TECHNICAL REPORT 09

Updated noise and vibration assessment—operational rail

(Part 1 of 2)

NARROMINE TO NARRABRI PROJECT

Contents overview

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ARTC INLAND RAIL

Narromine to Narrabri
Updated Noise and Vibration Assessment - Operational Rail

Prepared for:

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EXECUTIVE SUMMARY

The Proposal

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, via central-west New South Wales (NSW) and Toowoomba in Queensland. Inland Rail is a major national program that would enhance Australia's existing national rail network and serve the interstate freight market. This report relates to the Narromine to Narrabri section of Inland Rail (the proposal).

The proposal consists of about 306 kilometres (km) of new single-track standard gauge railway with crossing loops. The proposal also includes changes to some roads to facilitate construction and operation of the new section of railway, and ancillary infrastructure to support the proposal.

The proposal would link the Parkes to Narromine section of Inland Rail located in central western NSW, with the Narrabri to North Star section of Inland Rail located in north-west NSW. Australian Rail Track Corporation Ltd (ARTC) ('the proponent') is seeking approval to construct and operate the Narromine to Narrabri section of Inland Rail ('the proposal').

The proposal is State significant infrastructure and is subject to approval by the NSW Minister for Planning and Public Spaces under the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal is also determined to be a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and requires approval from the Australian Minister for the Environment.

This Report

This Noise and Vibration Assessment – Operational Rail initially was prepared on behalf of ARTC to support the environmental impact statement (EIS) for the proposal and responds to the Secretary environmental assessment requirements (SEARs) for the Proposal.

The assessment presented in this report has included a review of relevant legislation, consideration of the existing conditions, an impact assessment and a cumulative impact assessment. Recommended mitigation and management measures were identified in response to the impact assessment findings.

The EIS was placed on public exhibition by DPIE for a period of 62 days, commencing on 8 December 2020, and concluding on 7 February 2021.

During and following public exhibition of the EIS, ARTC has undertaken further investigations and is proposing a number of design amendments to the proposal. This report has been updated to include these amendments.

Railway noise

A detailed noise prediction model for the Proposal designs and the surrounding environment was developed to assess airborne noise from railway operations on the main line tracks, at level crossings and the crossing loops. The noise model covered an area 2 km either side of the alignment, which comprised a total area approximately 1,224 km^2 (>122,400 hectares) in size and 1,088 individual sensitive receivers.

The model adopted a database of noise emission levels for the specific locomotives and wagons proposed on the proposal. Noise modelling approaches were applied to account for the varying rail noise emissions along the alignment, including; the track gradients, train speeds and features such as tight-radius curves and turnouts.

Noise levels for the proposed daytime and night-time railway operations were predicted to achieve the airborne railway noise assessment criteria from the NSW Rail Infrastructure Noise Guideline (RING) at the majority of the sensitive receivers.

The predicted noise levels were above the noise assessment criteria at 41 sensitive residential receivers for railway operations at the commencement of operations (2026) and at 53 sensitive residential receivers (an additional 8 sensitive residential receivers) at the design year (2040). The predicted noise levels trigger the assessment criteria by less than 3 dBA (decibels) at the majority of these sensitive receivers. Such a margin above the trigger levels can be considered relatively minor in the context of a perceptible difference in noise level between the trigger level and the predicted noise level. The highest predicted railway noise level was 12 dBA above the noise assessment criteria.

There are non-residential sensitive receivers, such as schools and churches, that are located within the towns of Narrabri or Narromine. These sensitive receivers are generally located greater than 1 km from the proposal and noise levels at these receivers are not predicted to trigger the relevant assessment criteria.

Applying the predicted noise levels and the location of the sensitive receivers; the feasible and reasonable measures adopted by ARTC to reduce railway noise impacts, beyond controlling railway noise at its source, are expected to be at-property controls such as architectural property treatments and upgrades to property fencing. Options for receiver-specific measures to mitigate or manage potential noise, at identified sensitive receiver properties and land-uses, will be considered further during detailed design.

Whether at-property controls or other alternative noise mitigation measures are required will be subject to ongoing assessment of railway noise from Inland Rail. This will include further railway noise modelling, analysis of engineering constraints present, constructability issues and other potential and environmental matters (flooding implications and visual impacts as examples).

Consultation with directly affected landowners will continue and the verification of railway noise levels will be undertaken once Inland Rail operations commence on the proposal.

Vibration from train movements

The daily train passbys on the proposal can be a potential source of vibration and associated ground-borne noise. The ground-borne vibration levels associated with train movements on the track were assessed to achieve the relevant vibration criteria at all identified sensitive receivers.

Ground-borne noise levels from train movements may be at or above the assessment criteria at up to four individual receivers. These receivers were identified to be within approximately 50 m of the rail tracks. The predicted ground-borne noise levels are relatively low at the sensitive receivers adjacent to the proposal and the noise environment is expected to be dominated by the airborne railway noise.

At the EIS stage, the assessment of ground-borne noise and vibration applied reasonable assumptions. The ground-borne noise and vibration levels will be further assessed during the detail design and construction stages of the proposal to verify the potential emission levels and define, as-required, the feasible and reasonable measures to mitigate identified impacts.

Summary

Assuming the detailed design remains consistent with this assessment, the proposal is expected to achieve, at the majority of sensitive receivers, the objectives of the RING and the SEARs for the management of noise and vibration from railway operations. The best practice mitigation measures available to the proposal are also expected to assist in reducing noise and vibration levels at receivers and provide the feasible and reasonable control of potential impacts.

Nonetheless, achieving the adopted criteria does not preclude the potential for noise and vibration emissions during railway operations to be perceptible at sensitive receivers along the proposal.

Recommendations

Based on the assessment, key recommendations for the management of railway noise and vibration are:

- Review the feasible and reasonable noise and vibration mitigation options discussed in this report during the detailed design and construction stages of the proposal to confirm their ongoing eligibility. Mitigation options include modifications to trackform and noise screening elements, in addition to at-property treatments for identified sensitive receivers.
- Allow for the vibration mitigation measures modelled in this report ballasted track over bridge and viaducts to consider suitable resilient matting for ballast retention and vibration isolation.
- Further validate the noise and vibration prediction models and update predictions during the detailed design of the proposal.

The operational railway noise and vibration levels will be verified through noise and vibration monitoring once the proposal is operational. ARTC will investigate feasible and reasonable mitigation measures where monitored noise and/or vibration levels at sensitive receivers are confirmed to be above adopted railway noise and vibration criteria.

ABBREVIATIONS

Term	Definition
ARTC	Australian Rail Track Corporation
AS	Australian Standard
BS	British Standard
dBA	A-weighted decibel (referenced 20 µPa)
dBV	Vibration expressed as decibels (referenced level 1 nanometers/second)
DEC	(former) Department of Environment and Conservation (now NSW EPA)
DECC	(former) Department of Environment and Climate Change (now NSW EPA)
DIN	Deutches Institut für Normung (German Institute for Standardisation)
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
Hz	Hertz
ISO	International Standards Organisation
Km	Kilometres
Km/h	Kilometres per hour
Km^2	Square kilometres
L_{AE}	The level of noise for an individual event normalised to a 1-second event (Sound Exposure Level), allowing noise events of different duration to be compared.
LAeq	Equivalent continuous noise level, providing a representation of the cumulative level of noise exposure over a defined period.
$L_{Aeq(15hour)}$	The equivalent continuous noise level for the 15-hour daytime period of 7.00 am to 10.00 pm
$L_{Aeq(9hour)}$	The equivalent continuous noise for the 9-hour daytime period of 10.00 pm to 7.00 am
$L_{Aeq(1hour)}$	The equivalent continuous noise for the busiest 1-hour period.
L_{Amax}	The maximum noise level during the measurement or assessment period. The L_{AFmax} or Fast is averaged over 0.125 of a second and the L_{ASmax} or Slow is averaged over 1-second.
m	Metres
mm	Millimetres
mm/s	Millimetres per second
m/s	Metres per second
N2N	Narromine to Narrabri
N2NS	Narrabri to North Star
NSW	New South Wales
OEH	(former) Office of Environment and Heritage
P2N	Parkes to Narromine
PPV	Peak Particle Velocity
QLD	Queensland
RBL	Rating Background Level

Term	Definition
RING	Rail Infrastructure Noise Guideline
SEL	Sound Exposure Level (see L_{AE})
SEARs	Secretary's Environmental Assessment Requirements
TfNSW	Transport for New South Wales
VDV	Vibration Dose Value
Vppv	Vector peak particle velocity, which is the peak particle velocity calculated from the sum of the vibration in three directions; longitudinal, transverse and diagonal.

GLOSSARY

Term	Definition
Active level crossing	Where the movement of vehicular or pedestrian traffic across a railway crossing is controlled using signs or devices such as flashing signals, gates or barriers (or combination of these). The device(s) are active prior to, and during, the passage of the train through the crossing.
Airborne noise	Sound (noise) which travels through the air and commonly describes noise experienced within the outdoor environment.
Ballast	Crushed rock, stone used to provide a foundation for railway track. It usually forms the bed on which railway sleepers are laid, transmits the load from the train movements to the formation and restrains the track from movement.
Bunching and stretching	Wagons can touch from coming together or make a noise when they stretch and pull apart.
Consist	The set of wagons or carriages that form the train.
Continuously welded rail	Continuously welded rail shall be constructed on Inland Rail, and due to there being fewer joints, trains can travel faster on continuously welded steel rails than on jointed rails. The continuously welded rail can reduce noise and vibration emissions from passing trains.
Crossing loop	A section of track off to the side of the main track/s that allows a train to move to the side so that another can pass. Crossing loops also have a maintenance siding
Culvert	A structure that allows water to flow under a road, railway, track or similar obstruction.
Existing rail corridor	The corridor within existing rail infrastructure are located. The existing rail corridor is defined by ARTC to mean everywhere within 15 metres (m) of the outermost rails; or within the boundary fence (where fences are provided) and are closer than 15 m. If the property boundary is less than 15 m, the corridor is defined as the property boundary or a permanent structure such as a fence, wall or level crossing separating the operating rail corridor from other land.
Feasible	A measure is feasible if it can be engineered and is practical to build, given project constraints such as safety and maintenance requirements.
Formation	The earthworks/ material on which the ballast, sleepers and tracks are laid.
Ground-borne noise	Railway vibration in buildings at frequencies typically from about 30 Hz to about 200 Hz, can excite the floors and walls which then radiate a rumbling noise directly into the rooms. This ground-borne (or structure-borne) noise occurs without the masking from the airborne rail noise.
Level crossing	A place where rail lines and a road cross at the same elevation.
Passive level crossing	Where the movement of vehicular or pedestrian traffic across a railway crossing is controlled using signs or devices that are not activated by the approach or passage of a train, relying on the road user or pedestrian to detect the approach or presence of a train by direct observation.
Proposal	The construction and operation of the Narromine to Narrabri section of Inland Rail.
Rail corridor	The corridor within which the rail tracks and associated infrastructure are located.
Rail dampers	Elements that are attached to the sides of the rails to improve the rail's ability to absorb and dissipate vibration energy that results from the rolling contact between the wheel and rail.
Rail pads	Rail pads are plastic or rubber mats that are inserted between the rails and the sleepers. Their purpose is to evenly distribute the load from passing trains onto the sleepers. They can also act to reduce noise and vibration emissions from passing trains.
Rating background level	The underlying level of noise present in an area once transient and short-term noise events are filtered out.

Term	Definition
Reasonable	Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh adverse social, economic and environmental effects, including the cost of the measure.
Rollingstock	All rail vehicles operating on the rail lines.
Rolling noise	Noise emissions from the rolling of the wheels on the rail.
Sensitive receivers	Land uses detailed in railway noise and vibration guidelines, such as the RING, which are sensitive to potential noise and vibration impacts, such as residential dwellings, schools, places of worship and hospitals.
Study area	The assessment of noise and vibration from railway operations adopted a study area comprising approximately 1,224 km^2 based on a 2 km distance surrounding either side of the proposal.
Track	The structure consisting of rails, fasteners, sleepers and ballast, which sits on the formation.
Turnout	A junction point where a rail vehicle can leave a given track for a branching or parallel track.

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1 Introduction

1.1 Overview

1.1.1 Inland Rail and the Proposal

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, via central-west New South Wales (NSW) and Toowoomba in Queensland (QLD). Inland Rail is a major national program that will enhance Australia's existing national rail network and serve the interstate freight market.

The Inland Rail route, which is about 1,700 kilometres (km) long, involves:

- using the existing interstate rail line through Victoria and southern NSW
- upgrading about 400 km of existing track, mainly in western NSW
- providing about 600 km of new track in NSW and south-east Queensland.

The Inland Rail program has been divided into 13 sections, seven of which are located in NSW. Each of these projects can be delivered and operated independently with tie-in points on the existing railway.

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

1.1.2 Approval and assessment requirements

The proposal is State significant infrastructure and is subject to approval by the NSW Minister for Planning and Public Spaces under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal is also determined to be a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and requires approval from the Australian Minister for the Environment.

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) as part of the environmental impact statement (EIS) for the proposal. The EIS initially was prepared to support the application for approval of the proposal and to address the environmental assessment requirements of the Secretary of the NSW Department of Planning, Industry and Environment.

The EIS was placed on public exhibition by DPIE for a period of 62 days, commencing on 8 December 2020, and concluding on 7 February 2021.

1.1.3 Responding to Submissions and Proposed Amendments

During and following public exhibition of the EIS, ARTC has undertaken further investigations and is proposing a number of design amendments to the proposal. The aim of these amendments is to address issues raised during consultation and in submissions, and to minimise the potential impacts of the proposal where practicable, particularly in respect of land use and property, and traffic and access.

A summary of the proposed amendments is provided in **Table 1**. This report has been updated to provide an updated assessment on the basis of the proposed amendments.

Table 1 Summary of Amendments

Proposal Feature	Proposed Amendment
Crossing loops	• Relocation of the seven crossing loops to new locations to minimise overall impacts.
Public level crossings	• Changes to public level crossing numbers, locations and treatments due to changes to crossing loop locations, updated traffic data and refinement of sight distances.
Public road closures	• Reduction in the number of public road and access tracks that would need to be closed, mainly as a result of the crossing loop relocations.
Public road realignments	• Changes to the public roads requiring realignment to minimise property impacts.
Temporary workforce accommodation	• Changes to the locations of the Narromine North and Baradine temporary workforce accommodation facilities based on consultation with key stakeholders. • Mobile accommodation facilities are now proposed be provided within some of the general compounds for improved flexibility on the workforce approach.
Construction and operation footprints	• Adjustments to the construction and operational footprints to accommodate the above amendments and to minimise the amount of disturbance where possible.

1.2 The Proposal

The proposal consists of about 306 km of new single-track standard gauge railway with crossing loops. The proposal also includes changes to some roads to facilitate construction and operation of the new section of railway, and ancillary infrastructure to support the proposal.

The proposal would be constructed to accommodate double-stacked freight trains up to 1,800 metres (m) long and 6.5 m high. It would include infrastructure to accommodate possible future augmentation and upgrades of the track, including a possible future requirement for 3,600 m long trains.

The land requirements for the proposal would include a new rail corridor with a minimum width of 40 m, with some variation to accommodate particular infrastructure and to cater for local topography. The corridor would be of sufficient width to accommodate the infrastructure currently proposed for construction, as well as possible future expansion of crossing loops for 3,600 m long trains. Clearing of the proposal site would occur to allow for construction and to maintain the safe operation of the railway.

1.2.1 Location

The proposal would be located between the towns of Narromine and Narrabri in NSW. The proposal would link the Parkes to Narromine section of Inland Rail located in central western NSW, with the Narrabri to North Star section of Inland Rail located in north-west NSW. The location of the proposal is shown in **Figure 1.**

1.2.2 Key features

The key design features of the proposal (as amended) include:

Rail infrastructure

- a new 306 km long rail corridor between Narromine and Narrabri
- a single-track standard gauge railway and track formation within the new rail corridor
- seven crossing loops, at Burroway, Balladoran, Armatree/Tonderburine, Mt Tenandra, Baradine, The Pilliga and Bohena Creek
- bridges over rivers and other watercourses (including the Macquarie River, Castlereagh River and the Namoi River/Narrabri Creek system), floodplains and roads
- level crossings
- new rail connections and possible future connections with existing ARTC and Country Regional Network rail lines, including a new 1.2 kilometre long rail junction between the Parkes to Narromine section of Inland Rail and the existing Narromine to Cobar Line (the Narromine West connection)

Road infrastructure

- road realignments at various locations, including realignment of the Pilliga Forest Way for a distance of 6.7 km
- limited road closures.

Ancillary infrastructure to support the proposal would include signalling and communications, drainage, signage and fencing, and services and utilities. Further information on the proposal is provided in the EIS.

The key features of the proposal are shown in **Figure 2**.

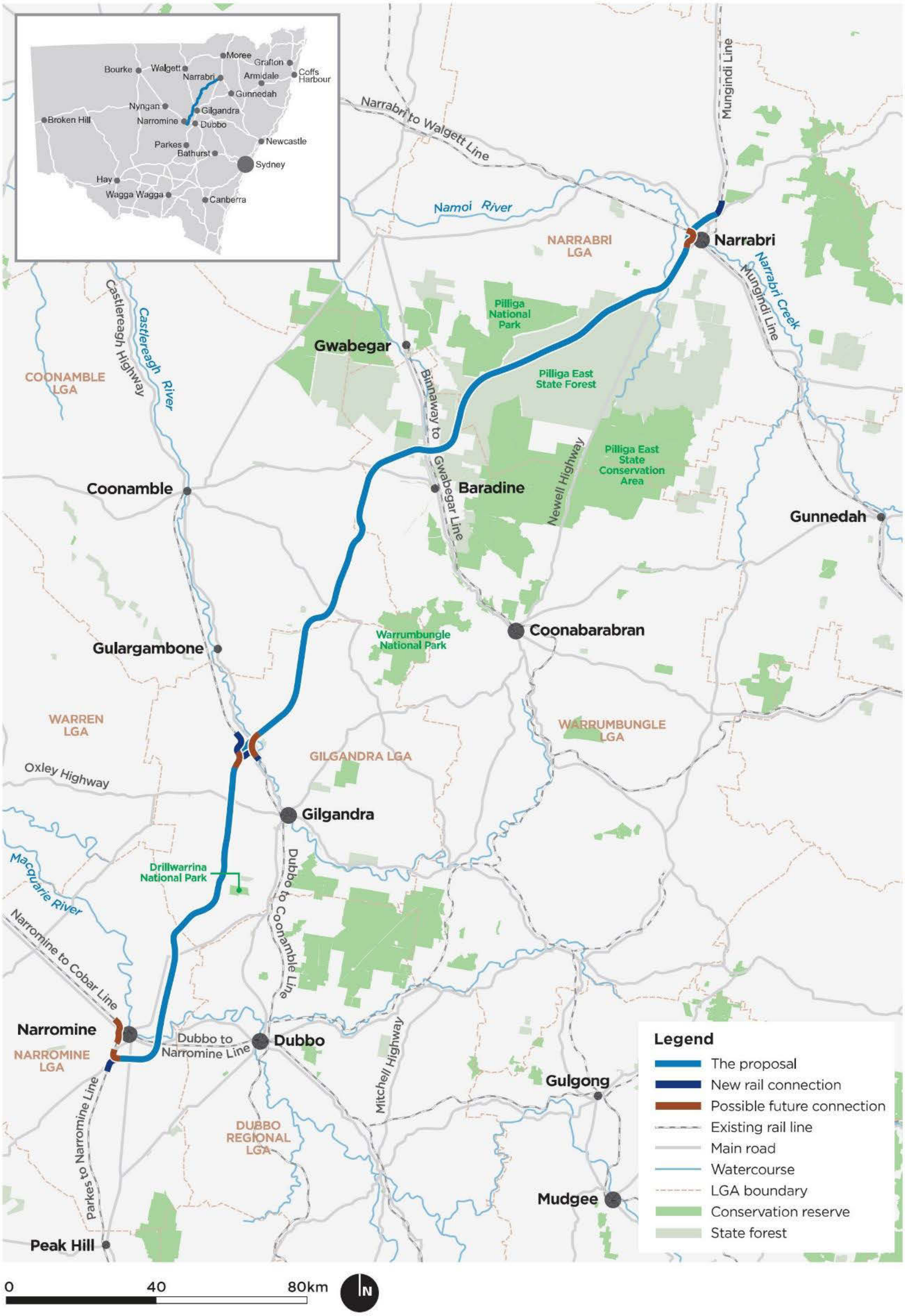


Figure 1 Location of the Proposal

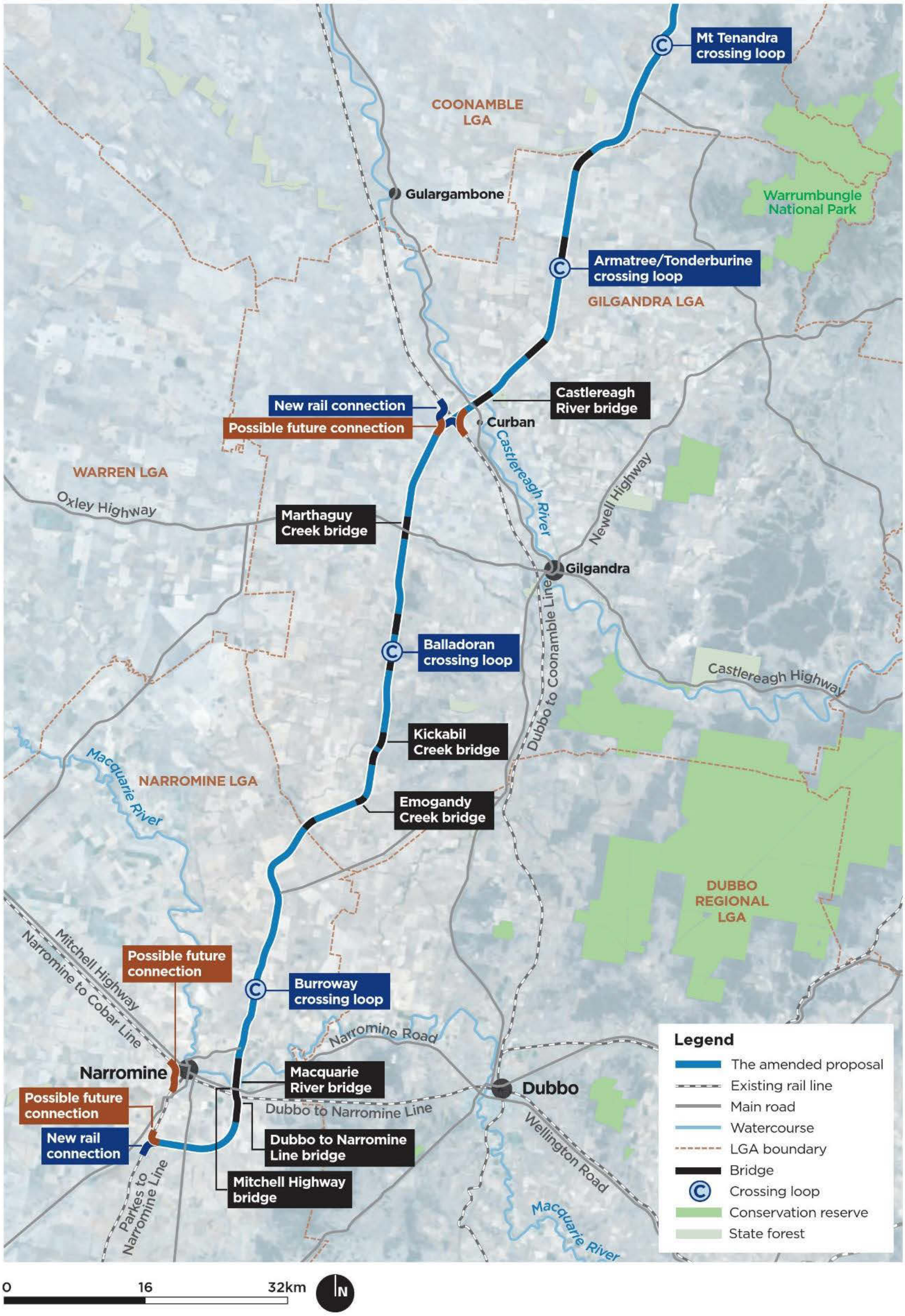


Figure 2 Key features of the Amended Proposal Map A

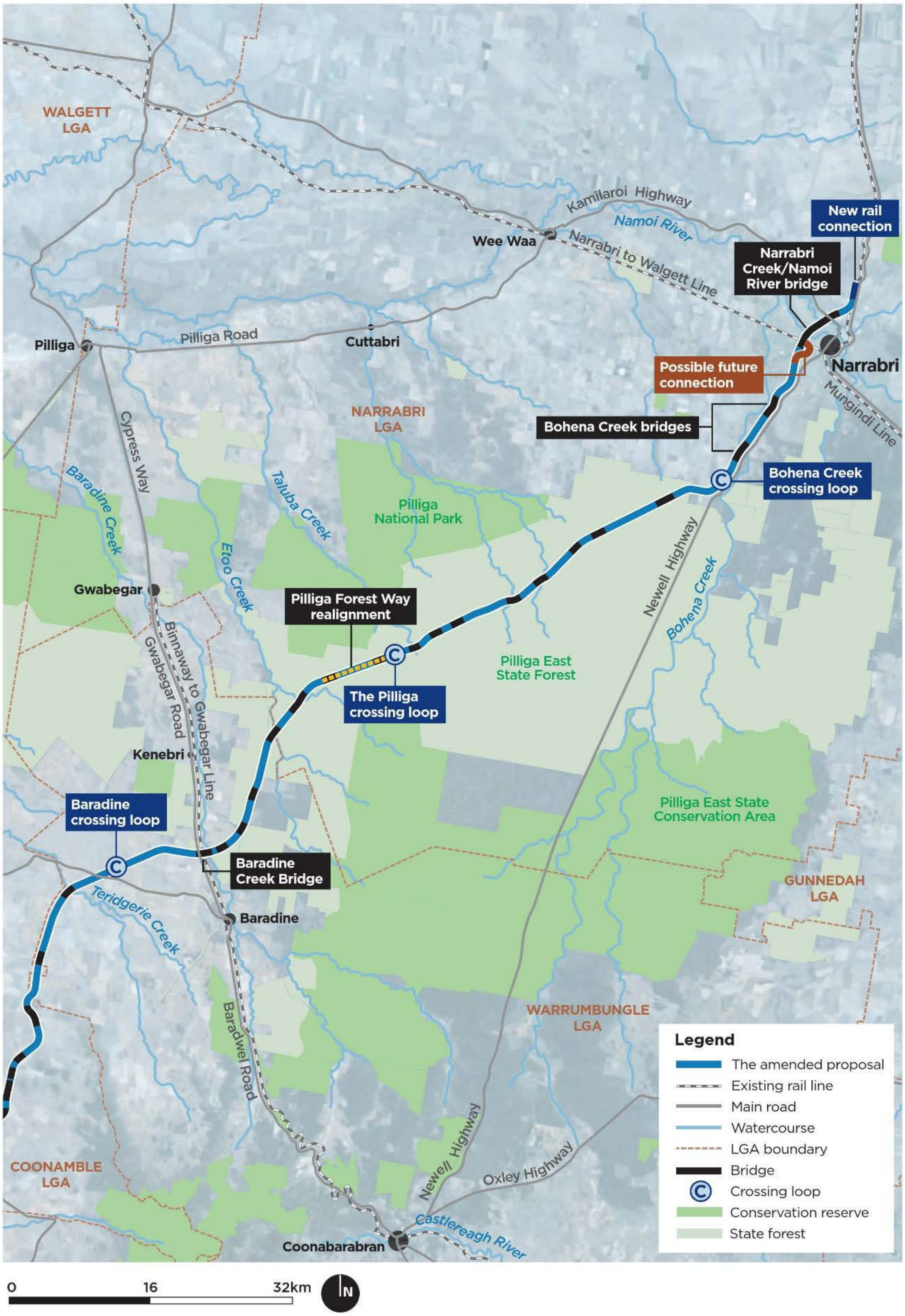


Figure 2 Key features of the Amended Proposal Map B

1.2.3 Construction overview

An indicative construction strategy has been developed from the current reference design that is being used as a basis for the environmental assessment process. Detailed construction planning, including programming, work methodologies, staging and work sequencing would be undertaken once construction contractor(s) have been engaged and during detailed design.

Timing and work phases

Construction of the proposal would involve five main phases of work as outlined in **Table 2**. It is anticipated that the first phase would commence in 2021, and construction would be completed in 2026.

Table 2 Main construction phases and indicative activities

Phase	Indicative construction activities
Pre-construction	• Establishment of areas to receive early material deliveries • Delivery of certain materials that need to be brought to site before the main construction
Site establishment	• Establishment of key construction infrastructure, work areas and other construction facilities • Installing environmental controls, fencing and site services • Preliminary activities including clearing/trimming of vegetation
Main construction works	• Construction of the proposed rail and road infrastructure, including earthworks, track, bridge and road works
Testing and commissioning	• Testing and commissioning of the rail line and communications and signalling systems
Finishing and rehabilitation	• Demobilisation and decommissioning of construction compounds and other construction infrastructure • Restoration and rehabilitation of disturbed areas

Key construction infrastructure

The following key infrastructure is proposed to support construction of the proposal:

- borrow pits at Tantitha Road, Narromine, Tomingley Road, Narromine, Euromedah Road, Narromine and Perimeter Road, Narrabri.
- three main compounds, which would include a range of facilities to support construction ('multi-function compounds'), located at Narromine South, Curban and Narrabri West.
- temporary workforce accommodation for the construction workforce:
  - within the Narromine South multi-function compound
  - Narromine North
  - Gilgandra
  - Baradine
  - within the Narrabri West multi-function compound.

Other construction infrastructure would include a number of smaller compounds of various sizes located along the proposal site, concrete batching plants, laydown areas, welding yards, a concrete pre-cast facility and groundwater bores for construction water supply.

1.2.4 Operation

The proposal would form part of the rail network managed and maintained by ARTC. Train services would be provided by a variety of operators. Inland Rail as a whole would be operational once all 13 sections are complete, which is estimated to be in 2026.

It is estimated that Inland Rail would be trafficked by an average of 10 trains per day (both directions) in 2026, increasing to about 14 trains per day (both directions) in 2040. This rail traffic would be in addition to the existing rail traffic using other lines that the proposal interacts with. The trains would be a mix of grain, bulk freight, and other general transport trains. Total annual freight tonnages would be about 10 million tonnes in 2026, increasing to about 17.5 million tonnes in 2040. Train speeds would vary according to axle loads and range from 80 kilometres per hour (km/h) to 115 km/h. The railway operations are discussed further in **Section 2**.

1.3 Purpose and scope of this report

The purpose of this report is to assess the potential noise and vibration impacts from the railway operations of the proposal. The report:

- addresses the relevant SEARs listed in **Table 3**.
- describes the existing environment with respect to noise and vibration sensitive receivers and presents existing ambient and background noise levels obtained through a noise monitoring survey.
- assesses the potential noise and vibration impacts of railway operations of the proposal at sensitive receivers, including the daily train movements and the operation of level crossings and crossing loops.
- recommends feasible and reasonable measures to mitigate and manage the impacts identified.

Table 3 SEARs relevant to this assessment

SEAR number	Requirements	Where addressed in this report
15.1	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).	The assessment and discussion of impacts from railway operations is detailed in: Section 3 assessment criteria Sections 7 to 11 airborne rail noise levels from railway operations Section 12 ground-borne vibration levels from railway operations Section 13 ground-borne noise levels from railway operations The assessment of construction works, road transport and stationary infrastructure is provided in *ARTC Inland Rail Narromine to Narrabri (N2N) Updated noise and vibration assessment – construction and other operations* (Jacobs-GHD Joint Venture, 2021)
15.2	The Proponent's assessment of construction and operational noise and vibration impacts must consider activities within the proposed corridor, activities at ancillary sites, including but not limited to borrow sites, and vehicle movements associated with the proposal, including haulage vehicles.	The assessment of construction works, road transport and stationary infrastructure is provided in *ARTC Inland Rail Narromine to Narrabri (N2N) Updated noise and vibration assessment – construction and other operations* (Jacobs-GHD Joint Venture, 2021)

SEAR number	Requirements	Where addressed in this report
15.3	The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Refer to assessment in *ARTC Inland Rail Narromine to Narrabri (N2N) Updated noise and vibration assessment – construction and other operations* (Jacobs-GHD Joint Venture, 2021)
16.1	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).	Assessment of impacts from railway operations are detailed in: Section 12 ground-borne vibration Section 13 ground-borne noise Refer also to *ARTC Inland Rail Narromine to Narrabri (N2N) Updated noise and vibration assessment – construction and other operations* (Jacobs-GHD Joint Venture, 2021)

Source This report was prepared to address SEARs dated 9 September 2020

This report is specific to railway operations and the impact assessment for the construction works, road transport and stationary infrastructure is detailed in *ARTC Inland Rail Narromine to Narrabri Updated Noise and Vibration Assessment – Construction and Other Operations* (JacobsGHD, 2020).

1.4 Structure of this report

The structure of the report is outlined in the following table.

Table 4 Structure of this report

Report section	Contents
Section 1	Provides an introduction to the proposal and this report
Section 2	Describes the proposal and key infrastructure
Section 3	Details the noise and vibration assessment criteria adopted for the impact assessment
Section 4	Details the assessment methodology
Section 5	Defines the sensitive receivers and the existing noise environment
Section 6	Description of the rail noise modelling
Sections 7 to 11	Assessment of railway noise levels from the proposal
Section 12	Assessment of ground-borne vibration from railway operations
Section 13	Assessment of ground-borne noise from railway operations
Section 14	Assessment of cumulative noise impacts
Section 15	Recommendations for managing noise and vibration and mitigation of identified potential impacts.
Section 16	Assessment of residual impacts
Section 17	Concluding comments on the assessment outcomes
Section 18	List of key references for reports, document, standards, policies and guidelines.

1.5 Report limitations

The findings of this report are based on the current design and may change as the proposal design progresses. Should the final design or conditions vary from the basis of this assessment, the noise and vibration levels and associated impacts may differ from the findings presented in this report.

Preliminary mitigation measures for railway noise and vibration have been presented in this assessment based on the adopted assessment criteria, identified sensitive receivers and the forecast noise and vibration emissions associated with the proposed future railway operations of the proposal.

As the proposal progresses through its detailed design and construction phases a final set of mitigation measures will be developed by ARTC. This is expected to require further assessment of railway noise and vibration and the monitoring of railway noise and vibration at the opening of the proposal.

2 Description of the railway infrastructure

2.1 Overview

The proposal involves the construction and operation of a section of Inland Rail between the towns of Narromine and Narrabri. The proposal would link the Parkes to Narromine (P2N) section of Inland Rail in central western NSW with the Narrabri to North Star (NS2B) section of Inland Rail in north western NSW.

The key components of the railway infrastructure are summarised in **Table 5** and described in further detail in this section. The discussion of the railway infrastructure considers the aspects most relevant to the noise and vibration emissions that can be generated by railway operations.

Table 5 Key infrastructure for the proposal

Key component	
Start and finish point	Narromine to Narrabri, NSW
Local government areas	Coonamble Shire, Gilgandra Shire, Narrabri Shire, Narromine Shire & Warrumbungle Shire
Length of alignment	306 km and a 1.2 km rail junction between Inland Rail P2N and Narromine to Cobar Lines.
Track dimensions	Rail corridor approximately 40 m wide, consisting of a single-track, standard gauge railway line to facilitate rail traffic in both directions.
Level crossings	79 level crossings comprising of, 17 new active crossings, 58 new passive crossings and 4 existing passive crossings
New rail bridges and viaducts	74 bridges and viaducts for crossing roads and waterways
Crossing loops	7 loops

2.2 Rail design

A single-track, standard gauge railway line (1,435 millimetre (mm)) is proposed to facilitate the travel of trains in both directions. The mainline track structure, including on bridges and viaducts, is typically a ballasted track system consisting of continuously welded rail, resilient track fasteners, rail pads and concrete dual gauge full-depth sleepers at 600 mm centres and ballast between 250 mm and 500 mm in depth with 300 mm shoulder width for lateral restraint.

2.3 Bridges

The proposal requires 74 new bridge and viaduct structures for rail to cross over existing roads and railways and local watercourses. The bridge superstructures include the track system, walkways, guard rails and barriers as appropriate, and are typically founded on piles supporting in-situ reinforced concrete substructures.

The sub-formation and ballast height will be approximately same as the deck edge resulting in minimal lateral screening of noise by the bridge and viaduct structures.

2.4 Level crossings

Level crossings are typically applied to facilitate vehicle and pedestrian access where public and private roads interface with rail corridors. For safety purposes, the level crossings can require alarm bells at each crossing and a requirement for each train to sound its horns as it approaches the crossing. The proposal is to include 75 level crossings, which can be either passive or active, as defined below.

- Passive – have static warning signs (e.g. stop and give way signs) that are visible on approach. There are no mechanical aspects or light devices.
- Active – flashing lights and audible alarm bells with or without boom barriers for motorists, and automated gates for pedestrians. These devices are activated prior to and during the passage of a train through the level crossing.

2.5 Crossing loops

Crossing loops enable a train to move from the main line track and allow another train to pass through on the main line. The crossing loops are used to manage train movements on the network, such as trains travelling in the opposite direction or trains travelling at different speeds.

The proposal incorporates seven new crossing loops, designed to accommodate an 1,800 m train length, with future provision for a 3,600 m train length. The crossing loops will be connected to the main line track at both ends so the crossing loops can be accessed by trains travelling in either direction.

The loops would be new sections of track parallel to the existing track at a distance of approximately 4.5 m spacing from the mainline track and incorporate a siding to enable maintenance of rollingstock without obstructing the track. The proposed location of the crossing loops is detailed in **Table 6**.

Table 6 Location of the proposed crossing loops

Crossing loop	General location
Burroway	Starting about 2.8 km south of the intersection of Eumungerie Road and Merrits Lane
Balladoran	Starting about 4.0 km north Milpulling Road
Armatree/Tonderburine	Starting about 2.5 km north of Yarrandale Road
Mount Tenandra	Starting about 4.7 km north of Tooraweenah Road
Baradine	Starting about 600 m east of the intersection of Coonamble Road and Carmel Lane
The Pilliga	Starting about 100 m south of the intersection of Pilliga Forest Way Road and Dunwarin Road
Bohena Creek	Starting about 2.9 km north of the intersection of Newell Highway and Dog Fence Road.

2.6 Turnouts

A turnout is a point where a train can leave a given track for a branching or parallel track. The proposal includes turnouts at the following locations:

- Each end of the proposal site to connect the proposal to existing track south of Narromine and north of Narrabri.
- Interactions with other rail lines.
- The beginning and end of each crossing loop (and maintenance siding).

2.7 Connections with other rail lines

The proposal connects with four existing rail lines that are part of the ARTC and Country Regional Network rail networks, as summarised in **Table 7**. The proposal crosses, and does not connect to, the Dubbo to Narromine Line and the Binnaway to Gwabegar Line.

Table 7 Connections with other rail lines

Existing rail line	Connection
Parkes to Narromine	At the southern end, the proposal would connect to the northern end of the P2N Inland Rail section, about 2.2 km south of Craigie Lea Lane. The connection would require adjustment to about 500 m of the existing Parkes to Narromine Line. The junction would provide for train movements between the proposal and Parkes to Narromine Line. The north to east leg is a possible future connection that may be constructed at a later date.
Dubbo to Coonamble Line	At Curban, an at-grade junction would provide full connectivity between the proposal and the Dubbo to Coonamble Line. The new junction would include about 4.6 km of new track. Two of the legs of the junction that enable movements from west to south and east to north are possible future connections that may be constructed at a later date.
Narrabri to Walgett Line	To the west of Narrabri, the proposal crosses the Narrabri to Walgett Line on a bridge. About 1.8 km of new track would be provided to allow trains to access the proposal and travel south. The new junction is a possible future connection that may be constructed at a later date.
Narrabri to North Star	At the northern end, the proposal connects to the N2NS section of Inland Rail about 2 km north of the intersection between the Newell Highway and Killarney Gap Road. The connection would require adjustment to about 600 m of the N2NS Inland Rail section. This tie-in would allow trains travelling south on the N2NS Inland Rail section to join the proposal and for trains travelling north on the proposal to enter the Narrabri to North Star section.

Compared to the adjacent train passbys on the main line, the train passbys on the rail connections will be infrequent, for example one to two trains per day. Furthermore, compared to the main line the trains on the rail connections are expected to operate at slower speeds as they tie into the existing rail corridors. Based on these assumptions, the noise assessment applied the daily train passbys on the main line as the dominant noise generating events within the rural environment surrounding the connections.

2.8 Narromine West connection

To the west of Narromine, a new junction would provide connectivity between the Parkes to Narromine Line and Narromine to Cobar Line. The new junction would include about 1.2 km of new track to allow trains from the west to access Inland Rail. Access to Inland Rail (including the proposal) for trains from the east is provided by existing track. The new junction is a possible future connection that may be constructed at a later date.

The Narromine West connection is shown in **Figure 2** as the possible future connection at Narromine. The connection is approximately 5 km to the west of the main line of the proposal. On this basis, the assessment of potential noise and vibration impacts from the Narromine West connection has been considered separate to the railway operations on the main line.

3 Environmental assessment criteria

3.1 Referenced documentation

Based on the requirements of the SEARs, the assessment of noise and vibration from railway operations was undertaken with consideration to the guidelines listed in **Table 8**.

Table 8 Referenced noise and vibration guidelines

Document	Publisher	Application in the assessment
NSW Rail Infrastructure Noise Guideline (NSW RING), 2013.	NSW Environment Protection Authority (NSW EPA)	• Airborne noise assessment criteria for railway infrastructure projects. • Ground-borne vibration assessment criteria for railway infrastructure projects. • Ground-borne noise assessment criteria for railway infrastructure projects. • Guidelines for the measurement, prediction and mitigation of railway noise.
Assessing Vibration: a technical guideline, 2006.	(former) NSW Department of Environment and Conservation	• Establishment of assessment criteria for ground-borne vibration. • Assessment methodologies for ground-borne vibration.
Development near rail corridor and busy roads – Interim guideline. NSW DoP, 2008	NSW DPIE	• Whilst included in the SEARs, this guideline does not apply to proponents of new or redeveloped rail infrastructure.
German Standard DIN 4150-3: Structural vibration – effects of vibration on structures ,2016.	German Institute for Standardisation	• Establishment of assessment criteria for ground-borne vibration impacts to structures.
British Standard BS 5228.2-200/2014: Code of practice for noise and vibration control on construction and open sites – Part 2: vibration, 2014.	British Standards	• Establishment of assessment criteria for ground-borne vibration impacts to sites of heritage significance.
British Standard BS 7385-2:1993 Evaluation and measurement for vibration in buildings, 1993.	British Standards	• Establishment of assessment criteria for ground-borne vibration impacts to sites of heritage significance.

Source NSW Department of Planning and Environment, SEARs – Inland Rail Project Narromine to Narrabri (SSI 18_9487), September 2020.

3.2 Airborne noise from railway operations

The most common form of noise experienced by people is termed ‘airborne noise’, indicating the noise travels through the air between the source, such as a railway, and the receiver. This is the primary form of noise that occurs adjacent to above ground level railway tracks.

Guidelines for the identification and assessment of airborne noise from railway operations are discussed below, including the airborne noise criteria applied by ARTC for the assessment and management of railway noise from the proposal.

3.2.1 Rail Infrastructure Noise Guideline

The NSW Rail Infrastructure Noise Guideline (RING) has been used to assess (airborne) rail noise from the railway operations on the proposal. Noise from railways and railway infrastructure covered under the RING includes:

- Train movements during the daytime and night-time, which includes noise from the propulsion of the rolling stock (usually diesel or electric locomotives) and wheel-rail noise associated with trains running on the tracks.
- Level crossing bells/alarms at road intersections and the use of train horns as safety and warning devices.
- The influence of specific track features such as bridges, tight-radius curves, turnouts and crossings.

The RING provides non-mandatory railway noise assessment criteria for sensitive receivers. Where the rail noise levels are above the assessment criteria, ARTC will investigate feasible and reasonable mitigation measures with the aim of reducing noise levels to meet the criteria and minimising potential noise impacts at sensitive receivers.

The main line and associated connections of the proposal is categorised as a new rail line development and the Narromine West connection is a redevelopment of existing railway infrastructure. The corresponding RING noise trigger levels for residential receivers for new rail line developments and redevelopment of existing rail lines are shown in **Table 9**.

Table 9 Airborne noise trigger levels for residential receivers

<table>
<tr><th rowspan="2">Type of development</th><th colspan="2">Noise trigger levels (External)</th></tr>
<tr><th>Day (7.00 am to 10.00 pm)</th><th>Night-time (10.00 pm to 7.00 am)</th></tr>
<tr><td rowspan="3">New rail line development</td><td colspan="2">Predicted rail noise levels exceed:</td></tr>
<tr><td>LAeq(15hour) 60 dBA</td><td>LAeq(9hour) 55 dBA</td></tr>
<tr><td>LAFmax 80 dBA</td><td>LAFmax 80 dBA</td></tr>
<tr><td rowspan="3">Redevelopment of existing rail line</td><td colspan="2">Development increase existing LAeq(period) rail noise levels by 2 dB or more, or existing LAFmax rail noise levels by 3 dB or more and predicted rail noise levels exceed:</td></tr>
<tr><td>LAeq(15hour) 65 dBA</td><td>LAeq(9hour) 60 dBA</td></tr>
<tr><td>LAFmax 85 dBA</td><td>LAFmax 85 dBA</td></tr>
</table>

Source NSW Rail Infrastructure Noise Guideline. NSW EPA, 2013.

The railway noise criteria are specific to the daytime period of 7.00 am to 10.00 pm and the night-time period of 10.00 pm to 7.00 am. The noise assessment criteria are lower for the night-time period due to the greater sensitivity of communities to noise during the night-time.

The assessment criteria are more stringent (lower) for new rail line developments on the premise the environment surrounding the future rail line may not currently experience railway noise and new rail line developments have greater opportunity to apply mitigation options during the planning and design stage.

The RING includes rail noise criteria for sensitive receivers other than residential land uses. The noise criteria for these receivers types is detailed in **Table 10**.

Table 10 Airborne noise assessment criteria for other sensitive receivers

Other sensitive land uses	Noise trigger levels (when in use)	
	New rail line development	Redevelopment of existing rail line
	Resulting rail noise levels exceed:	Development increases existing rail noise levels by 2 dB or more in L_{Aeq} for the period and resulting rail noise levels exceed:
Schools, educational institutions and child care centres	$L_{Aeq(1hour)}$ 40 dBA (internal)	$L_{Aeq(1hour)}$ 45 dBA (internal)
Places of worship	$L_{Aeq(1hour)}$ 40 dBA (internal)	$L_{Aeq(1hour)}$ 45 dBA (internal)
Hospital wards	$L_{Aeq(1hour)}$ 35 dBA (internal)	$L_{Aeq(1hour)}$ 40 dBA (internal)
Hospital other uses	$L_{Aeq(1hour)}$ 60 dBA (external)	$L_{Aeq(1hour)}$ 65 dBA (external)
Open space – passive use (e.g. parkland, bush reserves)	$L_{Aeq(15hour)}$ 60 dBA (external)	$L_{Aeq(15hour)}$ 65 dBA (external)
Open space – active use (e.g. sports field, golf course)	$L_{Aeq(15hour)}$ 65 dBA (external)	$L_{Aeq(15hour)}$ 65 dBA (external)

Source Rail Infrastructure Noise Guideline. NSW EPA, 2013.

The RING advises that rail operations can be inherently noisy and relatively high noise levels may still occur where the noise trigger levels in **Table 9** and **Table 10** are achieved, including where feasible and reasonable noise mitigation has been applied.

3.3 Ground-borne vibration guidelines

Railway vibration is generated by dynamic forces at the interface of the rail and train wheels. The resultant vibration from ground-level track can be transmitted into adjacent buildings via the intervening ground. If the levels of vibration are sufficiently high, then this vibration can be felt as tactile vibration by the occupants of nearby buildings.

People can perceive floor vibration at levels well below those likely to cause damage to buildings or their contents. Accordingly, the vibration criteria applied to manage potential impacts to human comfort at residences are usually the most stringent and it is generally not necessary to set separate criteria for vibration effects on typical building contents and structures.

The exception can be some scientific equipment, for example electron microscopes and microelectronics manufacturing equipment, which can require more stringent design goals than those applicable to human comfort. A desktop survey of land-uses adjacent to the proposal alignment did not identify premises expected to have these types of scientific equipment.

3.3.1 Ground-borne vibration assessment criteria for sensitive receivers

For intermittent events such as train passby events, the vibration dose value (VDV) is applied to assess potential impacts to human comfort from vibration. The VDV provides a cumulative measure of the vibration levels associated with all railway operations in a daytime or night-time assessment period. The VDV considers the combined effects of the level of the ground-borne vibration and the duration of vibration generating events and, as such, is suited for the assessment of transient sources such as train passbys.

The RING refers to the NSW EPA's (formerly DEC) Assessing Vibration: a technical guideline to establish assessment criteria for ground-borne vibration from rail lines. Railway operations are considered as sources of intermittent vibration and the 'preferred' and 'maximum' VDVs for human comfort are shown in **Table 11**.

The vibration guideline advises that activities should be designed to meet the preferred values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, vibration assessment values up to the maximum range may be used if they can be justified.

Table 11 Ground-borne vibration criteria for sensitive receivers

Building Type	Assessment Period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working Areas (e.g. operating theatres or laboratories)	Day or night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night-time	0.40	0.80
Workshops	Day or night-time	0.80	1.60

Note 1: The VDV accumulates vibration energy over the daytime and night-time assessment periods and is dependent on the level of vibration as well as the duration.

3.3.2 Ground-borne vibration criteria for heritage sites

Buildings which possess architectural, aesthetic, historic or cultural values may have certain sensitivities to vibration with respect to their long term preservation. In lieu of specific ground-borne vibration criteria for heritage sites in the documents referenced in the SEARs, a discussion of various standards relevant to vibration and its effects on buildings is provided in **Table 12**.

Table 12 Referenced standards associated with cosmetic building damage risk

Reference	Notes
British Standard BS 5228.2[1] British Standard BS 7385.2[2]	This standard notes that BS 7385-2 and BS ISO 4866:2010 provide guidance on vibration measurement, data analysis and reporting as well as building classification and guide values for building damage. BS 7385.2:1993 provides frequency dependent threshold levels which are judged to give a minimal risk of vibration-induced damage.
German Standard DIN 4150.3[3]	DIN 4150.3 prescribes levels as 'safe limits', up to which no damage due to vibration effects has been observed for the class of building. 'Damage' is defined by DIN 4150.3 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls DIN 4150.3 also states that when vibration levels higher than the 'safe limits' are present, it does not necessarily follow that damage will occur. Site specific criteria may be determined in conjunction with professional civil and/or structural engineering input based on the existing level of building condition and serviceability.

[1] British Standard, BS 5228.2-2014-Code of practice for noise and vibration control on construction and open sites–Part 2: Vibration.
[2] British Standard, BS7385-2:1993 Evaluation and measurement for vibration in buildings.
[3] DIN 4150-3 2016 Structural Vibration Part 3 – Effects of vibration on structures.

The Peak Particle Velocity (PPV) metric is applied as a measure of the maximum movement of the particles in the ground as a result of vibrations created from sources such as train passbys. It is commonly applied to evaluate the potential response of buildings and structures when exposed to vibration energy.

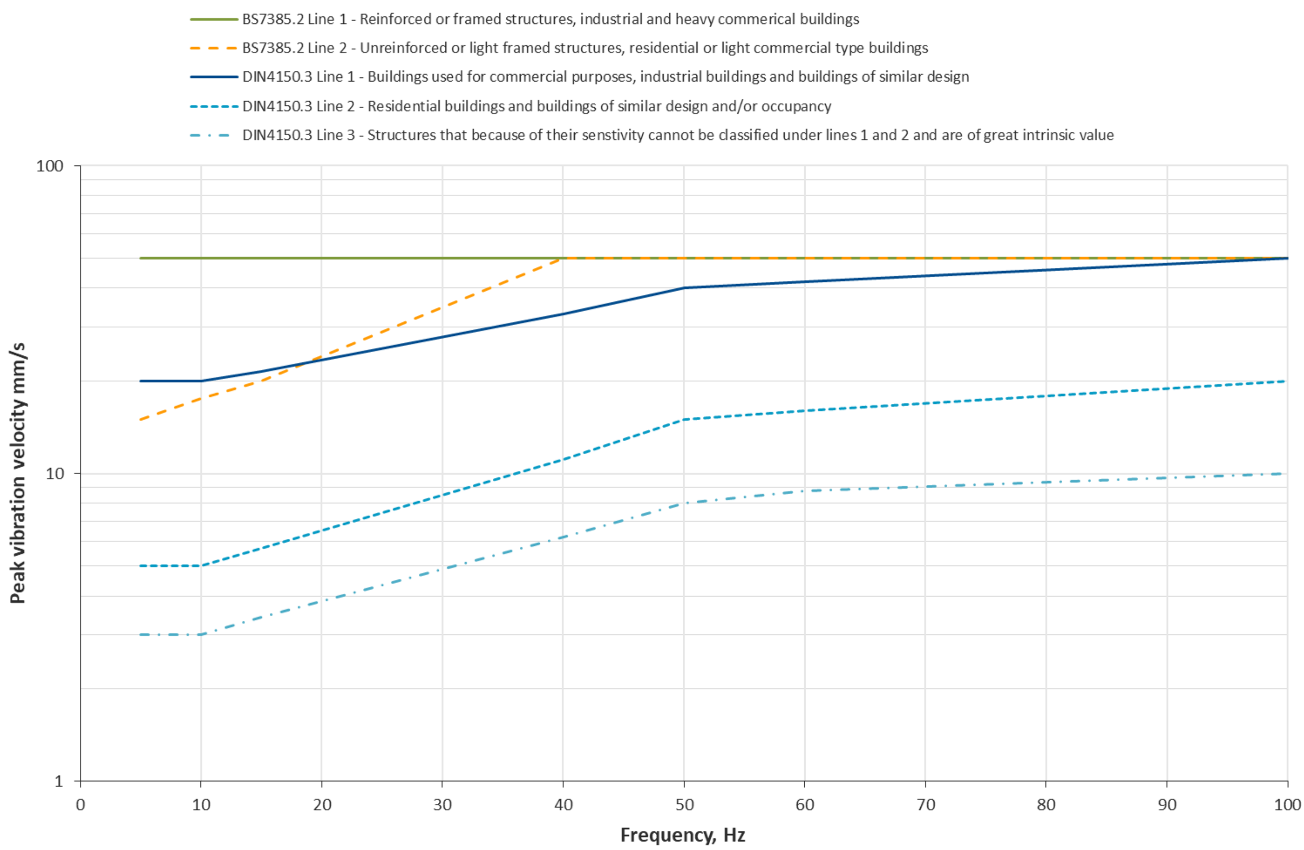
At the EIS stage, it is not possible to forecast with reasonable certainty the dominant (or resonant) frequencies of vibration at each building during train passby events. The adopted vibration criteria, irrespective of frequency, are the lowest applicable value; this is an appropriately conservative assessment approach.

Based on **Table 12**, the relevant PPV guidance values for assessment of ground-borne vibration at heritage sites are presented in **Figure 3**. From **Figure 3**, it can be seen that Line 3 of German Standard DIN 4150.3 is the lowest, most conservative vibration level. This includes where the vibration levels for Line 2 of British Standard BS 7385.2 are reduced by 50% in circumstances where there is concern over continuous vibration generating 'dynamic magnification' resonance effects.

The German Standard DIN 4150.3 recommends a V_{PPV} objective of 3 mm/s at low frequencies increasing to around V_{PPV} 8 mm to 10 mm/s at frequencies above 50 Hz for sensitive structure with great intrinsic value (refer Line 3 DIN 4150.3).

For this assessment, the 3 mm/s vibration level has been adopted as a vibration objective to provide a conservative assessment of potential structural impacts to heritage sites from railway operations.

Figure 3 Guidance values for short term vibration



3.4 Ground-borne noise guidelines

The ground-borne vibration from train passbys can be sufficient to cause floors or walls of the structure to vibrate and this can result in an audible low frequency rumble inside buildings. This is termed as ground-borne noise or regenerated noise.

The ground-borne noise criteria are generally implemented where the rail induced ground-borne noise levels are higher than the airborne noise from the railway operations, and where the ground-borne noise levels are expected to be audible within habitable rooms. The ground-borne noise trigger levels are provided in **Table 13**.

Table 13 RING ground-borne noise trigger levels

Sensitive Land Use	Time of Day	Internal Noise Trigger Level[1] (dBA)
Development increases existing rail noise levels by 3 dBA or more and resulting rail noise levels exceed:		
Residential	Daytime (7.00 am to 10.00 pm)	$L_{Amax(slow)}$ 40
	Night (10.00 pm to 7.00 am)	$L_{Amax(slow)}$ 35
Schools, educational institutions, places of worship	When in use	$L_{Amax(slow)}$ 40 - 45

Note 1 Maximum noise level not exceeded for 95% per cent of rail passby events.

The RING includes specific ground-borne noise criteria for residential, schools, educational institutions and places of worship. Based on assessment of ground-borne noise on other rail infrastructure projects, the ground-borne noise design objectives in **Table 14** have been used to assess the potential impacts at sensitive receivers that are not included in the RING.

Table 14 Ground-borne noise objectives for other sensitive receivers

Receiver type	Time of day	Noise trigger level[1,2]
Medical institutions	When in use	$L_{Amax(slow)}$ 40 to 45 dBA
Retail areas	When in use	$L_{Amax(slow)}$ 50 dBA
General office areas	When in use	$L_{Amax(slow)}$ 45 dBA
Private offices and conference rooms	When in use	$L_{Amax(slow)}$ 40 dBA
Cinemas, public halls and lecture theatres	When in use	$L_{Amax(slow)}$ 35 dBA

Note 1 The above criteria have been adopted by SLR as a guide to identifying potential impacts based on the sensitivity of the receiver type.
Note 2 Maximum noise level not exceeded for 95% per cent of rail passby events.

4 Assessment methodology

The assessment of noise and vibration from the railway operations applied the following methodology.

- A desktop survey was undertaken to identify sensitive receivers within a 2 km radius of the main line of the proposal alignment. An area greater than 1,224 km^2 (>122,400 hectares) was applied as the initial assessment area for railway noise and vibration.
- The 2 km study area was constrained to the limits of the proposal extents. Railway noise and vibration levels at sensitive receivers near to the proposal extents are being assessed on the corresponding P2N and N2NS projects on Inland Rail.
- A 750 m radius of the rail line connection was applied as the assessment area for the Narromine West connection.
- The applicable assessment criteria for airborne noise, ground-borne noise and ground-borne vibration were determined with reference to the relevant regulatory guidelines defined in the SEARs.
- Noise and vibration assessment scenarios were determined for the proposed rail operations based on the proposal description and the requirements of the SEARs. The year 2026 was applied for assessment of noise and vibration at the commencement of operations and the year 2040 was adopted as the year where rail operations would be at the designed freight capacity.
- The principle sources of airborne noise, ground-borne noise and ground-borne vibration from the operation of rollingstock were identified and each source was assigned an appropriate emission level.
- A detailed noise prediction model was developed for the calculation of airborne railway noise levels from rollingstock operations and associated sources of noise, including; level crossings and idling trains at crossing loops.
- The potential ground-borne vibration and ground-borne noise levels from rollingstock operations on the ground-level track were calculated based on ground-borne vibration levels from comparable rail freight movements.
- The predicted airborne noise, ground-borne vibration and ground-borne noise levels were evaluated against the assessment criteria and the requirements of the SEARs.
- The investigation of feasible and reasonable mitigation measures was triggered where the predicted levels were above the assessment criteria.
- The consideration of mitigation measures was not constrained by compliance to the assessment criteria, options for mitigation have been recommended as part of the overall strategy to minimise the potential noise and vibration impacts of the proposal through the implementation of best practice environmental management.
- The potential for residual impacts at sensitive receivers, after mitigation is implemented, was evaluated and recommendations were prepared for future noise and vibration assessment and monitoring works through the detailed design stage.

5 Existing environment

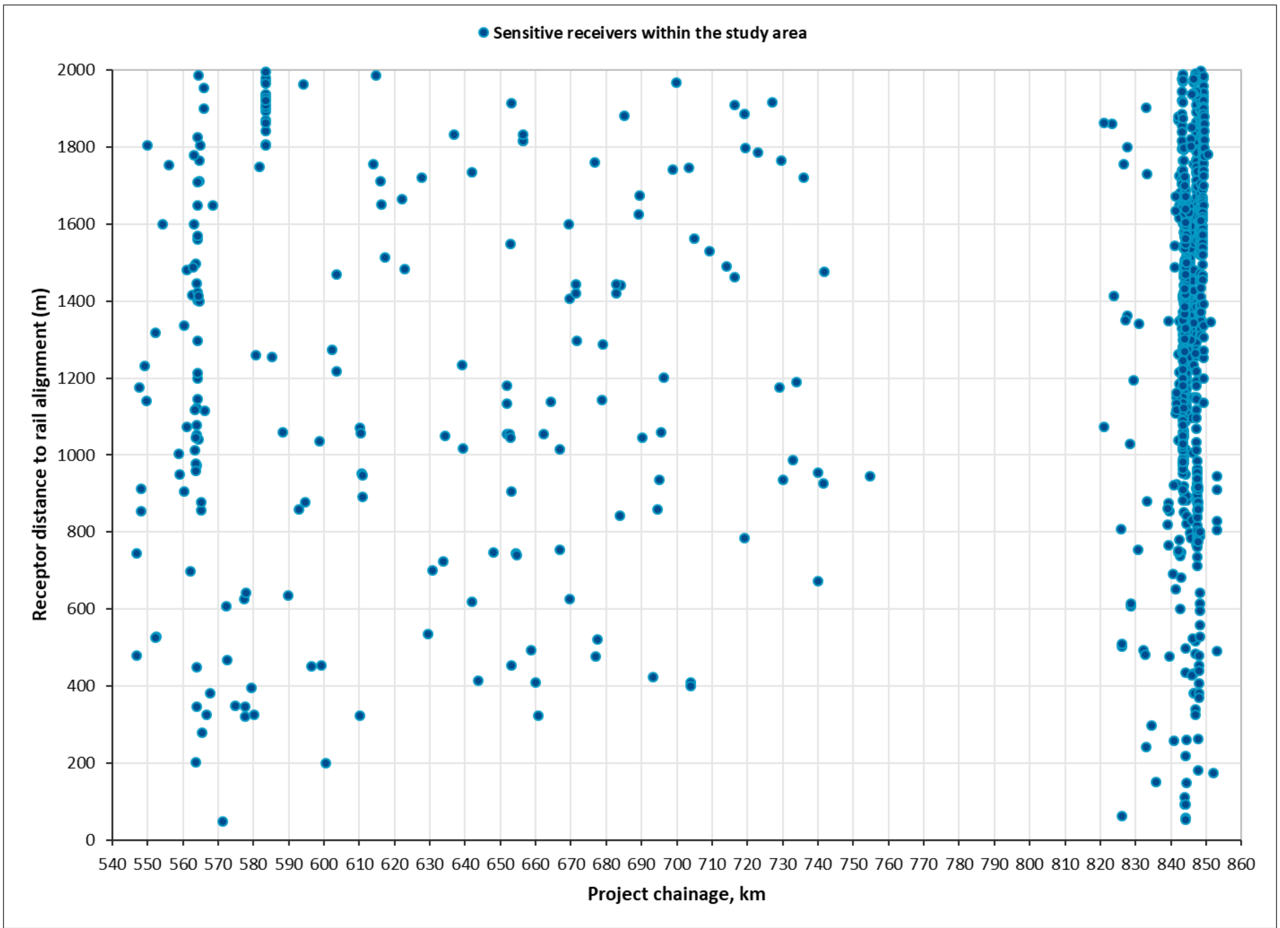
5.1 Sensitive receivers

Receivers potentially sensitive to noise and vibration have been categorised as residential dwellings, commercial/industrial buildings, or 'other sensitive' land uses which can include educational institutions, childcare centres, medical facilities, places of worship, as described in the RING.

To determine the sensitive receivers included in the assessment of railway noise and vibration, all buildings over 9 m^2 within the 2 km radius of the proposal alignment were identified from a national geospatial dataset of buildings from 2018. A total of 2,579 buildings were identified within the 2 km study area for the main line of the proposal and within the study area of the Narromine West connection. Each building was assigned a unique identification number for the purpose of the assessment.

The buildings that were clearly identified from aerial imagery as non-sensitive, such as hoppers, sheds and warehouses were retained in the assessment as they could provide screening of rail noise levels at nearby sensitive receivers. Railway noise and vibration levels were not assessed at the non-sensitive buildings. Of the buildings identified, a total of 1,088 receivers were identified as being potential noise and vibration sensitive receivers within the study areas. The location of the sensitive receivers along the main line alignment of the proposal is presented in **Figure 4**.

Figure 4 Distribution of sensitive receivers along the main line alignment

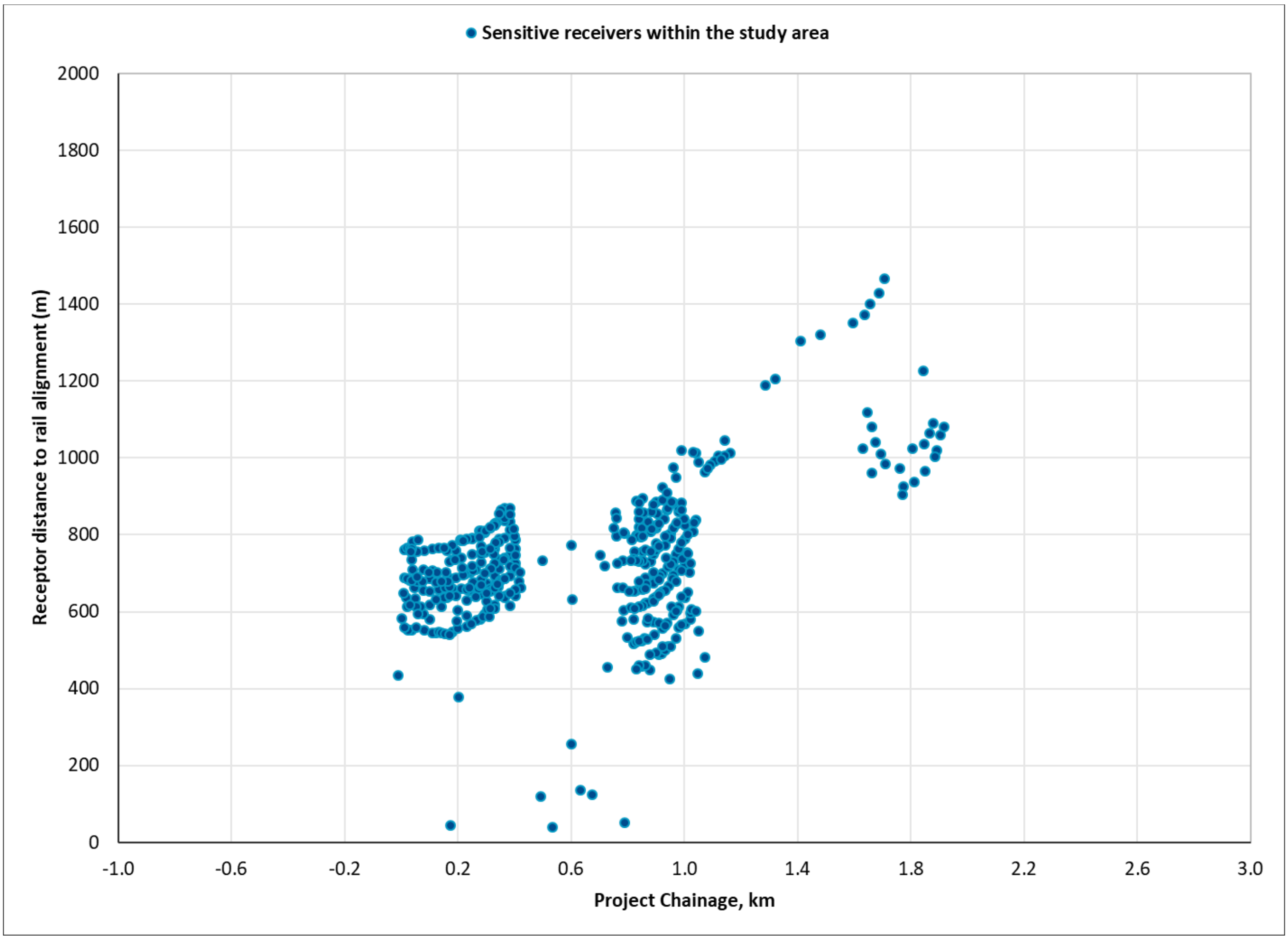


Note Some receivers are in the same location and the markers in the above figure may represent more than one receiver

Within the towns of Narromine and Narrabri there are non-residential receivers, such as schools, places of worship and child care centres. These receivers are at greater than 1 km from the main line and at this distance the railway noise will not trigger the assessment criteria.

The sensitive receivers adjacent the Narromine West connection are detailed in **Figure 5**.

Figure 5 Distribution of sensitive receivers along the Narromine West connection



Note Some receivers are in the same location and the markers in the above figure may represent more than one receiver.

The individual sensitive receivers within the study area of the main line alignment and the Narromine West connection are detailed in the route maps provided in **Appendix A**. The sensitive receivers are identified specific to the assessment of noise and vibration from railway operations and the adopted study area. Similarly, the *ARTC Inland Rail Narromine to Narrabri (N2N) Noise and vibration assessment – construction and other operations* has adopted sensitive receivers specific to the basis of that assessment.

5.2 Heritage sites

The non-Aboriginal heritage assessment prepared for the EIS identified the two listed and 10 potential heritage sites in proximity to the proposal site. A These sites are listed in **Table 15**.

Details of each site are provided in *ARTC Inland Rail Narromine to Narrabri Non-Aboriginal Assessment and Statement of Heritage Impact* (JacobsGHD, 2020).

Table 15 Non-indigenous heritage sites

Item name	Description	Building structures	Proximity to the Proposal
Listed sites			
Woodvale Park Private Cemetery	Historical cemetery site with records indicating graves dating from 1877 to 1893.	None	Partially within the proposal site. The location of the graves would be confirmed prior to construction.
Curban Inn site	Glass and ceramic artefacts identified on the site.	None	At least 125 m from the rail alignment
Potential heritage sites			
Drinane Public School site	Two school buildings remain and other structures	School buildings	280 m from rail alignment
“Kickabil” homestead and woolshed	Weatherboard building with iron roof with a separate woolshed.	Homestead and woolshed	250 m from rail alignment
“Allandale” homestead	Weatherboard building with Dutch gabled iron roof and wrap around verandah.	Homestead	300 m from rail alignment
Corrugated iron hut with chimney	Example of a rural workers dwelling.	None (Existing building to be removed prior to construction)	To be removed.
“Mount Tenandra” homestead	Collection of buildings, including residences and outbuildings including a woolshed.	Two residences and outbuildings	At least 850 m from alignment
“Digilah” homestead	Homestead and outbuildings. Limited site access available.	Residence and outbuildings	370 m from rail alignment
Convict road remains, Baradine	Stone road surface	None	55 m from rail alignment
“The Aloes” homestead and graves	Former homestead, structures and two graves.	One residence	At least 450 m from rail alignment
Rocky Creek mill	Archaeological remains of a house and surface artefacts (former forestry mill).	None	At least 160 m from rail alignment
Two storey barn/ shed at Bohena Creek	Remains of wooden construction/ building.	None (artefacts to be removed)	To be removed

5.3 Existing noise environment

A baseline environmental noise survey was undertaken in 2018 and 2019 to quantify and characterise the noise environment surrounding the proposal. The noise survey was conducted by JacobsGHD, a summary of the survey is provided below, with the noise monitoring survey detailed in *ARTC Inland Rail Narromine to Narrabri Noise and Vibration Assessment – Construction and Other Operations* (JacobsGHD, 2020).

Existing noise levels were monitored at 21 locations selected to be representative of the nearest communities to the proposal. The monitored L_{A90} noise levels defined the Rating Background Level (RBL) which quantifies the steady-state background noise environment.

Consistent with relevant acoustic guidelines, where the RBL levels are below 30 dBA, the RBL is set to 30 dBA. The monitored L_{Aeq} noise levels define the ambient noise environment, which considers all local sources of noise.

The monitored noise levels in **Table 16** confirm that the existing noise levels are generally low and characteristic of rural environments where the main sources of noise are local road traffic, residential activities and natural events, such as windblown vegetation and bird song.

Table 16 Existing environmental noise levels

Monitoring location	RBL noise levels, dBA			Ambient L_{Aeq} noise levels, dBA		
	Daytime	Evening	Night-time	Daytime	Evening	Night-time
M01	32	37	34	52	55	50
M02	30	30	30	50	50	48
M03	30	30	30	53	49	50
M04	30	30	30	50	49	45
M05	30	30	30	52	50	54
M06	31	30	30	50	46	41
M07	30	30	30	50	45	45
M08	30	30	30	60	60	57
M09	30	30	30	47	48	46
M10	30	30	30	49	48	42
M11	30	30	30	45	43	42
M12	31	34	32	61	58	54
M13	30	30	30	53	50	48
M14	30	30	30	62	60	56
M15	30	30	30	53	49	44
M16	30	30	30	55	49	45
M17	30	30	30	59	57	53
M18	30	30	30	58	53	51
M19	30	30	30	57	52	47
M20	30	30	30	49	41	45
M21	30	30	30	56	47	43

Note Daytime is 7.00 am to 6.00 pm, evening is 6.00 pm to 10.00 pm and night-time is 10.00 pm to 7.00 am.

Source *ARTC Inland Rail Narromine to Narrabri Noise and Vibration Assessment – Construction and Other Operations* (JacobsGHD, 2020).

6 Railway noise modelling

6.1 Prediction of railway noise

The noise emissions from the railway operations on the proposal were calculated through detailed noise prediction modelling using the SoundPLAN (version 7.4) noise prediction modelling software.

The noise prediction model included a detailed terrain model to develop a 3-dimensional (3D) representation of the proposal and the 2 km study area. The terrain datasets comprised elevation contours of the existing ground and the proposal designs at 0.5 m to 2 m intervals to recreate in detail the rail and road civil earthworks and infrastructure and the surrounding environment. The resultant terrain model represented the future environment with the Proposal.

The vertical and horizontal designs for the proposal were digitised in the model, including; cuttings, embankments, and the track formation (earthworks and track ballast). The elevated structures for the bridges and viaducts were modelled at the height above ground level consistent with the proposal designs. The base of the elevated structures was digitised to represent the concrete spans that form the main bridges and viaducts with the rail track, inclusive of ballast, modelled on top of the spans.

The buildings for the sensitive receivers and non-sensitive structures were set to the mean ground height. Building heights were determined from the referenced geospatial database, where the building height was not reported a 5 m building height was adopted as being representative of the single storey residences that are common in rural areas. The adopted building height would be conservative for non-sensitive buildings and structures, such as grain hoppers, sheds and warehouses which could shield railway noise.

Railway noise levels are typically calculated at a height of 1.5 m or 1.8 m above the finished floor level of the ground floor. In lieu of the known building construction for the 2,583 sensitive receivers a conservative approach was adopted to assess noise levels at 2.4 m above ground level at the centre of each façade on the sensitive receiver buildings.

The adopted receiver calculation height considered that properties in the rural environment can be elevated on stilts or stumps and the ground floor of the properties is likely to be above the conventional 1.5 m or 1.8 m receiver heights. The adopted calculation height is conservative for single story properties.

Furthermore, the majority of the rail tracks on the proposal are elevated above the surrounding ground level, either on constructed earthworks or the bridges and viaducts. The 2.4 m receiver calculation height also facilitated calculation of railway noise with a more direct line of sight between the rails and the receiver facades.

All external railway noise predictions were adjusted by +2.5 dBA to determine the façade corrected noise level.

The immediate area 600 m either side of the rail corridor was modelled with a ground absorption coefficient of zero (0) to be representative of a hard, reflective ground surface. Further than 600 m from the rail corridor a ground absorption coefficient of 0.6 was adopted to be representative of the mixed soft and hard ground areas within the suburban and rural environments beyond the rail corridor.

To calculate noise emissions from the operation of rollingstock, the model applied the Nordic Rail Traffic Noise Prediction Method (Kilde 130) methodology[4]. Both the SoundPLAN modelling software and the Nordic prediction methodology are widely applied in Australia for the prediction of railway noise levels.

[4] M. Ringheim, 1984, *Kilde Report 130 – Background Material for the Nordic Rail Traffic Noise Prediction Method*.

To confirm the suitability of the noise modelling on the NSW sections of the Inland Rail program, a survey of existing rollingstock noise emission levels was undertaken in 2019 at three locations in southern NSW where existing rail freight operations are comparable to the proposed rail freight on the proposal.

Details of the monitored rollingstock noise levels and the noise model verification are provided in **Appendix B**.

6.2 Daily railway operations

The daytime and night-time train movements on the proposal were provided by ARTC for the assessment of operational railway noise for the year the Proposal commences (2026) and the design year (2040). The daily train movements associated with the Proposal are detailed below and applied the following principles:

- The daily train numbers include the existing freight and coal services that will be accommodated on the proposal;
- Train movements in each time period are the combined northbound and southbound movements. For the purpose of the assessment the northbound and southbound rail movements were evenly distributed in the northbound and southbound directions; and,
- The noise assessment only considers whole trains so the train movements in each daytime and night-time period were rounded up to integers. The approach resulted in the daily train numbers being marginally higher than the actual daily train movements forecast for the proposal.

The daily train movements on the main line alignment between Narromine and Narrabri are detailed in **Table 17** for commencement of proposal operations in 2026 and the designed freight capacity in year 2040 in **Table 18**.

Table 17 Daily train movements – Main line (year 2026)

Train services	Train movements[1]		
	Daytime	Night-time	Total 24-hour
Year 2026 proposal commencement			
Inland Rail Express	1	2	3
Inland Rail Superfreighter	2	5	7
Daily totals year 2026	**3**	**7**	**10**

Note 1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

Table 18 Daily train movements – Main line (year 2040)

Train services	Train movements[1]		
	Daytime	Night-time	Total 24-hour
Year 2040 design year			
Inland Rail Express	1	3	4
Inland Rail Superfreighter	4	6	10
Daily totals year 2040	**5**	**9**	**14**

Note 1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

The daily train movements on the separate Narromine West connection are detailed in **Table 19**.

Table 19 Daily train movements – Narromine West connection

Train services	Train movements[1]		
	Daytime	Night-time	Total 24-hour
Existing rail movements			
Rail freight - minerals	1	1	2
Rail freight - grain	1	1	2
Year 2026 proposal commencement			
Rail freight - steel	1	0	1
Rail freight - grain	1	2	3
Rail freight - minerals	1	0	1
Daily totals year 2026	**3**	**2**	**5**
Year 2040 design year			
Rail freight - steel	1	1	2
Rail freight - grain	2	2	4
Rail freight - minerals	1	0	1
Daily totals year 2040	**4**	**3**	**7**

Note 1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

6.3 Operational railway noise model inputs

6.3.1 Track gradient and locomotive notch settings

To control the speed of the trains, the locomotives have a series of throttle controls, known as notches. Most locomotives have up to eight notches and follow the operational principles below. The notch setting of a locomotive is related to the noise emission, with higher notch settings generally causing higher noise levels.

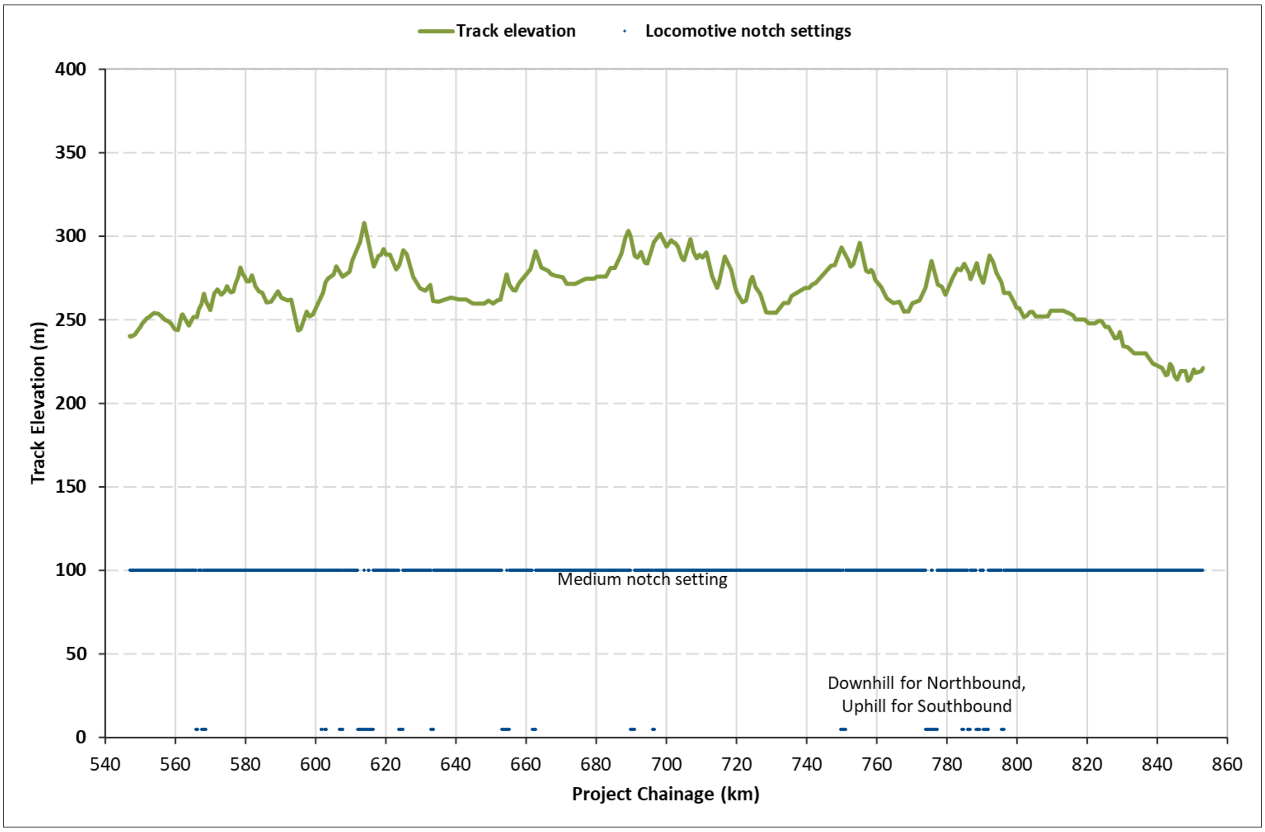
The noise prediction modelling applied the following principles for assumed notch settings:

- When operating on relatively flat or moderate gradients the locomotive would generally be operated at a medium notch setting (notch settings 3, 4 or 5).
- On downhill gradient track trains are often in low notch setting or can use dynamic braking where the traction motors that drive each locomotive axle are used to slow the train. Dynamic braking can be a source of additional noise as the radiator cooling fans are used to dissipate heat energy.
- For uphill gradients the load is increased which requires high notch settings (notch setting 6, 7 or 8). Often on uphill sections the train can be operating at lower speeds but at a higher notch setting.

At this stage of the design, the specific notch operations of the locomotives as they traverse the alignment was not confirmed. For the purpose of assessment, a gradient of 1 in 100 or less was applied to identify areas where uphill and downhill sections may require a high notch setting or dynamic braking. In practice, the selection of notch settings and dynamic braking will be determined by the driver and the 1 in 100 gradient was adopted to provide a conservative allowance for such events.

The track elevation for the proposal and the notch settings and dynamic braking applied in the assessment of airborne noise are shown in **Figure 6**.

Figure 6 Track elevation and locomotive notch setting



6.3.2 Train speeds

The trains on the proposal are can operate up to their designated line speed of up to 115 km/h for the Inland Rail Express and Inland Rail Superfreighter services. All trains (existing and future) were modelled at 50 km/h through the Narromine West connection.

The train speeds supplied by ARTC, and presented below, included a modelled 8 per cent reduction in the designated line speed to account for driver behaviour. The train speed will not be constant throughout the alignment, and the noise modelling applied speed profiles for each train type with the train speed detailed at 10 m intervals along the Proposal alignment.

To manage the railway operations, some trains will be required to slow down to access the crossing loops and then, on departure from the crossing loop, accelerate back up to the line speed.

Train speed profiles adopted in the noise modelling are presented in **Figure 7** (northbound) and **Figure 8** (southbound). The acute changes in train speed are associated with entry to and exit from each crossing loop. Note that stopping trains were modelled at a lower speed threshold of 30 km/hr to account for noise emissions from slowing/stopped trains due to the limitation associated with the modelling algorithm.

Figure 7 Track speed profiles, Narromine to Narrabri direction

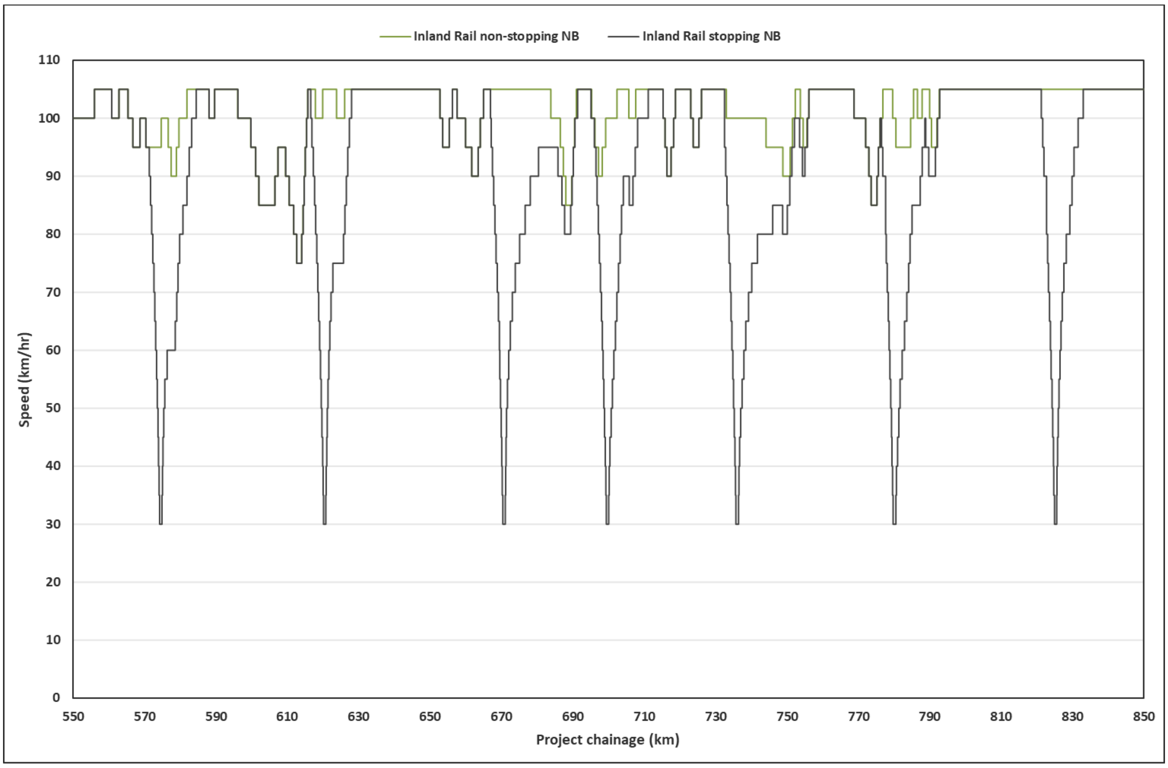
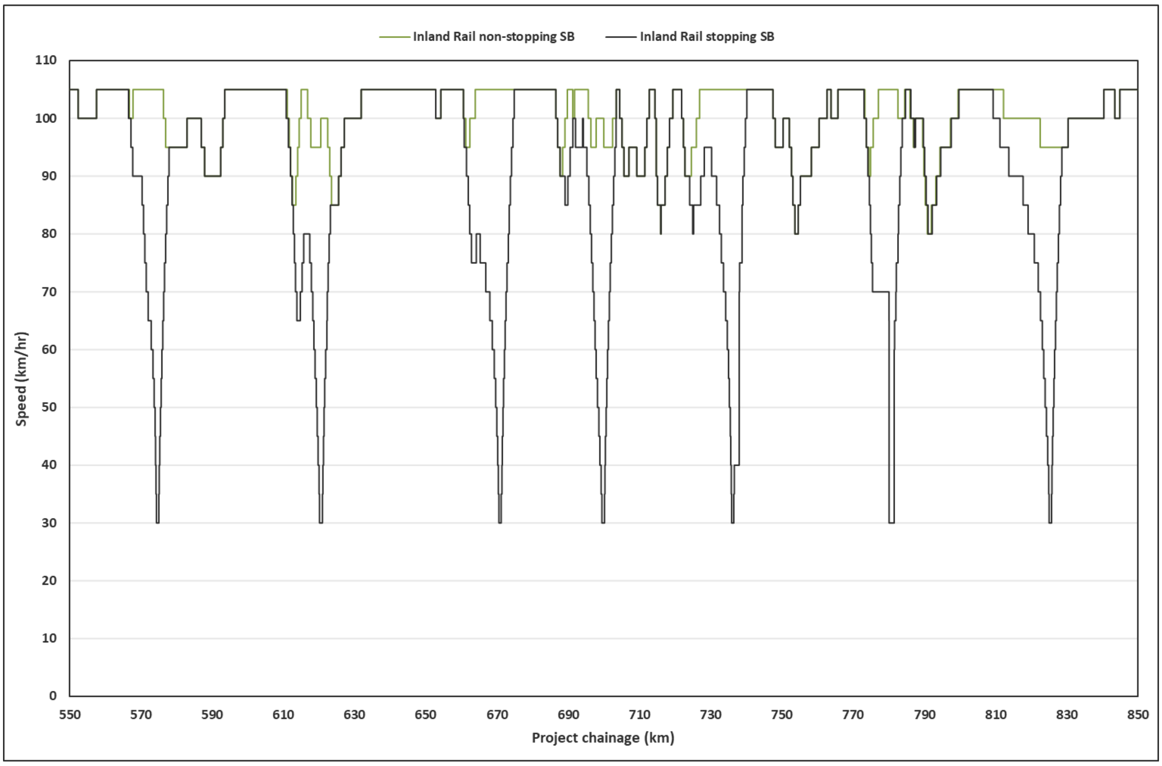


Figure 8 Example track speed profiles, Narrabri to Narromine direction



6.3.3 Train lengths and locomotive class

The length of each train type and the number of locomotives for the railway operations on the proposal are detailed in **Table 20** and **Table 21**. The train data was derived from ARTC's forecast daily train movements for Inland Rail.

Table 20 Train length and locomotive class

Train service	No. locomotives	Total locomotive length	Length of wagons	Total train length
Inland Rail Express (NR class)	3	66 m	1,680 m	1,746 m
Inland Rail Superfreighter (SCT class)	2	44 m	1,700 m	1,744 m

Table 21 Train length and locomotive class – Narromine West Connection

Train service	No. locomotives	Total locomotive length	Length of wagons	Total train length
Grain	2	44 m	940 m	984 m
Steel	3	66 m	920 m	986 m
Minerals	3	54 m	560 m	614 m

6.3.4 Source noise levels

Modelling of noise from railway operations requires defined source noise emission levels for the various classes of locomotives and rail wagons proposed to operate on the proposal. The Transport for NSW (TfNSW) Asset Standards Authority (ASA) Stage III Rail Noise Database was referenced by this assessment to provide a source noise emission inventory for the locomotive classes proposed for Inland Rail.

The TfNSW database defines reference noise levels for Australian rollingstock for use in commercial noise modelling software packages to conduct airborne noise predictions under a range of operating scenarios. The database contains over 840 measurements of freight and passenger rail sources, including rail freight proposed on the Proposal. The noise levels were measured and analysed in line with procedures outlined in specific railway noise standards; International Standards Organisation ISO 3095[5] and Australian Standard AS 2377[6].

As part of the assessment, the rail source noise emission levels derived from the TfNSW ASA database were validated against the ARTC Pollution Reduction Programme Rail Noise Study, which was prepared by ARTC to evaluate locomotive noise as part of ARTC's pollution reduction program.

The following principles were applied when determining the source noise emission levels for rollingstock:

- The SEL and maximum (L_{Amax}) noise emission levels are derived for each locomotive and set of wagons i.e. per unit.
- Noise emission levels are presented for a standardised train speed of 80 km/h at a distance of 15 m from the track centreline.
- Locomotive noise is determined from the required power output (notch setting) and only the rolling (wheel-rail) noise emissions for the wagons have been normalised to a speed of 80 km/h.

[5] International Standards Organisation, 2013. ISO 3095 *Railway applications – Acoustics – Measurement of noise emitted by railbound vehicles*.
[6] Standards Australia, 2002. AS 2377 *Acoustics – Methods for the measurement of railbound vehicle noise*.

- The noise levels for freight wagons account for a variety of wagon classes. The freight wagon reference noise levels are representative of typical wagon operations, and do not include a correction for increased noise levels that can result from unique operational influences (such as heavy braking) or significant defects (such as major wheel flats or bearing failures).
- The SEL noise level for an individual locomotive or consist of wagons is the logarithmic average of the referenced noise emissions levels and the L_{Amax} emission level is the overall 95th per centile L_{Amax} value derived from the database of noise measurements for each locomotive class or wagons.
- The source noise levels assume the track is in good condition and that the running surface of the rail head is free of defects. Wheel tread condition is also assumed to be in good to fair condition.

Conservatively, locomotive noise emissions are considered to be dominated by engine, cooling fans and exhaust systems, and for this reason the locomotive noise source is set to 4.0 m above the top of rail height to broadly represent the actual emissions of those items.

Noise emissions from wagons are considered to be dominated by 'rolling noise' generated equally by wheels and rail, so wagon noise emissions are set to the top of the rail height. On the basis that trains with defective wagons would not regularly be traversing the Proposal, the noise emission database does not account for local track defects, wheel flats or similar anomalies.

The referenced noise emission levels assume each train emits the same noise level and is therefore a typical worst-case noise generating event. Similarly, the method does not allow for deriving an arithmetic average of a range of maximum (L_{Amax}) noise levels for each train type as this could potentially result in lower daytime and night-time maximum noise level predictions.

The source noise emission levels for each rollingstock category are detailed in **Table 22**. The locomotive settings (notches) were assigned based on the gradient of track, which provided specific noise emissions based on the features of the railway infrastructure and its potential influence on the operation of the trains.

Table 22 Source rail noise emission levels

Rollingstock category	Rail source elevation	Train class	Reference length	Gradient	Reference noise level, dBA[1]	
					SEL	L_{Amax}
Diesel electric locomotives	4.0 m above the top of rail	NR	22 m	Flat	85	90
				Downhill	84	90
				Uphill	90	94
		GT46C[2]	21 m	Flat	84	88
				Downhill	84	91
				Uphill	89	92
		82	22 m	Flat	83	89
				Downhill	84	94
				Uphill	88	94
		PR22L	18 m	Flat	84	91
				Downhill	84	94
				Uphill	89	94
Wagons (all consist)	Top of rail	All	1,000 m	n/a	100	90

Note 1: Reference noise levels at 80 km/h, 15 m distance from track centreline, 1.5 m above top of rail, and ISO 3095 compliant track roughness.
Note 2: GT46C ACe model locomotive encompasses SCT, LDP, TT, WH, GWA, and SSR class designations.

6.3.5 Consideration of double-stack container freight

The Proposal will potentially operate some trains with containers on wagons in a double-stacked configuration. Concerns were raised by stakeholders and the community that double stacking the containers could lead to significantly different wagon noise emissions. The potential noise emission levels from double-stacked containers were investigated as part of this assessment and the key outcomes are outlined below.

ISO 3095 provides general guidance on the difference in noise level resulting from changes in axle loads and notes that an approximate doubling of axle loads (increased weight) may result in a reduction in noise levels of around 1 dB in L_{Aeq} terms. A variance in noise emission of 1 dB is negligible in the context of other factors which can affect noise and vibration emission levels, such as the wheel and track condition, speed and unsprung mass.

To support the assessment of noise on the Proposal, a noise and vibration monitoring survey was undertaken to investigate the potential influence of single and double stacked containers on noise and vibration emissions from freight trains. The details of the survey is provided in **Appendix C** and the survey determined the following:

- Consistent with ISO 3095, individual wagons with double-stacked containers have L_{Aeq} noise levels approximately 1 dB to 2 dB less than the individual wagons with single-stacked containers.
- Overall train passby noise levels are not significantly reduced by wagons with double-stacked containers given the minimal change in rolling noise emissions from the wagons.
- The loading of individual trains can substantially vary both in terms of the number of wagons with single-stacked and double-stacked containers but also the weight of each container on the train will vary from empty to fully loaded (a typical range of 3 tonnes to 30 tonnes).
- The overall passby noise levels, particularly L_{Amax} noise levels, are more influenced by factors other than the configurations of the containers on individual wagons.

On the basis of the above, correction factors to account for the potential configuration of containers on the wagons were not applied to the source noise emission levels in **Table 22**.

6.3.6 Track feature corrections

Impact noise from rail discontinuities such as turnouts, expansion joints or rail defects can increase noise levels from trains and are heard as impulsive noise as each train wheel passes over the discontinuity. Noise modelling correction factors were applied at each turnout to account for potential impact noise during the train passbys.

The elevated structures on the proposal are to be ballasted concrete bridges and viaducts. Consistent with guidelines for noise modelling, the rail noise emissions for the ballast track on the concrete bridges and viaducts were assumed to have noise emission levels and characteristics as the ballasted track at ground level.

The proposal includes tight radius curved track for the localised tie-ins to other rail lines. The noise modelling applied correction factors for potential curving noise emissions based on the assumption the new track will be designed to maximise the curve radius and track lubrication systems will be installed where required as part of measures to control potential curving noise.

The railway noise level corrections in **Table 23** were included in the railway noise prediction modelling to account for the potential influence of the rail infrastructure on the wheel-rail noise emissions.

Table 23 Noise model rail infrastructure corrections

Track feature and infrastructure	Modelling correction for wheel-rail contribution, dBA	
	SEL	LAmax[1]
Ballasted concrete rail bridges	0	0
Turnouts	+6	+6
At-grade active level crossings with the road network	+3	+3
Tight radius curves (≥300 m and <500 m radius)	+ 3	+3

Note The correction factors for tight-radius curved track are based on measurements and research from rail freight networks in Australia.

6.3.7 Level crossings

The noise assessment assumed all active level crossings included noise sources during each train passby for the crossing alarm bells and approaching train horns. The passive level crossings only included the train horns as noise sources.

At each active level crossing the noise sources included; a single alarm bell and two train horn source emissions, one located 100 m either side of the crossing to account for trains approaching from either direction. A source height of 2.0 m above ground level for the crossing alarm bells and 4.0 m above ground level was applied for the train horns.

The Nordic railway noise prediction methodology is specific to the rolling noise emissions. To calculate noise levels from the level crossing alarm bells and train horns at sensitive land uses, the ISO 9613-2[7] method for calculating the outdoor noise propagation was applied. The ISO method calculates noise levels with default meteorological conditions favourable for downwind propagation of noise (wind speeds between approximately 1 m/s and 5 m/s) or under a moderate ground-based temperature inversion.

The noise modelling applied the source noise levels for alarm bells and train horn detailed in **Table 24**. The noise levels were referenced from SLR's measurement of representative events on existing freight corridors.

Table 24 Level crossing and train horn source emission levels

Source	Noise emission level (LAeq) at 15 m, dBA										
	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Overall
Alarm bell	26	29	43	34	42	65	70	57	35	21	71
Train horn	38	52	68	81	93	98	95	92	82	62	101
Source	**Noise emission level (LAmax) at 15 m, dBA**										
	31.5 Hz	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**	**4 kHz**	**8 kHz**	**16 kHz**	**Overall**
Alarm bell[1]	31	35	48	46	57	68	73	60	45	33	74
Train horn[2]	43	57	73	86	98	103	100	97	87	67	106

Note 1 LAeq noise level is for an alarm bell event 20-seconds in duration prior to the noise of the train becoming the dominant noise contribution and masking the alarm bell noise contribution.

Note 2 LAeq noise level for a train horn event 2-seconds in duration.

[7] International Standards Organisation, 1996. ISO 9613-2:1996, *Acoustics – attenuation of sound during propagation outdoors – Part 2: General method of calculation*.

6.3.8 Train movements within the crossing loops

For the purpose of assessment, it has been assumed that approximately one in four trains per daytime or night-time period would access each crossing loop and each train could be held at the crossing loop for up to 1-hour. The details of the loop operations used in the noise prediction modelling are shown in **Table 25**.

Table 25 Proposed crossing loop occupancy

Assessment scenario	Number of trains accessing the loop per period		Total hours occupancy time per period	
	Daytime	Night-time	Daytime	Night-time
Year 2026	1	2	1	2
Year 2040	1	2	1	2

At a crossing loop the train will come to a complete stop from the main line track and idle until the train is signalled to return to the main line track. The assessment of airborne noise considered the noise emissions from the train locomotive engines idling whilst the train has stopped as well as short-lived noise events such as wagon bunching and stretching, which results in contact noise as the wagons come together.

For the purpose of assessing typical worst-case noise levels, the noise modelling included the faster and longer Inland Rail Express and Inland Rail Superfreighter on the main line track with the other general freight types held on the crossing loops.

The noise emission for an individual locomotive at idle was modelled as 70 dBA at a distance of 15 m, with a source height of 4 m above residual ground level. Because the idling of locomotive engines is a steady-state continuous noise emission, the emission level was referenced for the L_{Aeq} and L_{Amax} noise metrics. Acknowledging that trains can access each crossing loop from either direction, the noise modelling considered idling locomotives at both extents of each crossing loop.

The source noise emission levels for rolling noise, including potential wagon bunching, were referenced from previous freight train noise measurements. The noise emission level was applied as a contribution to the L_{Amax} level as the short-lived nature of bunching noise (1 to 2 seconds per event) would not be sufficient to influence the overall daily L_{Aeq} noise levels. A source height of 1 m above the residual ground level was adopted for bunching noise sources.

The noise prediction modelling for the crossing loops applied the ISO prediction methodology and each idling locomotive and bunching noise event was modelled as individual point noise sources.

The noise sources for the idling trains and wagons bunching referenced the source noise emission levels detailed in **Table 26**. The bunching sources were modelled at approximately 300 m intervals to anticipate the potential for such events along the length of the train.

Table 26 Crossing loop source emission levels

Source	Noise emission level (L_{Aeq}/L_{Amax}) at 15 m, dBA									
	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Overall
Idling train	47	52	47	47	57	58	69	46	39	21	70
Source	**Noise emission level (L_{Amax}) at 15 m, dBA**										
	31.5 Hz	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**	**4 kHz**	**8 kHz**	**16 kHz**	**Overall**
Bunching	51	63	71	62	53	56	53	52	48	40	72

7 Airborne rail noise levels – Proposal opening 2026

7.1 Overview

The predicted daytime and night-time railway noise levels for the commencement of railway operations in year 2026 are detailed in **Appendix D**. The railway noise levels include the combined effect of the train passbys, train operations on the crossing loops and the alarm bells and train horn events at the level crossings.

The assessment of daytime, night-time and maximum railway noise levels is discussed in the following sections. The predicted noise levels have been assessed against the adopted railway noise criteria to evaluate the potential noise impact of the proposal and identify where noise mitigation options are likely to be investigated.

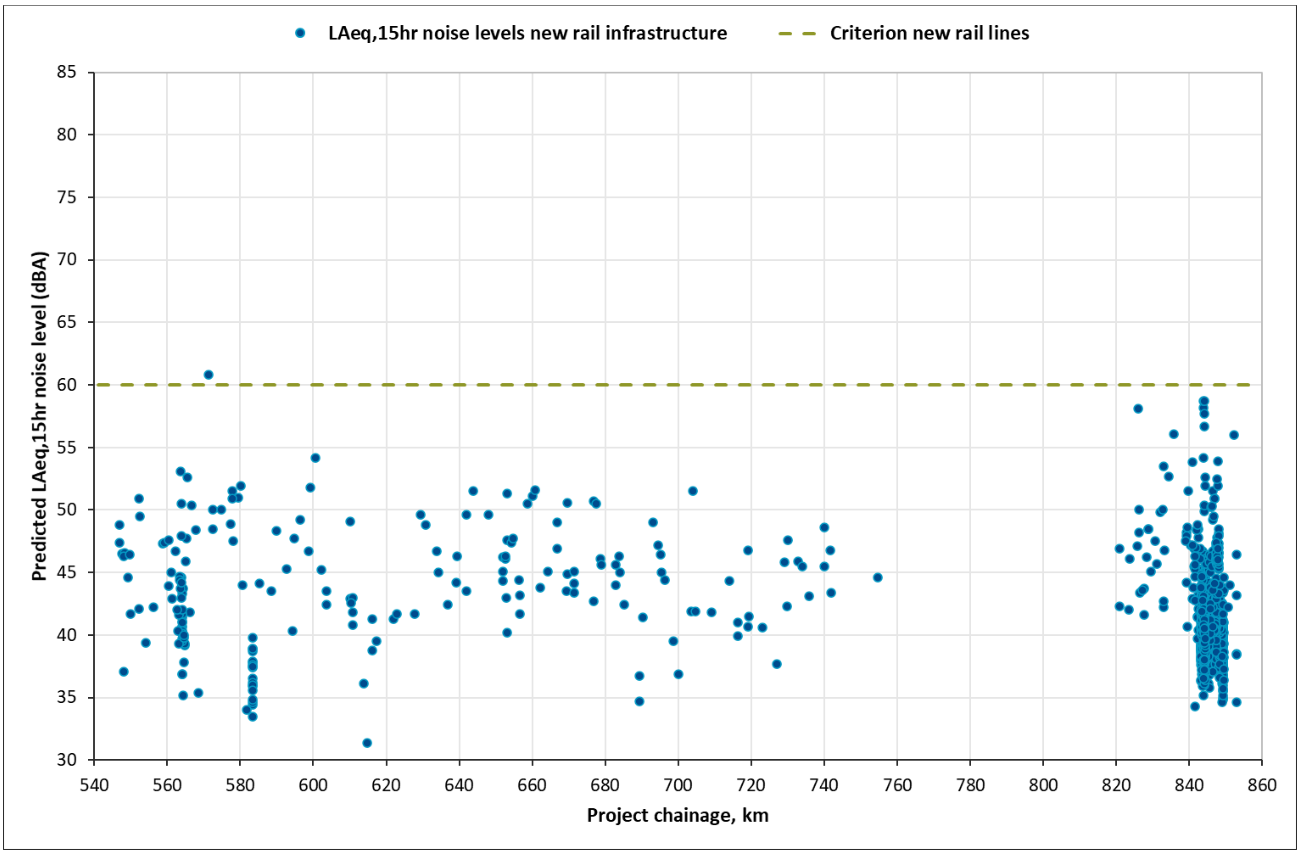
The noise predictions are for the railway operations on the main line of the proposal between Narromine and Narrabri. The railway noise levels predicted for the Narromine West connection are detailed in **Section 10**.

7.2 Railway noise levels at residential receivers

7.2.1 Daytime railway noise levels

The predicted $L_{Aeq(15hour)}$ railway noise levels at the noise sensitive residential receivers are detailed in **Figure 9**.

Figure 9 Predicted daytime $L_{Aeq(15hour)}$ railway noise levels (year 2026)



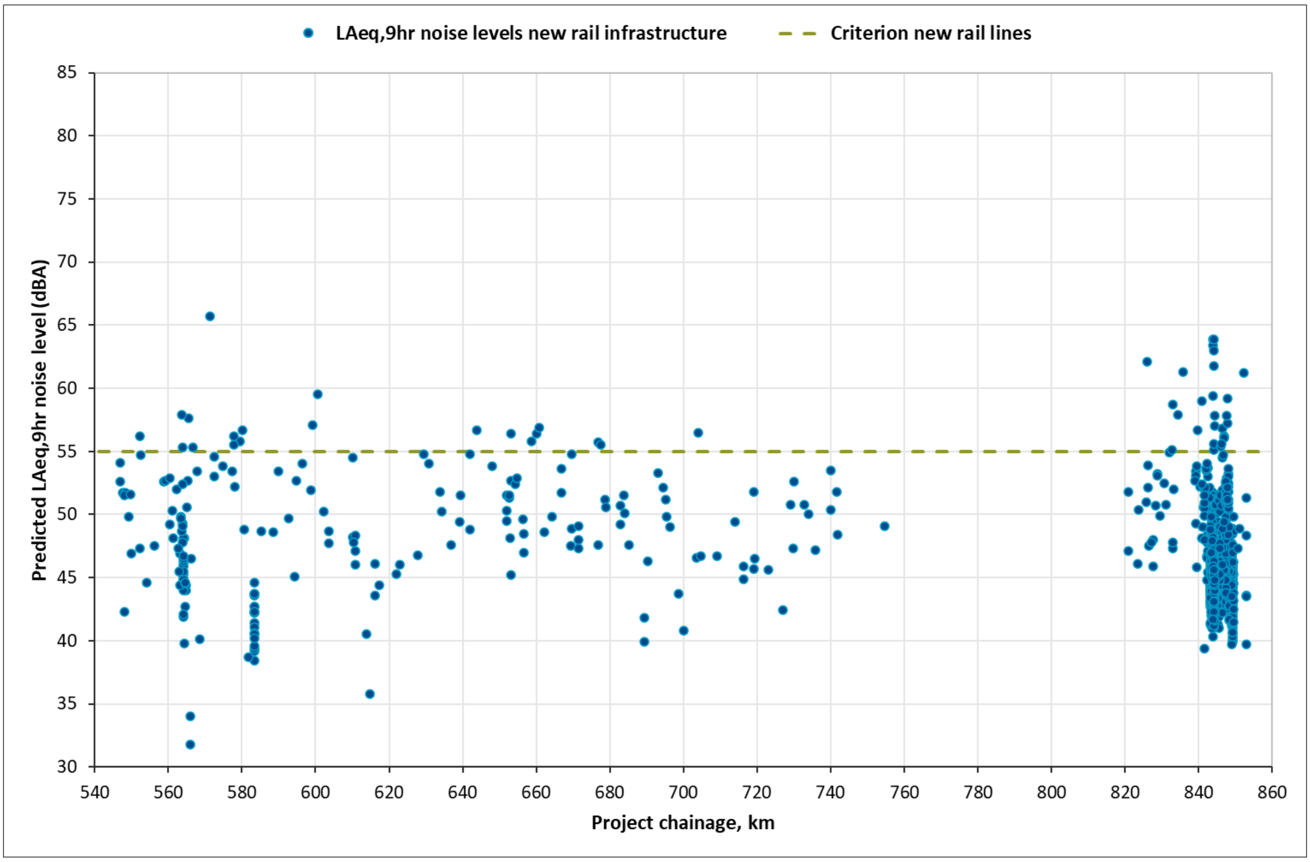
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

The predicted railway noise levels achieve the $L_{Aeq(15hour)}$ 60 dBA daytime noise trigger level at the majority of the sensitive residential receivers. There is one identified residences where the noise levels is predicted to be 1 dBA above the noise trigger level.

7.2.2 Night-time railway noise levels

The predicted night-time $L_{Aeq(9hour)}$ railway noise levels at the identified sensitive residential receivers are presented in **Figure 10**.

Figure 10 Predicted night-time $L_{Aeq(9hour)}$ railway noise levels (year 2026)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

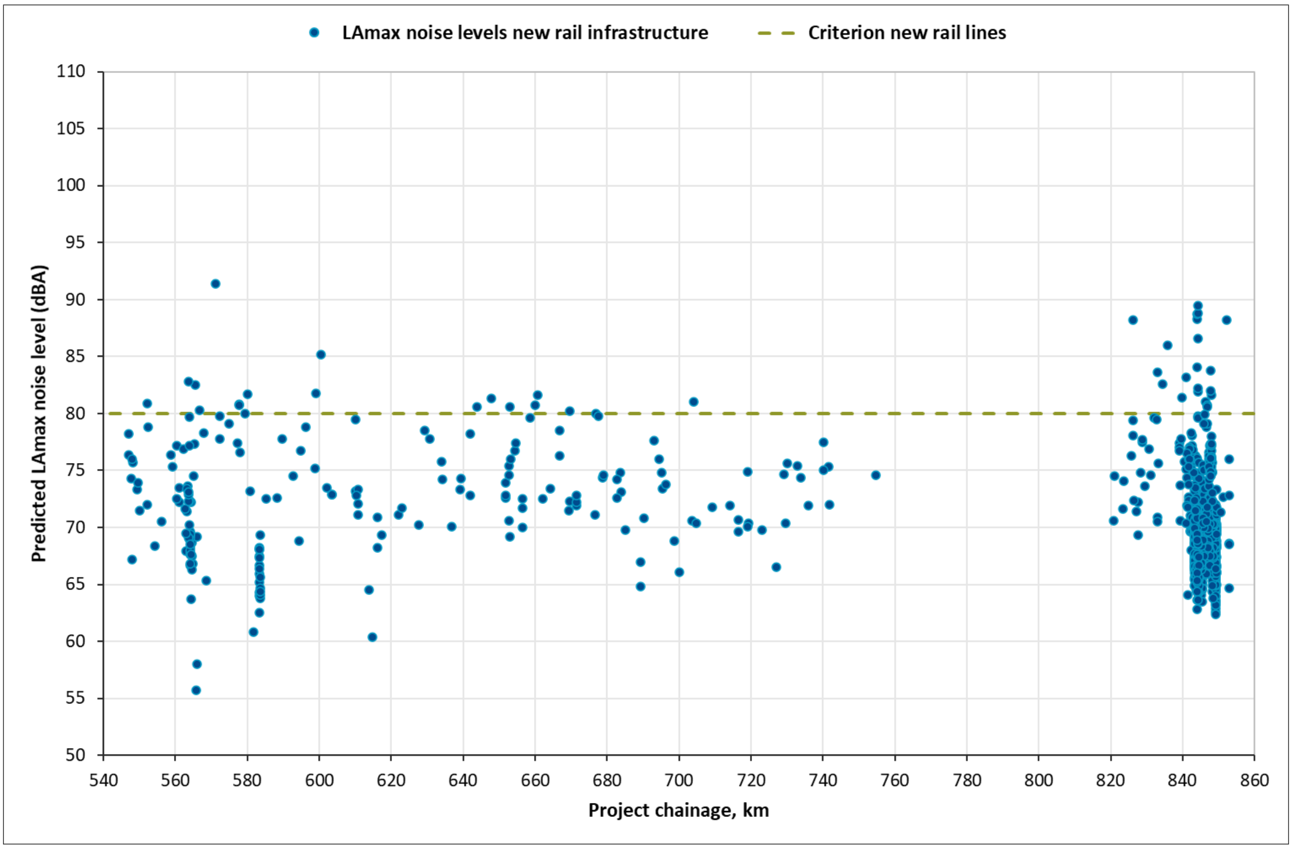
The predicted noise levels achieve the $L_{Aeq(9hour)}$ 55 dBA night-time noise trigger level at the majority of the identified residential receivers. There are up to 40 residences where the noise levels are 1 dBA to 11 dBA above the noise trigger level.

7.2.3 Daytime and night-time maximum railway noise levels

The maximum noise levels result from the highest discrete noise events from individual train passbys or the train operations on the level crossings or crossing loops. The predicted daytime and night-time L_{Amax} noise levels were generally consistent at the sensitive receivers, with a variation of less than 1 dBA. The higher predicted L_{Amax} noise level was adopted to assess the maximum noise levels in both the daytime and night-time periods.

The predicted daytime and night-time maximum (L_{Amax}) railway noise levels at the identified residential receivers are presented in **Figure 11**.

Figure 11 Predicted daytime and night-time maximum railway noise levels (year 2026)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

The predicted railway noise levels achieve the LAmax 80 dBA noise trigger level at the majority of the identified residential receivers adjacent to the sections of the new rail corridor. At 35 residences the predicted noise levels are 1 dBA to 11 dBA above the LAmax noise criterion.

The noise from level crossing operations also contributes to the overall noise levels. At most receivers the railway noise from mainline operations is the dominant noise source, however at two sensitive receivers the railway noise levels are equally influenced by the train horn noise at the crossing ID PU-5-RC9090 and PU-5-RC900 (Cains Crossing Road).

Overall, based on the LAeq and LAmax railway noise levels, there are 41 sensitive receivers where noise levels are predicted to be above the noise criteria and trigger an investigation of noise mitigation at the commencement of railway operations.

8 Airborne rail noise levels – Design year 2040

8.1 Overview

The predicted daytime and night-time railway noise levels for the design year 2040 are detailed in **Appendix E**. The railway noise levels are provided as tabulated noise level predictions at individual sensitive receivers and maps of railway noise contours for the proposal alignment.

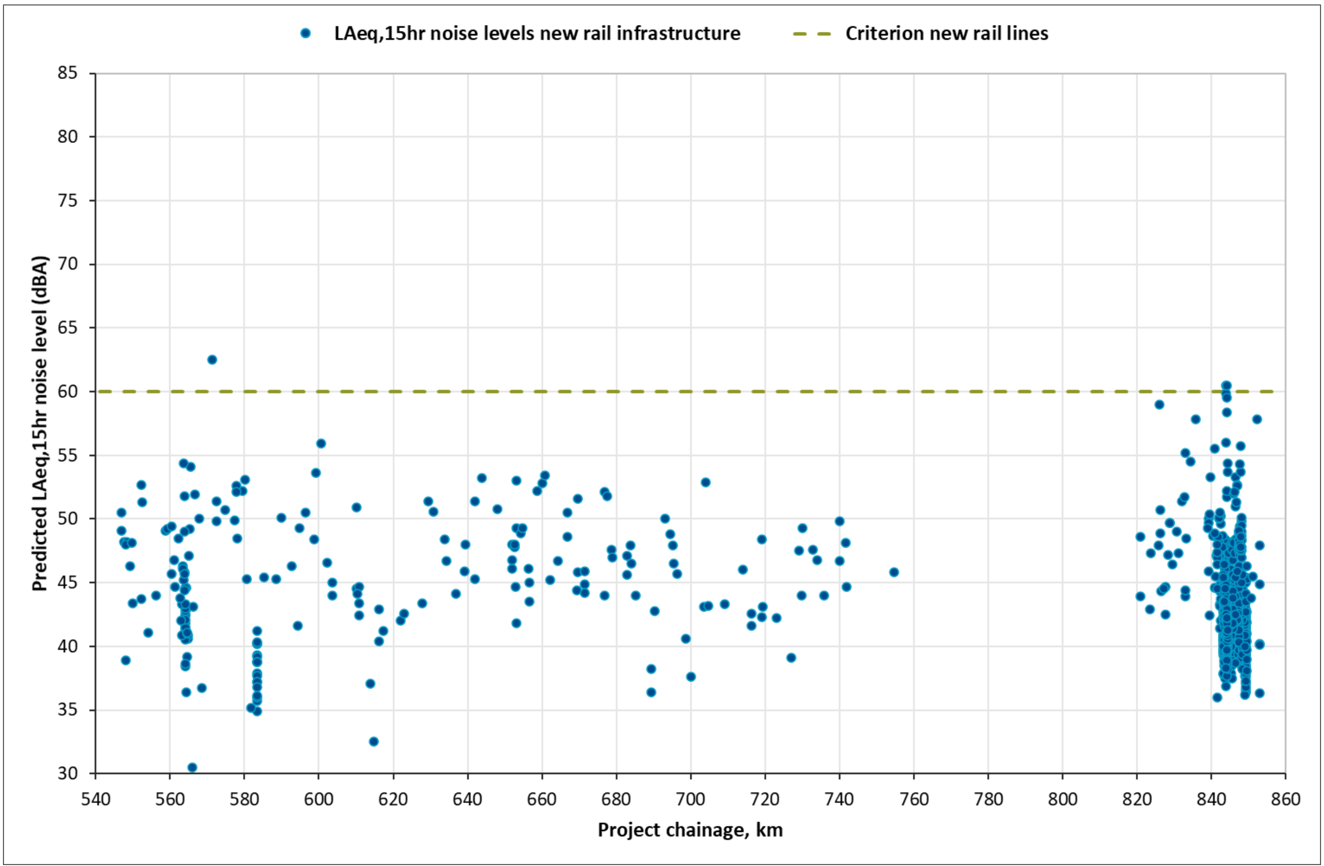
The assessment of daytime, night-time and maximum railway noise levels is discussed in the following sections. The noise predictions are for the railway operations on the main line of the proposal between Narromine and Narrabri. The railway noise levels predicted for the Narromine West connection are detailed in **Section 10**.

8.2 Railway noise levels at sensitive receivers

8.2.1 Predicted daytime $L_{Aeq(15hour)}$ railway noise levels (year 2040)

The predicted $L_{Aeq(15hour)}$ railway noise levels at the identified noise sensitive residential receivers are presented in **Figure 12**.

Figure 12 Predicted daytime $L_{Aeq(15hour)}$ railway noise levels (year 2040)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

The predicted railway noise levels achieve the $L_{Aeq(15hour)}$ 60 dBA daytime noise trigger level at the majority of the sensitive residential receivers. There are 3 identified residence where the noise levels are 1-3 dBA above the noise trigger level.

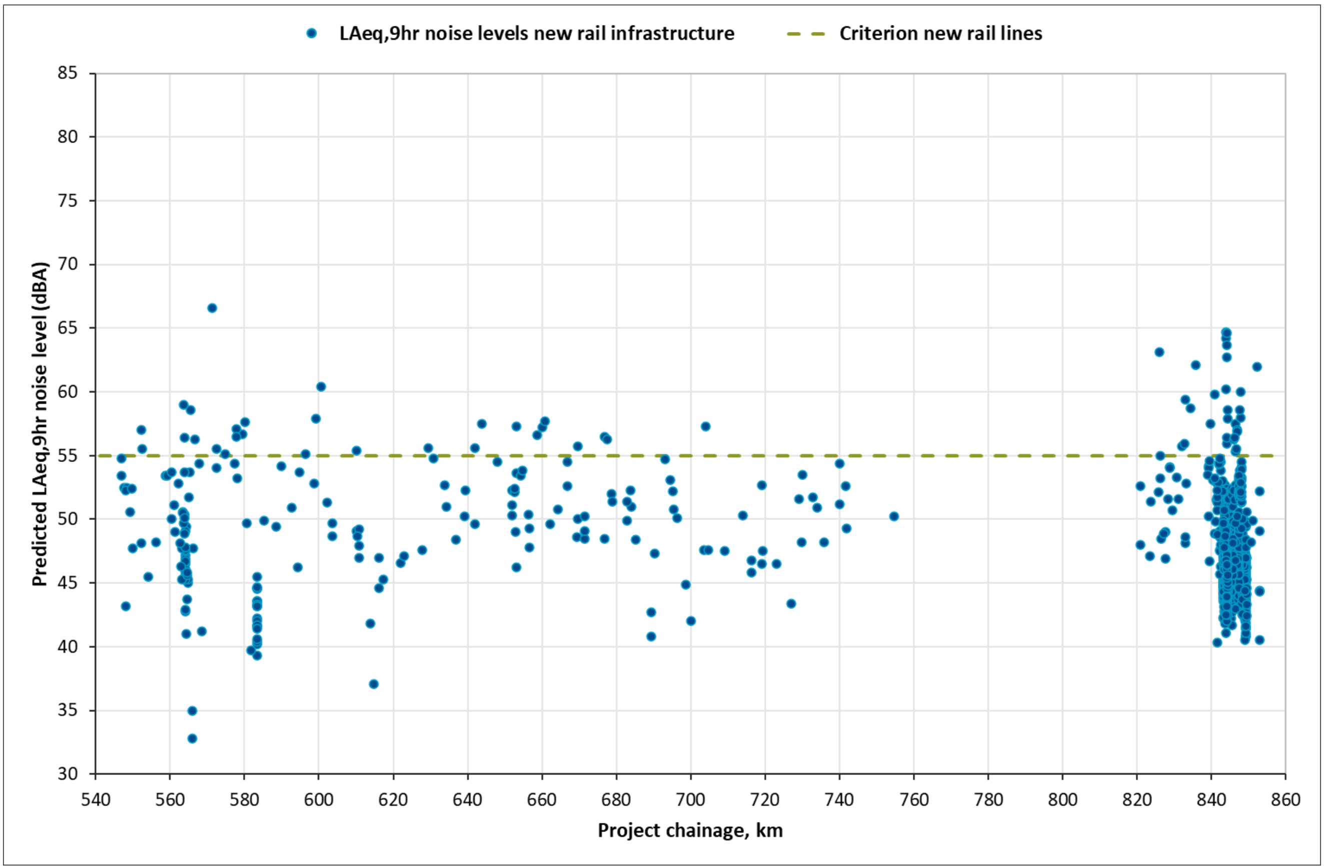
8.2.2 Night-time railway noise levels

The predicted night-time $L_{Aeq(9hour)}$ railway noise levels at the identified sensitive residential receivers are presented in **Figure 13**.

The predicted noise levels achieve the $L_{Aeq(9hour)}$ 55 dBA night-time noise trigger level at the majority of the identified residential receivers. There are up to 52 residences where the noise levels are 1 dBA to 12 dBA above the noise trigger level.

Consistent with the predicted daytime noise levels, the railway noise levels during the night-time are dominated by the train passbys on the main line

Figure 13 Predicted night-time $L_{Aeq(9hour)}$ railway noise levels (year 2040)



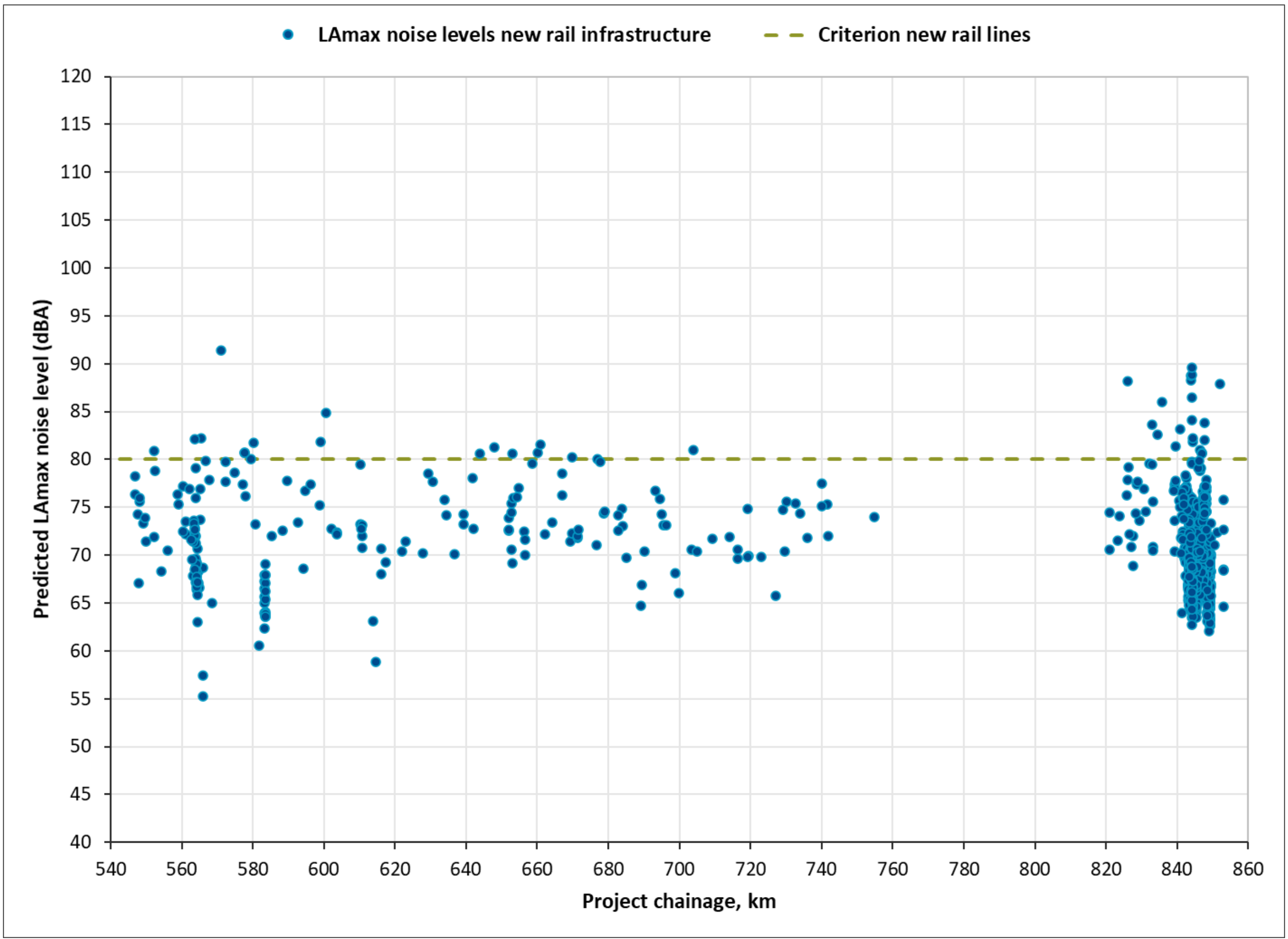
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

8.2.3 Daytime and night-time maximum railway noise levels

The maximum noise levels result from the highest discrete noise events from individual train passbys or the train operations on the level crossings or crossing loops. The predicted daytime and night-time L_{Amax} noise levels were generally consistent at the sensitive receivers, with a variation of less than 1 dBA. The higher predicted L_{Amax} noise level was adopted to assess the maximum noise levels in both the daytime and night-time periods.

The predicted daytime and night-time maximum (LAmax) railway noise levels at the identified residential receivers are presented in **Figure 14**.

Figure 14 Predicted daytime and night-time maximum railway noise levels (year 2040)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

The predicted railway noise levels achieve the LAmax 80 dBA noise trigger level at the majority of the identified residential receivers adjacent to the sections of the new rail corridor. At 35 residences the predicted noise levels are 1 dBA to 11 dBA above the LAmax noise criterion.

The noise from level crossing operations also contributes to the overall noise levels. At most receivers the railway noise from mainline operations is the dominant noise source, however at two sensitive receivers the railway noise levels are influenced by the train horn noise at the crossing ID PU-5-RC9090 and PU-5-RC900 (Cains Crossing Road).

Overall, there are 53 sensitive receivers where noise levels are predicted to be above the noise criteria and trigger an investigation of noise mitigation at the commencement of railway operations.

9 Airborne railway noise levels at non-residential receivers

The railway noise levels were predicted at the buildings and property identified as being noise sensitive receivers other than residential. For example, places of worship, schools and recreation facilities. Other than hospitals and outdoor recreation areas, which have external railway noise criteria, the noise assessment criteria for these sensitive receivers is an internal (indoor) noise level.

There was one non-residential sensitive receiver, the Narrabri Christian Fellowship, identified with the study area.

To assess potential internal railway noise levels, a conservative 7 dBA reduction was applied to the predicted external railway noise levels at the building façade to estimate the internal noise levels where windows are open for ventilation.

The predicted external and internal railway noise levels at the non-residential sensitive receivers is detailed in **Table 27**. The predicted railway noise levels are provided for the commencement of railway operations on the proposal in 2026 and the future railway operations in 2040. The non-residential receiver identified is predicted to be compliant with the established internal noise criteria.

Table 27 Predicted railway noise levels at sensitive receivers other than residential

Sensitive receiver	$L_{Aeq(1hr)}$ noise levels Year 2026, dBA				$L_{Aeq(1hr)}$ noise levels Year 2040, dBA			
	Daytime		Night-time		Daytime		Night-time	
	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside
Sensitive receivers (other than individual residences)								
Narrabri Christian Fellowship	40	33	44	37	40	33	45	38

The predicted internal noise levels is sensitive to the 7 dBA correction applied to external noise levels. The 7 dBA correction is commonly applied with consideration to the age and style of property and buildings in typical suburban and rural regions.

In practice, many of the sensitive receiver properties will be a modern building construction and likely to have air-conditioning so the windows would not need to be opened. During the detailed design of the proposal, the construction of property and buildings identified as non-residential noise sensitive receivers should be reviewed. Further assessment of internal noise levels would need to be undertaken where the adopted 7 dBA correction is deemed an overly conservative assessment assumption. Nevertheless, based on the current design, no exceedance of non-residential sensitive receiver is identified even with a conservative assumption of 7 dBA level difference correction.

10 Airborne railway noise levels – Narromine West connection

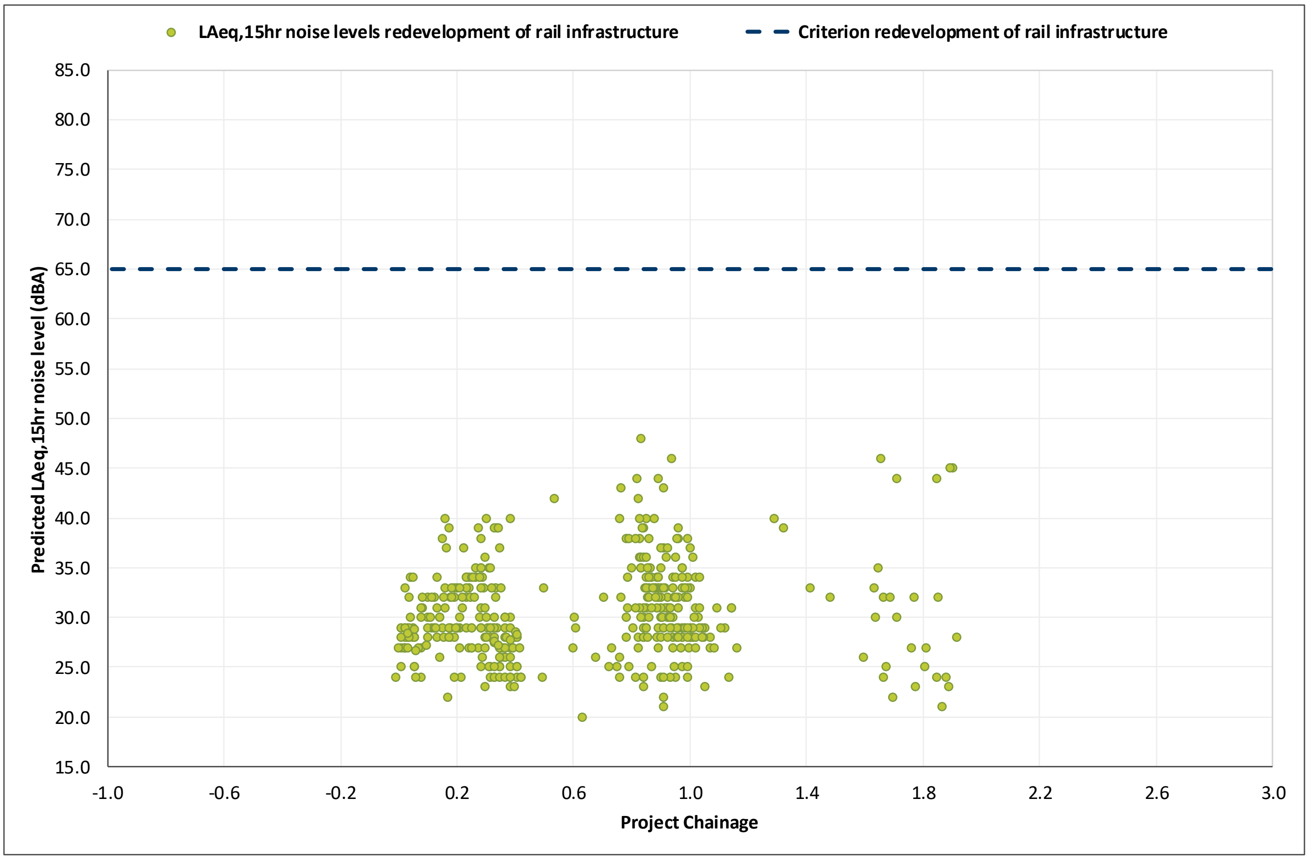
The Narromine West rail connection is located within the town of Narromine, approximately 5 km to the west of the main line of the proposal. The assessment of railway noise for the operation of the new railway connection is detailed in this section. The Narromine West connection involves the redevelopment of an existing rail line. The RING requires the assessment considers both the level of railway noise from the proposed connection and the potential change in railway noise levels between the existing rail infrastructure and the future infrastructure with the proposal.

10.1 Existing railway noise levels

For the purpose of the assessment, the daytime and night-time railway noise levels were predicted at the sensitive receivers within 750 m of the Narromine Connection. The current railway operations are relatively low with approximately 1 freight services during the daytime and 1 freight services during the night-time.

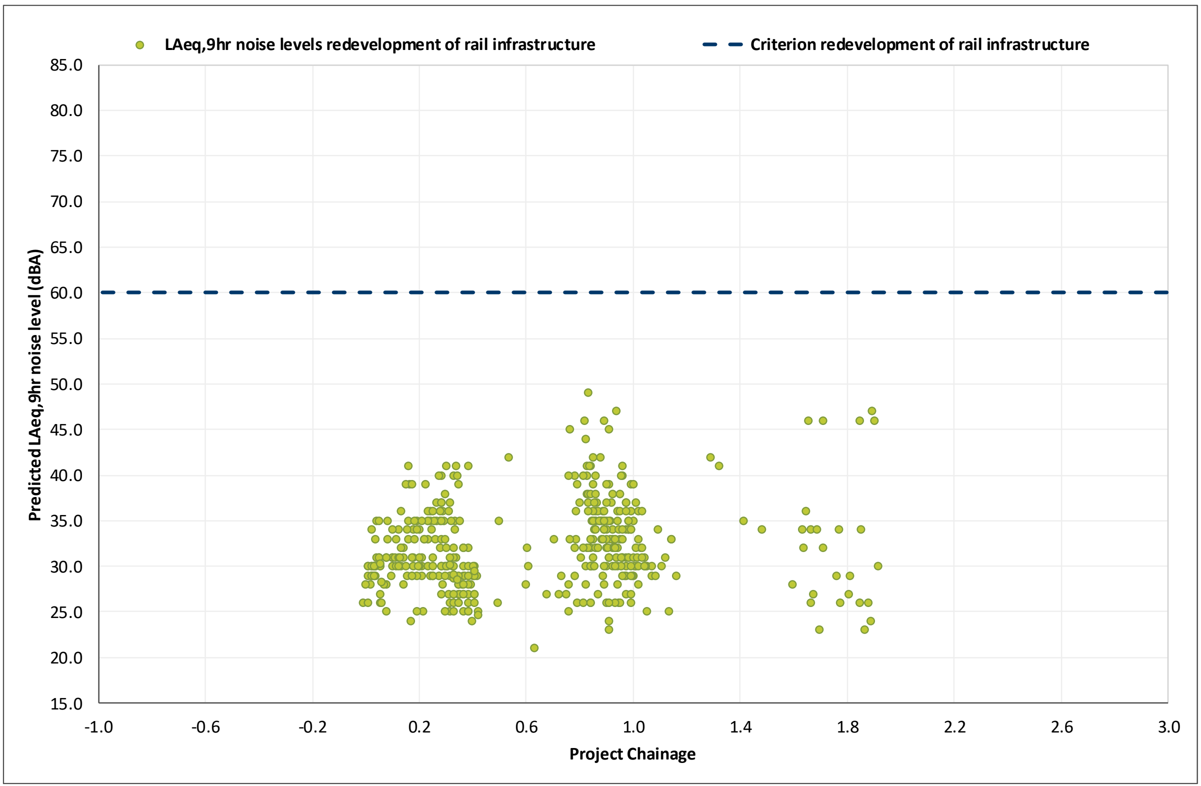
At time of the assessment, there were no known approved plans to enhance or upgrade the daily rail operations on the existing rail lines. The predicted noise levels were applied as the railway noise levels from existing railway infrastructure and compared to the year 2026 and year 2040 assessment scenarios. The predicted existing railway noise at the identified sensitive receivers is presented in **Figure 15** for the daytime $L_{Aeq(15hour)}$ noise levels and **Figure 16** for the night-time $L_{Aeq(9hour)}$ noise levels. The predicted maximum (L_{Amax}) noise levels are presented in **Figure 17**.

Figure 15 Predicted existing daytime $L_{Aeq(15hour)}$ railway noise levels



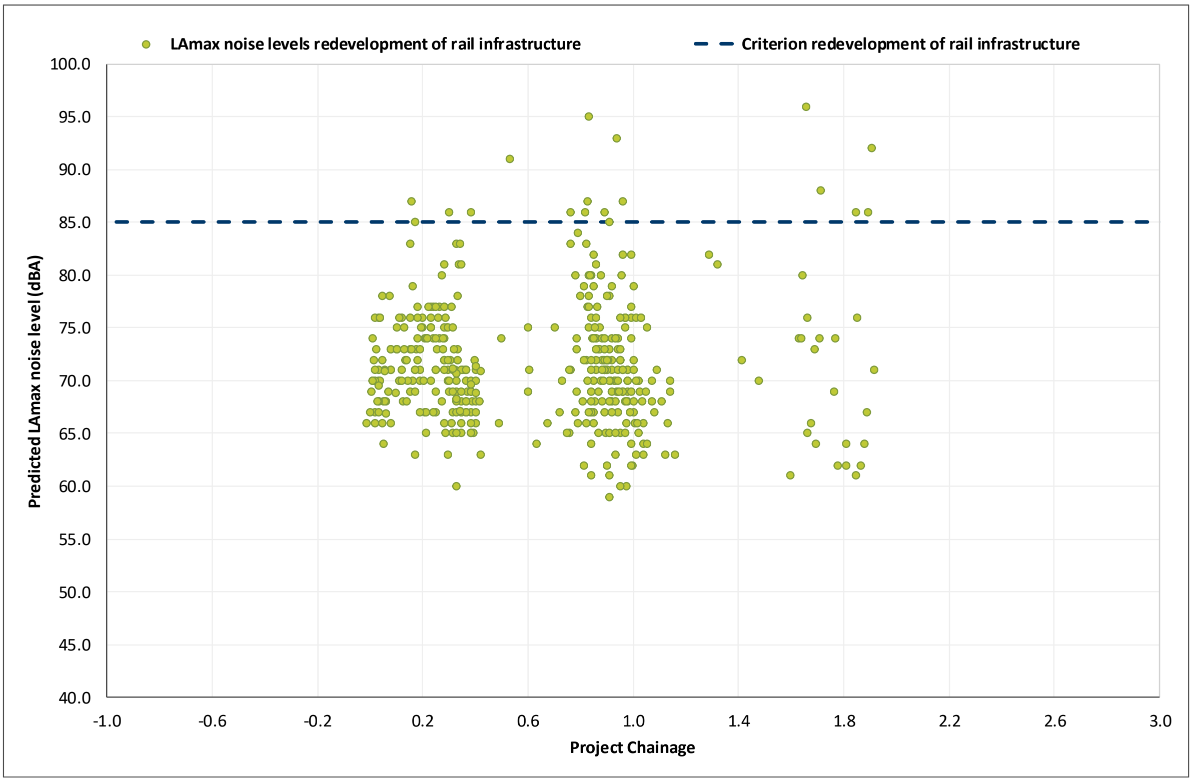
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

Figure 16 Predicted existing night-time $L_{Aeq(9hour)}$ noise levels



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

Figure 17 Predicted existing maximum railway noise levels



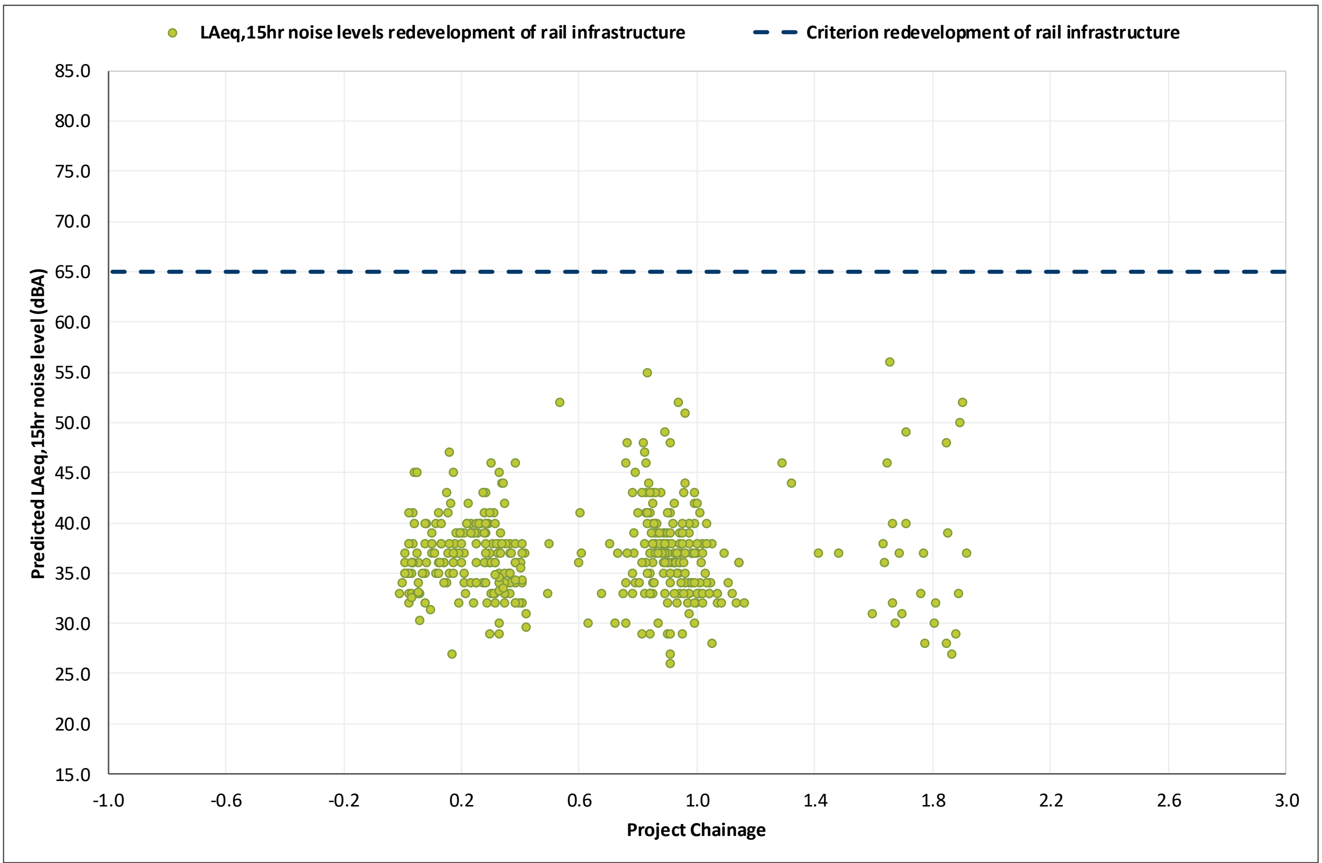
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

10.2 Railway noise levels at sensitive receivers – Proposal opening

10.2.1 Daytime railway noise levels

The predicted daytime $L_{Aeq(15hour)}$ railway noise levels at the identified sensitive receivers are detailed in **Figure 18**. The future railway noise levels achieve the daytime $L_{Aeq(15hour)}$ 65 dBA noise trigger level at all of the sensitive receivers.

Figure 18 Predicted daytime $L_{Aeq(15hour)}$ railway noise levels (year 2026)



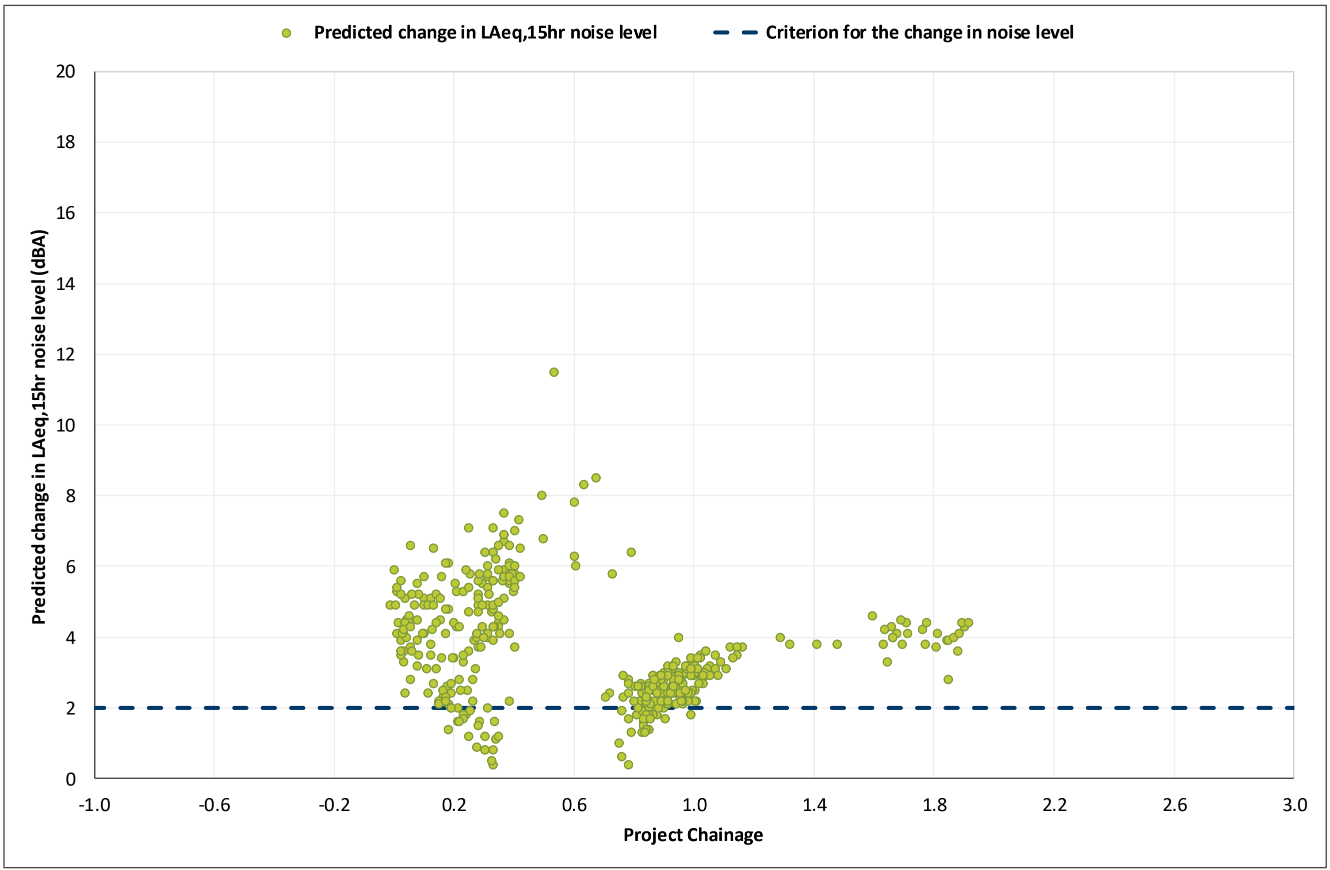
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

The noise trigger levels require the assessment to consider the potential change in railway noise levels with the operation of the proposal. The predicted change in the daytime railway noise levels are presented in **Figure 19**.

There is an expected increase in existing daytime rail noise levels as the introduction of the Narromine West connection increases the rail traffic from one train per day to three trains per day.

Whilst the noise levels at the majority of receivers are predicted to increase by more than 2 dBA, the daytime L_{Aeq} noise levels as shown in **Figure 18** are below the redeveloped trigger levels and as such, do not trigger the rail criterion

Figure 19 Predicted change from existing daytime $L_{Aeq(15hour)}$ railway noise levels (year 2026)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

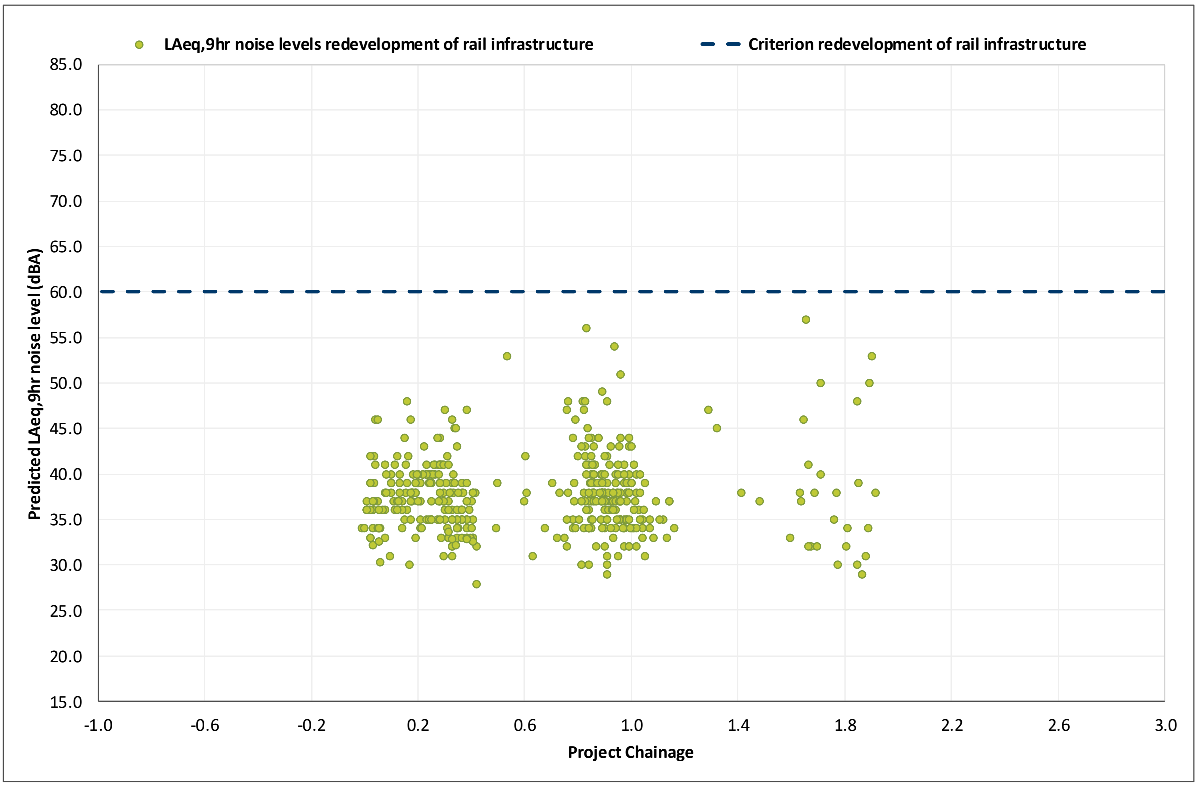
10.2.2 Night-time railway noise levels

The predicted night-time $L_{Aeq(9hour)}$ railway noise levels at the identified sensitive receivers are detailed in **Figure 20**. The future railway noise levels achieve the night-time $L_{Aeq(9hour)}$ 60 dBA noise trigger level at all of the sensitive receivers.

The predicted change in the night-time railway noise levels with the introduction of the Narromine West connection are presented in **Figure 21**.

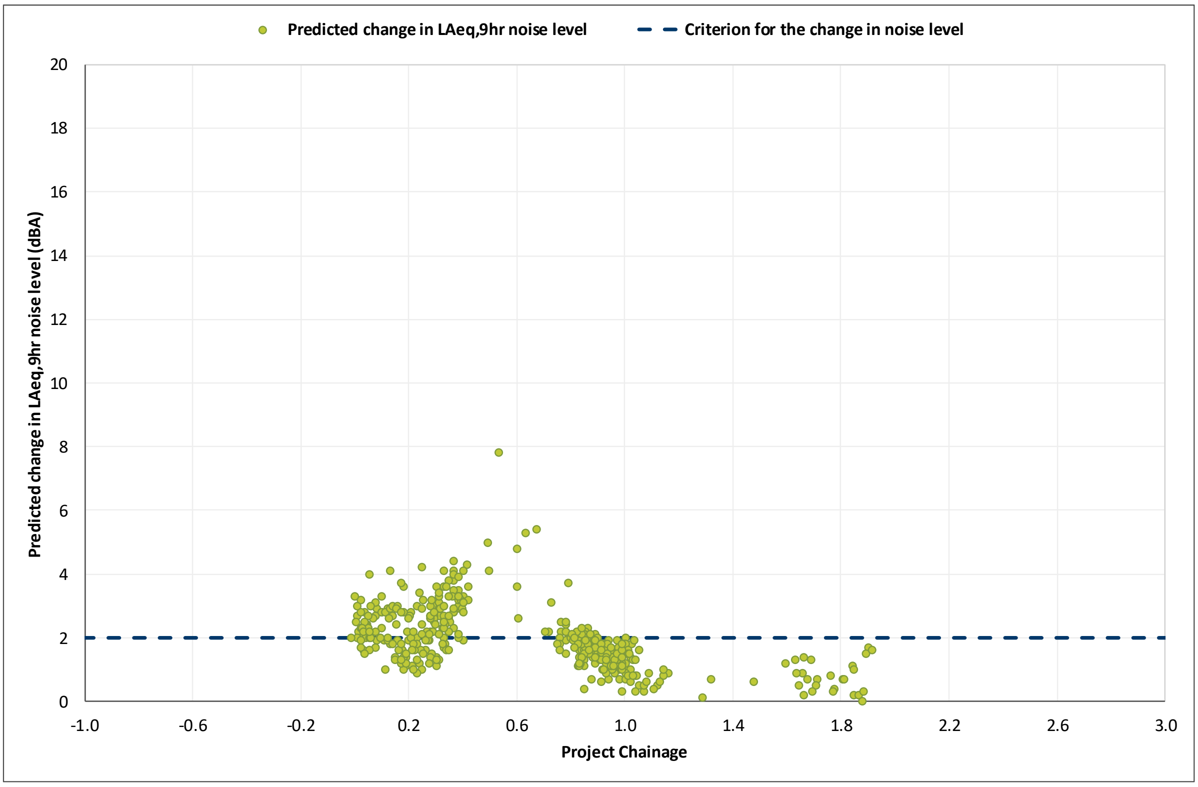
Similar to the daytime, noise levels at the majority of receivers are predicted to increase by more than 2 dBA during the night time. This is due to an increase number of trains operating on the rail line. Whilst there is a predicted increase in rail noise, the $L_{Aeq(9hour)}$ noise levels are predicted to be below the redeveloped trigger levels at all receivers and as such, do not trigger the assessment criterion.

Figure 20 Predicted night-time $L_{Aeq(9hour)}$ railway noise levels (year 2026)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

Figure 21 Predicted change from existing night-time $L_{Aeq(9hour)}$ railway noise levels (year 2026)

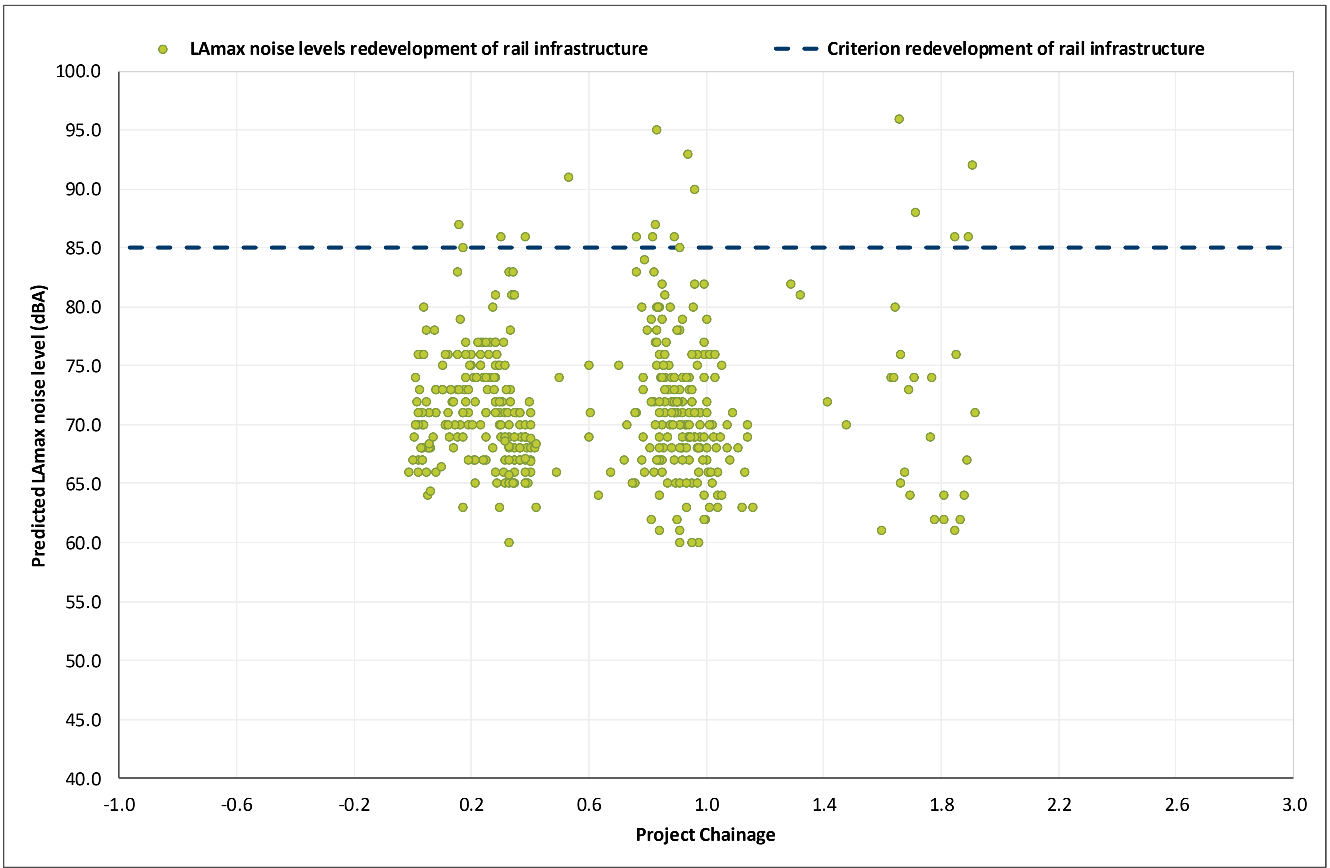


Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

10.2.3 Daytime and night-time maximum railway noise levels (Year 2026)

The predicted daytime and night-time maximum (LAmax) railway noise levels at the residential receivers are presented in **Figure 22**.

Figure 22 Predicted daytime and night-time maximum railway noise levels (Year 2026)

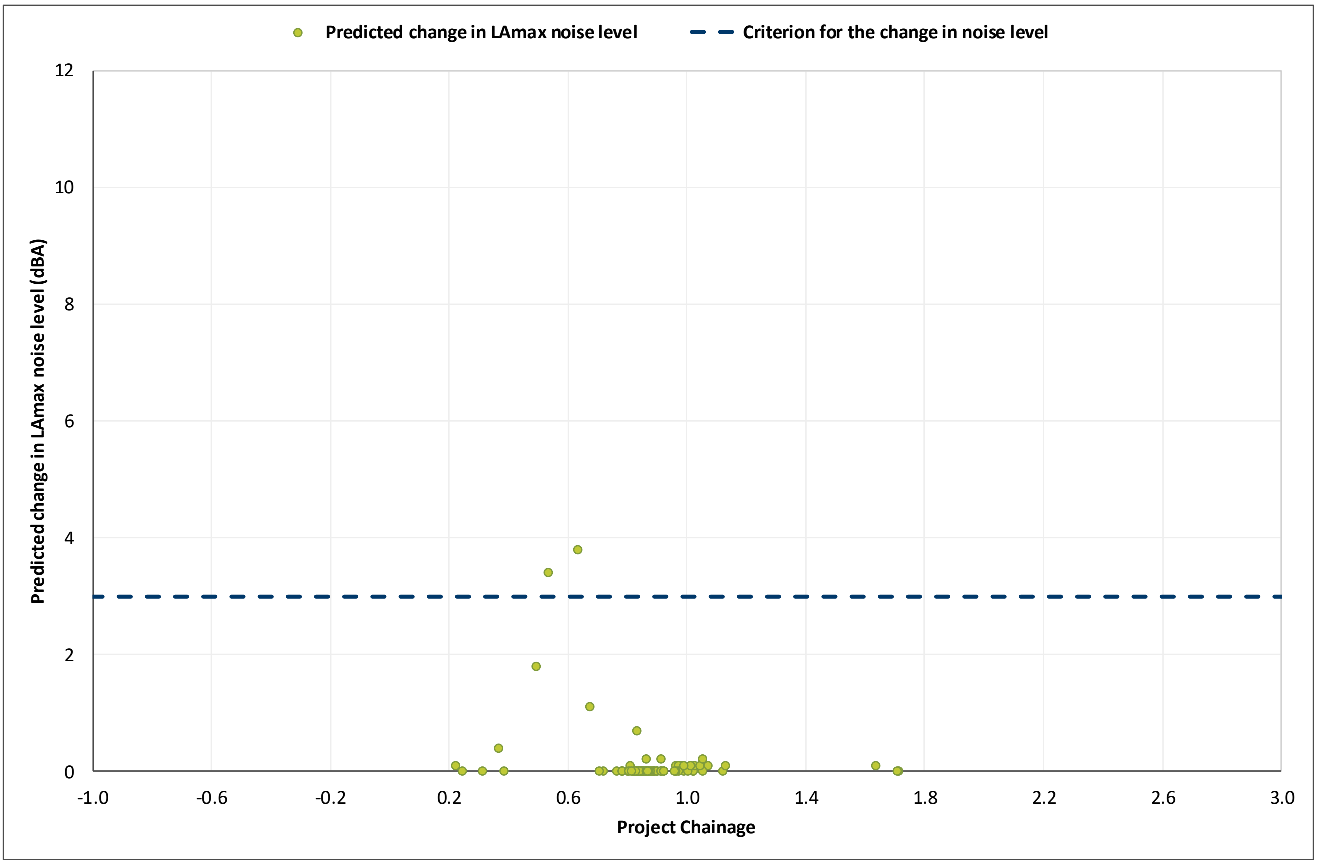


Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

The predicted noise levels achieve the LAmax 85 dBA noise criterion at the majority of the sensitive residential receivers. There are approximately 17 residential receivers where predicted noise levels are above the daytime LAmax noise criterion by 1 dBA to 11 dBA.

The predicted change in LAmax railway noise levels with the introduction of the Narromine West connection are presented in **Figure 23**. Of the 17 sensitive receivers where noise levels are above the LAmax 85 dBA noise criterion, the LAmax noise level is predicted to change by 3 dBA or more at only 1 (SLR ID 240863) sensitive receiver.

Figure 23 Predicted change from existing LAmax railway noise levels (Year 2026)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

Whilst **Figure 23** shows two receivers that are predicted to change by more than 3 dBA, only one of these receivers (SLR ID 240863) is above the 85 dBA noise criterion.

A review of the noise levels at receiver (SLR ID 240863) indicates that the change in noise level is due to the modelled train type for the proposed future inland rail operations. Currently, the model includes the operation of a locomotive type for the proposed future operations which is not current operating on the existing rail line.

The proposal is not changing the alignment of the existing rail line which is located approximately 40 m from this receiver. The maximum noise emission from the proposed train type is 3 dB higher than the assumed existing trains which operate on this rail line. It is the difference in the assumed train noise emissions, rather than the proposed change in railway infrastructure, that is primary influence on the future change in railway noise. Whilst this aspect is relevant for all assessed receivers, it is the determining factor in the identified trigger of the noise level criteria at SLR ID 240863.

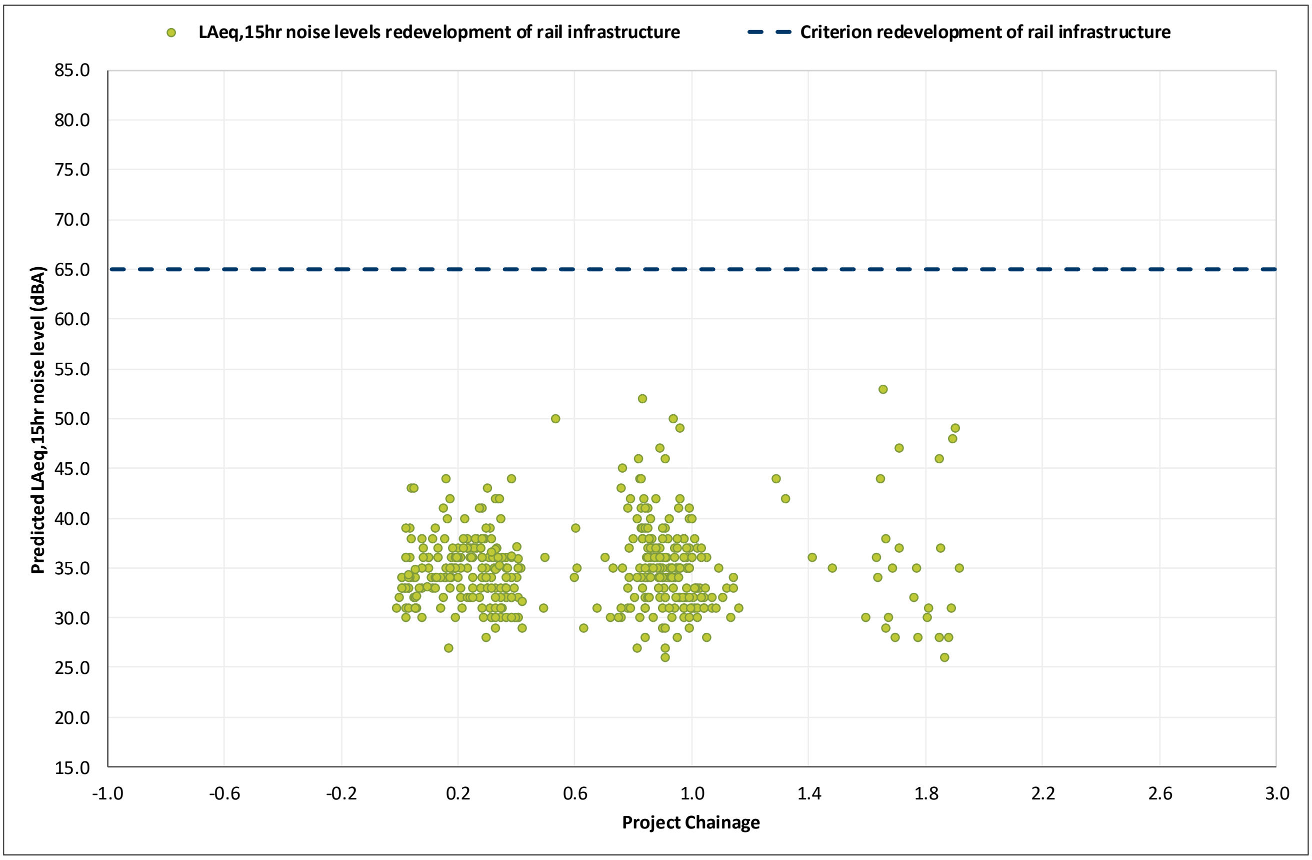
During detailed design it is recommended that the existing and future train operations be reviewed to confirm the final rolling stock operations where this is identified as a key influence on the forecast railway noise levels and a potential trigger for the review of noise mitigation.

10.3 Railway noise levels at sensitive receivers – Design year

10.3.1 Daytime railway noise levels

The predicted daytime $L_{Aeq(15hour)}$ railway noise levels at the identified sensitive receivers are detailed in **Figure 24**. The future railway noise levels achieve the daytime $L_{Aeq(15hour)}$ 65 dBA noise trigger level at all of the sensitive receivers.

Figure 24 Predicted daytime $L_{Aeq(15hour)}$ railway noise levels (year 2040)



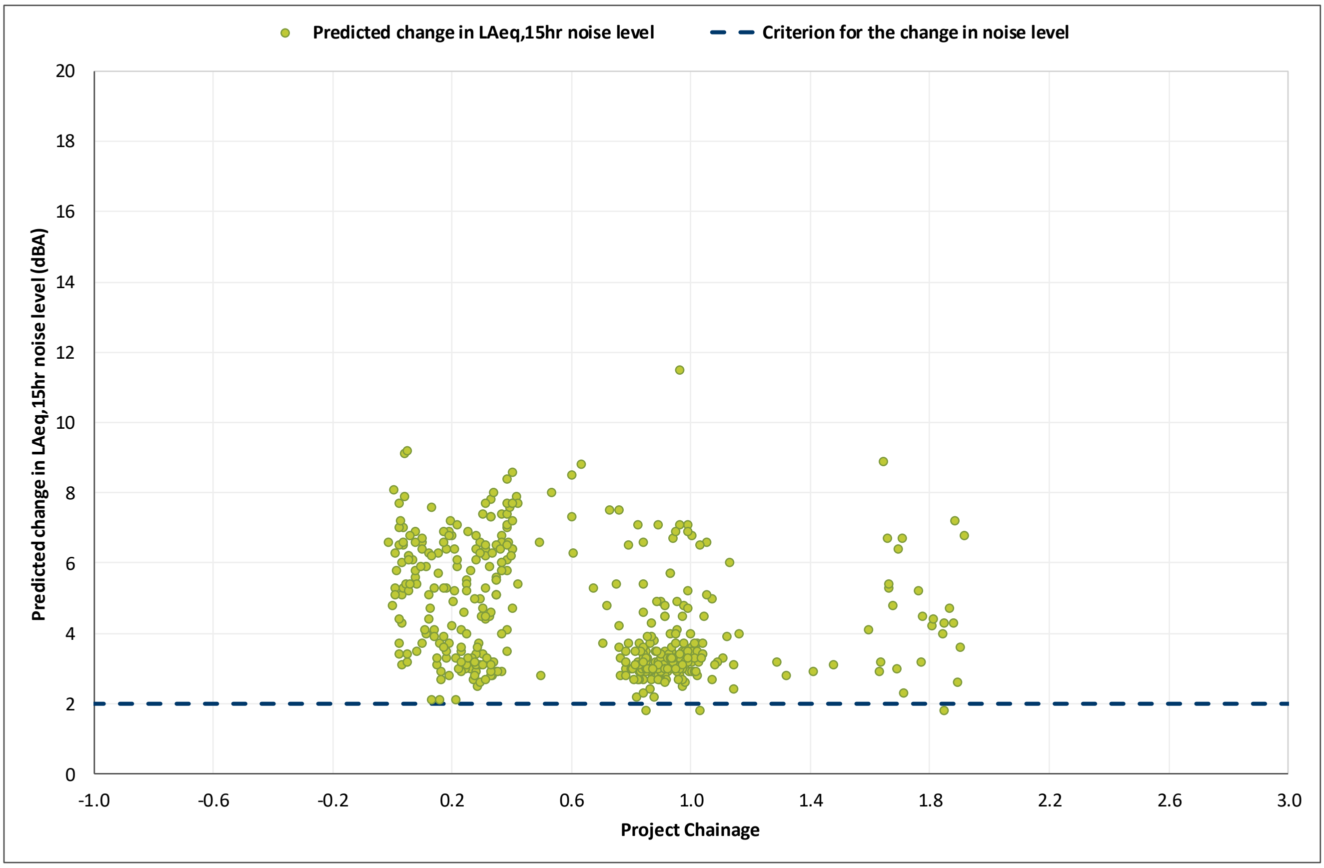
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

The noise trigger levels require the assessment to consider the potential change in railway noise levels with the operation of the proposal. The predicted change in the daytime railway noise levels are presented in **Figure 25**.

There is an expected increase in existing daytime rail noise levels as the introduction of the Narromine West connection increases the rail traffic from one train per day to four trains per day.

Whilst the noise levels at the majority of receivers are predicted to increase by more than 2 dBA, the daytime L_{Aeq} noise level as shown in **Figure 24** are below the redeveloped trigger levels and as such, do not trigger the rail criterion

Figure 25 Predicted change from existing daytime LAeq(15hour) railway noise levels (year 2040)

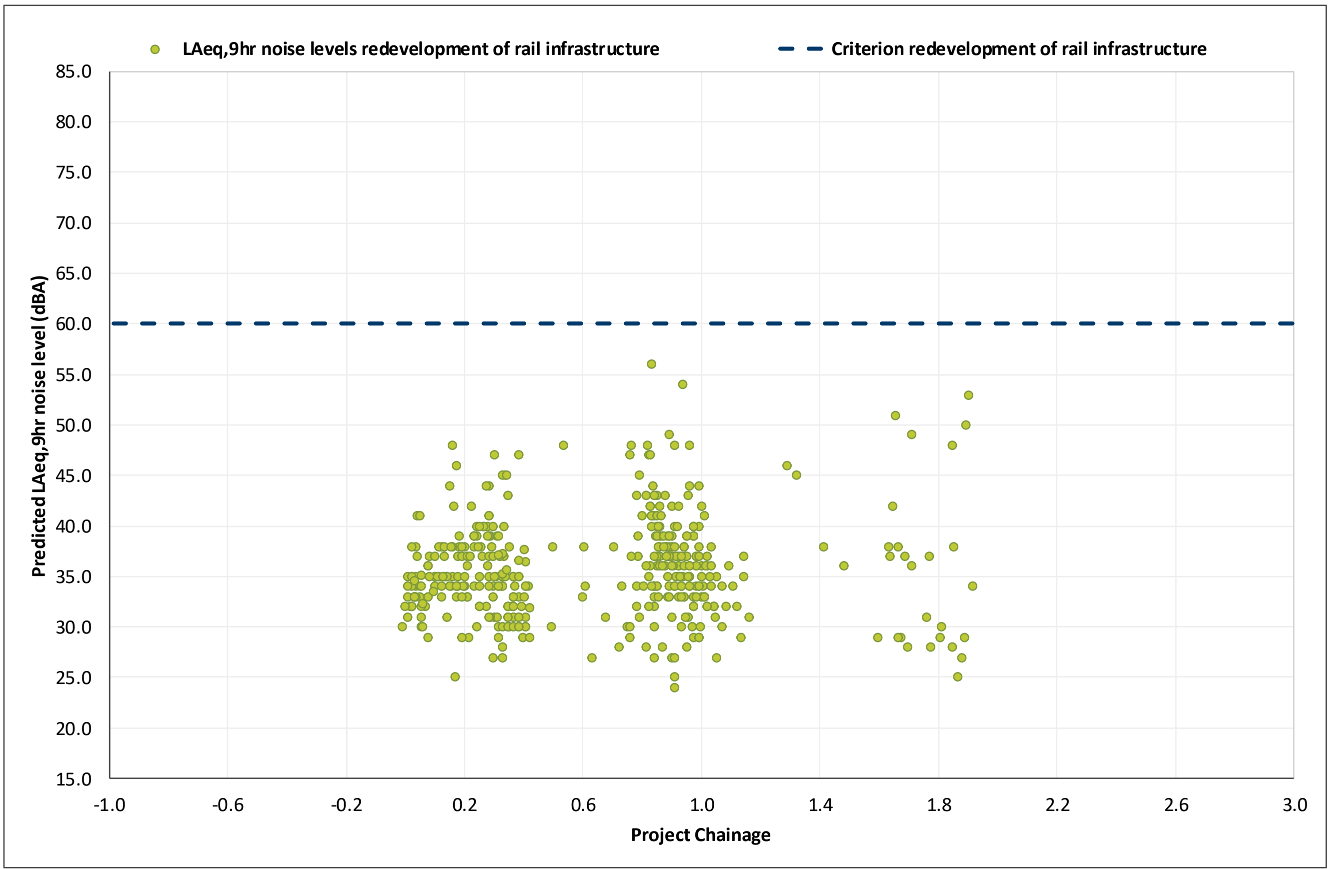


Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

10.3.2 Night-time railway noise levels

The predicted night-time LAeq(9hour) railway noise levels at the identified sensitive receivers are detailed in **Figure 26**. The future railway noise levels achieve the night-time LAeq(9hour) 60 dBA noise trigger level at all of the sensitive receivers.

Figure 26 Predicted night-time $L_{Aeq(9hour)}$ railway noise levels (year 2040)



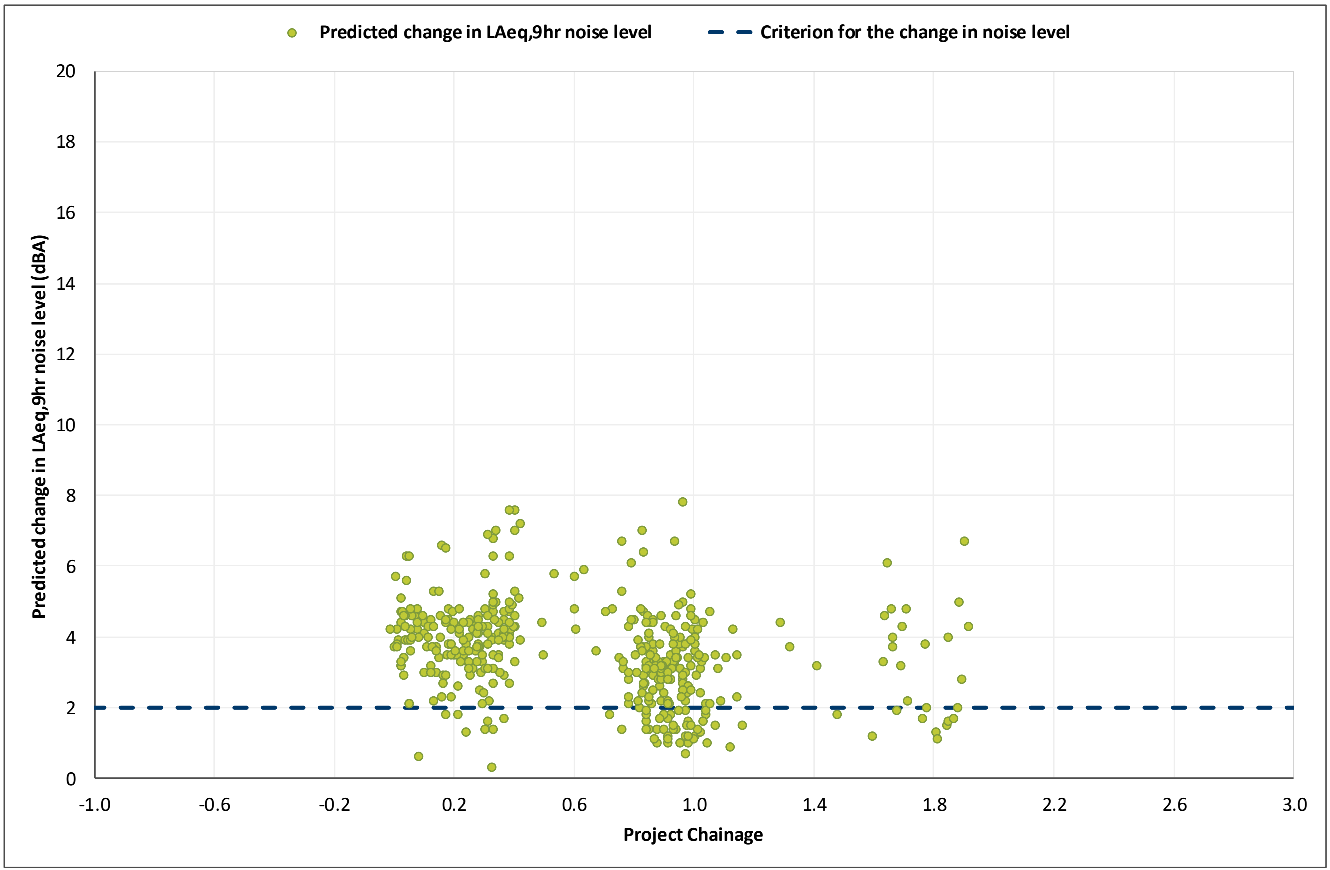
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

The predicted change in the night-time railway noise levels with the introduction of the Narromine West connection are presented in **Figure 27**.

Similar to the daytime, noise levels at the majority of receivers are predicted to increase by more than 2 dBA during the night time.

This is due to an increase number of trains operating on the rail line. Whilst there is a predicted increase in rail noise, the $L_{Aeq(9hour)}$ noise levels are predicted to be below the redeveloped trigger levels at all receivers and as such, do not trigger the assessment criterion.

Figure 27 Predicted change from existing night-time $L_{Aeq(9hour)}$ railway noise levels (year 2040)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

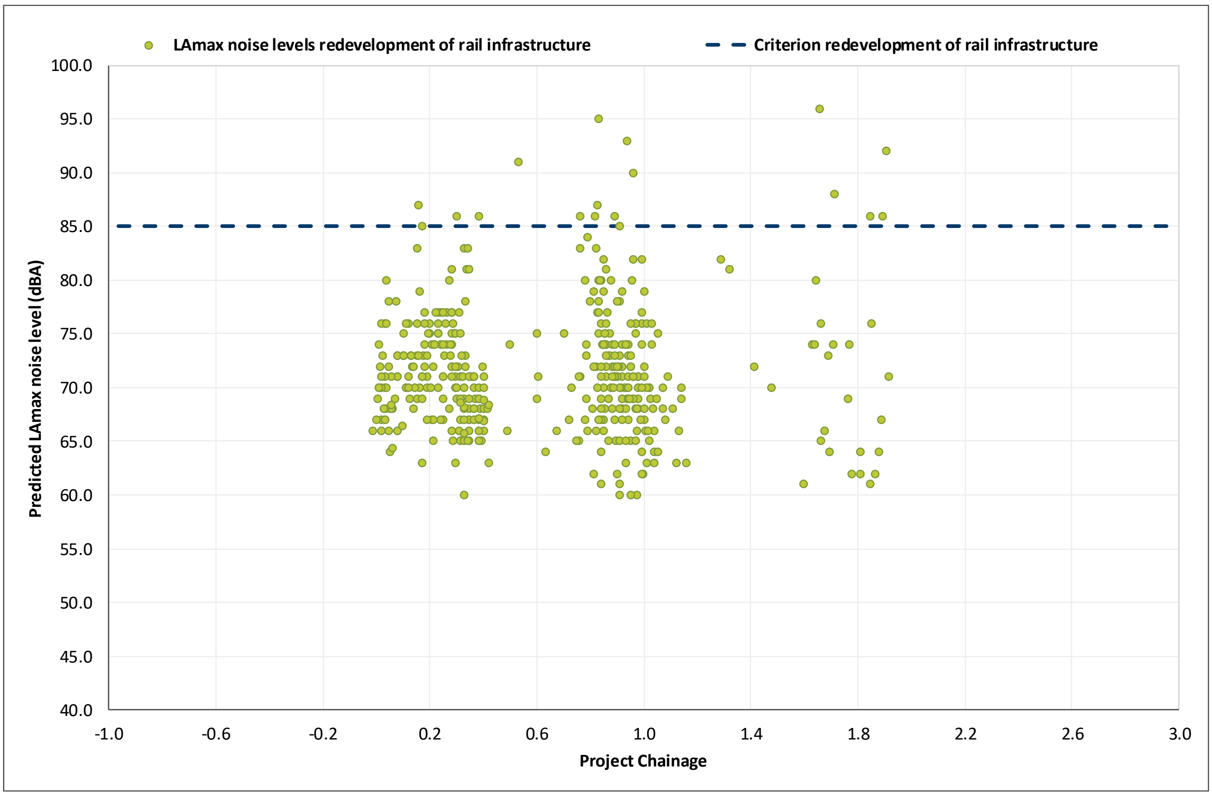
10.3.3 Daytime and night-time maximum railway noise levels (Year 2040)

The predicted daytime and night-time maximum (L_{Amax}) railway noise levels at the residential receivers are presented in **Figure 28**.

The predicted noise levels achieve the L_{Amax} 85 dBA noise criterion at the majority of the sensitive residential receivers. There are up to 17 residential receivers where predicted noise levels are above the daytime L_{Amax} noise criterion by 1 dBA to 11 dBA.

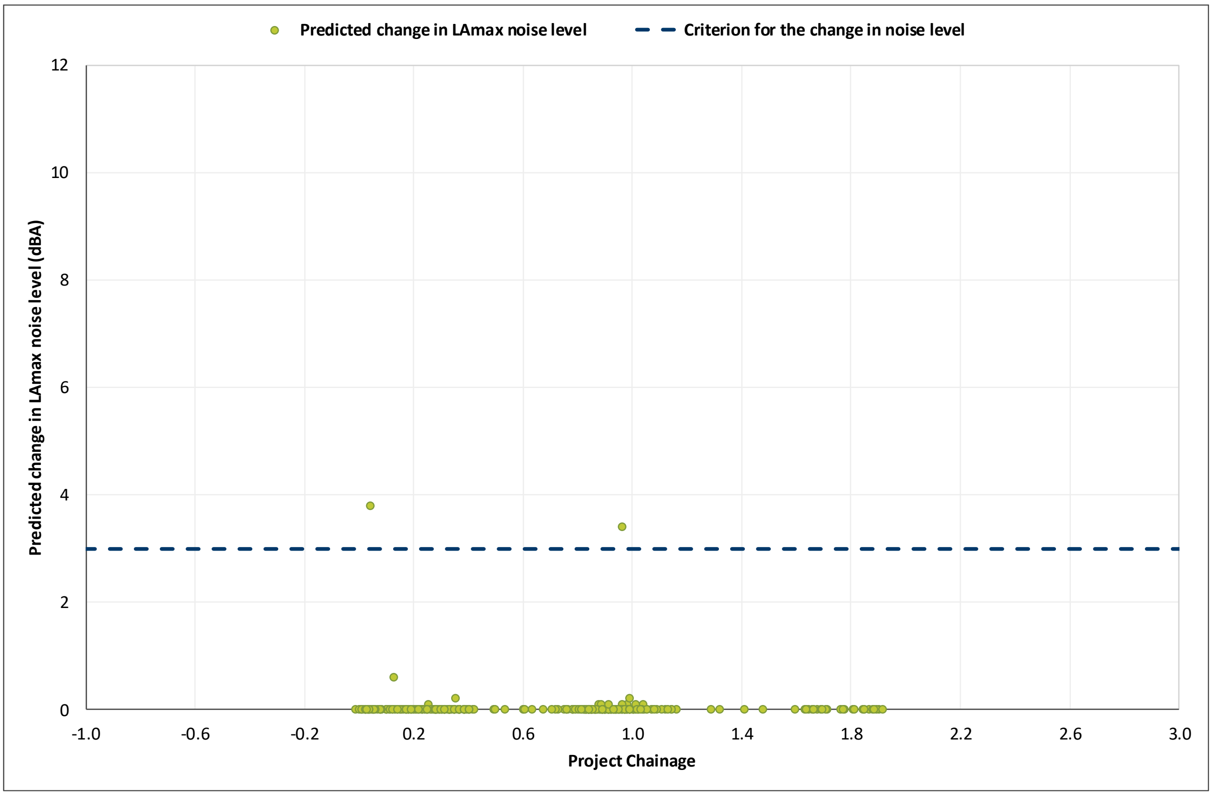
The predicted change in L_{Amax} railway noise levels with the introduction of the Narromine West connection are presented in **Figure 29**.

Figure 28 Predicted daytime and night-time maximum railway noise levels (Year 2040)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

Figure 29 Predicted change from existing LAmax railway noise levels (Year 2040)



Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

Of the 17 sensitive receivers where noise levels are above the L_{Amax} 85 dBA noise criterion, the L_{Amax} noise level is predicted to change by 3 dBA or more at only 1 (SLR ID 240863) sensitive receiver. Whilst **Figure 29** shows two receivers that are predicted to change by more than 3 dBA, only one of these receivers is above the 85 dBA noise criterion.

Consistent with the assessment of railway noise levels at the commencement of railway operations in 2026, a review of the noise levels at receiver (SLR ID 240863) indicates that the change in noise level is due to the modelled locomotive type for the proposed future inland rail operations.

During detailed design it is recommended that the existing and future train operations be reviewed to confirm the final rolling stock operations where this is identified as a key influence on the forecast railway noise levels and a potential trigger for the review of noise mitigation.

11 Summary of the railway noise assessment

11.1 Receivers triggering the investigation of noise mitigation

Where predicted railway noise levels at sensitive receivers are above the adopted noise criteria, ARTC will investigate feasible and reasonable measures to reduce noise levels and mitigate potential impacts.

The review of noise mitigation is triggered at up to 41 individual sensitive residential receivers for the commencement of railway operations 2026 and up to 53 individual sensitive residential receivers (12 additional receivers) for the design year operations in year 2040.

The total number of receivers triggering a review of mitigation considers that not all receivers trigger both the L_{Aeq} and L_{Amax} noise criteria. The total is the combined number of individual receivers with levels triggering one or both of the noise criteria metrics.

The noise criteria were most frequently triggered by the night-time L_{Aeq} rail noise levels, as the number of trains per hour is greater during the night-time and the noise criteria are 5 dBA more stringent than the daytime.

The sensitive residential receivers where noise levels were predicted above the night-time noise criteria are detailed in **Table 28** for rail operations in 2040, with the individual criteria triggers highlighted in bold. The predicted noise levels are provided for trains operating on the tracks of the main line and crossing loops and the separate contribution from the level crossings.

Where the level crossings were outside of the 2 km calculation area for an individual receiver, the predicted noise from the level crossing has been reported as <40 dBA L_{Aeq} and <60 dBA L_{Amax} and do not provide a cumulative increase to the railway noise levels from the main line and crossing loops.

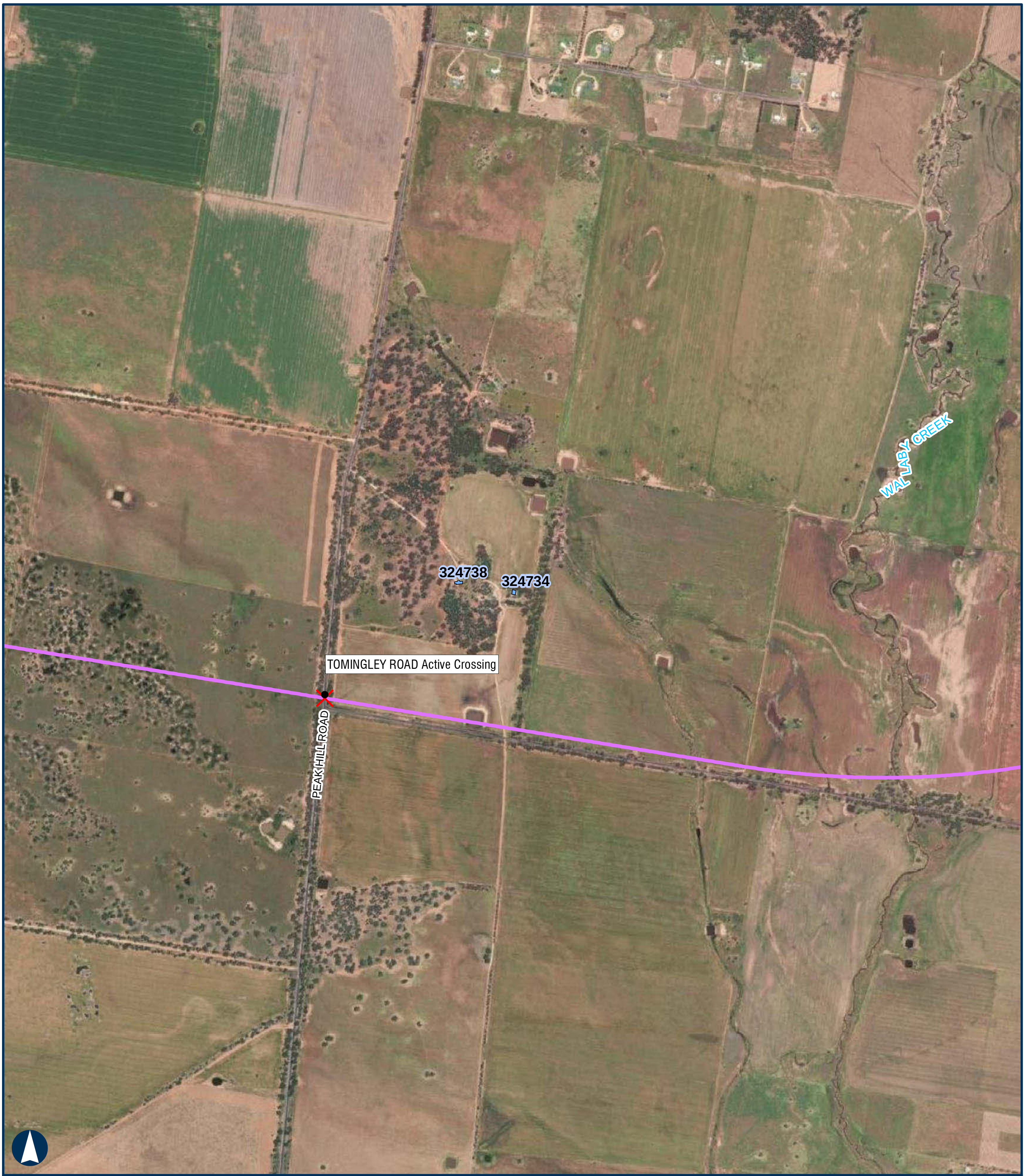
The location of the sensitive receivers, including the non-residential sensitive receivers, where noise levels trigger the assessment criteria are presented in **Figure 30**.

Table 28 Residential receivers triggering the investigation of noise mitigation (night-time 2040)

Sensitive receiver ID	Rail noise level from the main line and crossing loops, dBA		Noise from level crossings, dBA		Overall night-time operational rail noise levels, dBA	
	LAeq(9hour)	LAmax	LAeq(9hour)	LAmax	LAeq(9hour)	LAmax
243471	60	84	45	85	**60**	**85**
243473	58	82	39	79	**58**	**82**
243772	56	78	36	74	**56**	78
243791	58	81	36	74	**58**	**81**
243829	55	81	31	69	55	**81**
243868	57	81	38	77	**57**	**81**
243906	57	80	39	78	**57**	80
243927	57	81	30	68	**57**	**81**
243931	58	82	32	70	**58**	**82**
243996	56	80	20	60	**56**	**80**
244053	56	80	40	78	**56**	80
244057	56	80	33	72	**56**	80
244309	57	81	42	80	**57**	**81**
245432	64	88	15	55	**64**	**88**
245454	60	84	16	56	**60**	**84**
245459	65	89	15	56	**65**	**89**
245462	56	80	<40	<60	**56**	80
245512	65	89	<40	<60	**65**	**89**
245517	64	90	<40	<60	**64**	**90**
245523	58	82	<40	<60	**58**	**82**
245524	63	87	<40	<60	**63**	**87**
245541	59	82	<40	<60	**59**	**82**
245544	56	80	<40	<60	**56**	80
246054	58	81	<40	<60	**58**	**81**
246187	56	79	18	57	**56**	79
246221	57	81	18	56	**57**	**81**
246230	57	81	17	56	**57**	**81**
246271	56	79	<40	<60	**56**	79
246320	56	80	<40	<60	**56**	80
246470	58	82	26	64	**58**	**82**
246532	60	84	24	62	**60**	**84**

Sensitive receiver ID	Rail noise level from the main line and crossing loops, dBA		Noise from level crossings, dBA		Overall night-time operational rail noise levels, dBA	
	LAeq(9hour)	LAmax	LAeq(9hour)	LAmax	LAeq(9hour)	LAmax
246536	59	82	24	63	**59**	**82**
246673	62	86	49	88	**62**	**88**
324734	56	79	31	70	**56**	79
324738	57	81	37	76	**57**	**81**
331634	67	91	28	67	**67**	**91**
331710	57	80	33	72	**57**	80
331728	57	81	32	71	**57**	**81**
331749	56	80	39	77	**56**	**80**
331774	55	80	39	79	**55**	80
331834	56	79	25	64	**56**	79
331851	62	86	23	62	**62**	**86**
331852	59	83	35	74	**59**	**83**
331859	56	80	22	61	**56**	80
331860	59	84	36	75	**59**	**84**
331977	56	80	33	72	**56**	80
332038	57	81	31	70	**57**	**81**
332047	58	82	24	63	**58**	**82**
332063	63	88	33	72	**63**	**88**
332467	59	83	<40	<60	**59**	**83**
332471	56	80	<40	<60	**56**	80
332615	57	81	43	81	**58**	**81**
332835	60	83	38	77	**60**	**83**

Note Where predicted noise levels trigger the assessment criteria this has been highlighted in **bold**.



NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 1 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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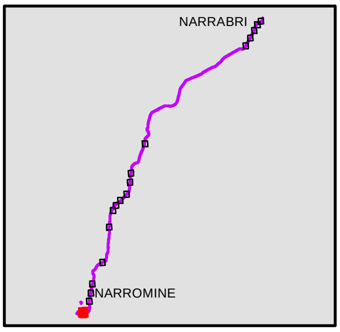
Paper: A4 Scale: 1:20,000
Date: 31-Aug-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive receivers triggering the investigation of noise mitigation



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NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 2 of 18

500m

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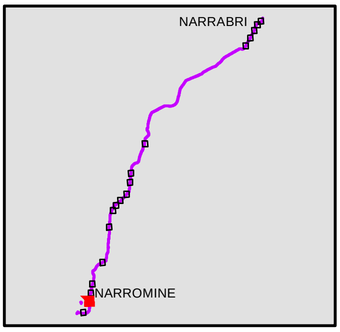

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NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 3 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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Scale: 1:20,000
Date: 31-Aug-2021
Author: JG

- Level Crossings
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- Bridges and Viaducts
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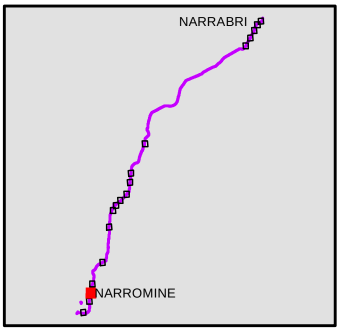

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NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 4 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

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- Rail Alignment/Centreline
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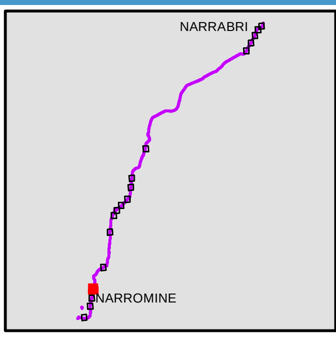

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NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 5 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

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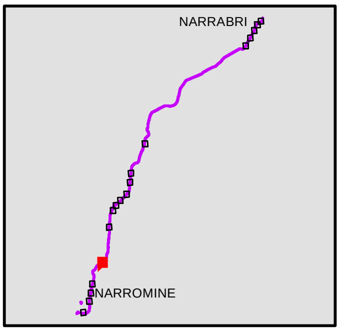
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive receivers triggering the investigation of noise mitigation



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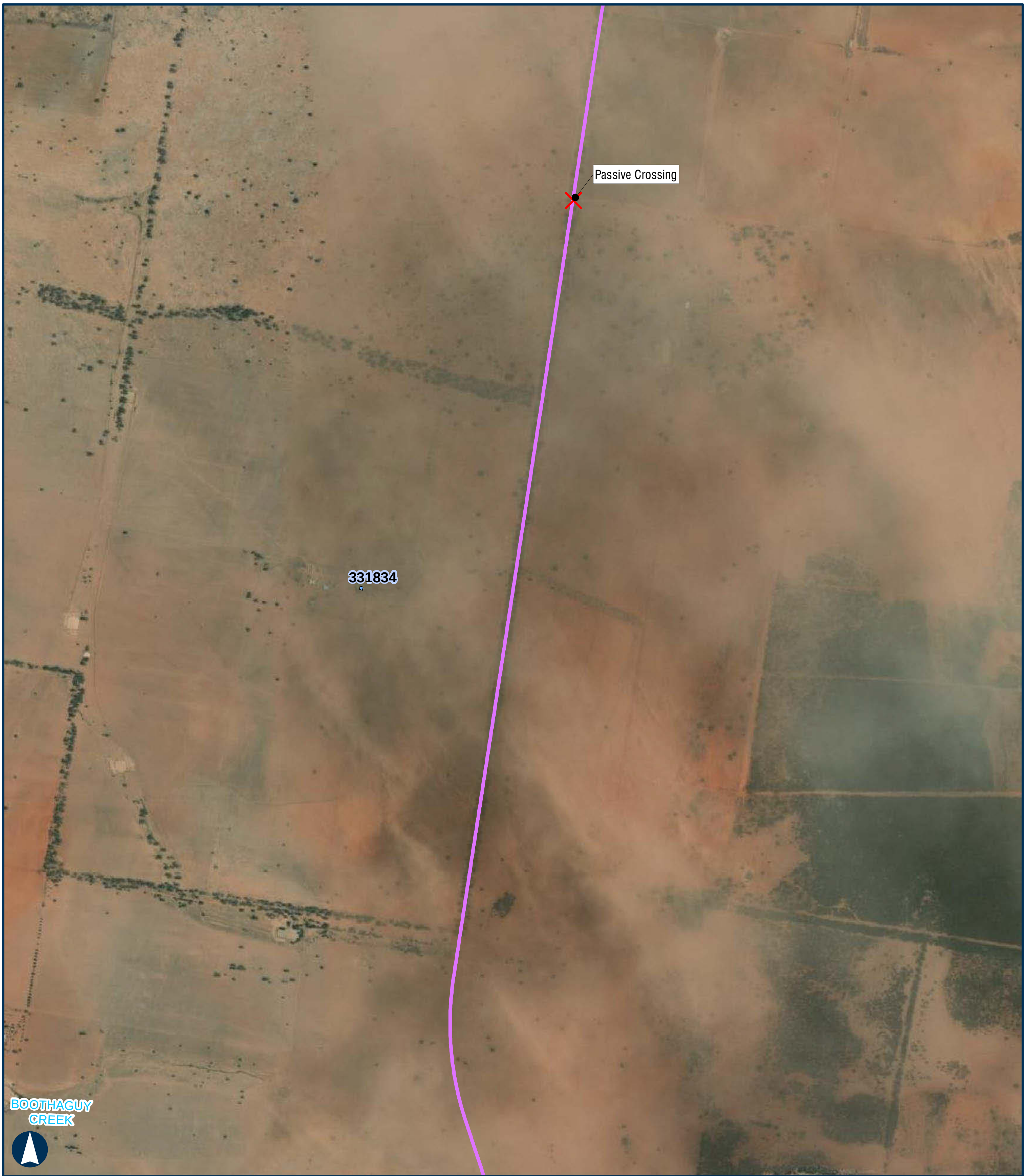

NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 6 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

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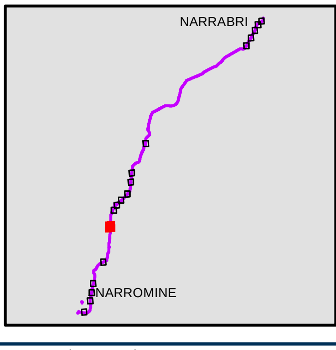
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive receivers triggering the investigation of noise mitigation



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Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 7 of 18

500m

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Date: 31-Aug-2021
Author: JG

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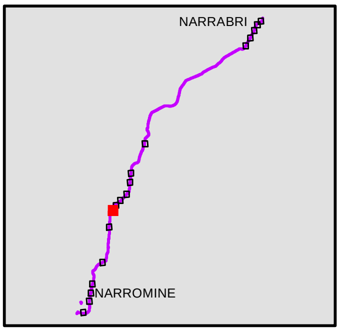

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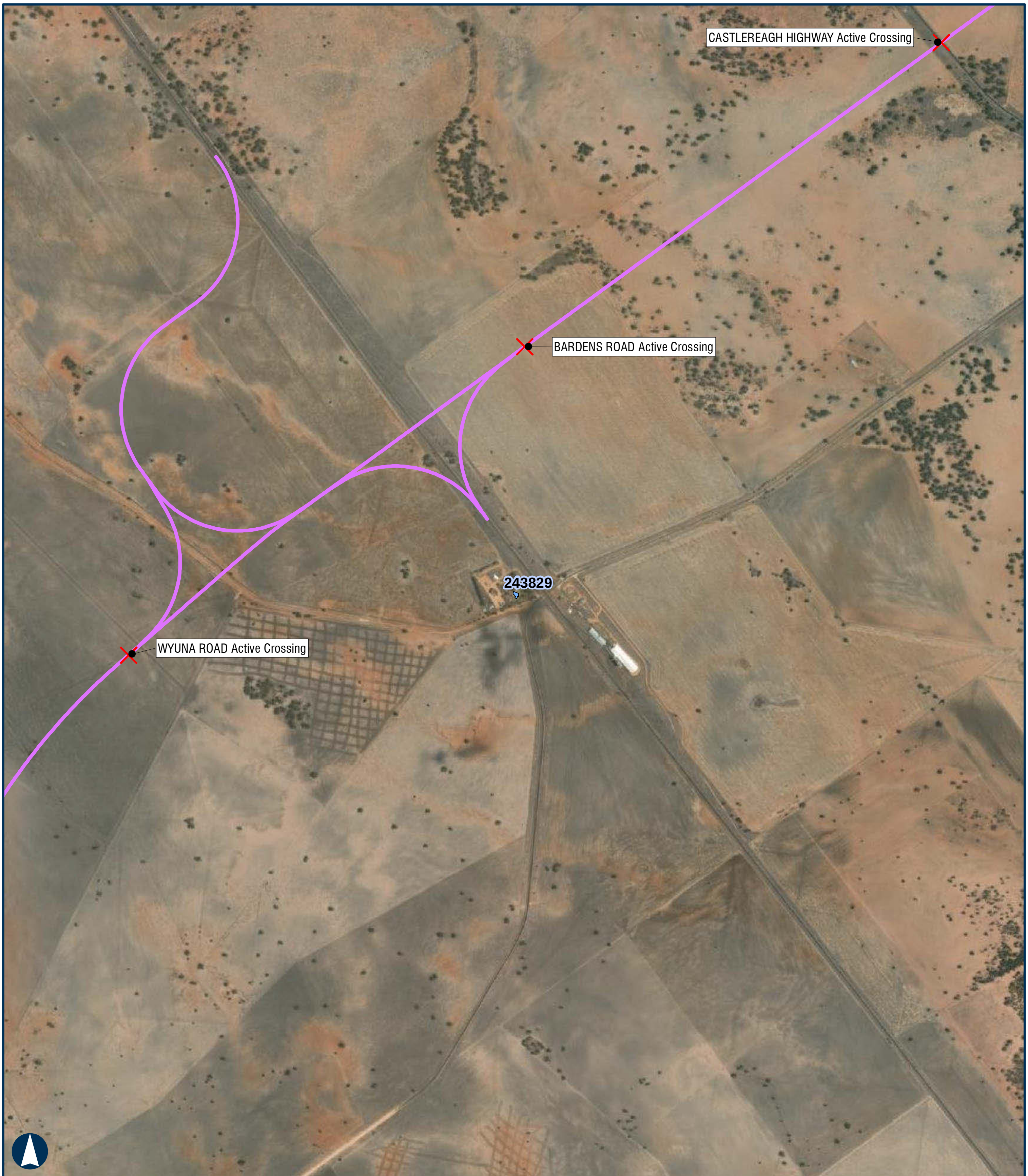

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Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 8 of 18

500m

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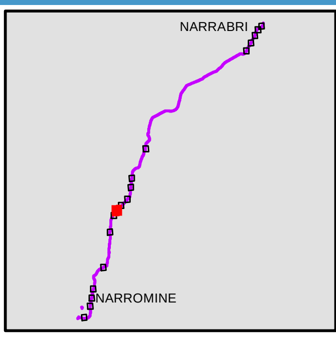
- Sensitive receivers triggering the investigation of noise mitigation



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Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 9 of 18

500m

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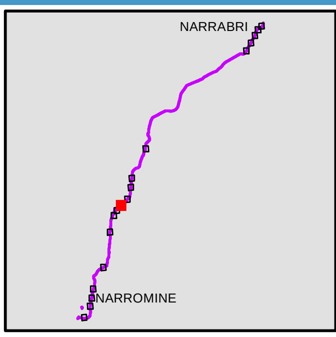

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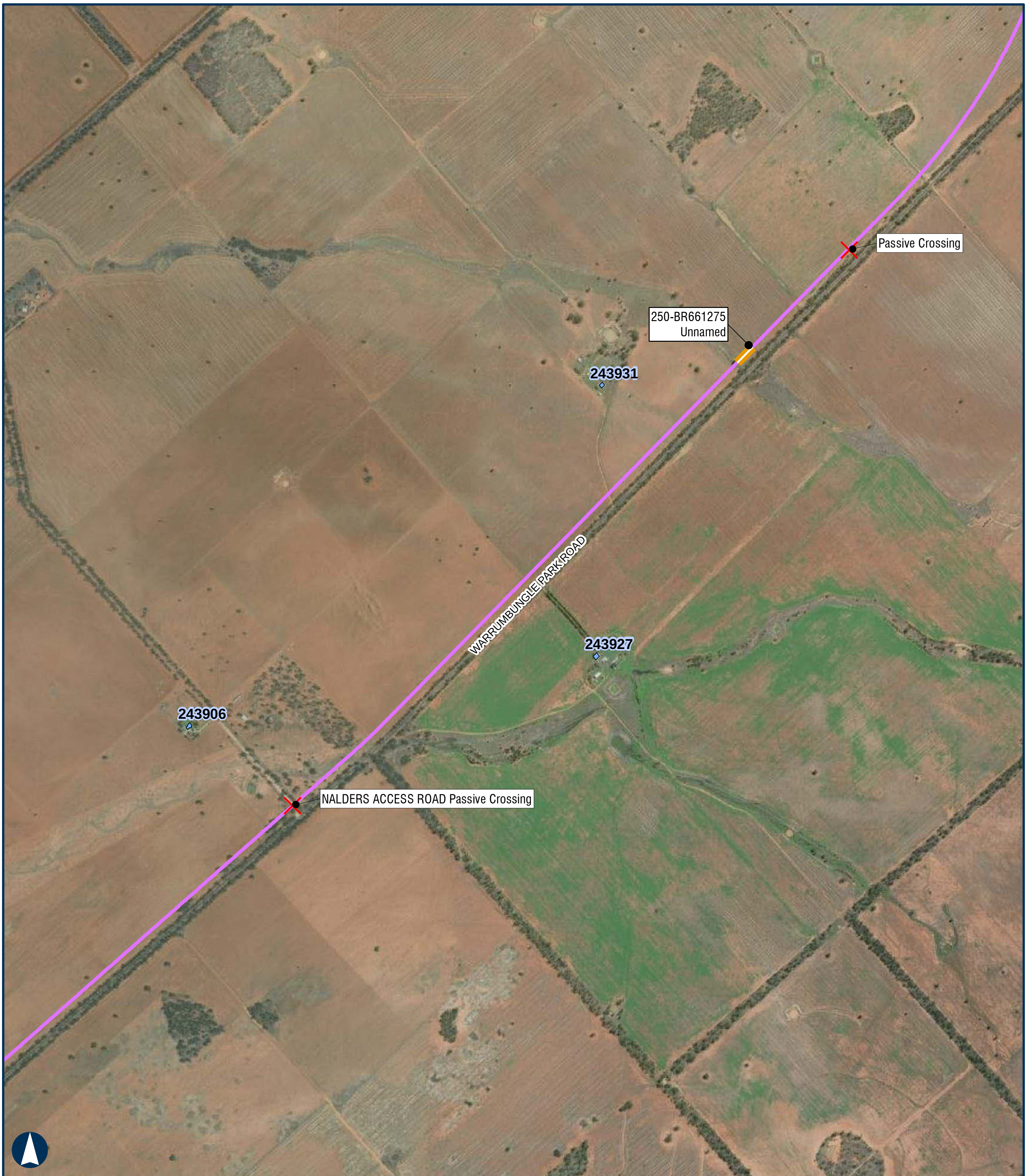

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Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 10 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
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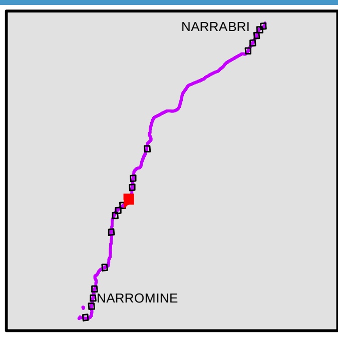

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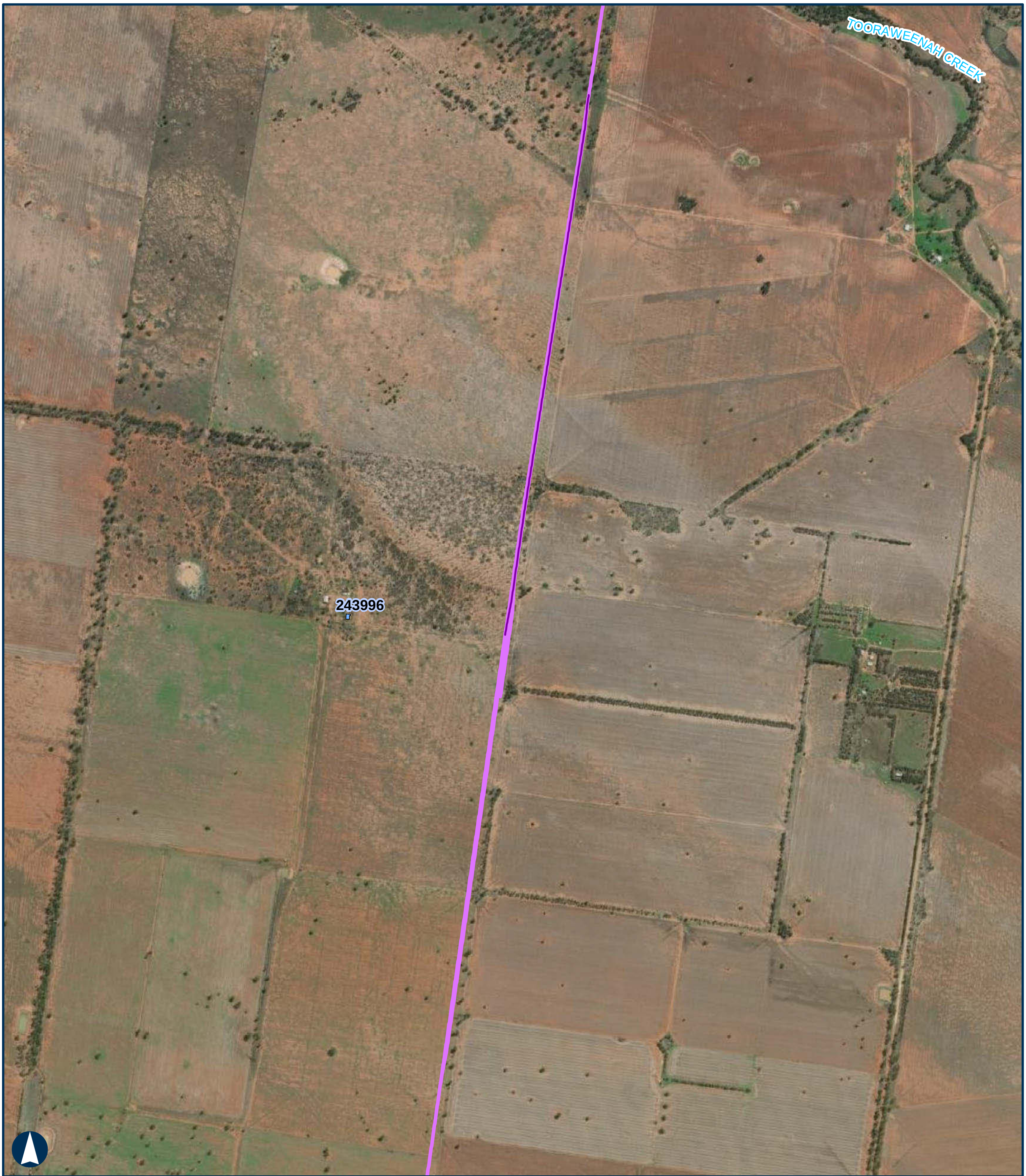

NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 11 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

- Level Crossings
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- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
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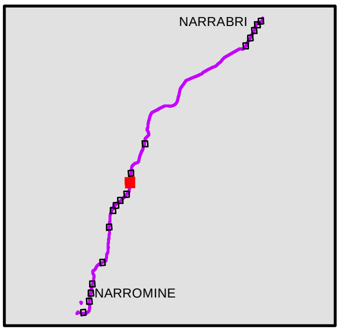

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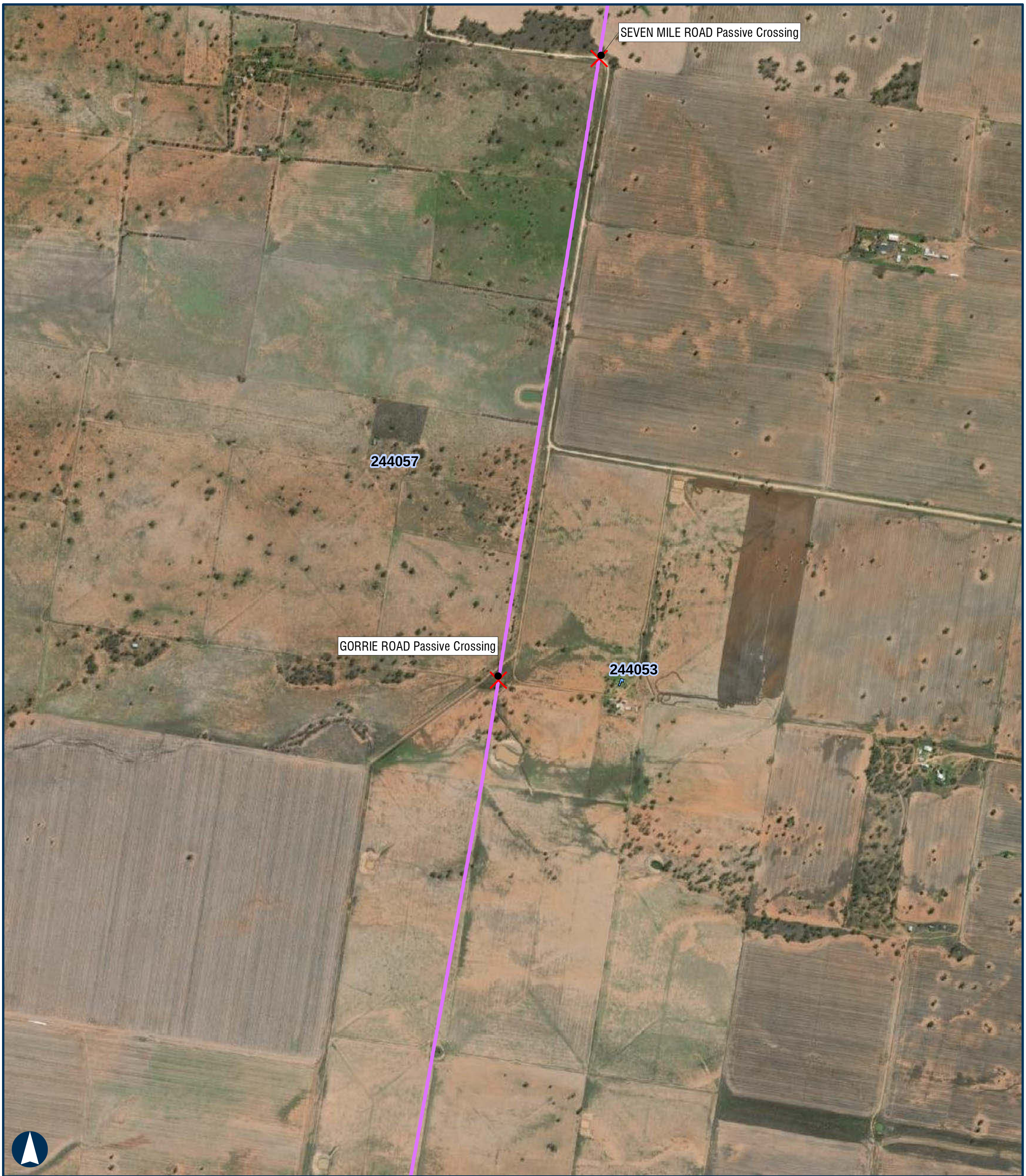

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Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 12 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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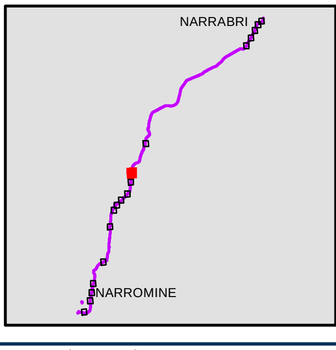

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NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 13 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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- Bridges and Viaducts
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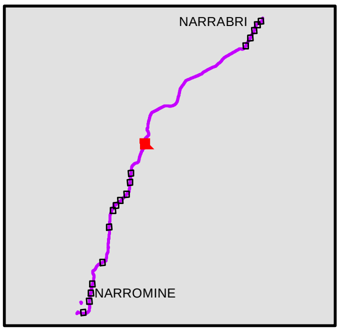

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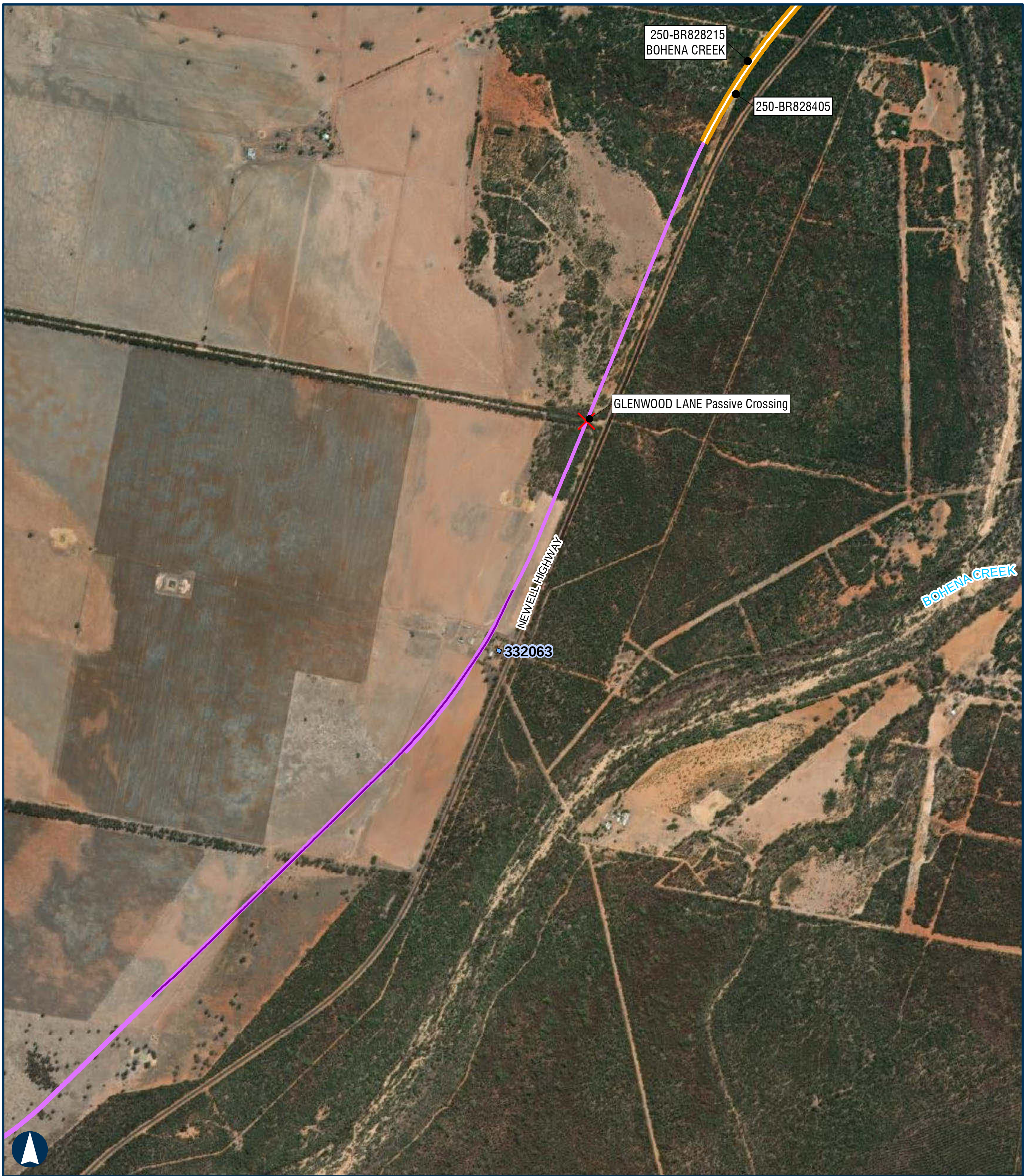

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Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 14 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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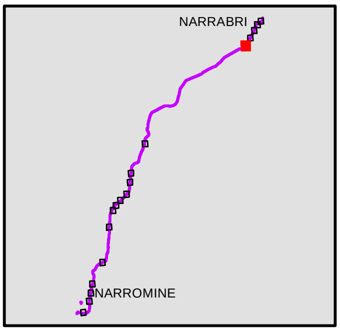
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive receivers triggering the investigation of noise mitigation



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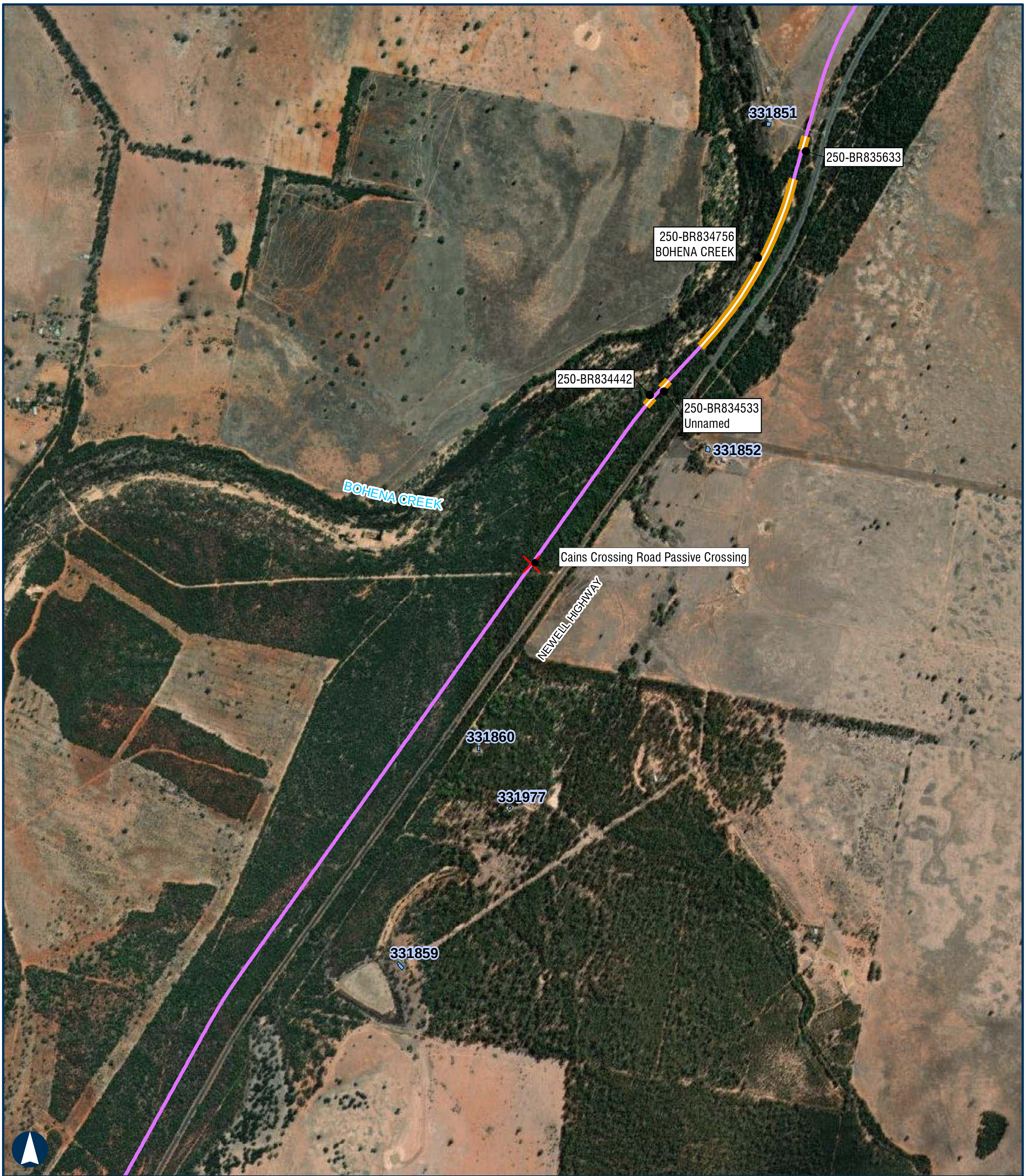

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Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 15 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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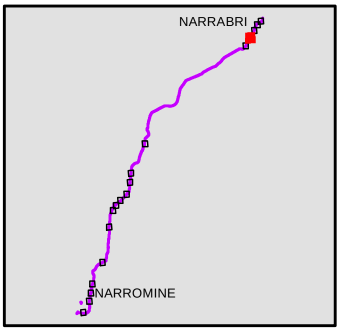
Author: JG

Level Crossings
Proposal Extent
Crossing Loops
Rail Alignment/Centreline
Bridges and Viaducts
Sensitive receivers triggering the investigation of noise mitigation



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Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 16 of 18

500m

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Date: 31-Aug-2021
Author: JG

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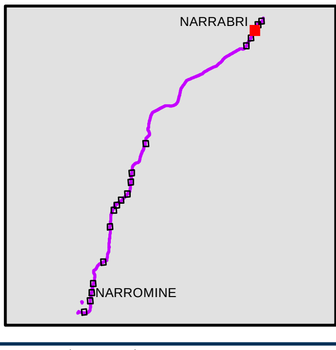
- Level Crossings
- Proposal Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive receivers triggering the investigation of noise mitigation



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NARROMINE TO NARRABRI

Sensitive Receivers Triggering the Investigation of Noise Mitigation

FIGURE 30 - Map 17 of 18

500m

Coordinate System: GDA 1994 MGA Zone 55

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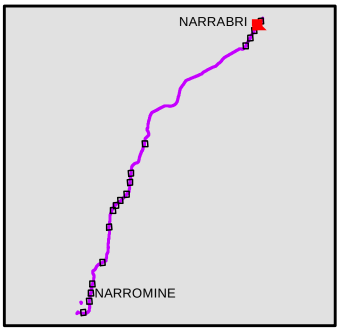

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500m

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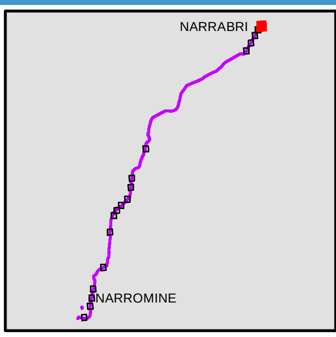

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11.2 Trains accessing the crossing loops

The assessment of L_{Aeq} and L_{Amax} railway noise levels in the previous sections included the contribution of railway operations at the crossing loops. A review of the predicted noise levels at the sensitive receivers determined the noise level contribution from the crossing loops were up to $L_{Aeq(15hour)}$ 36 dBA daytime, $L_{Aeq(9hour)}$ 42 dBA night-time and L_{Amax} 43 dBA for both the daytime and night-time periods.

The predicted noise levels from the crossing loops were within the ARTC noise management criteria and are lower than the railway noise levels from the daily train passby events on the main line. Because the crossing loops are within 4.5 m of the mainline tracks, they are not expected to be the primary influence on the overall predicted daytime and night-time predicted noise levels at the sensitive receivers.

11.3 Operation of level crossings

The predicted railway noise levels were reviewed to determine if the alarm bells (for active crossings) and train horns at each level crossing were triggering the railway noise assessment criteria. In most cases, whilst the level crossings are a potential source of noise in the local environment, the predicted noise levels at the sensitive receivers was primarily influenced by the train passbys on the main line track.

Based on the analysis the active level crossing proposed at the crossing ID PU-5-RC9090 and PU-5-RC900 (Cains Crossing Road) as a potential source of noise that is predicted to trigger the noise assessment criteria at nearby sensitive receivers. There is one sensitive receiver where noise levels are influenced by the private level crossing at the northern extent of the proposal. The train horns are sounded on approach to the level crossing and the horns are the principal source of the noise associated with the level crossing.

11.4 Potential for sleep disturbance

The night-time L_{Amax} (maximum) rail noise management criteria adopted from the RING assess potential sleep disturbance impacts, such as; awakening, disrupted sleep or a general reduction to the quality of sleep over time. The L_{Amax} noise management criteria account for the highest level of noise during train passbys and the number of passby events over the night-time period.

The assessment of rolling stock noise for the 2026 opening year and the 2040 design year determined the L_{Amax} noise management levels for new railways and upgrading existing railways were achieved at the majority of sensitive receivers.

There were up to 35 sensitive receivers where the predicted noise levels were above the L_{Amax} noise assessment criteria by up to 11 dBA within the night-time period. The noise predictions identified the L_{Amax} noise management criteria was generally achieved where receivers were further than 400 m from the rail corridor.

Railway noise has the potential to be audible at sensitive land uses, both externally and internally, even where the noise management criteria are achieved. To further the evaluation of potential for noise related impacts, the assessment has referenced guidance on sleep disturbance from the World Health Organisation (WHO).

The WHO guideline Night Noise Guidelines for Europe[8] provides an example of applying the L_{Amax} noise level to evaluate potential for sleep disturbance. The WHO acknowledges the establishment of relationships between single event noise indicators, such as L_{Amax}, and long-term health outcomes remains tentative.

[8] World Health Organisation, 2009. Night Noise Guidelines for Europe.

Based on the WHO research, a recommendation that internal (indoor) noise levels are not above L_{Amax} 42 dBA to preserve sleep quality has been referenced as a guide for assessing sleep disturbance impacts associated with rail operations on the proposal. The internal L_{Amax} 42 dBA level corresponds to a conservative external (outdoor) level of L_{Amax} 49 dBA, allowing for a conservative 7 dBA difference between indoor and outdoor noise levels where windows at rural residential properties are open for ventilation.

Based on the noise modelling, the noise levels from rolling stock could be above L_{Amax} 49 dBA within approximately 1 km from the rail corridor. The 1 km distance is a guide to where night-time noise levels may have the potential to result in sleep disturbance impacts. Individuals will respond to noise differently, and just because railway noise can be audible does not mean it will cause disturbance or annoyance impacts.
It would be expected that residential property, complying to Australian building codes and standards, would achieve façade noise reductions greater than the conservative 7 dBA assumption applied in this assessment. In such circumstances the building construction would assist in managing noise intrusion and the guideline values for internal noise amenity would be more readily achieved.

11.5 Consideration of local weather on railway noise

The regional weather conditions have the potential to influence the propagation of noise within the local environment. Downwind from a noise source, the wind conditions can enhance the propagation of noise and equally being upwind of a noise source, the wind conditions act to suppress noise propagation.

Temperature inversion conditions occur where the temperature of a layer of air in the atmosphere increases with height, rather than the typical conditions where air temperature decreases with height. This causes a layer of cool, still air being trapped below the warmer air. Temperature inversion conditions are most likely to occur during the early morning and night-time periods during the winter months. The stable conditions, with little or no vertical air movement of the cool air layer, can result in a refraction of sound waves and potentially enhance the propagation of noise.

The potential for railway noise at individual sensitive receivers to be influenced by local weather conditions will be based on the complex interaction between the moving noise source (train passby), the varying frequency content of the received noise, the weather conditions in the region and the local environment.

Whilst there may be periods when the weather conditions influence the propagation of noise from train passby events, the railway operation are forecast to be 1 to 2 train movements per hour with audible passby events likely to be 2 minutes to 5 minutes in duration. The combination of the duration and intermittency of the train passbys would diminish the influence of weather conditions on the railway noise levels assessed over the 15-hour daytime and 9-hour night-time periods.

The daily noise levels from the steady state noise emissions from idling trains at the crossing loops can be more readily influenced by local weather conditions than noise from the transient train passbys. In this regard, the ISO methodology applied for the calculation of noise levels from the crossing loops and level crossings included an allowance for downwind noise enhancing weather conditions and/or moderate temperature inversions.

11.6 Characteristics of railway noise

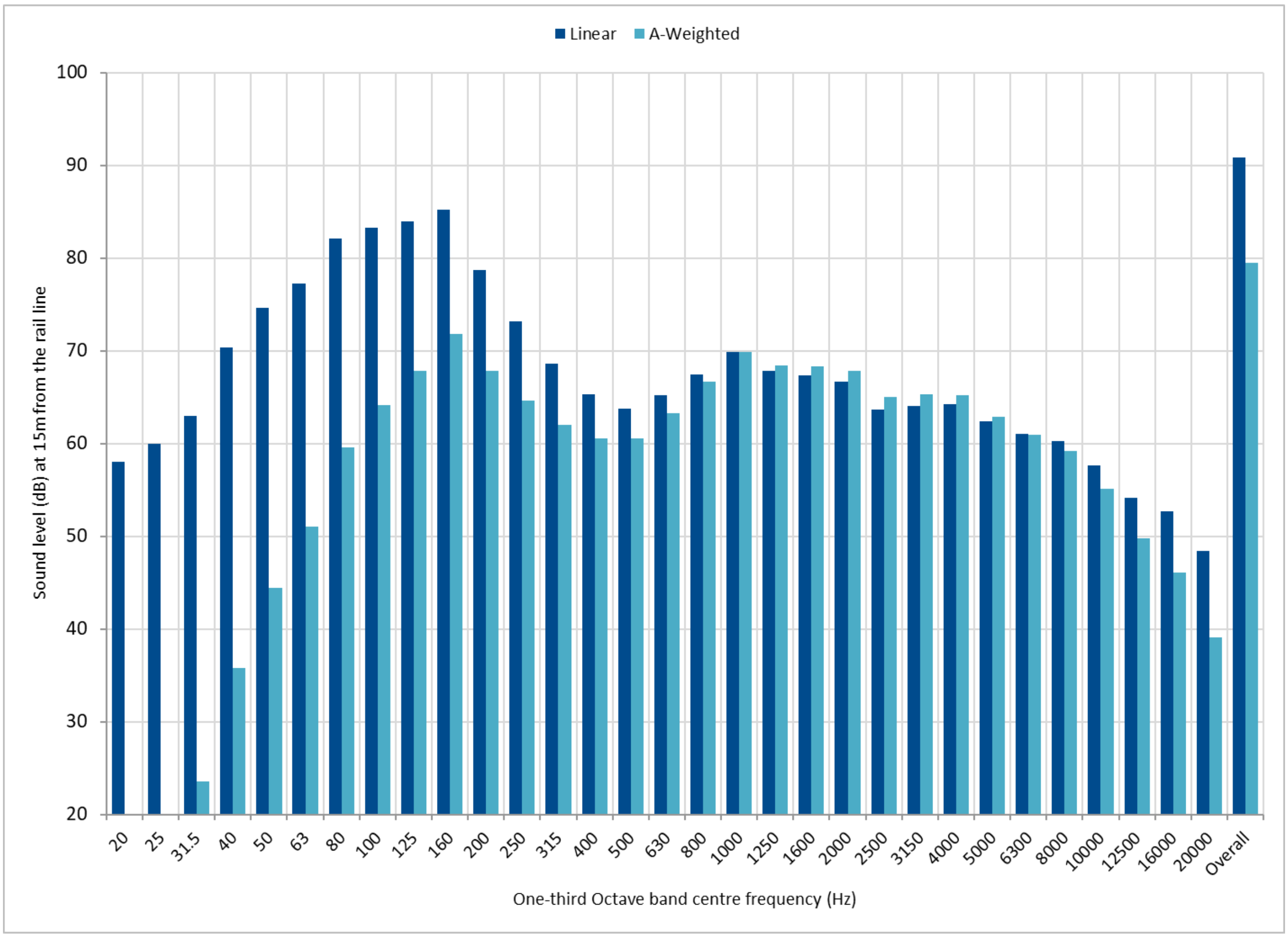
The potential impacts of noise from railway operations can be influenced by the characteristics of source noise emitted from the train passbys and rail operation at the crossing loops. A noise spectrum for a typical freight train passby events is detailed in **Figure 31**. The noise spectrum was derived from measurement of noise levels of 149 rail freight movements from existing rail lines on Inland Rail. The noise levels were measured at 15 m from the single rail line where trains were operating at approximately 60 km/h.

The typical train passby spectra identifies there is a prominent contribution of noise in the low frequency range between 80 Hz and 250 Hz at 15 m from the rail line. The diesel-electric locomotive engines and exhaust systems were the primary source of the low frequency noise content during the measured train passby events.

It is important to note that where the noise emission of the locomotives have a low frequency noise content in close proximity (within 200 m for example) to the rail line it does not mean that low frequency noise characteristics will necessarily be experienced at sensitive land uses.

The ability to detect features, such as low frequency noise, will also depend on the contribution of the other sources of noise in the local environment, which may influence an individual's perception of the loudness and character of the rollingstock noise.

Figure 31 Example noise emission spectra for rail freight



Note Noise spectra determined as the logarithmic average of daily coal and freight train passbys as measured at 15 m from the rail centreline.

The Nordic noise modelling methodology provides the overall A-weighted level of railway noise, it does not provide the frequency spectra for rollingstock noise at individual sensitive receivers. Notwithstanding, based on the typical frequency content of diesel electric locomotives, it would be reasonable to assume that where railway noise would be clearly audible above the ambient noise environment, such as within 300 m of the rail corridor, there could be low frequency noise content in the passby noise emission.

Analysis of the noise spectrum did not identify prominent tones at specific frequencies, and the noise emission from the rollingstock operations is not expected to include tonal noise characteristics.

Other general characteristics of railway noise are summarised as follows:

- Bunching or stretching can occur when the couplings on a train are subject to sudden changes in force during acceleration and deceleration, this can cause short-lived 'squeaks' and 'bangs'. Events of this nature may have subjective impulsive noise emission characteristics, although not necessarily quantified as impulsive noise at nearest sensitive receivers. Noise events from bunching or stretching have been assessed at the crossing loops proposed on the proposal.
- Short-lived 'booming' noise with potential low frequency characteristics can be caused by empty containers and wagons resonating. The occurrence of noise events of this nature is not readily forecast and have not been specifically accounted for in the noise modelling at this time.
- When trains depart from the crossing loops the locomotives may be required to initially operate under a high notch setting to accelerate from a standing position. This can cause increased noise emissions from the locomotives which may result in a perceptible increase in railway noise for a short time interval nearby to the crossing loops. Given the short duration present, the event would not be expected to influence the noise levels over the 15-hour daytime and 9-hour night-time assessment periods.
- Curving noise, such as wheel-squeal, can result in prominent tonal noise emissions. The noise modelling has accounted for potential curving noise at sections of track identified to have tight-radius curves.
- The condition of the track can be a primary influence on the rolling noise from the locomotives and the wagons. Features such as corrugation (deformation of the track) increase the roughness of the rails which can cause increased noise levels on both straight track and curves. The proposal will be newly constructed rail that shall be specifically designed for freight rail operations and subject to periodic maintenance.
- Features such as jointed track can increase rolling noise. The track for Inland Rail will be continuously welded rail which reduces the likelihood of 'clickety-clack' sounds from the wheel-rail interface.

12 Assessment of ground-borne vibration

12.1 Approach

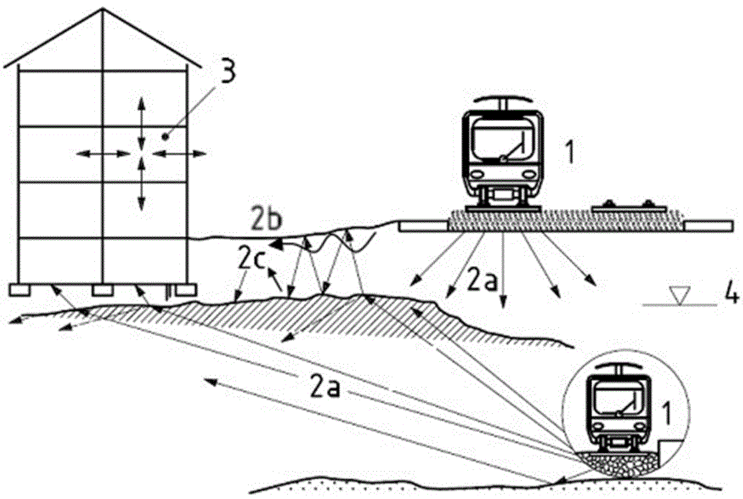
To inform the assessment of potential ground-borne vibration from the railway operations, guidance was referenced from ISO 14837[9] on the typical assessment requirements for new rail systems, including definitions of:

- **Scoping Model** at the very earliest stages.
- **Environmental Assessment Model** during planning process and preliminary design.
- **Detailed Design Model** to finalise extent and form of mitigation for construction.

For this assessment, a combined Scoping Model with elements of an Environmental Assessment Model was adopted. In accordance with the ISO standard, modelling for ground-borne noise and ground-borne vibration considers key parameters that are critical in determining the likely range levels of ground-borne noise and vibration and the benefits (or otherwise) of different design and mitigation options.

An overview of the modelling approach is illustrated in **Figure 32**. The approach considers the source vibration levels, the vibration propagation between the surrounding environment and nearby building foundations, and the propagation of vibration within the building elements.

Figure 32 Example of rail vibration source, propagation and receiver system



Key

1 source

2 propagation:
- 2 a body waves (compression, shear)
- 2 b surface waves (e.g. Rayleigh, Love)
- 2 c interface waves (e.g. Stoneley)

3 receiver (vibration, re-radiated noise)

4 water table

NOTE The components of the system comprising source, propagation and receiver are interdependent.

[9] International Standards Organisation, 2005. ISO 14837-1 2005 "*Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General guidance*.

The modelling has been carried out using a combination of theoretical and empirical relationships to determine the attenuation and/or amplification of ground-borne vibration levels with assumptions that include:

- Single frequency overall values vs distance.
- No adjustment for buildings of substantially greater mass or size than those used to inform published data (conservative).
- A crest factor[10] of 4.

Previous measurement and assessment of ground-borne vibration from existing rail freight corridors indicates that potential for ground-borne vibration impacts would be limited to sensitive receivers located within 100 m of the proposed rails. Predicted levels at properties beyond this distance are routinely expected to be within assessment criteria and the integrity of building structures is unlikely to be compromised by passing trains.

The calculation of ground-borne vibration from above ground rail operations refrained from applying estimated adjustments, such as loss of vibration energy as it is transferred to buildings (coupling loss), where adjustments could infer there would be no risk of impacts from ground-borne vibration outside of the rail corridor.

The bridge and viaduct structures are expected to be constructed from reinforced concrete and a ballasted track system. The inclusion of resilient matting for ballast retention will also be considered (which may provide some additional benefits for vibration isolation).

By inspection of the nearest sensitive locations and the modelled source vibration spectrum, the ground-borne vibration criteria are therefore expected to be met at ground level assessment positions near bridges and viaducts. On this basis, further assessment of rail induced vibration at the bridges and viaducts is not considered to be required.

12.2 Source vibration levels

The proposal does not have existing comparable rail freight operations or speeds as that proposed. Consequently, it was not possible to measure local vibration levels directly and a vibration prediction model was used to estimate potential impacts.

To determine a reference ground vibration level, detailed measurement surveys were completed on existing rail corridors between Wagga Wagga and Albury in NSW and Euroa and Wallan in Victoria. The locations are associated with Inland Rail in NSW and Victoria where there are comparable existing rail freight operations, with single-stacked freight wagons, on ballasted track form.

The rail corridor in these regions is mainly used for rail freight and had an average of 20 or more freight train movements per day operating at 60 km/h to 80 km/h. Ground-borne vibration levels were measured at three locations in each region, with measurements made at-grade (ground level) at distances of 15 m to 45 m from the outer rail line.

The train vibration measurements were referenced to calculate the W_b-weighted VDVs at 15 m from the outer rail. The calculated VDV (W_b weighted) varied at all sites from 0.01 $m/s^{1.75}$ to 0.04 $m/s^{1.75}$ for a single train passby event. The variation is representative of typical differences in rollingstock, wheel conditions and consists.

[10] Ratio of peak to root mean square (RMS) velocity level.

The adopted VDV (W_b weighted) of 0.04 m/$s^{1.75}$ at a setback of 15 m for a single train passby was based on the maximum derived VDVs. Accordingly, the assessment has assumed that each train is a potential worst-case vibration generating event and is therefore conservative.

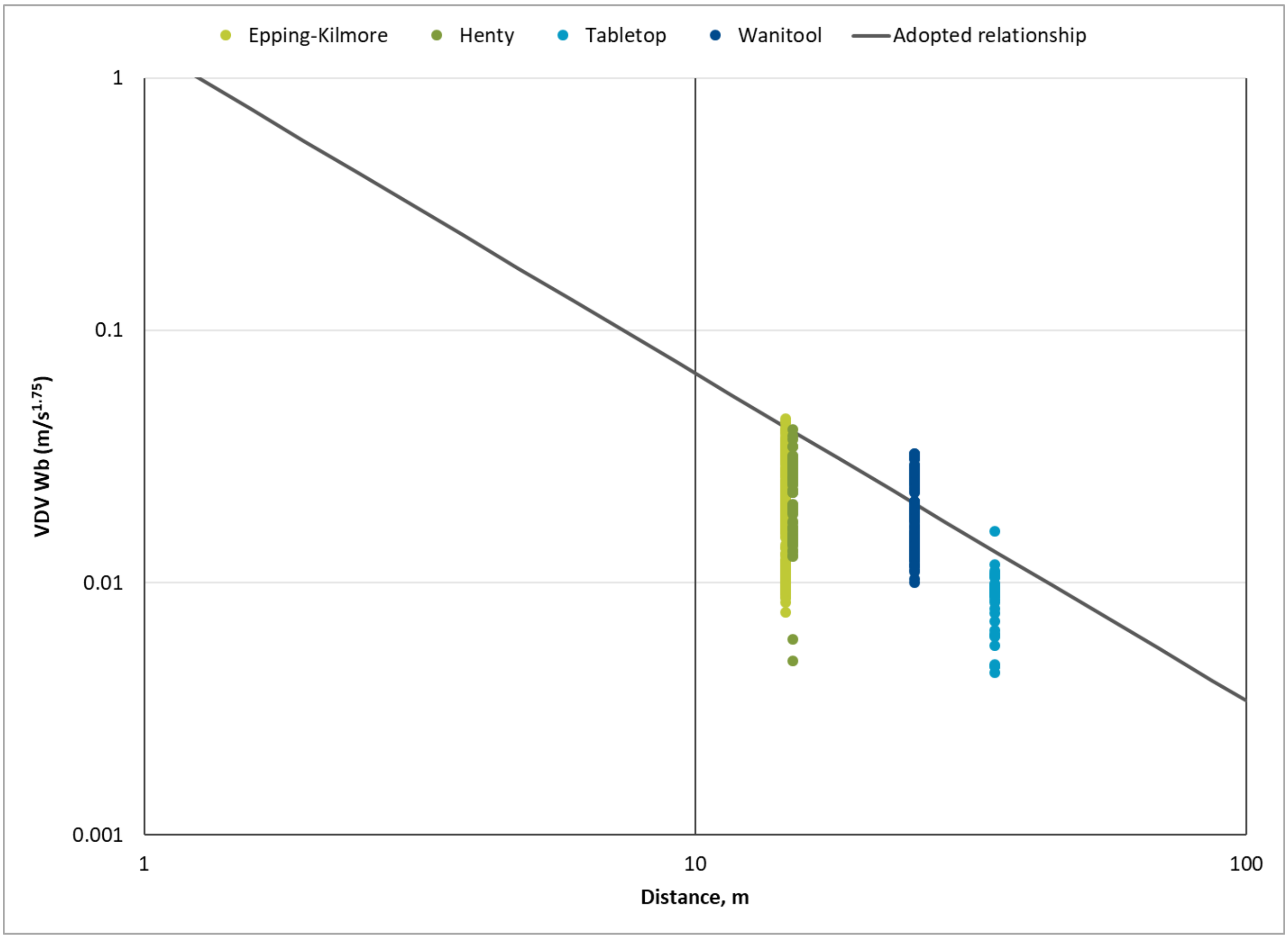
The change in VDV for a single train passby event with distance from the track is shown in **Figure 33**. The figure presents the monitored vibration levels at four separate sites and the adopted relationship between rail vibration and distance from the outer rail.

The figure shows the reduction of VDV with increasing distance from the track based on geometric spreading of the vibration energy only (ignoring site specific dampening).

The results obtained using this process had similar vibration spectra and relationships between overall levels and distance from the rail track. The modelled vibration spectrum in **Figure 34** is provided as one-third octave bands based on the logarithmic averages of the measurement data set. The approach has a bias for measurement sites with the highest ground-borne vibration levels during train passby events.

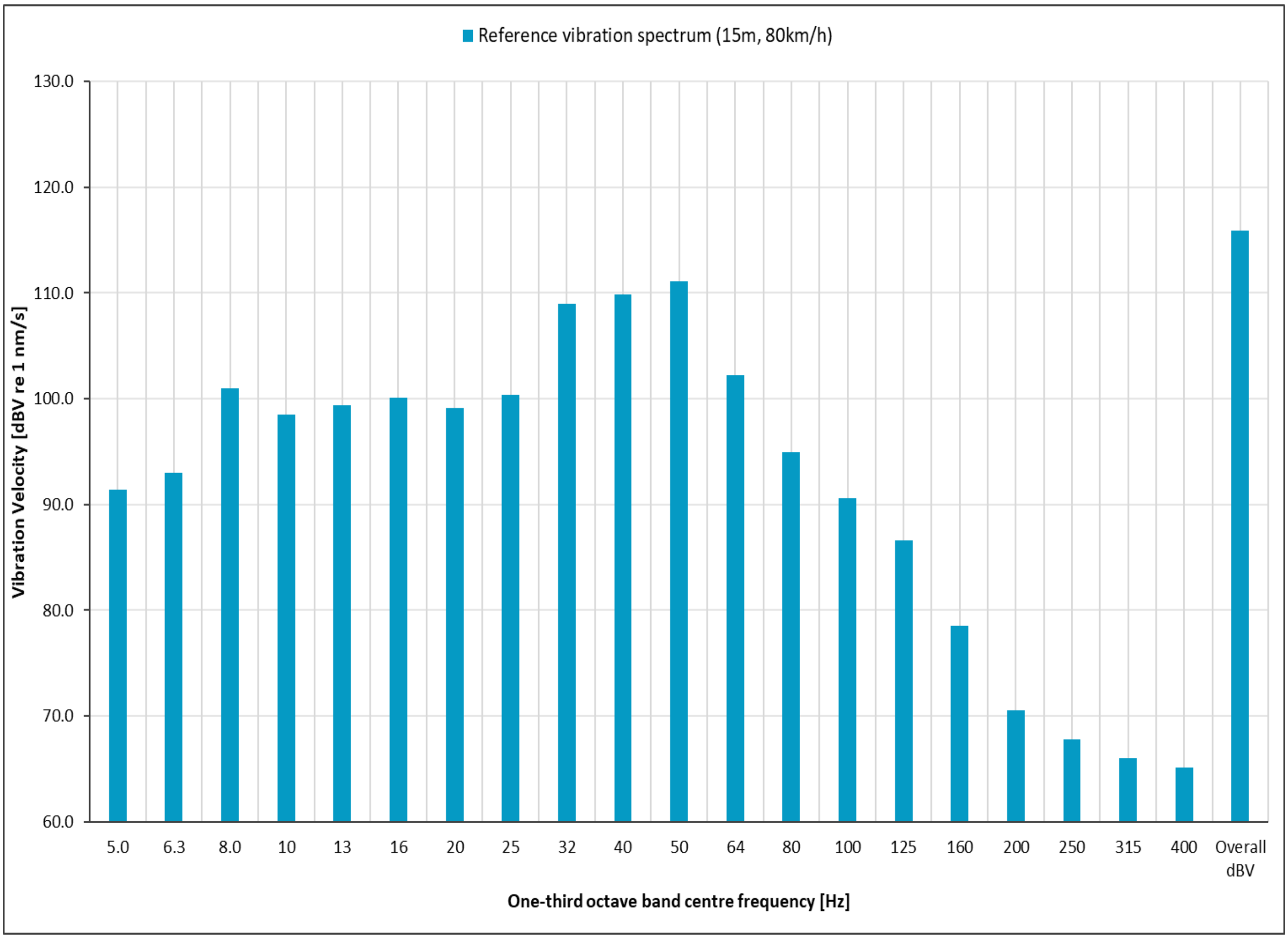
As ground-borne vibration propagates away from the track, the amplitude of the vibration wave attenuates with increasing distance. The reference vibration spectrum was adjusted to account for this reduction in amplitude.

Figure 33 Logarithmic relationship between VDV and distance



Note Reference VDV for a single freight train passby.

Figure 34 Vibration velocity spectrum at 15 m from the outer rail



Note Reference vibration velocity spectrum for a single freight train passby.

12.3 Ground-borne vibration from ground-level train passbys

The effects of vibration in buildings can be divided into two broad categories which are considered further in the following sections where the:

- Occupants or users of the building are inconvenienced or possibly disturbed either from tactile vibration or audible noise generated from the building vibration ('comfort risk').
- Building contents or internal linings may be noticeably affected or where the integrity of the building or the structure itself may be prejudiced ('cosmetic damage risk').

12.3.1 Residential and other occupied buildings

The VDV results were estimated based on daily train movements at the proposal opening in 2026 and the 2040 design year and the forecast train speeds. Estimated VDV levels for trains at 105 km/h were applied to determine the minimum off-set distance from the outer rail of the proposal where the ground-borne vibration criteria would be expected to be achieved.

Suggested off-set distances to achieve the daytime and night-time rail vibration criteria are shown in **Table 29**.

Based on the highest estimated off-set distance for the night-time railway operations for the design year 2040, an estimated off-set distance of 13 m from the outer rail would achieve ground-borne vibration criteria.

A review of the proposal alignment identified that all sensitive receivers would be outside of the 13 m off-set distance from the outer rail of the track. On this basis, the railway operations on the proposal would achieve the ground-borne vibration assessment criteria at all sensitive receivers.

Table 29 Screening assessment of ground-borne vibration levels

Year of operation	Estimated off-set to meet vibration criteria, subject to detailed review		Receivers within the off-set distance
	Daytime (0.2 $m/s^{1.75}$)	Night-time (0.13 $m/s^{1.75}$)	
2026 opening year	9 m (7 trains)	12 m (8 trains)	None
2040 design year	8 m (5 trains)	13 m (12 trains)	

Note The estimated off-set distances are based on the VDV reference, actual vibration levels at individual receivers can vary from the calculated levels due to the rail infrastructure and geological conditions.

VDV levels calculated applying the W_b-weighted vibration levels as per BS 6472 (2008 version).

Where ground-borne vibration from railway operations are within the assessment criteria, there can still be potential for rail operations to generate perceptible levels of ground-borne vibration at sensitive receivers. The ground-borne vibration levels would achieve the criteria for managing vibration disturbance, consequently the less stringent vibration criteria for managing risk of cosmetic damage to buildings would also be achieved.

12.3.2 Heritage sites

The assessment has considered the potential for ground-borne vibration from railway operations to impact sites along the proposal alignment that were identified as possessing historical or cultural values (refer **Section 5.2**)

As this study is not informed as to the existing structural condition of each heritage site, SLR has considered that heritage structures are not structurally unsound, on the understanding that:

- The proposal would include condition surveys of buildings and structures in the vicinity of the alignment – with any condition surveys carried out during detailed design.
- Where ground-borne vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and vibration monitoring would be carried, and potentially vibration monitoring, to confirm vibration levels remain below appropriate limits for that structure.
- For heritage items, any detailed assessment would determine specific sensitivities, present for the area of interest, in consultation with relevant specialists to ensure risks are adequately managed.
- If a heritage building or structure is found to be structurally unsound or specifically at risk (following inspection), a more conservative cosmetic damage objective would be considered (for example 2.5 mm/s peak component particle velocity for long term vibration from DIN 4150.3).

Based on the reference ground-borne vibration velocity for a freight train passby (**Figure 34**), the PPV levels would be within the vibration targets for minimising potential impacts at 15 m or more from the nearest rail, allowing for local factors such as turnouts. Within this distance it is to be acknowledged that:

- Depending on location, some assets may already be exposed to similar vibration levels, as the proposal shall be collocating within an existing corridor that is primarily used by coal and freight trains.
- Ground-borne vibration levels may still be within the guidelines given the conservative assumptions and the dominant frequencies of rail vibration.

The screening assessment of vibration impacts at the sites of potential non-indigenous heritage significance (areas of interest) is provided in **Table 30**.

The two listed and 10 potential heritage sites are all located outside of the 15 m offset distance for vibration induced impacts. On this basis, structural impacts due to railway induced vibration are not expected with the proposal.

Table 30 Assessment of vibration impacts on listed and potential heritage items

Item name	Proximity to the Proposal	Assessment outcome
Listed sites		
Woodvale Park Private Cemetery	Partially within the Proposal site, to be confirmed during construction.	No impacts, subject to further review at construction.
Curban Inn site	At least 125 m from the rail alignment	No impacts
Potential heritage sites		
Drinane Public School site	280 m from rail alignment	No impacts
“Kickabil” homestead and woolshed	250 m from rail alignment	No impacts
“Allandale” homestead	300 m from rail alignment	No impacts
Corrugated iron hut with chimney	To be removed.	No impacts
“Mount Tenandra” homestead	At least 850 m from alignment	No impacts
“Digilah” homestead	370 m from rail alignment	No impacts
Convict road remains, Baradine	55 m from rail alignment	No impacts
“The Aloes” homestead and graves	At least 450 m from rail alignment	No impacts
Rocky Creek mill	At least 160 m from rail alignment	No impacts
Two storey barn/ shed at Bohena Creek	To be removed	No impacts

13 Assessment of ground-borne noise

The specific building types and construction details of the sensitive receivers are not known at the EIS stage and substantial variations in the form of construction could be present. To conservatively estimate the ground-borne noise levels at sensitive receivers, the calculations applied the following key assumptions:

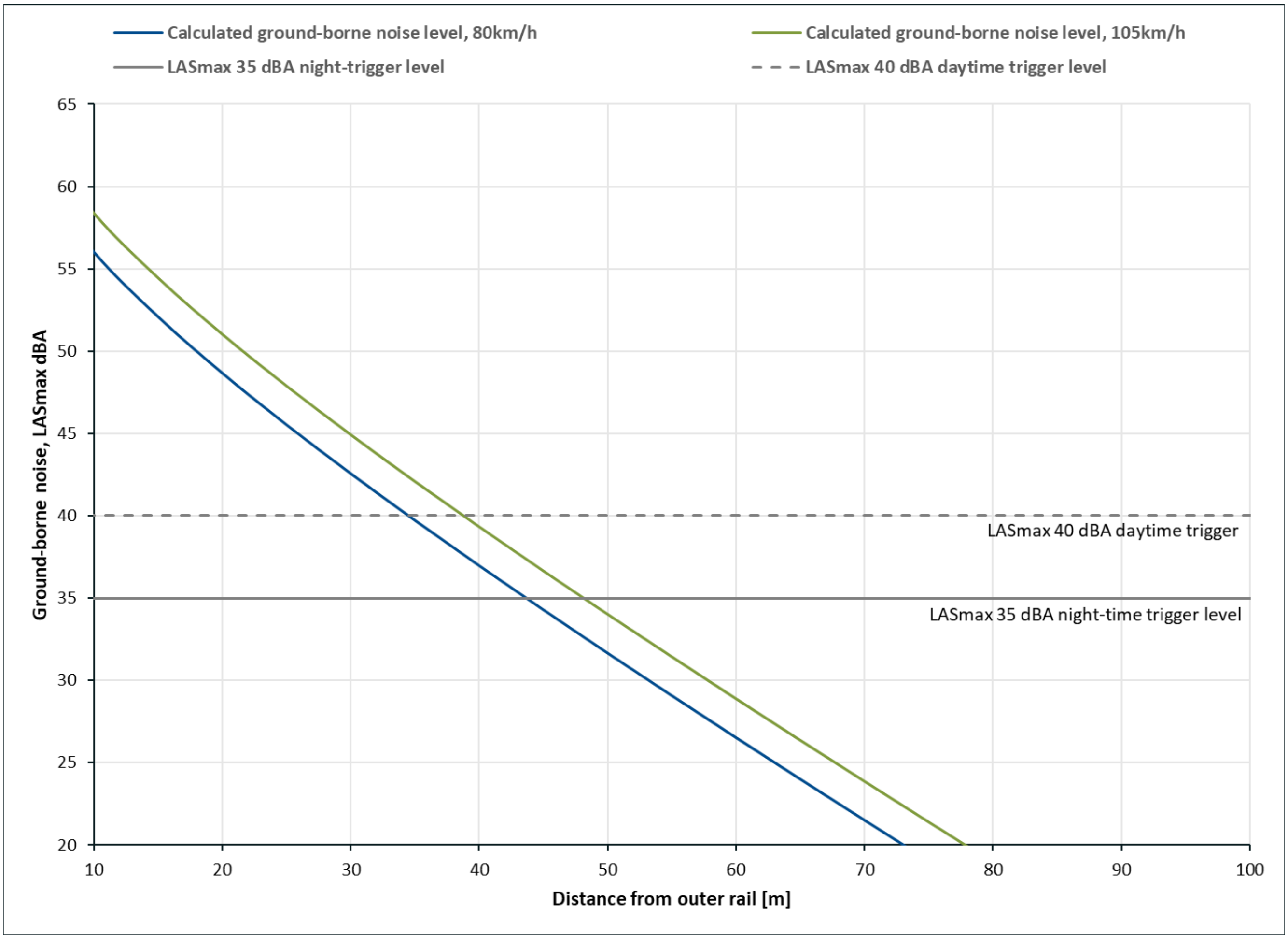
- No coupling loss between the ground and the receiver building structures to account for loss of energy as vibration enters the building footings.
- No floor amplification effects or floor-to-floor losses within the receiver structures.
- Use of a vibration to sound pressure (noise) conversion factor of -32 dB[11].
- Application of a 0.05 per metre damping loss estimated from the rail vibration measurements described in **Section 12**.

The calculated ground-borne noise levels in decibels, at increasing distance from the outer rail of the proposal, is detailed in **Figure 35**. The ground-borne noise levels are presented for a train speed of 80 km/h and 105 km/h.

[11] Acoustics and Noise Consultants, Guideline *Measurement & Assessment of Groundborne Noise & Vibration*, 2nd Edition 2012.

The predicted ground-borne noise levels determined the L_{ASmax} 40 dBA daytime and L_{ASmax} 35 dBA night-time ground-borne noise assessment criteria would be achieved at greater than 50 m from the outer rail.

Figure 35 Calculated ground-borne noise levels from train passbys

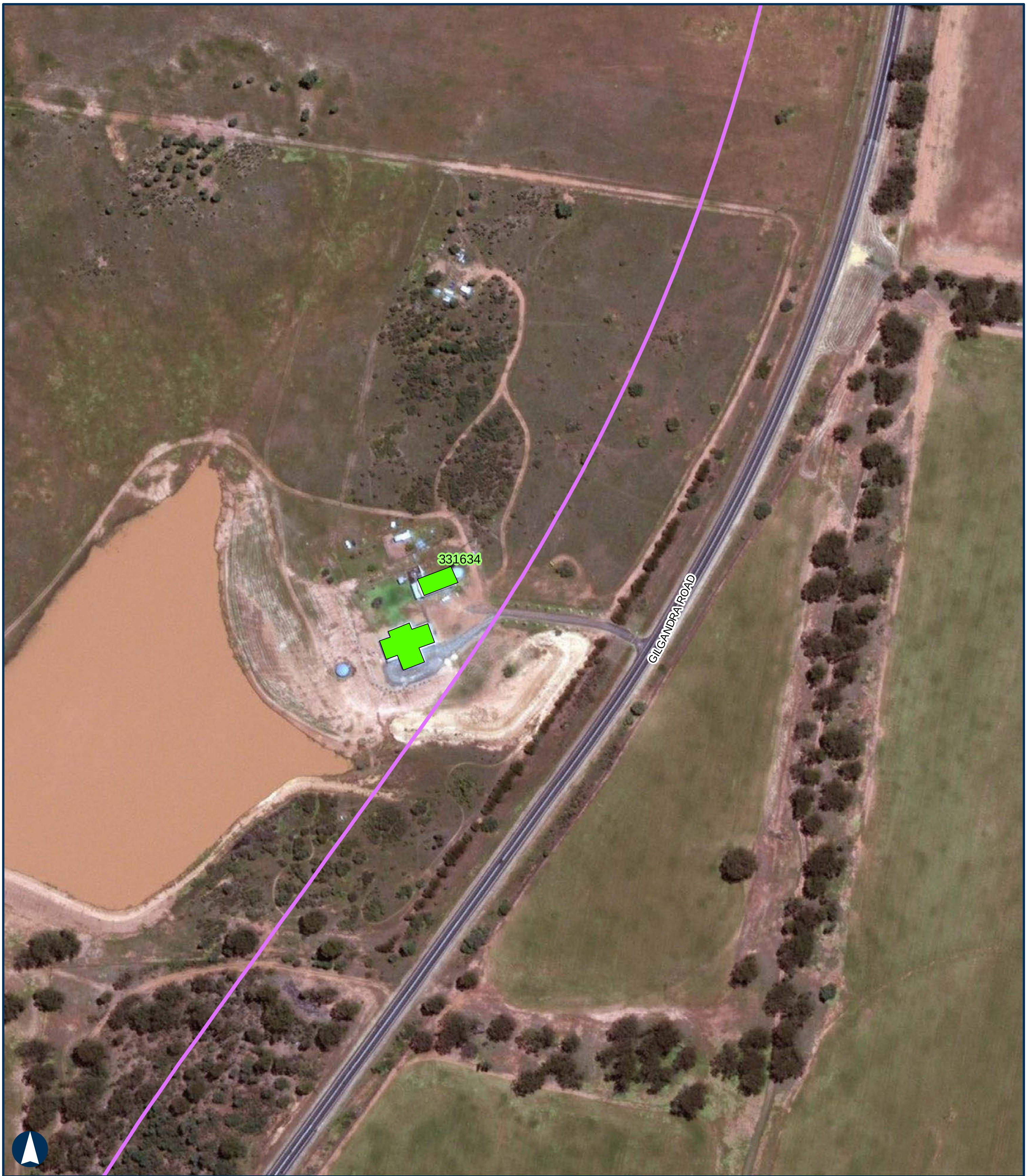


Note Estimated distance to achieve the ground-borne noise criteria is conservatively rounded to 50 m.

There were four individual sensitive receivers identified to be approximately 50 m from the outer rail of the proposal alignment. The sensitive receivers are identified as SLR ID 331634, SLR ID 245517 SLR ID 245512 and SLR ID 332063. The location of these sensitive receivers is shown in **Figure 36**.

At the 50 m off-set distance, the outdoor noise environment would be dominated by the airborne noise which would likely mask the potential ground-borne noise content at the nearest habitable rooms facing the rail corridor. Within other habitable rooms, where the airborne noise component can be lower, there is potential for the airborne noise to not fully mask potential ground-borne noise and perceptible ground-borne noise impacts may be experienced.

Whilst ground-borne noise levels at sensitive receivers located greater than 50 m from the outer rail were calculated to be within the assessment criteria, there can still be a risk of minor perceptible ground-borne noise. The assessment outcomes are proposed to be reviewed during the detailed design to verify future options to manage and mitigate ground-borne noise.



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Sensitive Receivers Triggering a Review of Ground-borne Noise

FIGURE 36 - Map 1 of 3

100 Metres

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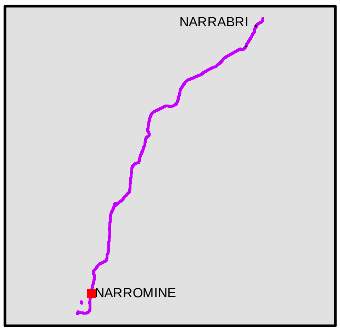

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Sensitive Receivers Triggering a Review of Ground-borne Noise

FIGURE 36 - Map 2 of 3

100 Metres

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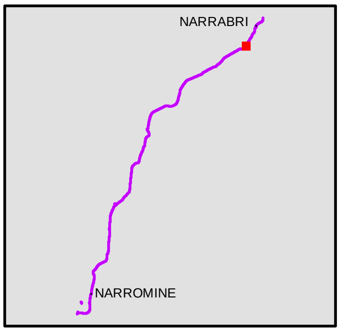

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NARROMINE TO NARRABRI

Sensitive Receivers Triggering a Review of Ground-borne Noise

FIGURE 36 - Map 3 of 3

100 Metres

Coordinate System: GDA 1994 MGA Zone 55

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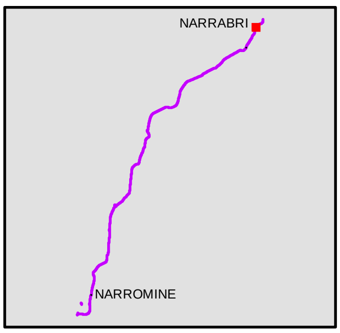
Paper: A4 Scale: 1:3,000
Date: 01-Sep-2020
Author: JG

- Proposal Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive receivers triggering a review of ground-borne noise



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H:\Projects-SLR\620-BNE\620-BNE\620.12209 Inland Rail\06 SLR Data\06 CADGIS\ArcGIS\N2N\SLR62012209_N2N_ReceptorExceedances_GroundborneNoise.mxd
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14 Cumulative impacts

The proposal directly links to the south with the adjoining P2N section and links directly to the N2NS section to the north. At the sensitive receivers within the proposal area, the primary source of rail noise will be the Inland Rail trains as they travel on the proposal. Rail noise from the arrival and departure of the trains from the adjacent P2N and N2NS sections will occur further from the proposal. Consequently, adjacent rail operations are not expected to result in a cumulative increase in daily railway noise levels at the sensitive receivers within the proposal study area.

Whilst Inland Rail is being delivered as separate sections, once in operation the source of railway noise and vibration would unlikely be defined by sensitive receivers as being within the extent of a specific section. In this regard, subjective cumulative noise or vibration impacts from trains operating within individual sections on Inland Rail is not anticipated to occur.

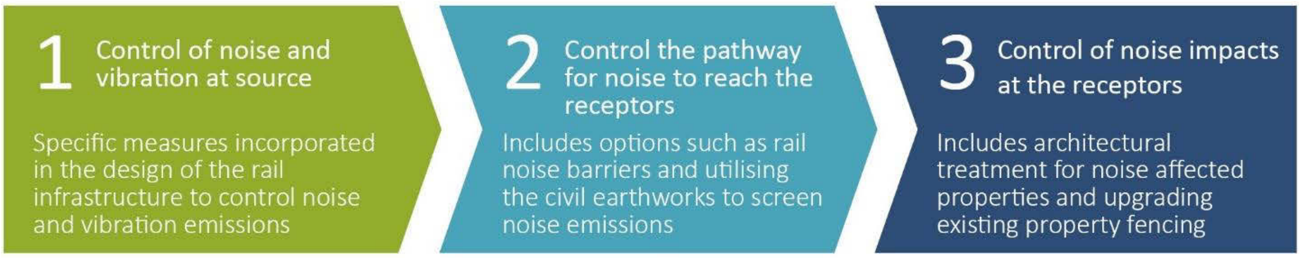
The proposal shall connect or intersect with existing rail lines and given the relatively low utilisation and seasonal rail traffic on the other rail lines the Inland Rail operations are expected to the be the primary (dominant) source of railway noise.

15 Recommendations

15.1 Feasible and reasonable mitigation measures

Mitigation measures shall be investigated where the predicted or monitored railway noise, ground-borne noise or ground-borne vibration levels are determined to be above the criteria. The investigation of noise and vibration mitigation for the proposal follows a hierarchy of control options, as summarised in **Figure 37**.

Figure 37 Hierarchy of noise and vibration mitigation measures



On Inland Rail, ARTC is applying the following strategy as the basis for selecting feasible and reasonable noise mitigation:

- Noise barriers are generally only considered where groups of triggered sensitive receivers are apparent. For isolated sensitive receivers, such as single dwellings, noise barriers would generally not be considered.
- The noise mitigation for isolated sensitive receivers is expected to include:
  - At-property architectural treatments to the building (such as increased glazing or facade constructions) to control rail noise inside building; and/or,
  - Upgrades to the receiver property boundary fencing to improve screening of rail noise.
- For two sensitive receivers on the same side of the track, the potential for a noise barrier or architectural treatment of the building will be considered on a case by case basis.

- For three or more sensitive receivers in close proximity on the same side of the track noise barriers will be considered as a primary noise mitigation option.

Further to the above strategy, the selection and specification of as-required noise mitigation also requires the consideration of a of range of safety (operations, maintenance), community (preferences, amenity), engineering (constructability, feasibility), environmental (noise levels, hydrology, visual) and social factors (land-use, connectivity). Whole of life cost and total benefits achieved are also key factors adopted in the final selection, design and implementation of any proposed mitigation option.

The terms feasible and reasonable, with respect to noise and vibration mitigation, are outlined below in **Table 31**.

Table 31 Evaluation of feasible and reasonable for noise mitigation

Term	Description	
Feasible (practicable)	The noise mitigation should be a conventional and available noise mitigation approach. Ideally the option is consistent with industry best practice and does not introduce novel or untried technology. The mitigation should be practical to build with consideration to the constructability, engineering, maintenance and reliability of the option.	
Reasonable	When determining if mitigation is reasonable, the following factors should be considered:	
	Safety	The mitigation should not adversely impact the safety of the public or the safety of implications of rail operations within the rail corridor. For example, pedestrians should be able to audibly and visually detect trains at pedestrian crossings.
	Noise impacts	The effect of the noise mitigation to change aspects such as the overall noise levels, the amenity of the ambient noise environment and how frequently the rail noise levels could trigger mitigation are all considered.
	Noise mitigation benefits	The noise reduction performance achieved by the mitigation is reviewed, along with the perceptible change in noise level that could be experienced.
	Community views	The views of landowners and the community should be consulted and options that have support from the affected community should be considered.
	State government requirements	Consider any State specific requirements for what constitutes reasonable or practicable.
	Cost	The costs should be reasonable in context of the overall project cost and spending on other similarly affected residents. The cost should consider the overall project costs including on-going maintenance. Any residual costs to the community, such as running air-conditioning, should also be reviewed.

15.2 Noise and vibration mitigation options

A review of potential feasible and reasonable mitigation options to reduce and control noise and/ or vibration levels, and related impacts at sensitive receivers, is provided in **Table 32**.

The options demonstrate the range of mitigation measures that can be implemented on the proposal. The final decision on mitigation measures will be determined during the detailed design and construction of the proposal. This is expected to include further noise and vibration works to verify the outcomes of this assessment.

The mitigation measures are specific to the sources of noise and vibration, for example wheel-rail (rolling) noise, locomotive noise emissions or potential ground-borne noise from train passbys. The detailed design may determine a combination of options would be implemented to provide the feasible and reasonable control of the noise and vibration, targeted to minimising potential impacts.

Table 32 Review of potential noise mitigation measures

Noise source	Aspect	Commentary
Rolling noise	Noise walls or barriers at the rail corridor boundary	Rail noise barriers can be an effective noise mitigation option to control the noise emissions from both the wheel-rail interface and from the locomotives. Appropriately designed noise walls and barriers can typically reduce the overall noise levels between 5 dBA to 15 dBA, where the line of sight between the sensitive receiver and the source(s) is fully impeded by the barrier structure. The proposal would only consider noise walls or barriers where noise levels can be effectively controlled at groups of sensitive land uses and receiver buildings and where noise level reductions of generally 5 dBA or more are required at sensitive receivers.
		The key considerations with rail noise walls or barriers, include: • The proximity of key infrastructure such as local roads, crossings, utilities, waterways and drainage culverts. Adjacent infrastructure can constrain the location, extent and performance of noise walls or barriers. These factors can prevent noise walls and barriers from being a reasonable or practicable noise mitigation option. • There would be little or no reduction in the noise emissions from the locomotive exhaust and train horns unless the wall or barrier structures are constructed to a height of at least 4 m and located within the rail corridor. • Availability of suitable land between the rail line and sensitive receivers may constrain the construction of the base/ foundations of the noise wall or barrier (this includes existing/proposed embankments or sub-surface conditions present). • The design of the noise walls or barriers would need to achieve; a minimum noise reduction performance, control reflected noise and edge diffraction effects and meet specifications for earthworks, cross drainage, flooding, surface water run-off, stabilisation, wind loading, erosion and durability. • Social and environmental factors include; loss of open aspect and breezes, connectivity, cohesion, severance, potential for vandalism and a need for graffiti removal, safety in design, collapse consequence, reduction in visual amenity of the landscape, loss of views and vistas and lighting/ shadow effects.

Noise source	Aspect	Commentary
Rolling noise	Low height noise barriers	In situations where the primary noise source is from the wheel-rail interface, low height barriers (for example less than 2 m in height) can be constructed close to the outer rail track. Such barriers can achieve similar noise reductions to noise walls or barriers at the rail corridor boundary. Typically, this mitigation option only suits single tracks and where only the rolling noise needs to be controlled. Given the overall noise levels from rail freight are a combination of rolling noise and locomotive noise emissions the low height noise barriers could have a negligible influence on achieving the adopted noise criteria. In some cases, the use of low height barriers may achieve a perceptible change in railway noise. Reductions in noise levels by at least 3 dBA could result in a perceptible improvement to the loudness of train passby events.
	Earth mounds at the rail corridor boundary	Earth mounds can be an alternative to or complement noise walls and barriers. The earth mounds can mitigate noise by impeding the direct line of sight between the noise source and receiver. To reduce noise levels between 5 dBA to 10 dBA, earth mounds would need to be a comparable height and length to potential rail noise walls or barriers.
		The required height of noise walls or barriers can be achieved where the structure is constructed on an earth mound base. This approach provides the required screening of noise and can reduce the associated costs of the noise wall or barrier. When reviewing the practical application of earth mounds, the following should be considered: • The construction of earth bunds can be constrained by the available space between the rail corridor and neighbouring infrastructure. • Earth mounds require considerably more space than the footprint of a rail noise barrier. A 2 m height earth mound could require an 8 m wide base. • Earth mounds could provide a benefit to control perceptible rail noise impacts. Reductions in noise levels by at least 3 dBA could result in a perceptible improvement to the loudness of train passby events. • Whilst earth mounds may not achieve specific noise reduction performance as can be achieved with noise walls or barriers, they can assist in reducing the overall noise levels to be closer to the assessment criteria. • In addition to the potential constraints associated with noise walls and barriers, the earth mound would also need to be designed to meet environmental and design requirements. • The implications to water through flow and flooding will need careful consideration to ensure the earth mounding does not adversely impede cross-drainage or the movement of surface water. • The required extent and height of the earth mounds to achieve material balances and the availability of spoil material.

Noise source	Aspect	Commentary
Rolling noise	Rail dampers	Rail dampers may provide localised benefit for the control of rolling noise where the contribution from the rail is a primary factor. International experience suggests a reduction in rolling noise of 3 dBA could be achieved and there is limited evidence that suggests rail dampers can provide some benefit in controlling curving noise. The effectiveness of rail dampers may be limited by the stiffness of the ballasted track and concrete sleepers, the forces exerted by the heavy rail freight and the long-term durability and maintenance of such measures. Sections of generally straight track, that are not highly susceptible to prominent or regular wear, would be most suited for the consideration of rail dampers.
	Maintaining defective rollingstock	Defects with the wagons, such as wheel flats or misaligned axles/ bogies, can cause discrete and potentially annoying high noise events. ARTC currently implements Wayside Monitoring Systems across the rail network to identify individual rollingstock and the specific sources for targeted mitigation. The Wayside Monitoring Systems include: • Wheel impact and load detector, bearing acoustic monitoring (RailBAM) and Squeal acoustic detector (RailSQAD). • Angle of attack, hunting detector and wheel profile monitoring. A similar monitoring program could be implemented to identify sources of high noise events. Once identified, defects can be repaired to address factors contributing to higher noise levels or discrete annoying noise characteristics. It is likely the overall reduction to L_{Aeq} and average L_{Amax} noise levels would be minor but would assist in managing noise events that could cause disturbance.
Managing curving noise	Track lubrication systems	Diagnosis and control of curving noise can require detailed investigation of the track systems and rollingstock. Track lubrication systems are an effective control measure to reduce, and even eliminate, curving noise. Wayside lubrication systems include gauge-face lubrication and top of rail friction modifiers. The proposal includes an existing section of curved track at the Narromine West connection which has a radius <500 m. Track lubrication systems should be considered for the curved track on the Narromine West connection where curving noise is identified or expected.
Locomotives	Exhaust mufflers	The exhaust outlets of the locomotives can be a primary source of low frequency and overall noise emissions from the train passbys. The exhaust systems of new and existing locomotives can be modified with exhaust mufflers to improve attenuation of noise emissions, including low frequency noise. Because such measures require specifications for the rollingstock they will not be readily implementable by ARTC without appropriate commitments from rail operators.
Safety warning devices	Safety requirements	The operation of devices such as train horns and level crossing alarms are exempt from compliance to airborne noise criteria due to public safety obligations. The following mitigation options are proposed as part of ARTC's commitment to managing potential noise impacts.

Noise source	Aspect	Commentary
Safety warning devices	Wayside horns	A wayside horn is an automated audible warning located at the level crossing. Instead of the train sounding its horn on approach to a level crossing the wayside horn automatically sounds to provide a targeted audible noise event for vehicles and pedestrians at the level crossing. The objectives are to remove the need for the train to sound its horn adjacent to sensitive receivers and to implement a horn event that has a noise emission level and noise directivity focused to the users of the level crossing. It is expected that respite from train horns could reduce L_{Amax} noise levels by more than 10 dBA at sensitive receivers and provide a notable improvement in loudness and potential risk for annoyance, particularly where there can be more than two train horn events every hour with the proposal.
	Soft tone alarm bells	The design of level crossing alarm (warning) bells will be required to confirm to specific design standards. Typically, loud tone alarm bells operate at L_{Amax} noise levels between 85 dBA to 105 dBA at 3 m. A soft tone bell design, which has a lower L_{Amax} noise emission level between 75 dBA to 85 dBA at 3 m can be applied, where practicable, to reduce maximum noise levels from the alarm bells by approximately 10 dBA. The L_{Aeq} noise level would have a more marginal improvement as the noise environment surrounding level crossings is primarily influenced by the train passby events.
Property controls	Architectural treatment of property	Where external rail noise levels are validated, through measurement, to exceed the assessment criteria a potential option is to mitigate the intrusion of rail noise within the affected property. The provision of architectural treatment would depend on a number of factors and is expected to only apply to habitable rooms or acoustically significant rooms/uses of sensitive buildings. Typically, measures such as upgraded acoustic glazing, acoustic window and door seals and acoustic insulation for the roof are considered to mitigate noise intrusion. The provision of upgrades to ventilation, such as fresh air ventilation (acoustic ducting) or air-conditioning will allow windows to be kept closed as a mitigation option whilst maintaining air flow.
		Appropriately designed measures, where windows are closed, can mitigate the intrusion of noise by more than 10 dBA. However, these measures can be more effective to control the intrusion of rolling noise as it is more broadband in nature and often does not have prominent tonal or low frequency components. All consideration of architectural property treatment would be subject to the individual property. Suitability will be confirmed prior to the implementation of at-property noise control treatments.
	Property construction	In rural locations, the age and construction of residential properties can influence the practical implementation of modern architectural treatments. The review of architectural treatments will require a further review of the eligible properties and advice from suitably qualified professionals.

Noise source	Aspect	Commentary
Property controls	Consideration of low frequency noise content	Noise which is considered to have low frequency and/or tonal content can be increasingly annoying. Where the control of low frequency noise is required at properties, the architectural acoustic treatments would need to consider options for the control of low frequency noise intrusion. The approach applied would need to achieve an overall improvement to the internal rail noise levels and potential characteristics that could cause annoyance. The control of low frequency noise within a property is challenging and care needs to be taken to manage residual impacts such as the architectural treatments controlling the mid and high frequencies which may cause the low frequency noise to become more perceptible. The United Kingdom Department of Environment, Food and Rural Affairs has published a reference curve for assessing low frequency noise indoors[12]. This curve should be considered as a design target for architectural treatments where measured external rail noise levels at sensitive receivers are above the assessment criteria and prominent low frequency noise content is identified.
	Upgrades to existing property fencing	Existing fencing at the boundary of individual receivers can be upgraded by replacing part or all of the existing fencing with an 'acoustic' fence design. Compared to standard residential property fencing, an acoustic fence, such as aerated concrete (solid masonry), has an improved acoustic transmission loss performance. Whilst the noise reduction performance will be specific to individual properties, upgrades to existing property fencing are likely to be suitable only where noise reductions of less than 10 dBA are required. The potential for upgrading existing property fencing can be limited by the line of sight between the railway and the receiver, the available land and the requirements of local Councils and regulatory authorities with respect to the height and materials permitted for property boundary fencing. Agreement between the landowner and ARTC would be required for ARTC to undertake works on private property.
	Property relocation	In rural locations, individual residential property can be located on large land holdings. It may be possible to relocate the residential property within the same land so that it is further from the rail corridor and noise levels would be lower. The relocation of property would be assessed on a case by case basis to ensure there would be a notable improvement to the noise environment at the relocation site. As a general rule, where the distance between the dwelling and the rail line is doubled the rail noise levels can reduce by approximately 3 dBA.
	Negotiated agreements	The implementation of architectural treatments and other measures to private property would likely be subject to the agreement of commercial and legal terms between ARTC and the property owner.

15.3 Summary of noise mitigation

The noise assessment identified that potential railway noise levels triggered the review of noise mitigation at up to 41 residential receivers at commencement of operations in 2026, with an additional 12 residential receivers triggering the criteria at the design year 2040; a total of 53 residential receivers triggering investigation of noise mitigation.

A review of the noise mitigation triggers, based on the margin the predicted noise levels are above the criteria, is provided in **Table 33**.

[12] UK Department of Environment, Food and Rural Affairs, 2005. *Proposed Criteria for the Assessment of Low Frequency Noise Disturbance*, University of Salford.

Table 33 Summary of residential noise mitigation triggers

Assessment criteria margin	Sensitive receivers triggering the assessment criteria
Year 2026 – proposal opening	
1 dBA to 2 dBA	23
>2 dBA to 5 dBA	9
>5 dBA to 10 dBA	8
>10 dBA	1
Total receivers triggering noise mitigation – proposal opening	**41**
Year 2040 – design year	
1 dBA to 2 dBA	27
>2 dBA to 5 dBA	17
>5 dBA to 10 dBA	8
>10 dBA	1
Total receivers triggering noise mitigation - design year	**53 (including the 41 receivers triggering in 2026)**

The noise levels at the majority of sensitive receivers are within 2 dBA of the criteria, which is a relatively minor margin above the trigger levels in the context of a perceptible difference between the trigger level and the predicted noise levels.

A review of the location of these sensitive receivers determined the properties are isolated properties dispersed along both sides of the proposal. In addition to evaluating the location of the sensitive receivers, rail noise barriers' heights, extents, costs and other project and community elements have to be considered, especially for receivers where noise levels are within 5 dBA of the assessment criteria.

Based on both the location of the sensitive receivers and the margin by which the noise criteria is triggered; the feasible and reasonable noise mitigation options, in addition to at-source controls, are expected to be:

- Architectural acoustic treatments to the buildings triggering the assessment criteria to control rail noise within the internal environment of the building; and/or,
- Upgrades to any existing property boundary fencing to improve screening of rail noise levels.
- Review operation of the ID PU-5-RC9090 and PU-5-RC900 (Cains Crossing Road) level crossings to reduce source noise emissions from the level crossing alarm bell and the train horns.

During the detailed design phase, the sensitive receivers shall be surveyed to exclude rooms and buildings that are not noise sensitive from the consideration of at-property treatments, such as; storage areas, bathrooms, hallways and corridors The surveys would need to investigate the noise attenuation performance of the existing property facades and, as-required, revise the assessment of potential internal rail noise levels.

15.4 Mitigation for ground-borne vibration and ground-borne noise

The assessment identified the potential for ground-borne noise levels to be above the adopted assessment criteria at up to four sensitive receivers located within 50 m of the proposed main line. Furthermore, there can still be potential for perceptible ground-borne noise and vibration even where the respective criteria are achieved.

The following recommendations are provided to inform the detailed design of the Proposal.

- A key component will be verifying the outcomes of this assessment and managing the potential for disturbance impacts from perceptible ground-borne noise and vibration during train passbys. It is recommended that further assessment is undertaken during detailed design to verify the screening assessment outcomes.
- The prediction of ground-borne noise and vibration levels from the train movements will need to be assessed during detailed design once additional detailed information on the track form, pad stiffness and geotechnical conditions is available.
- Where ground-borne noise is required to be managed, it is common to apply softer rail pad systems to those proposed. There are a range of engineering and maintenance implications with the application of softer rail pad systems for rail freight and the implementation of such measures to control ground-borne noise will need to be investigated.
- The effectiveness of alternative or supplementary measures, such as rail pads and rail dampers, may be significantly limited by the stiffness of the track and concrete sleepers, the forces exerted by the passage of heavy rail freight and the long-term durability and maintenance of such measures.

15.5 Further noise prediction modelling

The noise prediction modelling for this assessment adopted the Nordic method (Kilde 130) for calculating rail noise emissions and the propagation of rail noise within the environment. Whilst the Nordic methodology is accepted to provide reliable predictions, it is inherently conservative in order to assess worst-case impacts.

It is recommended that during the detailed design of the proposal, when aspects such as noise mitigation will be confirmed, the rail noise prediction modelling is updated. The modelling should include the potential for assessing the frequency content of the railway noise emissions and the influence of regional meteorological conditions.

The consideration of the frequency content from the rollingstock is important where predicted external rail noise levels are applied to determine the appropriate architectural property treatments or the design of mitigation such as rail noise barriers.

15.6 Validation of noise and vibration levels during operation

A programme of noise and vibration monitoring is recommended to be undertaken within six months of the commencement of railway operations on the proposal. The purpose of the monitoring surveys shall be to:

- Quantify the rail noise and vibration levels from the daytime and night-time rail operations and determine the $L_{Aeq(15hour)}$ daytime, $L_{Aeq(9hour)}$ night-time and L_{Amax} rail noise levels at the most affected sensitive receivers.
- Assess compliance with any relevant conditions of approval relating to noise and vibration emissions from the operation of the proposal.
- Provide an assessment of the effectiveness of any noise and vibration management and mitigation measures implemented on the proposal.
- Identify, if required, further noise and vibration mitigation measures to meet the ARTC's noise and vibration management criteria and relevant conditions of approval.

The recommendations below have been developed to assist the preparation of a noise and vibration monitoring plan:

- Provide a monitoring strategy consistent with the requirements of relevant acoustic standards and guidelines for monitoring environmental and transport noise and vibration.
- Plan and schedule the monitoring surveys with consideration to:
  - The rail movements during each daytime and night-time period. The survey period shall include the days during which the highest number of train movements would be expected and cover a period of consecutive days to be representative of typical operations.
  - At locations free from localised buildings and structures (other than noise barriers) that may screen or reflect noise.
  - The condition of the rails and other rail infrastructure.
  - Weather conditions during the monitoring periods.
- Monitoring should be conducted at the sensitive receivers with the potential for the highest received noise and vibration levels from rail operations.
- Where feasible, noise levels should be assessed 1 m in front of the most affected building façade. Where noise levels are monitored in the free-field a +2.5 dBA correction should be considered to adjust the free-field level for a noise level at the building façade.
- Should monitoring be required within a property, the noise monitoring would be conducted at the centre of the habitable room that is most exposed to noise from rail operations.
- Vibration shall be monitored in the three axes representing horizontal, vertical and axial direction of displacement (movement). Vibration shall be monitored as the Peak Particle Velocity (mm/s) and vibration acceleration (m/s^2).
- If required, the monitored noise and vibration levels can be referenced to update and re-assess the predicted rail noise levels at the sensitive receivers aligning the proposal.
- If the noise and/or vibration levels are above the applicable criteria at any sensitive receivers, allowing for any monitoring and compliance tolerances, the key sources of rail noise and contributing factors (e.g. rail defects, excessive rail roughness levels, turnouts, locomotive engine exhausts) shall be identified to inform the investigation of feasible and reasonable mitigation measures.
- A noise and vibration compliance report is to be prepared to detail the outcomes of the compliance monitoring and assessment works.
- Should the monitoring and validation identify that relevant noise and vibration requirements may not be met, the following management procedures would be implemented:
  - Feasible and reasonable mitigation measures, additional to those already implemented, would be investigated.
  - For any heritage items potentially affected, a heritage specialist shall be consultant to confirm the risks are adequately managed.
  - Further monitoring of noise and vibration may be undertaken to confirm outcomes and quantify the improvements achieved through the implementation of management and mitigation measures.

16 Residual impacts

The rail noise and vibration assessment criteria are designed to manage aspects such as environmental harm and nuisance. The intent of the criteria is to identify where feasible and reasonable mitigations should be implemented to manage the potential for impacts. The assessment has been based on a best practice approach for environmental management.

The rail noise criteria do not require noise from railway operations, including where noise mitigation is implemented, to be inaudible at sensitive receivers. The potential for annoyance or disturbance from rail noise is subjective and can remain a potential impact even where noise mitigation is implemented, and noise levels are well within the noise criteria.

The predicted noise levels in this report identify there may by up to 77 sensitive receivers where the noise criteria may not be achieved without the implementation of noise management and mitigation measures.

The feasible and reasonable noise mitigation for the proposal is expected to primarily be at-property treatments, such as upgrading existing glazing or the provision of air-conditioning, to manage the intrusion of rail noise and maintain internal (indoor) noise amenity within habitable rooms.

These treatments do not address the source emission of rollingstock noise or the external (outdoor) rail noise levels within the environment surrounding the rail corridor. On this basis, the rail noise levels can remain above the external rail noise assessment criteria, and be perceptible, at the sensitive receivers with the implementation of at-property noise mitigation measures. Notwithstanding, the at-property treatments would be implemented to reduce internal railway noise levels to achieve targeted improvements to the indoor acoustic environment of habitable rooms.

Referencing conventional building construction treatments and acoustic glazing specifications, it is reasonable to assume the internal railway noise could be reduced by at least 5 dBA. Reducing noise levels by this margin would be a perceptible improvement to building occupants, where noise characteristics such as low frequency are also suitably controlled.

The assessment identified that ground-borne noise and vibration levels are likely to be within the assessment criteria for most sensitive receivers. There is potential for ground-borne noise and vibration to be perceptible where the assessment criteria are achieved. However, disturbance or annoyance impacts would not necessarily be experienced due to the relatively low levels of ground-borne noise and vibration predicted at the sensitive receivers.

17 Conclusion

The railway operations on the proposal have the potential to be a source of airborne noise, ground-borne noise and ground-borne vibration within the environment surrounding the proposal. This assessment has identified where the predicted levels of noise and vibration from the railway operations would achieve assessment criteria and where the levels trigger an investigation of feasible and reasonable mitigation options.

Based on the assessment of potential noise levels from the daily train movements on the proposal at 1,089 sensitive receivers, the noise criteria for the daytime and night-time periods are achieved at the majority of the identified receivers. There are up to 53 sensitive receivers, where predicted noise levels trigger a review of mitigation from inland rail operations on the mainline. There is one sensitive receiver where predicted noise levels trigger a review of mitigation from inland rail operations at the Narromine West junction.

The location of the sensitive receivers, the predicted noise levels at each receiver and the principles of ARTC's management of noise on Inland Rail were reviewed to identify the appropriate noise mitigation options. In addition to source noise controls implemented in the design and construction of the proposal, the feasible and reasonable noise mitigation is expected to include at-property treatment for sensitive receivers.

At-property mitigations can include architectural treatments to control railway noise within the building and upgrades to property fencing. Whether at-property controls or other alternative mitigation options are required will ultimately be determined through the detailed design of the proposal. This will include consultation with the property owners, further railway noise assessment works, analysis of engineering and environmental constraints and the verification of noise levels once railway operations commence on the proposal.

The assessment of ground-borne noise and vibration from railway operations determined that predicted levels would achieve the criteria for ground-borne noise and ground-borne vibration at the majority of sensitive receivers. Further detailed investigation should be undertaken at detailed design to verify the outcomes of this assessment and, if required, the application of additional measures to mitigate ground-borne noise.

Where the noise and vibration criteria are achieved there can still be potential for noise and vibration from railway operations to be audible/ perceptible within the environment. It is not unreasonable for outdoor noise from railway operations to be audible and perceptible at least 1 km from the proposal alignment.

The airborne noise, ground-borne noise and ground-borne vibration levels will continue to be assessed during the detail design and construction of the proposal. It is recommended that the predicted noise and vibration levels and assessment outcomes presented in this report are verified as part of the on-going assessments.

Where the detailed design remains consistent with this assessment and allowing for the implementation of recommended noise and vibration mitigation measures, the proposal is expected to achieve the objectives of the SEARs for the management of railway noise and vibration.

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APPENDICES

NARROMINE TO NARRABRI PROJECT

TECHNICAL REPORT 09

Updated noise and vibration assessment—operational rail

Appendix A Identified sensitive receivers

NARROMINE TO NARRABRI PROJECT

NARROMINE TO NARRABRI
Sensitive Receivers

200 m

Coordinate System: GDA 1994 MGA Zone 55

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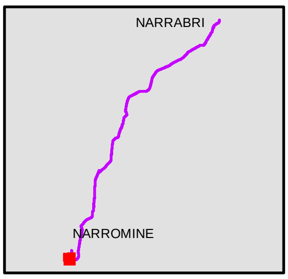
Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



ARTC InlandRail

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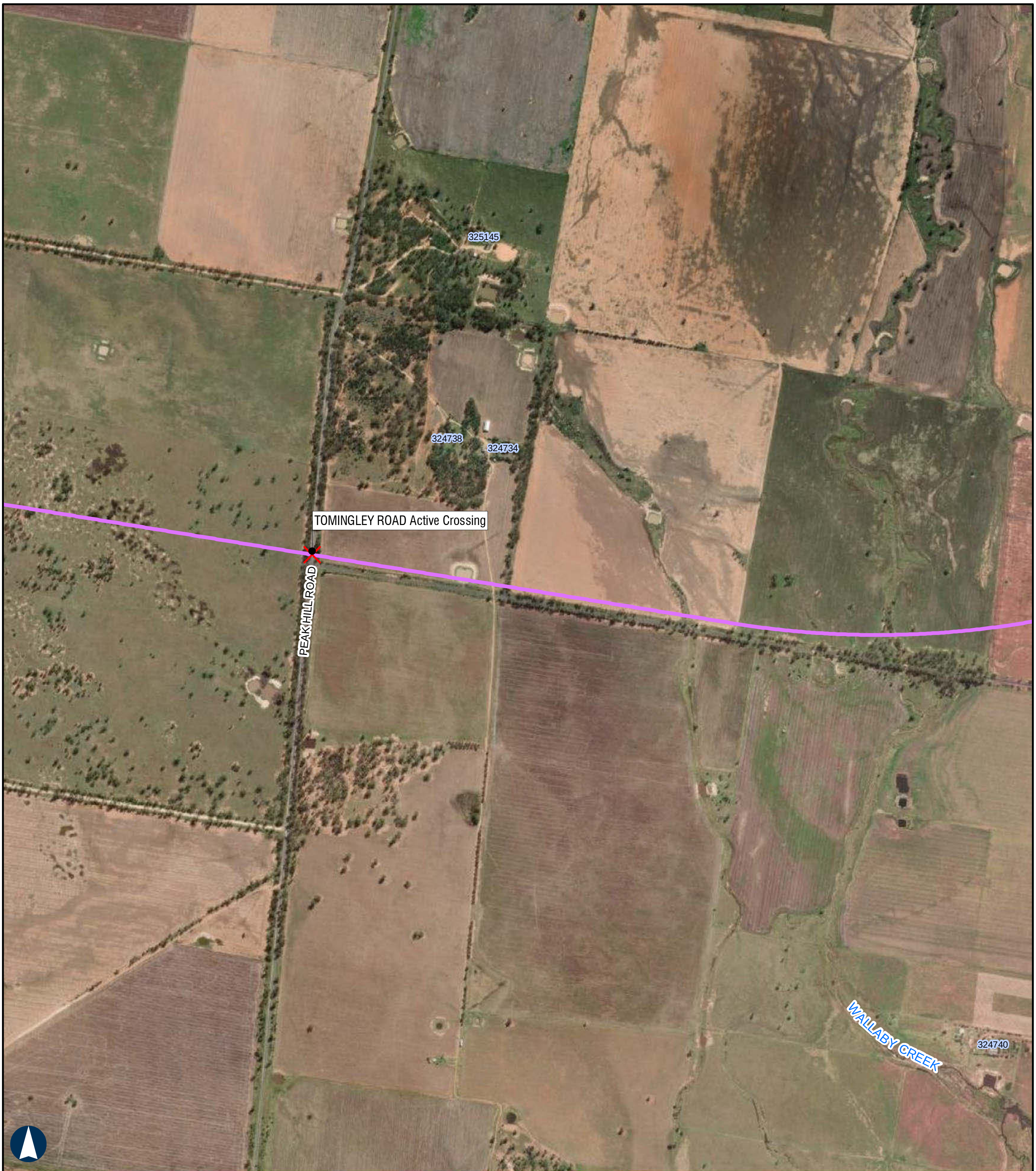

NARROMINE TO NARRABRI

Sensitive Receivers

200 m

Coordinate System: GDA 1994 MGA Zone 55

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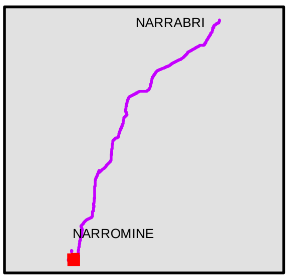
Paper: A4
Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI

Sensitive Receivers

APPENDIX A - Map 3 of 74

200 m

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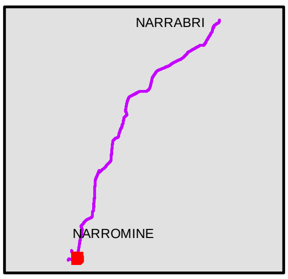
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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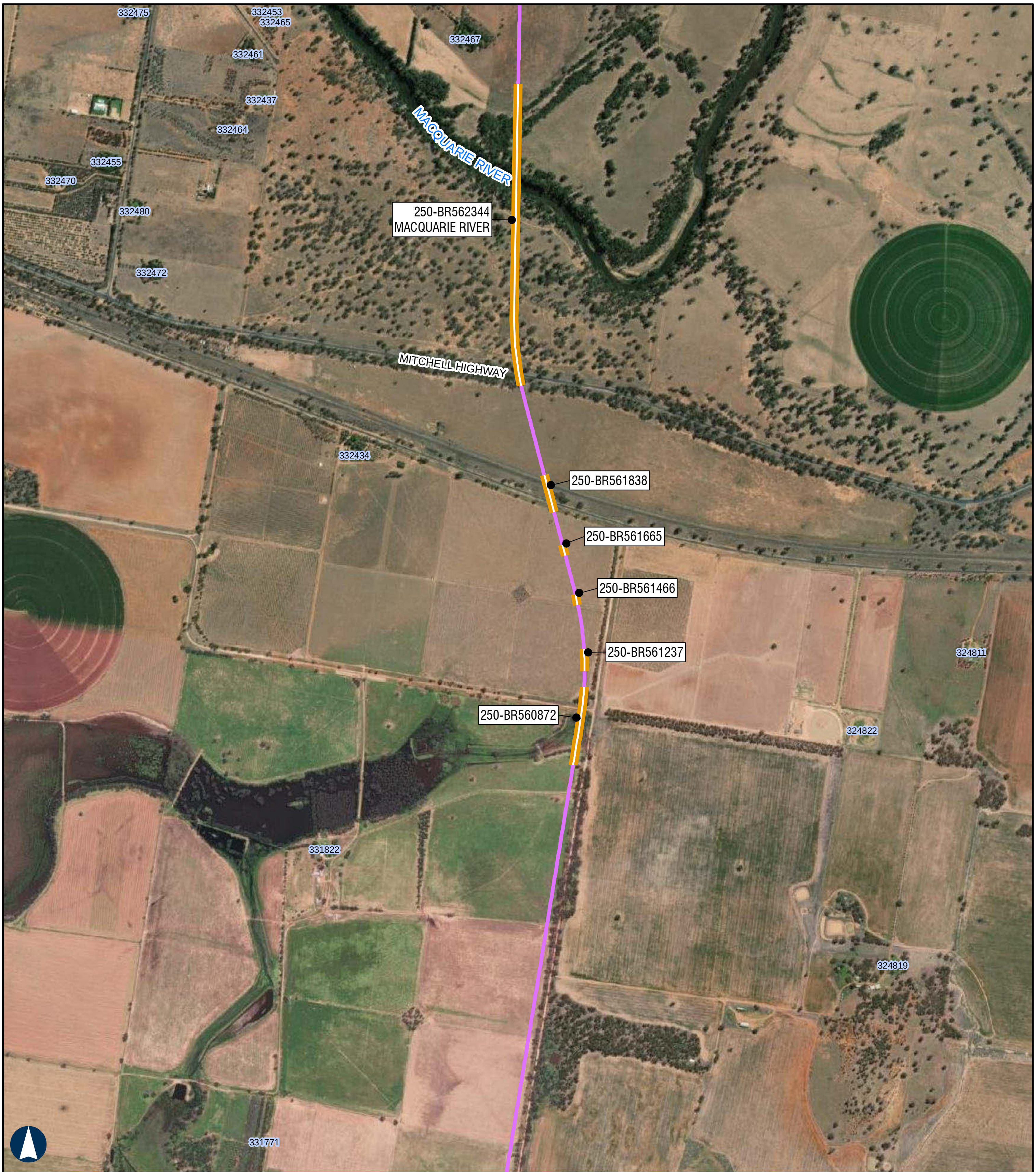

NARROMINE TO NARRABRI Sensitive Receivers

200 m

Coordinate System: GDA 1994 MGA Zone 55

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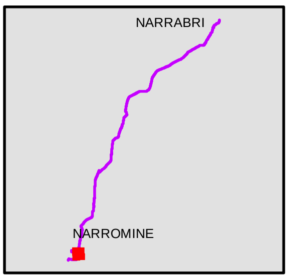
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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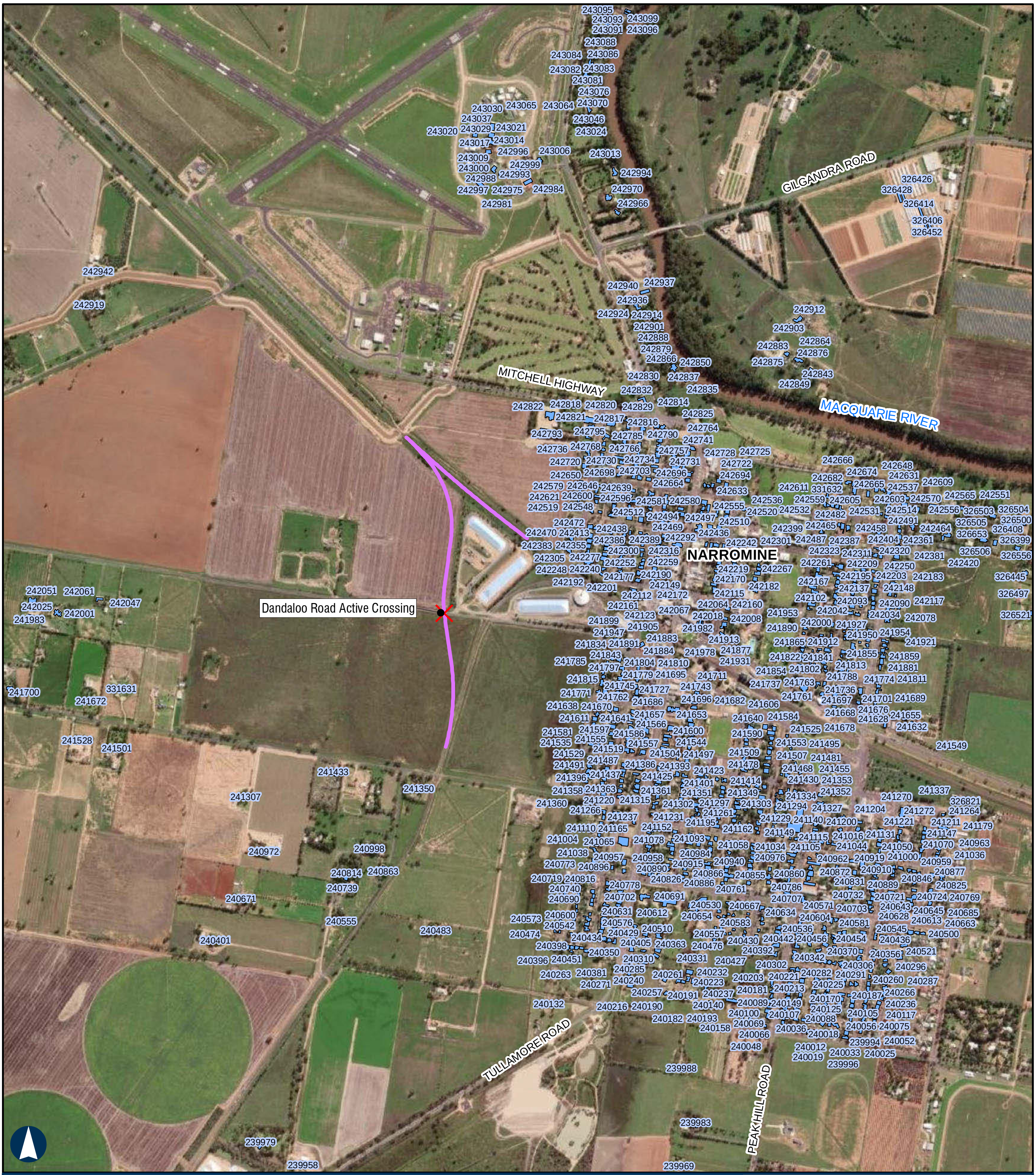

NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 5 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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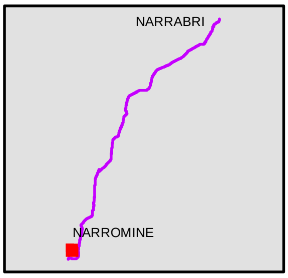
Paper: A4 Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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APPENDIX A - Map 6 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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- Level Crossings
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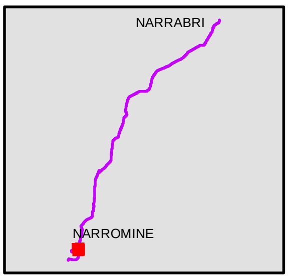
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



Paper: A4 Scale: 1:22,000
Date: 01-Feb-2022
Author: JG

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NARROMINE TO NARRABRI
Sensitive Receivers

200 m

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- Level Crossings
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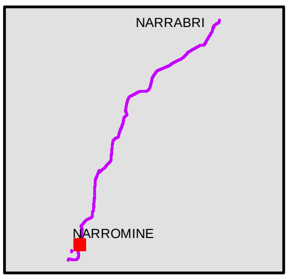
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI

Sensitive Receivers

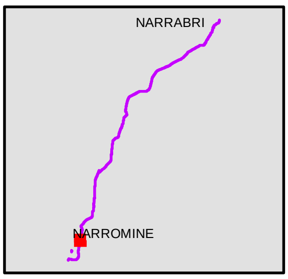
APPENDIX A - Map 8 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4
Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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Sensitive Receivers

APPENDIX A - Map 9 of 74

200 m

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Author: JG

- Level Crossings
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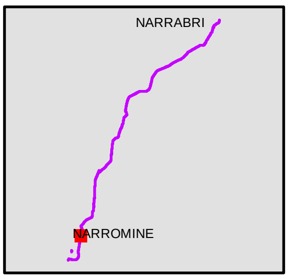
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI

Sensitive Receivers

APPENDIX A - Map 10 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

- Level Crossings
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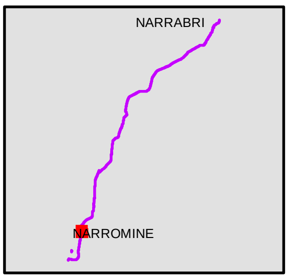
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI

Sensitive Receivers

APPENDIX A - Map 11 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
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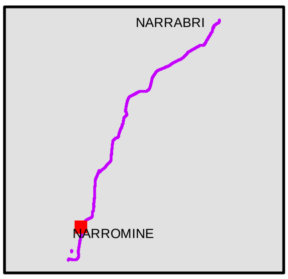
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI Sensitive Receivers

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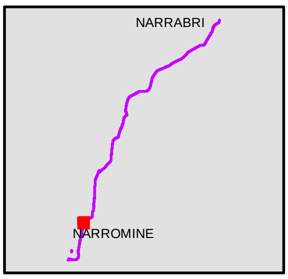
- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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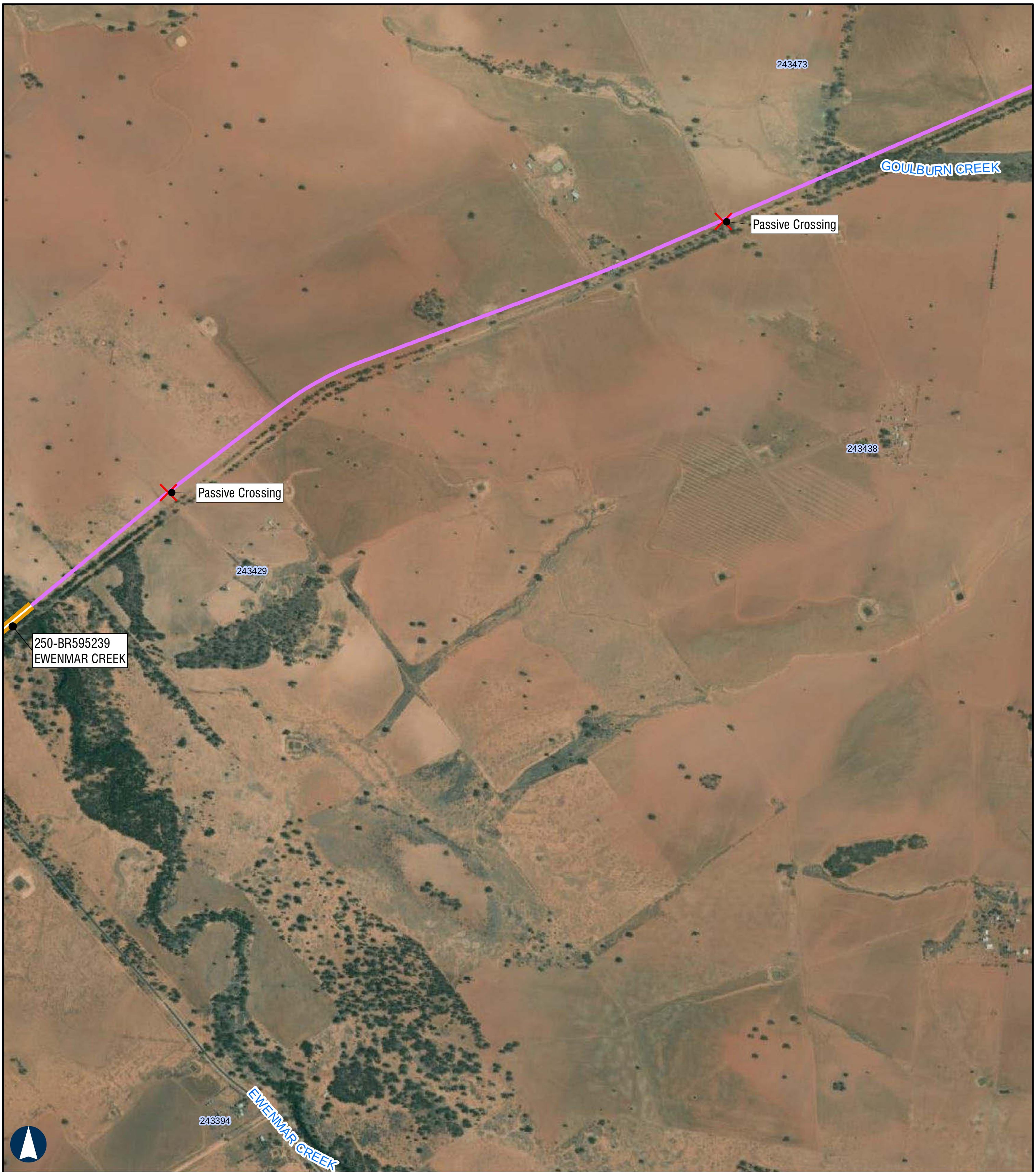

NARROMINE TO NARRABRI
Sensitive Receivers

200 m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
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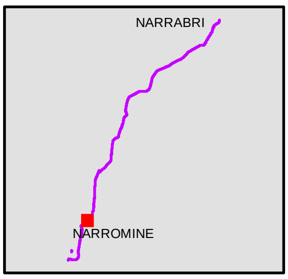
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 14 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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- Level Crossings
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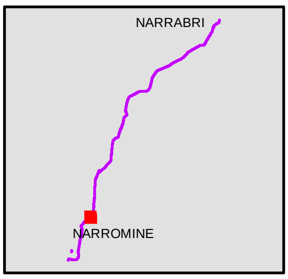
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI

Sensitive Receivers

200 m

Coordinate System: GDA 1994 MGA Zone 55

- Level Crossings
- Project Extent
- Crossing Loops
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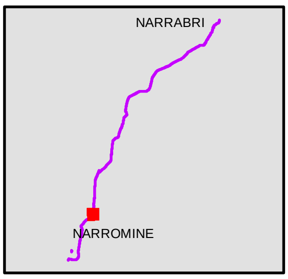

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NARROMINE TO NARRABRI
Sensitive Receivers

APPENDIX A - Map 16 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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Date: 01-Feb-2022
Author: JG

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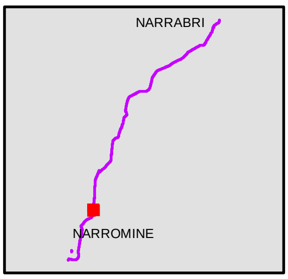

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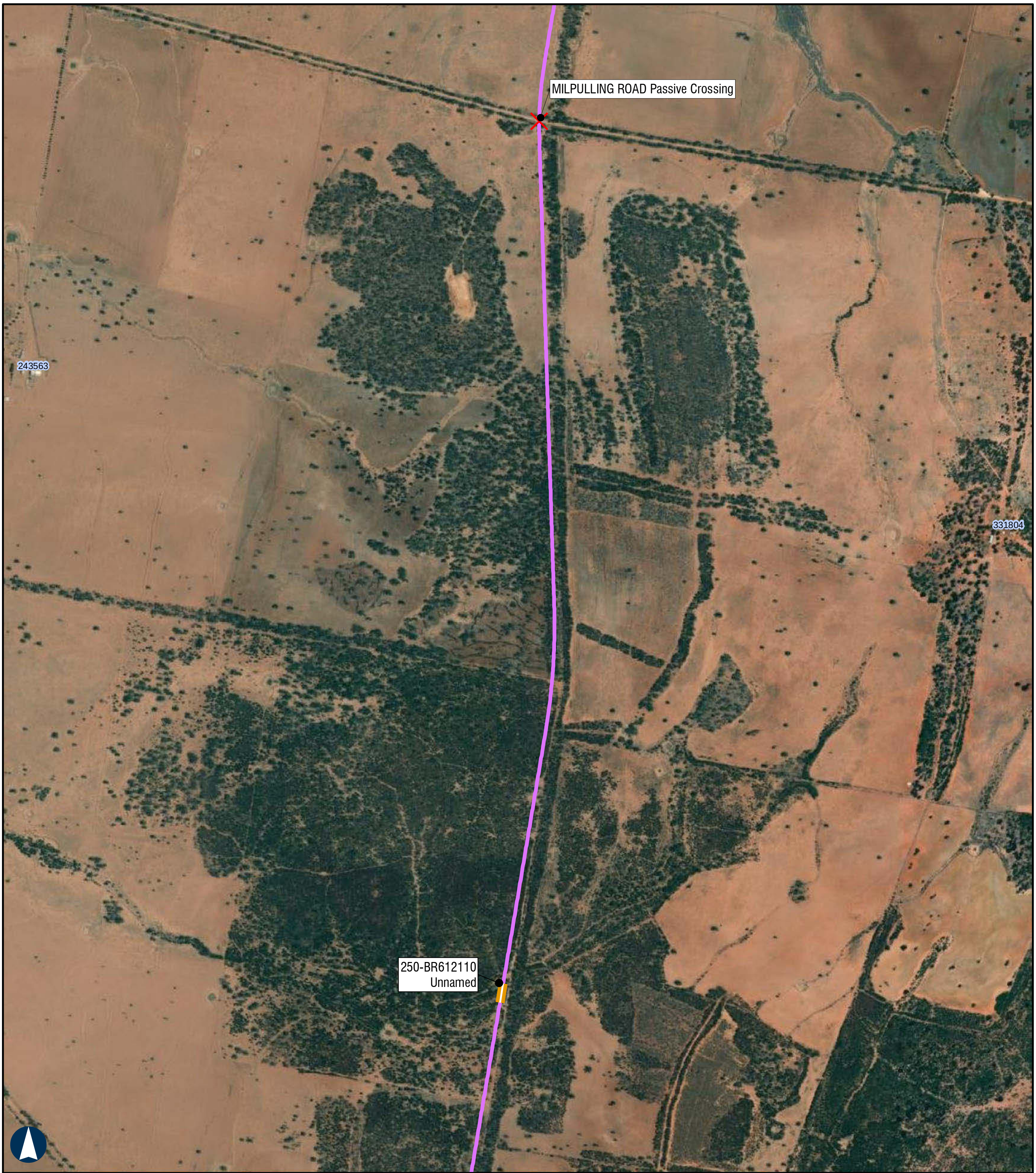

NARROMINE TO NARRABRI

Sensitive Receivers

APPENDIX A - Map 17 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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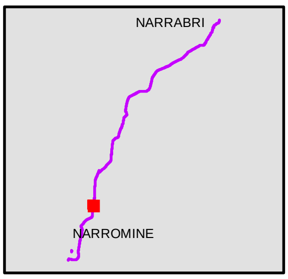

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NARROMINE TO NARRABRI Sensitive Receivers

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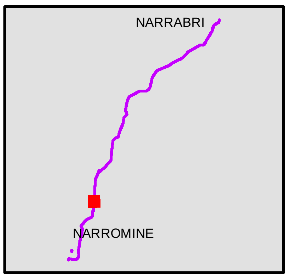

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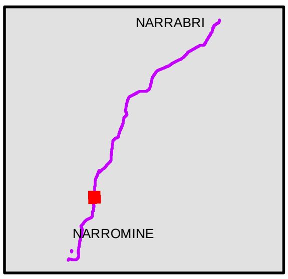

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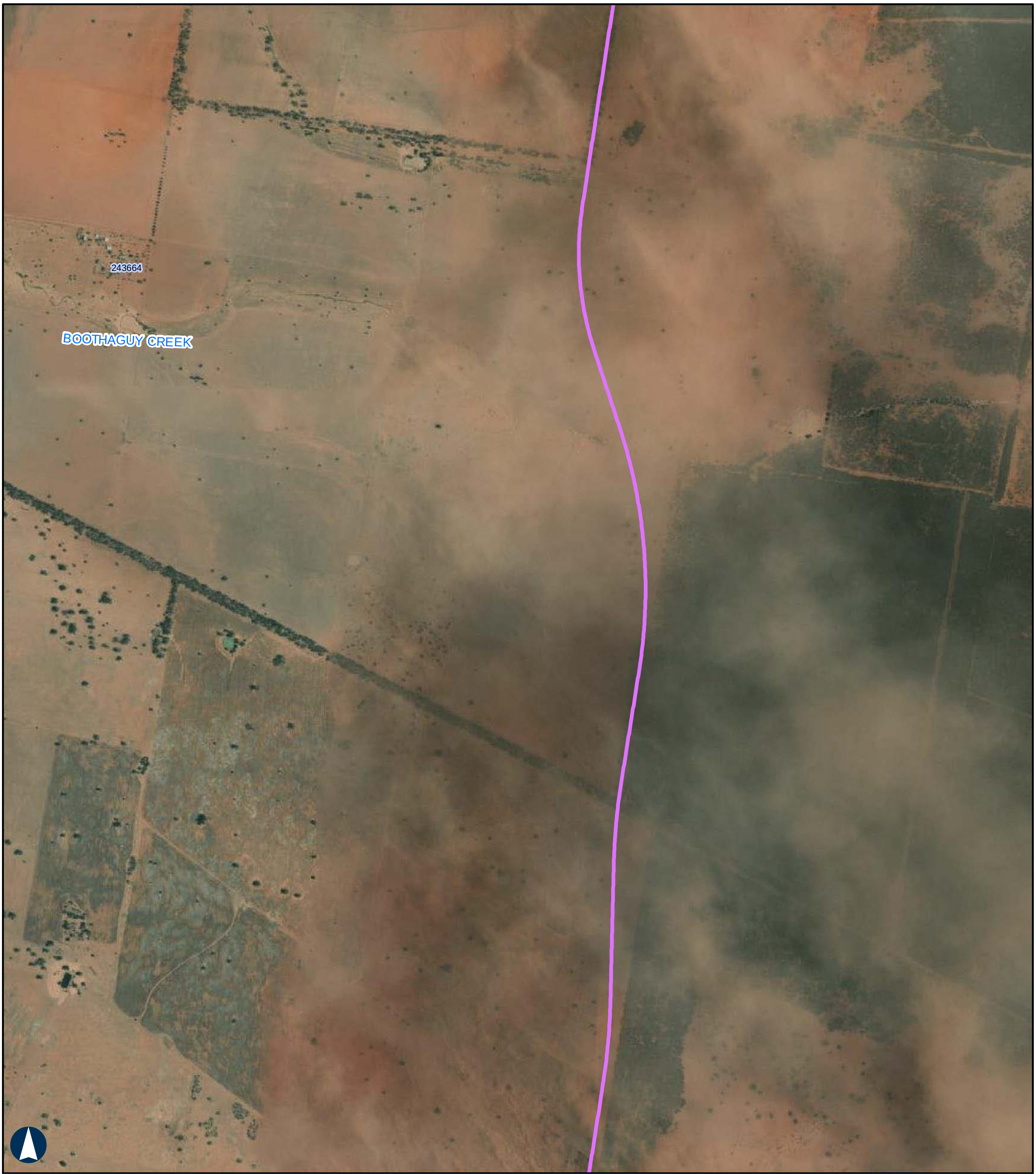

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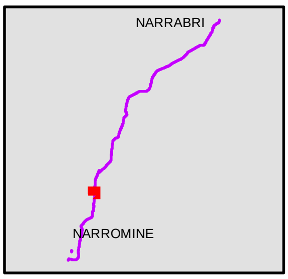
200 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4 Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI
Sensitive Receivers

200 m

Coordinate System: GDA 1994 MGA Zone 55

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Scale: 1:20,000
Date: 01-Feb-2022
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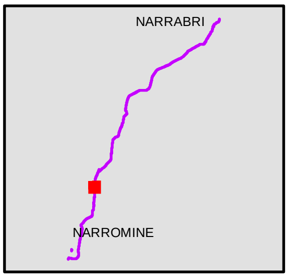

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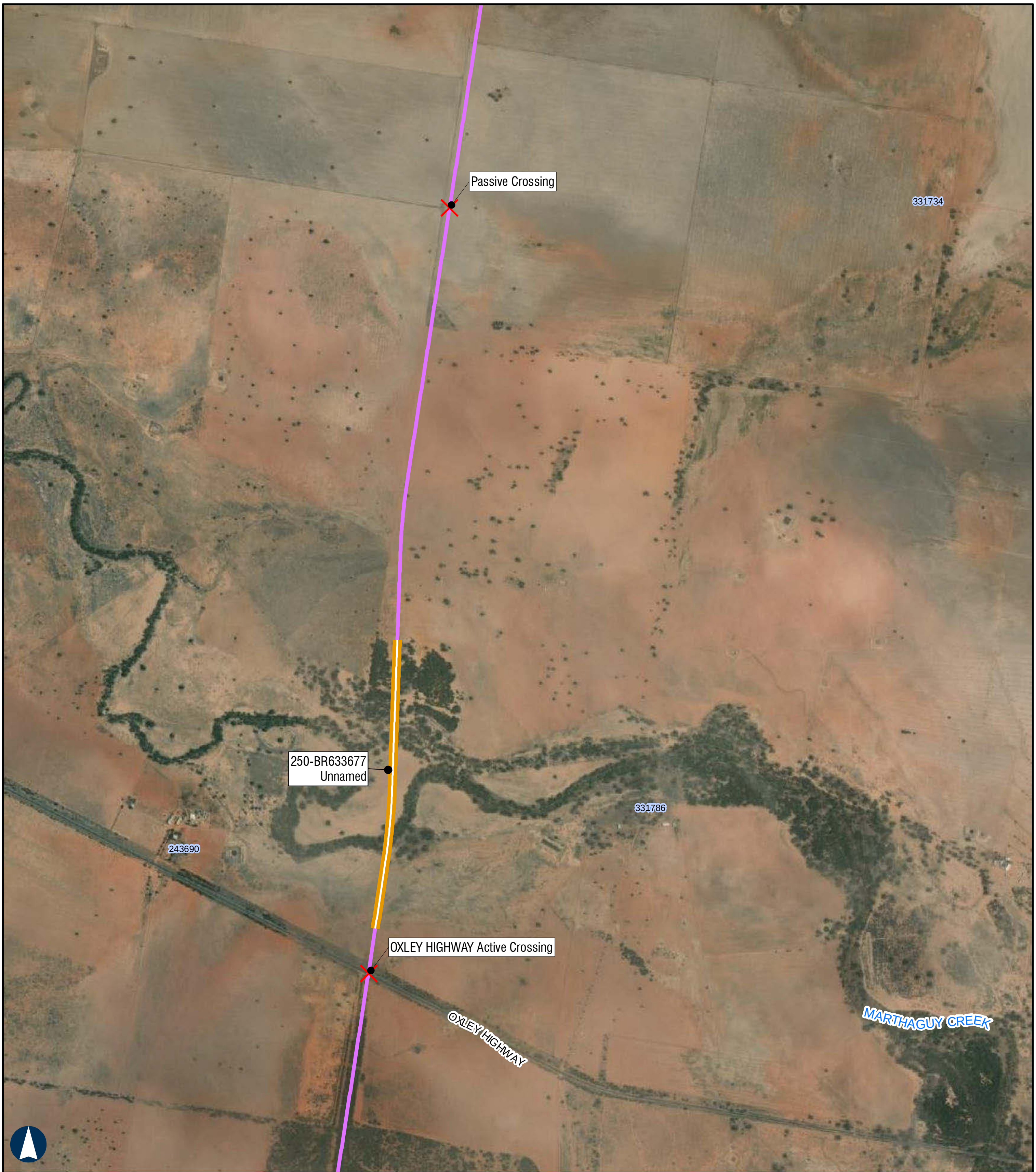

NARROMINE TO NARRABRI

Sensitive Receivers

200 m

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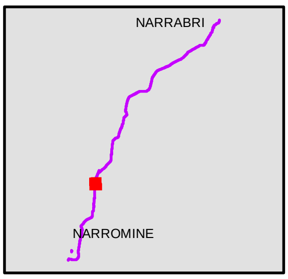

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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 23 of 74

200 m

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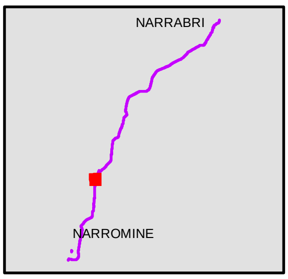

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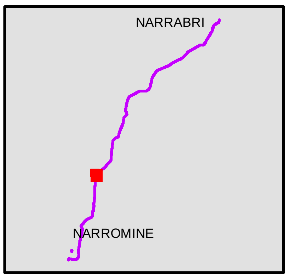

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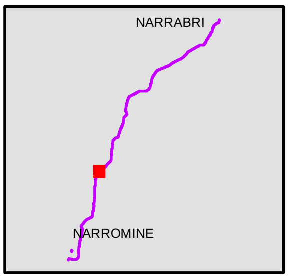

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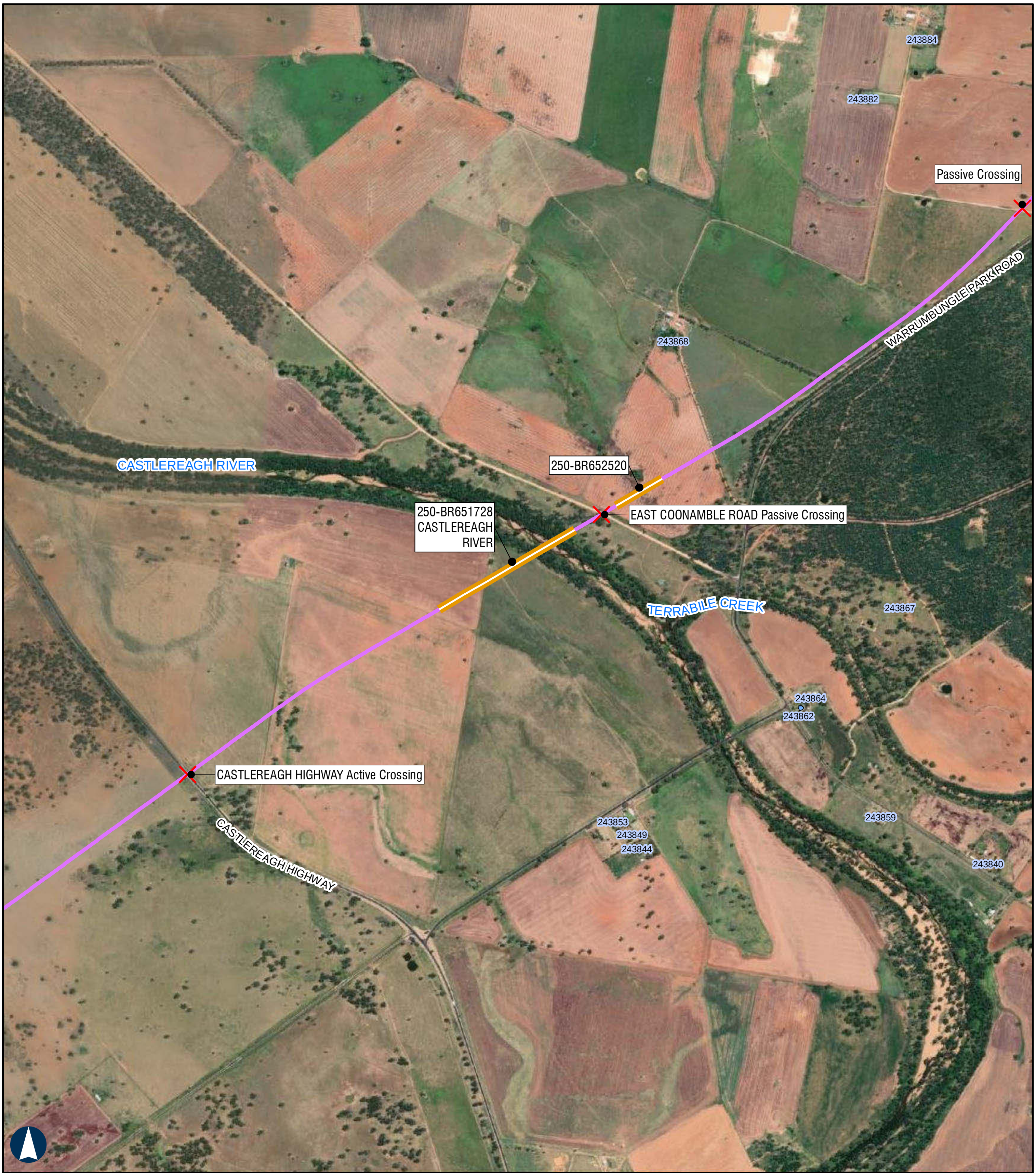

NARROMINE TO NARRABRI

Sensitive Receivers

200 m

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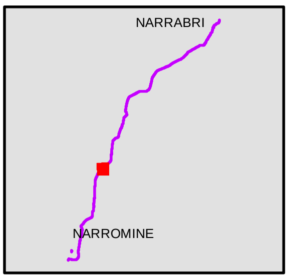

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APPENDIX A - Map 27 of 74

200 m

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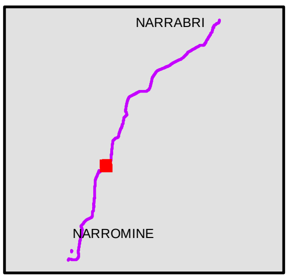

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NARROMINE TO NARRABRI

Sensitive Receivers

200 m

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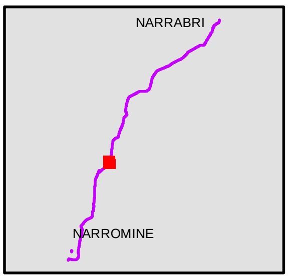

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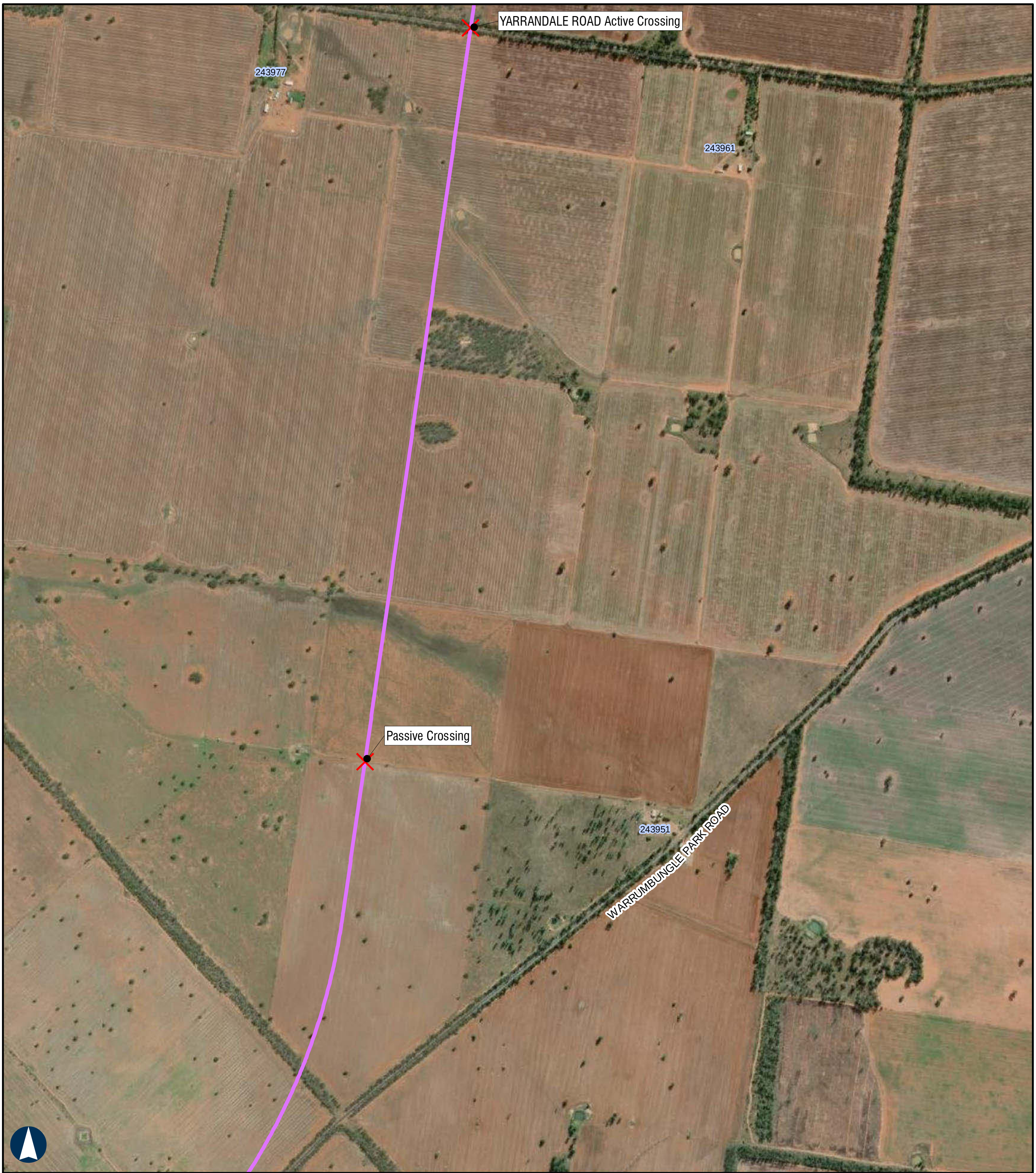

NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 29 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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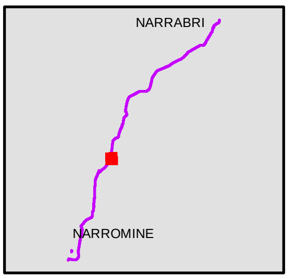

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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 30 of 74

200 m

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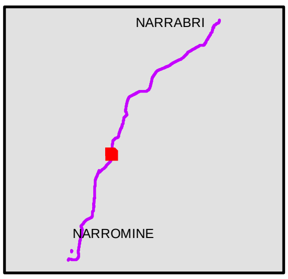

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NARROMINE TO NARRABRI

Sensitive Receivers

APPENDIX A - Map 31 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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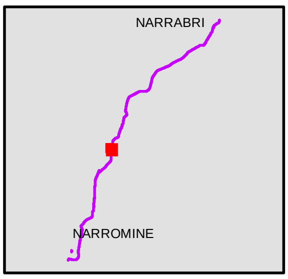

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APPENDIX A - Map 32 of 74

200 m

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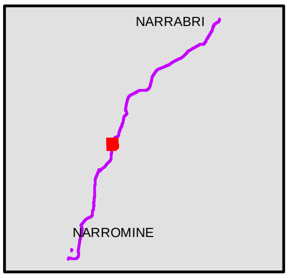

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Sensitive Receivers

APPENDIX A - Map 33 of 74

200 m

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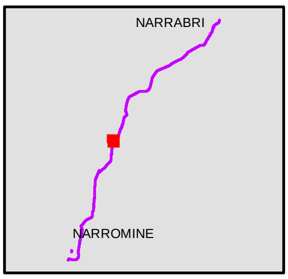

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NARROMINE TO NARRABRI
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APPENDIX A - Map 34 of 74

200 m

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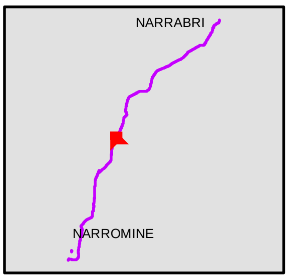

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NARROMINE TO NARRABRI
Sensitive Receivers

APPENDIX A - Map 35 of 74

200 m

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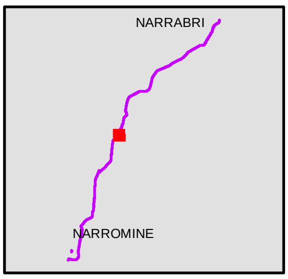

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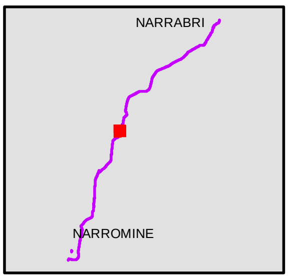

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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 37 of 74

200 m

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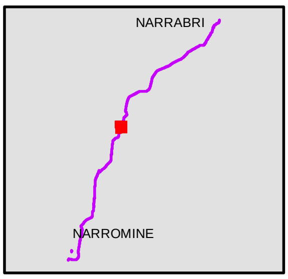

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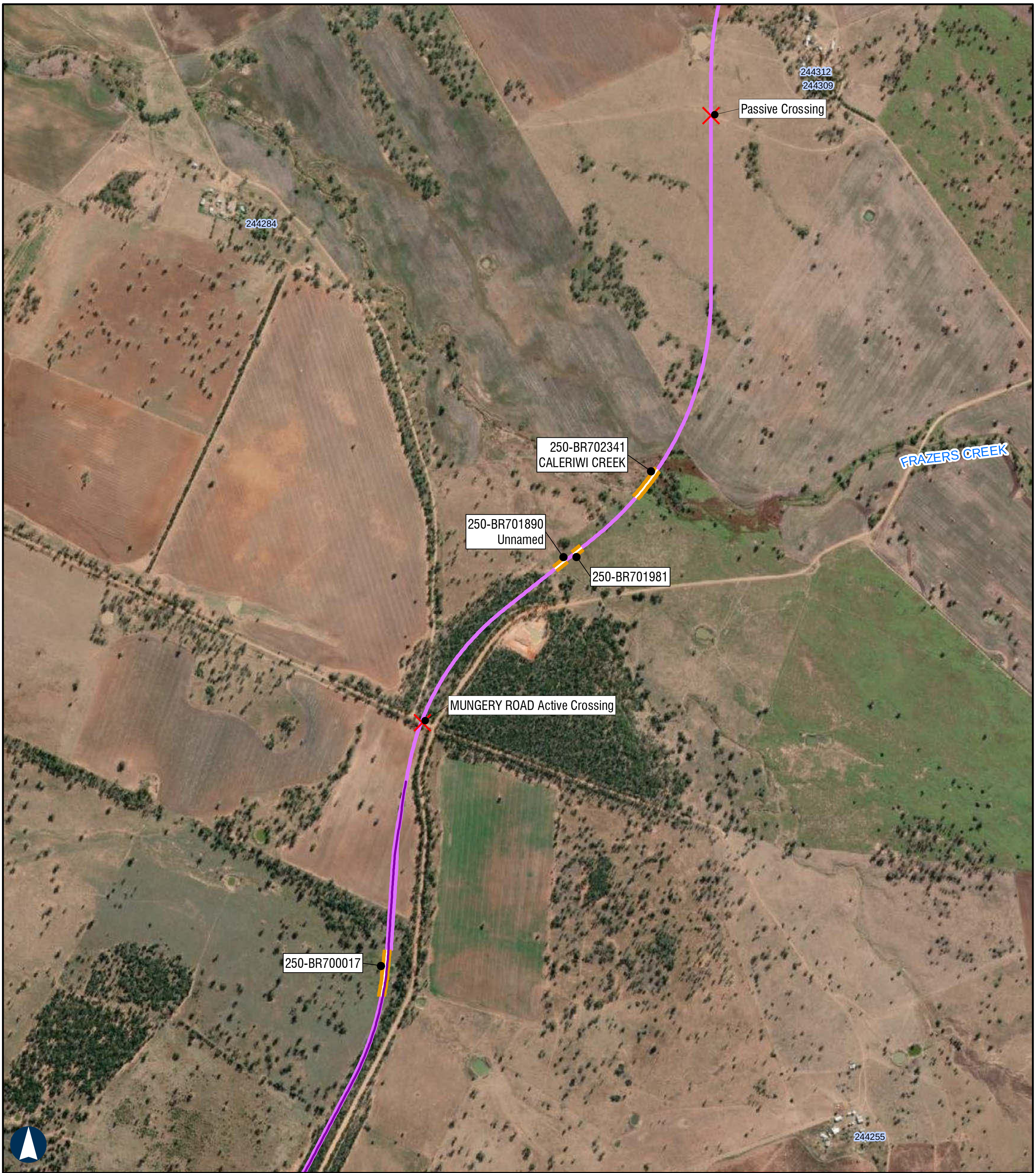

NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 38 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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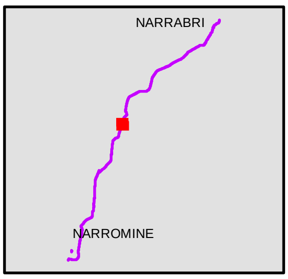
Paper: A4 Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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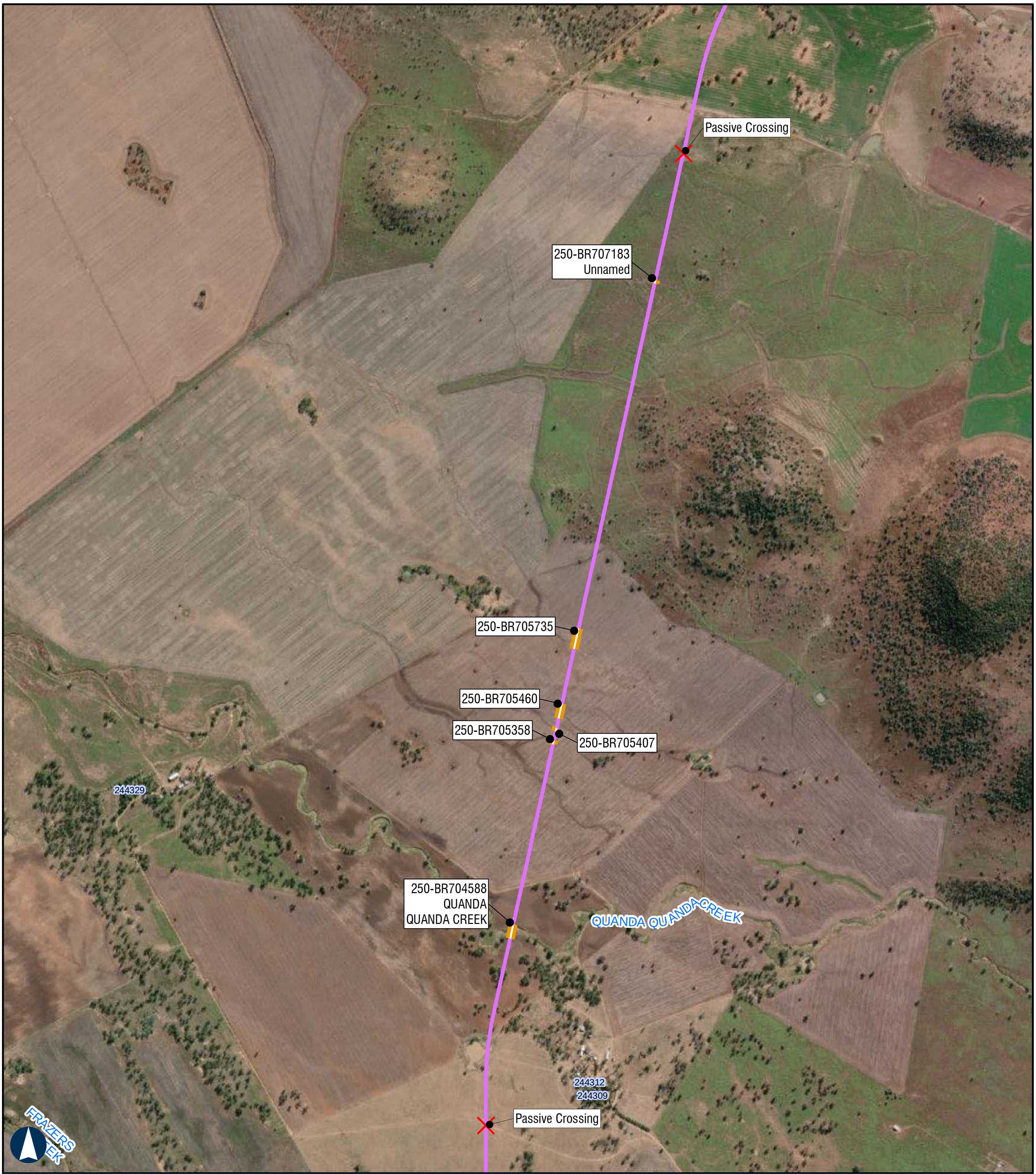


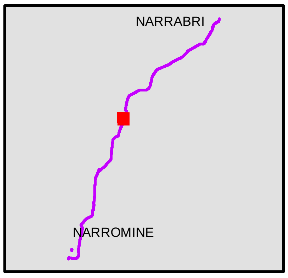
NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 39 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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Date: 01-Feb-2022
Author: JG

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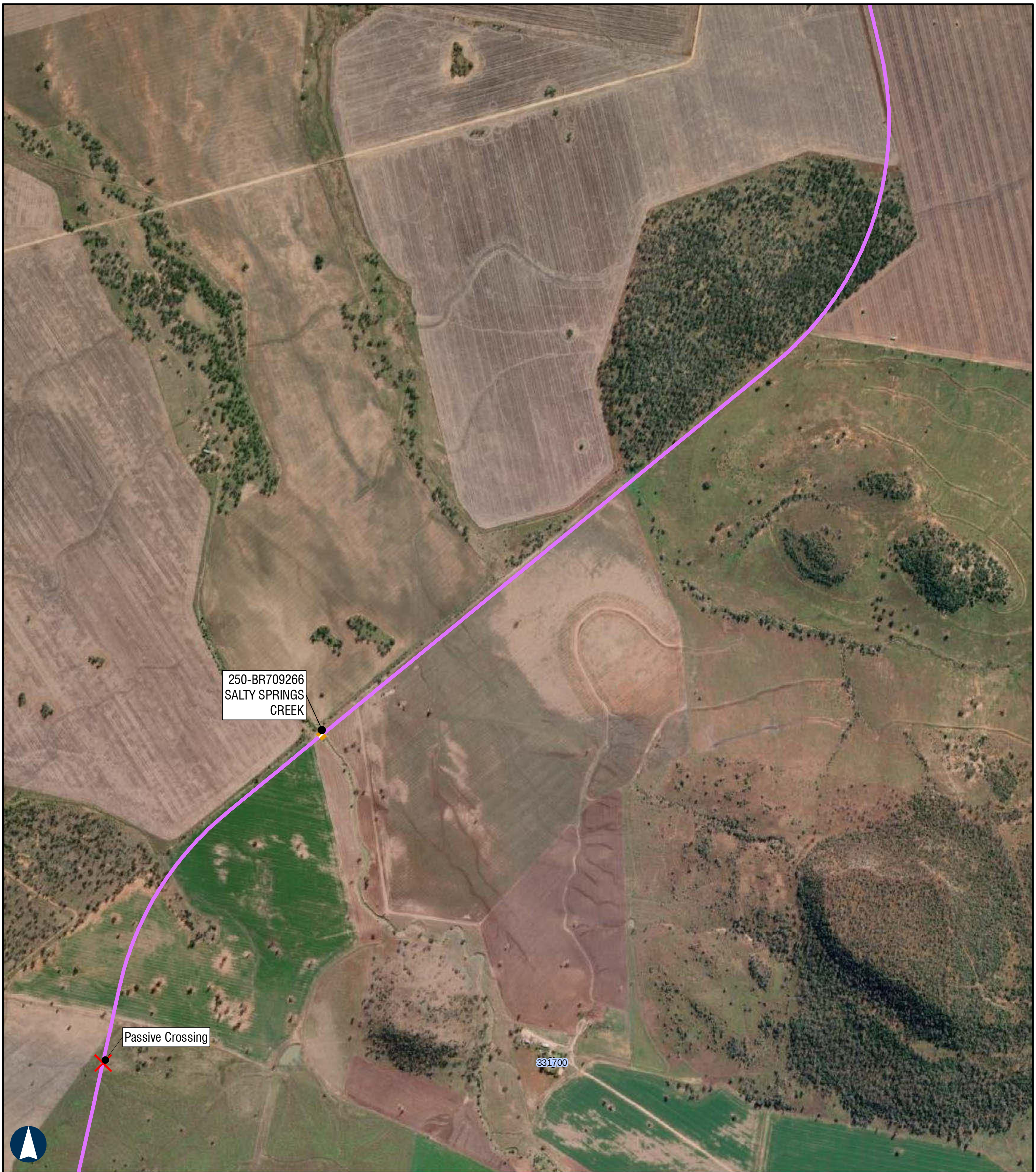

NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 40 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)

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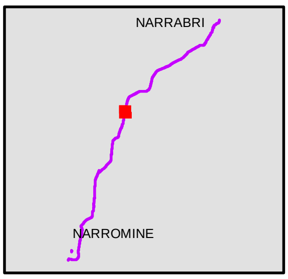
- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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Author: JG

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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 42 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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Date: 01-Feb-2022
Author: JG

- Level Crossings
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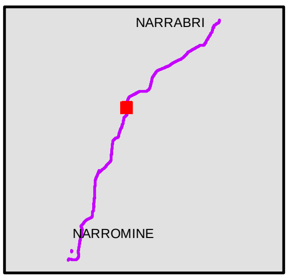
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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200 m

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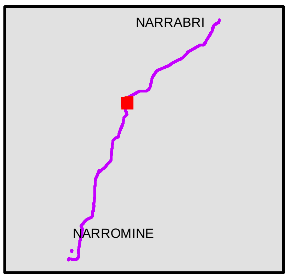
Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI

Sensitive Receivers

200 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4
Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
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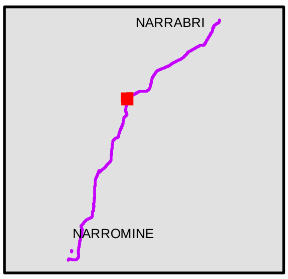
- Sensitive Receptors (Residential)



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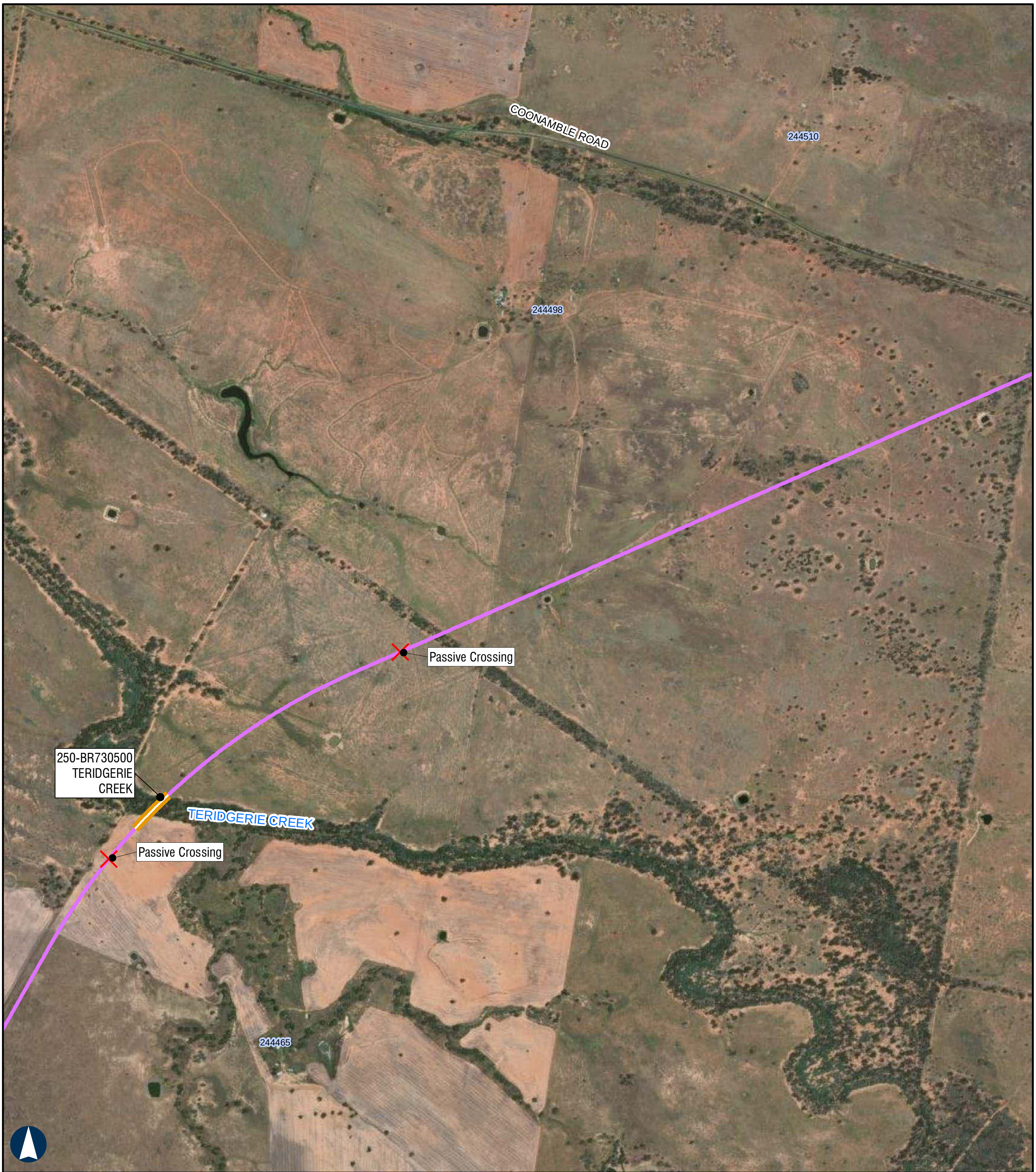


NARROMINE TO NARRABRI

Sensitive Receivers

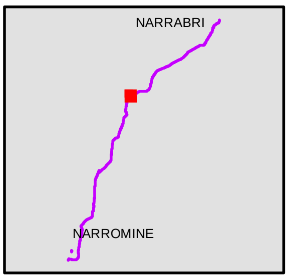
APPENDIX A - Map 45 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4
Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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200 m

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Author: JG

- Level Crossings
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- Crossing Loops
- Rail Alignment/Centreline
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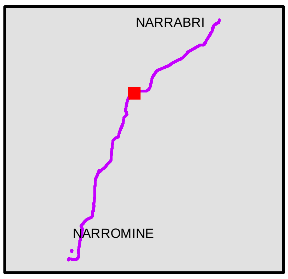
- Sensitive Receptors (Residential)



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Sensitive Receivers

200 m

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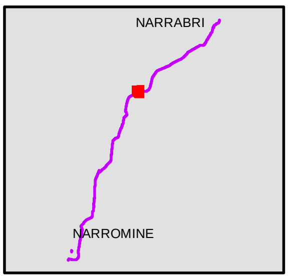
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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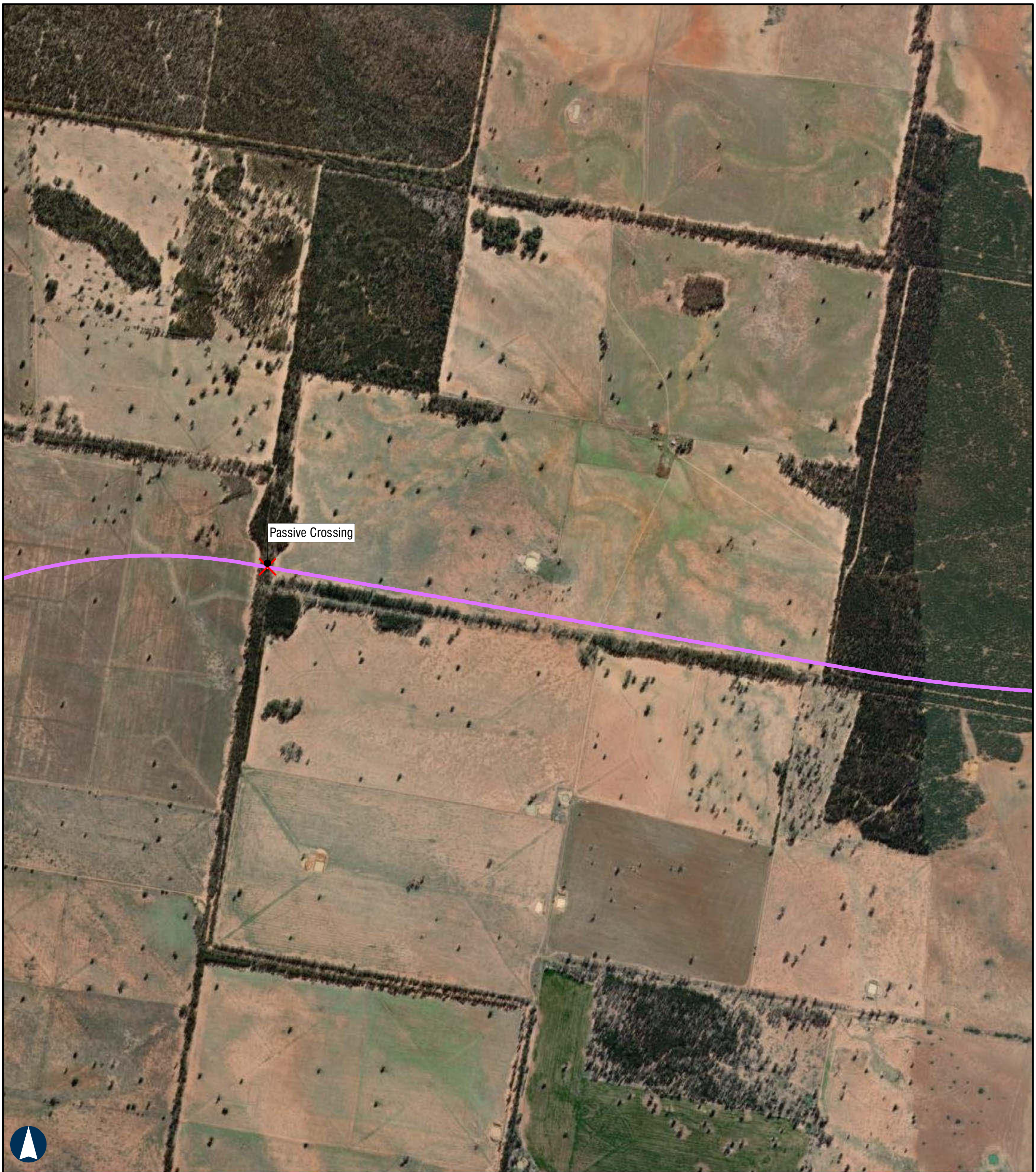

NARROMINE TO NARRABRI Sensitive Receivers

200 m

Coordinate System: GDA 1994 MGA Zone 55

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- Level Crossings
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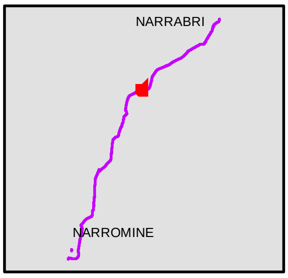

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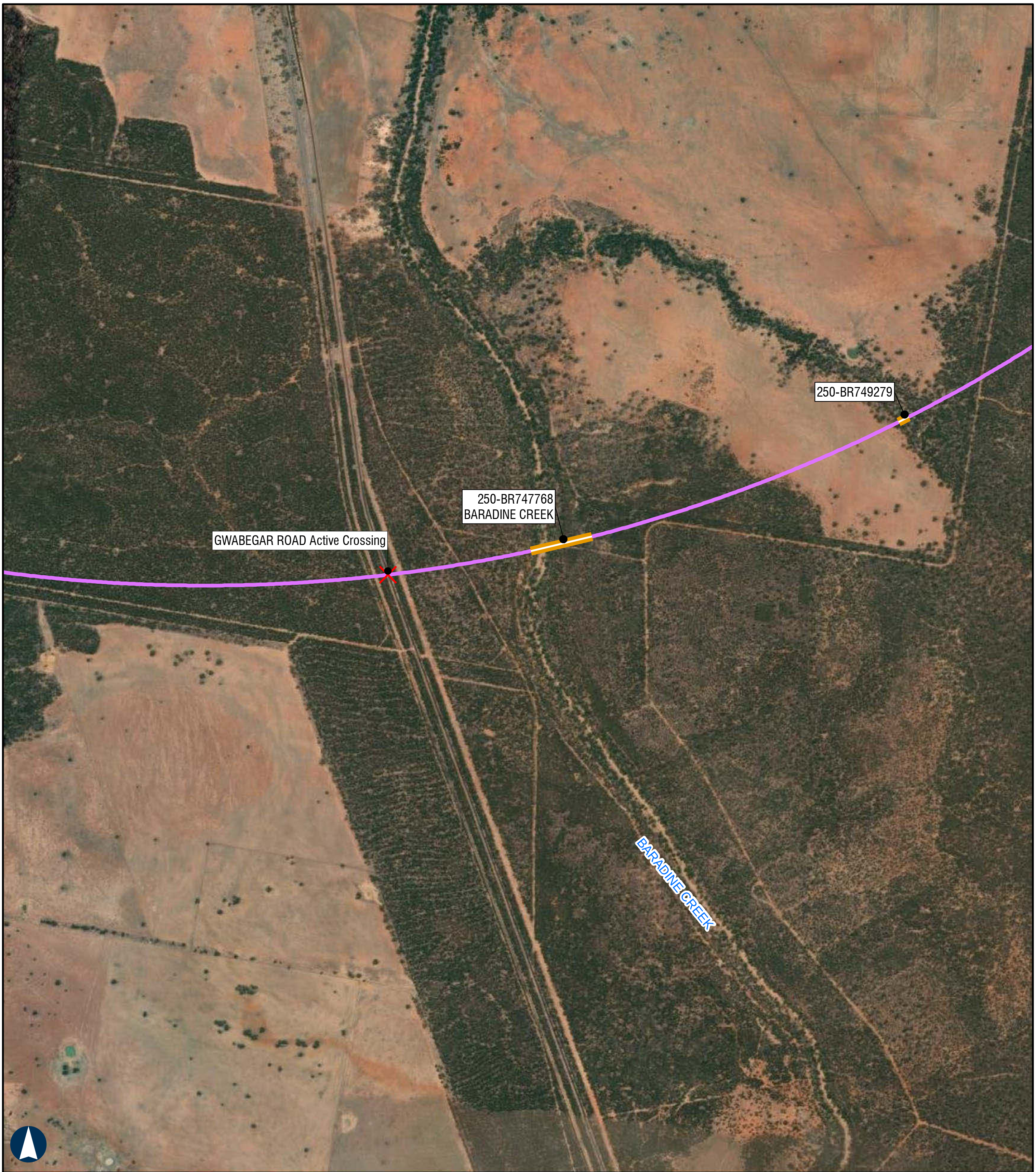


NARROMINE TO NARRABRI
Sensitive Receivers

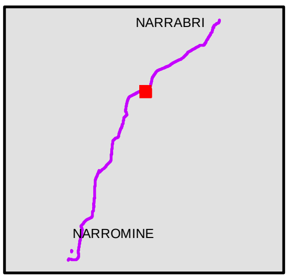
APPENDIX A - Map 49 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4
Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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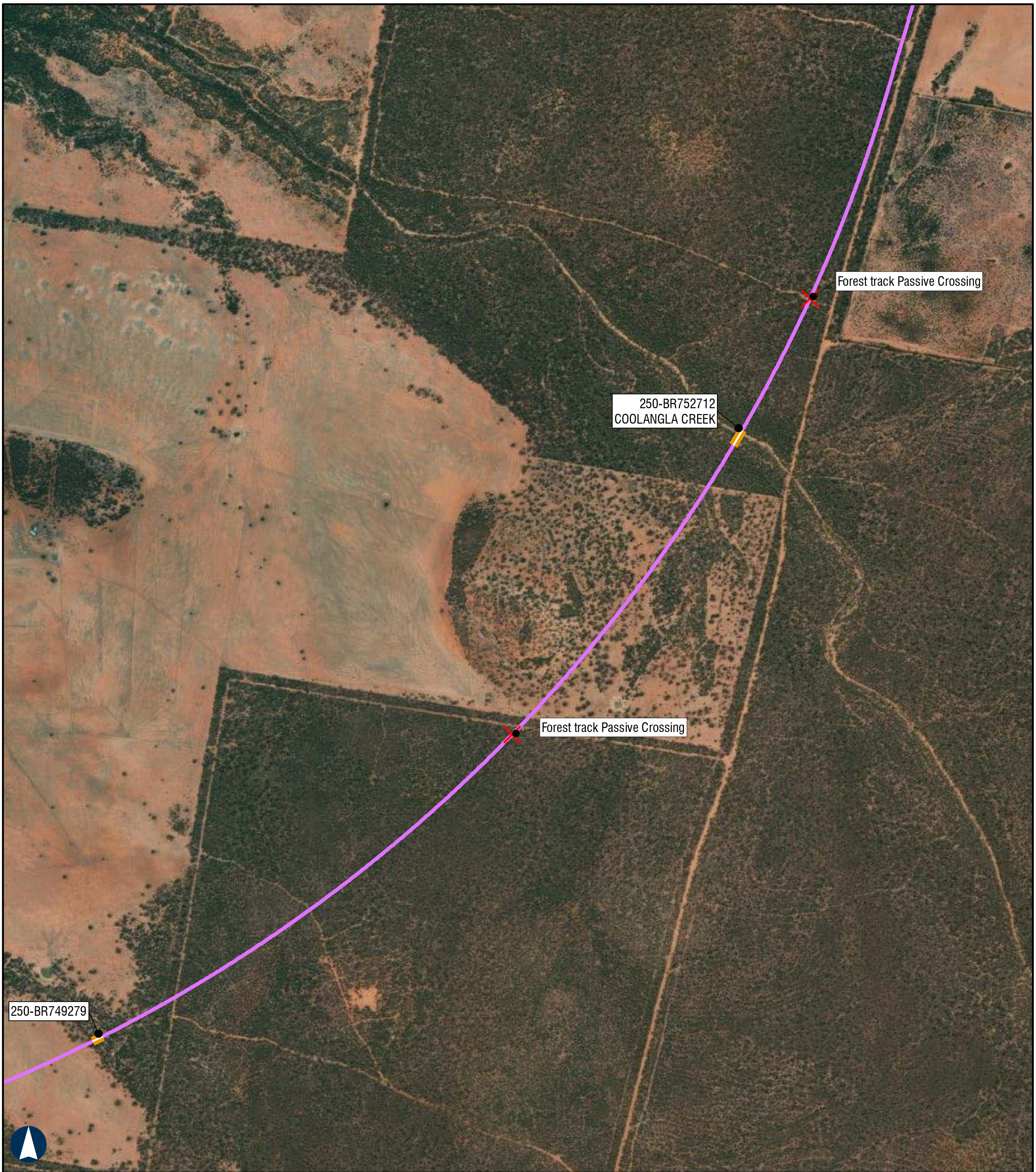

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Sensitive Receivers

200 m

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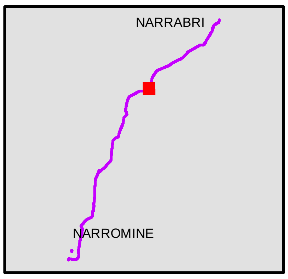

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APPENDIX A - Map 51 of 74

Coordinate System: GDA 1994 MGA Zone 55

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- Level Crossings
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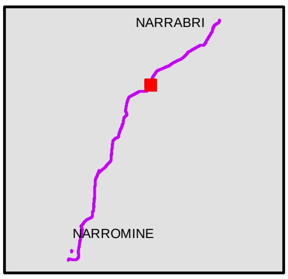
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 52 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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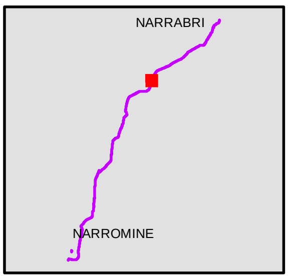

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APPENDIX A - Map 53 of 74

200 m

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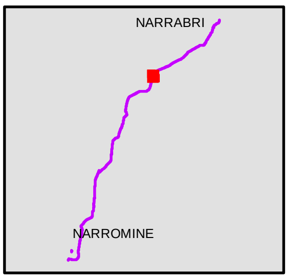

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NARROMINE TO NARRABRI

Sensitive Receivers

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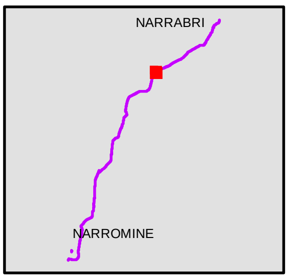

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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 55 of 74

200 m

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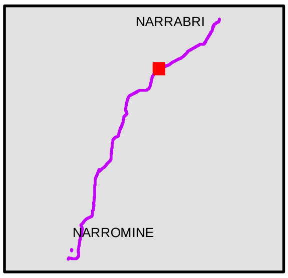

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NARROMINE TO NARRABRI Sensitive Receivers

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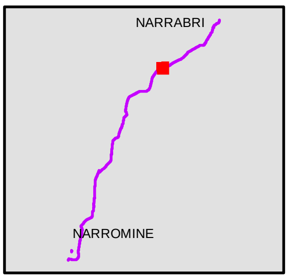

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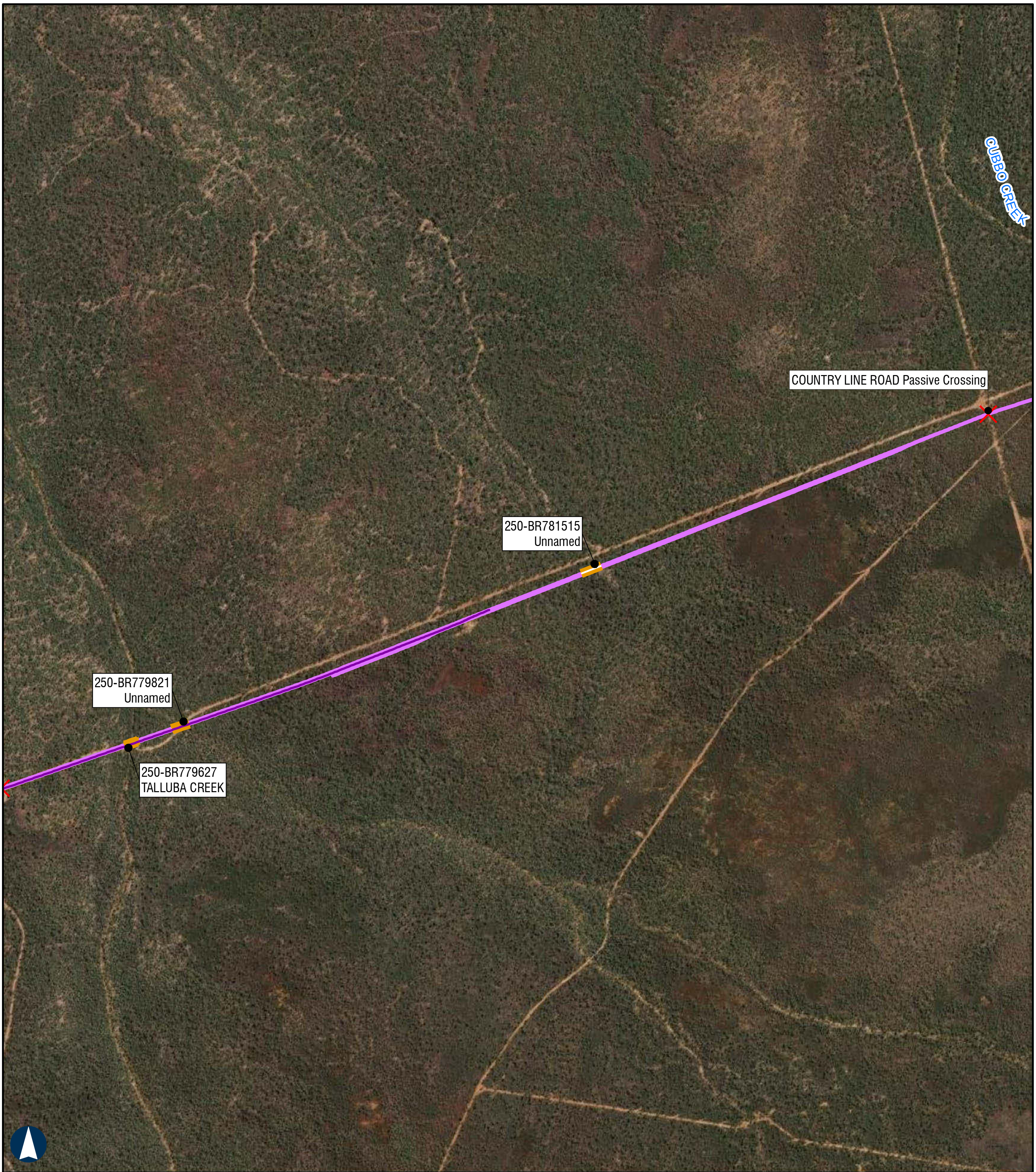

NARROMINE TO NARRABRI

Sensitive Receivers

APPENDIX A - Map 57 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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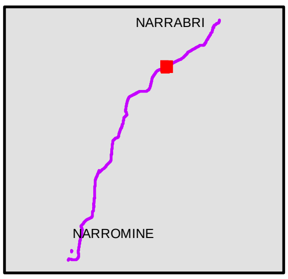
Paper: A4
Scale: 1:20,000
Date: 01-Feb-2022
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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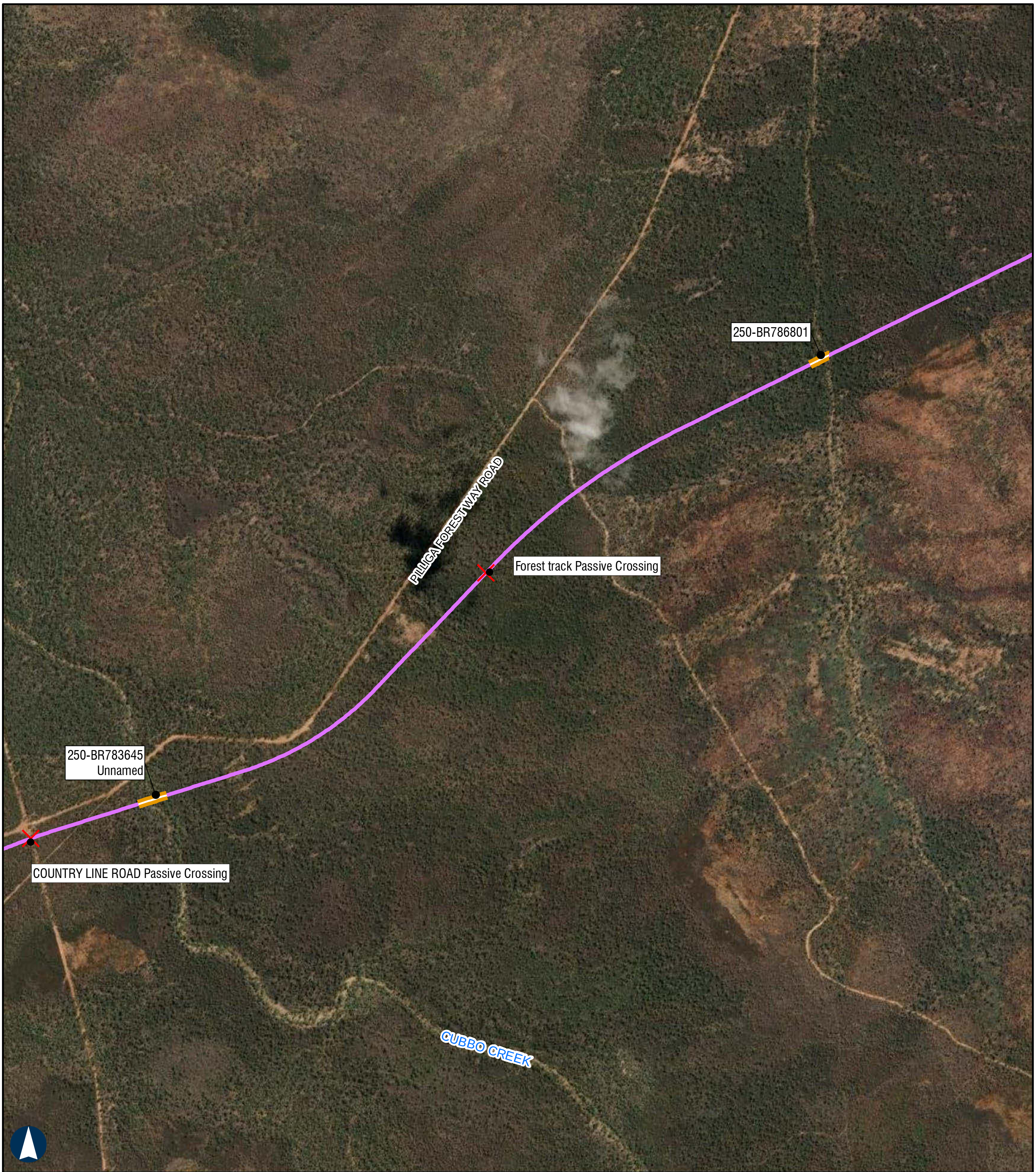

NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 58 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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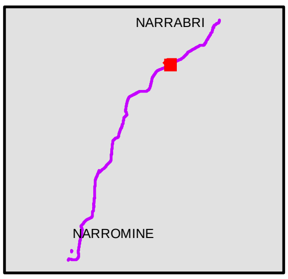
- Sensitive Receptors (Residential)



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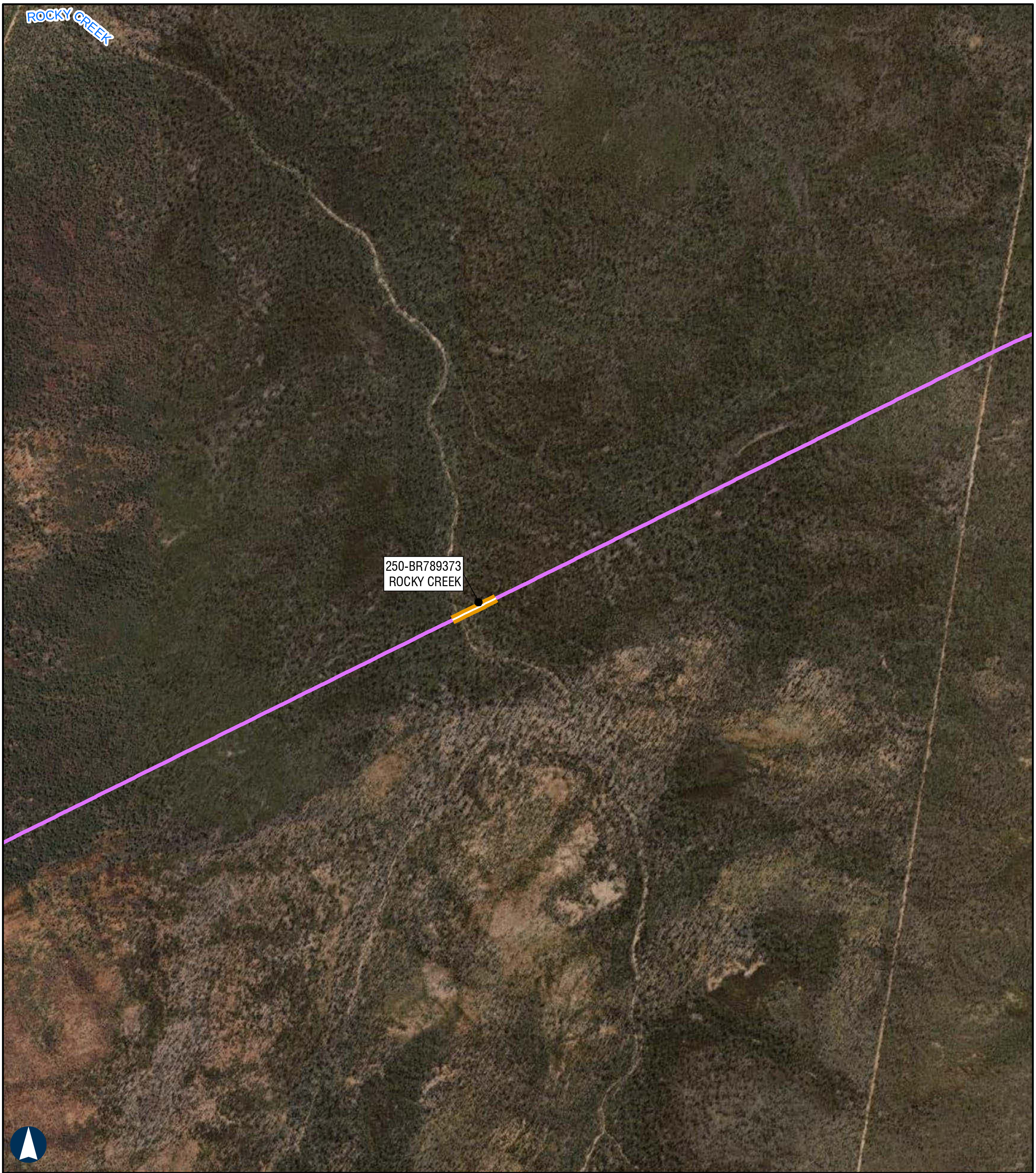

NARROMINE TO NARRABRI Sensitive Receivers

200 m

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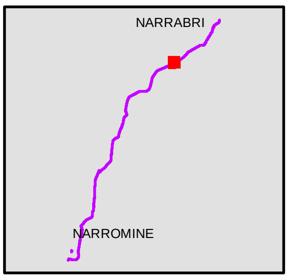
- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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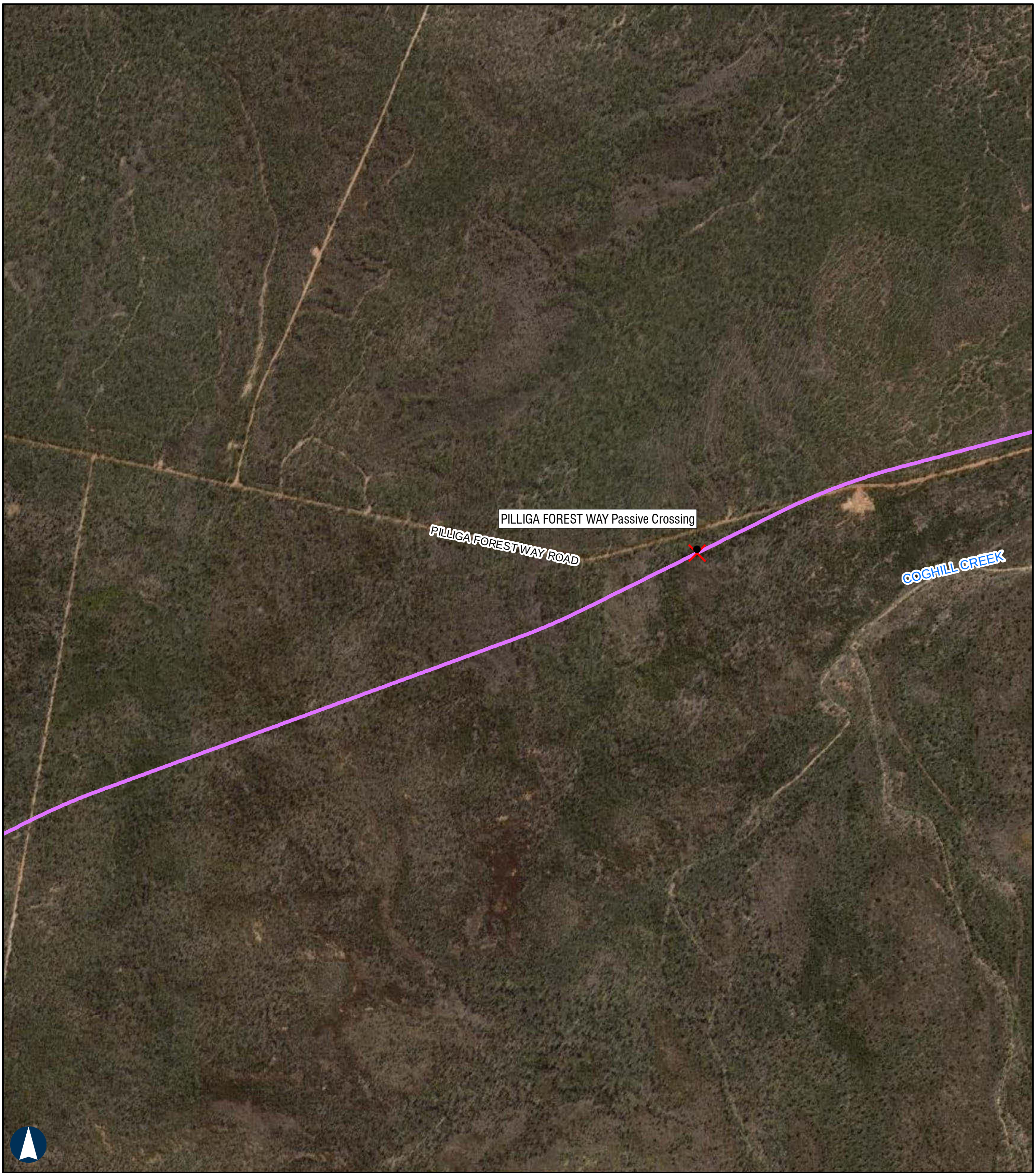

NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 60 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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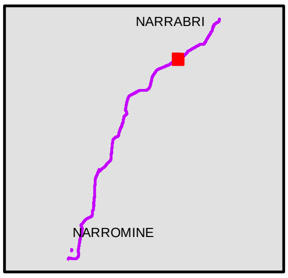
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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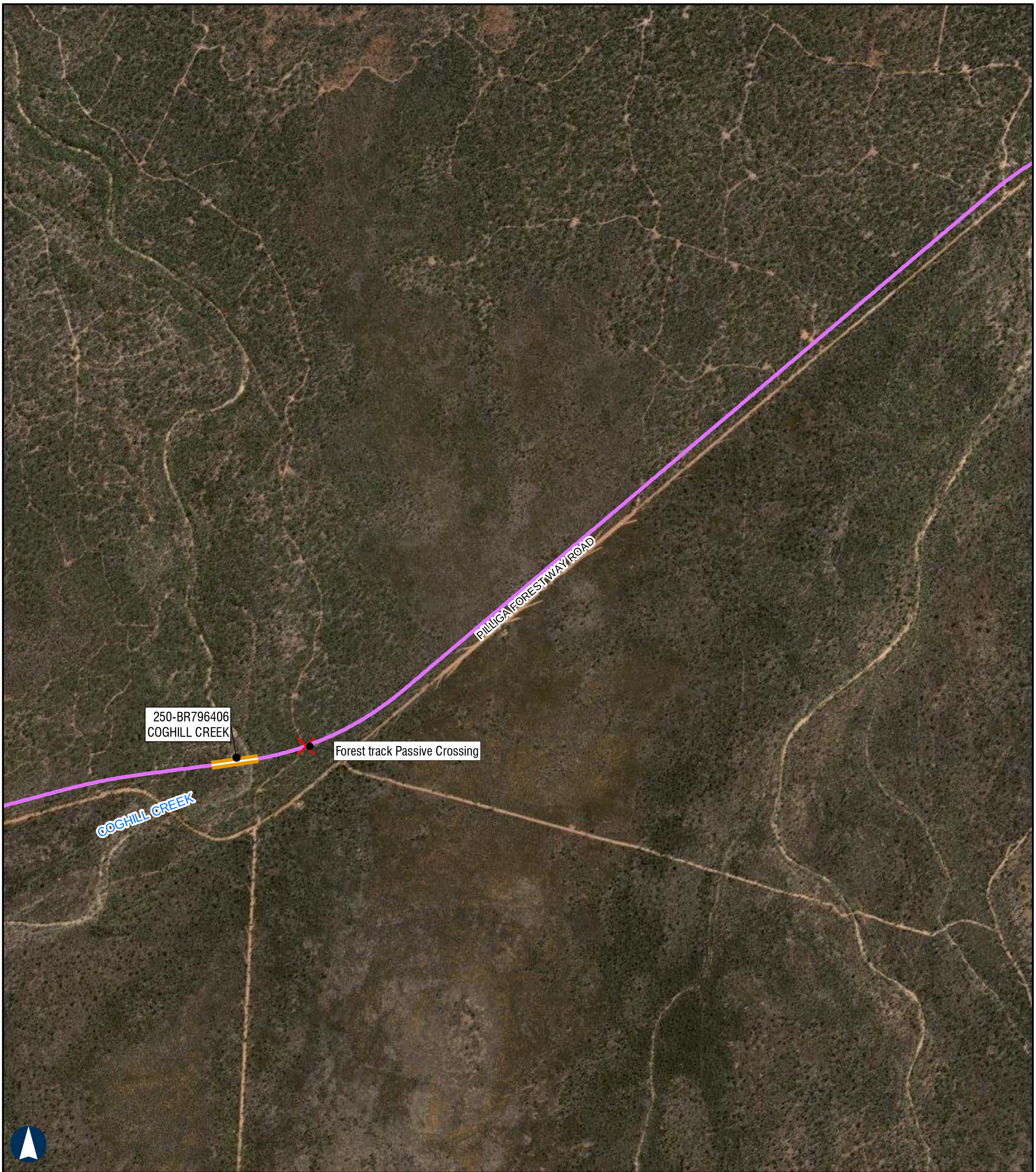

NARROMINE TO NARRABRI
Sensitive Receivers

200 m

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- Level Crossings
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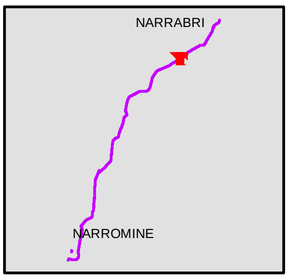
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 62 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

Scale: 1:20,000

- Level Crossings
- Project Extent
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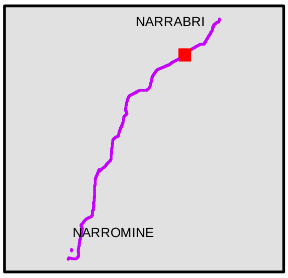
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI
Sensitive Receivers

APPENDIX A - Map 63 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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- Crossing Loops
- Rail Alignment/Centreline
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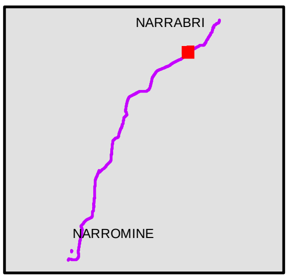
- Sensitive Receptors (Residential)



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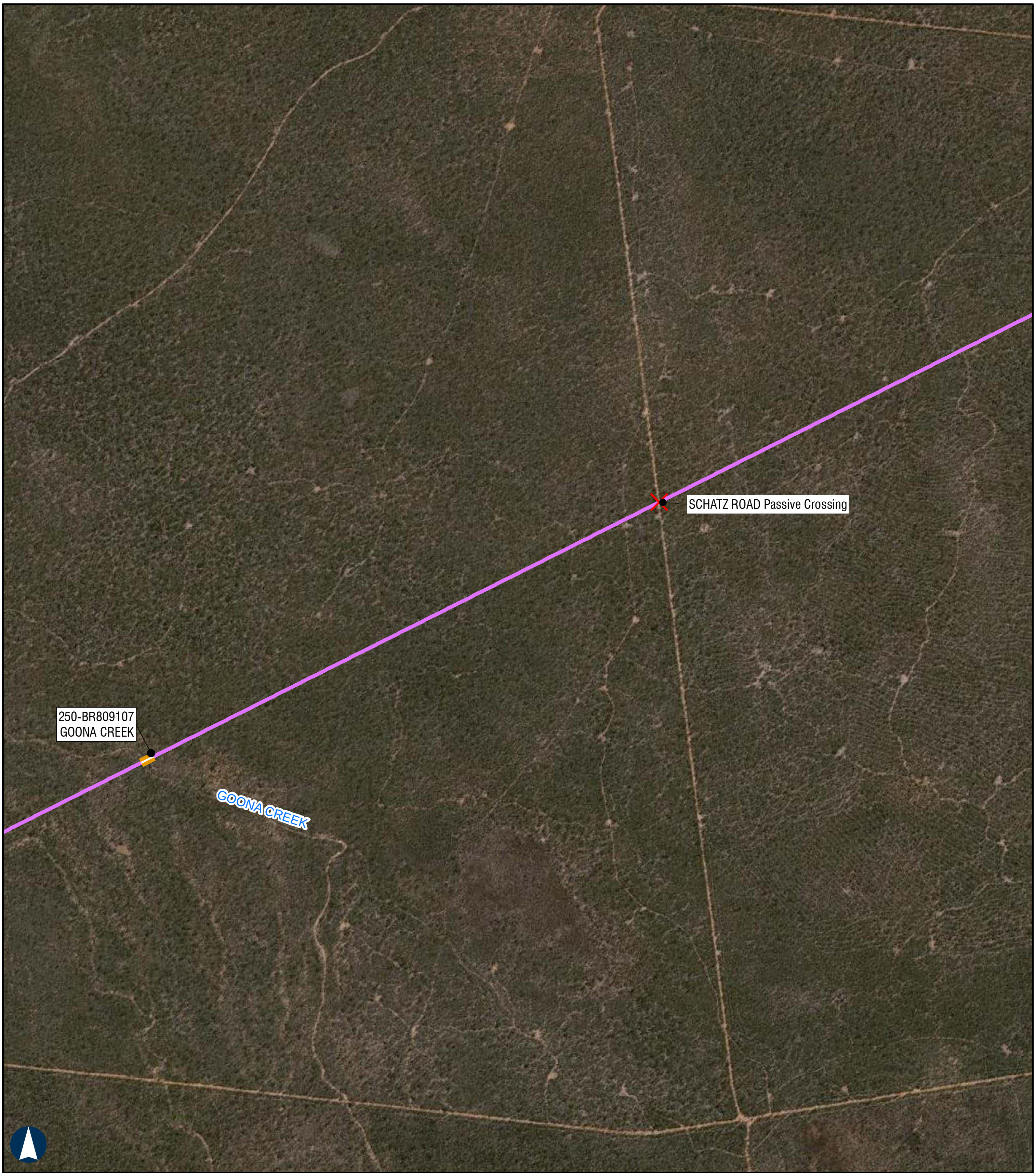

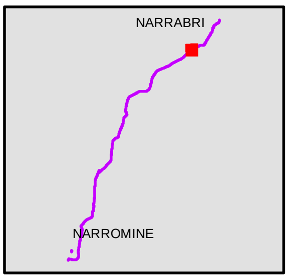

NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 64 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)

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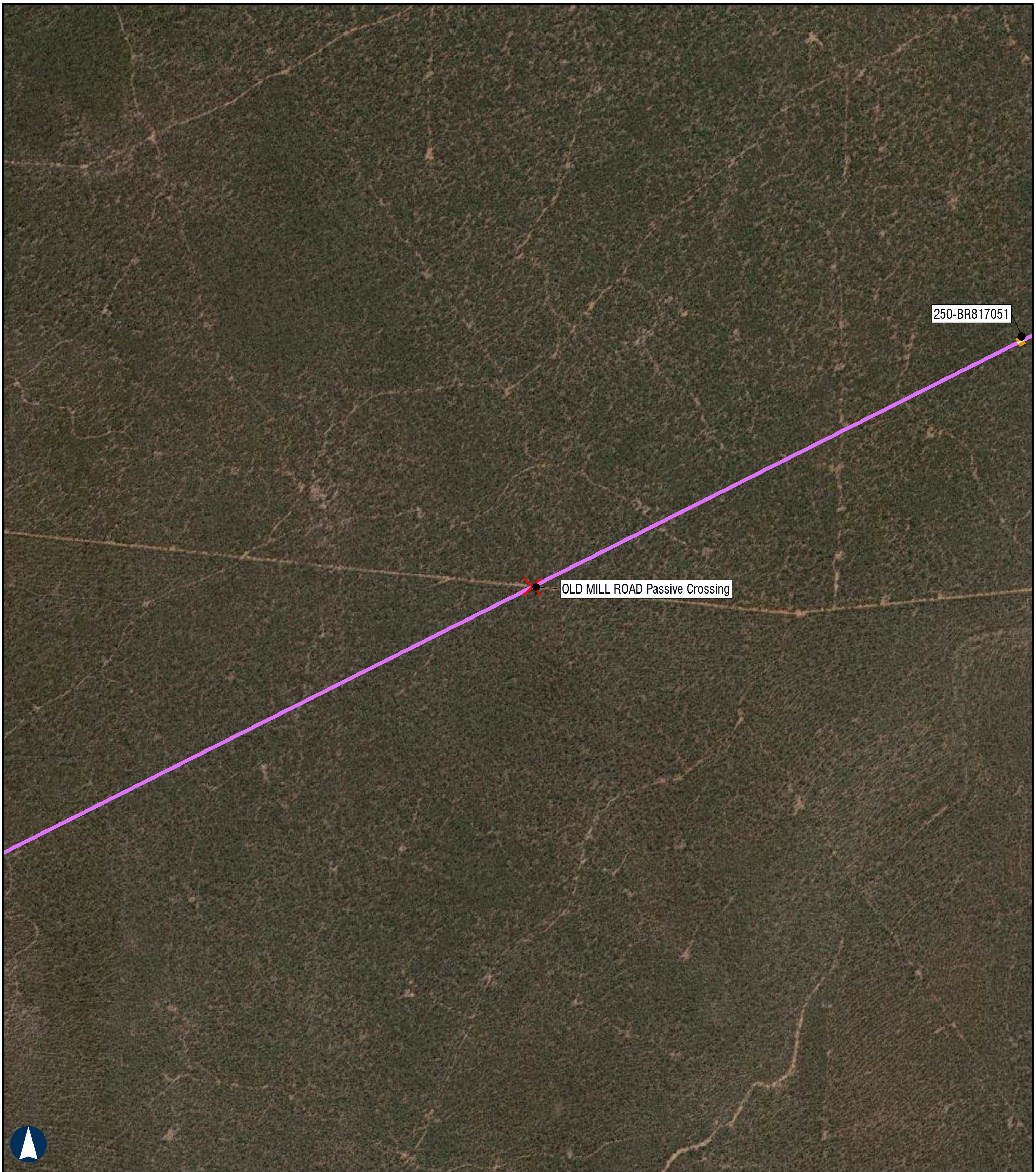

NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 65 of 74

200 m

Coordinate System: GDA 1994 MGA Zone 55

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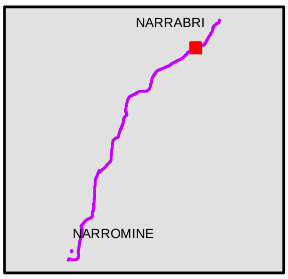
- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI
Sensitive Receivers

200 m

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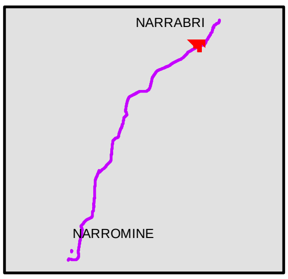
- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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200 m

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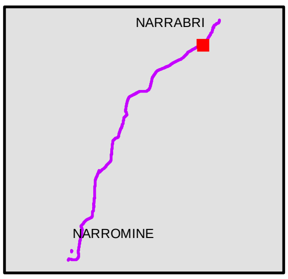

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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 68 of 74

200 m

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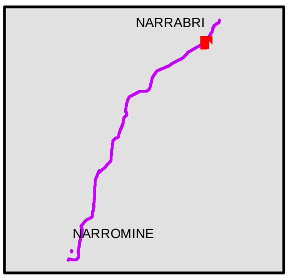

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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 69 of 74

200 m

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- Crossing Loops
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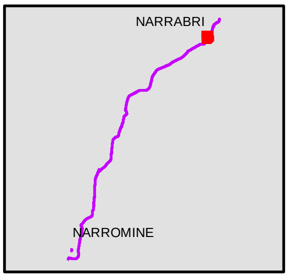
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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NARROMINE TO NARRABRI Sensitive Receivers

APPENDIX A - Map 70 of 74

200 m

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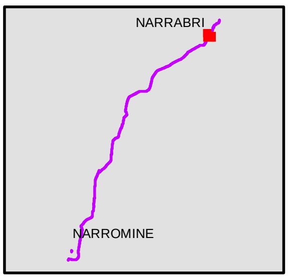

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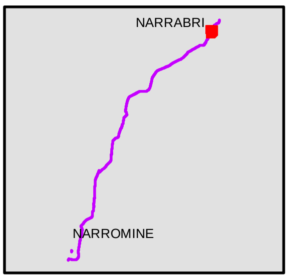

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NARROMINE TO NARRABRI
Sensitive Receivers

200 m

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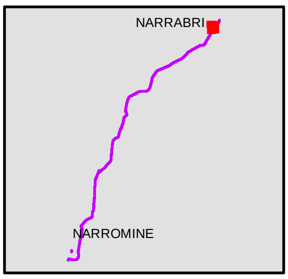

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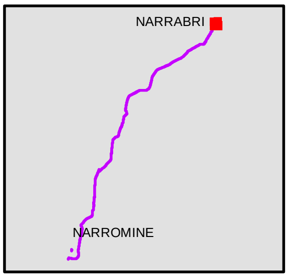

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NARROMINE TO NARRABRI

Sensitive Receivers

APPENDIX A - Map 74 of 74

200 m

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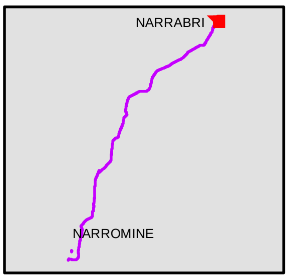
- Bridges and Viaducts
- Sensitive Receptors (Residential)



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Author: JG

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TECHNICAL REPORT 09

Updated noise and vibration assessment—operational rail

Appendix B Noise prediction model verification (NSW)

NARROMINE TO NARRABRI PROJECT

Overview

The level and character of railway noise within the local environment is specific to the rollingstock operations, condition of the rails and the daily rail traffic. Because of the wide range in variability of these factors, noise prediction models for railway infrastructure are commonly developed from a database of verified source noise emission levels for the rollingstock.

Organisations such as TfNSW have train noise emission databases for the use in noise modelling and railway noise impact assessments. A similar verified noise emission database has been adopted for assessment of railway noise on Inland Rail (refer **Table 22** of this report).

The methodology to predict railway noise has also been verified with reference to existing railway noise levels monitored by SLR at sections of existing railway operations that shall become part of Inland Rail in NSW. The details of the railway noise monitoring and noise model verification at three locations in NSW are provided in the following sections.

Noise monitoring locations and methodology

The noise monitoring locations were selected based on the following criteria, designed to provide a consistent across the noise monitoring locations:

- At monitoring sites adjacent to the rail line(s) that could be safely and regularly accessed without requiring entry to the rail corridor.
- Located approximately 15 m from the rail line to be representative of the nearest sensitive receivers and to be close enough to limit the potential influence of local weather conditions.
- Where the track was generally straight and observed to be in relatively good condition. This requirement limited the potential influence of unique factors such as curving noise or prominent track wear which can substantially increase localised rail noise levels.
- Where daily rail traffic was comparable to the proposed rail movements on Inland Rail.
- Railway operations were predominately heavy rail traffic (general freight and intermodal trains) and the locomotives were expected to generally be at a constant speed to minimise potential for discrete events such as braking or acceleration (high notch).

Railway noise levels for the daily existing trains movements were monitored at three nearby to Table Top, Henty and Wanitool, as summarised in **Table B1**.

Table B1 Noise monitoring locations in NSW

SLR ID	Location	Monitoring dates	Equipment[1,2]
1	331 Perryman Lane, Table Top NSW. 15 m from the outer rail	14 to 22 November 2018	NGARA noise logger (s/n 878000)
2	262 Henty-Walla Road, Henty NSW. 15 m from the outer rail.	14 to 22 November 2018	NGARA noise logger (s/n 8780C7)
3	731 Ballengoarrah Lane, Wanitool NSW. 13 m from the southbound outer rail and 17 m from the northbound outer rail	29 November to 7 December 2018	NGARA noise logger (s/n 878042)

Note 1 All monitoring equipment complies with the requirements of Australian Standard AS1259-1990 (part 1 and 2) and IEC 61672.

Note 2 All equipment was calibrated before and after the monitoring period with any drift in signal less than 1 dB.

To avoid the influence of surrounding buildings and structures on the railway noise levels, the railway noise levels were monitored in the free-field environment at 1.5 m above ground level for a period of seven consecutive days at each location.

The noise levels were measured at intervals of 1/10th of a second in order to isolate the discrete noise contribution from the train passby events.

The noise monitoring data was analysed to determine the noise emission level and duration of each clearly discernible train passby event. Applying principles from ISO 3095, the noise levels were analysed to define each train passby event. The analytical process for each location adopted the following approach:

- Identifying all noise level events above an initial threshold and sustained for a defined period of time; this was site specific and provided a first pass filter to identify likely train passby events.
- The length of each event was identified from the start and end points where the noise levels reached 10 dB above the background noise level at the time of each event.
- Each event was visually inspected to identify statistically valid train profiles i.e. a train passby signature that can be used to refine the processing of identifying each passby event.
- The audio data for each identified noise event was reviewed to confirm it was a train passby and not erroneous, activity nearby to the monitoring location.

Monitored rail passbys

The sound exposure level (L_{AE}) for each individually processed train passby was calculated as part of the analysis process. The discrete L_{AE} of each identified Freight and XPT train are plotted in **Figure B1** and **Figure B2** below for the three monitoring locations.

The average L_{AE} is plotted with comparison to the modelled value representative of a 1,000 m freight train with NR class locomotive, as per **Table 22**. The relevant existing train speeds at the monitoring locations were estimated from posted track speeds and site observations. Based on the distribution of data, both sides of the double-track at Wanitool are in use, while the other two monitoring locations represent single track conditions.

Figure B1 Monitored freight train passby sound exposure levels

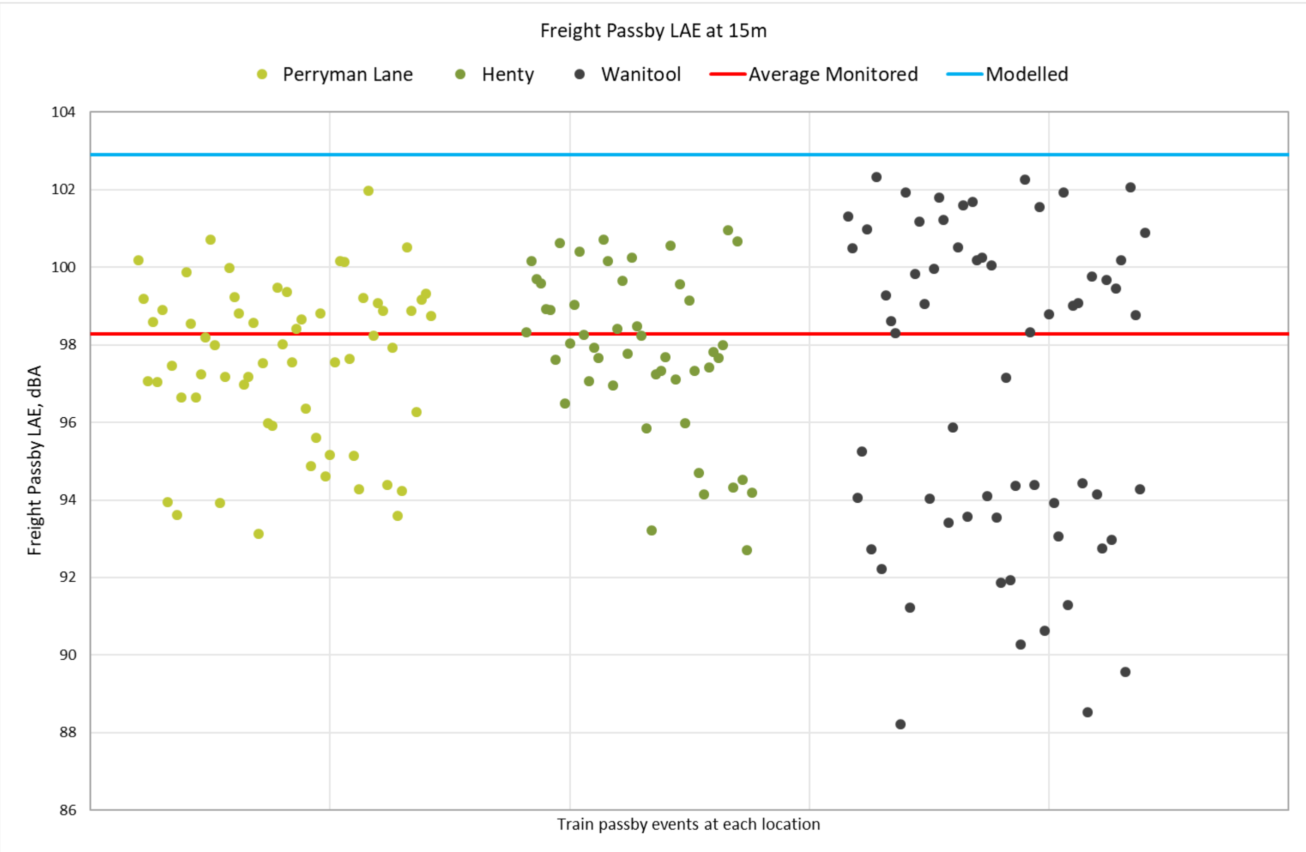
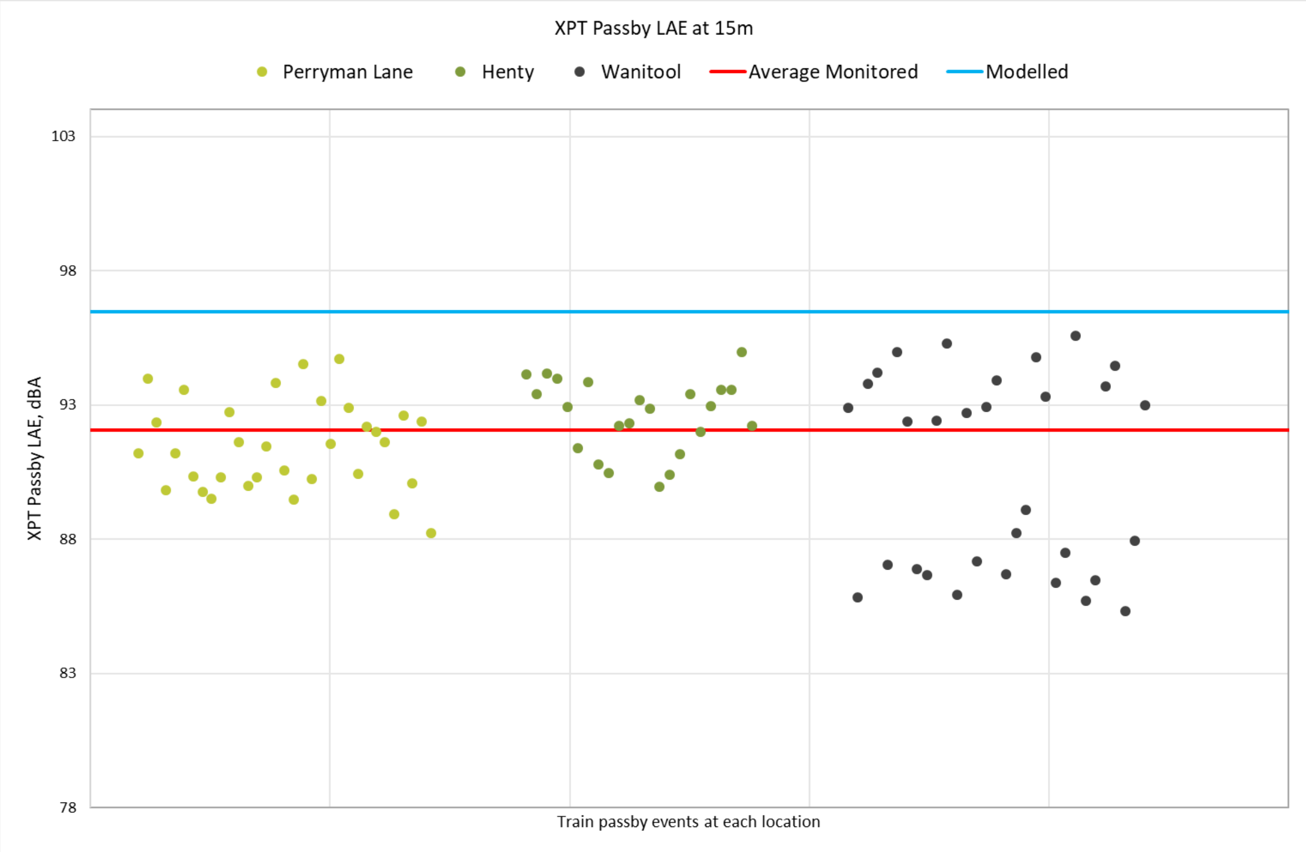


Figure B2 Monitored XPT train passby sound exposure levels



Monitored daily rail noise levels

The monitored daily LAeq railway noise levels at each monitoring location are detailed in the following table. The daily LAeq noise levels for validation are calculated from the noise level of each train passby, averaged over each day monitored and applied to the modelled number of trains on this section.

Weather data was referenced from the nearest Bureau of Meteorology weather stations to the monitoring locations. The local weather conditions, principally wind speed and precipitation, were found to not have influenced the monitoring noise levels for the train passby events. This was also, in part, due to the proximity of the monitoring locations to the rail lines. The daily railway noise levels, based on monitored data, at the locations at the monitoring locations are detailed in **Table B2**.

Table B2 Monitored daily railway noise levels

Monitoring location	Monitored railway noise levels, dBA	
	Daytime	Night-time
	LAeq(15hour)	LAeq(9hour)
Perryman Lane	61.5	64.3
Henty	60.6	63.6
Wanitool	62.7	65.4

The analysis of the monitored noise levels and audio recordings for the train passbys, along with on-site observations, identified the following:

- The daytime and night-time L_{Aeq} noise levels correlate closely between sites, with a total variability of approximately 2 dB. This reaffirms that the same rail traffic is dominant across all monitoring locations.
- The night-time L_{Aeq} noise levels are generally higher than the daytime L_{Aeq} noise levels, due to a similar volume of train passbys occurring over a shorter time period.
- The noise statistics are lower at Henty when compared with the other two monitoring locations. Given there were no local structures or geographical features to impede the propagation of railway noise, it was assumed that the train speeds in this section are lower than at the other monitoring locations.

Noise modelling

To enable verification of the monitored noise levels, the SoundPLAN noise modelling method, as discussed in **Section 6** of this report, was applied to calculate railway noise levels at each noise monitoring location. A summary of the key noise modelling data is provided in **Table B3**.

Table B3 Noise modelling inputs

Noise model attribute	Source data/ modelling approach
Daily train movements	As per the existing rail operations (volumes are consistent for day and night periods): 3 x Intermodal, 1 x Steel, 1 x General Freight, 1 x Grain – 1 and 2x XPT.
Rail line speeds	Referencing the posted speed data and monitoring observations the freight train speeds were estimated as 110 km/h at Perryman Ln, 90 km/h in Henty and 115 km/h at Wanitool. The XPT speeds were estimated as 150 km/h for all monitoring locations.
Railway acoustic corrections	Nil, all track was straight with no tight-radius curves, turnouts etc. within 100 m of each monitoring location.
Track strings	The alignment of the existing rail tracks was referenced from publicly available datasets and rail corridor designs supplied by ARTC.
Consist information	All trains modelled as per the existing consists.
Passenger rail traffic	Two XPT passenger train movements are included for both the day and night-time periods at all monitoring locations.
Local environment	3-dimensonal digital terrain models were developed for the environment at each monitoring location. Ground conditions were modelled as soft ground (ground absorption co-efficient of 0.6).

Noise model verification

The predicted and monitored L_{Aeq} railway noise levels at each location were compared as part of the noise model verification, as detailed in **Table B4**. The model was determined to be verified to a suitable accuracy where the predicted L_{Aeq} noise levels were within ±2 dBA of the measured railway noise levels.

Table B4 Modelled railway noise levels

Monitoring location	Monitored railway noise levels, dBA	
	Daytime	Night-time
	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Perryman Lane	63.2	65.2
Henty	62.3	64.2
Wanitool	64.1	66.0

The monitored and modelled L_{Aeq} noise levels at each location were compared, as detailed in **Table B5**. The noise model validation was determined for all three noise monitoring locations. Overall, the L_{Aeq} noise levels verify within 2 dBA of the monitored L_{Aeq} noise levels during the daytime and night-time periods and achieves NSW guidelines on transport noise model validation.

At the EIS stage it is satisfactory to slightly over-predict the railway noise levels to provide conservatism in both the assessment of potential noise impacts and the recommendations for potential noise mitigations.

Table B5 Noise model verification

Monitoring location	Railway noise level differences (predicted vs measured), dBA	
	Daytime	Night-time
	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Perryman Lane	1.6	0.9
Henty	1.8	0.6
Wanitool	1.3	0.6

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Appendix C Noise and vibration from double-stacked freight wagons

NARROMINE TO NARRABRI PROJECT

The load on the axles from freight wagons has the potential to influence the noise and vibration emission levels during the train passby event. The load will vary depending on the configuration of single stacked and double stacked containers and the contents of the containers which can vary from empty to the capacity weight.

To investigate the noise and vibration emission levels, SLR conducted a noise and vibration monitoring survey in January 2019 at a section of straight track near to Merriton, approximately 170 km north of Adelaide. The freight trains in the area were known to have both single stacked and double stacked containers on the wagons.

Based on site observations from outside the rail corridor area, the following features of the track were identified:

- The track was single line, on a ballasted track with concrete sleepers with train movements in both directions.
- The depth of the ballast was estimated at 700 mm on clay and sandy top soil.
- Based on site observations the train speeds ranged from 80 km/h to 100 km/h.

During train passby events, noise and vibration levels were monitored simultaneously at six locations (three noise and three vibration) along the track section. A comparison of the noise and vibration level across the whole train passby was made for the trains that had only single stacked containers on the wagons and those trains with a combination of double stacked and single stacked containers. It was noted that no trains had all wagons loaded with double stacked containers and the analysis did not isolate those wagons that were empty or stacked with empty containers.

The noise level over the duration of the train passby events are presented for the three noise monitoring locations (Channel 4, Channel 5 and Channel 6) in **Figure C1**. Spot 2D acoustic intensity measurements confirmed the rail and wheel are key noise sources (and not radiated vibration of containers).

The locomotives at the front of the train are the initial elevated noise levels with the sections of known single stacked and double stacked containers identified thereafter. It can be seen that the noise levels at the three monitoring locations were approximately 2 dBA or less during the passby of the double stacked wagons.

As shown in **Figure C2**, consistent with the measured noise levels, albeit a more marginal difference, the vibration velocity levels (in dBV) are higher with the single stacked container wagons.

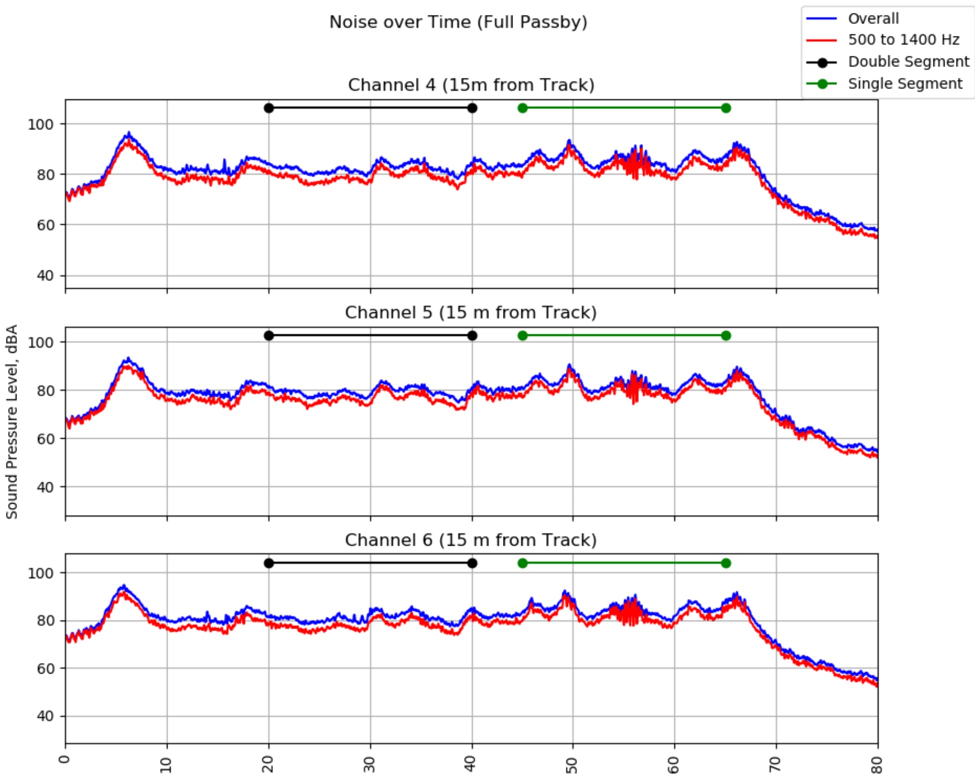
It is considered that if a noise emission correction factor were to be applied to the stacking configuration, this would be complicated by many factors in practice, particularly the:

- Proportion of wagons with single and double stacked containers and where they are located.
- Number and position of empty wagons (no containers).
- Load of the individual wagons, which can vary from empty to the maximum load capacity.

Consequently, whilst the loading of the freight consist can vary considerably depending on the mix of empty or fully loaded containers, the measurements find it insignificant with respect to rolling noise and vibration emissions compared to other factors such as individual wheel and track condition.

On the basis of the above analysis, correction factors to the noise and/or vibration emissions from double stacked wagons have not be considered in the Inland Rail operational rail noise and vibration assessments (at the EIS stage).

Figure C1 A-weighted noise levels for the entire train passby



The ground vibration levels at three locations (Channel 1, Channel 2 and Channel 3) for the same train passby event is presented in **Figure C2**.

Figure C2 Vibration velocity levels for the entire train passby