per day carrying about 1.7 million tonnes of grain per year.

Train speeds between Narrabri and Moree are limited to a maximum of 90 to 100 kilometres per hour, with local speed restrictions due to limitations associated with the existing track. Between Moree and North Star, train speeds are limited to a maximum of 80 kilometres. There are also local speed restrictions.

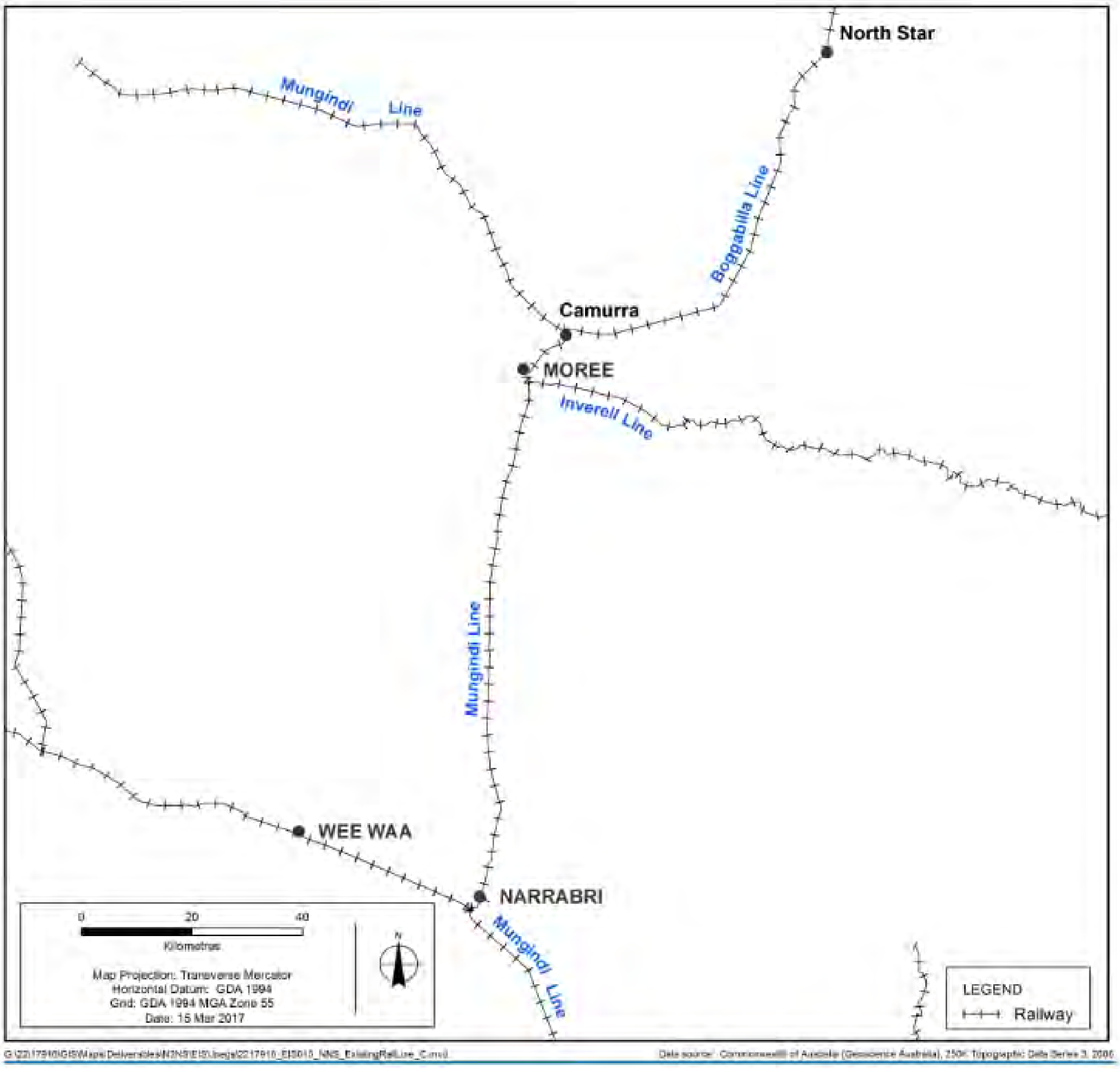


Figure 2.1 Existing rail lines in the study area

Maintenance

Maintenance works and other minor works along the Mungindi line are undertaken by ARTC in accordance with existing ARTC procedures and processes, and relevant State legislative requirements.

2.2 Location of study area

The area surrounding the proposal consists of open space, rural land, residential land and commercial land. The proposal passes through several small rural towns.

For the operational rail noise assessment, the study area was defined as the area that extends about two kilometres either side of the rail corridor and bounded by the extent of works. Noise and vibration sensitive receivers were identified within the operational assessment study area and are shown in Figure 2.2.

For the construction noise and vibration assessment study area, a 2 kilometre buffer from the proposal in all directions was used to identify sensitive receiver locations. The construction assessment study area therefore extends beyond the southern end of the proposal to include some receiver locations within Narrabri. The construction noise and vibration study area is shown in Figure 2.2.

The extents of both the operational and construction noise and vibration assessment study areas will be further reviewed at detailed design stage.

2.3 Identification of sensitive receivers

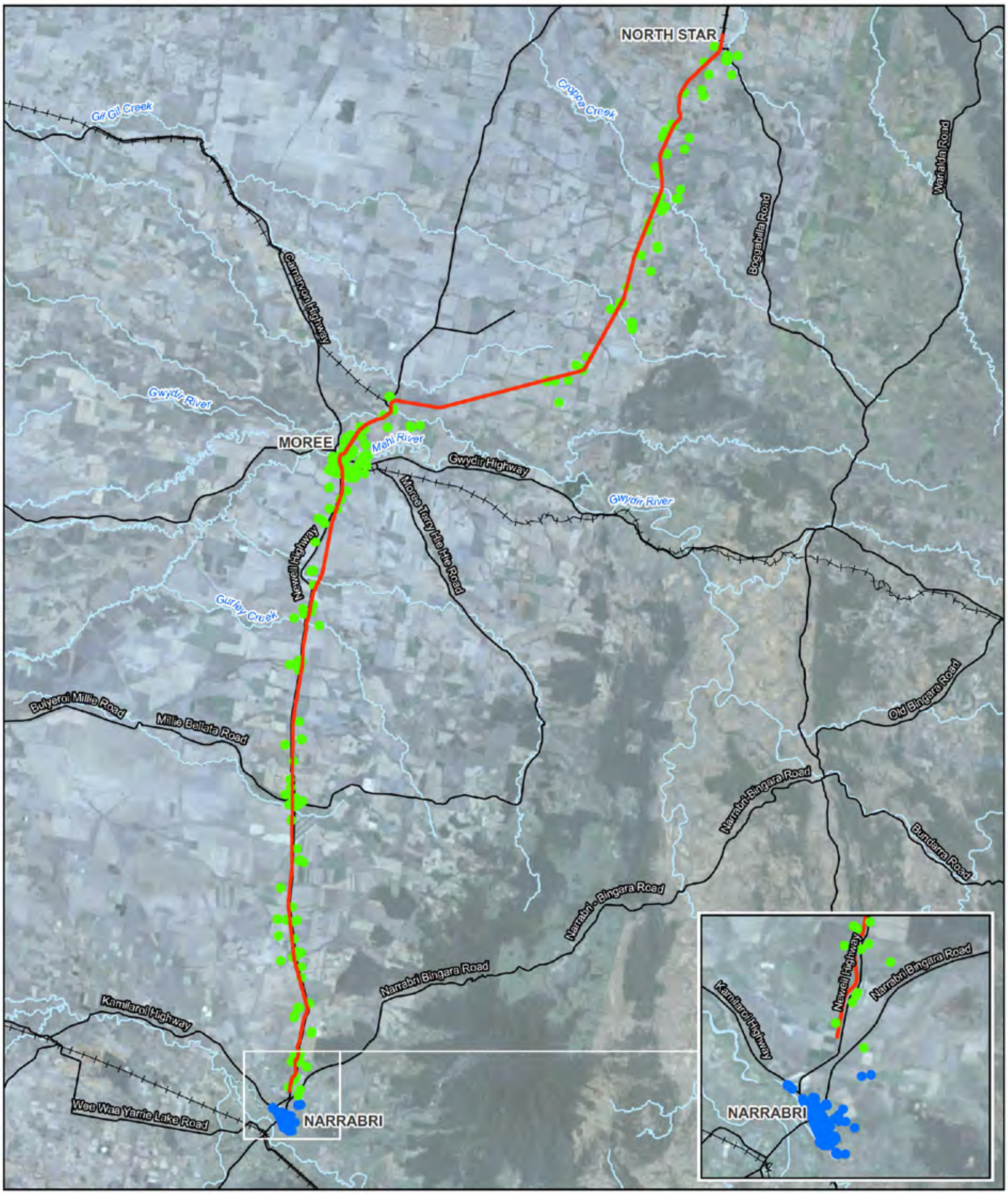
Within the study area, residential sensitive receivers include dwellings located within towns such as Moree, Narrabri, Gurley and Bellata, or are scattered across large areas between the major towns. Noise sensitive receiver locations were identified using aerial imagery and geospatial information.

For the operational noise and vibration assessment, (section 4) 1668 residential receivers were identified within the operational assessment study area. 58 non-residential noise receivers were also identified including: two places of worship, three educational facilities, one medical facility, six active and two passive recreation areas. For the operational noise assessment, all residential receivers will have their own specific noise criteria based on their exposure to noise from the proposal and existing exposure to rail noise. This is discussed in more detail in Section 3.1. The receivers are individually identified in Appendix C.

Non-residential receivers including schools, places of worship (churches) and outdoor recreation areas are summarised in Table 2.1.

For the construction noise and vibration assessment (section 6), there is a total of 2384 residential receivers and 58 non-residential receivers. This differs from the operational noise assessment because some construction activities have the potential to impact a wider area than rail operation associated with the proposal. The non-residential noise receivers are the same as those identified within the operational assessment study area. A number of commercial and industrial facilities are also located adjacent to the rail corridor and are subject to assessment for construction noise only.

Identification of receivers in this assessment was based principally on inspection of aerial imagery. Where receivers have been identified as qualifying for noise mitigation from this proposal, preliminary noise mitigation solutions have been identified to meet the requirements of the SEARs (refer to section 7.2.2) and a more detailed review will be undertaken when further information is available to verify the number of receivers affected and which should be considered for mitigation. Similarly, for non-residential receivers, qualification for noise mitigation will be dependent upon the results of façade testing to determine if the internal noise criteria are exceeded.



LEGEND

- Construction receiver
- Construction and operational receiver
- The proposal
- Road
- Railway
- Watercourse

Paper Size A4

0 2.5 5 10 15 20 25

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Australian Rail Track Corporation
Inland Rail - Narrabri to North Star

Job Number | 22-17916
Revision | 0
Date | 03 Aug 2017

Construction and operational sensitive receiver locations

Figure 2-2

G:\22\17916\GIS\Maps\Deliverables\N2NS\Noise\2217916_N008_NNS_Construction_Operational_0 Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

Data source: LPI: Imagery, 2012. Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2006. Created by: tmorton, fmackay, kpsroba

Table 2.1 Non-residential receivers

Receiver ID	Description	Receiver Type	Easting	Northing
NNS_WORx0001	Place of worship	Place of Worship	776842.8	6735618.5
NNS_WORx0002	Place of worship	Place of Worship	830720.2	6794764.4
NNS_WORx0003	Place of worship	Place of Worship	776347.1	6735727.1
NNS_WORx0004	Place of worship	Place of Worship	775591.0	6736206.5
NNS_WORx0005	Presbyterian church	Place of Worship	775410.5	6737128.3
NNS_WORx0006	Uniting church	Place of Worship	775694.8	6737404.5
NNS_WORx0007	Catholic church	Place of Worship	769517.7	6686849.4
NNS_WORx0008	Anglican church	Place of Worship	769860.8	6686930.3
NNS_HOSx0001	Moree district hospital	Hospital Ward	775372.1	6736505.1
NNS_EDUx0001	Moree Secondary College	School	775376.5	6735266.7
NNS_EDUx0002	The Barwon learning centre	School	775574.5	6735297.3
NNS_EDUx0003	TAFE New England institute Moree campus Carol Avenue campus	School	775756.2	6737387.0
NNS_EDUx0004	Moree secondary college Albert Street	School	775660.7	6737052.7
NNS_EDUx0005	Tafe Moree campus agricultural school	School	779205.4	6740681.0
NNS_EDUx0006	North Star public school	School	830807.9	6795347.0
NNS_EDUx0007	Croppa Creek public school	School	822056.8	6773631.0
NNS_EDUx0008	Bellata public school	School	769937.4	6686968.4
NNS_EDUx0009	Moree East public school	School	775486.4	6735779.6
NNS_REPx0001	Mary Brand park	Open Space- Passive	775863.6	6737528.3
NNS_REPx0002	Park	Open Space- Passive	822064.8	6773866.1
NNS_REPx0003	Park	Open Space- Passive	821543.3	6773918.4
NNS_REPx0004	Allambie Place park	Open Space- Passive	775297.2	6736308.4
NNS_REPx0005	Railway park	Open Space- Passive	776134.0	6736214.5
NNS_REPx0006	Elizabeth street park	Open Space- Passive	776905.3	6735665.4
NNS_REPx0007	Park	Open Space- Passive	775650.6	6736474.2

Receiver ID	Description	Receiver Type	Easting	Northing
NNS_REPx0008	Park	Open Space- Passive	770277.3	6707461.3
NNS_REPx0009	Kirkby park	Open Space- Passive	775654.0	6736792.8
NNS_REPx0010	Jellicoe park	Open Space- Passive	775846.1	6736581.6
NNS_REPx0011	Park	Open Space- Passive	831180.5	6794811.1
NNS_REPx0012	Lions park	Open Space- Passive	776417.6	6736305.3
NNS_REPx0013	Sullivan place park	Open Space- Passive	776954.5	6735876.6
NNS_REPx0014	Sugars park	Open Space- Passive	769446.8	6686954.3
NNS_REPx0015	Bellata park	Open Space- Passive	769657.9	6686952.8
NNS_REPx0016	Park	Open Space- Passive	775550.7	6734454.0
NNS_REAx0001	Squash courts	Open Space- Active	776110.1	6735167.9
NNS_REAx0002	Basketball centre	Open Space- Active	775317.5	6735604.8
NNS_REAx0003	Golf course	Open Space- Active	770402.4	6686754.2
NNS_REAx0004	Golf course	Open Space- Active	831369.2	6795125.5
NNS_REAx0005	Moree racecourse	Open Space- Active	776375.5	6738005.3
NNS_REAx0006	Moree showground	Open Space- Active	776122.1	6736841.9
NNS_REAx0007	Tennis courts	Open Space- Active	775348.5	6736898.5
NNS_REAx0008	Tennis courts	Open Space- Active	776150.1	6736310.9
NNS_REAx0009	Broughton oval	Open Space- Active	775563.7	6735635.2
NNS_REAx0010	Playing fields	Open Space- Active	775523.5	6735236.4
NNS_REAx0011	Sports field	Open Space- Active	777275.4	6731746.9
NNS_REAx0012	Services oval	Open Space- Active	776101.7	6737288.9
NNS_REAx0013	Playing fields	Open Space- Active	775346.5	6735800.2
NNS_REAx0014	Bloomfield oval	Open Space- Active	775816.8	6736981.3
NNS_REAx0015	Taylor oval	Open Space- Active	775453.7	6737006.6
NNS_REAx0016	Swimming pool	Open Space- Active	776037.2	6736096.3
NNS_REAx0017	Tennis courts	Open Space- Active	769929.4	6686886.1
NNS_REAx0018	Moree gun club	Open Space- Active	785069.4	6744063.2
NNS_REAx0019	Sports courts and field	Open Space- Active	822024.4	6773765.4

2.4 Baseline monitoring

2.4.1 Noise monitoring methodology

Baseline unattended noise monitoring took place at 17 locations in the proposal area between 1 September 2015 and 7 April 2016 in accordance with procedures in the *Industrial Noise Policy* (INP) guideline. Logger locations were selected to capture noise characteristics at a variety of locations throughout the study area. Logger locations included sites within the existing rail corridor, residential locations and commercial locations. Selection considerations included land topography, distance from rail activities and contribution from other noise activities, such as road noise. The logger locations used for the assessment were considered to be representative of the existing background and ambient noise environment in the study area and can be seen in Appendix B.

Noise monitoring locations were constrained to locations where property access was possible on the day of deployment. Access constraints included train schedules precluding track access by HiRail. Security against theft and vandalism were also important considerations when choosing noise monitoring locations.

The objectives of the monitoring were to measure the existing background noise levels in the areas surrounding the proposal site and to measure rail noise from train pass-bys.

The noise loggers were programmed to accumulate L_{A90}, L_{A10}, L_{Aeq} and L_{Amax} noise descriptors continuously over sampling periods of 15 minutes for the entire monitoring period. Two attended noise measurements were also conducted at each logger location for 15 minute durations in order to identify ambient noise sources and validate logger data. Instantaneous noise levels for operator-identified noise sources were observed and noted during the measurements.

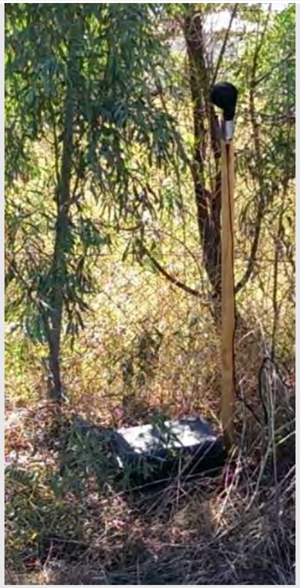
Several of the noise loggers were programmed to record the noise descriptors at more frequent time intervals. The more frequent time intervals were used to enable recording of individual train pass-bys and for determination of the relevant rail noise descriptors.

Prior to deployment, a calibration check was performed on the noise monitoring equipment using a Bruel and Kjaer Type 4231 sound level calibrator (serial number 2542101). At completion of the measurements, the equipment was re-checked to ensure the sensitivity of the noise monitoring equipment had not varied. The noise loggers were found to be within the acceptable tolerance of ± 0.5 dB(A).

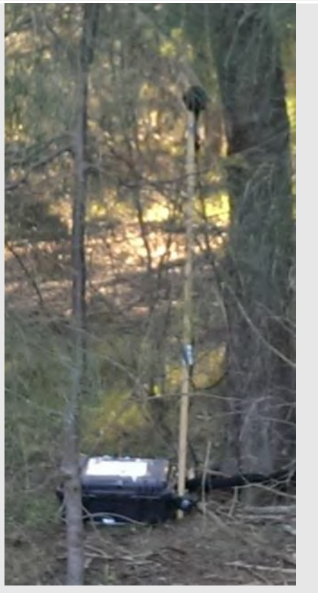
The data collected by the loggers was downloaded and analysed, and any invalid data removed. Invalid data generally refers to periods of time where average wind speeds were greater than 5 metre per second, or when rainfall occurred in accordance with the INP. Concurrent half hourly weather data was sourced from the Bureau of Meteorology's Dubbo automatic weather station and Parkes automatic weather station to identify any periods of weather which may have affected the monitoring results.

All sampling activities were undertaken with consideration to the specifications outlined in AS 1055 (1997) *Acoustics - Description and Measurement of Environmental Noise* and the *Industrial Noise Policy* (INP). Table 2.2 provides details of the noise loggers utilised for unattended monitoring.

Table 2.2 Unattended Noise Logger Details

Noise Logger	L01NNS	L02NNS	L03NNS	L04NNS	L05NNS
Location	Approximate chainage 757.2 km	Approximate chainage 749 km	Approximate chainage 734 km	Approximate chainage 716.4 km	Approximate chainage 700 km
Equipment type (serial)	SVAN 955 (27624)	SVAN 955 (27613)	SVAN 955 (27621)	SVAN 955 (27625)	SVAN 955 (27623)
Measurement started	1/3/2016, 10.00	1/3/2016, 11.30	1/3/2016, 13.00	1/3/2016, 14.30	1/3/2016, 17.30
Measurement ceased	10/3/2016, 09.15	10/3/2016 09.30	10/3/2016, 10.30	10/3/2016, 11.00	10/3/2016, 12.00
Frequency weighting	A	A	A	A	A
Time Response	Fast	Fast	Fast	Fast	Fast
Photo					

Noise Logger	L06NNS	L07NNS	L08NNS	L09NNS	L10NNS
Location	Approximate chainage 678.2 km	Approximate chainage 667.8 km	Reece Plumbing, approximate chainage 664.6 km	Moree council depot, approximate chainage 664.7 km	468 Frome St, approximate chainage 664.7 km
Equipment type (serial)	SVAN 977 (36821)	SVAN 955 (27612)	SVAN 977 (36819)	Rion NL-52 (131630)	Rion NL-21 (773193)
Measurement started	1/3/2016, 16.30	2/3/2016, 13.15	24/3/2016, 9.15	10/3/2016, 12.45	11/3/2016, 10.45
Measurement ceased	10/3/2016, 13.00	10/3/2016, 13.45	7/4/2016, 9.00	23/03/2016, 16.30	20/03/2016, 14.00
Frequency weighting	A	A	A	A	A
Time Response	Fast	Fast	Fast	Fast	Fast
Photo					

Noise Logger	L11NNS	L12NNS	L13NNS	L14NNS	L15NNS
Location	John Deere, approximate chainage 664.4 km	Approximate chainage 660 km	Approximate chainage 643 km	Approximate chainage 635.8 km	Approximate chainage 626 km
Equipment type (serial)	SVAN 977 (36819)	SVAN 955 (27622)	SVAN 955 (27615)	SVAN 955 (27614)	SVAN 955 (27621)
Measurement started	11/3/2016, 09.15	2/3/2016, 11.45	2/3/2016, 10.45	2/3/2016, 09.45	1/9/2015, 15.30
Measurement ceased	23/3/2016, 09.00	9/3/2016, 19.45	9/3/2016, 19.30	9/3/2016, 19.00	15/9/2015, 15.00
Frequency weighting	A	A	A	A	A
Time Response	Fast	Fast	Fast	Fast	Fast
Photo		Image not available			

Noise Logger	L16NNS	L17NNS	L18NNS
Location	Bellata Post office backyard	Graincorp- Edgeroi Silo	Newell Highway, “Rock dale”
Equipment type (serial)	SVAN 955 (27614)	SVAN 955 (27614)	Rion NL-52 (00131630)
Measurement started	11/3/2016, 13.45	24/3/2016, 11.45	24/3/2016, 11.00
Measurement ceased	23/03/2016, 14.00	7/4/2016, 10.30	6/4/2016, 16.15
Frequency weighting	A	A	A
Time Response	Fast	Fast	Fast
Photo			

2.4.2 Attended noise monitoring

Baseline attended noise measurements were conducted at the above monitoring locations to supplement the unattended noise monitoring data and assist with noise source identification. The attended noise measurements were conducted between 21 March 2016 and 6 April 2016 using a B&K 2250 Sound Level Meter (SLM). This SLM is capable of measuring continuous sound pressure levels and is able to record L_{A90}, L_{A10}, L_{Aeq} and the maximum sound level recorded during the measurement period (L_{Amax}) noise descriptors.

Prior to deployment, the meter was calibrated using a B&K Type 4231 Class 1 acoustic calibrator (serial number 2542101) with a sound pressure level of 94 dB at one kilohertz. Calibration was checked prior to the commencement and at completion of the measurements. The difference was less than the acceptable tolerance of +/- 0.5 dB.

All sampling activities were undertaken with consideration to the specifications outlined in AS1055 (1997) *Acoustics - Description and Measurement of Environmental Noise* and the NSW *Industrial Noise Policy* (EPA, 2000).

2.4.3 Ambient noise monitoring results

Unattended monitoring

A summary of the calculated rating background level (RBL) $L_{A90(period)}$ and $L_{Aeq(period)}$ noise monitoring results are shown in Table 2.3. The RBL represents the existing background noise environment in the area of the proposal. Detailed noise monitoring charts are provided in Appendix A.

Table 2.3 RBL $L_{A90\ (period)}$ and $L_{Aeq\ (period)}$ Noise Monitoring Results, dB(A)[1][2]

Location	L_{A90} RBL noise levels			L_{Aeq} ambient noise levels		
	Day	Evening	Night	Day	Evening	Night
L01NNS	39	39	41	49	50	50
L02NNS	19	23	32	46	43	41
L03NNS	27	30	35	45	47	45
L04NNS	21	21	33	49	50	46
L05NNS	20	21	36	40	46	46
L06NNS	26	28	28	48	56	52
L07NNS	41	34	29	48	47	42
L08NNS	36	38	28	53	52	47
L09NNS	35	36	37	54	50	47
L10NNS	42	37	29	54	52	48
L11NNS	43	38	35	65	64	60
L12NNS	38	38	39	54	57	53
L13NNS	28	29	30	51	55	52
L14NNS	30	32	40	49	51	48
L15NNS	30	22	18	58	58	55

[1] The NSW INP states that where the RBL is less than 30 dB(A), then it is set to 30 dB(A). The INP also states that the evening RBL should not be higher than the day time RBL, and that the night time RBL should not be higher than the evening RBL.

[2] The NSW INP defines day as the period from 7:00 am to 6:00 pm Monday to Saturday; or 8:00 am to 6:00 pm on Sundays and Public Holidays. Evening is defined as the period from 6:00 pm to 10:00 pm. Night time is defined as the remaining period.

Location	L_{A90} RBL noise levels			L_{Aeq} ambient noise levels		
	Day	Evening	Night	Day	Evening	Night
L16NNS	34	32	29	46	46	42
L17NNS	34	36	29	52	55	53
L18NNS	35	36	34	53	51	47

Attended monitoring

A summary of the attended noise monitoring results are given in Table 2.4.

Table 2.4 Attended Monitoring Results

Location and date	Measurement Time		Measured noise levels dB(A)			Observations and instantaneous noise levels dB(A)
	Start	Stop	L_{90}	L_{10}	L_{Aeq}	
L01NNS, 1/03/2016	09.50	10.05	39	52	51	Road noise, 44-65 Birds, 38-52 Insects, 36-38 Silo operations, 45-48
	10.09	10.24	41	55	55	Road noise, 45-70 Birds, 40-60 Insects, 35-45 Silo operations, 45-52
L02NNS 1/03/2016	11.21	11.36	27	47	43	Road noise, 30-35 Birds, 28-30 Wind noise, 35-57 Insects, 25-30
	11.38	11.53	25	43	40	Insects, 35-30 Road noise, 25-30 Wind noise, 30-57
L03NNS, 1/03/2016	12.59	13.14	31	44	43	Birds, 30-50 Wind noise, 30-45 Road noise, 33-39
	13.16	13.31	33	48	46	Birds, 30-60 Wind noise, 30-40 Road noise, 40-57
L04NNS, 1/03/2016	14.19	14.35	22	33	32	Insects, 20-30 Birds, 20-35 Wind noise, 20-40
	14.36	14.52	23	34	35	Wind noise, 20-40 Insects, 25-35 Birds, 25-35
L05NNS, 1/03/2016	17.35	17.50	27	41	41	Birds, 30-45 Insects, 25-30 Wind noise, 25-43 Road noise, 35-45
	17.51	18.06	31	41	41	Birds, 28-38 Insects, 25-30 Wind noise, 25-42

Location and date	Measurement Time		Measured noise levels dB(A)			Observations and instantaneous noise levels dB(A)
	Start	Stop	L_{90}	L_{10}	L_{Aeq}	
L06NNS, 1/03/2016	16.15	16.30	28	45	40	Road noise, 30-53 Insects, 20-30
	16.52	17.07	26	43	40	Road noise, 30-50 Insects, 25-35
L07NNS, 2/03/2016	13.13	13.28	31	39	39	Road noise, 30-41 Birds, 30-40 Insects, 30-35 Conversations, 30-45 Wind noise, 32-36
	13.30	13.45	31	39	37	Birds, 30-48 Road noise, 30-39 Insects, 32-36 Wind noise, 32-35
L08NNS, 24/3/2016	8.54	9.09	42	51	49	Road noise, 48-60 Birds, <40 Wind noise, <40
	9.11	9.26	41	51	53	Road noise, 42-61 Birds, 40-50 Aircraft, 60-76
L09NNS 23/3/2016	15.46	16.01	41	56	54	Road noise, 52-66 Vehicles in depot, 48-64 Aircraft, 50-55
	16.02	16.17	40	53	51	Road noise, 40-60 Vehicles in depot, 50-53 Dog barking, 48-60 Wind noise, <30 Aircraft, 48-58
L10NNS, 11/03/2016	10.06	10.21	45	60	59	Road noise, 50-61 Birds, 40-50 Wind noise, 40-45
	10.45	11.00	45	60	57	Road noise, 50-60 Birds, 40-50 Wind noise, 40-45
L11NNS, 11/03/2016	09.05	09.20	55	71	68	Road noise, 55-80 Insects, <50 Wind noise, <50 Site operations (banging, forklifts), 50-57 Birds, <50
	09.30	09.45	53	71	67	Road noise, 55-80 Insects, <50 Wind noise, <50 Site operations (banging, forklifts), 50-57 Birds, <50

Location and date	Measurement Time		Measured noise levels dB(A)			Observations and instantaneous noise levels dB(A)
	Start	Stop	L_{90}	L_{10}	L_{Aeq}	
L12NNS, 2/03/2016	11.30	12.00	43	58	54	Road noise, 48-62 Birds, 40-45 Machinery, 40-45 Insects, <30
	11.46	12.01	43	56	52	Road noise, 48-65 Birds, 40-50 Machinery, 40-44 Insects, 38-43
L13NNS, 2/03/2016	10.26	10.31	33	53	49	Road noise, 40-58 Insects, 32-36 Wind noise, 38-42 Birds, 35-40
	10.42	10.57	36	54	50	Road noise, 33-62 Insects, 30-36 Birds, 30-40 Wind noise, 37-46
L14NNS, 2/03/2016	09.34	09.49	38	51	48	Road noise, 40-60 Bird noise, 40-42 Banging/hammering, 48-42 Wind noise, 35-45 Insects, <30
	09.51	10.06	39	50	47	Road noise, 40-57 Wind noise, 40-45 Birds, 38-50
L15NNS, 1/9/2015	15.33	15.49	40	62	58	Road noise, 54-63 Birds audible
L16NNS, 11/03/2016	13.32	13.47	35	49	47	Birds, 40-43 Insects, 35-40 Road noise, 40-60 Wind noise, 40-43
	13.49	14.04	36	46	46	Birds, 36-52 Road noise, 40-50 Insects, 35-40 Wind noise, <35
L17NNS, 24/3/2016	11.32	11.47	40	54	50	Road noise, 42-54 Wind noise, 40-45
	11.48	12.03	39	55	50	Road noise, 45-63 Wind noise, 40-43 Birds, <40
L18NNS, 24/3/2016	10.27	10.42	43	54	50	Road noise, 48-63 Wind noise, 40-45 Birds, <40
	10.48	11.03	40	52	49	Road noise, 47-61 Wind noise, 40-45 Birds, <40

2.4.4 Train pass-by noise levels

Data from the unattended noise loggers located adjacent to existing rail lines were reviewed and analysed to identify train pass-by events which occurred during the monitoring period. The relevant train noise parameters were calculated and are summarised in Table 2.5.

Table 2.5 Identified Train Pass-by Summary

Monitoring Location	Distance to nearest rail track (m)	Train type	Average noise level SEL dB(A)	Average duration (s)
L12NNS	20	Freight	98	52
L13NNS	30	Freight	93	52
L14NNS	65	Freight	86	83
L16NNS	60	Freight	90	77

The results from the noise monitoring were used to determine the L_{Aeq} over the relevant time period (day and night) for rail pass-by noise during the monitoring period and is further discussed in Section 4.2.

3. Legislative context

3.1 Operational rail noise criteria

Operational rail noise criteria are derived from the *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013).

This guideline presents non-mandatory noise criteria for receivers affected by the proposal. Where receivers are predicted to exceed the relevant noise criteria, an assessment of possible mitigation measures to ameliorate these impacts would be conducted. These mitigation measures would be considered if they can be reasonably and feasibly implemented.

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

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

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

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

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

For this assessment, ARTC considers the Inland Rail proposal to be a 'redevelopment of an existing heavy rail line' as the proposal will be developed on land within an existing operational rail corridor. The Camurra Bypass section of the proposal is to be substantially realigned based on the definitions provided in the RING, however there are no nearby receivers that are located close enough to the Camurra bypass to be considered for noise mitigation under the RING and therefore only the redevelopment criteria is relevant for this assessment. Therefore, the 'redevelopment of existing rail line' criteria listed in Table 3.1 apply to this assessment.

For residential receivers, the noise trigger levels for absolute levels of rail noise have two components, L_{Aeq} and L_{Amax}. The L_{Aeq} contribution level of rail noise is assessed over the day or night period and the maximum noise level (L_{Amax}) from pass-by events. The trigger values listed in Table 3.1 need to be exceeded to initiate an assessment of rail noise impacts and investigate potential mitigation measures.

Table 3.1 Airborne rail traffic noise trigger levels for residential land uses

Type of Development	Noise Trigger Levels dB(A) (External)	
	Day (7.00 – 22.00)	Night (22.00 – 7.00)
Redevelopment of existing rail line	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 or more, or existing L_{Amax} rail noise levels by 3 or more and predicted rail noise levels exceed	
	65 $L_{Aeq(15h)}$ OR 85 L_{AFmax}	60 $L_{Aeq(9h)}$ OR 85 L_{AFmax}
New rail line development	Predicted rail noise levels exceed:	
	60 $L_{Aeq(15h)}$ OR 80 L_{AFmax}[3]	55 $L_{Aeq(9h)}$ OR 80 L_{AFmax}

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

In accordance with the RING, other non-residential sensitive land uses including hospitals, schools and outdoor recreational areas have their own specific noise trigger levels for heavy rail redevelopments that are applicable when the facility or space is in use. Noise trigger levels for these receivers are applicable as internal or external levels depending on the land use. For internal noise criteria, the acoustic performance of the building façade affects the transmission of noise into the premises. As construction materials and the façade acoustic performance of these buildings is unknown and may vary, a conservative 10 dBA reduction in noise between the external level and internal level has been assumed[4]. The RING criteria for non-residential land uses are shown Table 3.2.

Table 3.2 Airborne rail traffic noise trigger levels for non-residential land uses

Land use type	Noise Trigger Levels dB(A) (When in use)	
	New rail line development	Redevelopment of existing rail line
	Resulting rail noise levels exceed:	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more ***and*** resulting rail noise levels exceed:
Schools, educational institutions and child care centres	40 $L_{Aeq(1h)}$ Internal	45 $L_{Aeq(1h)}$ Internal
Places of worship	40 $L_{Aeq(1h)}$ Internal	45 $L_{Aeq(1h)}$ Internal
Hospital wards	35 $L_{Aeq(1h)}$ Internal	40 $L_{Aeq(1h)}$ Internal
Hospitals – other uses	60 $L_{Aeq(1h)}$ External	65 $L_{Aeq(1h)}$ External
Open space – Passive use	60 $L_{Aeq(15h)}$ External	65 $L_{Aeq(15h)}$ External
Open space – Active use	65 $L_{Aeq(15h)}$ External	65 $L_{Aeq(15h)}$ External

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

[3] The L_{AFMAX} level is the L_{AMax} level using a fast time response

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

3.2 Road traffic noise criteria

Operational road traffic noise criteria for sensitive receivers are based on the NSW *Road Noise Policy* (RNP) (DECCW, 2011). Application of noise criteria has been conducted in accordance with the RMS *Noise Criteria Guideline* (NCG). The assessment timeframe for operational road traffic noise are in the proposed year of 2020 (the year of operation of the new and upgraded roads) and ten years after this in 2030.

The criteria applied at residential receivers within the study area are dependent on the functional class of the road and the road development type. For the purposes of determining road noise criteria, the NCG classifies road development types as new, redeveloped and transition zone. Noise criteria is calculated for each building façade and the criteria developed at the most affected façade is considered the most stringent and will be used in this assessment.

Where a residential receiver is exposed to noise from both new and redeveloped roads a transition zone is created to establish the appropriate criteria. A further check using the relative increase criterion is used to prevent excessive changes in noise levels.

The proposal consists of both new and redeveloped segments with transition zones at the following locations:

- Jones Avenue (existing) to Jones Avenue (new alignment/bridge). Two transitions have been identified at the ends of the new bridge connecting to Jones Avenue and Tycannah Street.
- Newell Highway existing to Newell Highway (new alignment). Two transition zones have been identified at either end where the new alignment connects with the existing alignment.

Noise criteria for residences exposed to noise from roads in the transition zone will be between the new and redeveloped NCG noise criteria. The road proposal is considered new where the road has been substantially realigned. The criteria for residences are summarised in Table 3.3.

Table 3.3 NCG assessment criteria for residential land uses, $L_{Aeq(period)}$,dBA

Road category	Type of project	Assessment criteria (external)	
		Day (7:00 am to 10:00 pm)	Night (10:00 pm to 7:00 am)
Arterial roads/ sub-arterial roads	Existing residences affected by noise from new arterial road corridors	$L_{Aeq(15hr)}$ 55 (external)	$L_{Aeq(9hr)}$ 50 (external)
	Existing residences affected by noise from redevelopment of an existing arterial road	$L_{Aeq(15hr)}$ 60 (external)	$L_{Aeq(9hr)}$ 55 (external)
	Existing residences affected by both new roads and the redevelopment of existing arterial/sub-arterial roads in a Transition Zone	$L_{Aeq(15hr)}$ 55-60 (external)	$L_{Aeq(9hr)}$ 50-55 (external)
	Existing residences affected by increases in traffic noise of 12dBA or more from new arterial/sub-arterial roads	$L_{Aeq(15hr)}$ 42-55 (external)	$L_{Aeq(9hr)}$ 42-50 (external)
	Existing residences affected by increases in traffic noise of 12dBA or more from redevelopment of existing arterial/sub-arterial roads	Between $L_{Aeq(15hr)}$ 42-60 (external)	Between $L_{Aeq(9hr)}$ 42-55 (external)

When the proposal specific criteria have been exceeded, a receiver may qualify for consideration of noise mitigation. The qualifying process from the Noise Mitigation Guideline (NMG) is provided in Section 3.2.3.

3.2.1 Sleep disturbance

The RNP provides a literature review for the assessment of sleep arousal due to traffic noise however does not set a sleep disturbance assessment criterion.

Sleep disturbance impacts are likely to depend on the following:

- Maximum noise level of an event
- Number of occurrences
- Duration of the event
- Level above background or ambient noise levels

Sleep disturbance criteria are based on ENMM Practice Note III:

- Maximum internal noise levels below 55 dBA are unlikely to cause awakening reactions.
- One or two maximum internal noise level events of 65 dBA are not likely to significantly affect health and well-being.

For continuous rather than intermittent traffic flow, the ENMM recommends L_{Amax} noise pass-by events should not exceed $L_{Aeq\ (1hr)}$ noise levels by more than 15 dBA. The ENMM advises that maximum noise levels can be used as a tool to prioritise and rank mitigation strategies, but should not be applied as a decisive criterion in itself.

3.2.2 Proposal specific operational noise criteria

A summary of the road classifications in the study area is provided in Table 3.4. Classification changes have been qualitatively assessed based on expected traffic flows as a result of the proposal.

Table 3.4 Road types and classifications

Road name	Road classification	Type of road (as per NCG)	Change in road classification?
Jones Avenue	Sub-arterial	Redeveloped	Yes
Jones Avenue	Sub-arterial	New	Yes
Newell Highway	Arterial	Redeveloped	No
Newell Highway	Arterial	New	No

Noise contribution differences have been calculated and the noise criteria at residential receivers within the transition zones and all other receivers are summarised in Appendix H.

3.2.3 Guidance on the evaluation of noise mitigation measures for road traffic noise

The Noise Mitigation Guideline (NMG) provides guidance in managing and controlling road traffic generated noise and describes the principles to be applied when reviewing noise mitigation. The NMG recognises that the criteria recommended by the NCG are not always practicable and that it is not always feasible or reasonable to expect that they should be achieved.

The NMG notes that the most effective way of minimising noise from vehicles and traffic is to control vehicle noise at the source. Where source measures are not practical, or do not provide sufficient noise reduction, additional methods are required to reduce levels to within acceptable margins. Such additional methods may include the use of noise barriers and/or consideration for architectural treatment of residences.

The NMG provides three triggers where a receiver may qualify for consideration of noise mitigation (beyond the adoption of road design and traffic management measures). These are:

- The predicted Build noise level exceeds the NCG controlling criterion and the noise level increase due to the proposal (i.e. the noise predictions for the Build minus the No Build) is greater than 2 dBA.
- The predicted Build noise level is 5 dBA or more above the criteria (exceeds the cumulative limit) and the receiver is significantly influenced by proposal road noise, regardless of the incremental impact of the project.
- Where the cumulative limit does not apply (i.e. most of the noise causing the cumulative limit to be exceeded comes from a road that is not assessed as part of the project), if the noise level contribution from the road proposal is acute (daytime $L_{Aeq(15\ hour)}$ 65 dB or higher, or night-time $L_{Aeq(9\ hour)}$ 60 dB or higher) then it qualifies for consideration of noise mitigation even if noise levels are dominated by another road.

The NMG mitigation guidance is presented as a flowchart in Figure 3.1.

3.3 Construction noise criteria

The ICNG (DECC 2009) provides recommended standard hours for construction activities as follows:

- 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

ARTC operates its rail network in accordance with an Environmental Protection Licence (EPL) administered by the EPA. The licence sets out performance standards and criteria for discharges to air, water and land, including noise from construction and operation of the network.

In accordance with EPL 3142, the upgrade of existing rail infrastructure is classified as “maintenance”. EPL 3142 condition O4.1 states maintenance work should be undertaken within recommended standard hours “where to do so would not adversely affect ARTC’s ability to provide safe and reliable services or a safe working environment”. EPL 3142 condition O4.1 defines the same standard working hours as the ICNG.

Scheduling three track possessions (that is, the times that the movement of trains along the rail corridor are stopped for maintenance) to complete the works is the most efficient manner in which ARTC can continue to provide reliable services while maintaining a safe working environment for construction team members.

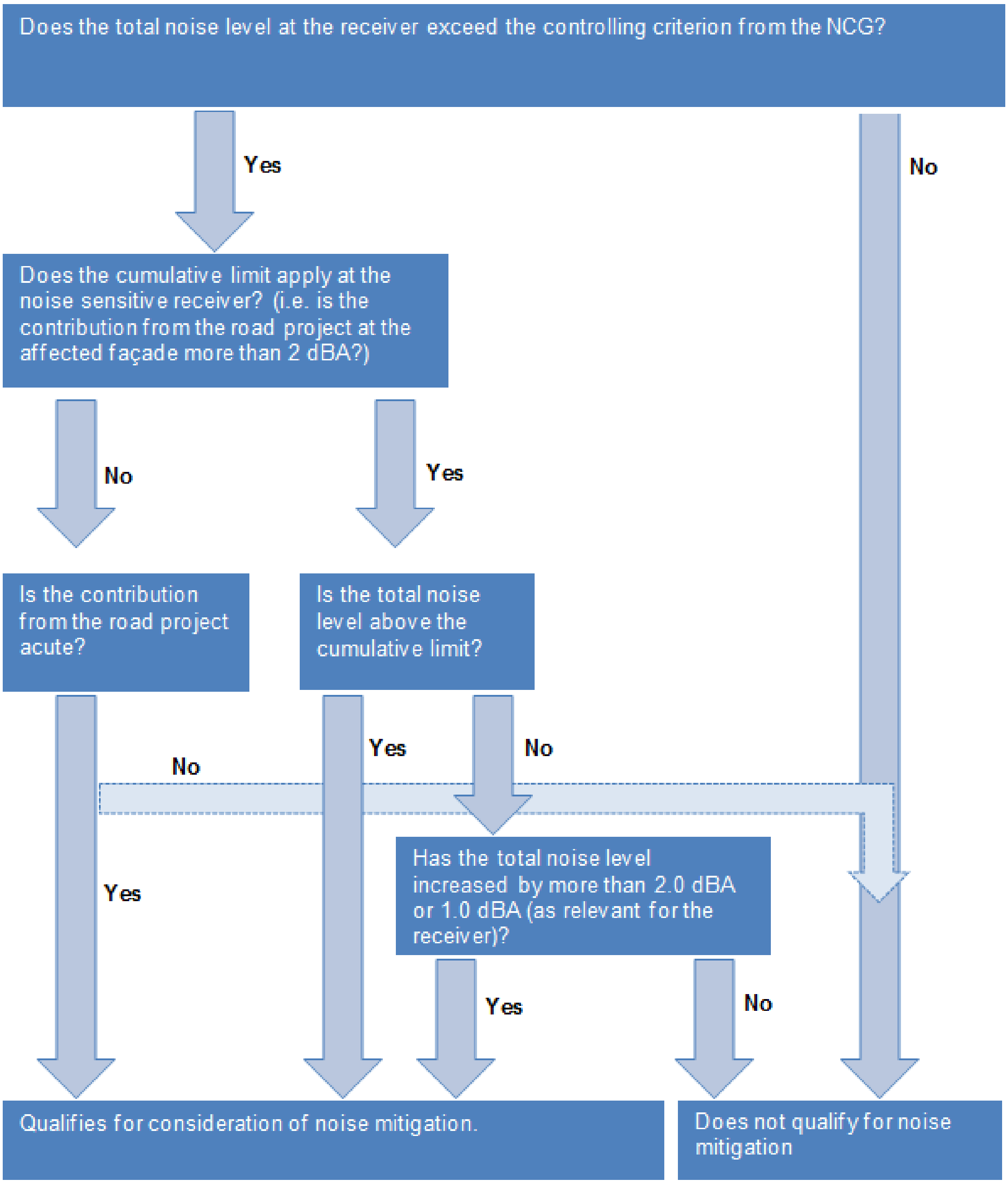


Figure 3.1 Noise mitigation flowchart (derived from the NMG)

EPL 3142 condition O4.3 states:

Where maintenance activities are undertaken, including outside of the hours specified in condition O4.1, noise impacts must be managed in accordance with those provisions of the Interim Construction Noise Guideline (DECC, 2009) which require the licensee to:

- *identify noise sensitive receivers that may be affected at least 7 days prior to the proposed commencement date; except where the licensee first becomes aware of the need to undertake the railway maintenance activities less than 7 days prior to the proposed commencement date, in which case the identification must be undertaken as soon as practicable after becoming aware of the need to undertake the railway maintenance activities;*
- *identify hours for the proposed activities;*
- *identify noise impacts at noise sensitive receivers;*
- *select and apply reasonable and feasible work practices to minimise noise impacts; and*
- *notify the noise sensitive receivers at least 5 days prior to the commencement of railway maintenance activities undertaken outside of the hours specified in Condition O4.1, except where the licensee first becomes aware of the need to undertake those railway maintenance activities less than 5 days prior to the proposed commencement date, in which case the notification must be provided as soon as practicable after becoming aware of the need to undertake the railway maintenance activities.*

The construction the Camurra bypass and the construction of crossing loops are considered ‘construction’ activities under EPL 3142. The EPL states that:

O4.6 So far as is reasonably practicable and where to do so would not adversely affect ARTC's ability to provide safe and reliable services or a safe working environment, construction activities must be undertaken: a) between the hours of 7.00 am and 6.00 pm Mondays to Friday b) between the hours of 8.00 am and 1.00 pm Saturday; and c) not on Sundays or public holidays.

O4.9: When construction activities are required to be undertaken outside of the hours specified in Condition O4.6, any high noise generating works must only be undertaken: a) between the hours of 8.00 am and 10.00 pm Monday to Friday; b) between the hours of 8.00 am and 6.00 pm Saturdays and Sundays; and c) where the high noise impact generating works are likely to impact the same noise sensitive receivers, in blocks of no more than 3 hours, with at least a 1 hour respite between each block of work.

O4.10: Where construction activities are undertaken, including outside of the hours specified in Condition O4.6, noise impacts must be managed in accordance with those provisions of the Interim Construction Noise Guideline (DECC, 2009) which require the licensee to: a) identify noise sensitive receivers that may be affected at least 7 days prior to the proposed commencement date; b) identify hours for the proposed activities; c) identify noise impacts at noise sensitive receivers; d) select and apply reasonable and feasible work practices to minimise noise impacts; and e) notify the noise sensitive receivers as per Condition O4.11.

Table 3.5 and Table 3.6 list the ICNG (DECC 2009) construction noise criteria at surrounding residential and industrial receivers.

The 'noise affected' management level represents the point above which there may be some community reaction to noise. Where the noise affected management level is exceeded, all feasible and reasonable work practices to minimise noise need to be applied and all potentially affected receivers informed of the nature of the works, expected noise levels, duration of works and a method of contact. The noise affected management level is the background noise level plus 10 dB(A) during recommended standard hours and the background noise level plus 5 dB(A) outside of recommended standard hours.

The 'highly noise affected' management level represents the point above which there may be strong community reaction to noise. Where noise is above this management level, any feasible and reasonable ways to reduce noise below this level would be applied. If no quieter work method is feasible and reasonable, the affected residence would be advised of the duration and noise levels of the works and any respite periods that will be provided. The highly noise affected management level for standard working hours is 75 dB(A).

The ICNG defines what is considered to be feasible and reasonable as follows:

'Feasible - A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.

Reasonable - Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.'

Table 3.5 ICNG construction noise criteria for residential receivers, dB(A)

Time Period	ICNG Management Level $L_{Aeq(15\ min)}$
Recommended standard hours: Day Mon-Fri (7:00 am – 6:00 pm) Sat (8:00 am – 1:00 pm) Sun/Pub Hol (Nil)	Noise affected level: RBL+10 dB(A) Highly noise affected level (all residential receivers) - 75 dB(A)
Outside of standard hours: Evening Mon-Fri (6:00 pm – 10:00 pm) Sat (1:00 pm – 10:00 pm) Sun/Pub Hol (8:00 am – 6:00 pm)	Noise affected level – RBL+5 dB(A)
Outside of standard hours: Night Mon-Fri (10:00 pm – 7:00 am) Sat (10:00 pm – 8:00 am) Sun/Pub Hol (6:00 pm – 7:00 am)	Noise affected level – RBL+5 dB(A)

Source: Interim Construction Noise Guideline (DECC 2009)

Note 1: The INP states that where the RBL is less than 30 dB(A), then it is set to 30 dB(A)

Table 3.6 ICNG construction noise criteria for industrial premises, dB(A)

Time period	Background level $L_{A90(period)}$	ICNG management level $L_{Aeq(15\ min)}$
When in use	NA	75 dB(A)

Source: Interim Construction Noise Guideline (DECC 2009)

3.3.1 Proposal specific construction noise management level

Construction of the proposal is expected to be undertaken during the primary proposal construction hours in accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework. Construction work would be undertaken during the following primary proposal construction hours:

- Monday to Friday: 6.00 am to 6.00 pm
- Saturday: 6.00 am to 6.00 pm
- Sundays and public holidays: 6.00 am to 6.00 pm

As the proposal construction hours would be undertaken during and outside of the ICNG standard construction hours (Table 3.5), the preferred approach for the proposal is that the more stringent level night noise management level will be adopted as the proposal specific construction noise management level. This corresponds to a level of 35 dB(A) for all logger locations, with the exception of L01NNS, L09NNS, L11NNS, L12NNS and L18NNS. Site observations and analysis of logger data at these locations indicate that the elevated background levels were due to insect noise. In accordance with the INP, background levels at these locations may not be representative of the noise environment during seasonal variations where noise from this source may not occur. As such, and to provide a consistent mitigation approach, the lower noise management level of 35 dB(A) has been adopted across this project.

Table 3.7 ICNG construction noise criteria for residential receivers, dB(A)

Time period	Proposal specific construction noise management level LAeq(15 min)
All periods	35 dB(A)

The EIS provides further details on the anticipated work hours and construction methodology.

3.4 Construction traffic noise criteria

The *Road Noise Policy* (RNP) (DECCW 2011) provides non-mandatory traffic noise assessment criteria for land use developments with the potential to create additional traffic on existing freeways, arterial, sub-arterial and local roads.

The relevant construction traffic noise criteria are listed in Table 3.5.

Table 3.8 Construction traffic noise criteria for residential land uses

Road Category	Type of proposal/Land Use	Assessment Criteria – external dB(A)	
		Day (7:00 am–10:00 pm)	Night (10:00 pm–7:00 am)
Freeway/ arterial road/sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq\ (15\ hour)}$ 60 (external)	$L_{Aeq\ (9\ hour)}$ 55 (external)
Local road	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq\ (1\ hour)}$ 55 (external)	$L_{Aeq\ (1\ hour)}$ 50 (external)

Source: Road Noise Policy (DECCW 2011)

Note: Section 2.4 of the RNP indicates that where existing road traffic noise levels already exceed the assessment criteria, an increase of less than 2 dB represents a minor impact that is barely perceptible to the average person.

The accepted application of Section 2.4 of the RNP is that where existing road traffic noise levels already exceed the assessment criteria, an increase of less than 2 dB represents a minor impact that is barely perceptible to the average person.

3.5 Vibration criteria

3.5.1 Human vibration criteria

The DEC's publication, *Assessing vibration: A technical guideline* 2006 outlines methods of assessing potential impacts and ways to manage vibration from construction activities as well as rail operations such as ground-induced vibration created by rolling stock movements.

Assessing vibration: a technical guideline is based on guidelines contained in British Standard BS 6472:1992 *Evaluation of human exposure to vibration in buildings* (1–80 Hz).

Typically, construction works generate ground vibration of an intermittent nature. In accordance with BS 6472–1992, intermittent vibration is assessed using the Vibration Dose Value (VDV). Further, operational vibration produced by train pass-bys are classified as intermittent vibration. Acceptable VDV's, as outlined in *Assessing vibration: A technical guideline*, are listed in Table 3.9.

Table 3.9 Acceptable vibration dose values for intermittent vibration

Location	Daytime[1] ($m/s^{1.75}$)		Night-time[1] ($m/s^{1.75}$)	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Source: Table 2.4 Assessing vibration: A technical guideline (DEC 2006)

Notes:

1. Daytime is 7.00 to 22.00 and night-time is 22.00 to 7.00.
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be need to assess intermittent values against the continuous or impulsive criteria for critical areas.

Whilst the assessment of response to vibration in BS 6472-1:1992 is based on VDV and weighted acceleration, for construction-related vibration, it is considered more appropriate to provide guidance in terms of PPV, since this parameter is more likely to be routinely measured based on the more usual concern over potential building damage.

Humans are capable of detecting vibration at levels well below those that risk causing damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in British Standard BS 5228-2:2009 *Code of practice for noise and vibration on construction and open sites – Part 2: Vibration* as listed below in Table 3.10.

Table 3.10 Guidance on the effects of vibration levels

Approximate Vibration Level	Degree of Perception
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.30 mm/s	Vibration might be just perceptible in residential environments.
1.00 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10.00 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

Source: BS 5228-2:2009 Code of practice for noise and vibration on construction and open sites – Part 2: Vibration

3.5.2 Structural damage criteria

Currently, there is no Australian Standard that sets criteria for the assessment of building damage caused by vibration. Consistent with other major projects of a similar type, guidance on limiting vibration values has been obtained by reference to German Standard *DIN 4150-3: 1999-02 Structural Vibration – Part 3: Effects of vibration on structures.* Short-term vibration guideline values are listed in Table 3.11.

Table 3.11 Guideline values for short term vibration on structures

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

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

Notes:

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

3.6 Blasting

The proposal does not include blasting as part of the construction works, therefore blasting is not discussed further in this assessment.

3.7 Other standards and guidelines

The following additional standards and guidelines have been referenced in this assessment:

- Environmental Noise Management Manual (ENMM) (RTA 2001)
- *Industrial Noise Policy* (INP) and Application Notes, EPA, 2000
- Construction Noise Strategy (CNS), TfNSW, 2012
- Environmental Management System Guide: Noise and Vibration from Rail Facilities (NVRF), Sydney Trains, 2013
- Development near rail corridors and busy roads – interim guideline, Department of Planning, 2008
- Australian Standard AS 1055 - 1997 Acoustics – Description and Measurement of Environmental Noise
- Australian Standard AS 2436 – 2010 Guide to noise and vibration control on construction, demolition and maintenance sites
- *Transit noise and vibration impact assessment,* US Department of Transportation Federal Transit Administration (FTA), 2006
- NSW Sustainable Design Guidelines Version 3.0, TfNSW, 2013

4. Operational rail noise and vibration assessment

4.1 Methodology

4.1.1 Overview

The approach to assessing operational rail noise can be summarised as follows:

- Identify the existing and proposed rail traffic volumes and speeds for the study area (provided by ARTC).
- Calculate L_{Aeq} and L_{Amax} using noise logger data obtained at the monitoring locations.
- Validate noise model using the calculated noise levels from noise loggers.
- Model operational rail (L_{Aeq} and L_{AMax}) noise for the agreed scenarios.
- Assess operational rail noise predictions (L_{Aeq} and L_{AMax}) against the relevant RING trigger levels.
- Consider noise mitigation options where exceedances of the trigger levels are predicted.

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

4.1.2 Noise modelling scenarios

The operational rail noise scenarios used in the assessment were developed to clearly identify noise levels resulting from existing operations and future rail operations with the inclusion of the proposal. A scenario was also developed which identifies the likely future rail operations noise without the proposal so that the effect of the proposal can be clearly identified.

The RING states that noise trigger levels are to be evaluated at two points in time: Immediately after operations commence and for a design year, typically 10 years later. The Inland Rail project is composed of a number of individual brownfield and greenfield proposals, each with their own planning conditions. Therefore, for the proposal, assessment timeframes should consider changes in operations within the study area that are enabled by the Inland Rail project as a whole.

Inland Rail 'through connection' operation will occur once all component proposals are completed, therefore completion of a single brownfield proposal will have minor impact on train numbers and speeds in the years immediately after completion other than improvements in local operating conditions. After through connection is established in 2025 by completion of the remaining brownfield and greenfield proposals, Inland Rail trains will begin to operate, generating an overall increase in train volumes on each proposal. Because each proposal is subject to individual approval conditions, the impacts of both the individual proposal in isolation and the overall Inland Rail project need to be assessed against the RING trigger levels.

Consequently, the following three assessment timeframes have been evaluated within the proposal's operational assessment study area for both build and no build scenarios:

1. Proposal: the individual proposal to which the planning conditions apply:
   - No build and build scenarios for the year in which operations commence following construction completion, 2020.
2. Through connection: the estimated time at which Inland Rail through connection between Brisbane and Melbourne is anticipated:
   - No build and build scenarios within the proposal's operational assessment study area at the through connection year, 2025.
3. Design year: a future scenario that reflects the normal operation of the Inland Rail project:
   - No build and build scenarios within the proposal's operational assessment area at the design year, 2040.

Rail operational volumes and speeds are not expected to change within the operational assessment study area if the proposal is not implemented (no build scenario), therefore only one no build model is needed, which represents the no build assessment scenarios at 2020 proposal opening year, 2025 Inland Rail through connection year and 2040 Inland Rail design year.

For the proposal opening year, the primary difference in operating conditions between the 2020 no build and 2020 build scenarios are the speed increases enabled through track improvements, while train volumes remain unchanged. For through connection and design years, operating volumes increase significantly at 2025 when through connection is established, then gradually grow through to 2040.

Noise modelling was also completed to demonstrate the existing noise environment and validate predictions. For this proposal, the existing operations were modelled for the year 2016.

The noise modelling scenarios used for the assessment are described in Table 4.1.

Table 4.1 Noise modelling scenarios

Time Frame:	Proposal build	No proposal build
	Includes: - Higher growth in projected volumes due to the proposal - Increases in train speeds due to the proposal	Includes: - Lower growth in projected volumes due to natural growth only without the proposal - No increases in train speeds
2016 – model for calibration against noise logger data		L_{Aeq}
2020 – Proposal opening year	L_{Aeq} note 1	L_{Aeq} note 1
2025 – Through connection opening year	L_{Aeq} and L_{Amax} note 2	L_{Aeq} and L_{Amax} note 2
2040 – Proposal design year[1]	L_{Aeq} and L_{Amax} note 2	L_{Aeq} and L_{Amax} note 2

Notes:

1. L_{Amax} levels are not expected to change at project opening as operating trains and train speeds are assumed to be unchanged until through connection opening year.

2. L_{Amax} levels are unrelated to volumes, therefore equivalent at 2025 and 2040 assessment timeframes.

4.1.3 Existing and future rail capacity

Rail volumes have been provided by ARTC for the current conditions as well as for the future conditions. Note that the volumes used in this assessment are different from those provided in the EIS Chapter 7. The noise assessment has been based on a more conservative estimate (greater numbers) of projected train volumes.

An equal split of day/night train movements was assumed over each 1-hour period. The data used for noise modelling inputs are listed in Table 4.2 and Table 4.3 below.

Table 4.2 Proposal rail volumes (trains per 24 hours)

Year	Track segment	Train Type			
		Grain	InterCapital	General	Passenger
2020-Proposal opening year	North Star - Moree	-	-	-	-
	Moree - Narrabri South Jct	1.7	-	-	1.8
2025-Through Connection	North Star - Moree	0.4	8.4	0.8	-
	Moree - Narrabri South Jct	1.7	8.4	-	1.8
2040-Design Year	North Star - Moree	0.4	18.0	0.9	-
	Moree - Narrabri South Jct	1.7	18.0	-	1.8

Source: ARTC

Table 4.3 Proposal train lengths (metres)

Train type	2020 - Proposal opening year		2025 - Through Connection		2040 - Design Year	
	no build	build	no build	build	no build	build
Grain	710	710	710	710	710	710
Intercapital	-	-	-	1800	-	1800
General	926	926	926	926	926	926
Passenger	50	215	50	215	50	215

Source: ARTC

4.1.4 Train speeds

For the purposes of this assessment, train speeds have been taken from ARTC's Route Access Standard for Dubbo to Goobang Junction (RAS I5, version 1.5, February 2016). Train speed graphs along the proposal track section are shown in Figure 4.1 and Figure 4.2. These speed profiles have been used in the noise model.

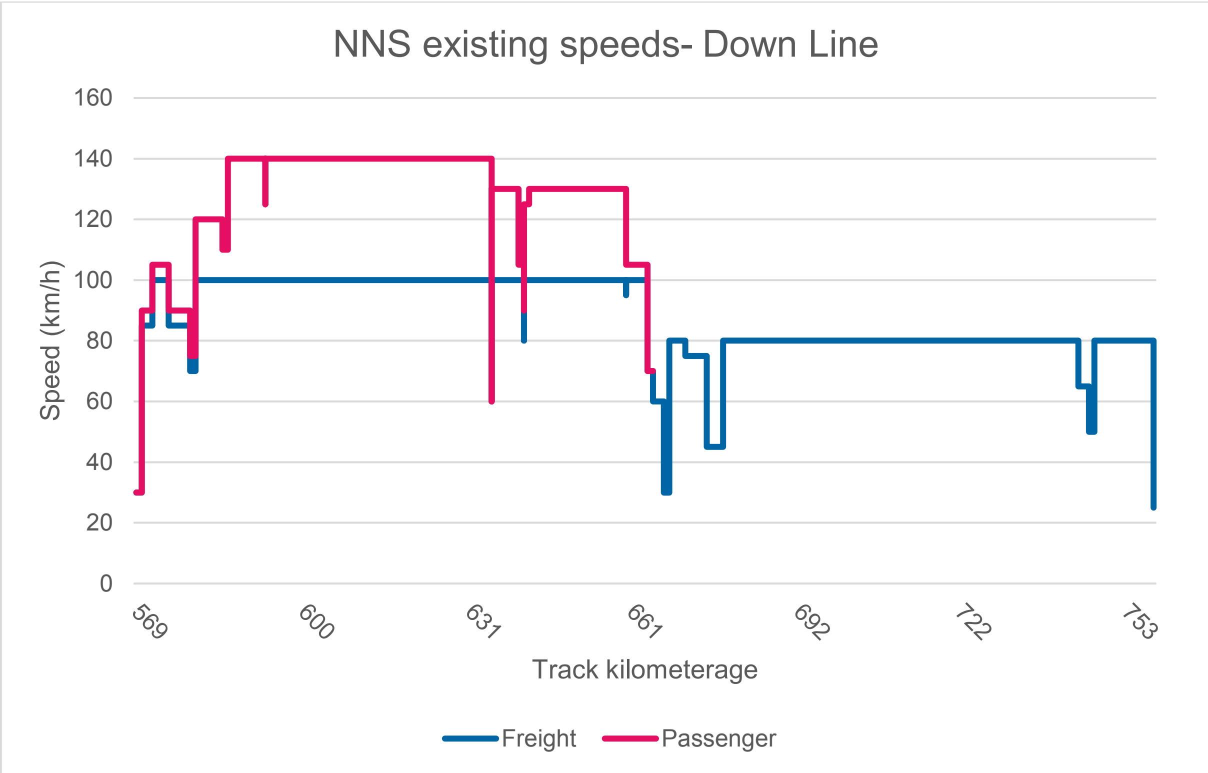


Figure 4.1 Existing track speeds- Down Line

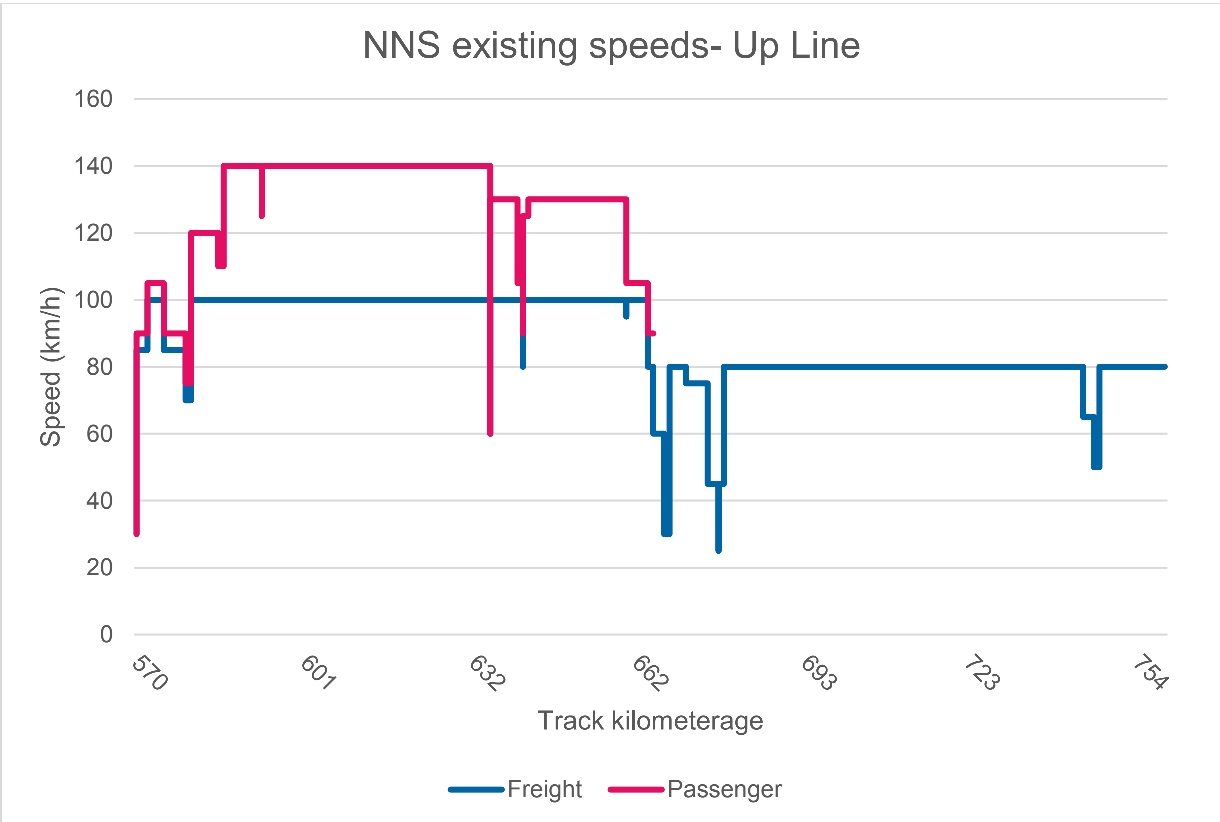


Figure 4.2 Existing track speeds- Up Line

4.1.5 NNS design speeds

The proposal will allow for an increase of freight train speeds up to 115 km/h and passenger train speeds up to 145 km/h. For some sections of track, speed will be limited due to curves, turnouts, crossings, crossing loops and sidings. As details of speed board locations were not available at the time of this assessment, the noise modelling adopts the track design speed which is limited by track geometry only and this will result in the assessment being conservative and over-predicting future noise levels. For each train type, the modelled speed is the lower of the design speed at a given location on the track and the train type speed limitations shown in Table 4.4. Track design speeds are shown in Figure 4.3 and apply to both up and down directions.

Table 4.4 Train type maximum speeds

Train type	Grain	Intercapital	General	Passenger
Type speed	80	115	80	140

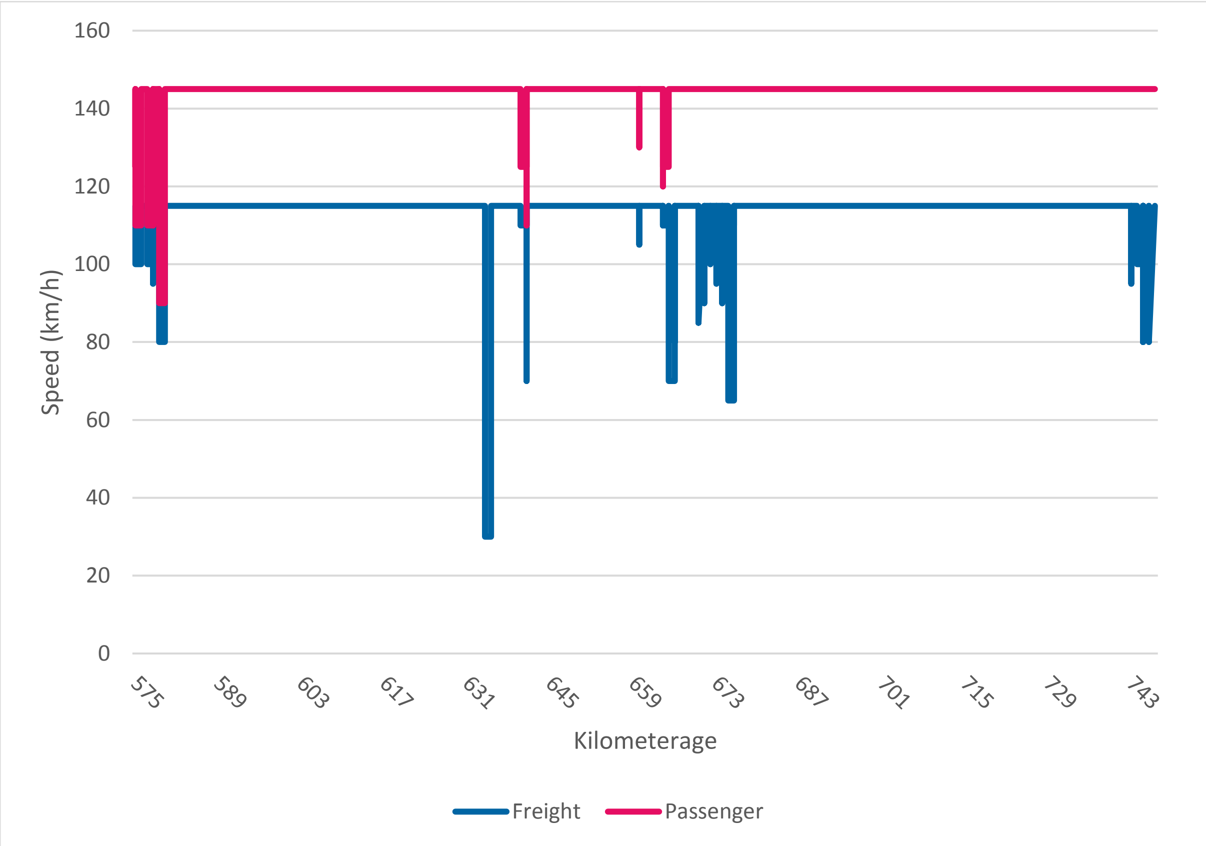


Figure 4.3 Proposal Design Speeds

4.1.6 Rail noise model setup

Acoustic modelling was undertaken using the computer prediction software Computer Aided Noise Abatement (CadnaA) version 4.6 to predict the effects of rail traffic noise from the proposal. The Nordic prediction method (TemaNord 1996:524) was used for modelling as this is able to produce L_{Aeq} and L_{AmaxF} levels.

The proposed development has been modelled based on available data at the time of the assessment, and as such, should be used for comparison purposes only. In particular, the model reflects the status of the design at the time of the assessment.

Model configuration

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

- A general ground absorption coefficient of 1.0 was used.
- Atmospheric conditions of 10°C and 70 per cent humidity were adopted..
- Neutral weather and atmospheric conditions were assumed
- Topographical information was based on Lidar data provided by ARTC.
- Receivers were modelled at a height of 1.5 metres above ground.
- Buildings close to the rail line have been modelled based on aerial imagery. Buildings have been assumed to be single storey at a height of 4.5 metres.
- Existing rail alignments were based on data provided by ARTC.

Rail traffic assumptions

In regards to rail traffic, for modelling purposes it is assumed that rail capacity and speeds are as described in Section 4.1.3 and 4.1.4 and represent a conservative operational rail scenario for predicting noise impacts.

Rail source levels for representative trains from the Nordic prediction method are presented in Table 4.5.

Table 4.5 Train source SELn values

Train type	SELn dB 1/Oct						
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Diesel Goods Train	89.5	92.5	94.5	98.5	93.5	92.5	86.5
Passenger Train	86.5	84.5	88.5	97.5	97.5	94.5	90.5

Note: Values are normalised to: 100 km/h speed, 100 metre length, reference position 10 metres from the track and 1.5 metres above ground.

Track corrections

The following track corrections have been made in the model:

- +3 dB correction for partial track length on bridges with ballast (ThemaNord 1996:524).
- +6 dB correction for partial track length on bridges without ballast (ThemaNord 1996:524).

- +6 dB correction per 10 metres track length for each unit of switches and crossings (ThemaNord 1996:524).
- +3 dB correction for track curves with radius of 300-500 metres (Schall 03, 2006).

Based on information provided by ARTC, the following assumptions have been made for noise produced in crossing loops:

- 25 per cent of the total trains will utilise each crossing loop.
- All loops were modelled as being utilised equally.
- An indicative source level of 90 dB(A) at 15 metres from the rail source has been assumed for bunching noise.
- Bunching noise events have been modelled as 1 second duration events between each wagon.
- An indicative source level of 70 dB(A) at 15 metres from the rail source has been assumed for idling noise.
- Train idling durations have been assumed to be 20 minutes.

Warning bells and horns

Warning bells at level crossing have been modelled based on the following assumptions:

- Crossing bells will activate 30 seconds prior to train entering level crossing and remain audible throughout train pass-by.
- An indicative source level of 105 dB(A) at 3 metres from the source has been assumed for warning bells at level crossings. This is based on the AREMA Communications and signal manual Part 3.2.60.

Noise emitted from train horns have been modelled based on the following assumptions:

- All trains will use horns 150 m before entering a level crossing.
- An indicative source level of 88 dB(A) at 200 metres from the source has been assumed for train horns. This is based on ARTC's Locomotive Specific Interface Requirements (WOS 01.300).

4.2 Existing rail noise levels and model validation

Existing rail noise levels were calculated using the results from the baseline monitoring described in Section 2.4. Existing rail noise levels were calculated based on the noise logger data obtained at locations L12NNS, L13NNS, L14NNS and L16NNS. Passby information for loggers within Moree town were not suitable for calibration due to the infrequency of trains and the nearby Newell Highway resulting in the rail pass-bys being indistinguishable from road traffic events.

With consideration to the RING, the existing rail noise L_{Aeq}'s at the monitoring locations are determined as follows:

$$L_{Aeq(T)} = 10 \times \log_{10}(1/T \times (\Sigma (n_i \times t_i \times 10^{0.1L_{Aeq(i)}})))$$

Where:

- T is the total time in the relevant period (day or night) in seconds

- t_i is the average time of each type of event in seconds
- n_i is the number of each type of event

$L_{Aeq(i)}$ is the representative L_{Aeq} level for each type of event as measured at the receiver and is summed over the different types of events.

Noise modelling was undertaken for the existing 2016 scenario for comparison to measured existing rail noise levels to confirm the model's accuracy and validity for assessing the subsequent modelling scenarios.

Table 4.6 presents the measured 2016 rail noise levels and modelling results for the existing 2016 scenario to demonstrate the calibration of the noise model achieved.

Table 4.6 Measured absolute existing rail noise levels and model validation

Location	Measured absolute existing 2016 rail noise levels (dB)		Noise model predictions, 2016 existing scenario (dB)		Difference (dB)
	Day $L_{Aeq\ (15hr)}$	Night $L_{Aeq\ (9hr)}$	Day $L_{Aeq\ (15hr)}$	Night $L_{Aeq\ (9hr)}$	
L12NNS	50.9	50.9	51.0	51.0	+0.1
L13NNS	46.5	46.5	47.7	47.7	+1.2
L14NNS	39.0	39.0	40.8	40.8	+1.8
L16NNS	43.3	43.3	44.5	44.5	+1.2

As indicated by the above table, the predicted 2016 noise levels are within 2 dB of the measured rail noise levels with the difference ranging between +0.1 to +1.8 dB. Therefore, the model is considered to be validated.

4.3 Operational rail noise model results

Table 4.7 presents a summary of the modelling results where the RING trigger levels are predicted to be exceeded for residential receivers. In order to be considered for mitigation, L_{Aeq} noise levels must exceed the relevant day/night criteria and the level at receivers must also increase by 2 dB or more from the no build scenario. Receivers can also be considered for mitigation where there is a predicted increase of 3 dB or more due to the proposal at an assessment timeframe and L_{Amax} levels are predicted to exceed 85 dBA.

Note that due to the proportional day/night split of train movements assumed (i.e. the same number of trains per each 1-hour period), the $L_{Aeq(15hr)}$ and $L_{Aeq(9hr)}$ model noise levels were equal. The RING night time trigger levels are 5 dB lower than daytime and therefore provides the controlling criteria for identification of receivers that qualify for consideration of noise mitigation measures.

Non-residential receivers including schools, places of worship (churches) and outdoor recreation areas have different RING noise criteria for operational noise.

Table 4.8 presents a summary of the modelling results where the RING trigger levels are predicted to be exceeded for non-residential receivers.

For the year 2040 scenario, the following number of residential receivers were found to have qualified for mitigation consideration under the RING:

- 14 receivers in North Star
- 16 receivers in Moree-North Star
- 79 receivers in Moree Town
- 15 receivers in Bellata-Moree
- 19 receivers in Bellata
- 9 receivers in Narrabri-Bellata.

Table 4.7 Predicted rail noise levels for residential receivers exceeding RING trigger levels – Narrabri to North Star (dBA)

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}-2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered-2025	L_{Aeq} RING Triggered-2040	L_{Amax} RING Triggered
NNS_Rx 2377	830847	6795448	North Star	-	58	61	61.1	76	81	5.5		Y	
NNS_Rx 2369	830741	6795303	North Star	-	62	66	65.6	83	88	5.1	Y	Y	Y
NNS_Rx 2367	830804	6795196	North Star	-	58	61	60.8	75	81	6.3		Y	
NNS_Rx 2361	830704	6795098	North Star	-	62	65	64.8	83	88	4.9	Y	Y	Y
NNS_Rx 2359	830694	6795077	North Star	-	63	66	65.9	84	89	4.9	Y	Y	Y
NNS_Rx 2358	830704	6795051	North Star	-	59	63	62.5	80	85	4.8		Y	
NNS_Rx 2356	830688	6795036	North Star	-	63	66	65.9	85	88	3.7	Y	Y	Y
NNS_Rx 2355	830745	6795005	North Star	-	58	62	61.5	79	82	3.5		Y	
NNS_Rx 2352	830674	6794961	North Star	-	63	66	66.1	89	89	0.0	Y	Y	
NNS_Rx 2350	830673	6794913	North Star	-	63	66	65.6	91	91	0.0	Y	Y	
NNS_Rx 2347	830705	6794865	North Star	-	59	62	61.9	88	88	0.0		Y	
NNS_Rx 2346	830661	6794852	North Star	-	63	66	66.2	91	91	0.0	Y	Y	
NNS_Rx 2344	830729	6794793	North Star	-	58	61	60.5	82	82	0.0		Y	
NNS_Rx 2342	830647	6794779	North Star	-	63	66	66.1	88	88	0.0	Y	Y	
NNS_Rx 2324	821992	6776886	Moree-North Star	-	59	62	61.9	77	82	5.3		Y	

Receiver	Easting	Northing	Locality	LAeq No Build	LAeq-2025 Build	LAeq 2040 Build	LAeq 2040 Build Increase	LAmax Existing	LAmax Design	LAmax increase	LAeq RING Triggered-2025	LAeq RING Triggered-2040	LAmax RING Triggered
NNS_Rx 2320	822002	6773892	Moree-North Star	-	61	65	64.6	84	86	2.7	Y	Y	
NNS_Rx 2311	821641	6773452	Moree-North Star	-	64	67	66.9	91	91	0.0	Y	Y	
NNS_Rx 2308	821521	6773400	Moree-North Star	-	58	61	60.6	80	80	0.2		Y	
NNS_Rx 2306	821570	6773346	Moree-North Star	-	61	64	64.3	84	86	2.2	Y	Y	
NNS_Rx 2305	821487	6773321	Moree-North Star	-	58	61	60.7	81	81	0.0		Y	
NNS_Rx 2304	821480	6773303	Moree-North Star	-	58	61	60.8	81	81	0.0		Y	
NNS_Rx 2302	821559	6773293	Moree-North Star	-	61	64	63.9	82	86	3.8	Y	Y	Y
NNS_Rx 2301	821460	6773248	Moree-North Star	-	58	61	60.7	79	80	0.9		Y	
NNS_Rx 2300	821596	6772924	Moree-North Star	-	62	65	64.7	82	87	5.0	Y	Y	Y
NNS_Rx 2299	820349	6769982	Moree-North Star	-	63	67	66.5	86	90	3.6	Y	Y	Y
NNS_Rx 2298	820098	6768936	Moree-North Star	-	57	61	60.5	82	82	0.0		Y	

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered- 2025	L_{Aeq} RING Triggered- 2040	L_{Amax} RING Triggered
NNS_Rx 2287	816238	6758238	Moree-North Star	-	65	68	67.9	92	92	0.0	Y	Y	
NNS_Rx 2270	810881	6749030	Moree-North Star	-	58	61	61.2	84	84	0.0		Y	
NNS_Rx 2267	805767	6747404	Moree-North Star	-	65	69	68.5	87	92	5.0	Y	Y	Y
NNS_Rx 2251	779279	6740688	Moree-North Star	8	60	63	55.1	87	87	0.0		Y	
NNS_Rx 2144	777254	6737902	Moree Town	18	60	61	43.0	74	80	5.8		Y	
NNS_Rx 2095	777139	6737718	Moree Town	19	59	61	41.4	76	79	3.4		Y	
NNS_Rx 2043	776930	6737468	Moree Town	21	60	61	40.2	81	81	0.0		Y	
NNS_Rx 2012	776676	6737051	Moree Town	24	62	62	38.3	79	83	4.2	Y	Y	
NNS_Rx 2005	776865	6736746	Moree Town	27	61	61	34.3	80	83	2.3	Y	Y	
NNS_Rx 2002	776172	6736658	Moree Town	31	64	65	34.3	89	89	0.2	Y	Y	
NNS_Rx 2001	776190	6736667	Moree Town	30	65	66	35.2	89	91	2.1	Y	Y	
NNS_Rx 2000	776103	6736671	Moree Town	30	60	61	31.1	85	85	0.0		Y	
NNS_Rx 1999	776363	6736669	Moree Town	18	66	67	49.0	84	91	6.4	Y	Y	Y
NNS_Rx 1998	776333	6736668	Moree Town	17	69	69	52.6	88	96	8.2	Y	Y	Y

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered-2025	L_{Aeq} RING Triggered-2040	L_{Amax} RING Triggered
NNS_Rx 1997	776417	6736665	Moree Town	18	64	65	47.2	81	89	8.1	Y	Y	Y
NNS_Rx 1995	776105	6736651	Moree Town	31	61	62	31.1	86	86	0.0	Y	Y	
NNS_Rx 1994	776417	6736648	Moree Town	29	61	62	33.1	78	87	8.9	Y	Y	Y
NNS_Rx 1993	776362	6736648	Moree Town	29	61	61	32.6	79	87	8.4	Y	Y	Y
NNS_Rx 1991	776087	6736633	Moree Town	24	61	61	37.6	86	86	0.0	Y	Y	
NNS_Rx 1990	776415	6736634	Moree Town	29	61	61	32.0	78	87	9.0	Y	Y	Y
NNS_Rx 1989	776276	6736628	Moree Town	30	73	73	43.8	92	101	8.6	Y	Y	Y
NNS_Rx 1986	776414	6736620	Moree Town	30	60	61	31.5	80	86	6.1		Y	Y
NNS_Rx 1985	776084	6736620	Moree Town	22	60	61	38.4	86	86	0.0		Y	
NNS_Rx 1984	776414	6736605	Moree Town	30	60	61	30.7	78	85	7.1		Y	
NNS_Rx 1983	776277	6736604	Moree Town	29	70	70	40.8	92	97	4.9	Y	Y	Y
NNS_Rx 1982	776356	6736603	Moree Town	30	60	61	31.0	86	86	0.0		Y	
NNS_Rx 1980	776099	6736592	Moree Town	32	62	63	31.3	88	88	0.0	Y	Y	
NNS_Rx 1979	776275	6736590	Moree Town	31	69	70	39	94	97	2.9	Y	Y	
NNS_Rx 1975	776353	6736575	Moree Town	24	60	61	36.9	84	85	0.7		Y	
NNS_Rx 1973	776099	6736568	Moree Town	32	62	63	31.4	88	88	0.0	Y	Y	

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered-2025	L_{Aeq} RING Triggered-2040	L_{Amax} RING Triggered
NNS_Rx 1972	776279	6736568	Moree Town	28	67	68	40.0	94	94	0.0	Y	Y	
NNS_Rx 1969	776096	6736547	Moree Town	32	62	63	31.9	88	88	0.0	Y	Y	
NNS_Rx 1968	776306	6736551	Moree Town	28	62	63	35.1	91	91	0.0	Y	Y	
NNS_Rx 1967	776276	6736546	Moree Town	31	67	68	36.8	95	95	0.0	Y	Y	
NNS_Rx 1962	776097	6736528	Moree Town	30	62	64	33.3	88	88	0.0	Y	Y	
NNS_Rx 1959	776225	6736523	Moree Town	22	74	75	53.0	101	102	1.4	Y	Y	
NNS_Rx 1958	776275	6736523	Moree Town	27	65	67	39.3	94	94	0.0	Y	Y	
NNS_Rx 1957	776223	6736511	Moree Town	32	74	74	42.5	98	102	4.0	Y	Y	Y
NNS_Rx 1955	776273	6736510	Moree Town	25	65	66	41.7	93	93	0.0	Y	Y	
NNS_Rx 1954	776097	6736503	Moree Town	23	62	63	40.7	87	87	0.0	Y	Y	
NNS_Rx 1928	776296	6736399	Moree Town	30	60	62	31.3	80	85	4.7		Y	
NNS_Rx 1925	776268	6736397	Moree Town	34	65	67	33.2	86	92	6.1	Y	Y	Y
NNS_Rx 1918	776269	6736370	Moree Town	35	65	67	32.8	87	92	4.4	Y	Y	Y
NNS_Rx 1908	776269	6736351	Moree Town	35	65	67	32.3	88	91	3.2	Y	Y	Y
NNS_Rx 1897	776269	6736339	Moree Town	36	65	68	32.0	89	92	2.6	Y	Y	
NNS_Rx 1886	776269	6736313	Moree Town	36	65	67	31.0	91	91	0.8	Y	Y	

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered- 2025	L_{Aeq} RING Triggered- 2040	L_{Amax} RING Triggered
NNS_Rx 1876	776268	6736299	Moree Town	37	65	68	30.5	92	92	0.0	Y	Y	
NNS_Rx 1862	776267	6736274	Moree Town	38	65	68	29.2	93	93	0.0	Y	Y	
NNS_Rx 1848	776269	6736255	Moree Town	39	65	67	27.9	93	93	0.0	Y	Y	
NNS_Rx 1834	776267	6736235	Moree Town	40	64	67	26.4	93	93	0.0	Y	Y	
NNS_Rx 1820	776275	6736216	Moree Town	38	62	65	26.4	91	91	0.0	Y	Y	
NNS_Rx 1801	776265	6736193	Moree Town	43	63	66	22.5	91	91	0.0	Y	Y	
NNS_Rx 1793	776266	6736174	Moree Town	45	63	66	21.0	89	89	0.1	Y	Y	
NNS_Rx 1774	776263	6736128	Moree Town	46	63	65	19.0	83	90	6.5	Y	Y	Y
NNS_Rx 1741	776267	6736082	Moree Town	47	62	65	18.4	83	90	7.2	Y	Y	Y
NNS_Rx 1733	776263	6736068	Moree Town	47	63	65	18.2	83	91	7.3	Y	Y	Y
NNS_Rx 1721	776262	6736057	Moree Town	47	63	66	18.1	84	91	7.4	Y	Y	Y
NNS_Rx 1715	776261	6736047	Moree Town	48	63	66	18.0	84	91	7.5	Y	Y	Y
NNS_Rx 1705	776263	6736038	Moree Town	48	63	65	17.9	84	91	7.3	Y	Y	Y
NNS_Rx 1699	776087	6736032	Moree Town	46	61	64	18.5	82	88	5.4	Y	Y	Y
NNS_Rx 1685	776085	6736015	Moree Town	46	61	64	18.3	82	88	5.9	Y	Y	Y
NNS_Rx 1679	776258	6736005	Moree Town	48	63	66	17.7	84	92	7.5	Y	Y	Y

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered-2025	L_{Aeq} RING Triggered-2040	L_{Amax} RING Triggered
NNS_Rx 1664	776083	6735991	Moree Town	46	61	64	18.2	81	87	6.4	Y	Y	Y
NNS_Rx 2457	776267	6735987	Moree Town	47	61	64	17.4	83	90	7.7	Y	Y	Y
NNS_Rx 1649	776082	6735975	Moree Town	45	61	64	18.2	81	87	6.7	Y	Y	Y
NNS_Rx 1648	776263	6735969	Moree Town	48	62	65	17.5	83	91	7.2	Y	Y	Y
NNS_Rx 1635	776087	6735956	Moree Town	46	61	64	18.1	80	88	7.3	Y	Y	Y
NNS_Rx 1630	776266	6735953	Moree Town	47	62	65	17.5	83	90	7.2	Y	Y	Y
NNS_Rx 1618	776087	6735938	Moree Town	45	61	64	18.1	80	87	7.2	Y	Y	Y
NNS_Rx 1610	776262	6735936	Moree Town	48	63	66	17.6	84	91	7.1	Y	Y	Y
NNS_Rx 1591	776269	6735919	Moree Town	47	61	64	17.3	82	90	7.3	Y	Y	Y
NNS_Rx 1578	776267	6735902	Moree Town	47	62	65	17.5	83	90	7.1	Y	Y	Y
NNS_Rx 1552	776244	6735851	Moree Town	50	64	67	17.2	86	93	7.2	Y	Y	Y
NNS_Rx 1548	776263	6735845	Moree Town	44	59	62	17.6	80	87	6.8		Y	Y
NNS_Rx 1526	776261	6735823	Moree Town	47	62	65	17.4	83	91	7.8	Y	Y	Y
NNS_Rx 1508	776082	6735798	Moree Town	46	60	63	17.7	80	87	6.8		Y	Y
NNS_Rx 1493	776084	6735780	Moree Town	46	61	63	17.4	80	87	7.0	Y	Y	Y
NNS_Rx 1445	776095	6735719	Moree Town	47	61	64	17.3	81	88	6.8	Y	Y	Y

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered-2025	L_{Aeq} RING Triggered-2040	L_{Amax} RING Triggered
NNS_Rx 1420	776367	6735668	Moree Town	44	59	62	17.4	76	84	8.2		Y	
NNS_Rx 1387	776357	6735622	Moree Town	45	60	63	18.1	77	86	8.1		Y	Y
NNS_Rx 1365	776383	6735607	Moree Town	44	59	62	17.3	76	85	8.5		Y	
NNS_Rx 1259	776535	6735130	Moree Town	49	60	63	13.9	88	88	0.0		Y	
NNS_Rx 1257	776534	6735107	Moree Town	50	61	64	14.0	88	88	0.0	Y	Y	
NNS_Rx 0898	776333	6730531	Bellata-Moree	53	64	67	13.6	90	90	0.0	Y	Y	
NNS_Rx 0897	776328	6730479	Bellata-Moree	52	63	66	13.8	87	89	1.9	Y	Y	
NNS_Rx 0896	776352	6730476	Bellata-Moree	47	58	61	13.6	84	84	0.3		Y	
NNS_Rx 0892	776313	6730410	Bellata-Moree	52	63	66	13.7	86	88	2.0	Y	Y	
NNS_Rx 0891	776332	6730407	Bellata-Moree	49	59	62	13.3	84	84	0.0		Y	
NNS_Rx 0890	776355	6730402	Bellata-Moree	47	58	61	13.3	81	81	0.3		Y	
NNS_Rx 0887	776308	6730373	Bellata-Moree	51	63	65	13.7	87	87	0.2	Y	Y	
NNS_Rx 0885	775930	6729006	Bellata-Moree	47	58	61	14.4	83	83	0.0		Y	
NNS_Rx 0867	770794	6707372	Bellata-Moree	51	63	66	14.3	85	88	3.6	Y	Y	Y
NNS_Rx 0863	770799	6707269	Bellata-Moree	53	64	66	13.6	91	91	0.0	Y	Y	
NNS_Rx 0862	770796	6707241	Bellata-Moree	53	64	66	12.9	92	92	0.0	Y	Y	

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered- 2025	L_{Aeq} RING Triggered- 2040	L_{Amax} RING Triggered
NNS_Rx 0861	770713	6707213	Bellata-Moree	48	59	61	13.1	86	86	0.0		Y	
NNS_Rx 0860	770791	6707193	Bellata-Moree	54	64	66	12.7	92	92	0.0	Y	Y	
NNS_Rx 0859	770779	6707134	Bellata-Moree	52	63	66	13.9	89	89	0.8	Y	Y	
NNS_Rx 0841	769253	6689283	Bellata-Moree	45	58	61	15.3	78	83	4.6		Y	
NNS_Rx 0838	769516	6687824	Bellata	50	62	65	14.9	84	88	3.7	Y	Y	Y
NNS_Rx 0837	769510	6687556	Bellata	52	63	66	13.7	87	88	1.1	Y	Y	
NNS_Rx 0836	769581	6687480	Bellata	48	59	62	13.8	83	83	0.0		Y	
NNS_Rx 0835	769506	6687458	Bellata	52	64	66	13.9	87	89	2.1	Y	Y	
NNS_Rx 0834	769561	6687457	Bellata	49	59	62	13.3	85	85	0.0		Y	
NNS_Rx 0832	769516	6687418	Bellata	52	63	66	13.8	88	88	0.0	Y	Y	
NNS_Rx 0830	769582	6687362	Bellata	48	59	62	14.2	85	85	0.0		Y	
NNS_Rx 0827	769499	6687293	Bellata	52	63	66	14.2	90	90	0.2	Y	Y	
NNS_Rx 0823	769509	6687265	Bellata	50	62	65	14.4	87	89	1.1	Y	Y	
NNS_Rx 0822	769508	6687244	Bellata	50	62	65	14.7	86	89	2.1	Y	Y	
NNS_Rx 0819	769510	6687224	Bellata	50	61	64	14.7	85	88	2.6	Y	Y	
NNS_Rx 0817	769511	6687198	Bellata	48	60	63	15.6	82	88	5.7		Y	Y

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered-2025	L_{Aeq} RING Triggered-2040	L_{Amax} RING Triggered
NNS_Rx 0812	769519	6687140	Bellata	45	58	61	15.9	79	83	4.7		Y	
NNS_Rx 0800	769491	6687002	Bellata	49	62	65	15.8	85	90	4.9	Y	Y	Y
NNS_Rx 0797	769500	6686959	Bellata	48	61	64	15.9	83	88	5.5	Y	Y	Y
NNS_Rx 0794	769496	6686911	Bellata	49	62	65	16.0	84	88	4.3	Y	Y	Y
NNS_Rx 0786	769500	6686819	Bellata	49	62	65	16.0	83	89	5.4	Y	Y	Y
NNS_Rx 0783	769570	6686803	Bellata	45	58	61	15.8	77	83	5.6		Y	
NNS_Rx 0778	769516	6686737	Bellata	49	62	65	16.1	81	87	5.8	Y	Y	Y
NNS_Rx 0767	769302	6684642	Narrabri-Bellata	52	63	66	13.3	89	89	0.0	Y	Y	
NNS_Rx 0766	769298	6684556	Narrabri-Bellata	52	63	66	13.4	85	88	3.1	Y	Y	Y
NNS_Rx 0748	769745	6665301	Narrabri-Bellata	45	58	61	15.8	79	82	2.7		Y	
NNS_Rx 0745	769723	6665202	Narrabri-Bellata	49	63	65	16.0	83	89	5.9	Y	Y	Y
NNS_Rx 0744	769723	6665184	Narrabri-Bellata	49	63	65	15.9	83	89	5.6	Y	Y	Y
NNS_Rx 0743	769856	6665174	Narrabri-Bellata	46	58	61	14.7	82	82	0.0		Y	
NNS_Rx 0742	769870	6665132	Narrabri-Bellata	46	58	61	14.3	82	82	0.0		Y	

Receiver	Easting	Northing	Locality	L_{Aeq} No Build	L_{Aeq}- 2025 Build	L_{Aeq} 2040 Build	L_{Aeq} 2040 Build Increase	L_{Amax} Existing	L_{Amax} Design	L_{Amax} increase	L_{Aeq} RING Triggered-2025	L_{Aeq} RING Triggered-2040	L_{Amax} RING Triggered
NNS_Rx 0741	769516	6665054	Narrabri-Bellata	46	58	61	14.8	82	82	0.0		Y	
NNS_Rx 0718	768945	6646456	Narrabri-Bellata	48	60	63	14.8	86	86	0.0		Y	

Notes:

$L_{Aeq(15hr)}$ and $L_{Aeq(9hr)}$ model predictions were equal. The results are provided as one value for L_{Aeq} which represents both $L_{Aeq(15hr)}$ and $L_{Aeq(9hr)}$.

The 'increase' in noise should be calculated to a single decimal place before comparing it with the 2 dB and 3 dB noise-increase trigger levels. However, the absolute noise levels should be calculated to the nearest whole decibel number before comparing them with the absolute trigger (RING).

The L_{AMax} levels do not depend on train volumes. Therefore, the L_{Amax} levels for design years 2025 and 2040 will be equal.

Table 4.8 Predicted rail noise levels for non-residential receivers exceeding RING trigger levels – Narrabri to North Star (dBA)

Receiver ID	Easting	Northing	Locality	L_{Aeq} Levels - No Build	L_{Aeq} Levels - 2025 Build	L_{Aeq} Levels - 2040 Build	L_{Aeq} Increase - 2025	L_{Aeq} Increase - 2040	Controlling Criteria (External L_{Aeq} level)	Controlling Criteria Exceeded
NNS_WORx0007	769513	6686849	Bellata	47	61	63	13.3	16.0	55	Y
NNS_WORx0003	776323	6735725	Moree Town	45	59	62	14.4	17.3	55	Y
NNS_WORx0002	830720	6794764	North Star	-	58	62	58.4	61.5	55	Y
NNS_REPx0014	769447	6686954	Bellata	53	66	69	12.9	15.9	65	Y
NNS_REPx0005	776134	6736215	Moree Town	44	66	69	21.7	24.4	65	Y
NNS_REAx0008	776150	6736311	Moree Town	39	68	71	29.3	31.6	65	Y
NNS_EDUx0007	822057	6773631	Moree-North Star	-	57	60	56.5	59.6	55	Y
NNS_EDUx0006	830764	6795354	North Star	-	61	65	61.4	64.6	55	Y
NNS_EDUx0005	779224	6740673	Moree-North Star	8	59	62	50.9	54.1	55	Y

Notes:

$L_{Aeq(15hr)}$ and $L_{Aeq(9hr)}$ model predictions were equal. The results are provided as one value for L_{Aeq} which represents both $L_{Aeq(15hr)}$ and $L_{Aeq(9hr)}$.

The 'increase' in noise should be calculated to a single decimal place before comparing it with the 2 dB and 3 dB noise-increase trigger levels. However, the absolute noise levels should be calculated to the nearest whole decibel number before comparing them with the absolute trigger (RING).

The L_{AMax} levels do not depend on train volumes. Therefore, the L_{Amax} levels for design years 2025 and 2040 will be equal.
Where receivers are subject to internal noise criteria, these have been converted to external levels based on a conservative 10 dB internal-external correction.

4.3.1 Discussion

In general, for a largely homogeneous rail line with consistent volumes, constant speeds and few tight radius curves, the level of rail noise exposure for any given receiver is a function of the distance to the track, the angle of view and the presence or absence of any shielding terrain or objects.

Most of the RING exceedances were around the towns, such as Moree, North Star and Bellata areas, with the remainder scattered throughout the study area. This is due to the higher density of receivers in these areas that are located in close proximity to the rail line. Section 7.1 provides an assessment of reasonable and feasible mitigation measures to reduce noise levels at receivers found to exceed RING criteria.

A number of non-residential receivers were found to exceed the relevant RING criteria. For non-residential receivers with internal noise criteria, a conservative 10 dB internal-external noise correction was assumed. Qualification for noise mitigation will be dependent upon the results of façade testing to determine if the internal noise criteria are exceeded.

The accuracy of noise predictions depends on a variety of factors. It is important to note that the modelling is largely dependent on the model inputs and assumptions detailed in Section 4.1.

Full operational noise results are presented in Appendix D. Noise contour plots showing receiver locations are presented in Appendix E for L_{Aeq} levels and Appendix F for L_{Amax} levels.

4.4 Horn noise

Horns are an important safety device and are a normal part of train operation. Trains are generally required to sound their horns as they pass through level crossings and additionally at other times. ARTC's *Locomotive Specific Interface Requirements (WOS 01.300)* provides minimum and maximum levels for horn noise. The purpose of these prescribed noise levels is to provide safe operating conditions for people close to the rail line. Note that both 'town' and 'country' horns can be fitted that have high and low noise level features.

For a rail redevelopment project to trigger the RING's L_{Amax} level of 85 dB(A) at a noise sensitive receiver, a 3 dB or greater increase in L_{Amax} level is required. Receivers affected by horn noise have been assessed in the operational noise modelling, as detailed in Section 4.1.6. Horn noise has been assessed in the L_{Aeq} and L_{Amax} models:

- The L_{Amax} models assess the maximum noise impacts from the instantaneous high level of noise generated by horns.
- The L_{Aeq} models assess the effect of horn noise to the overall day ($L_{Aeq15hr}$) and night (L_{Aeq9hr}) noise levels.

It should be noted that an appreciable difference in the number of horn events is expected due to the projected volume growth.

It is expected that the number of horn noise events would be comparable to the increase in trains per day. For example, in the year 2040 in the Moree-Narrabri section of track, there is expected to be approximately 22 trains per 24 hour period, increasing from the existing approximately 4 trains per 24 hour period. For the North Star-Moree section of track, existing train volumes are very infrequent. This section of track is expected to have 19 trains per 24 hour period in the year 2040.

While noise levels at receivers from horn usage locations may exceed 85dB(A) L_{Amax} noise levels, there are no additional proposed locations of horn usage in the proposal and the RING redevelopment trigger of 3dB increase in L_{Amax} levels is not expected to be achieved by horns.

4.5 Operational vibration

Vibration from the operation of heavy rail infrastructure can adversely affect sensitive receivers located near a rail line. Vibration can cause buildings, windows and other fixtures to shake; contribute to annoyance and impacts on residents and other land uses; and interfere with vibration-sensitive equipment. Building damage is not usually likely for operation of rail infrastructure, however annoyance can occur at significantly lower vibration levels which are often only slightly higher than the limits of human perception. Therefore, human comfort goals provide the controlling criteria for operational vibration for the proposal.

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

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

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

Propagation and perception of vibration is further influenced by the soil, geological conditions and building characteristics such as:

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

4.5.1 Operational vibration assessment

Axle loading

The increase to 30 tonne axle load capacity from an existing 23 tonnes is not expected to result in substantially increased vibration levels as the proposed intercapital trains have axle loads of 21 tonnes while bulk freight is expected to have 25 tonne axle loads. Typically, a doubling of axle load can be expected to double vibration, and a proportional increase in vibration due to increased axle loading is likely.

Track condition

For the main alignment, vibration levels may decrease (or possibly offset any increase) as a result of the proposal due to improved ballast/sleeper heterogeneity and rail surface smoothness, both features which have greater potential to influence rail-induced vibration levels than axle loading or speed alone. Additional reductions in vibration may also be realised by reducing the need for acceleration and braking as more constant speeds would be achieved through a removal of some level crossings and lifting of existing temporary speed restrictions at sections of track, for instance dilapidated bridges being replaced as part of the proposal.

Speed

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

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

Distance attenuation

The distance attenuation relationship of ground vibration measurements was derived from the FTA base curve for locomotive-powered freight/passenger trains. Vibration measurements from similar rail proposals undertaken by GHD, can be seen in Figure 4.4. Note that these values have been adjusted to the reference speed of 80 kilometres per hour, using the 20 $\log_{10}$(speed/speed$_{ref}$) relationship.

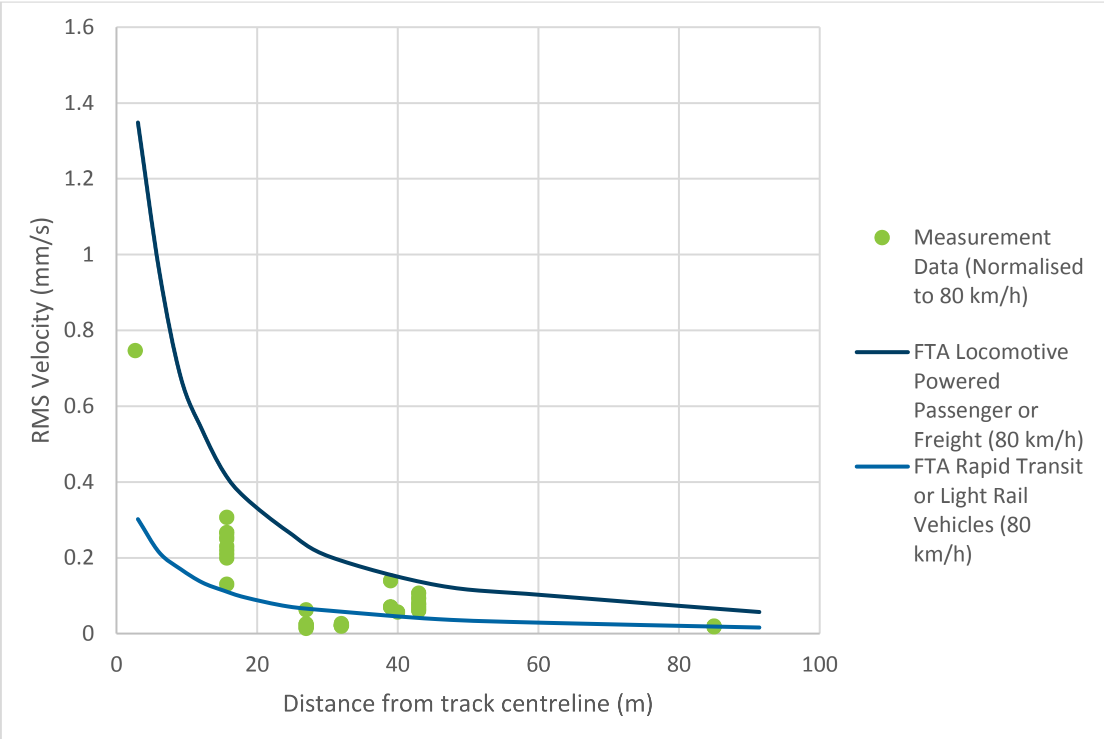


Figure 4.4 Ground vibration levels

Vibration measurements are highly variable and are largely dependent on local geological conditions. Further, track irregularities may significantly increase vibration levels (for example, at crossovers and joints). A significant variation in vibration levels for similar systems are not uncommon and the FTA curves represent the upper range of measurement data for well-maintained systems. The measured vibration data presented in Figure 4.4 are consistently lower than that upper-range vibration curve from the FTA guideline. Therefore, the use of levels from the FTA locomotive curve are expected to provide a conservative estimate of vibration levels.

For the purposes of this assessment, the track has been assumed to be in good condition and track irregularities such as joints or crossovers have not been assessed due to the current lack of design detail. An assessment of these factors should be completed once the detailed design has been finalised.

4.5.2 Human comfort assessment

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

British Standard BS 6472 provides a method to calculate the estimated VDV using RMS vibration velocity. The estimated VDV is calculated as:

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

Where t= duration of the event.

The eVDV's for this proposal have been estimated by adjusting vibration levels for speed, duration and distance from the track.

The following assumptions have been made:

- maximum train lengths as specified in Table 4.3
- maximum train speeds as specified in Table 4.4
- track in good condition with no track irregularities
- train volumes specified in section 4.1.3
- proportional day/night splits of trains.

These assumptions are expected to provide a conservative estimate of future vibration levels. The predicted future eVDV values for day and night-time, as well as the respective residential criteria, can be seen in Figure 4.5 and Figure 4.6.

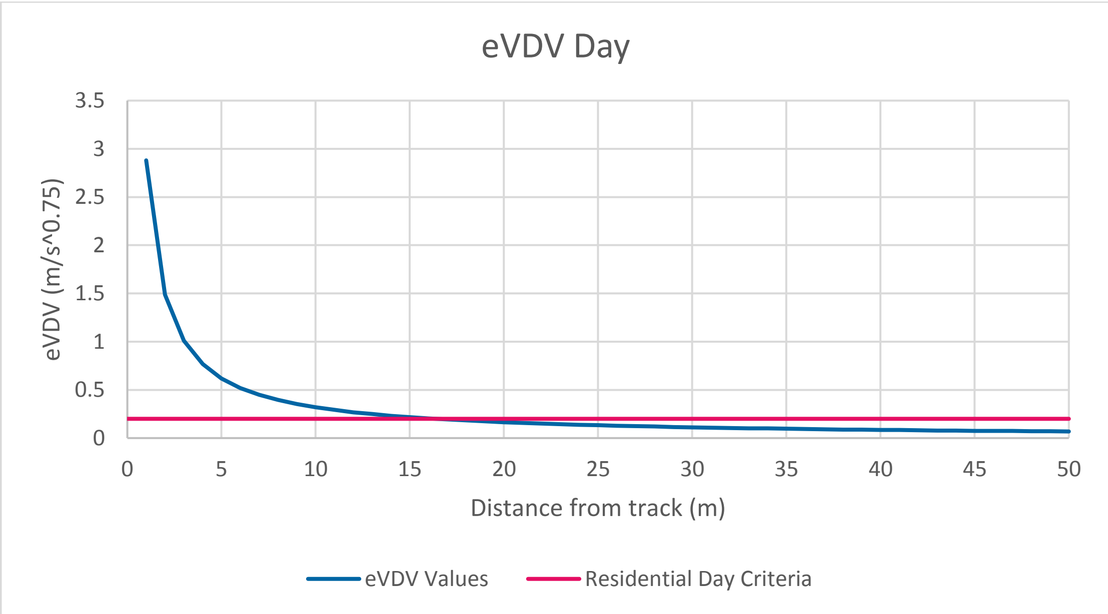


Figure 4.5 Daytime VDV levels (2040)

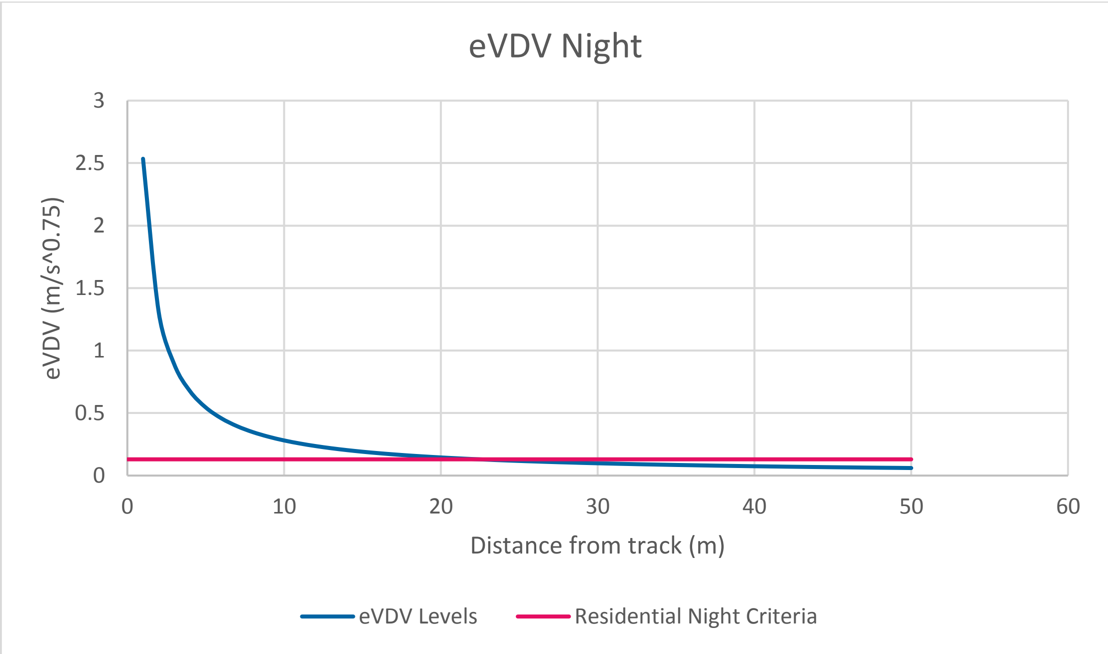


Figure 4.6 Night-time VDV levels (2040)

Estimated vibration levels at three receivers are predicted to trigger the night-time human comfort criteria. These receivers are located in Moree and are summarised in Table 4.9. Vibration mitigation strategies to reduce vibration impacts are discussed in Section 7.2.2.

Table 4.9 Receivers potentially affected by operational vibration

Receiver	Locality	Easting	Northing	Approximate distance from track
NNS_Rx1957	Moree	776222	6736511	18
NNS_Rx1959	Moree	776225	6736523	16
NNS_Rx1989	Moree	776276	6736628	15

5. Operational road traffic noise assessment

5.1 Noise modelling methodology

The methodology for the road traffic noise assessment included the following:

- The noise study area was established in accordance with the NCG.
- Road classification changes were assessed for existing side roads.
- Transition zones were established between new and road redevelopment segments and between the proposal and existing roads by preparing a separate transition zone contribution difference model.
- Transition zones created between new and redeveloped sections were based on a 42 metre buffer from the edge of the existing road corridor (using cadastre data with a seven metre total lane width).
- A traffic noise model was prepared to predict the existing level of road traffic noise for the current year. The current year noise model was used for the operational noise model verification process.
- Noise predictions were undertaken for the following cases:
  - Year 2020 'no build option' (traffic flow on the existing alignment for year opening).
  - Year 2030 'no build option' (traffic flow on the existing alignment 10 years after opening).
  - Year 2020 'build option' (proposed design for year opening).
  - Year 2030 'build option' (proposed design 10 years after opening).
- These models were used to assess the potential noise impact against the noise criteria and assess any increase in road traffic noise at sensitive receivers.

5.1.1 Modelling inputs and assumptions

The noise model inputs and assumptions for the existing, 2020 and 2030 No Build and Build scenarios are presented in Table 5.1.

Table 5.1 Operational noise model inputs and assumptions

Inputs/assumptions	Data incorporated into noise model
Noise model	SoundPLAN Version 7.4
Prediction algorithm	United Kingdom Department of Transport, Calculation of Road Traffic Noise (CoRTN) adapted for NSW conditions.
Heavy vehicle %	Day and night heavy vehicle (HV) percentages obtained from GHD Traffic and Transport Impact Assessment.
Verification model traffic speeds	Sign-posted traffic speeds were used for the verification model. Traffic count data were based off observations during attended noise monitoring.
Future traffic speeds	Sign-posted traffic speeds used in future 2020 and 2030 No Build and Build models. • Newell highway: 110 km/h • Moree bypass: 60 km/h

Inputs/assumptions	Data incorporated into noise model
	• Local roads in Moree: 50 km/h
Traffic volumes	Existing scenario based on traffic monitoring taken concurrently with attended noise measurements. No build traffic data assumed to be the same as the predicted build traffic data (2020 and 2030). Predicted traffic on roads in Moree based on GHD Traffic and Transport Impact Assessment. Assumptions: • No HV on Jones Avenue bridge Predicted traffic on Newell Highway based on AADT in 2008 with 0.9% growth.
Low traffic flow	Disabled
Road gradient	Taken into account based on the road design
Terrain resolution	1 m
Grid contour spacing	20 m
Buildings	4.5 m – single storey buildings 7.5 m – double storey buildings
Road surface adjustments	Dense graded asphalt (DGA) – 0 dBA
Façade correction	+2.5 dBA to account for noise reflected from the façade.
CoRTN conversion factors	CoRTN predicts $L_{A10(1hr)}$ noise levels which is converted to the $L_{Aeq(1hr)}$ descriptor with a -3 dBA correction factor.
CoRTN factor (Adapted to Australian conditions through research undertaken by the Australian Road Research Board)	-1.7 façade -0.7 freefield
Source height	Cars - 0.5 m Truck engines - 1.5 m, include -0.6 dBA source correction Truck exhausts - 3.6 m, includes -8.6 dBA source correction
Receiver heights	1.5 m above terrain level for ground floor 4.5 m above terrain level for first floor
Ground absorption	G = 0.75 for rural areas G = 0 for water

5.2 Traffic data

5.2.1 Existing traffic flows

Existing traffic volumes at four locations were recorded during short-term attended noise monitoring and are provided in Table 5.2.

Table 5.2 Existing traffic volumes, hourly

Receiver ID	Location	Address	Light	Heavy	Speed
L08NNS	Reece Plumbing	71 Tycannah Street	252	88	60

Receiver ID	Location	Address	Light	Heavy	Speed
L09NNS	Moree Council Depot	52 Tycannah Street	92	52	60
L10NNS	468 Frome Street	468 Frome Street	320	36	60
L11NNS	John Deere	2 Amaroo Drive	208	96	60

5.2.2 Future traffic flows

Projected traffic volumes in 2020 and 2030 in Moree were sourced from the Inland Rail Traffic and Transport Impact Assessment (GHD, 2016). A summary of the traffic volumes for roads in Moree during the day-time and night-time periods are provided in Table 5.3.

Table 5.3 Moree projected traffic volumes

Description	Day-time (15 hour)				Night-time (9 hour)			
	Light	Heavy	Total	% HV	Light	Heavy	Total	% HV
2020 No-Build								
Moree Bypass	1,822	620	2,442	25	181	61	242	25
Jones Avenue (Bridge overpass)	-	-	-	-	-	-	-	-
Jones Avenue (West of Newell Highway)	1,787	785	2,572	31	177	78	255	31
Jones Avenue (East of Newell Highway)	283	4	287	1	28	0	28	1
Tycannah Street (North of Jones Avenue)	1,391	303	1,695	18	138	30	168	18
Tycannah Street (South of Jones Avenue)	1,353	341	1,695	20	134	34	168	20
Bullus Drive	2,049	623	2,672	23	203	62	265	23
2020 Build								
Moree Bypass	1,822	620	2,442	25	181	61	242	25
Jones Avenue (Bridge overpass)	1,044	0	1,044	0	103	0	103	0
Jones Avenue (West of Newell Highway)	1,932	849	2,781	31	191	84	276	31
Jones Avenue (East of Newell Highway)	1,313	17	1,331	1	130	2	132	1
Tycannah Street (North of Jones Avenue)	1,927	420	2,348	18	191	42	233	18
Tycannah Street (South of Jones Avenue)	1,665	420	2,086	20	165	42	207	20
Bullus Drive	1,749	532	2,281	23	173	53	226	23
2030 No-Build								
Moree Bypass	1,997	680	2,677	25	198	67	265	25
Jones Avenue (Bridge overpass)	-	-	-	-	-	-	-	-

Description	Day-time (15 hour)				Night-time (9 hour)			
	Light	Heavy	Total	% HV	Light	Heavy	Total	% HV
Jones Avenue (West of Newell Highway)	1,959	860	2,819	31	194	85	279	31
Jones Avenue (East of Newell Highway)	310	4	314	1	31	0	31	1
Tycannah Street (North of Jones Avenue)	1,525	333	1,858	18	151	33	184	18
Tycannah Street (South of Jones Avenue)	1,483	374	1,858	20	147	37	184	20
Bullus Drive	2,246	683	2,929	23	223	68	290	23
2030 Build								
Moree Bypass	1,997	680	2,677	25	198	67	265	25
Jones Avenue (Bridge overpass)	1,144	0	1,144	0	113	0	113	0
Jones Avenue (West of Newell Highway)	2,118	930	3,048	31	210	92	302	31
Jones Avenue (East of Newell Highway)	1,440	19	1,459	1	143	2	145	1
Tycannah Street (North of Jones Avenue)	2,113	461	2,573	18	209	46	255	18
Tycannah Street (South of Jones Avenue)	1,826	461	2,286	20	181	46	227	20
Bullus Drive	1,918	583	2,500	23	190	58	248	23

Road traffic volumes along Newell Highway at the proposed location of the overpass were sourced from traffic count station 91022 located 120 metres north of Brigalow Lane (RMS Traffic Volume Viewer). Traffic volumes in the opening and design year were calculated based on an AADT of 1,231 vehicles for northbound traffic and an AADT of 1,169 vehicles for southbound traffic in 2008. A growth rate of 0.9% based on traffic volume increase in Moree was applied to predict traffic volumes. The projected traffic volumes on Newell Highway are provided in Table 5.4.

The following assumptions were used to predict the traffic volumes in the opening and design year:

- 0.9% growth rate
- day/night traffic splits based on the hourly profile on the RMS Traffic Volume Viewer
- northbound/southbound splits based on 2008 data.

Table 5.4 Newell Highway projected traffic volumes

Description	Day-time (15 hour)				Night-time (9 hour)			
	Light	Heavy	Total	% HV	Light	Heavy	Total	% HV
2020 No-Build/Build								
Newell Highway (Northbound)	680	545	1225	44.5	64	107	171	62.5
Newell Highway (Southbound)	680	439	1119	39.2	56	154	210	73.3

Description	Day-time (15 hour)				Night-time (9 hour)			
	Light	Heavy	Total	% HV	Light	Heavy	Total	% HV
2030 No-Build/Build								
Newell Highway (Northbound)	744	596	1340	44.5	70	117	187	62.5
Newell Highway (Southbound)	744	480	1224	39.2	61	168	229	73.3

5.3 Noise modelling verification

Long-term noise monitoring results were used to verify and calibrate the noise model. Verification of the noise model demonstrates the accuracy of the noise model and the validity of the CoRTN algorithm adjusted for NSW conditions used to predict road traffic noise. This enables noise levels for future scenarios to be predicted with a higher level of confidence. In addition, verification of the noise model allows the assumptions used for the road surface and vehicle source heights to be justified by comparing them against measured data (traffic volumes, noise levels).

The noise model used for validation was generated using traffic data and sign-posted vehicle speeds were used. Results from the noise model were compared to short-term attended measurements and any variations between the levels were analysed. Variations between the measured and modelled results are deemed to be acceptable if the levels are within ± 2 dBA.

A comparison of the measured and modelled results is shown in Table 5.5. The predicted results and measured results have an acceptable average variance within 2 dBA. Model calibration depends on a variety of inputs including the road surface, average traffic volumes, vehicle types and speed, ground absorption and any obstacles obstruction the sound transmission path.

Table 5.5 Noise model verification, dBA

Location	$L_{Aeq(15\ hr)}$ – Day 7:00 am – 10:00 pm		Change, dBA
	Measured	Modelled	
L08NNS	54.4	54.1	-0.3
L09NNS	62.2	61.8	-0.4
L10NNS	56.9	58.1	+1.2
L11NNS	67.1	66.2	-0.9
Median			-0.35

Corrections to calibrate the operational noise model during the opening and design years was not required as the results from model verification are within acceptable values.

5.4 Predicted noise levels

The predicted 'no-build' and 'build' day and night-time noise levels for each receiver in the year 2020 and year 2030 are detailed in Appendix H including the road traffic criteria calculated with consideration to the RNP and NCG.

All road traffic noise levels include a +2.5 dBA façade correction and a -1.7 dBA ARRB correction.

Day and night-time façade noise results for the design year 'no build' and 'build' options are provided in Appendix H.

5.5 Assessment of impacts

Assessment of the expected noise impacts in accordance with the RNP are as follows:

- The controlling criteria is expected to be exceeded at six receivers (NNS_Rx1325, NNS_Rx1326, NNS_Rx1327, NNS_Rx1328, NNS_Rx1540, NNS_Rx1758) during the day-time period. The maximum exceedance of the criteria is 1.4 dBA at NNS_Rx1328. It should be noted however that these are due to noise from existing roads or roads not part of the proposal and therefore would not qualify for mitigation treatment.
- The controlling criteria is not expected to be exceeded during the night-time period.
- Noise levels are not predicted to exceed the day-time acute criteria of 65 dBA $L_{Aeq(15\ hr)}$ or night-time acute criteria of 60 dBA $L_{Aeq(9\ hr)}$.
- The increase in noise levels between the no-build and build scenarios are less than 2 dB for the receivers that exceed the controlling criterion during the day-time period, therefore mitigation measures are not warranted.
- The Relative Increase Criterion is not applicable to any receiver due to realignment of the Newell Highway overpass or construction of the Jones Avenue bridge.

The proposed overpass at Newell Highway and the Jones Avenue bridge are not expected to adversely impact any sensitive receiver from a noise perspective within the assessment area.

5.6 Maximum noise level/sleep disturbance assessment

The *Road Noise Policy* provides a literature review for the assessment of sleep arousal due to traffic noise however does not set a sleep disturbance assessment criterion. Sleep disturbance impacts are likely to be dependent on the following:

- maximum noise level of an event
- number of occurrences
- duration of the event
- level above background or ambient noise levels.

For continuous rather than intermittent traffic flow, the ENMM recommends L_{Amax} noise pass-by events may lead to sleep disturbance if the L_{Amax} noise levels exceeds the L_{Aeq} noise level by more than 15 dBA when the L_{Amax} noise levels is greater than 65 dBA (external).

The ENMM advises that the maximum noise level can be used as a tool to prioritise and rank mitigation strategies, but should not be applied as a decisive noise criterion for selection of mitigation treatments.

The L_{Amax} and $L_{Aeq(1hr)}$ noise levels during the night-time period (10 pm to 7am) at four road traffic noise monitoring locations are summarised in Table 5.6.

Table 5.6 Summary of maximum noise levels (10 pm to 7 am) - dBA

Noise monitoring location	$L_{Amax(1hr)}$ range	$L_{Aeq(1hr)}$	Highest $L_{Amax(1hr)}$ - $L_{Aeq(1hr)}$	$L_{Amax(1hr)}$ - $L_{Aeq(1hr)}$ average	Number of $L_{Amax(1hr)}$ events > 65 dBA	Number of $L_{Amax(1 hr)}$ > 15 dBA above $L_{Aeq(1hr)}$
Location 1 L08NNS	43-78	36-53	31	19	5	14
Location 2 L09NNS	42-79	33-58	29	17	5	10
Location 3 L10NNS	54-83	41-53	33	20	9	13
Location 4 L11NNS	42-92	51-65	30	22	29	26

The current maximum noise levels exceed the $L_{Aeq(1hr)}$ noise levels by more than 15 dBA and are above 65 dBA on several occasions per night. Based on the measurement taken at location L11NNS (John Deere) there are 39 $L_{Amax(1 hour)}$ events above 65 dBA. This location is not representative of the area surrounding Jones Avenue as the measurements include traffic travelling along Moree Bypass and Newell Highway.

Five external $L_{Amax(1 hour)}$ events above 65 dBA were measured on the eastern side of the rail line at L09NNS (Moree Council Depot). The number of internal maximum noise level events at this location is one assuming a reduction of 10 dBA from external to internal noise levels.

Construction of the bridge at Jones Avenue is unlikely to increase the number of maximum noise levels events on the western side of the rail due to noise level contributions from Moree Bypass and Newell Highway. However, maximum noise level events causing sleep disturbance impacts on the eastern side of the rail has the potential to increase. However, construction of a new road will not increase the maximum noise levels due to an improved road surface which is likely to reduce road irregularities and associated maximum noise level events.

6. Construction noise and vibration assessment

6.1 Construction methodology

6.1.1 Construction timing and duration

Construction staging

Construction of the proposal would commence once all necessary approvals are obtained, and the detailed design is complete. It is anticipated that construction would take about 24 months, commencing in mid 2018, and concluding in mid 2020.

Construction along the existing rail corridor would depend on the possession strategy however it is anticipated that progress would involve four main stages:

- Stage 1- Camurra to North Star
- Stage 2- Narrabri to Bellata
- Stage 3- Bellata to Moree South
- Stage 4- Moree South to Camurra

Construction of the Newell Highway overbridge, the bridges over the Mehi and Gwydir rivers and Croppa Creek, the Camurra bypass, and the Jones Avenue overbridge would be undertaken in parallel with the above stages.

For the works along the existing rail corridor, it is anticipated that it would take about eight to 10 weeks to construct a 4.5 to 5 kilometre section of track. This does not include location specific works such as culverts and underbridges or the relocation of services and utilities.

Proposal working hours

Construction work would be undertaken during the following primary proposal construction hours:

- Monday to Friday: 6:00 am to 6:00 pm
- Saturday: 6:00 am to 6:00 pm
- Sundays and public holidays: 6:00 am to 6:00 pm

Some minor works may also be undertaken during scheduled rail corridor possession periods (that is, the times that the movement of trains along the rail corridor are stopped for maintenance). This could include, for example, the connection of the tracks at either end of each stage, and some finishing works. During possessions, works may need to be undertaken on a 24 hour basis.

The primary proposal construction hours have been developed to:

- accommodate the remote location of worksites and the efficient use of the workforce
- reduce the duration of impact on individual receivers and minimise disruption to commuters and freight operators using existing operational lines
- avoid sleep disturbance by limiting work to daylight hours.

Out of hours works protocol

An out-of-hours work protocol would be developed to guide the assessment and management of works outside the primary proposal construction hours. The out of hours works protocol would:

- address the requirements of consent conditions allocated to the proposal relating to works outside of standard construction hours
- provide details on what would need to be considered to justify works being undertaken outside standard work hours
- describe the assessment process for out of hours works against relevant noise and vibration criteria
- provide specific mitigation measures for any residual impacts (in addition to general mitigation measures)
- describe the communication plan including notification arrangements for potentially impacted receivers
- detail how exceedances or non-conformances would be handled.

As detailed in section 2.2 of the Inland Rail Construction Noise and Vibration Management Framework some activities, including emergency works and delivery of oversized plant, can occur outside of the proposal hours without an out of hours work protocol.

6.1.2 Construction activities

The proposed track formation works and structure renewals are located between (569.240 km) and North Star (758.255 km). Temporary works include access into and out of the construction impact zone (CIZ). Table 6.1 lists the site establishment activities, Table 6.2 lists the main upgrading construction activities and Table 6.3 lists the post-construction activities. The construction hours are also provided in these tables to indicate the activities that are generally expected to occur during the primary proposal construction hours and the activities that are expected to occur during possessions.

Table 6.1 Site establishment activities

Activity	Works to be undertaken	Construction Hours
Site establishment	• Consult land owners/occupants where required • Install site environment management and traffic controls in accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework and the CEMP • Establish site compounds and facilities • Clear vegetation • Erect temporary fencing • Establish site access roads where required • Utility relocations as required • Deliver and stockpile materials including rail, sleepers, ballast, culverts and structural fill	Primary proposal construction hours

Table 6.2 Main upgrading construction activities

Activity	Works to be undertaken	Construction Hours
Track upgrading - skim reconditioning/skim plus reconditioning	• Remove fastenings, rail and sleepers and stockpile to one side of the rail corridor • Trim and level the existing ballast bed and compact • (Skim plus reconditioning only) place new capping material on top of compacted ballast • Place concrete sleepers and rail track on prepared ballast bed and weld up rails • Place new ballast on top of the sleepers • Tamp and profile the ballast around the sleepers and line to a smooth alignment	Primary proposal construction hours During possessions when connecting stage sections
Track upgrading - track reconstruction	• Remove fastenings, rail and sleepers and stockpile to one side of the rail corridor • Excavate the existing ballast and earth formation • Place new earth and recycled ballast into the excavated area and compact • Place new ballast on top of the earth formation and compact • Place concrete sleepers and rail tracks on prepared ballast bed and weld up rails • Place new ballast on top of the sleepers • Tamp and profile the ballast around the sleepers and line to a smooth alignment	Primary proposal construction hours During possessions when connecting stage sections
Drainage construction	• Prepare survey control points for planned excavation of cess drains • Excavate earth material from the side of the existing track formation, and trim and compact base and sides of the drain • Form spoil mounds	Primary proposal construction hours
Level crossings – upgrading controls	• Remove existing controls, excavate to a suitable depth as required, place new formation material and ballast, replace track and surface panel as required • Install new controls • Provide standard road signs and road markings The pedestrian level crossing at Moree Station would be upgraded as follows: • Remove existing pedestrian crossing • Construct pedestrian footpath and pedestrian maze • Install relevant track circuitry for active crossing control • Line marking and installation of signage	Primary proposal construction hours

Activity	Works to be undertaken	Construction Hours
Level crossings-consolidating level crossings	• Complete road works and appropriate road signage to redirect traffic • Remove level crossing signs and road markings • Upgrade tracks	Primary proposal construction hours During possessions when connecting stage sections
Culvert replacement	• Remove existing culvert structure (either concrete or steel pipes) • Excavate to the required depth • Place and compact bedding material • Install substructure as required • Place pre-fabricated culvert structures on the new formation area and fasten together • Place ballast, sleepers and rail on top of the culverts and tamp and profile the ballast under and around the sleepers and weld up tracks	Primary proposal construction hours
Turnout construction	• Cut existing track, remove and dispose of existing turnout (at existing sidings only) • Undertake formation improvement works as required • Install ballast and rails • Install control mechanisms (points motor, power supply etc.) • Testing and commissioning	Primary proposal construction hours
Underbridge replacement	• Install substructure components including bored/ precast concrete/steel piles beneath the existing structure • During a track possession remove existing superstructure (including girders) and substructure components (abutments and piers) and store at nominated locations within the rail corridor • Install any new substructure precast concrete components on the new substructure/piles • Place new girders (concrete) on the new concrete substructures • Place ballast, sleepers and rail on top of the girders • Place ballast, sleepers and rail on top of the new bridge and tamp and profile the ballast under and around the sleepers and weld up tracks • Install guard rails as required	Primary proposal construction hours

Activity	Works to be undertaken	Construction Hours
Mehi River bridge, Gwydir River bridge and Croppa Creek bridge	• Install substructure components including bored/ precast concrete/steel piles alongside the existing underbridge • Install any new substructure precast concrete components on the new substructure/piles • Remove existing bridge superstructure and demolish the existing visible substructure as far as required • Place new girders (concrete) on the new concrete substructures • Construct new earth formation to connect between the existing track alignment and the new bridge alignment • Place ballast, sleepers and rail on top of the new bridge and tamp and profile the ballast under and around the sleepers and weld up tracks • Install guard rails as required Demolition of the existing bridges over the Mehi and Gwydir rivers and Croppa Creek would generally involve the following: • Establish a crane pad for an appropriately sized crane (probably at least one on each side of the river bank) • Demolish the steel superstructure (lifting sections onto trucks to be disposed of at nearby recycling facility) • Demolish the visible existing brick or concrete piers • Dispose of waste material offsite	Primary proposal construction hours
Crossing loop Constructions	• Excavate beside the existing track for the length of the crossing loop • Place and compact formation material • Place ballast, sleepers and rail tracks on top of the new formation • Install signal equipment and associated equipment • Testing and commissioning	Primary proposal construction hours
Rail Station Works	Station realignment works at Bellata, Gurley and Moree stations would be undertaken as follows: • Excavate and remove existing track and formation • Construct new track as described above • Weld and adjust track to interface back into existing track alignment	Primary proposal construction hours

Activity	Works to be undertaken	Construction Hours
Newell highway overbridge construction	Bridge works: • Construct cast-in-place piles at abutments and piers • Construct spill through abutments, column extensions and pier headstocks • Install pre-stressed concrete girders and construct reinforced concrete deck • Construct reinforced concrete approach slabs • Install expansion joints and steel traffic barrier railing • Install waterproof membrane and asphalt Embankment and pavement works • Place bulk general fill to construct approach embankments • As part of constructing approach embankments install a culvert suitable for the travelling stock route • Construct new pavement, including placing and compacting select fill, sub base and asphalt wearing surface • Tie into the existing Newell Highway Finishing and landscaping • Rehabilitate disturbed areas and landscape in accordance with the rehabilitation plan • Line marking and sign posting • Final site clean-up • Switch traffic • Demolish the existing bridge	Primary proposal construction hours

Activity	Works to be undertaken	Construction Hours
Jones Avenue overbridge construction	Bridge works • Construct cast-in-place piles at abutments and piers • Construct spill through abutment on eastern side and reinforced soil wall abutment on western side • Construct column extensions and pier headstocks • Install girders and construct reinforced concrete deck • Install pedestrian footpath • Construct reinforced concrete approach slabs • Install throw screens • Install expansion joints and steel traffic barrier railing • Install waterproof membrane and asphalt Embankment and pavement works • Place bulk general fill to construct approach embankments • Construct new pavement, including placing and compacting select fill, sub base and asphalt wearing surface • Construct pedestrian walkway down the side of the embankments to be *Disability Discrimination Act 1992* compliant • Tie into existing Jones Avenue Finishing and landscaping • Rehabilitate disturbed areas and landscape in accordance with the rehabilitation plan • Line marking and sign posting • Construct cul-de-sac at existing Joyce Avenue intersection with Jones Avenue • Relocate property accesses for affected properties • Final site clean-up	Primary proposal construction hours

Activity	Works to be undertaken	Construction Hours
Camurra bypass construction	• Excavate to a depth determined by geotechnical investigations and design • Place imported formation material into the excavated area and compact using vibratory compaction rollers • Place bottom ballast • Place skeletonised track consisting of fastenings, rail and sleepers on bottom ballast • Place ballast on top of the track • Tamp and profile the ballast around the sleepers and line to the design's vertical and horizontal alignment • Construct cess drainage • Construct tie ins to the existing alignment and install turnouts	Primary proposal construction hours
Earthworks	Earthworks would be required: • Where upgrades to the formation are required • To widen existing embankments and cuttings to meet design requirements • To construct the new crossing loops • To construct the Newell Highway and Jones Avenue overbridges and Mehi River, Gwydir River and Croppa Creek bridges • To construct the Camurra bypass • To construct culverts and underbridges Minor earthworks would also be required to construct the ancillary infrastructure and undertake the ancillary works associated with the proposal.	Primary proposal construction hours

Table 6.3 Post-construction activities

Activity	Works to be undertaken
Post possession (finishing works/reinstatement)	• Demobilise site compounds and facilities • Remove all materials, waste and redundant structures from the works sites • Forming, and stabilising of spoil mounds • Decommission all temporary work site signs • Remove temporary fencing • Establish permanent fencing • Decommission site access roads that are no longer required • Restoration of disturbed areas as required, including revegetation where required

6.1.3 Construction compounds

Minor compounds/storage areas are areas that would be used temporarily for the assembly of adjacent infrastructure such as culverts and turnouts. These compounds would be located within the rail corridor.

Larger compound sites would be established for general construction activities associated with each stage of work. For the purposes of the EIS, it is assumed that temporary compounds would be sited outside the existing rail corridor every 4.5 to five kilometres Indicative compound locations are provided in the EIS and would be confirmed by the contractor prior to works commencing.

Each larger compound site would contain:

- stockpiles
- track infrastructure laydown area
- bunded refuelling area
- fencing as required
- office area including parking, offices and ablutions
- hazardous material storage.

Activities undertaken at compound sites would include the following:

- site office operations
- delivery and stockpiling of various construction materials including rail, sleepers, ballast, culverts and structural fill
- movement of plant and equipment
- operation of mobile concrete batching plant
- maintenance of site environmental management controls.

Not all of the above activities would be undertaken at every compound site.

As locations for construction compounds have not yet been finalised, specific impacts could not be assessed on an individual basis. Instead the above compound activities have been accounted for within the modelled construction scenario S1 (site establishment) and impacts have been modelled for the entire alignment. Compounds would be located at least one kilometre from the nearest residence or other noise sensitive receiver where possible, and if required, compounds would be further assessed once locations are finalised.

Mobile concrete batching plant

In addition to the plant and equipment listed in Table 6.4 the use of mobile concrete batching plants, to supplement supply from existing readymix plants, is proposed for the following construction works:

- earthworks and drainage
- road overbridges and underbridges.

The size of the plant would be about 15 metres by 10 metres, and up to eight metres high. The plant and ancillary features would have a footprint of about 100 by 150 metres to account for a water tanker, concrete trailer and storage of materials including aggregate and sand. The location of the plant would be wholly within the proposal site.

The assessment results from the Site Establishment (S1) modelling scenario provides indicative assessment of impacts as they may be positioned at various locations along the alignment within compound sites. Batching plants would be further assessed once locations are finalised.

6.1.4 Haul roads

While a detailed haulage program has not yet been developed, it is expected that some of the proposal's components would be delivered by rail. Other transport would be undertaken by heavy vehicles using the Newell Highway, Gwydir Highway/Alice Street and Kamilaroi Highway and then local roads and existing access roads along the rail corridor.

It is likely that rail components, including sleepers, ballast, and track, would be transported to the work areas via dedicated rail trains; while pre-fabricated concrete units, fill and equipment deliveries would most likely be via road from suppliers or town centres.

6.1.5 Construction noise assessment methodology

The methodology for the construction noise and vibration assessment included:

- The rating background levels (RBL) for the proposal were calculated from the baseline noise monitoring data. The RBLs were used to establish the construction noise management levels in accordance with the ICNG.
- A list of likely construction activities and machinery was provided. Representative sound power levels for the selected equipment were obtained from the TfNSW CNS and AS 2436 – 2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* and British Standard *BS 5228.1 Code of Practice for noise and vibration control on construction and open sites: Part 1 Noise.*
- Noise propagation calculations were carried out for the anticipated equipment.
- Vibration from construction plant and equipment was predicted and assessed with consideration to Assessing Vibration: A Technical Guideline and German Standard DIN 4150, Part 3: Structural Vibration in Buildings: Effects on Structures.
- Where noise and vibration levels were predicted to exceed the construction noise management levels, appropriate construction noise and vibration mitigation measures were provided to reduce potential impacts.

6.1.6 Construction plant and equipment

Noise emissions from construction activities have been assessed at identified sensitive receivers in the study area during the primary proposal construction hours and outside the primary proposal construction hours. A quantitative assessment has been carried out with consideration to the ICNG.

Plant and equipment to be used to construct the proposal would be confirmed by the construction contractor once appointed. At this stage of development, the plant and equipment have been selected using professional judgement. Construction equipment will move about the project site and will operate at maximum power for only brief periods. At other times, noise levels will be reduced as the machinery may not require full power or will operate in a different location. It is highly unlikely that all assumed construction equipment would be operating at maximum power simultaneously. However, in accordance with the ICNG prediction procedure, the two loudest construction plant are assumed to operate concurrently and used to predict the expected construction noise levels. A number of these assumptions therefore provide a degree of conservatism in the predicted results.

The predicted construction sound power levels are shown in Table 6.4 for the construction activities and the plant and equipment expected to be used for the proposal.

Table 6.4 Construction activities and corresponding equipment

Modelling scenario	General tasks	Representative equipment	Equipment individual sound power level, LWdB(A)	Adopted activity sound power level, LW dB(A)	Location
S1	Site establishment works	Hand tools	102	118	Full alignment
		Road truck	108		
		Excavator	110		
		Water cart	107		
		Grader	110		
		Dump truck	117		
S2	Track upgrading - skim reconditioning/skim plus reconditioning	Dump truck	117	118	Full alignment
		Rail saw	107		
		Vibratory roller	113		
		Front end loader	111		
		Grader	110		
		Tamper and regulator	112		
S3	Track upgrading –track reconstruction	Dump truck	117	118	Full alignment
		Rail saw	107		
		Vibratory roller	113		
		Front end loader	111		
		Grader	110		
		Tamper and regulator	112		
S4	Drainage construction	Excavator	110	118	Full alignment
		Dump truck	117		
		Franna crane	98		
		Vibratory roller	113		
		Batching Plant (Concrete)	113		

Modelling scenario	General tasks	Representative equipment	Equipment individual sound power level, LWdB(A)	Adopted activity sound power level, LW dB(A)	Location
S5	Level crossings - upgrade to signalised level crossing	Asphalt paver	108	115	Signalised level crossings
		Franna crane	98		
		Excavator	110		
		Vibratory roller	113		
		Hand tools	102		
S6	Upgrade passive protection (Give Way Signs to Stop Signs)	Hand tools	102	109	Level crossings
		Road truck	108		
S7	Level Crossing Consolidation	Hand tools	102	116	Level crossings for removal
		Excavator	110		
		Front end loader	111		
		Vibratory roller	113		
		Road truck	108		
		Tamper and regulator	112		
		Franna crane	98		
S8	Culvert replacement	Crane	110	118	Culverts
		Excavator	110		
		Dump truck	117		
		Road truck	108		
		Vibratory roller	113		
		Tamper and regulator	112		
		Batching Plant (Concrete)	113		
S9	Underbridge replacement	Piling (bored)	111	116	Underbridges
		Drilling rig	111		
		Crane	110		
		Excavator	110		

Modelling scenario	General tasks	Representative equipment	Equipment individual sound power level, LWdB(A)	Adopted activity sound power level, LW dB(A)	Location
		Road truck	108		
		Vibratory roller	113		
		Tamper and regulator	112		
		Concrete truck	112		
		Batching Plant (Concrete)	113		
S10	Mehi River bridge, Gwydir River bridge and Croppa Creek bridge	Piling (bored)	111	116	Mehi River bridge, Gwydir River bridge and Croppa Creek bridge
		Drilling rig	111		
		Crane	110		
		Excavator	110		
		Road truck	108		
		Vibratory roller	113		
		Tamper and regulator	112		
		Concrete truck	112		
		Batching Plant (Concrete)	113		
S11	Crossing loop Constructions	Excavator	110	118	Crossing loops
		Dump truck	117		
		Vibratory roller	113		
		Front end loader	111		
S12	Rail station works	Dump truck	117	118	Rail Stations
		Vibratory roller	113		
		Excavator	110		
		Tamper and regulator	112		
S13	Overbridge construction- Newell Highway	Piling (bored)	111	117	Newell Highway
		Compactor	113		
		Vibratory roller	113		

Modelling scenario	General tasks	Representative equipment	Equipment individual sound power level, LWdB(A)	Adopted activity sound power level, LW dB(A)	Location
		Concrete truck	112		
		Batching Plant (Concrete)	113		
		Drilling rig	111		
		Pavement laying machine	114		
S14	Overbridge construction- Jones Avenue	Piling (bored)	111	117	Jones Avenue
		Compactor	113		
		Vibratory roller	113		
		Concrete truck	112		
		Batching Plant (Concrete)	113		
		Drilling rig	111		
		Pavement laying machine	114		
S15	Camurra bypass construction	Dump truck	117	118	Camurra bypass
		Rail saw	107		
		Vibratory roller	113		
		Front end loader	111		
		Grader	110		
		Tamper and regulator	112		
		Batching Plant (Concrete)	113		
S16	Post possession works	Road truck	108	113	Full alignment
		Hand tools	102		
		Crane	110		
		Excavator	110		

6.1.7 Construction noise prediction method

The noise emissions generated by construction activities have been determined using a computer software model Computer Aided Noise Abatement (CadnaA v4.6) to predict noise levels at the nearest sensitive receivers.

CadnaA is a computer program for the calculation, assessment and prognosis of noise propagation. CadnaA calculates sound propagation according to ISO 9613-2, "*Acoustics – Attenuation of sound during propagation outdoors*". The ISO 9613-2 algorithm also takes into account the presence of a well-developed moderate ground based temperature inversion, such as commonly occurs on clear, calm nights or 'downwind' conditions which are favourable to sound propagation.

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

Model configuration

The noise model inputs and assumptions for the construction assessment are provided in Table 6.5.

Table 6.5 Construction noise modelling assumptions

Modelling component	Assumption
Prediction algorithm	*ISO 9613 – 2 Acoustics – Attenuation of sound during propagation outdoors*
Modelling period	Typical worst case 15 minute period of operation where the two loudest items of equipment are running at full power
Meteorology	ISO 9613 considers the presence of a well-developed moderate ground based temperature inversion, such as commonly occurs on clear, calm nights or 'downwind' conditions which are favourable to sound propagation
Ground absorption coefficient	G = 1.0 for rural areas
Atmospheric absorption	Based on an average temperature of 10 °C and an average humidity of 70 %
Receiver heights	1.5 m above building ground level (ground floor)
Operating intensity	Construction scenario sound power levels have been adopted

The magnitude of the noise levels associated with construction activities would be dependent upon a number of factors:

- the intensity and location of construction activities
- the type of equipment used
- existing local noise sources
- intervening terrain
- the prevailing weather conditions.

6.2 Construction noise level prediction

Sound power levels presented in Table 6.4 were grouped into activity based noise levels for input into the noise model. Using the sound power level from the two loudest pieces of equipment operating simultaneously is considered a conservative approach. The predicted noise management level exceedances for each activity scenario are shown in Table 6.6 while the numbers of receivers exceeding each management level are presented in Table 6.7. The number of exceedances for non-residential receivers are presented in Table 6.8.

Table 6.6 Activity-based construction noise management level exceedances for residential receivers

Construction noise management level (CNML)	CNML dBA $L_{Aeq\ 15min}$	Maximum predicted exceedance of construction noise management level										
		Full alignment works: S1, S2, S3, S4, S12	S5: Signalised Xing	S6: Give Way Xing	S7: Level Xing removal	S8: Culvert works	S9, S10: Bridge works	S11: Crossing loops	S13: Newell Highway Overbridge	S14: Jones Avenue Overbridge	S15: Camurra Bypass	S16: Post possession
Highly Affected	75	3	-	-	-	-	-	-	-	1	-	-
Proposal specific CNML (all periods)	35	43	22	12	9	39	24	27	13	41	10	38

Table 6.7 Activity-based construction noise management level, number of exceedances for residential receivers

Construction noise management level (CNML)	CNML dBA $L_{Aeq\ 15min}$	Number of exceedances of construction noise management level										
		Full alignment works: S1, S2, S3, S4, S12	S5: Signalised Xing	S6: Give Way Xing	S7: Level Xing removal	S8: Culvert works	S9, S10: Bridge works	S11: Crossing loops	S13: Newell Highway Overbridge	S14: Jones Avenue Overbridge	S15: Camurra Bypass	S16: Post possession
Highly Affected	75	3	0	0	0	0	0	0	0	1	0	0
Proposal specific CNML (all periods)	35	1574	252	22	1	653	682	685	2	1098	3	834

Table 6.8 Construction activity, number of exceedances - Non-residential receivers

Land Use	Number of receivers	Number of exceedances of construction noise management level										
		Full alignment works: S1, S2, S3, S4, S12	S5: Signalised Xing	S6: Give Way Xing	S7: Level Xing removal	S8: Culvert works	S9, S10: Bridge works	S11: Crossing loops	S13: Newell Highway Overbridge	S14: Jones Avenue Overbridge	S15: Camurra Bypass	S16: Post possession
Place of Worship	8	2	0	0	0	0	0	2	0	0	0	2
Hospital Ward	1	0	0	0	0	0	0	0	0	0	0	0
Schools	9	0	0	0	0	0	0	0	0	0	0	0
Recreational-Passive	16	1	0	0	0	0	0	0	0	0	0	1
Recreational-Active	19	1	0	0	0	0	0	1	0	0	0	1

6.2.1 Impacts of construction activities for the key proposal features

Based on the results listed in Table 6.6, Table 6.7 and Table 6.8, the findings of the construction noise assessment in relation to the key features of the proposal for residential receivers are discussed below.

Track works

Activities that encompass the entire proposal site (i.e. the full alignment), such as pre possession works (S1), skim track reconditioning (S2), full depth reconditioning (S3), and drainage construction (S4), are predicted to exceed the construction noise management levels:

- in North Star at 37 residential receivers with impacts up to 27 dB and one educational facility up to 5 dB
- between Moree and North Star at 70 residential receivers with impacts up to 29 dB
- in Moree at 922 residential receivers with impacts up to 43 dB
- between Bellata and Moree at 48 residential receivers with impacts up to 22 dB
- in Bellata at 71 residential receivers with impacts up to 23 dB and one recreational area by up to 6 dB
- between Narrabri and Bellata at 38 residential receivers with impacts up to 24 dB
- in Narrabri at 388 residential receivers with impacts up to 20 dB.

Construction would progress along the route, therefore, noise impacts would be experienced for a relatively short time at most locations.

Level crossing upgrades and consolidation

Construction activities of crossing signalisation (S5), give way crossing upgrades (S6), and level crossing consolidation (S7) are predicted to exceed the construction noise management levels:

- in North Star at 22 residential receivers with impacts up to 18 dB
- between Moree and North Star at 9 residential receivers with impacts up to 9 dB
- in Moree at 205 residential receivers with impacts up to 22 dB and one recreational receiver by up to 1 dB
- between Bellata and Moree at 24 residential receivers with impacts up to 17 dB
- in Bellata at 11 residential receivers with impacts up to 11 dB and at one recreational receiver by up to 7 dB
- between Narrabri and Bellata at four residential receivers with impacts up to 12 dB
- no impacts are predicted in Narrabri.

Culvert works

Replacement and upgrade of existing culverts and bridges (culvert works, S8) are predicted to exceed the construction noise management levels:

- in North Star at 30 residential receivers with impacts up to 22 dB
- between Moree and North Star at 22 residential receivers with impacts up to 22 dB

- in Moree at 489 residential receivers with impacts up to 39 dB
- between Bellata and Moree at 22 residential receivers with impacts up to 8 dB
- in Bellata at 65 residential receivers with impacts up to 16 dB
- between Narrabri and Bellata at 25 residential receivers with impacts up to 19 dB
- no impacts are predicted in Narrabri.

Bridge works

Construction of bridges (S09, S10) are predicted to exceed the construction noise management levels:

- between Moree and North Star at 37 residential receivers with impacts up to 15 dB
- in Moree at 639 residential receivers with impacts up to 24 dB
- between Bellata and Moree at two residential receivers with impacts up to 4 dB
- no impacts are predicted in Bellata or Narrabri
- between Narrabri and Bellata at four residential receivers with impacts up to 11 dB
- no impacts are predicted in North Star.

Construction of the Mehi and Gwydir river bridges would take about six to eight months each to complete. Construction of the Croppa Creek bridge would take about seven months to complete.

Crossing loops

Construction of crossing loops (S11) is predicted to exceed the construction noise management levels:

- in North Star at 36 residential receivers with impacts up to 22 dB
- between Moree and North Star at 24 residential receivers with impacts up to 24 dB
- in Moree at 517 residential receivers with impacts up to 27 dB
- between Bellata and Moree at 29 residential receivers with impacts up to 23 dB
- in Bellata at 69 residential receivers with impacts up to 21 dB
- between Narrabri and Bellata at 10 residential receivers with impacts up to 18 dB
- no impacts are predicted in Narrabri.

Newell highway overbridge

Construction of the Newell highway overbridge (S13) is predicted to exceed the construction noise management levels:

- between Bellata and Moree at two residential receivers with impacts up to 13 dB
- no impacts are predicted for other receiver areas.

Construction of the Newell highway overbridge would take about 10 months to complete.

Jones avenue overbridge

Construction of the Jones Avenue overbridge (S14) is predicted to exceed the construction noise management levels:

- in Moree at 1098 residential receivers with impacts up to 41 dB
- no impacts are predicted for other receiver areas.

Construction of the Jones Avenue overbridge would take about six to eight months to complete.

Camurra Bypass

Construction of the Camurra bypass (S15) is predicted to exceed the construction noise management levels:

- between Moree and North Star at three residential receivers with impacts up to 10 dB
- no impacts are predicted for other receiver areas.

6.2.2 Impacts of construction activities in relation to working hours

Works during primary proposal construction hours

The assessment indicates that:

- The highly affected level of 75 dB(A) L_{Aeq} is predicted to be exceeded at three receivers.
- Rail line redevelopment construction activities are predicted to exceed the noise management level at receivers nearest to the construction footprint. Impacted receivers are within about 700 metres of the works and includes up to 1574 identified noise sensitive residential receiver locations. Noise levels are predicted to exceed the proposal specific construction management level by up to 43 dB.
- Newell highway overbridge construction is predicted to exceed the proposal specific construction management level by up to 13 dB at two residential receivers.
- Jones Avenue overbridge construction is predicted to exceed the proposal specific construction management level by up to 41 dB at 1098 residential receivers.
- Construction activities during the primary proposal construction hours have the potential to exceed the noise management level at non-residential sensitive receivers including educational, child care and hospital facilities. Construction noise management levels are applicable as an internal level only when the facilities are in use.
- Construction activities during the primary proposal construction hours have the potential to exceed the noise management level at recreational areas including bushland areas, parks and sporting facilities when these areas are in use.

In accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework the noise and vibration mitigation measures detailed in Section 7 would be implemented where feasible and reasonable to protect the environment and reduce the potential for noise exceedances at receivers. All potentially affected receivers should be informed of the nature of the works, expected noise levels, duration of works and a method of contact.

6.3 Construction traffic noise

It is expected that vehicles will access working sites via arterial, sub-arterial and local roads.

Limited existing traffic volume data is available for most roads in and around the study area, although in most cases, volumes are expected to range between 50 vehicles per day for lower order roads, up to 9,000 vehicles per day on some of the more significant roads radiating from Moree.

The proposed works will temporarily increase truck movements on major roads during construction. Predictions of the change in traffic noise level due to the addition of construction traffic were undertaken using the United Kingdom Department of Transport's 'Calculation of Road Traffic Noise' CoRTN algorithm.

The exact number of construction vehicles will vary at different stages of the construction works and will be confirmed when the construction contractor is appointed.

Construction of the proposal would result in temporary impacts to traffic and access within the study area, and an increase in both heavy and light vehicle movements on the local road network. The most significant impacts will be during the days of delivery where heavy vehicle volumes on the roads between Narrabri and North Star may increase by up to 234 vehicles per day.

However, it is estimated that during the busiest construction period, there will be approximately 404 vehicle movements, including 234 heavy vehicle movements and this peak volume has been used to provide a conservative analysis of the likely level of noise levels.

The traffic information and expected noise level increase from additional traffic on major roads in the area are summarised in Table 6.9. It is anticipated that the contribution of additional construction traffic will have a minimal impact on the noise levels along the highway. The increase in noise levels due to construction traffic is estimated to be less than 2 dB which will not be noticeable at receivers.

Table 6.9 Construction traffic noise increase

Road	Location	AADT	Existing heavy vehicle percentage	Approximate noise level increase (dBA)
Newell Highway/Moree Bypass	North of Narrabri	3,100	39	0.7
Newell Highway/Moree Bypass	South of Moree (between Bellata and Gurley)	2,400	45	0.8
Newell Highway/Moree Bypass	North of Moree (between Croppa Moree Road and Buckie Road)	2,000	46	0.9
Alice St/Gwydir Highway	Moree (west of the Moree bypass)	9,000	-[5]	0.7
Bullus Drive		2,800	8%[6]	1.5

[5] Heavy vehicle percentage not available

[6] 8% during afternoon peak

6.4 Sleep disturbance impacts

The *Interim Construction Noise Guideline* (DECC, 2009) states that '*where construction works are planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed works*'.

Typically, $L_{A1(1minute)}$ or, L_{Amax} noise levels are around 5 dB to 10 dB greater than the $L_{Aeq(15minute)}$ noise levels. Typically, a standard window will provide a 10 dB reduction when partially open and a 20 dB reduction when closed. To be conservative, it is assumed that windows would be kept partially open during night-time construction activities.

The *Environmental Criteria for Road Traffic Noise* (EPA, 1999) acknowledges that based on the current level of understanding, no absolute noise level criteria have been established that correlate to an acceptable level of sleep disturbance. However, the RNP suggests that internal noise levels below 50 dB(A) L_{Amax} to 55 dB(A) L_{Amax} are unlikely to cause awakening reactions and one or two events per night, with internal noise levels of 65 dB(A) L_{Amax} to 70 dB(A) L_{Amax} (inside dwellings) are not likely to significantly affect health and wellbeing.

There is the potential for sleep disturbance impacts, with consideration to the RNP sleep disturbance levels, if construction activities occur during the night-time period. Table 6.10 lists each construction scenario and estimates the number of receivers where sleep disturbance could result.

Table 6.10 Sleep disturbance, number of exceedances

L_{AMax} Internal Level[7]	Number of predicted exceedances of sleep disturbance criteria										
	Full alignment works: S1, S2, S3, S4, S12	S5: Signalised Xing	S6: Give Way Xing	S7: Level Xing removal	S8: Culvert works	S9, S10: Bridge works	S11: Crossing loops	S13: Newell Highway Overbridge	S14: Jones Avenue Overbridge	S15: Camurra Bypass	S16: Post possession
55 dB(A)	75	2	0	0	11	8	23	0	43	0	23

Given the potential for sleep disturbance impacts, construction activities likely to generate the highest levels of noise should be scheduled to occur at the beginning of the shift (before 11 pm) to minimise the potential for sleep disturbance. All workers should be briefed on the need to minimise noise as a result of their activities.

The noise and vibration mitigation measures detailed in section 7 would be implemented to manage potential sleep disturbance impacts during construction.

[7] 55 dB(A) internal level from the RNP. L_{AMax} levels were estimated as 10 dB greater than the LAeq(15minute) levels and external noise levels were assessed as 10 dB above internal levels.

6.5 Construction vibration assessment

6.5.1 Potential impacts of individual equipment

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

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

Table 6.11 outlines typical vibration levels for different plant activities sourced from the RMS *Environmental Noise Management Manual* (ENMM) (2001), British Standard *BS 5228.1 Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration* and the *Construction Noise Strategy* (Transport for NSW 2012).

As stated in the ENMM (RMS 2001), it can be assumed that the vibration level of a source is inversely proportional to the distance source-receiver. Field variations show that the distance relationship generally varies between $d^{-0.8}$ and $d^{-1.6}$, rather than d^{-1}.

Table 6.11 Typical vibration levels for construction equipment

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

Note 1: Based on levels derived at 8 m from: Tyan, A. E. *Ground Vibrations. Damaging effects to Buildings*. Road Research Board 1973
Note 2: Based on levels derived from BS5228-2. *Bored piling through stones or other obstruction*. Vibratory piling based on relationship provided in Table E.1

Based on the typical vibration levels listed in Table 6.11, the potential vibration levels due to the construction works at various distances are shown in Table 6.12.

Table 6.12 Predicted construction vibration levels

Vibration source	Distance to Source/Peak Particle Velocity (mm/s)			
	10 m	20 m	50 m	100 m
Roller	6.0	3.4	1.7	1.0
15 tonne vibratory roller	8.0	4.6	2.2	1.3
7 tonne compactor	6.0	3.4	1.7	1.0

Vibration source	Distance to Source/Peak Particle Velocity (mm/s)			
	10 m	20 m	50 m	100 m
Dozer	4.0	2.3	1.1	0.6
Backhoe	1.0	0.6	0.3	0.2
Excavator	2.1	1.2	0.6	0.3
Piling (impact)	30	17.2	8.3	4.8
Piling (vibratory)[1]	16.8	7.3	2.4	1.1
Piling (bored)[1]	7.4	4.3	2.1	1.2

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

Construction vibration buffer distances

Predicted safe working buffer distances to comply with the human comfort, cosmetic damage, standard dwelling and heritage building structural damage criteria were calculated for typical vibration values and listed in Table 6.12. This table is based on advice given in British Standard BS 7385:1993 – *Evaluation and measurement of vibration in buildings.*

Vibration may be amplified in multi-level buildings through the structure to the upper floors. A doubling of the buffer distances provided in Table 6.13 would provide a conservative allowance for this possible effect. The number of receivers within these buffer zones are provided in Table 6.14. For the purposes of this assessment, non-residential receiver structures such as educational facilities, churches and medical facilities are assumed to have equivalent construction to standard dwellings. Passive and active recreational receivers have also been included as these may include facilities building, club houses or buildings for equipment storage.

Table 6.13 Vibration buffer distances

Activity	Human comfort BS 5228-2 criteria (1.0mm/s)	Structural damage	
		Heritage building/structure DIN 4150-3 criteria (3.0mm/s)	Standard dwellings DIN 4150-3 criteria (5.0mm/s)
General construction activities			
Roller	90 m	24 m	13 m
15 tonne vibratory roller	140 m	35 m	18 m
7 tonne compactor	90 m	24 m	13 m
Dozer	60 m	15 m	8 m
Backhoe	10 m	3 m	2 m
Excavator	25 m	7 m	4 m
Piling (Bridges)			
Piling (impact)	700 m	180 m	100 m
Piling (vibratory)[2]	110 m	50 m	30 m
Piling (bored)[2]	120 m	35 m	17 m

Note 1: Based on advice given in British Standard BS 7385:1993 – Evaluation and measurement of vibration in buildings.
Note 2: Based on levels derived from BS 5228-2. *Bored piling through stones or other obstruction*. Vibratory piling based on relationship provided in Table E.1.

Table 6.14 Construction vibration activities- number of potentially impacted receivers

Activity	Human comfort BS 5228-2 criteria	Heritage building/structure DIN 4150-3 criteria	Standard dwellings DIN 4150-3 criteria
General construction activities			
Roller	144	2	13
15 tonne vibratory roller	219	2	20
7 tonne compactor	144	2	13
Dozer	79	2	6
Backhoe	7	1	4
Excavator	28	1	5
Piling (Bridges)			
Piling (impact)	820	0	45
Piling (vibratory)	50	0	5
Piling (bored)	56	0	1

General construction activities

With consideration to structural damage vibration impacts from general construction activities, the expected magnitude of ground vibration should not be sufficient to cause damage if the equipment operates at distances greater than 18 metres from buildings of equivalent standard dwelling construction or 35 metres from heritage structures.

The number of potentially impacted receivers are provided in Table 6.14 for the anticipated vibration generating equipment. During general construction activities, vibration is predicted to be perceptible at up to 219 sensitive receivers that are within 140 metres of the proposal. These receivers are generally spread along the length of the proposal, but are also in greater density within Moree, Bellata, Edgeroi, Gurley, Croppa Creek and North Star.

Twenty structures have been identified within 18 metres of potential general construction activities and may receive vibration levels exceeding the 5 mm/s structural damage criteria. These structures are mostly located within Bellata and Moree, with two also situated adjacent to the proposal between Moree and North Star.

The noise and vibration mitigation measures detailed in Section 7 should be implemented to reduce the potential for construction vibration impacts to occur.

Piling

Vibration impacts due to piling activities associated with bridge construction works have the potential to exceed structural vibration values for standard dwellings at distances from the activity of 100 metres for impact piling, 30 metres for vibratory piling and 17 metres for bored piling.

About 820 receivers may receive perceptible vibration where impact piling is used. These receivers are mostly within Moree and are near to either the Mehi River rail bridge or the Jones Avenue road over bridge.

In the event that these buffer distances are not possible to achieve, other methods may be investigated such as CFA piling, press-in hydraulic piling or jacked-in piling. These methods generally exhibit much lower vibration levels compared to impact, vibratory and bored piling.

6.5.2 Construction vibration impacts on heritage structures

As noted in Table 6.13, construction vibration impacts for heritage items may extend up to 180 metres from the proposal site. Heritage listed items located within this distance have been identified as part of the heritage report undertaken for the EIS (refer Umwelt, 2017, *Australian Rail Track Corporation Inland Rail – Narrabri to North Star Non-Aboriginal Heritage Impact Statement*) and are provided in Table 6.15 for comparison to the structural damage buffer distances stated in Table 6.13.

Table 6.15 Heritage listed items

Item name	Location	Distance to corridor/track
Mehi River Bridge	Moree – Mungindi Line 666.340 kilometres from Sydney	On alignment
Moree Railway Station	As listed in LEP: Gosport Street, Moree Adjacent to Lot 158, DP 1157018 As listed on S170: Morton Street	On alignment/Immediately adjacent
Gwydir River Bridge	Camurra – Mungindi Line 676.220 kilometres from Sydney	On alignment
Victoria Hotel	339 Gosport Street, Moree	Approximately 100 metres to west
Moree Baths and swimming pool	Corner of Anne and Warialda Street, Moree	Approximately 100 metres to west
Moree Showground	Warialda St, Moree	Approximately 100 metres to northwest (Pavilion mentioned in listing, approximately 270 metres to the northwest)
Gwydir River Underbridge, Camurra	Camurra – Mungindi Line 676.220 kilometres from Sydney	Approximately 180 metres west of alignment (different bridge to above)
A.B. Meppem and Co.	30 Railway Pde (Newell Highway), Bellata	Approximately 80 metres to east
Bellata Police Station and Official Residence	24 Railway Pde (Newell Highway), Bellata	Approximately 80 metres to east
Oldhams Smallgoods	26 Railway Pde (Newell Highway), Bellata	Approximately 80 metres to east
Post Office	28 Railway Pde (Newell Highway), Bellata	Approximately 80 metres to east
LS Rowe Stock and Station Agents	40 Railway Pde (Newell Highway), Bellata	Approximately 80 metres to east
Nandewar Hotel	Lot 1 Railway Pde (Newell Highway), Bellata	Approximately 80 metres to east

The non-Aboriginal heritage assessment also identified potential items with potential heritage significance within and in the vicinity of the proposal site. Potential heritage items that may be impacted by vibration include:

- the rail line (including underbridges and associated rail infrastructure)
- 13 former railway station sites and one existing station (Bellata) located within the proposal site

- one former and one existing station (Camurra and Narrabri respectively) located close to the proposal site
- Edgeroi Woolshed, located adjacent to the rail line near the site of the former Woolenget Station, about 10 metres from the fence marking the edge of the rail corridor.

General construction activities

Heritage structures in the proposal area include station buildings, sidings and silos. Many of these structures are directly adjacent to the track alignment. With consideration to structural damage, vibration impacts for general construction activities, the expected magnitude of ground vibration should not be sufficient to cause damage if the equipment operates at distances greater than 35 metres from heritage buildings and structures. Moree Station and some potential heritage items are located within this buffer distance. The Mehi River, Gwydir River and Croppa Creek bridges are also located with this buffer distance, but would be removed as part of the proposal.

If vibration generating activities (non-piling) are being undertaken within 35 m of the heritage listed structures, alternative work methods will be implemented so the vibration impacts are reduced to acceptable levels. Prior to commencement of construction, a dilapidation survey of the nearby heritage structures (within 35 m of the works) would be undertaken. Measured vibration levels by GHD on other projects in the Hunter Valley during removal and excavation of old track indicated a maximum recorded PVS of 2.87 millimetres per second. Tamping and ballast regulation generated a maximum PVS of 0.98 millimetres per second at the floor of the station building. These vibration velocities are within the DIN 4150-3 criteria for heritage structures of 3 millimetres per second. As identical works are proposed to be undertaken for the proposal, vibration damage for adjacent station structures is not anticipated, however it is recommended that the mitigation measures detailed in Section 7 be considered and implemented where feasible and reasonable.

Piling

Vibration impacts due to piling activities have the potential to exceed structural vibration criteria for heritage structures at distances from the activity of 180 metres for impact piling, 50 metres for vibratory piling and 35 metres for bored piling.

In the event that these buffer distances are not achievable, other methods may be investigated such as CFA piling, press-in hydraulic piling or jacked-in piling. These methods generally exhibit much lower vibration levels compared to impact, vibratory and bored piling. Prior to commencement of construction, a dilapidation survey of the nearby heritage structures (within the relevant piling buffer distance) would be undertaken.

6.5.3 Human comfort impacts

Humans are capable of detecting vibration at levels well below those causing risk of damage to buildings. The degree of perception for humans and sensitive areas are suggested by the vibration level categories given in British Standard BS 5228:2009 and shown in Table 6.12 and Table 6.13.

Based on the conservative estimates detailed in Section 6.5.1, it is possible that construction vibration from general construction work and at crossing loops may be perceptible at distances of up to 140 metres from the works. There are 208 residential receivers identified within this buffer distance. Therefore it is recommended that the mitigation measures detailed in Section 7 be considered and implemented where feasible and reasonable.

Piling works are required for bridge construction. About 820 receivers may receive perceptible vibration where impact piling is used. These receivers are within 700 metres of piling locations. They are located mostly within Moree and are near to either the Mehi River rail bridge or the Jones Avenue road overbridge.

Vibration impacts due to boring of the cast in-situ piles has the potential to impact receivers up to 120 metres from the work area. There are 56 receivers located within this buffer distance from proposed piling locations.

7. Mitigation measures

7.1 Approach to mitigation

An operational noise and vibration review (ONVR) would be prepared to detail how the predicted operation impacts would be mitigated.

A Construction Environment Management Plan (CEMP) and activity specific Construction Noise and Vibration Impact Statements (CNVIS) would be developed based on the requirements and methodologies presented in the Inland Rail NSW Construction Noise and Vibration Management Framework. These documents provide the approach to managing noise and vibration during construction.

The proposal would be designed, constructed, and operated in accordance with the CEMP, the Inland Rail NSW Construction Noise and Vibration Management Framework, the Operational Noise and Vibration Review, the conditions of approval for the proposal, and the environment protection licence for Inland Rail.

7.2 Operational noise and vibration

7.2.1 Noise control strategy

A noise and vibration impact assessment has been completed on the basis of the existing design and other information available for the proposal. While the assessment has been limited due to the preliminary nature and availability of design information, exceedances of the RING criteria are predicted and mitigation measures are therefore necessary to reduce the potential for impacts.

Given the preliminary nature of information about the proposal, it is not possible to be definitive about the mitigation measures required. However, in broad terms there are three main strategies for reducing operational noise and vibration impacts:

- controlling noise and vibration at the source
- controlling noise and vibration along the transmission pathway
- controlling noise and vibration at the receiver.

The RING recommends that these control strategies are considered in this order so that all measures to reduce noise are exhausted before localised ‘at source’ mitigation measures are considered.

The RING also requires that feasible and reasonable mitigation measures are implemented. A feasible mitigation measure is a measure that can be engineered and is practical to build, given constraints such as safety, maintenance and reliability requirements. It may also include options such as amending operational practices (e.g. reviewing idling times or speeds) to achieve noise reduction.

Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measure. To make such a judgement, the following aspects are typically considered:

- noise impacts:
  - existing and future levels, and projected changes in noise levels
  - level of amenity before the proposal, e.g. the number of people affected or annoyed
  - any noise performance criteria for the development, e.g. internal noise levels for certain rooms
  - the amount by which the trigger levels are exceeded.
- noise mitigation benefits:
  - the amount of noise reduction expected, including the cumulative effectiveness of proposed mitigation measures
  - the number of people protected.
- cost-effectiveness of noise mitigation:
  - the total cost of mitigation measures, taking into account the physical attributes of the site, e.g. topography, geology, and the cost variation to the proposal given the expected benefit
  - noise mitigation costs compared with total proposal costs, taking into account capital and maintenance costs
  - ongoing operational and maintenance cost borne by the community, e.g. running air conditioners or mechanical ventilation.
- community views:
  - aesthetic and other impacts of noise mitigation measures with consideration to the affected land users
  - consider the views of all affected land users, not just those making representations, through early community consultation
  - consider noise mitigation measures that have majority support from the affected community.

Based on these considerations, the aim of the mitigation strategy is to strike a balance between the proposal's benefits for the wider community and the costs and benefits of mitigation measures.

Identification of specific noise abatement measures is not possible during this stage of the project, however a range of abatement measures have been identified to reduce noise levels to below the RING trigger levels. Potential noise control options are listed in Table 7.1. The effectiveness and appropriateness of these measures will be considered following detailed design and community consultation.

Table 7.1 Potential noise control options

Noise control strategy	Mitigation option	Description
Controlling noise at source	Rail dampers	Rail dampers are preformed elements made of an elastic material containing steel strips. Dampers are placed on the sides of the rail, dampening the vibration of the rails as the train passes over them and thereby reducing noise emissions. Noise reduction in the order of 2 to 5dBA is possible, depending on the rail roughness (the smoother the rail, the less attenuation). However, this is only valid when the wheel-rail interface is the main noise source. In the context of coal or freight train pass-bys, rail dampers would not attenuate L_{Amax} levels, which are normally dominated by locomotive noise, but would reduce wagon noise. This option could be considered for the proposal where small noise reductions are needed.
	Track lubrication	Trackside lubrication strategies can be employed to improve the performance of the rail track and reduce noise generated, particularly from rail squeal and flanging on tight curves. These strategies are as follows: • Improvements in grease transfer by placing trackside lubricators on moderate curves in advance of the sharp curves which are the main target • Improvements in the lubricant used by choosing a high performance product Track lubrication improves the rail/track interface and can reduce/eliminate curve squeal and flanging at affected locations. This can result in a substantial noise reduction in L_{Aeq}, L_{Amax} levels. Note that there are very few tight radius curves in the proposal, so track lubrication would have limited application.
Controlling noise on the transmission pathway	Noise barriers	Noise barriers are typically constructed on the edge of the rail corridor to shield sensitive receivers from rail vehicles. Depending on the situation, noise barriers can achieve 10 to 15 dBA attenuation. Noise barriers often result in significant costs and visual impacts. They are generally considered preferable where noise attenuation at a larger number of receivers is required and typically not cost-effective for small number of receivers.

Noise control strategy	Mitigation option	Description
	Earth mounds	Earth mounds are generally constructed at a distance from the near rail to shield sensitive receivers from rail vehicles. Earth mounds can provide effective mitigation of noise if sufficient spoil and space is available. However, earth mounds generally provide less attenuation of noise than noise barriers and require a larger area also. During detailed design the potential to utilise the proposed spoil mounds (described in the EIS) as noise barriers would be investigated.
Controlling noise at the receiver	Architectural treatment	Architectural treatment consists of reducing noise levels at affected residences in order to meet internal noise levels. Treatment could include retrofitting thicker window glazing, roof insulation, door and windows acoustic seals and the like. It could also include boundary fences if it would be effective in reducing external noise levels. Noise attenuation is substantially dependant on the condition and design of the existing residence. Note that architectural treatment may also include fitting of mechanical/forced ventilation so that windows can be kept closed if the occupant desires. Architectural treatment is often the most practical option where individual receivers require noise mitigation and where other mitigation options have been considered and exhausted.

An Operational Noise and Vibration Review (ONVR) shall be prepared for the project to confirm noise and vibration control measures based on the final proposal design and operation. The ONVR shall:

- Confirm predicted project noise and vibration levels at sensitive receivers. This may include the results of façade testing for non-residential receivers.
- Assess feasible and reasonable noise and vibration measures consistent with RING and in a hierarchical manner.
- Specify noise and vibration abatement measures for all relevant sensitive receivers.
- Include a consultation strategy to seek feedback from directly affected property owners on the proposed noise and vibration abatement measures.
- Include a timetable for delivery of abatement prior to operation of the Inland Rail.
- Outline post-operational monitoring to verify noise and vibration predictions.

Typically, a post construction noise and vibration assessment including monitoring would be undertaken to validate predicted noise levels and identify any unforeseen impacts. However, as noise and vibration levels are not expected to appreciably change until Inland Rail through connection in 2025, it is considered appropriate to undertake the post construction noise and vibration assessment within six months following through connection. The assessment would be undertaken to confirm compliances with the predicted levels, or as modified by the reasonable and feasible review. If the results of modelling indicated that the predicted noise and vibration levels are exceeded, then additional reasonable and feasible mitigation measures would be implemented in consultation with the affected property owners.

7.2.2 Operational vibration

A number of receivers were predicted to experience human comfort impacts from operation of the project. Although no prescribed methodology is available to ameliorate impacts from operational vibration, the FTA guidelines provides guidance on methods that can be considered. The vibration mitigation options detailed in Table 7.2 should be implemented where it is reasonable and feasible.

Table 7.2 Potential vibration control options

Vibration control strategy	Mitigation option	Description
Planning and design of special trackwork (turnouts, crossings, etc.)		Certain track components, such as turnouts and crossings, are a major contributor to operational vibration impacts. Strategic location of these track components away from sensitive receivers can minimise operational impacts. Another method to reduce vibration impacts is to install special devices at crossovers and turnouts that incorporate mechanisms that close the gaps between running rails. Spring-loaded mechanisms and movable points can be implemented to significantly reduce the severity of vibration impacts.
Special track support systems	Resilient fasteners	Resilient fasteners are very stiff in the vertical direction and are used to fasten the rail to concrete track slabs. Resilient fasteners are effective at reducing vibration at frequencies above 30-40 Hz.
	Ballast mats	Ballast mats consist of an elastomer pad (e.g. rubber) that is placed under the ballast. To be effective, the mat is typically placed upon a concrete pad. Ballast mats are generally not effective if placed on soil or sub-ballast, therefore ballast mats are typically applied to subways or elevated structures. Ballast mats can provide effective attenuation at frequencies above 25-30 Hz.
	Resiliently supported ties	This system consists of concrete ties that are supported by rubber pads. Standard rail clips are used to directly fasten rails to the concrete ties. Measurement data indicates that this system is very effective in reducing low frequency vibration (15-40 Hz).
Building modifications		Impacted buildings can be modified to reduce the vibration levels if practical. Vibration isolation involves supporting the building on elastomer pads. Vibration isolation of existing buildings is typically not a practical option and is normally only applied to the construction of new buildings.
Trenches		Installation of trenches can be used to block the propagation of vibration waves through the ground. This method is analogous to installing noise barriers for mitigation of noise impacts.

Vibration control strategy	Mitigation option	Description
Buffer zones		Expanding the rail right-of-way can be an economical solution to reduce vibration impacts. Similarly, vibration easements can be negotiated with the affected property owners.

7.3 Construction noise and vibration

The Inland Rail NSW Construction Noise and Vibration Management Framework (provided in the EIS) has been developed to show how construction noise and vibration will be managed for Inland Rail in NSW. It provides a framework for managing construction noise and vibration impacts in accordance with the ICNG, to provide a consistent approach to management and mitigation across Inland Rail in NSW.

Specifically the Inland Rail NSW Construction Noise and Vibration Management Framework identifies the requirements and methodology to develop Construction Noise and Vibration Impact Statements. These would be prepared prior to specific construction activities and based on a more detailed understanding of the construction methods, including the size and type of construction equipment, duration and timing of works, and detailed reviews of local receivers if required. A Construction Noise Impact Statement would include:

- A more detailed understanding of surrounding receivers, including particularly sensitive receivers such as education and child care, and vibration sensitive medical, imaging, and scientific equipment.
- Application of appropriate noise and vibration criteria for each receiver type.
- An assessment of the potential noise and vibration impacts as a result of different construction activities.
- Minimum requirements in relation to standard noise and vibration mitigation measures.
- Noise and vibration auditing and monitoring requirements.
- Additional mitigation measures to be implemented when exceedances to the noise management levels are likely to occur - these measures are aimed at pro-active engagement with potentially affected receivers, provision of respite periods, and alternative accommodation for defined exceedance levels.

The proposal would be constructed in accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework, the CEMP, site-specific Construction Noise and Vibration Impact Statements, the conditions of approval for the proposal, and the construction EPL.

Practical and reasonable measures would be implemented to reduce the noise and vibration levels at sensitive receivers. Section 7 outlines additional measures to manage noise and vibration where the construction noise assessment identified exceedances of the relevant management levels.

7.3.1 Management of construction noise and vibration exceedances

The approach to managing exceedances of noise management levels will be undertaken in accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework and ARTC's NSW communication strategy for Inland Rail.

Mitigation management practices are listed below and the contexts in which they should be implemented are described in Table 7.3 and Table 7.4.

Communication (CO)

The level of noise and vibration impact and duration will guide communication with receivers. Accurate and timely communication is essential to manage and understand community expectations for works undertaken outside of the primary proposal construction hours.

Measures have been developed to manage communication with receivers affected by works undertaken outside of the primary proposal construction hours. Two categories of communication have been developed commensurate with the scale of the impact. The purpose of the communication is described below, but the method of communication will be at the discretion of the proposal and detailed in the NSW communication strategy for Inland Rail.

- Category 1 CO1: Communication should be personalised (e.g. door knock, meeting, telephone call). Contact with these residents should commence early to enable feedback to be considered by the proposal.
- Category 2 CO2: Communication to provide information on the proposal via letter box drop, email, newsletter, media advertisements and/or website a minimum of five days prior to the works commencing.

At minimum the information provided to stakeholders (CO1 or CO2) will include:

- the reason the work is required to be undertaken outside of the primary proposal construction
- a diagram that identifies the location of the proposed works in relation to nearby cross streets and local landmarks
- the nature, scope and duration of the works, including start and finish times
- the expected noise impacts on receivers
- information on how to obtain further information or make a complaint, including an after-hours number and Programme website.

Respite Offer (RO)

Residents subjected to lengthy periods of noise or vibration may be eligible for a respite offer. The purpose of such an offer is to provide residents with respite from an ongoing impact across more than two consecutive evening periods. The offer could comprise pre-purchased movie tickets or similar offer.

Alternate Accommodation (AA)

Alternate accommodation options (i.e. accommodation in motels away from the worksite) may be provided residents living in close proximity to construction sites that are likely to incur noise levels significantly above the applicable level across two or more consecutive sleep periods.

Acceptable accommodation measures will be developed with the affected community and project team.

Assigning additional mitigation measures

The implementation of the above measures is determined by matching the predicted exceedance to the appropriate mitigation measures as detailed in Table 7.3 below. The specific details of communication are to be outlined in the communication strategy for the proposal.

Table 7.3 Additional mitigation measures – Airborne construction noise

Time Period		NML, dB(A)	Perception	Exceedance of NML, dB(A)	Mitigation Measures
All hours		-	Highly affected, >75 dB(A)	-	RO, CO
OOHW Rest Period Evenings	Monday to Sunday 6:00 pm – 10:00 pm (including public holidays)	35	Noticeable	<5	CO1
			Clearly audible	5-15	CO1
			Moderately intrusive	15-25	CO1, CO2
			Highly intrusive	>25	CO1, CO2, RO (>2 consecutive periods)
OOHW Sleep Period Night	Monday to Sunday 10:00 pm – 6:00 am (including public holidays)	35	Noticeable	<5	CO1
			Clearly audible	5-15	CO1
			Moderately intrusive	15-25	CO1, CO2, RO (>2 consecutive periods)
			Highly intrusive	>25	CO1, CO2, RO, AA (>2 consecutive periods)

Notes: OOHW: Out Of Hours Work
CO – Communication. RO – Respite Offer. AA – Alternate Accommodation

Table 7.4 Additional mitigation measures –Construction vibration

Time Period		Mitigation Measures	
		Predicted vibration levels exceed preferred levels	Predicted vibration levels exceed maximum levels
OOHW Rest Period Evenings	Monday to Sunday 6:00 pm – 10:00 pm (including public holidays)	CO1, CO2	CO1, CO2, RO
OOHW Sleep Period Night	Monday to Sunday 10:00 pm – 6:00 am (including public holidays)	CO1, CO2, RO	CO1, CO2, RO, AA

Note 1: OOHW= Out-of-hours Work
CO – Communication. RO – Respite Offer. AA – Alternate Accommodation

7.3.2 Standard construction noise and vibration mitigation measures

Table 7.5 lists the standard mitigation measures which would be implemented for the proposal.

Table 7.5 Standard construction noise and vibration management controls

No	Environmental Management Controls
1.1	Site inductions for all employees and contractors will address: • Environmental aspects and impacts • Proposal specific and standard noise management measures • Licence and approval conditions • Hours of work • Environmental incident reporting and management procedures • Complaint management
1.2	Daily site specific briefings for all employees and contractors will include: • Site specific noise management measures • Location of nearest noise sensitive receivers • Construction employee parking areas • Behavioural practices (e.g. avoid swearing, shouting, dropping materials from heights) • Designated loading/unloading areas and procedures
1.3	Work compounds, storage areas, parking areas, unloading/loading areas and other semi-permanent construction sites should be located away from noise sensitive receivers. Where this is not possible, the orientation and layout of the work site will consider noise impacts, and opportunities to shield receivers from noise through the use of site buildings and stockpiles should be considered.
1.4	When working adjacent to schools, medical centres, childcare centres or places of worship, particularly noisy activities will be scheduled outside of operating or service hours where possible.
1.5	Equipment that is used intermittently is to be shut down when not in use.
1.6	Temporary construction noise barriers and acoustic shrouds will be used to mitigate noise impacts at affected receivers where noise from fixed plant items is predicted to exceed construction noise management levels. These are most suited to mitigate noise impacts from fixed plant items, such as compounds and lighting rigs and may not be suitable for mobile activities.
1.7	The off-set distance between noisy plant and noise sensitive receivers will be maximised.
1.8	The number of vehicle trips to and from site will be optimised.
1.9	Regularly inspect and maintain equipment to ensure it is operating correctly.
1.10	Avoid the simultaneous operation of noisy plant within discernible range of noise sensitive receivers where possible.
1.11	Use of non-tonal reversing alarms for all permanent mobile plant.
1.12	Where available, equipment selection will favour the use of quieter and less vibration emitting construction methods.
1.13	A telephone, email and web based community information service will be established to allow the community to obtain additional information on construction activities, provide feedback or make a complaint.
1.14	Regular communications on the activities and progress of the proposal will be provided to the community (e.g. via newsletter, email and/or website).
1.15	Noise or vibration monitoring in response to complaints will be undertaken where the results or the process assist in resolving or understanding the receiver’s issue.

No	Environmental Management Controls
1.16	If vibration-generating activities are conducted within 25 m of a residence attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration limits are within the acceptable range. Where vibration levels are found to be unacceptable, alternative work methods will be implemented so the vibration impacts are reduced to acceptable levels.
1.17	If vibration generating activities (non-piling) are being undertaken within 35 m of the heritage listed structures, alternative work methods will be implemented so the vibration impacts are reduced to acceptable levels. For piling, this distance is increased to 180 m.
1.18	Prior to commencement of construction a dilapidation survey of the nearby heritage structures (within 35 m of the works) would be undertaken. These items must be protected from accidental damage for the duration of the works.
1.19	Based on the conservative estimate it is possible that construction vibration may exceed the guidance limits for critical and sensitive areas. The predictions do not account for possible reduced internal vibration levels which may be realised due to the structure of the buildings. It is not known how the structure will respond to external ground vibration sources. Specific consultation would be undertaken with potentially impacted receivers with sensitive equipment prior to commencement of vibration generating activities, and as required throughout the construction phase, with regards to potential detectable vibration levels and possible impacts on critical activities at the facility. Where required specific work practices or scheduling arrangements would be considered to minimise potential impacts on the facility.

7.4 Operational road traffic noise mitigation

Predicted noise levels are not expected to exceed the controlling criterion during the day or night-time periods. Therefore, no residential properties qualify for noise mitigation.

Where noise mitigation is required the RMS *Noise Mitigation Guideline* (NMG) provides recommendations that should be considered during the road design stage. The NMG recommends the following noise mitigation options in order of preference:

- Quieter pavement surfaces
- Noise mounds
- Noise walls
- At-property treatments

7.4.1 Post construction noise monitoring program

To confirm that the noise level targets are achieved, the NMG refers to the ENMM Practice Note VIII which recommends that a post-construction noise monitoring program be undertaken.

The noise monitoring program (including simultaneous traffic counts) should be undertaken within 12 months of opening once traffic flows have stabilised. Monitoring locations should be selected along the route at the monitoring locations undertaken in this assessment and at locations where any noise complaints are received.

The measured noise levels should be compared to the noise level assessment targets. If the noise level targets are exceeded the ENMM recommends the following action:

- If the exceedance is less than two dBA, 'the prediction methodology and suitability of noise mitigation measures should be reassessed and the reasons for the marginal exceedance should be identified in the report'.
- If the exceedance is greater than two dBA, 'the adequacy of the noise mitigation measures needs to be reviewed, and if problems are identified steps need to be taken to rectify the situation. Additional noise treatments may be required to achieve the design noise level, where this is feasible and reasonable.'

The NMG states: '*Note that where the outcome of the compliance report is that further noise mitigation should be considered the processes in this guideline should be followed.*

8. Conclusion

Based on the modelling results and findings of this noise and vibration assessment, the following conclusions are made with consideration to the assumptions detailed in this report.

8.1 Operational rail noise and vibration

Operational noise modelling indicates that the RING $L_{Aeq\ day}$ and $L_{Aeq\ Night}$ rail noise trigger levels are predicted to be exceeded at a number of receivers near to the rail corridor and that increases in noise due to the proposal are more than 2 dB for a number of receivers. This indicates that the conditions for the consideration of noise mitigation have been triggered at these receivers with regards to the RING.

Further, noise modelling indicates that a number of receivers are expected to exceed the RING L_{Amax} trigger levels and that increases in noise due to the proposal are more than 3 dB for a number of receivers. Therefore, mitigation measures will be required for operational noise at the nearest receivers with consideration to L_{Amax} levels.

Based on train volumes and speeds provided by ARTC, a total of 152 residential receivers were found to exceed the redeveloped rail line RING criteria. The operational noise model is based on a number of conservative assumptions and the information available at the time of the assessment in relation to proposed operations, design and receiver locations and an updated assessment will be undertaken at subsequent stages of the proposal where additional detail is available.

A number of non-residential receivers within the study were also predicted to exceed the internal RING trigger levels for the 2040 design assessment year including three educational receivers, three worship receivers this assumes a 10 dB external to internal reduction. Additionally two passive recreation receivers and one active recreation receiver were predicted to exceed the respective RING trigger level at 2040.A number of potential mitigation measures have been identified to address exceedances of the RING trigger levels. A feasible and reasonable assessment of these measures will be undertaken in consultation with the affected community, following completion of detailed design.

Estimated vibration levels at three receivers within Moree are predicted to exceed the night-time human comfort criteria. Vibration mitigation strategies to reduce vibration impacts are discussed in Section 7.2.2.

Post construction noise monitoring is to be undertaken at representative locations to verify the effectiveness of the applied mitigation measures with respect to the RING trigger levels.

8.2 Operational road traffic noise

Assessment of the expected noise impacts in accordance with the RNP are as follows:

- The controlling criteria is expected to be exceeded at six receivers during the day-time period. The maximum exceedance of the criteria is 1.4 dBA. It should be noted however that these are due to noise from existing roads or roads not part of the proposal and therefore would not quality for mitigation treatment.
- The controlling criteria is not expected to be exceeded during the night-time period.

- Noise levels are not predicted to exceed the day-time acute criteria of 65 dBA $L_{Aeq(15\ hr)}$ or night-time acute criteria of 60 dBA $L_{Aeq(9\ hr)}$.
- The increase in noise levels between the no-build and build scenarios are less than 2 dB for the receivers that exceed the controlling criterion during the day-time period, therefore mitigation measures are not warranted.
- The Relative Increase Criterion is not applicable to any receiver due to realignment of the Newell Highway overpass or construction of the Jones Avenue bridge.

The proposed overpass at Newell Highway and the Jones Avenue bridge are not expected to adversely impact any sensitive receiver from a noise perspective within the assessment area.

8.3 Construction noise

During construction there is the potential for noise impacts to the surrounding community.

- In relation to construction activities:
  - Activities such as pre-possession (construction scenario S1), skim track reconditioning (construction scenario S2), full depth reconditioning (construction scenario S3), and drainage construction, are likely to impact the largest number of receivers due to the higher level of noise emitted by the anticipated equipment.
- In relation to the primary proposal construction and construction noise management levels:
  - The highly affected level of 75 dB(A) L_{Aeq} is predicted to be exceeded at three receivers.
  - Rail line redevelopment construction activities are predicted to exceed the noise management level at receivers nearest to the construction footprint. Impacted receivers are within about 700 metres of the works and includes up to 1574 identified noise sensitive residential receiver locations. Noise levels are predicted to exceed the proposal specific construction management level by up to 43 dB.
  - Newell highway overbridge construction is predicted to exceed the proposal specific construction management level by up to 13 dB at two residential receivers.
  - Jones Avenue overbridge construction is predicted to exceed the proposal specific construction management level by up to 41 dB at 1098 residential receivers.
  - Construction activities during the primary proposal construction hours have the potential to exceed the noise management level at non-residential sensitive receivers including educational, child care and hospital facilities. Construction noise management levels are applicable as an internal level only when the facilities are in use.
  - Construction activities during the primary proposal construction hours have the potential to exceed the noise management level at recreational areas including bushland areas, parks and sporting facilities when these areas are in use.

It is recommended that the mitigation measures detailed in Section 7 be considered and implemented where feasible and reasonable to reduce construction noise impacts.

8.4 Construction vibration

General construction activities

With consideration to structural damage vibration impacts for general construction activities, the expected magnitude of ground vibrations should not be sufficient to cause damage if the equipment operates at distances greater than 18 metres from standard residential buildings or structures of similar construction.

Many heritage structures nearby the Proposal consist of station buildings, sidings and silos which are directly adjacent to the track and bridges that are on the actual alignment. With consideration to structural damage vibration impacts for general construction activities, the expected magnitude of ground vibrations should not be sufficient to cause damage if the equipment operates at distances greater than 35 metres from heritage buildings and structures. Many items are potentially within this buffer from the intended works and may be impacted.

It is recommended that the noise and vibration mitigation measures detailed in Section 7 be implemented to manage potential construction vibration impacts.

Piling

Vibration impacts due to piling activities have the potential to exceed structural vibration values for standard dwellings at distances from the activity of 100 metres for impact piling, 30 metres for vibratory piling and 17 metres for bored piling.

Piling activities have the potential to exceed structural vibration values for heritage structures at distances from the activity of 180 metres for impact piling, 50 metres for vibratory piling and 35 metres for bored piling.

In the event that these buffer distances are not practical, other methods may be investigated such as press-in hydraulic piling or jacked-in piling. These methods generally exhibit much lower vibration levels compared to impact, vibratory and bored piling.

Human comfort

Humans are capable of detecting vibration at levels well below those causing risk of damage to buildings. Based on a conservative assessment, it is possible that construction vibration from general construction activities may be perceptible at times at distances up to 140 m of the works.

Piling works are required for bridge construction. About 820 receivers may receive perceptible vibration where impact piling is used. These receivers are within 700 metres of piling locations. They are located mostly within Moree and are near to either the Mehi River rail bridge or the Jones Avenue road over bridge.

Vibration impacts due to boring of the cast in-situ piles has the potential to impact receivers up to 120 metres from the work area. There are 56 receivers within this buffer distance from proposed piling locations.

To minimise human comfort impacts, alternatives to impact piling are recommended where feasible. The mitigation measures detailed in Section 7 should also be considered where feasible and reasonable to reduce the potential for human comfort vibration impacts from general construction and piling activities.

8.5 Summary

The Australian Rail Track Corporation (ARTC) has engaged GHD Pty Ltd (GHD) to prepare a Noise and Vibration assessment for the proposed upgrade of the Narrabri to North Star section of the inland rail project. This upgrade is located in between Narrabri and North Star, New South Wales.

Based on the findings of this assessment, it is considered that the noise and vibration impacts associated with the proposal can be managed and controlled both from the construction and operational points of view provided that the recommendations outlined in this report or equivalent are implemented.

8.6 Limitations

This report has been prepared by GHD for Australian Rail Track Corporation and may only be used and relied on by Australian Rail Track Corporation for the purpose agreed between GHD and the Australian Rail Track Corporation as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Australian Rail Track Corporation arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Australian Rail Track Corporation and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

It is not the intention of the assessment to cover every element of the acoustical environment, but rather to conduct the assessment with consideration to the prescribed work scope.

The findings of the acoustic assessment represent the findings apparent at the date and time of the monitoring and the conditions of the area at that time. It is the nature of environmental monitoring that not all variations in environmental conditions can be accessed and all uncertainty concerning the conditions of the ambient noise environment cannot be eliminated. Professional judgement must be exercised in the investigation and interpretation of observations.